Transport for NSW

January 2023

Great Western Highway Blackheath to Little Hartley

Environmental Impact Statement

NSW GOVERNMENT

EIS declaration

Project details		
Project name	Great Western Highway Blackheath to Little Hartley	
Application number	SSI-22004371	
Address of the land on which the infrastructure is to be carried out: The project would be located in the upper Blue Mountains within the Dharug language group. The project would extend between Blackheath and Little Hartley and be located within the Blue Mountains and Lithgow local government areas.		
Proponent details		
Proponent name	Transport for NSW	
ABN	18 804 239 602	
Proponent address	Level 8, 231 Elizabeth Street, Sydney, NSW 2000	
Details of person by whom this EIS was prepared		
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Professional qualifications	Bachelor of Land and Water Science (Hons)	Master of Environmental Law, Bachelor of Science (Zoology), Bachelor of Chemical Engineering (Hons)
Declaration by registered environmental assessment practitioner		
Name	William Miles Technical Director, AECOM Australia Pty Ltd	
Registration number	R80018	
Organisation registered with	Certified Environmental Practitioner – Impact Assessment Specialism Environment Institute of Australia and New Zealand	
Declaration	The undersigned declares that this EIS: • has been prepared in accordance with Part 8 Division 5 of the Environmental Planning and Assessment Regulation 2021; • contains all available information relevant to the environmental assessment of the development, activity or infrastructure to which the EIS relates; • does not contain information that is false or misleading; • addresses the Planning Secretary's environmental assessment requirements (SEARs) for the project; • identifies and addresses the relevant statutory requirements for the project including any relevant matters for consideration in environmental planning instruments; • has been prepared having regard to the Department's State Significant Infrastructure Guidelines – Preparing an Environmental Impact Statement; • contains a simple and easy to understand summary of the project as a whole, having regard to the economic, environmental and social impacts of the project and the principles of ecologically sustainable development; • contains a consolidated description of the project in a single chapter of the EIS; • contains an accurate summary of the findings of any community engagement; and • contains an accurate summary of the detailed technical assessment of the impacts of the project as a whole.	

Declaration by registered environmental assessment practitioner	
Signature	
Date	15 December 2022

Responsible person:	
Name:	Jonathon Blizzard Senior Manager Environment and Sustainability Transport for NSW
Address:	Level 8, 231 Elizabeth Street Sydney, NSW 2000

Acknowledgement of Country

Transport for NSW acknowledges the traditional custodians of the land on which the upgrade of the Great Western Highway between Blackheath and Little Hartley is proposed, being the Dharug, Deerubbin, Gundungurra and Wiradjuri country with surrounding language groups including Darkinung to the north and Kuring-gai, Eora, and Tharawal to the east.

We pay our respects to their Elders past and present and celebrate the diversity of Aboriginal people and their ongoing cultures and connections to the lands and waters of NSW.

Many of the transport routes we use today – from rail lines, to roads, to water crossings – follow the traditional Songlines, trade routes and ceremonial paths in Country that our nation's First Peoples followed for tens of thousands of years.

Transport for NSW is committed to honouring Aboriginal peoples' cultural and spiritual connections to the land, waters and seas and their rich contribution to society.

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Summary

Overview

The Great Western Highway is the key east-west road freight and transport route between Sydney and Central West New South Wales (NSW). Together, the Australian Government and the NSW Government are investing more than $4.5 billion towards upgrading the Great Western Highway between Katoomba and Lithgow (the Upgrade Program). Once upgraded, over 95 kilometres of the Great Western Highway will be two lanes in each direction between Emu Plains and Wallerawang.

Transport for NSW (Transport) is seeking approval to upgrade the Great Western Highway between Blackheath and Little Hartley (the project) as part of the Upgrade Program. The project would comprise the construction and operation of new twin tunnels around 11 kilometres in length between Blackheath and Little Hartley, and associated surface road upgrade work for tie-ins to the east and west of the tunnel portals (i.e. the entrance and exit points for the tunnels).

The project would be located around 90 kilometres west of the Sydney central business district and within the Blue Mountains and Lithgow local government areas. The majority of the project would be located below ground, generally along or adjacent to the existing Great Western Highway alignment between Blackheath and Little Hartley. The Blue Mountains National Park and Greater Blue Mountains World Heritage Area are located generally to the east of the existing Great Western Highway. A large part of the project is also located within the Sydney Drinking Water Catchment. Low and medium density residential and commercial areas are generally located in the town centres of Blackheath and Mount Victoria. The location of the project is shown in Figure 1.

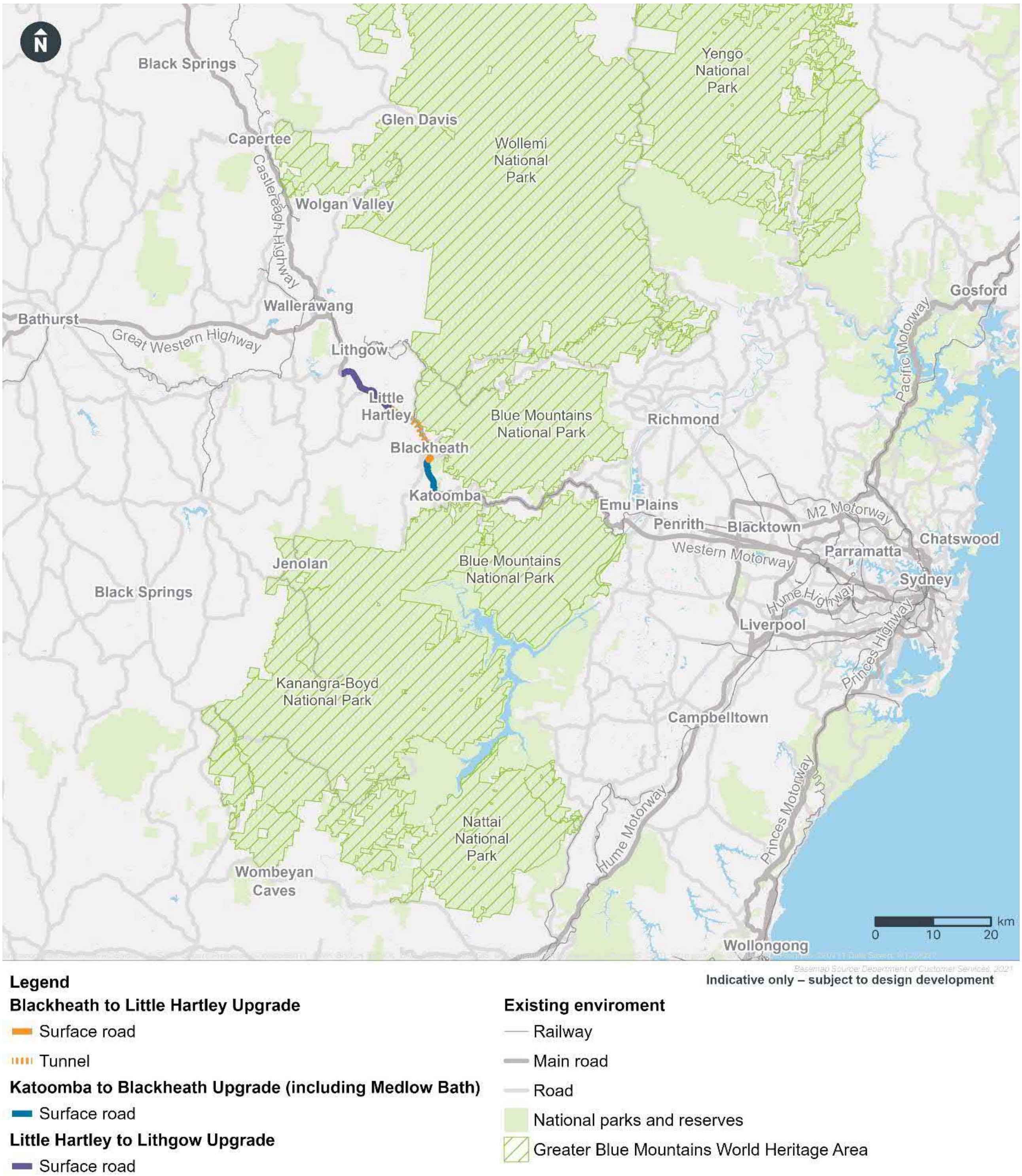


Figure 1 Regional context of the project

Environmental impact statement

Transport has prepared an environmental impact statement (EIS) based on the preliminary concept design and construction methodology for the project which would be confirmed during design development. The EIS describes the project, discusses the alternatives that were considered, explains why the project is the preferred option, and assesses how the project would impact the environment.

The EIS also describes how Transport has engaged with project stakeholders including the local community, Aboriginal stakeholders and government agencies during the development of the project.

Transport is seeking State significant infrastructure and critical State significant infrastructure declaration for the project by the Minister for Planning.

Transport has submitted a referral under the *Environment Protection and Biodiversity Conservation Act* 1999 (Commonwealth) (EPBC Act) to the Department of Climate Change, Energy, the Environment and Water (DCCEEW). At the time of finalisation of this EIS there has been no decision by DCCEEW on whether the project is a controlled action or not.

Why is an upgrade of the highway needed?

The Great Western Highway provides the main transport link through the Blue Mountains for access between the Central West of NSW (Bathurst, Orange, Parkes and Dubbo region) and the Sydney motorway network for freight, tourist and general traffic. It also plays a vital role in local traffic distribution between the townships of the Blue Mountains.

Supporting the current needs and future growth of Sydney and Central West NSW through an efficient transport network is fundamental to the liveability, productivity and sustainability of Greater Sydney and NSW. The need to address these issues is recognised in a number of strategic plans for improving transport, placemaking, and freight efficiency across Greater Sydney and regional NSW.

The existing Great Western Highway between Blackheath and Little Hartley is mostly a two-way undivided carriageway with one lane in each direction. Traffic volumes are expected to grow by two per cent per annum between Blackheath and Forty Bends, and visitors to regional NSW grew by 23 per cent between 2010 and 2017 prior to travel disruptions caused by the COVID-19 pandemic. The critical function of the Great Western Highway is being the key east-west road freight and transport route between Sydney and Central West NSW. Heavy vehicle movements along the Great Western Highway are predicted to increase by around 30 per cent by 2036. Growth in demand for this east-west transport route has led to the need for the upgrade of the Great Western Highway between Katoomba and Lithgow to a four lane carriageway (the Upgrade Program) and the project is a key component of this program.

The Great Western Highway is currently susceptible to closure during natural disasters and extreme weather events, has steep grades with limited overtaking opportunities and does not currently accommodate larger freight vehicles. The current constraints affecting the Great Western Highway which would be addressed by the project are shown in Figure 2.

The critical functions of the Great Western Highway coupled with growth in demand for these functions has led to the need for the project, as part of the broader Upgrade Program.

Constraints	Project objectives	Project benefits
Growing freight inefficiency	Improve economic development, productivity and freight accessibility in and through the Blue Mountains, Central West and Orana regions	Improved economic development, productivity and recovery
Vulnerability to closure	Improve the resilience of the corridor between Blackheath and Little Hartley to ensure continuity and safety of transport and essential services	Improved resilience and future-proofing
Sub-optimal travel times	Improve transport network performance and efficiency along the corridor between Blackheath and Little Hartley to meet the needs of customers	Improved network performance
Safety issues	Improve the overall safety of the corridor for all transport users between Blackheath and Little Hartley	Safety improvements
Amenity issues	Enhance the liveability and be sensitive to the unique environmental and cultural assets along the corridor between Blackheath and Little Hartley	Movement, place and amenity improvements
Project delivery	A value for money, sustainable and deliverable solution	Socio-economic opportunities

Figure 2 Constraints, project objectives and project benefits

Alternatives considered

The project has undergone years of investigation including consideration of various strategic alternatives and route options. Following the selection of the Great Western Highway Upgrade Program as the preferred strategic alternative, four separate projects were identified including:

- the Great Western Highway East – Katoomba to Blackheath Upgrade (Katoomba to Blackheath Upgrade)
- the Great Western Highway Upgrade – Medlow Bath (Medlow Bath Upgrade)
- the Great Western Highway Blackheath to Little Hartley (the project)
- the Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade).

The project alternatives and options development process is shown in Figure 3. Strategic alternatives and project options were assessed against the project objectives, which are consistent with the Upgrade Program objectives. Strategic alternatives and project options were also informed by outcomes of community and stakeholder engagement.

The project has been developed through an environment-led design process whereby preliminary environmental investigations, assessment and advice and community and stakeholder consultation has informed the design to avoid, where possible, or otherwise minimise potential impacts to sensitive environments and communities in this part of the Blue Mountains. Table 1 contains a summary of project design elements adopted to avoid or minimise potential environmental impacts. Options were also considered for specific project elements, including interchanges, tunnel ventilation, construction sites and spoil transport. Ongoing design development would continue to explore opportunities to reduce environmental and community impacts.

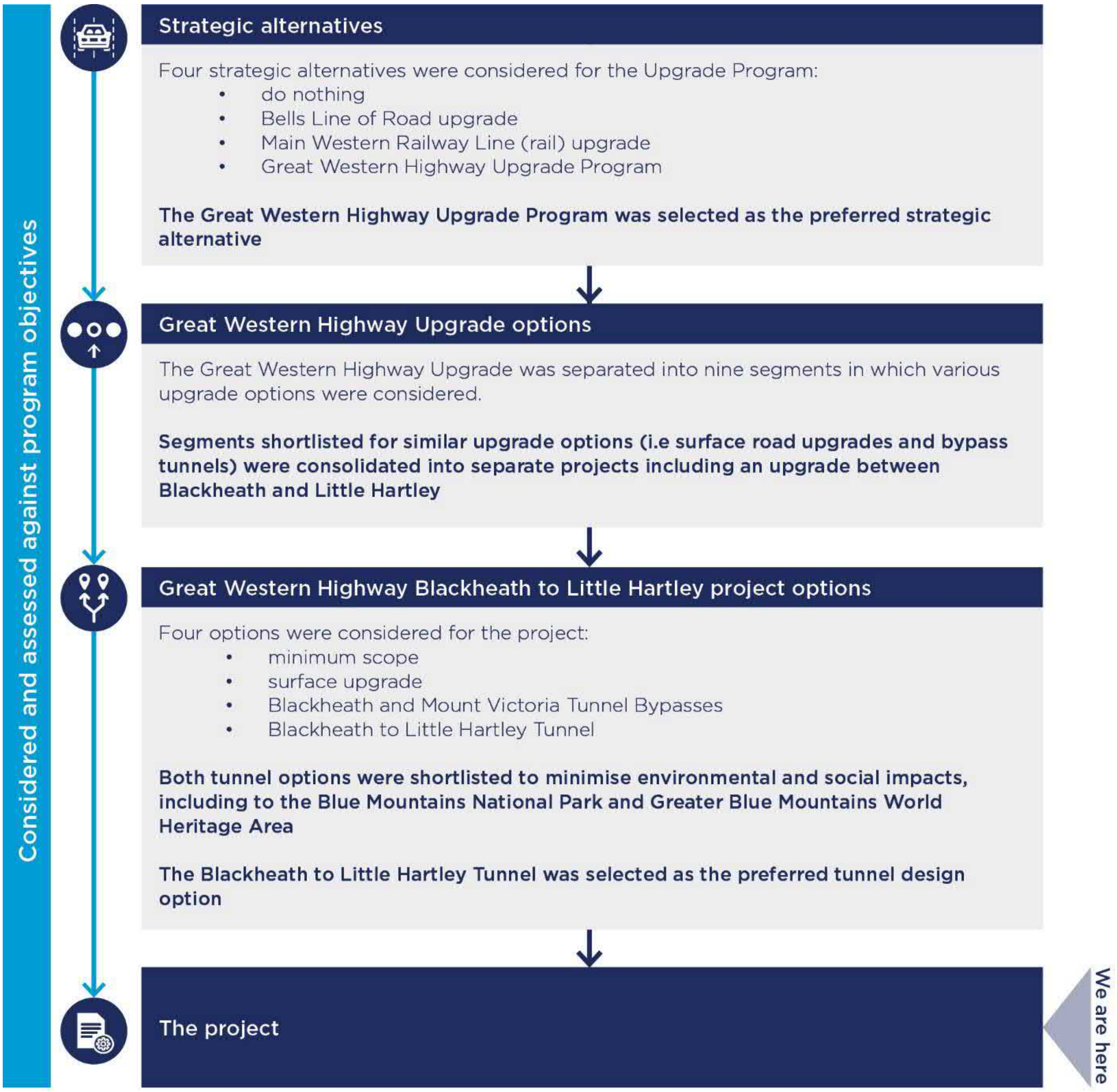


Figure 3 Approach to project alternatives and options development

Table 1 Design refinements to minimise and/or avoid environmental impacts

Design development	Environmental impact minimised and/or avoided
Construction	
Using tunnel boring machines (TBMs) as primary tunnel excavation method rather than roadheaders	• minimised construction duration due to faster rate of excavation compared to roadheaders • ability to progressively install precast structural, waterproof tunnel lining to minimise the extent of groundwater drawdown and potential impacts on groundwater dependent ecosystems • reduced number of tunnel excavation access points required compared with using roadheaders, minimising the construction footprint and spoil haulage route.
Excavating from west only rather than from both east and west	• minimised construction footprint at Blackheath, reducing native vegetation clearance, as the site would not need to accommodate TBM launch • reduced spoil haulage through Blackheath and Mount Victoria (including associated potential safety and amenity impacts), as spoil would primarily be hauled westbound from the Little Hartley construction site.
Optimised construction methodology which has reduced the construction footprint and number of construction sites	The project would use parts of the construction sites used for the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade to minimise vegetation clearance. Potential construction sites at Browntown Oval and at the old Blackheath tip site were considered (and discounted) to support construction. Avoiding use of these sites would result in: • reduced amenity impacts for residents near Browntown Oval and the old Blackheath tip site associated with use of, and access to and from, these sites • avoidance of impacts to social infrastructure at Browntown Oval which would continue to be available for recreational purposes • reduced impacts to human and ecological health (by limiting the risk of exposure to contaminated lands and friable asbestos at the old Blackheath tip site) • minimised biodiversity impacts (to the observed wetland and Commonwealth listed threatened species (Gang-gang Cockatoos and Blue Mountains Water Skink) identified near the old Blackheath tip site) • minimised construction noise impacts and construction traffic impacts through Blackheath • shorter construction duration at Blackheath, and reduced construction impacts to the community.
Revised tunnel alignment deviating from the existing Great Western Highway alignment to achieve a shorter and straighter tunnel	• less spoil, and shorter construction duration associated with a shorter tunnel length.

Design development	Environmental impact minimised and/or avoided
Operation	
Revised tunnel alignment deviating from the existing Great Western Highway alignment to achieve a shorter and straighter tunnel	• improved sustainability outcomes associated with reduced vehicle emissions from travelling along a shorter and straighter tunnel alignment • improved sustainability outcomes given the lower resource use and energy consumption associated with a shorter tunnel alignment • improved driver safety outcomes (minimising curvature and extending sight distance).
Reduced operational footprint at the Blackheath portal	• minimised visual impacts for road users, tourists and residents near the Blackheath portal • simplification of the Blackheath interchange and associated improved driver safety outcomes • increased opportunities for landscaping and better visual outcomes.
Physical separation of tunnel entry and exit portals at Blackheath and Little Hartley	• reduced localised air quality impacts if the portal emissions option is preferred • avoidance of portal emissions from the exit portal of one tunnel re-entering the entry portal of the adjacent tunnel • allows space for ventilation buildings and outlets for the ventilation outlet option (if identified as the preferred option), without requiring a change to the project footprint.
Use of portal emissions instead of ventilation outlets (if identified as the preferred option)	• minimised visual impacts as a result of removing the need for ventilation outlets • improved sustainability outcomes given the lower resource use, greenhouse gas emissions and energy consumption associated with operating under a portal emissions option.

Description of the project

The project would comprise new twin tunnels between Blackheath and Little Hartley and forms part of the Upgrade Program.

The key components of the project are summarised in Table 2. An overview of the project is shown in Figure 4. The operational configuration of the project at Blackheath and Little Hartley is shown in Figure 5 and Figure 6 respectively.

The existing Great Western Highway would be retained between Blackheath and Little Hartley and would continue to function as an alternative route for local and tourist traffic. It would also be an alternative route should there be planned or unplanned shutdowns of the tunnels.

Two options for ventilation facilities are being considered for the project including ventilation design to support emissions via ventilation outlets or via the tunnel exit portals. If required, ventilation outlets would require a ventilation building and ventilation outlet around 10 metres above ground level at the tunnel portals at Blackheath and Little Hartley. The portal emissions option would not require outlets or buildings, and emissions would be dispersed via the tunnel exit portals.

Table 2 Key components of the project

Key project component	Summary
Tunnels	Twin tunnels around 11 kilometres in length between Blackheath and Little Hartley, connecting to the upgraded Great Western Highway at both ends. Each tunnel would include two lanes of traffic and road shoulders and would range in depth from just below the surface near the tunnel portals, to up to around 200 metres underground at Mount Victoria.
Surface work	Surface road upgrade work would be required to connect the tunnels and surface road networks south of Blackheath and at Little Hartley. The twin tunnels would connect to the surface road network via: • mainline carriageways and on- and off-ramps at the Blackheath portal, located adjacent to the existing Great Western Highway and south of Evans Lookout Road • mainline carriageways at the Little Hartley portal, located adjacent to the existing Great Western Highway at the base of the western escarpment below Victoria Pass and southwest of Butlers Creek.

Operational infrastructure	Operational infrastructure provided by the project would include:
	• a tunnel operations facility adjacent to the Blackheath portal
	• in-tunnel ventilation systems including jet fans and ventilation ducts connecting to the ventilation facilities
	• one of two potential options for tunnel ventilation currently being investigated, being:
	  – ventilation design to support emissions via ventilation outlets; or
	  – ventilation design to support emissions via portals
	• drainage and water quality infrastructure including sediment and water quality basins, an onsite detention tank at Blackheath and a water treatment plant at Little Hartley
	• fire and life safety systems, emergency evacuation and ventilation infrastructure and closed circuit television
	• lighting and signage including variable message signs and associated infrastructure such as overhead gantries.

Utilities	Key utilities required for the project would include: • a new electricity substation at Little Hartley for construction and operational power supply • a new pipeline between Little Hartley and Lithgow for construction and operational water supply • other utility connections and modifications, including electricity substations in the project tunnels.
Other project elements	The project would also include: • integrated urban design initiatives • landscaping planting.

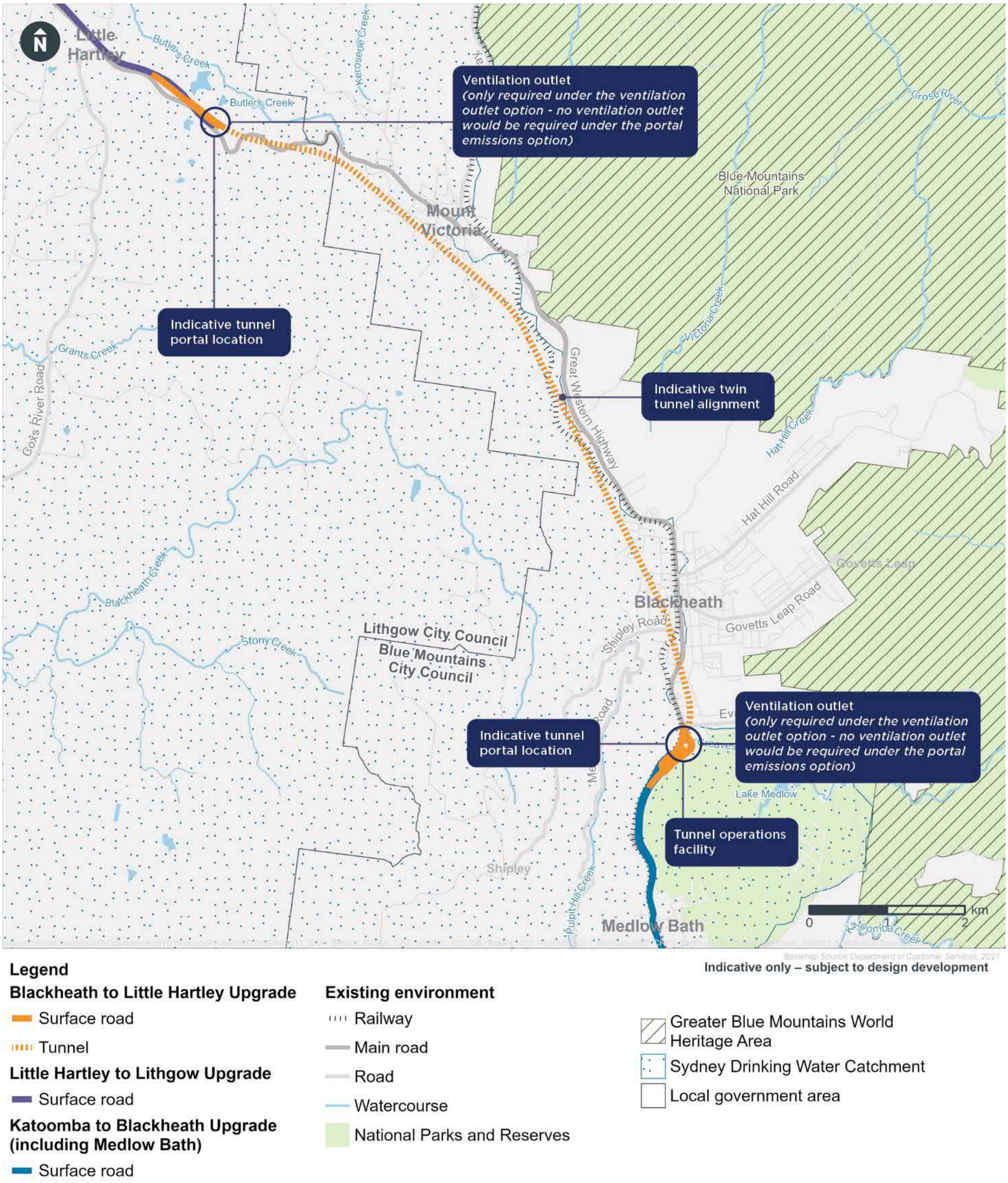


Figure 4 Overview of the project

Figure 5 Indicative operational configuration at Blackheath

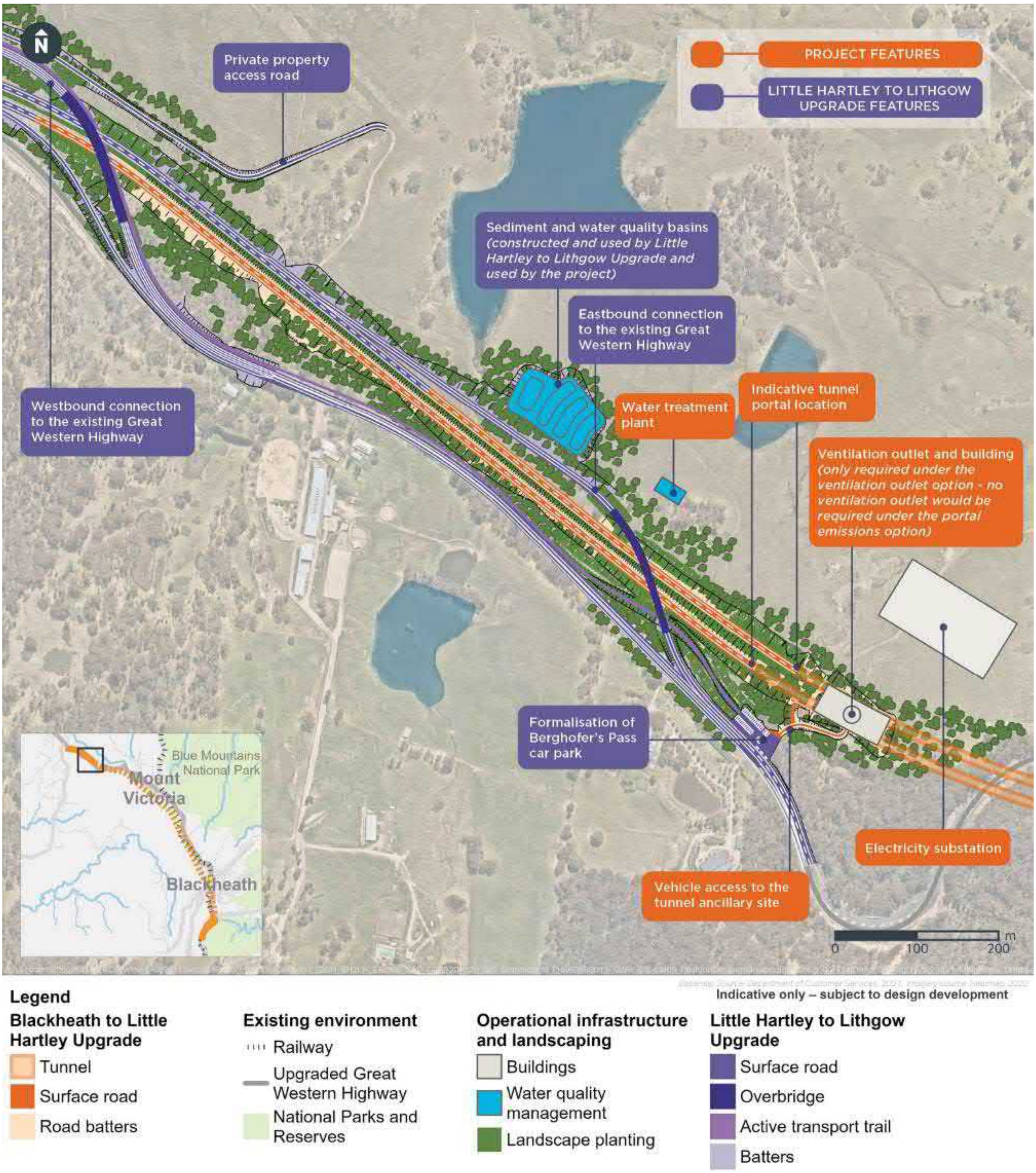


Figure 6 Indicative operational configuration at Little Hartley

Construction

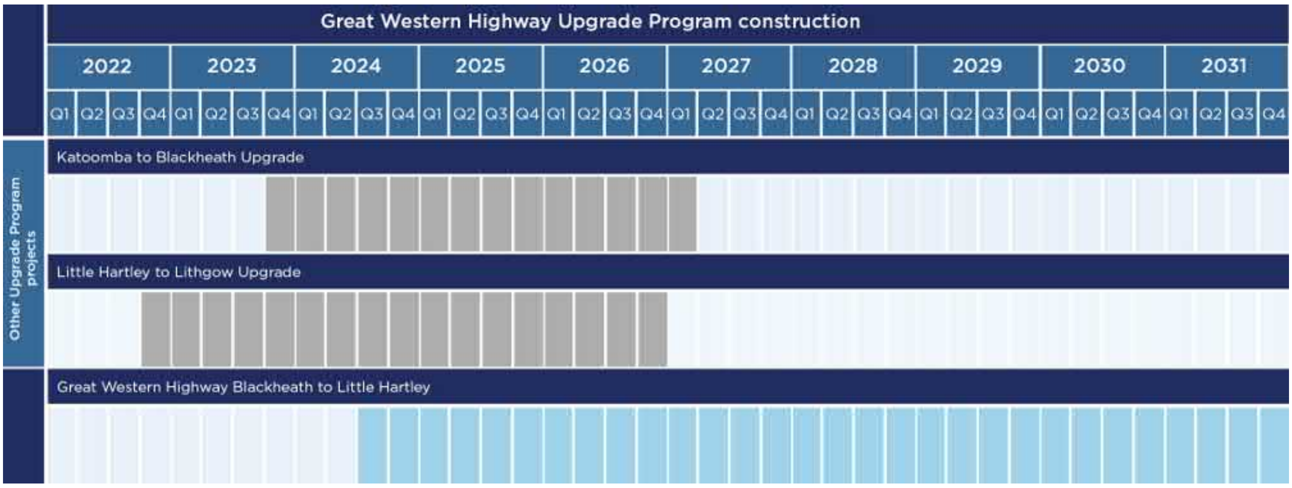
Subject to planning approval, construction is planned to commence in early 2024 and continue until 2031. The project is expected be open to traffic by 2030. The indicative construction program for the project including the relationship with other components of the upgrade of the Great Western Highway between Katoomba and Lithgow (the Upgrade Program) is shown in Table 3.

The project is expected to support an indicative peak construction workforce of up to 1,100 full time equivalent jobs (direct employment) during the eight years of construction.

The proposed construction activities required for the project include:

- site establishment and enabling works
- tunnel portal construction
- tunnelling and associated works
- surface road upgrade works
- operational infrastructure construction and fit-out, including construction of operational environmental controls
- finishing works, testing and commissioning.

Table 3 Indicative construction program



The indicative construction footprint for the project is shown in Figure 7 to Figure 9.

To minimise environmental impacts, parts of the construction sites used for the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade would be used to support construction of the project. As shown in Table 4, construction of these projects is expected to be underway before the commencement of this project. These areas are shown in Figure 7 and Figure 9. The project would also require a new construction site at Soldiers Pinch.

Figure 7 Indicative construction footprint at Blackheath

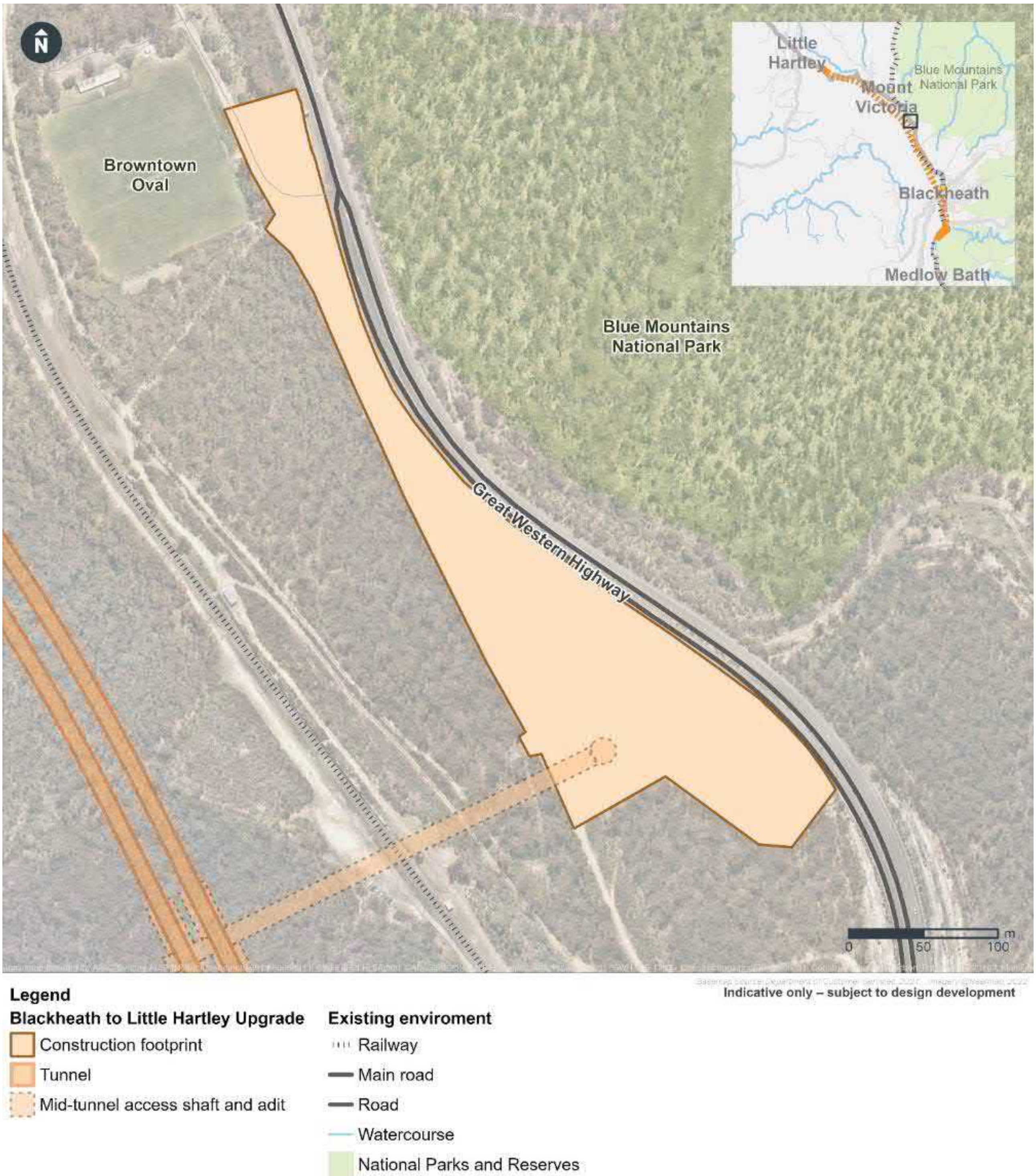


Figure 8 Indicative construction footprint at Soldiers Pinch

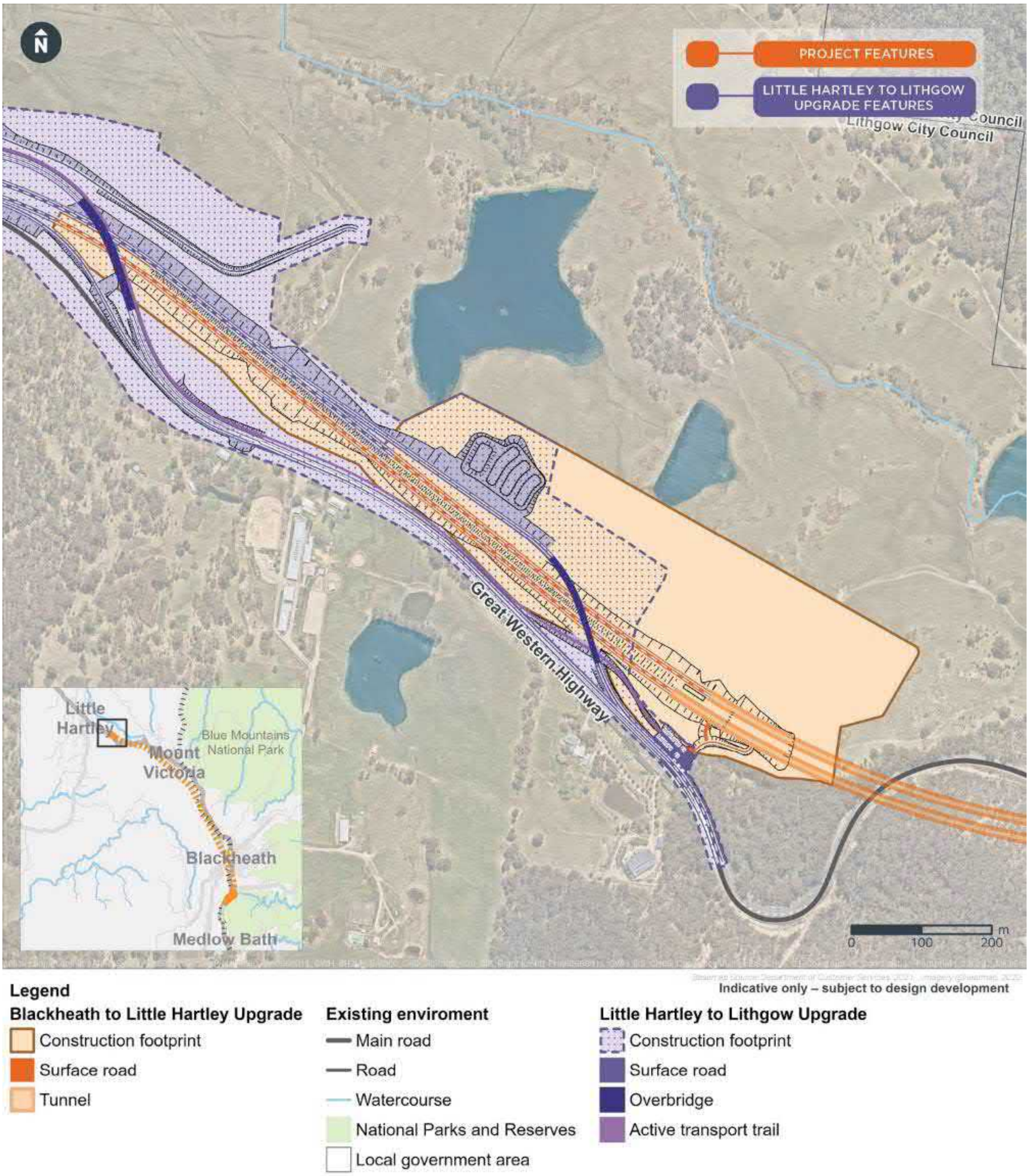


Figure 9 Indicative construction footprint at Little Hartley

Benefits of the project

The key benefits of the project would include:

- improved economic development, productivity, and recovery – during the first ten years of operation, the project would contribute up to around $10 million per year in net output for the regional area (refer to Chapter 20 (Business, land use and property)) and would create a faster, safer, and more efficient freight connection between Blackheath and Little Hartley. During construction, the project would create up to 1,100 jobs and is expected to contribute around $130 million per year to the regional economy

- improved resilience and future-proofing – the project would provide an alternative route to the current Great Western Highway between Blackheath and Little Hartley and would improve access for emergency vehicles in the event of an incident. It would also assist in minimising broader traffic delays and disruptions that may be caused by an incident. The project has been designed to improve the level of service for predicted traffic volumes in future years with scope to accommodate future growth
- improved network performance – the project would reduce light vehicle travel times between Blackheath and Little Hartley by around nine minutes, and heavy vehicle travel times by around nine minutes during the weekday AM peak hour period. The project would also provide a connection for high productivity vehicles longer than 20 metres (with an upper limit of 36 metres) between Blackheath and Little Hartley, contributing to a total reduction in the current route for these vehicles by up to 100 kilometres between Sydney and Central West NSW. The project would substantially reduce traffic on the existing Great Western Highway between Blackheath and Little Hartley improving travel time, speeds and safety on this part of the route
- safety improvements – the project would provide a safer alternative to the current steep grades, limited overtaking opportunities and at-grade intersections along sections of the Great Western Highway between Blackheath and Little Hartley. The project would provide a bypass route for heavy vehicles, avoiding local townships and two school zones and allowing separation of through and freight traffic from local and tourist traffic
- movement, place, and amenity improvements – the project would result in improved amenity for residents of Blackheath and Mount Victoria due to a substantial reduction in traffic and associated reductions in traffic noise and vehicle emissions along the existing Great Western Highway. The project would also incorporate urban design principles as described in Chapter 4 (Project description) and create potential opportunities for placemaking initiatives by reducing through traffic, including freight vehicles, at key locations along the Great Western Highway, particularly at Blackheath and Mount Victoria. These placemaking opportunities are consistent with the Movement and Place Framework (NSW Government, 2020a) adopted by Transport for the Upgrade Program.

In addition, the project (as part of the Upgrade Program) would present socio-economic opportunities, including:

- improving connections between the national high productivity vehicle network and Sydney
- strengthening supply chains due to better access to regions
- improving access to employment opportunities and services.

Community and stakeholder consultation

Consultation and engagement activities undertaken for the project and planned moving forward include:

- consultation for the Upgrade Program relevant to early project development, strategic corridor options, route options and engagement with the Blackheath Co-Design Committee (comprising various stakeholder group representatives, independently selected community representatives, Blue Mountains City Council, Lithgow City Council and emergency services representatives)
- consultation for the project during preparation of the EIS, including for the preferred option in May 2022
- engagement during and following the public exhibition of the EIS, including the display of the EIS and the preparation of a submissions report and an amendment report (if required)
- engagement carried out during construction of the project, including proposed engagement activities during project delivery.

Assessment of environmental impacts

The EIS is a comprehensive document that considers a wide range of potential environmental impacts.

For the purposes of this assessment, it has been assumed that parts of the Blackheath and Little Hartley construction footprints will have been prepared for use as part of the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade, including being cleared of vegetation and installation of water quality controls.

The environmental impacts associated with these works have been assessed as part of the Katoomba to Blackheath Upgrade Review of Environmental Factors (REF) and the Little Hartley to Lithgow Upgrade REF. These areas, as modified by these other projects, form the baseline environment considered at Blackheath and Little Hartley for the purposes of the EIS. At Soldiers Pinch, the existing environment forms the baseline environment for the purposes of the EIS.

Assessment of impacts on the Greater Blue Mountains World Heritage Area

The project is located nearby the Greater Blue Mountains World Heritage Area which is listed on the World Heritage List. This is an area of breathtaking views, rugged tablelands, sheer cliffs, deep, inaccessible valleys and swamps which support a rich and diverse ecosystem. The area demonstrates the evolution of Australia's unique eucalypt vegetation and its associated communities, plants and animals.

The project has been designed to avoid and minimise impacts to the values of the Greater Blue Mountains World Heritage Area, including selecting a tunnel option instead of surface road upgrades and an optimised construction methodology to reduce the construction footprint at the surface, particularly at Blackheath. The project would not directly impact the Greater Blue Mountains World Heritage Area.

Transport and traffic

There would be an increase in traffic on the existing Great Western Highway during construction as a result of spoil haulage, other construction vehicles and the construction workforce travelling to and from construction sites. Design refinements described in Table 1 and in Chapter 3 (Project alternatives and options) have minimised construction spoil haulage through the townships of Blackheath and Mount Victoria, minimising the interaction of heavy vehicles with pedestrians and cyclists and other vehicles in these areas. The tunnel boring machine construction methodology whereby spoil would be transported westbound from the Little Hartley construction site would also minimises the number of additional heavy vehicles that need to use Victoria Pass, which frequently experiences heavy vehicle breakdowns due to steep grades. In addition, the management of construction traffic would be in accordance with a Construction Transport and Access Management Plan and site-specific mitigation measures, including minimising haulage vehicle movements and peak traffic generating activities during the AM and PM peak hours, weekend peak hours and on peak weekends and public holidays where practicable.

Temporary modifications to the existing road network such as construction site access arrangements, staged works and speed zone changes would be required during construction of the project. During construction, relatively small and manageable increases in traffic volumes of up to five per cent are expected through Blackheath and Mount Victoria, and up to 13 per cent in Little Hartley. Minor increases to weekday peak hour travel times of about one minute for both directions along the existing Great Western Highway between Blackheath and Little Hartley are also expected during construction. Additional right turning construction traffic combined with background traffic growth along this section of the Great Western Highway would contribute to decreased levels of service at the Great Western Highway and Evans Lookout Road intersection. Opportunities to minimise the impacts of construction traffic on the level of service at this intersection are being investigated.

Emergency vehicles would also potentially be affected by minor road network impacts such as increased traffic volumes, increased travel times and reduced intersection performance during construction of the project. Vehicular access to the Blue Mountains National Park and Sydney Drinking Water Catchment at Blackheath would be maintained during construction and operation. The Construction Transport and Access Management Plan for the project would be developed in consultation with relevant emergency services, ensuring that procedures are in place to maintain safe, priority access for emergency vehicles through or around construction zones.

Given that the project comprises new underground infrastructure separate to the existing road network, the potential transport and traffic impacts of the project have been largely minimised. During operation, weekday traffic volumes are expected to be reduced by about 60 per cent in Blackheath and nearly 80 per cent in Mount Victoria. Heavy vehicle volumes are expected to reduce by around 80 and 90 per cent in Blackheath and Mount Victoria respectively. The large reduction in traffic volumes along the existing Great Western Highway through Blackheath and Mount Victoria would noticeably improve accessibility, amenity and safety for these townships including for active transport users.

The tunnels would accommodate two lanes of traffic in each direction and are expected to have adequate capacity to cater for predicted growth in traffic volumes in the future. The tunnels would be designed to accommodate larger freight vehicles. The project is expected to provide substantial travel time reductions in the area, along with a number of road safety benefits including improved grades, fewer intersections, wider lanes, improved sightlines, improved overtaking opportunities and separation of opposing traffic flows. Improved grades are also expected to provide better heavy vehicle performance, and by allowing the use of High Productivity Vehicles, the project would result in fewer heavy vehicles but with increased load capacity.

Air quality

Air quality during construction of the project would be adequately managed in accordance with standard mitigation measures.

During construction of the project, the risk of dust soiling for human receptors was considered medium to high at Blackheath construction site due to the proximity of sensitive receptors to the north, and low at Soldiers Pinch and Little Hartley construction sites. Due to the low density of sensitive receptors and low existing PM_{10} (particulate matter equal to or less than 10 micrometres in diameter) background concentrations, unmitigated dust health risks were considered low across all construction sites. Construction traffic emissions and mobile and stationary plant and equipment exhaust emissions are unlikely to have a significant impact on local air quality.

The assessment approach for assessing portal emissions was developed by Transport in consultation with and endorsed by the Advisory Committee on Tunnel Air Quality. Operational air quality impacts were assessed for both tunnel ventilation design options currently being investigated for the project (emissions via ventilation outlets or portals).

In both ventilation outlet and portal emissions scenarios, predicted total ground level concentrations of pollutants were below the NSW Environment Protection Authority’s criteria for all pollutants and all modelled scenarios at the most affected receptors. The results of the modelling indicate an improvement in air quality due to the improved traffic flow and reduced traffic volumes along the existing Great Western Highway as a result of traffic diverting to the tunnel, and the reduced gradient in the tunnel compared to the existing Victoria Pass, as well as improved emissions standards. Assessment of ecological impacts for all examined pollutants found no significant air quality related ecological impacts are anticipated from the project for either ventilation option.

Human health

The human health impact assessment focused on health-related impacts associated with air quality, noise and vibration and social impacts of the project.

During construction, unmitigated dust impacts would pose a low risk to community health. With the implementation of appropriate mitigation measures, dust related impacts would be minimised including the potential for associated health impacts such as stress and anxiety. Construction noise has the potential to exceed health-based noise criteria during and outside during standard hours.

With the implementation of noise mitigation measures, the potential for human health impacts from construction noise would be low to moderate. Potential health impacts associated with changes in access and connectivity, property acquisition and changes to visual amenity during construction would be low. The increased employment and improved economic vitality caused by construction of the project would provide potential benefit to community health.

Potential health impacts from changes to ambient air quality during operation include negligible impacts from volatile organic compounds and carbon monoxide, and low and acceptable exposures to benzene, polycyclic aromatic hydrocarbons, diesel particulate matter and PM_{10}. The project would result in potential long term health benefits by decreasing the level of exposure to nitrogen dioxide and $PM_{2.5}$. The proposed in-tunnel air quality limits for carbon monoxide and nitrogen dioxide would be adequately protective of the health of users of the project during operation. The project would result in reduced noise levels at a number of sensitive receptors where the tunnel provides a bypass to the existing Great Western Highway at Blackheath and Mount Victoria. Increases in road traffic noise during operation of the project at levels that may be of concern to health would be limited to two properties. Subject to the implementation of proposed noise mitigation measures, no substantial health impacts are expected for these properties.

Potential health impacts associated with changes in access and connectivity, and changes to visual amenity during construction would be low. The ongoing economic benefits provided by the project, including increased business productivity and increased tourism spend in the area, would provide considerable community health benefits.

Noise and vibration

Construction noise and vibration would be managed through a Construction Noise and Vibration Management Plan to be prepared as part of the Construction Environmental Management Plan (CEMP). The final number, degree and nature of the mitigation measures within this plan would ultimately depend on the construction strategy and work carried out.

During construction, noise levels may exceed noise management levels at some residential receivers, largely near the Blackheath construction site. Most of these noise exceedances are in the range of about one to 10 decibels and would occur mainly during tunnelling and surface road works. A number of exceedances are also predicted during site establishment and tunnel portal construction at Blackheath, also in the range of about 10 decibels. Relatively few exceedances above 10 decibels are predicted to occur, however the majority of these are also at Blackheath. Some night works may also exceed sleep disturbance criteria during construction, particularly near the Little Hartley construction site where around 19 residential receivers may experience some level of sleep disturbance. While most construction activities are expected to occur during standard construction hours it is possible that some noisy construction activities for the project may occur at the same time in close proximity to each other, thereby increasing construction noise levels.

Some receivers located near shallower sections of the tunnel, closer to the tunnel portals are predicted to experience levels of ground-borne noise (noise generated from vibration propagated through the ground) which would exceed the ground-borne noise criteria. Ground-borne noise at these receivers would be temporary (for a few days at a time) as the TBMs progress at an average rate of around 70 to 90 metres per week. As the works are expected to be staged and progressive, the number of affected residential receivers at any one time would be limited.

Construction vibration may be generated due to the vibration intensive equipment to be used during some stages of the project. Equipment size would be selected by the construction contractor and would take into account the minimum working distances and the distance between the area of construction and the nearest receiver. If vibration intensive works are required within these minimum working distances, mitigation measures to control excessive vibration would be implemented.

Operation of the project is expected to result in reduced noise levels at around 2,000 residential receivers located adjacent to the existing Great Western Highway between Blackheath and Little Hartley where the tunnel provides a bypass to the existing surface road. By providing an improved gradient and alignment, the project would also reduce maximum noise levels and events associated with truck engine braking, exhausts and horns. Two receivers located adjacent to new and upgraded sections of surface road may experience elevated levels of operational road traffic noise. The use of low noise road pavement or at-receiver noise mitigation would be investigated to reduce traffic noise at these receivers.

For the portal emissions design option, 16 receivers at Blackheath may experience exceedances of up to four decibels mainly due to the operation of jet fans located near the Blackheath portal. No exceedances for receivers at Little Hartley are expected. To reduce the noise levels emanating from the tunnel portals, quieter jet fans could be used or the use of attenuators could be investigated.

For the ventilation outlet design option, 26 receivers at Blackheath may experience exceedances of up to five decibels, and two receivers at Little Hartley may experience exceedances of up to four decibels. These exceedances would be caused by the fire pump which would operate under emergency conditions only.

Biodiversity

The project has been designed to minimise biodiversity impacts in the following ways:

- selecting a tunnel option between Blackheath and Little Hartley to minimise surface impacts including vegetation clearance
- the size of the Blackheath and Little Hartley construction sites have been minimised and partially located within the footprints of the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade projects which will have been cleared for construction of these projects, minimising the total impact to vegetation
- use of TBMs rather than road headers meaning that the excavated sections of tunnel are only exposed for a short duration of time before the concrete segments which line the tunnel are installed, minimising groundwater drawdown and potential impacts on groundwater dependent ecosystems.

The key biodiversity impacts include:

- removal of around 9.71 hectares of native vegetation and up to 20 hollow-bearing trees
- potential impacts to habitat for threatened Large-eared Pied Bat, Greater Glider and Purple Copper Butterfly
- potential groundwater drawdown and changes to baseflow within the Greaves Creek sub-catchment during construction and operation of the project, potentially impacting on groundwater dependent ecosystems (GDEs) associated with Temperate Highland Peat Swamps on Sandstone (THPSS) (listed as endangered under both NSW and Commonwealth legislation)
- potential indirect impacts on GDEs resulting from changes to water quality and hydrological processes, particularly from increased runoff volumes from discharge locations at Little Hartley.

There are no impacts to threatened flora. Other potential indirect impacts such as inadvertent impacts on adjacent habitat vegetation and bush rock removal and disturbance can be managed by adopting standard mitigation measures. Opportunities to minimise these impacts would be investigated further during design development, and mitigation measures have been proposed to minimise and/or avoid potential biodiversity impacts which have not been avoided through design.

Residual biodiversity impacts would be offset in accordance with the NSW Biodiversity Assessment Method. Up to 279 ecosystem credits and 510 species credits may be required to offset impacts to threatened fauna, flora and ecological communities.

Groundwater and geology

To limit potential groundwater inflows and groundwater drawdown, the tunnels would be tanked (designed to prevent the inflow of groundwater, typically using concrete lining and waterproofing membranes). Use of TBMs would mean that the excavated sections of tunnel are only exposed for a short duration of time before the concrete segments which line the tunnel are installed.

Impacts to groundwater flow during construction may include localised changes to flow rates and drawdown near the Blackheath portal and mid-tunnel access shaft, adit and caverns. Given the low magnitude and localised spatial extent of groundwater drawdown, the project would have a low impact on regional groundwater flow patterns. Groundwater collected during construction would be treated at construction water treatment plants at Blackheath, Soldiers Point and Little Hartley before discharge. With the application of standard mitigation measures and management plans, construction activities would be low risk and impacts to groundwater quality during construction of the project would be unlikely.

Potential dewatering due to construction activities is predicted to impact baseflow within the Fairy Bower sub-catchment, however this impact would be low given that the greatest predicted baseflow reduction would be during wet periods.

The areas which are most likely to be affected by tunnel excavation induced settlement are where tunnelling is closest to the ground surface (shallowest), around the tunnel portals and entry and exit ramps. The typical predicted settlement at the location of the tunnels would have a negligible ground movement risk during construction. Settlement induced as a result of groundwater drawdown is expected to be negligible.

During operation, groundwater drawdown would occur at permanently drained structures, being the Blackheath and Little Hartley portals and the mid-tunnel caverns. Maximum drawdown is predicted to be between 5.1 to 20 metres and between 2.1 to 5 metres at the Blackheath and Little Hartley portals, respectively. Groundwater drawdown would potentially affect 33 registered bores during operation (2030 to 2130), however modelling shows that no registered water supply bores would experience a maximum drawdown greater than two metres during operation or longer-term. Given the low magnitude and spatial extent of groundwater drawdown, the project would have a low impact on regional groundwater flow patterns. With the application of standard mitigation measures and management plans, activities during operation are considered low risk and impacts to groundwater quality are considered unlikely.

Potential dewatering and changes to baseflow within the Greaves Creek sub-catchment near the Blackheath portal could impact on water availability for water supply purposes at Lake Greaves and Lake Medlow. Reduction in baseflows could also affect GDEs associated with THPSS at Greaves Creek. During further design development and prior to construction, the numerical groundwater model will be updated and the existing groundwater monitoring network will be reviewed and maintained around the project to characterise the hydrogeological environment along and around Greaves Creek and associated GDEs. Subject to the outcomes of further consideration of potential impacts on GDEs, options to avoid and/ or minimise anticipated impacts will be identified and implemented if reasonable and feasible.

Surface water and flooding

Water quality

Construction activities have the potential to temporarily impact the water quality of surrounding waterways and downstream of the project. Erosion and sedimentation management measures and water treatment plant maintenance procedures would be detailed in the CEMP for the project. These measures would be implemented in accordance with Managing Urban Stormwater – Soils and Construction, commonly referred to as the 'Blue Book'. With the implementation of these controls, potential water quality impacts during construction would be appropriately managed and would be minor.

During operation, there is the potential for increased sedimentation and turbidity, nutrient runoff, visual amenity impacts (from turbid/polluted water), potential pollution, increase in scour and erosion and increase in surface water acidity if surface water runoff is not managed appropriately. These potential surface water runoff impacts would be mitigated through stormwater treatment devices and procedures for spills management. Therefore, the project would not be expected to impact the environmental values and water quality objectives of the receiving environment.

The project is located within the Sydney Drinking Water Catchment. A neutral or beneficial effect (NorBE) assessment has been carried out and has found that the project would have a beneficial effect on water quality in the Sydney Drinking Water Catchment.

Flooding

The project has been and would continue to be designed to avoid potential flooding impacts.

At Blackheath, there would be some overland flow risk during construction due to temporary blockage or diversion of waterways and drainage lines due to construction activities. These temporary impacts would be minor and would be managed through the implementation of standard construction techniques. At Little Hartley, there is potential for inundation and damage to occur during construction if a flood event larger than a one in twenty year flood event were to occur. Site planning would be conducted to minimise potential flooding and scour impacts during construction. The Soldiers Pinch construction site is unlikely to be affected by flooding during construction.

At Blackheath, operation of the project is not expected to adversely impact existing flow path characteristics. At Little Hartley, potential overtopping of the Great Western Highway may occur under a one per cent annual exceedance probability flood event. Drainage design would be further refined as part of design development to mitigate overtopping of the road. Impacts to existing and proposed community emergency management arrangements for flooding would be minimal. Improvements in flood immunity of the existing Great Western Highway at Little Hartley are expected as a result of the project. Key project infrastructure such as tunnel portals are not predicted to be impacted during nominated flood events.

Soils and contamination

Soils

Construction of the project would temporarily expose the natural ground surface and subsurface through the removal of vegetation, excavation and compaction of topsoil. The temporary exposure of soil to water runoff and wind could result in soil erosion. There is the potential that exposed soils and other unconsolidated materials (such as spoil, sand and other aggregates) could be transported from the construction sites into surrounding waterways via stormwater runoff. Erosion controls would be implemented and managed in accordance with relevant guidelines to manage this risk and achieve a beneficial effect on receiving watercourses.

It is unlikely that saline or acid sulfate soils would be encountered during construction. Potential oxidation and/or runoff from stockpiles comprising acid sulfate rock at Little Hartley during construction excavation, earthworks and tunnelling could occur. An Acid Sulfate Rock Management Plan will be prepared in accordance with the appropriate acid sulfate soil management guidelines.

During operation, soil would generally not be disturbed.

Contamination

No areas likely to be affected during construction have been identified as having a high risk of potential contamination. Areas identified as having a medium risk of potential contamination would be subject to targeted site investigations during ongoing design development. Where required, remedial actions will be developed for contamination identified through targeted site investigations.

Given the majority of the project tunnels would be constructed within bedrock and the majority of the tunnel would be tanked to minimise groundwater ingress, the potential for contaminated groundwater to be intercepted would be low. The potential to encounter coal seam gas during tunnelling would be mitigated through measures such as advance investigation and monitoring, and possibly gas drainage (depressurising the coal seams of gas and water).

Aboriginal cultural heritage

The key design feature adopted to minimise impacts on Aboriginal heritage was selection of a tunnel option between Blackheath and Little Hartley to minimise surface disturbance and the potential to impact Aboriginal heritage sites located along the Great Western Highway.

No direct Aboriginal cultural heritage impacts are anticipated as a result of the project. Vibration from tunnelling is unlikely to impact artefact-bearing deposits near the ground surface as the tunnels are deep enough as to not impact subsurface deposits. One Aboriginal cultural heritage within the minimum working distances for some types of vibration intensive plant consists of individual stone artefacts within or adjacent dirt roads regularly traversed by vehicles, and therefore potential impacts from vibration are unlikely. Based on the settlement analysis, predicted settlement calculations indicate that no known Aboriginal heritage items would be affected by settlement.

Transport recognises the potential for the project to indirectly impact Aboriginal cultural heritage values. A preliminary Aboriginal Narrative Report and Body of Story Report has been prepared for the Upgrade Program to assist with the interpretation and integration of intangible Aboriginal cultural values identified during Aboriginal consultation and exploratory workshops by giving Aboriginal communities a voice in the design of the Upgrade Program. The report includes a series of core narratives and stories and outlines a set of overarching cultural design principles to inform the projects design principles. These highlight opportunities to develop a design that would deepen the understanding of place and the rich history of the Aboriginal cultural, spiritual and physical connection to the area and importantly will facilitate greater Aboriginal visibility.

Consultation was undertaken with Aboriginal stakeholders including Local Aboriginal Land Councils during preparation of the assessment, along with consultation with Registered Aboriginal Parties, who attended site surveys.

If unexpected items of potential Aboriginal cultural heritage significance, including potential Aboriginal burials or skeletal material, are discovered during construction of the project, all relevant activities will cease and the unexpected/chance finds requirements specified in the Unexpected Heritage Items Procedure will be followed.

Non-Aboriginal heritage

The project would not directly impact the Greater Blue Mountains World Heritage Area. Potential indirect impacts to this item would include temporary visual impacts during construction at the Soldiers Pinch construction site.

The Blackheath construction site and north-eastern portion of the Soldiers Pinch construction site are located within the Greater Blue Mountains Area (Additional Values), an item nominated for the National Heritage List. Biodiversity values related to this nominated item include high condition native vegetation. During construction of the project, there would be minor impacts to this nominated item associated with vegetation clearance at the Blackheath and Soldiers Pinch construction sites. Opportunities to minimise the extent of native vegetation clearing within the footprint of the Greater Blue Mountains Area (Additional Values) nominated item will be considered during further design development.

The Little Hartley construction site would result in moderate indirect visual impacts to the Rosedale local heritage item, and potential moderate impacts on archaeology at the Mount Victoria Stockade site (archaeological site) during construction. Subject to confirmation of the precise location of the site of the Plough Inn (archaeological site), there may also be potential major impacts on archaeology from construction at the Little Hartley construction site. Based on current construction programming, impacts from the Little Hartley to Lithgow Upgrade project on the Plough Inn site are likely to occur before commencement of the project.

A detailed archaeological survey will be carried out within those parts of the Mount Victoria Stockade site and the potential Plough Inn site that would be directly affected by construction of the project, and which have not been previously disturbed/ surveyed by the Little Hartley to Lithgow Upgrade project.

If unexpected items of potential non-Aboriginal heritage significance are discovered during construction of the project, all relevant activities will cease and the unexpected/chance finds requirements specified in the Unexpected Heritage Items Procedure will be followed.

The project may result in potential indirect visual impacts to heritage items from the addition of operational infrastructure at the tunnel portals, such as the tunnel operations facility at Blackheath, water treatment plant and substation at Little Hartley, landscaping and ventilation outlets (if selected as the ventilation design). The Rosedale heritage item would likely be visually impacted by elevated project elements including mainline carriageways, operational ancillary facilities and tunnel portals proposed at Little Hartley. Vegetation screening including retention of existing mature trees proposed as part of the project would serve to provide a visual screen of operational infrastructure and help to reduce the visual impact of the project at Rosedale.

Landscape and visual

Construction of the project would result in moderate to high (adverse) impacts to landscape character. At Little Hartley in particular, the Little Hartley construction site and adjacent Little Hartley to Lithgow Upgrade would impact the rural valley centred around Butlers Creek, including the presence of large equipment, activities and ancillary facilities within the landscape. At Blackheath, the extension of vegetation clearing from the Katoomba to Blackheath Upgrade would result in the spatial widening of the Great Western Highway, with a distinct shift in the local character of the area within the Great Western Highway corridor and within the local area of bushland to the east, within the Blue Mountains National Park. Mitigation measures such as establishing tree protection zones around trees to be retained would be implemented to minimise impacts during construction.

Road users on the Great Western Highway, including tourists or those accessing recreational attractions, would have prominent views of the Blackheath construction site as well as a widened road corridor due to vegetation clearance. At Blackheath, a small number of residents on Evans Lookout Road between Valley View Road and the Great Western Highway would be able to see the Blackheath construction site fencing and hoarding from the rear of their properties. At Soldiers Pinch, road users would have limited views of the construction site.

At Little Hartley, road users and a small number of residents would see construction works at the Little Hartley construction site. A small number of residents would be able to view the construction site and associated work from their properties on the Great Western Highway in Little Hartley. Construction activities and/or machinery that would be visible to these receivers include lighting required for night-time works, TBM operations, an acoustic shed and other large construction infrastructure. Mitigation measures including tree protection, providing cut-off or directed lighting at construction sites, and keeping construction sites clean and tidy would be implemented to minimise impacts during construction.

During operation, the project would be in tunnel for the majority of its length, which generally limits the potential for landscape character and visual impacts to the areas around the tunnel portals where surface works and operational infrastructure are proposed. At Blackheath, visual impacts are considered to be moderate (adverse), as the increased width of the Great Western Highway corridor, portal, tunnel operations facility and ventilation outlet (if selected as the ventilation design) would result in substantial long-term changes uncharacteristic of the surrounding environment.

At Little Hartley, considering the picturesque character of the Little Hartley valley, the high volume of tourist traffic and activity and recreational hiking trails nearby, visual impacts from the ventilation outlet (if selected as the ventilation design), water treatment plant and the substation are also considered to be moderate (adverse). Landscaping and other measures, such as considering murals and surface decoration of ventilation outlets (if selected as the ventilation design), and landscaping imitating pockets of native and exotic trees, would be considered to reduce potential landscape character and visual impacts.

Social impacts

The main social impacts associated with construction of the project would relate to community health and wellbeing, including increased stress due to construction impacts, impacts to the way in which residents and visitors experience their surroundings due to temporary reductions in local amenity, and impacts on elements which the community have identified as being highly valued - including the natural environment, community facilities and services, social interaction and the quiet local character of the area. These impacts are mainly temporary and would be managed through the implementation of appropriate mitigation measures for other issues, including transport and traffic, noise and vibration, landscape character and visual amenity and air quality.

Operation of the project would result in a number of positive social impacts, with the majority of potential negative impacts considered to be low risk. By diverting a substantial proportion of traffic (including freight) into the project tunnels, the project would allow the existing Great Western Highway to mainly cater for local traffic which would substantially improve movement for residents in and around Blackheath and Mount Victoria. A reduction in traffic on the existing Great Western Highway would improve people’s ability to safely and efficiently interact in the local area, particularly in Blackheath and Mount Victoria.

A Social Impact Management Plan (SIMP) will be prepared and implemented during construction and for the first three years of operation of the project. The SIMP will be prepared in consultation with the relevant local councils and will guide monitoring and adaptive management of social impacts resulting from the project.

Business, land use and property

Given that the project largely comprises underground infrastructure and generally follows the existing Great Western Highway alignment, potential impacts to business, property and land use have largely been avoided.

Potential business impacts due to construction of the project would be more than offset by the increased economic activity related to the capital expenditure during construction. Local businesses would experience potential flow on impacts from construction including a temporary uplift in local commercial accommodation occupancy, retail revenue as a result of spending from construction workers, and local construction business revenue. The project would also have positive regional economic and employment impacts, creating up to $130 million dollars in value added annually.

Construction land use impacts would be mostly temporary in nature. The project has been designed to minimise property acquisitions, however some permanent acquisition would be required for the Upgrade Program, including two private properties (across multiple Lot/DPs) required for the project at Little Hartley.

Operation of the project is expected to increase tourism expenditure within the region, benefitting accommodation and other local businesses. Downturns in passing trade are expected to be short-term, and the long-term impacts on passing trade would generally be positive. Transport would identify opportunities such as the development and implementation of a directional signage strategy for the project, which would encourage visitors to areas that are bypassed by the project. The regional economy is expected to be positively impacted during operation, with between around $8 million and $10 million in value added annually.

The location of operational infrastructure has been designed to minimise potential land use impacts, including locating operational infrastructure as close to the tunnel portals as possible. The project would create potential opportunities for placemaking initiatives by reducing through traffic, including freight vehicles, at key locations along the Great Western Highway, particularly at Blackheath and Mount Victoria. This would include consideration of opportunities to improve at-surface active transport infrastructure between Blackheath and Little Hartley, connecting to the active transport trails to be delivered by the Katoomba to Blackheath Upgrade and Little Hartley to

Lithgow Upgrade in consultation with the relevant councils. This active transport infrastructure would be subject to separate assessment and approval and may be delivered by others.

Resource use and waste management

The CEMP prepared for the project will include specific measures and procedures for managing project waste materials, detail waste reporting requirements and the process for identifying waste re-use sites. A Spoil Management Plan would also be prepared for the project, detailing spoil haulage routes, opportunities for spoil reuse, and confirmed spoil disposal sites.

The resource requirements of the project have the potential to temporarily impact resource availability within the Blue Mountains region over the construction period. However, the period between the approval of the project and the start of major construction would be sufficient to allow the market to prepare for the needs of the project in conjunction with the resource needs of other infrastructure projects being constructed in NSW. The preferred option for project water supply is to source water from Lithgow via a pipeline delivered as part of the project.

The largest waste stream associated with construction of the project would be spoil generated from the excavation of the tunnels in excess of what can be reused for the project. It is estimated that the project would generate around 7.8 million tonnes of spoil during construction. Excess spoil would be reused within the project, for the other adjacent or nearby Transport projects, or removed from site for appropriate off-site reuse.

Options for resource recycling would continue to be investigated during ongoing design development and would include consideration of alternatives for high impact resources such as concrete, aggregates and steel.

Materials used for the operation of the project would be limited to those required for ongoing maintenance activities, and for the operation of the tunnel operations facility and support facilities. The volume and type of waste would be typical of an operational tunnel and could be accommodated by existing waste management facilities. With the implementation of standard waste management practices, the overall impact of operational waste streams would be minimal.

Hazards and risk

Potential hazards during construction may be associated with bushfires, storage, use and transportation of dangerous goods and hazardous substances, damage or disruption of utilities and services, potential release of coal seam gas as a result of tunnelling activities, and worker health and safety risks including tunnel hazards, rock falls and the operation of mobile plant and other machinery. These potential impacts would be managed in accordance with standard mitigation measures including a Bushfire Management Plan, and the development of an Incident Response Management Plan.

Potential hazards during operation of the project include those associated with bushfires and other natural disasters, storage, use and transportation of dangerous goods and hazardous substances, and worker safety including the operation of mobile plant and other machinery. Operational ancillary facilities would be located and designed taking into account Planning for Bush Fire Protection and AS3959-2018 guidelines which prescribe minimum setback distances for infrastructure near bushfire prone land.

A decision on whether vehicles carrying dangerous goods would be allowed to travel through the tunnel would be made during ongoing design development. The capacity of fire and life safety measures to manage potential dangerous good incidents would be confirmed at that time. Safety hazards during operational activities would be managed by the implementation of the Bushfire Management Plan and Incident Response Management Plan. Should there be planned or unplanned shutdowns of either the project or the existing Great Western Highway due to an incident or emergency, the other road would function as an alternative route for traffic.

Sustainability, climate change and greenhouse gas

Climate change risk assessment

Climate change risks were identified for key climate hazards (extreme heat, bushfire, drought, extreme rainfall and flooding, and extreme storms).

Potential mitigation and adaptation measures were identified to address all high and severe risks, and the majority of medium risks. These measures will be considered for implementation in later phases of the project. Of the one high risk and one medium risk identified for project construction, proposed adaptation measures have resulted in a residual risk rating of two medium risks. These risks relate to increased extreme heat days and increased storm intensity, and examples of adaptation measures include limiting work hours during extreme weather conditions to minimise health and safety risks to construction workers.

For project operation in 2030 (to assess short-term impacts of climate change) and 2090 (to assess long-term impacts of climate change), proposed adaptation measures have resulted in all severe and high risks lowered to a residual risk rating of medium or low. These adaptation measures may include incorporating First Nations burning practices into operational maintenance plans to minimise the risk of extreme bushfires and selecting drought- and heat-tolerant vegetation, especially native species, for project landscaping to reduce temperature and drought impacts.

This assessment of climate risks would be reviewed and updated during future stages of the project lifecycle to ensure new and emerging risks are addressed and appropriate controls have been implemented.

Sustainability

Sustainability of the project will be assessed in accordance with the Infrastructure Sustainability Council Rating Tool. The project is seeking a minimum Infrastructure Sustainability 'Design' and 'As-Built' rating of 'Excellent', through the application of version 1.2 of the tool. Version 2.1 credits would be applied where beneficial to achieving sustainable project outcomes.

Sustainability initiatives have been identified for planning and design consideration to embed specific sustainability commitments and targets for implementation by the construction contractor. An Infrastructure Sustainability Management Plan will be prepared and implemented during detailed design and construction of the project to guide the implementation of sustainability initiatives. The Plan will detail how the project will achieve an Infrastructure Sustainability rating of 'Excellent'.

Greenhouse gas assessment

Construction of the project is estimated to produce around 1,407,140 tonnes of carbon dioxide equivalent emissions (t CO_2e). The difference in greenhouse gas emissions during construction between the two ventilation options would be negligible. The majority of emissions during construction are estimated to occur from the large electricity requirements of the tunnelling plant and equipment over the construction period.

For the ventilation outlet option, operation and maintenance of the project is estimated to produce around 3,550,000 t CO_2e emissions over a nominal 100-year operational period. For the portal emissions option, operation and maintenance of the project is estimated to produce around 1,300,000 t CO_2e emissions over a nominal 100-year operational period. The majority of operational emissions are expected to occur from electricity consumption of the project's ventilation, lighting and other electrical equipment.

Opportunities to minimise greenhouse gas emissions from the project will be identified as part of further design development and will be implemented during construction and operation where reasonable and feasible. These opportunities may include selecting construction materials with reduced embodied greenhouse gas emissions, through reduced materials use, lower emissions construction materials, and/ or local sourcing of materials and selecting plant and equipment with lower fuel/ electricity consumption and/ or greater energy efficiency.

Cumulative impacts

Cumulative impacts have the potential to occur when benefits or impacts from a project overlap or interact with those of other projects, potentially resulting in a larger overall impact (positive or negative) on the environment or local communities. Cumulative impacts may occur when projects are constructed or operated concurrently or consecutively. Once the project is operational, other projects which interact with the project may enhance the project and create positive cumulative benefits.

The potential cumulative impacts of the project and the other components of the Upgrade Program, including the Katoomba to Blackheath Upgrade, the Great Western Highway Upgrade – Medlow Bath (Medlow Bath Upgrade) and the Little Hartley to Lithgow Upgrade are shown in Table 4.

Table 4 Summary of potential cumulative impacts

Environmental aspect	Cumulative impact
Transport and traffic	A temporary localised increase in congestion, poor intersection performance, and more extensive speed limit reductions as a result of overlapping construction activities associated with the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade, which are due to be complete in 2027 and 2026 respectively. Longer term cumulative impacts following completion of the project, the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade include substantial travel time savings for heavy vehicles, reductions in travel times, and increases in average vehicle speeds between Katoomba and Lithgow.
Air quality	Potential cumulative dust impacts as a result of overlapping construction activities associated with the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade. During operation in both ventilation outlet and portal emissions scenarios, predicted total ground level concentrations were below the NSW Environment Protection Authority's criteria for all pollutants and all modelled scenarios at all receptors.
Noise and vibration	Sensitive receivers located near where the project overlaps with the Katoomba to Blackheath Upgrade (at Blackheath) and the Little Hartley to Lithgow Upgrade (at Little Hartley) may be affected by cumulative construction noise. Operation of the Upgrade Program is expected to result in reduced noise levels at around 2,000 residential receivers where the tunnel provides a bypass to the existing surface road between Blackheath and Little Hartley. Some receivers located adjacent to where new and upgraded sections of surface road are proposed may experience elevated levels of operational road traffic noise. Where predicted cumulative traffic noise levels exceed criteria, mitigation options for noise affected receivers will be considered.
Biodiversity	Potential cumulative biodiversity impacts associated with native vegetation removal and the removal of hollow-bearing trees from the project and other components of the Upgrade Program, including removal of up to 128.52 hectares of native vegetation and 369 hollow-bearing trees across all four components of the Upgrade Program.

Environmental aspect	Cumulative impact
Groundwater and geology	Potential cumulative groundwater drawdown impacts associated with areas of proposed cutting/excavation during construction of the Little Hartley to Lithgow Upgrade and the project's tunnel portals at Little Hartley would be negligible.
Surface water and flooding	Potential cumulative water quality impacts due to the increase in impervious surfaces from operation of the Katoomba to Blackheath and Little Hartley to Lithgow Upgrade.
Aboriginal heritage	Potential cumulative impacts to 22 Aboriginal sites. These sites are of increased significance due to their rarity in an increasingly developed environment. The Aboriginal cultural heritage values across the Upgrade Program would be reduced if complete loss of these sites was to occur. Potential negligible or indirect impacts to a site are not considered to be a risk for cumulative impacts to the region's Aboriginal cultural heritage.
Non-Aboriginal heritage	Potential cumulative impacts to the site of Plough Inn archaeological site from construction of the Little Hartley to Lithgow Upgrade and the project (noting the precise location of the Inn is not certain, and it is possible that the Inn will be outside of the construction footprint of both the Little Hartley to Lithgow Upgrade and the project).
Landscape and visual	Potential visual and landscape character impacts at Blackheath and Little Hartley associated with increased construction sites and the length of time construction activity would occur at these locations from the project and other components of the Upgrade Program. The scale of the widened road corridor and the larger pieces of infrastructure that would be added to the landscape as part of the Upgrade Program would be uncharacteristic with the existing landscape setting.
Social	Potential adverse cumulative impacts during construction on people's way of life and ability to move around associated with increased congestion, poor intersection performance and reduced travel speeds, impacts to people's sense of place and wellbeing, impacts to the natural landscape (vegetation removal) which is valued by the community, and potential construction fatigue. Cumulative construction impacts may result in improvements to people's capacity to earn an income and associated benefits to livelihood, as some retail and construction businesses would experience higher levels of spending across the Upgrade Program. Cumulative social impacts during operation primarily consist of social benefits as a result of substantial travel time improvements and decreases in congestion on the existing Great Western Highway as a result of the Upgrade Program, including improved accessibility and substantial safety and amenity improvements.

Environmental aspect	Cumulative impact
Local business and economics	Flow-on benefits on the local and regional economies from cumulative capital expenditure and number of workers associated with the project and other components of the Upgrade Program, including higher levels of spending over the duration of construction. During operation, increased productivity for local workers and improved accessibility and attractiveness for local tourists are expected as a result of substantial travel time reductions and increased vehicle speeds through the Blue Mountains.
Sustainability, climate change and greenhouse gas	Cumulative greenhouse gas emissions during construction of the project and the Little Hartley to Lithgow Upgrade are equivalent to 0.096 per cent of total NSW annual emissions in 2020. Cumulative greenhouse gas emissions during operation of the project and the Little Hartley to Lithgow Upgrade are equivalent to 0.027 and 0.011 per cent of total NSW annual emissions in 2020 for the ventilation outlet and portal emissions options respectively. While the Katoomba to Blackheath Upgrade and Medlow Bath Upgrade greenhouse gas emissions haven't been quantified, these would be of a similar order of magnitude as the Little Hartley to Lithgow Upgrade.

There is the potential for some receivers, particularly at Little Hartley and Blackheath, to experience construction fatigue associated with overlapping construction activities from the Little Hartley to Lithgow Upgrade and Katoomba to Blackheath Upgrade. Opportunities to minimise and manage cumulative impacts across the Great Western Highway Upgrade Program will be identified in consultation with other projects in the Upgrade Program, and implemented where reasonable and feasible. Key focus areas for the minimisation and management of cumulative impacts will include:

- construction planning and staging, including coordination of constructive activities and provision of respite periods to manage construction fatigue
- stakeholder notification and engagement activities, with a focus on managing construction and engagement fatigue
- construction amenity issues, particularly in relation to construction traffic, dust, noise and vibration
- avoidance and minimisation of impacts on biodiversity, Aboriginal heritage and non-Aboriginal heritage, including consolidated monitoring and/ or offsets where relevant
- coordination of waste and resource management, including spoil/ cut-and-fill balances, surface water and water supply requirements, recycling and sustainability initiatives.

Environmental management

A CEMP will be prepared for the project and may be developed as a series of complementary and coordinated CEMPs to address specific construction sites, construction activities or stages during the construction period. The CEMP(s) will detail the approach to environmental mitigation, management, monitoring and reporting during construction of the project. The CEMP(s) will provide a consolidated environmental management framework, supplemented by more detailed sub-plans and other documentation focused on key environmental issues during construction.

Key issues that will be addressed in the CEMP(s), where relevant, will include:

- minimisation and management of air emissions, including dust generation and emissions from plant and equipment
- minimisation and management of noise and vibration, including construction scheduling, protocols for the management of noisy activities outside standard construction hours, protection of sensitive structures and receivers from vibration, and management of ground vibration during tunnelling
- management of construction traffic, including site access arrangements and minimisation of impacts associated with heavy vehicle movements, including spoil haulage
- management of water, including surface, groundwater and wastewater, treatment and reuse standards, discharge locations and requirements, mitigation and management of erosion and sedimentation risks and management of works within areas prone to flooding
- protection of Aboriginal and non-Aboriginal heritage during construction, procedures for managing and salvage of archaeology where relevant, and protocols for the management of unexpected finds
- protection of biodiversity within and around construction sites
- mitigation and management of potential impacts on social infrastructure and businesses, including access requirements, notifications and engagement, and property impacts
- management of waste, including transport and disposal requirements, and resource efficiency and sustainability measures.

During operation, the project's environmental performance would be managed under Transport's existing environmental management system (or similar), prepared in accordance with the AS/NZS ISO 14000 Environmental Management System series. Detailed operational policies and procedures specific to the project would be developed consistent with the environmental management system, and to reflect project-specific requirements arising from the assessments presented in this EIS, conditions of approval that may be applied to the project, and other issues that may arise through ongoing consultation with stakeholders. Performance outcomes and project specific environmental mitigation measures for the project are listed in Appendix R (Compilation of environmental mitigation measures).

A Stakeholder Engagement Strategy has been prepared for the Upgrade Program and would be used to guide community and stakeholder engagement activities during construction of the project. Engagement during construction will include updates on planned construction activities and will respond to concerns and enquiries in a timely manner, seeking to minimise potential impacts where possible.

Next steps

The NSW Department of Planning and Environment (DPE) has placed this EIS on public exhibition. During this exhibition period project stakeholders and community members can review the EIS and make a written submission to DPE for consideration in its assessment of the project.

Copies of submissions made during exhibition of the EIS would be provided from the Secretary for DPE to Transport as the proponent. The Secretary will then require Transport to respond to issues raised in submissions through a submissions report, and an amendment report (where required) to outline any proposed changes to the project.

DPE would prepare the Secretary's environmental assessment report and provide it to the Minister for Planning, who would then decide whether to approve the project. If approved, the Minister would identify a set of conditions of approval for Transport to adhere to during construction and operation of the project.

The next steps in the assessment and approval process are shown in Figure 10. During the assessment process, Transport will continue to engage with community and key stakeholders regarding development of the project.

At the time of finalisation of this EIS there has been no decision by DCCEEW on whether the project is a controlled action or not. If the project is not determined a controlled action, Transport is not required to provide a separate assessment of the project under a Commonwealth approval pathway. If the project is determined a controlled action, Transport will need to prepare a draft environmental assessment under the EPBC Act to assess the project under additional requirements as required.

If the project is approved, Transport would engage a construction contractor(s) to carry out design development and construction of the project. Communication and engagement with stakeholders and the community during project construction would be the responsibility of Transport and the construction contractor. Community engagement during construction of the project would include engagement carried out for the other components of the Upgrade Program which would be under construction at the same time as the project.

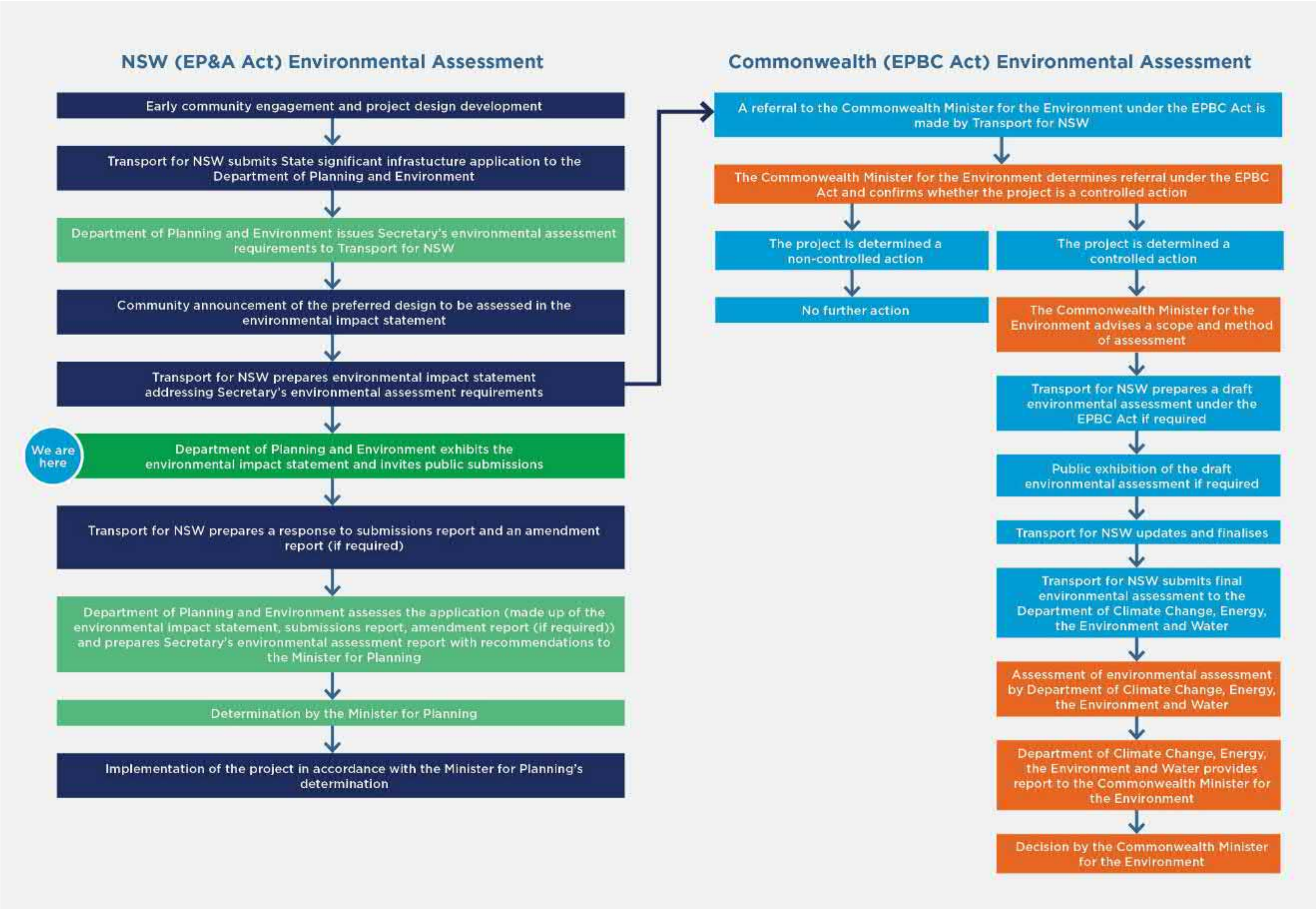


Figure 10 Assessment and approvals process for the project

1 Introduction and background

1.1 Overview

The Great Western Highway is the key east-west road freight and transport route between Sydney and Central West New South Wales (NSW). Together, the Australian Government and the NSW Government are investing more than $4.5 billion towards upgrading the Great Western Highway between Katoomba and Lithgow (the Upgrade Program). Once upgraded, over 95 kilometres of the Great Western Highway will be two lanes in each direction between Emu Plains and Wallerawang.

The Upgrade Program comprises the following components:

- Great Western Highway Upgrade – Medlow Bath (Medlow Bath Upgrade): upgrade and duplication of the existing surface road corridor with intersection improvements and a new pedestrian bridge (approved)
- Great Western Highway East – Katoomba to Blackheath (Katoomba to Blackheath Upgrade): upgrade, duplication and widening of the existing surface road corridor, with connections to the existing Great Western Highway east of Blackheath (approved)
- Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade): upgrade, duplication and widening of the existing surface road corridor, with connections to the existing Great Western Highway at Little Hartley (approved)
- Great Western Highway Blackheath to Little Hartley (the project): construction and operation of a twin tunnel bypass of Blackheath and Mount Victoria and surface road works for tie-ins to the east and west of the tunnel (the subject of this environmental impact statement (EIS)).

The components of the Upgrade Program are shown in Figure 1-1.

The Upgrade Program would support regional economic development by providing a more efficient connection between Central West NSW and the Sydney motorway network, as well as delivering improved safety conditions and travel times for freight, tourist, and general traffic. The Upgrade Program would also facilitate opportunities to improve connectivity, placemaking outcomes and liveability for residents of and visitors to the Blue Mountains. These benefits are discussed in Chapter 3 (Project alternatives and options).

The project would form a key component of the Upgrade Program. Chapter 2 (Strategic context and project need) outlines the need for, objectives and benefits of the project. A discussion of the history of the project as well as key strategies adopted to avoid and/or minimise the impacts of the project is provided in Chapter 3 (Project alternatives and options). The justification for the project is provided in Chapter 25 (Justification and conclusion).

1.2 Consultation undertaken

Engagement with the community and key stakeholders regarding the project commenced in November 2019 and has continued through to the preparation of the EIS. Community and stakeholder feedback was a key input into the decision-making process for a preferred route option and design for the project. An overview of community engagement is provided in Chapter 7 (Community and stakeholder engagement). An overview of how community and stakeholder engagement has informed the project design is detailed in Chapter 3 (Project alternatives and options).

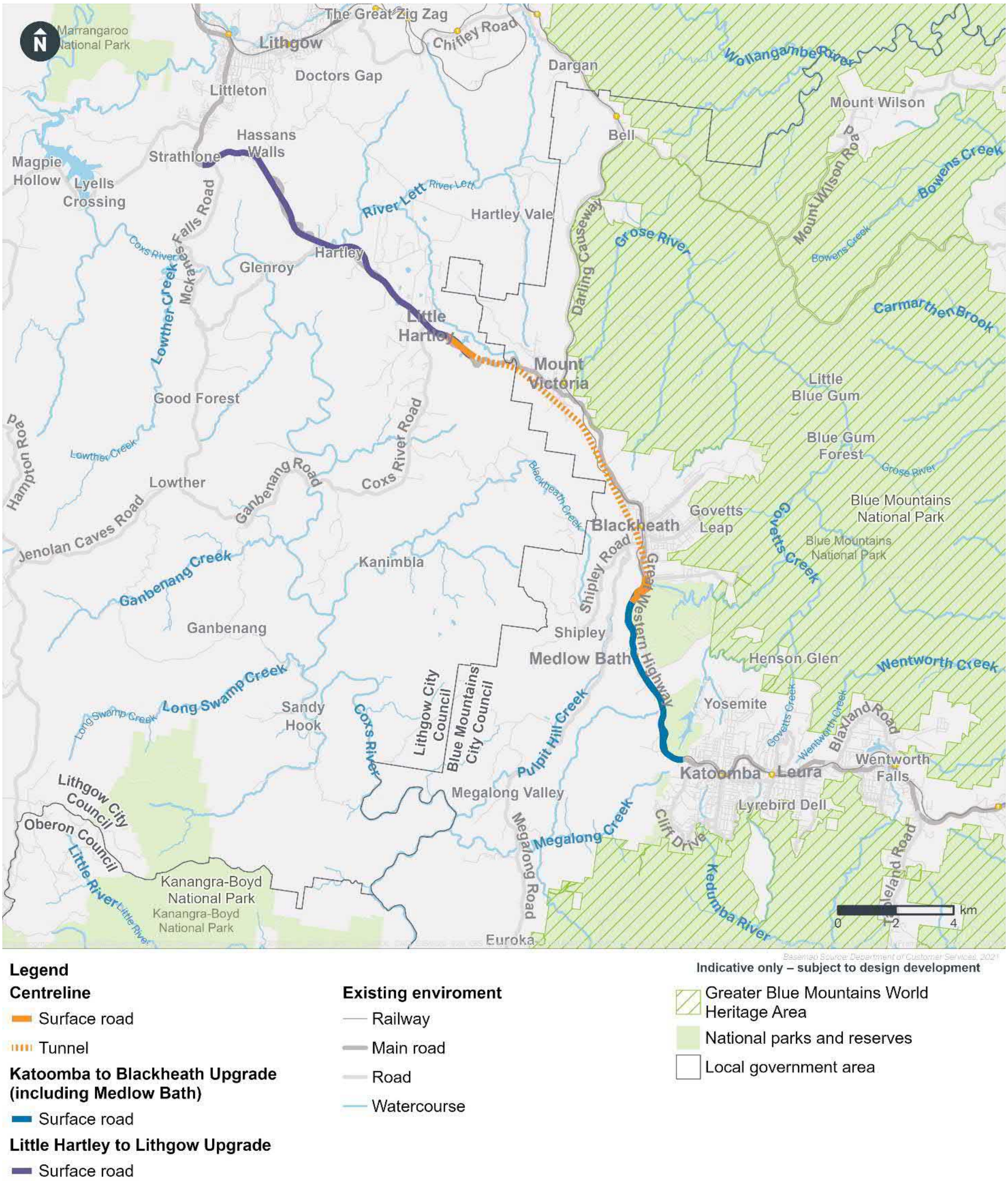


Figure 1-1 The Great Western Highway Upgrade Program

1.3 The project

As the proponent[1], Transport for NSW is seeking approval under Division 5.2, Part 5 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act) to upgrade the Great Western Highway between Blackheath and Little Hartley (the project). The project would comprise the construction and operation of new twin tunnels around 11 kilometres in length between Blackheath and Little Hartley, and associated surface road upgrade work for tie-ins to the east and west of the project tunnel portals (i.e., the entrance and exit points for the tunnels).

Key components of the project are summarised in Table 1-1 and shown in Figure 1-2. Further description of the project is provided in Chapter 4 (Project description) and construction of the project is described in Chapter 5 (Construction).

Subject to approval, the project is anticipated to be open to traffic in 2030.

Table 1-1 Key components of the project

Key project component	Summary
Tunnels	Twin tunnels around 11 kilometres in length between Blackheath and Little Hartley, connecting to the upgraded Great Western Highway at both ends. Each tunnel would include two lanes of traffic and road shoulders and would range in depth from just below the surface near the tunnel portals, to up to around 200 metres underground at Mount Victoria.
Surface work	Surface road upgrade work would be required to connect the tunnels and surface road networks south of Blackheath and at Little Hartley. The twin tunnels would connect to the surface road network via: • mainline carriageways and on- and off-ramps at the Blackheath portal, located adjacent to the existing Great Western Highway and south of Evans Lookout Road • mainline carriageways at the Little Hartley portal, located adjacent to the existing Great Western Highway at the base of the western escarpment below Victoria Pass and southwest of Butlers Creek.

Operational infrastructure	Operational infrastructure provided by the project would include:
	• a tunnel operations facility adjacent to the Blackheath portal
	• in-tunnel ventilation systems including jet fans and ventilation ducts connecting to the ventilation facilities
	• one of two potential options for tunnel ventilation currently being investigated, being:
	  – ventilation design to support emissions via ventilation outlets; or
	  – ventilation design to support emissions via portals
	• drainage and water quality infrastructure including sediment and water quality basins, an onsite detention tank at Blackheath and a water treatment plant at Little Hartley
	• fire and life safety systems, emergency evacuation and ventilation infrastructure and closed circuit television
	• lighting and signage including variable message signs and associated infrastructure such as overhead gantries.

[1] Proponent details: Transport for NSW; 231 Elizabeth Street, Sydney NSW 2000, PO Box K659; ABN: 18 804 239 602

Key project component	Summary
Utilities	Key utilities required for the project would include: • a new electricity substation at Little Hartley for construction and operational power supply • a new pipeline between Little Hartley and Lithgow for construction and operational water supply • other utility connections and modifications, including electricity substations in the project tunnels.
Other project elements	The project would also include: • integrated urban design initiatives • landscape planting.

1.3.1 Related development

The project would form a component of the Upgrade Program, which consists of the three other projects described in Section 1.1 and are subject to separate planning approval processes. Consideration of the potential cumulative impacts of the project in combination with the other projects that make up the Upgrade Program is provided in Chapter 24 (Cumulative impacts).

In addition, other work would be required to support construction and operation of the project. This work would be considered under separate assessment and approvals processes, and would include:

- a powerline connection to the new electricity substation at Little Hartley (delivered as part of the project) for construction and operational power supply
- a tunnel boring machine precast segment manufacture and storage facility and concrete batching plant likely to be located to the west of the project.

The potential cumulative impacts of these activities would be assessed in the relevant environmental assessments carried out for these projects.

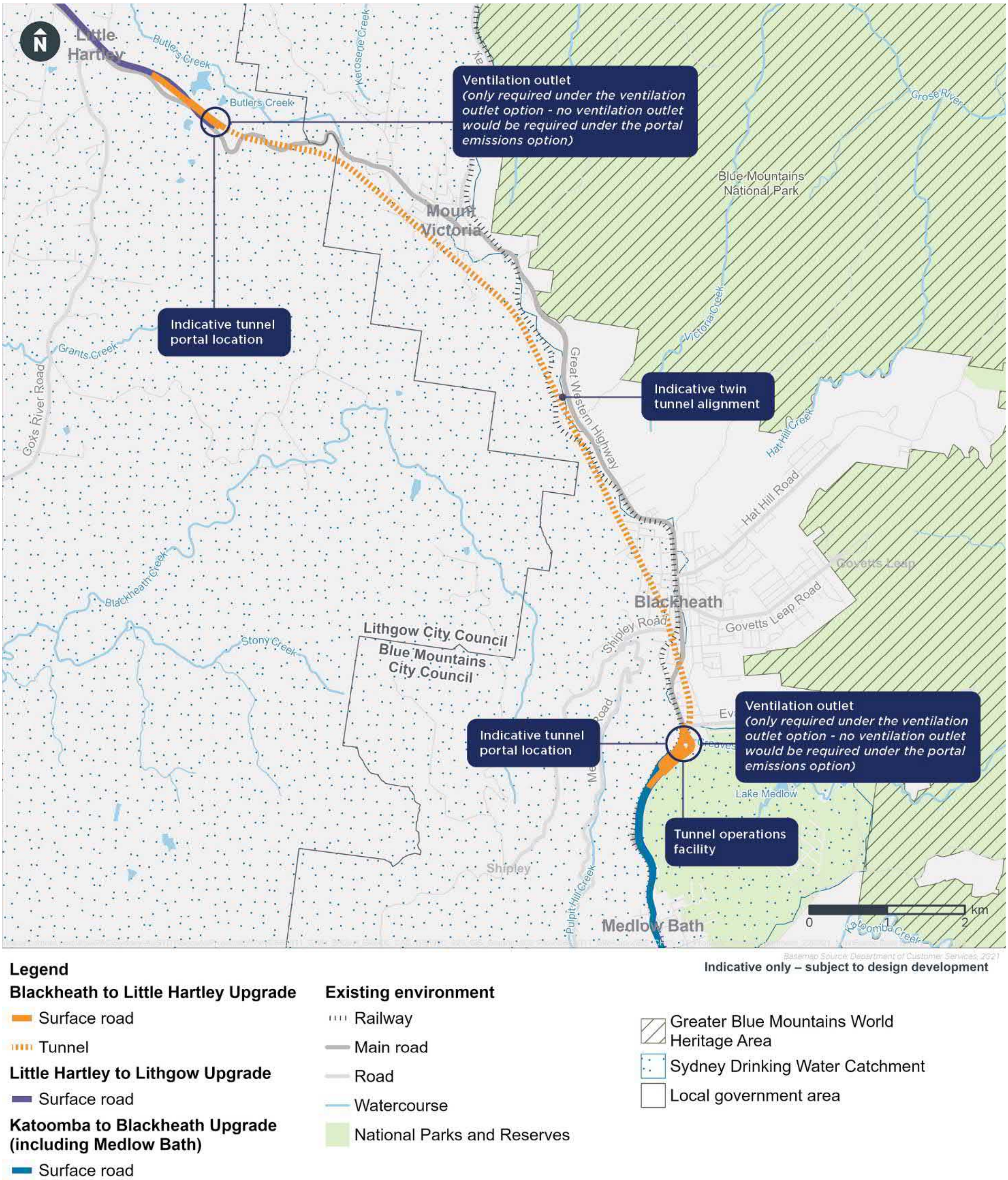


Figure 1-2 Project overview and key features

1.4 Project location

The project would be located around 90 kilometres west of the Sydney central business district and within the Blue Mountains and Lithgow local government areas (LGAs). The regional context of the project is shown in Figure 1-3.

The majority of the project would be located below ground, generally along or adjacent to the existing Great Western Highway alignment between Blackheath and Little Hartley.

The Blue Mountains National Park and the Greater Blue Mountains World Heritage Area are located generally to the east of the existing Great Western Highway alignment. A large part of the project is also located within the declared drinking water catchment for Sydney. Low density and medium density residential and commercial areas are generally located in the town centres of Blackheath, Mount Victoria and Little Hartley.

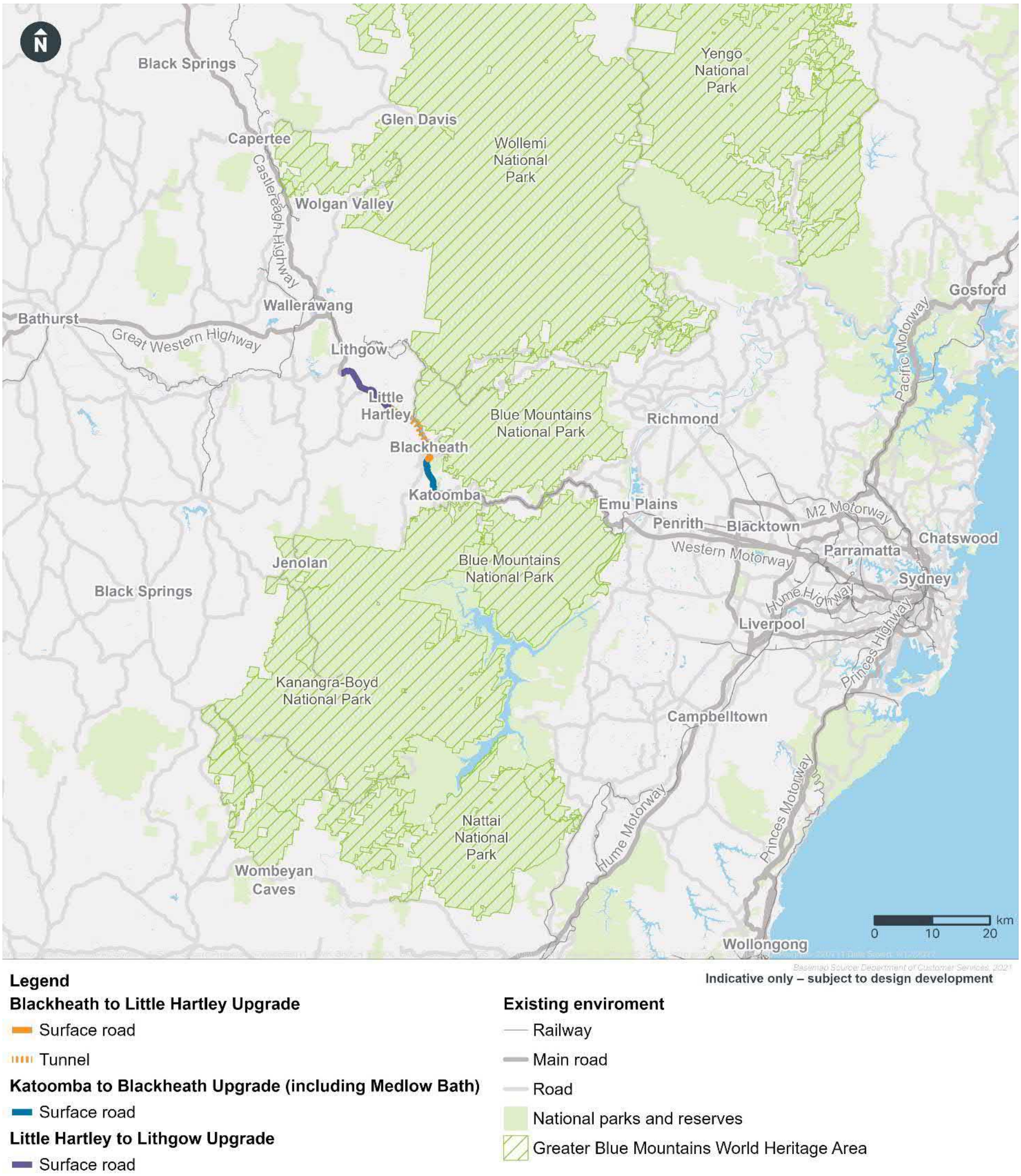


Figure 1-3 Regional context of the project

1.5 Purpose and structure of this environmental impact statement

The purpose of this EIS is to provide a detailed description of the project to allow an assessment of its potential impacts, including a description of the existing environment and assessment of potential direct, indirect and cumulative impacts. This EIS also identifies measures and strategies to be implemented to avoid, minimise, manage, mitigate, offset and/or monitor the potential impacts.

This EIS has been prepared to comply with the requirements issued by the Secretary of the NSW Department of Planning and Environment (DPE) on 27 August 2021 and the relevant provisions of Division 5 of Part 8 of the *Environmental Planning and Assessment Regulation 2021* (NSW).

An assessment of the project's potential impacts on Commonwealth matters of national environmental significance (MNES) (as discussed in Chapter 12 (Biodiversity) and 17 (Non-Aboriginal heritage)) has found that the project's impacts on MNES would not be significant. Notwithstanding, Transport has referred the project to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) to confirm that approval under that Act would not be required. At the time of finalisation of this EIS there has been no decision by DCCEEW on whether the project is a controlled action or not.

This EIS is presented in two parts:

- Part 1 comprises the main body of the EIS and includes summaries of the technical environmental assessments
- Part 2 comprises the appendices to the EIS and includes the technical environmental assessments and other supporting information.

The structure and content of the EIS is outlined in Figure 1-4.

Part 1

Main environmental impact statement

Chapter 1	**Introduction and background**	Provides a broad overview of the project and where it is located
Chapter 2	**Strategic context and project need**	Provides the strategic context, explains the need for the project and identifies the project objectives
Chapter 3	**Project alternatives and options**	Reviews the alternatives and options considered in developing the project including the consequences of not proceeding
Chapter 4	**Project description**	Provides a summary of the project including the alignment, design standards and key features
Chapter 5	**Construction**	Provides a summary of the proposed construction methodology for the project
Chapter 6	**Statutory context**	Outlines the statutory requirements and explains the steps in the assessment and approval process
Chapter 7	**Community and stakeholder engagement**	Outlines the consultation activities undertaken to date, key issues raised and how these have been addressed
Chapters 8-24	**Environmental assessment**	Provides the results of the environmental assessment and outlines environmental mitigation measures
Chapter 25	**Justification and conclusion**	Provides a conclusion to the EIS, including justification for the project and whether the project achieves the project objectives
Chapter 26	**References and terminology**	

Part 2

Appendices

Appendix A	Assessment requirements	
Appendix B	Statutory compliance	
Appendix C	Community engagement	
Appendix D	Technical report – Transport and traffic	Technical environmental assessments
Appendix E	Technical report – Air quality	Technical environmental assessments
Appendix F	Technical report – Human health	Technical environmental assessments
Appendix G	Technical report – Noise and vibration	Technical environmental assessments
Appendix H	Technical report – Biodiversity	Technical environmental assessments
Appendix I	Technical report – Groundwater	Technical environmental assessments
Appendix J	Technical report – Surface water and flooding	Technical environmental assessments
Appendix K	Technical report – Contamination	Technical environmental assessments
Appendix L	Technical report – Aboriginal heritage	Technical environmental assessments
Appendix M	Technical report – Non-Aboriginal heritage	Technical environmental assessments
Appendix N	Technical report – Urban design, landscape and visual	Technical environmental assessments
Appendix O	Technical report – Social	Technical environmental assessments
Appendix P	Technical report – Economics and business	Technical environmental assessments
Appendix Q	Technical report – Climate change and sustainability	Technical environmental assessments
Appendix R	Compilation of environmental mitigation measures	

Figure 1-4 Structure and content of this environmental impact statement

2 Strategic context and project need

2.1 Overview

This chapter outlines the need for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). It explains how the project would address the existing constraints of this section of the Great Western Highway, which are discussed in Section 2.2. These constraints have informed the project objectives outlined in Section 2.3. By addressing these objectives, the project would result in the benefits outlined in Section 2.4.

The need for the project as outlined in Commonwealth, NSW and regional infrastructure planning strategies is detailed in Section 2.2.6.

Key strategic context issues that are relevant to the assessment of the project include:

- the local and regional community – Chapter 19 (Social impacts)
- land use and ownership – Chapter 20 (Business, land use and property)
- important natural features such as the Greater Blue Mountains World Heritage Area, Blue Mountains National Park, scenic landscapes, conservation areas and culturally important landscapes – Chapter 12 (Biodiversity), Chapter 16 (Aboriginal cultural heritage), Chapter 17 (Non-Aboriginal heritage), Chapter 18 (Landscape and visual) and Chapter 20 (Business, land use and property)
- key risks or hazards such as flooding, bushfires, landslips and climate change – Chapter 14 (Surface water and flooding), Chapter 22 (Hazards and risk) and Chapter 23 (Sustainability, climate change and greenhouse gas).

2.2 Project need

The Great Western Highway provides the main road transport connection through the Blue Mountains for access between the Central West of NSW (Bathurst, Orange, Parkes and Dubbo region) and the Sydney motorway network for freight, tourist and general traffic. It also plays a vital role in local traffic movements between the townships of the Blue Mountains.

Supporting the current needs and future growth of Sydney and Central West NSW through an efficient transport network is fundamental to the liveability, productivity and sustainability of Greater Sydney and NSW. The need to address these issues is recognised in strategic plans for improving transport, placemaking, and freight efficiency across Greater Sydney and regional NSW, as discussed in Section 2.2.6.

The existing Great Western Highway between Blackheath and Little Hartley is mostly a two-way undivided carriageway with one lane in each direction. Traffic volumes are expected to grow by two per cent per annum between Blackheath and Forty Bends, and visitors to regional NSW have grown by 23 per cent between 2010 to 2017 (Transport for NSW, 2021d). The critical function of the Great Western Highway is being the key east-west road freight and transport route between Sydney and Central West NSW. Heavy vehicle movements along the Great Western Highway are predicted to increase by around 30 per cent by 2036 (Transport for NSW, 2021d). Growth in demand for this east-west transport route has led to the need for the upgrade of the Great Western Highway between Katoomba and Lithgow to a four lane carriageway (the Upgrade Program) and the project is a key component of this program.

The current constraints of the Great Western Highway are shown graphically in Figure 2-1 and described in further detail in the following sections.

2.2.1 Growing freight inefficiency

There is a relatively high proportion of heavy vehicles (up to around 24 per cent) travelling on the Great Western Highway through the Blue Mountains, reflective of the 18,800 tonnes of freight transported daily between the Central West region and Sydney (10,300 tonnes towards Sydney and 8,500 tonnes towards the Central West region) (Transport for NSW, 2021d). Limited overtaking opportunities, steep grades and lengthy travel times on the Great Western Highway, including between Blackheath and Little Hartley, affect the efficiency of these freight movements. Left unaddressed, this will constrain access between Sydney and proposed future freight infrastructure (and associated land use changes) in the Central West region, including the Parkes National Logistics Hub and the Inland Rail Program. Without action to provide additional transport capacity, freight efficiency would further deteriorate to unacceptable levels.

As outlined in Chapter 3 (Project alternatives and options), the Great Western Highway remains the most viable freight route to and from the Central West region, however, freight vehicles currently using the Great Western Highway are limited to a maximum of 20 metres in length. Freight vehicles that exceed 20 metres in length and need to travel between Sydney and the Central West region are currently required to travel an additional 100 kilometres via Goulburn or Newcastle (Transport for NSW, 2019).

Constraints	Project objectives	Project benefits
Growing freight inefficiency	Improve economic development, productivity and freight accessibility in and through the Blue Mountains, Central West and Orana regions	Improved economic development, productivity and recovery
Vulnerability to closure	Improve the resilience of the corridor between Blackheath and Little Hartley to ensure continuity and safety of transport and essential services	Improved resilience and future-proofing
Sub-optimal travel times	Improve transport network performance and efficiency along the corridor between Blackheath and Little Hartley to meet the needs of customers	Improved network performance
Safety issues	Improve the overall safety of the corridor for all transport users between Blackheath and Little Hartley	Safety improvements
Amenity issues	Enhance the liveability and be sensitive to the unique environmental and cultural assets along the corridor between Blackheath and Little Hartley	Movement, place and amenity improvements
Project delivery	A value for money, sustainable and deliverable solution	Socio-economic opportunities (see Section 2.4)

Figure 2-1 Constraints, project objectives and project benefits

2.2.2 Vulnerability to closure

The Great Western Highway is vulnerable to closure through the Blue Mountains because it is only one lane in each direction in some sections that have yet to be upgraded, and there is a lack of alternative routes. When lanes are closed because of an incident, traffic cannot be easily diverted around or through the incident, due to there being only one lane in each direction. This often results in major delays, particularly on weekends and peak holiday periods. For example, at Mount Victoria, the steep grades of Victoria Pass often cause vehicle breakdowns or require traffic to merge at differing speeds, which can lead to queues of up to eight kilometres in length and delays of up to 80 minutes (Transport for NSW, 2021d).

The Great Western Highway is also susceptible to closure during natural disasters and extreme weather events. For example, in March 2022, consistent heavy rainfall caused road instability and a subsequent landslip on a section of the Great Western Highway at Mount Victoria. Again, in July 2022 a landslip near the rail corridor at Blackheath also resulted in heavy delays on the existing Great Western Highway. The eastbound lane of the Great Western Highway was closed, and traffic was able to pass in both directions via the single remaining lane under contra-flow traffic control arrangements. However, the closure of the eastbound lane, reductions of speed to 40 kilometres per hour, and the alternative route on Bells Line of Road being closed due to flooding, meant that significant delays were experienced on the Great Western Highway and surrounding road network between Katoomba and Lithgow. These events are expected to become increasingly prevalent with climate change.

2.2.3 Sub-optimal travel times

Road transport plays a vital role in supporting the Central West region and the Blue Mountains. Average daily traffic volumes along the Great Western Highway vary from around 15,000 to 20,000 vehicles per day near Blackheath to around 8,500 vehicles per day near Little Hartley (Transport for NSW, 2021d). The Central West and Orana regions are anticipated to experience population growth of up to around 23,450 more people by 2036 (Department of Planning and Environment (DPE), 2017), which will further increase traffic volumes.

The current performance of the Blackheath to Little Hartley section of the Great Western Highway affects travel times for road users and will constrain access between Sydney and areas of future economic development, more generally in the Central West region. While the eight intersections along this section of the Great Western Highway currently operate at an acceptable level of service, lengthy delays and vehicle queuing are often experienced on minor roads. This includes at the signalised intersections of Bundarra Street and Govetts Leap Road in Blackheath and Station Street at Mount Victoria, as the traffic signal phasing prioritises the Great Western Highway movements. Without additional transport capacity, travel times and intersection levels of service would further deteriorate during peak periods. Further discussion of current and future road performance is provided in Chapter 8 (Transport and traffic).

The Great Western Highway also sees spikes in demand during weekends and peak holiday periods. This can cause major delays along the corridor. For example, during the 2021 Easter long weekend, delays of more than two hours were experienced on the Great Western Highway through the Blue Mountains (Transport for NSW, 2021b).

As the region's population grows, strain on the road network is likely to increase.

2.2.4 Safety issues

Safety issues which currently affect the performance of the Great Western Highway between Blackheath and Little Hartley include:

- tight curves and narrow verges which pose safety risks to road users, with the average crash severity index of 1.36, compared to the NSW average of 1.27 indicating the Great Western Highway has a higher than average proportion of fatal and injury crashes (further discussed in Appendix D (Technical report – Transport and traffic))
- the up gradient on Victoria Pass is more than double the recommended maximum for roads of this type. This results in a large average speed difference between light and heavy vehicles travelling eastbound up Victoria Pass, and coupled with a merge from two lanes to one, often results in traffic delays which can result in safety issues for road users
- the steep down grades at Victoria Pass can require vehicles unable to slow down, stop safely or maintain speed, to use the safety ramps travelling westbound and vehicle breakdown zone travelling eastbound
- limited overtaking opportunities and intersection capacity, which can encourage risk-taking behaviour from road users.

2.2.5 Amenity issues

Several townships are located along the Great Western Highway adjacent to and within the project corridor, including Blackheath, Mount Victoria and Little Hartley. In addition to its inter-regional transport function, the Great Western Highway supports local traffic movements and is the main road providing access between these towns. However, congestion on weekends and peak holiday periods caused by increased numbers of light vehicles can make local trips on the Great Western Highway difficult. This issue is exacerbated by high proportions of heavy vehicles (up to 24 per cent of vehicles) using the Great Western Highway at any given time. This increased congestion limits access to the local road network by making crossing or entering the Great Western Highway away from the limited number of signalised crossings difficult, including for cyclists and pedestrians.

Limited access to the road network may result in local residents electing not to travel locally across the Blue Mountains particularly during peak periods.

Freight vehicles, which use the Great Western Highway 24 hours a day, seven days a week, also contribute to amenity issues through increased noise and vehicle emissions. For example, in 2018, the highest proportion of heavy vehicles on a weekday occurred between 10pm and 4am averaging 60 per cent of all traffic per hour and reaching a peak of 75 per cent of all traffic at 2am.

2.2.6 Commonwealth and NSW strategic planning framework

The project is consistent with Commonwealth and NSW strategic plans relating to the improvement of transport and freight efficiency as outlined in Table 2-1.

The key design strategies, policies, and plans that have informed and influenced the project objectives and design development process are discussed in Chapter 4 (Project description).

Table 2-1 Strategic planning policies relevant to the project

Planning policy	Project relevance
State Infrastructure Strategy 2018-2038 (Infrastructure NSW, 2018)	The project would: • address the constraints that limit freight movement along this section of the Great Western Highway, identified in the State Infrastructure Strategy 2018-2038. • support regional economic development, productivity and recovery by improving network performance, travel times and safety along this section of the Great Western Highway • support recommendations 41, 42, 50 and 51 by increasing the freight capacity and efficiency of the road network while enhancing accessibility and improving road safety.
State Infrastructure Strategy 2022-2042 (Infrastructure NSW, 2022)	The NSW Government has committed $2.5 billion to the Upgrade Program, $2 billion of which is available for the project. The importance of the Upgrade Program has been recognised by Infrastructure Australia which has included the Upgrade Program in the National Infrastructure Priority List (Infrastructure Australia, 2020). Additional Australian Government funding is being sought to enable delivery of the project, given the national contribution to gross product that the Upgrade Program has the capacity to deliver. Transport for NSW, in consultation with other relevant agencies, is continuing to investigate appropriate delivery models for the project. Consultation with the construction industry has confirmed that there is sufficient capacity to deliver the project at this time.

Planning policy	Project relevance
Future Transport Strategy: Our vision for transport in NSW (Transport for NSW, 2022g)	The project aligns with the following transport outcomes and strategic directions: • connecting our customer's whole lives: - C1: connectivity is improved across NSW – by providing new, high quality, efficient transport infrastructure that connects Sydney through the Blue Mountains to the Central West region - C2: multimodal mobility supports end-to-end journeys – by facilitating freight connectivity and access and improving freight transportation capacity and efficiency across the Blue Mountains - C4: our transport networks are safe – by contributing to delivering strategies to achieve ambitious safety targets, forming a part of an integrated Safe Systems approach, improving safety for active transport users and providing opportunities for future active transport infrastructure by removing traffic from the Great Western Highway • successful places for communities: - P2: transport infrastructure makes a tangible improvement to places – improving amenity of places along State Roads by removing traffic from the Great Western Highway, as well as delivering high quality urban design that would contribute to making places more liveable and successful - P4: transport minimises environmental impacts – by following an environment-led design process that has sought to avoid and minimise environmental impacts through construction and operation, including a commitment to deliver a net increase in urban trees and no net loss in biodiversity, improvements in air quality, a reduction in noise and minimisation of the construction footprint as far as possible - P5: transport is resilient and adaptable to shocks and stresses – delivering a more resilient transport network by providing additional transport capacity across the Blue Mountains and an alternative route in the event of natural or other incidents and emergencies, as well as consideration of future climate changes impacts in the design • enabling economic activity: - E1: freight networks and supply chains are efficient and reliable – by providing an additional, high quality network capacity in the road network to support freight movements across the Blue Mountains and between the Sydney and Central West regions - E3: transport supports the visitor economy – the additional capacity provided by the project and the reduction in surface traffic would improve access and experiences and would support visitor access - E5: leverage our procurement power for better outcomes – the project has been and would continue to be procured to promote sustainable and ethical practices.
A Map for Action: Towards a More Sustainable Blue Mountains 2000-2025 (Blue Mountains City Council, 2000)	The project help would address the following objectives by improving traffic network performance and efficiency between Blackheath and Little Hartley and considering the unique Blue Mountains identity in the landscaping and urban design elements of the project: • reducing increased traffic congestion on the Great Western Highway and in towns and villages • retaining a distinct Blue Mountains identity and avoiding incorporation into Greater Sydney • reducing the social and environmental impacts of large numbers of people commuting to work in Sydney.

Planning policy	Project relevance
Regional NSW Services and Infrastructure Plan 2018 (Transport for NSW, 2018b)	The project would support the objective to improve freight connectivity from inland NSW to Sydney, including along the Great Western Highway, by providing a connection for high productivity vehicles longer than 20 metres between Blackheath and Little Hartley, contributing to a total reduction in the current route for these vehicles by up to 100 kilometres between Sydney and Central West NSW.
Tourism and Transport Plan 2018 (Transport for NSW, 2018a)	By improving transport infrastructure on the main road used to access Central West NSW, the project aligns with customer outcome 2 (greater access to more of NSW). The project also aligns with customer outcomes 1 (enhancing the visitor experience) and 3 (making transport the attraction) by applying improved urban design and placemaking principles that benefit both road users and local areas between Blackheath and Little Hartley.
Road Safety Plan 2021 (Transport for NSW, 2018c)	Within the Road Safety Plan 2021, the project would align with the Saving Lives on Country Roads program to address challenges to road safety including high risk curves on NSW roads by providing an alternative to the tight curves and steep grades on the Great Western Highway, particularly at Mount Victoria.
Central West and Orana Regional Plan 2036 (DPE, 2017)	The project is consistent with the following directions under Goal 3: Quality freight, transport and infrastructure networks: • direction 18 – improve freight connections to markets and global gateways • direction 19 – enhance road and rail freight links.
NSW Freight and Ports Plan 2018-2023 (NSW Government, 2018)	The project would support the objective to ensure safe, efficient and sustainable freight access to places by providing a connection for high productivity vehicles longer than 20 metres between Blackheath and Little Hartley, contributing to a total reduction in the current route for these vehicles by up to 100 kilometres between Sydney and Central West NSW (Transport for NSW, 2019).
2021 Australian Infrastructure Plan (Infrastructure Australia, 2021)	Infrastructure Australia's Infrastructure Priority List identifies the need for improvements to the Great Western Highway between Katoomba and Lithgow. The project would address this need specifically between Blackheath and Little Hartley. The project aligns with the following key focus areas: • place-based outcomes for communities – by improving local access movements around Blackheath and Mount Victoria by separating through traffic into the project tunnels and local traffic onto the surface roads, particularly during weekends and peak holiday periods. This would improve amenity for residents of Blackheath and Mount Victoria due to less traffic on the Great Western Highway including through reductions in traffic noise and vehicle emissions • sustainability and resilience – by providing an alternative route to the Great Western Highway improving access for emergency vehicles in the event of an incident • transport – by reducing travel times and improving road safety on this section of the Great Western Highway • waste – by using recycled materials, reusing or repurposing generated waste (including spoil) where feasible, and otherwise disposing of waste in an environmentally sustainable manner.

2.3 Project objectives

The project objectives are consistent with the objectives for the Upgrade Program. These objectives are outlined in Figure 2-1 and include:

- improve economic development, productivity and freight accessibility in and through the Blue Mountains, Central West and Orana regions
- improve the resilience of the corridor between Blackheath and Little Hartley to ensure continuity and safety of transport and essential services
- improve transport network performance and efficiency along the corridor between Blackheath and Little Hartley to meet the needs of all our customers
- improve the safety of the corridor for all transport users between Blackheath and Little Hartley
- enhance the liveability and be sensitive to the unique environmental and cultural assets along the corridor between Blackheath and Little Hartley
- provide value for money, sustainable and deliverable infrastructure.

These objectives have informed the alternative and options evaluation process for the project, described in Chapter 3 (Project alternatives and options), and have guided the design development to date. These objectives will also be used to guide future decisions during ongoing design development for the project.

2.4 Project benefits

The key benefits of the project are outlined in Figure 2-1 and would include:

- improved economic development, productivity, and recovery – during the first ten years of operation, the project would contribute up to around $10 million per year in net output for the regional area (refer to Chapter 20 (Business, land use and property)) and would create a faster, safer, and more efficient freight connection between Blackheath and Little Hartley. During construction, the project would create up to 1,100 jobs and is expected to contribute around $130 million per year to the regional economy
- improved resilience and future-proofing – the project would provide an alternative route to the current Great Western Highway between Blackheath and Little Hartley and would improve access for emergency vehicles in the event of an incident. It would also assist in minimising broader traffic delays and disruptions that may be caused by an incident. The project has been designed to improve the level of service for predicted traffic volumes in future years with scope to accommodate future growth
- improved network performance – the project would reduce light vehicle travel times between Blackheath and Little Hartley by around nine minutes, and heavy vehicle travel times by around nine minutes during the weekday AM peak hour period. The project would also provide a connection for high productivity vehicles longer than 20 metres (with an upper limit of 36 metres) between Blackheath and Little Hartley, contributing to a total reduction in the current route for these vehicles by up to 100 kilometres between Sydney and Central West NSW. The project would substantially reduce traffic on the existing Great Western Highway between Blackheath and Little Hartley improving travel time, speeds and safety on this part of the route
- safety improvements – the project would provide a safer alternative to the current steep grades, limited overtaking opportunities and at-grade intersections along sections of the Great Western Highway between Blackheath and Little Hartley. The project would provide a bypass route for heavy vehicles, avoiding local townships and two school zones and allowing separation of through and freight traffic from local and tourist traffic
- movement, place, and amenity improvements – the project would result in improved amenity for residents of Blackheath and Mount Victoria due to a substantial reduction in traffic and associated reductions in traffic noise and vehicle emissions along the existing Great Western

Highway. The project would also incorporate urban design principles as described in Chapter 4 (Project description) and create potential opportunities for placemaking initiatives by reducing through traffic, including freight vehicles, at key locations along the Great Western Highway, particularly at Blackheath and Mount Victoria. These placemaking opportunities are consistent with the Movement and Place Framework (NSW Government, 2020a) adopted by Transport for the Upgrade Program.

In addition, the project (as part of the Upgrade Program) would present socio-economic opportunities, including:

- improving connections between the national high productivity vehicle network and Sydney
- strengthening supply chains due to better access to regions
- improving access to employment opportunities and services.

3 Project alternatives and options

3.1 Background

The upgrade of the Great Western Highway between Blackheath and Little Hartley (the project) has undergone many years of investigation. This has included consideration of various strategic alternatives and route options as part of the upgrade of the Great Western Highway between Katoomba and Lithgow to a four lane carriageway (the Upgrade Program).

An initial phase of work started in 2008 and included an NSW Government announcement of an upgrade from Mount Victoria to Lithgow. Four corridors were initially identified (the strategic alternatives described in Section 3.3). The Great Western Highway and Bells Line of Road were identified as the preferred strategic alternatives due to the presence of existing motorway infrastructure.

Investigations were then carried out for the Upgrade Program in 2019. This work included a review of the initial 2008 phase of work and a review of previous and new strategic options. The outcomes of these 2019 investigations are discussed in Section 3.3. Following the selection of the Great Western Highway Upgrade Program as the preferred strategic alternative, four separate projects were identified including:

- the Great Western Highway East – Katoomba to Blackheath Upgrade (Katoomba to Blackheath Upgrade)
- the Great Western Highway Upgrade – Medlow Bath (Medlow Bath Upgrade)
- the Great Western Highway Blackheath to Little Hartley (the project)
- the Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade).

A discussion of how these four projects were identified is provided in Section 3.4.

Further design development for the project continued from 2021 and included investigations into two different tunnel options, the Blackheath and Mount Victoria tunnel bypasses and the Blackheath to Little Hartley tunnel, described further in Sections 3.5.3 and 3.5.4.

Upon identification of the Blackheath to Little Hartley tunnel as the preferred option, further investigations have focussed on construction methods and other design refinements to avoid and minimise potential environmental impacts, as described in Section 3.7.

3.2 Approach

The project alternatives and option development process is shown in Figure 3-1. Strategic alternatives and project options were assessed against the project objectives, which are consistent with the Upgrade Program objectives and detailed in Chapter 2 (Strategic context and project need). Strategic alternatives and project options have also been informed by the outcomes of community and stakeholder engagement, as detailed in Chapter 7 (Community and stakeholder engagement).

Options relating to specific project elements are outlined in Section 3.6 and include tunnel construction methodologies and spoil transport options as well as design elements including options for the proposed ventilation system design.

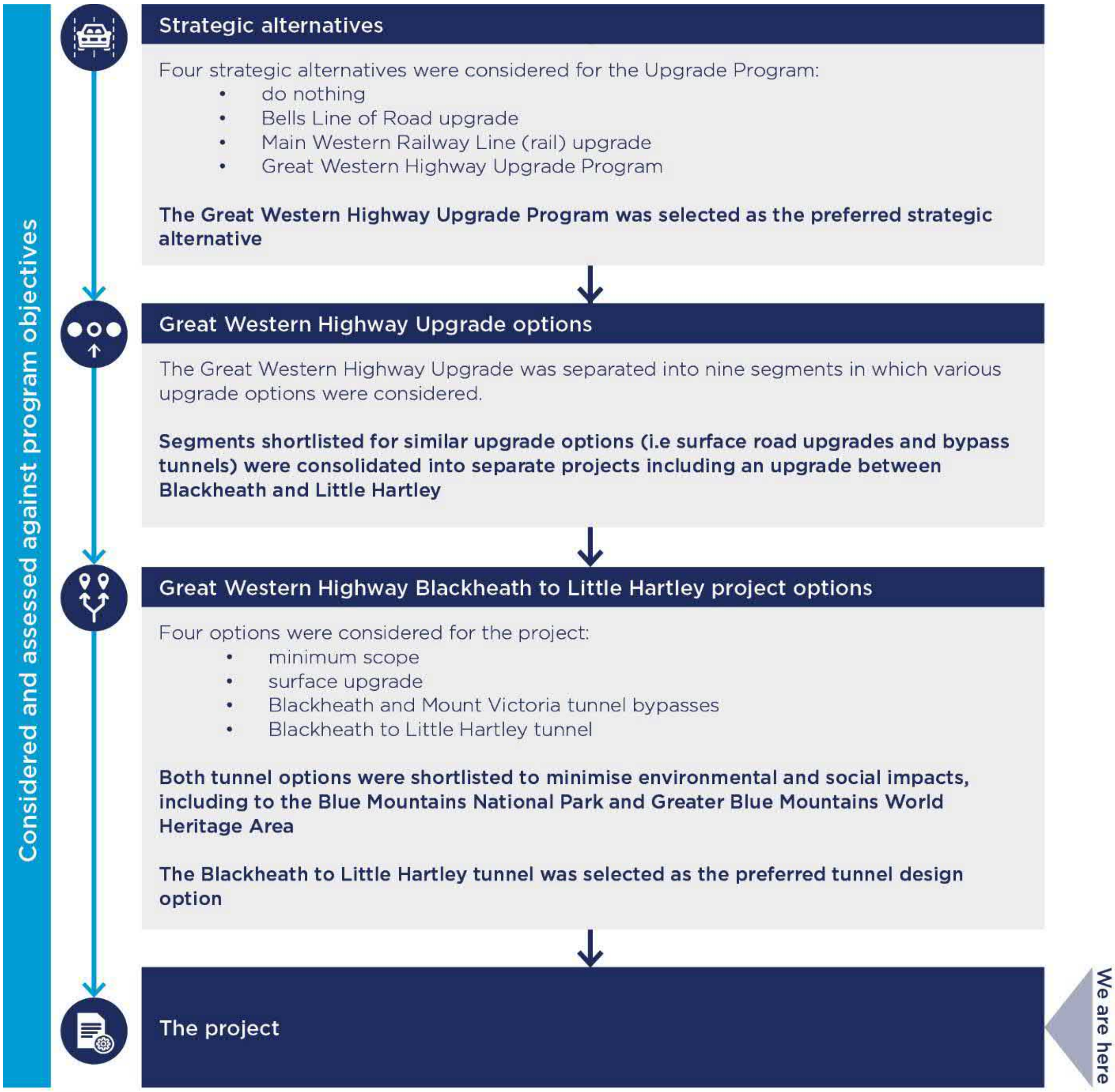


Figure 3-1 Approach to project alternatives and options development

3.3 Strategic alternatives considered

Given the strategic context outlined in Chapter 2 (Strategic context and project need), four strategic alternatives were considered to address the project need and meet the project objectives. These options included:

- do nothing
- Bells Line of Road upgrade
- Main Western Railway Line (rail) upgrade
- Great Western Highway Upgrade Program.

The strategic alternatives were assessed against the project objectives using a traffic light rating system to demonstrate strong alignment (green), some or neutral alignment (yellow) or limited or no alignment (red), as shown in Figure 3-2. A discussion of each of the strategic alternatives considered, and their performance against the project objectives, is provided in the following sections.

Figure 3-2 Assessment of strategic alternatives against the objectives

3.3.1 Do nothing

The do nothing alternative would rely on the continued operation of existing transport networks and other transport projects to meet current and future transport needs. A summary of how the do nothing strategic alternative performed against the project objectives is provided in Table 3-1.

Ultimately the do nothing strategic alternative would not address the project need and is not consistent with the objectives described in Chapter 2 (Strategic context and project need). As such this strategic alternative was not progressed.

Table 3-1 Performance of the do nothing strategic alternative against the project objectives

Objective	Strategic alternative performance against the project objectives	Rating
Economic development	• would not address limited overtaking opportunities, steep grades and lengthy travel times on the Great Western Highway that currently affect freight movements. Left unaddressed, this would constrain access between Sydney and proposed future freight infrastructure (and associated land use change) in the Central West, including the Parkes National Logistics Hub and the Inland Rail Program • under the do nothing alternative, freight efficiency would further deteriorate to unacceptable levels.	●
Resilience	• given the single lane two-way traffic arrangements in many sections of the existing Great Western Highway, the do nothing alternative would not change the current vulnerability of the highway to closure from climate events and traffic incidents.	●

Objective	Strategic alternative performance against the project objectives	Rating
Transport network performance	• forecast traffic modelling described in Chapter 8 (Traffic and transport) indicates that under the do nothing alternative, the Great Western Highway would be unable to accommodate efficient road travel through the Blue Mountains in the future, resulting in considerable delays • would not address freight efficiency given provision of a B-double (a truck and two trailers) capable road is currently not provided or would not be provided.	●
Safety	• would not address current road safety issues such as steep gradients which exceed safety standards at Victoria Pass (between Mount Victoria and the base of the Blue Mountains escarpment in the west), tight curves around mountains and non-compliant clear zones (a roadside area free of objects where an out-of-control vehicle can traverse safely) • would not address the current incident rate between Katoomba to Lithgow where an incident occurs every four days that forces a road closure for up to 80 minutes (Transport for NSW, 2021d) • would not address current safety issues for active transport users, given there would be no separation of through (freight) traffic from local traffic using the local road network and the Great Western Highway.	●
Environment	• no environmental impacts due to construction or land use disturbance • would result in continued increased traffic congestion, idling and concentration of vehicle emissions creating localised noise and air pollution.	●
Value for money	• would avoid construction costs however would not provide a value for money outcome because no additional transport capacity or improved freight accessibility would be provided between Sydney and the Central West and Orana regions • would not address the need for the project described in Chapter 2 (Strategic context and project need).	●

3.3.2 Bells Line of Road upgrade

In 2000 and 2004, the Australian and NSW governments investigated the feasibility of upgrading the Bells Line of Road corridor which runs between Windsor in northwest Sydney and Bell in the Blue Mountains. The upgrade included widening the existing two lane road corridor to a four lane B-double capable road. This information was reviewed in light of the project need and a summary of how this strategic alternative performed against the project objectives is provided in Table 3-2.

Ultimately the Bells Line of Road strategic alternative was not progressed due to significant costs, engineering challenges, direct impacts to the Greater Blue Mountains World Heritage Area, impacts to land use through Sydney’s north-western suburbs, and substantially greater travel distance and likely greater travel times between regional centres (Sydney and the Central West region).

Table 3-2 Performance of the Bells Line of Road strategic alternative against the project objectives

Objective	Strategic alternative performance against the project objectives	Rating
Economic development	• would not upgrade a key freight and road corridor, given Bells Line of Road is not designated as a Road of National Importance (as part of the Auslink National Network) • would provide a less direct connection to freight hubs between Sydney and the Central West and Orana regions.	🔴
Resilience	• would partially improve resilience of the road network across the Blue Mountains given additional lanes would enable increased capacity and safety opportunities, allowing essential services better access to the area via Bells Line of Road during vehicle incidents or extreme weather events • would not provide an alternative route or separated carriageway in addition to existing road networks across the Blue Mountains.	🟡
Transport network performance	• Bells Line of Road near Bell carries about 3,000 vehicles per day compared to 11,000 vehicles near Mount Victoria along the Great Western Highway (Transport for NSW, 2022a), which indicates that an upgrade of Bells Line of Road would not improve network performance and efficiency for as many road users as an upgrade to the Great Western Highway • would improve transport network performance across the Blue Mountains, however, would also result in a greater travel time between Sydney and the Central West region when compared to an upgrade to the Great Western Highway.	🟡
Safety	• would partially address safety of the Bells Line of Road corridor but would not provide safety improvements on the Great Western Highway, which is the more frequently used corridor for freight and other road users across the Blue Mountains.	🟡
Environment	• would have impacts to the Blue Mountains National Park and the Greater Blue Mountains World Heritage Area given their proximity to Bells Line of Road between Kurrajong in Sydney's northwest to around the town of Dargan • would not improve local amenity of the Blue Mountains townships located off the Great Western Highway.	🔴
Value for money	• would require substantial costs due to the steep terrain and extent of work required to the existing Bells Line of Road, which is currently susceptible to extreme weather events (Transport for NSW, 2021d) • would require further costs for property acquisition and local road and bridge upgrades in Sydney (such as over the Hawkesbury River and at Richmond Road) required to provide an adequate connection to Bells Line of Road.	🔴

3.3.3 Main Western Railway Line (rail) upgrade

An upgrade and strengthening of the resilience of the existing Main Western Railway Line, a railway route which runs between Sydney Central in the east via the Blue Mountains and Lithgow to Dubbo in the west, was considered as a strategic alternative to meet the project objectives. The existing passenger railway line terminates at Lithgow (where passengers must change travel modes), whereas the freight line extends to Orange, Wellington, Dubbo and Nyngan. A summary of how this strategic alternative performed against the project objectives is provided in Table 3-3.

Ultimately this strategic alternative was not progressed given it would require substantial property acquisition and a significant construction timeframe.

The Australian Government has committed $8 million to fund investigations into faster rail options from Sydney to Parkes (via Bathurst and Orange) in partnership with the NSW Government (Department of Infrastructure, Transport, Regional Development and Communities, 2021). Potential future provision of railway improvements across the Blue Mountains would likely be captured by this initiative.

Table 3-3 Performance of the Main Western Railway Line (rail) upgrade strategic alternative against the project objectives

Objective	Strategic alternative performance against the project objectives	Rating
Economic development	• would require substantial additional infrastructure to separate freight and passenger services to meet this objective • without significant investment to allow for sufficient separation of freight and passenger services, freight accessibility would be constrained to a predominantly single track arrangement unable to provide capacity for increased freight services through the area and thereby limiting economic development and productivity through the regions • would not fully address freight accessibility improvements, given the majority of freight movements are via the road corridor.	●
Resilience	• would partially improve the resilience of the corridor through upgrades including electrical signalling and communication infrastructure, substations, power poles and components of safe working systems, however the railway line would still be vulnerable to closure (such as from bushfires and landslides) • would not address the resilience of the road corridor which is used by the majority of transport users and essential services.	●
Transport network performance	• would not address current and future congestion for the majority of travellers. Light vehicle movements are the primary mode of transport across the Blue Mountains (Transport for NSW, 2021d) • would not be efficient given the semi-rural nature of the Blue Mountains. Local residents using a rail service would still likely require another form of transport for part of their journey, which would likely be a private vehicle on the local road network • would help facilitate a shift from road freight to rail freight thereby reducing the number of heavy vehicle movements on the Great Western Highway.	●
Safety	• would not provide improved road safety outcomes, with road vehicles comprising the primary mode of transport in the region.	●
Environment	• would promote the use of public transport • would not address the existing amenity impacts for towns located adjacent to the existing Great Western Highway associated with trucks and traffic using the highway.	●

Objective	Strategic alternative performance against the project objectives	Rating
Value for money	• while promoting public transport as a sustainable travel mode, this strategic alternative would likely have substantial costs, as a result of construction on steep gradients with tight track curvature (Roads and Traffic Authority, 2008) • would require substantial acquisition of residential and commercial land to extend the railway.	🟡

3.3.4 Great Western Highway Upgrade Program

The Great Western Highway Upgrade Program strategic alternative included upgrade of the Great Western Highway between Katoomba and Lithgow to a four lane carriageway. At the strategic alternative level, there was no definition around whether the Upgrade Program would comprise a surface upgrade or a tunnel (refer to Section 3.4 for this discussion). A summary of how the strategic alternative performed against the project objectives is provided in Table 3-4.

Table 3-4 Performance of the Great Western Highway Upgrade Program strategic alternative against the project objectives

Objective	Strategic alternative performance against the project objectives	Rating
Economic development	• would upgrade a key freight and road corridor, given the road is designated as a Road of National Importance (as part of the Auslink National Network) • would provide additional transport capacity across the Blue Mountains and would enhance connection between the regions • would improve freight accessibility by providing access for B-doubles and Performance Based Standards (PBS) level 2 vehicles up to 26 metres long where four lanes are provided along the Great Western Highway • would help to address the predicted 30 per cent rise in truck volumes on the Great Western Highway by 2036 (Transport for NSW, 2021d) • would provide additional transport capacity and improve freight accessibility between Sydney and the Central West and Orana regions. This would result in cost savings associated with freight transportation efficiency and would encourage goods production and agricultural trade between the regions.	🟢
Resilience	• would improve resilience given additional lanes would enable increased capacity and safety opportunities, allowing essential services better access to the area during vehicle incidents or extreme weather events.	🟡
Transport network performance	• the Great Western Highway near Mount Victoria carries about 11,000 vehicles per day with forecast growth rates of up to around two per cent expected annually, as compared to Bells Line of Road near Bell which carries about 3,000 vehicles per day (Transport for NSW, 2022a), indicating that the strategic alternative would accommodate a higher number of road transport users than the Bells Line of Road strategic alternative • would provide additional transport capacity which would reduce current traffic queues for both private and commercial vehicles on the Great Western Highway which can be up to eight kilometres in length and incur delays of up to 80 minutes in peak periods (Transport for NSW, 2021d)	🟢

Objective	Strategic alternative performance against the project objectives	Rating
	• would allow opportunities for overtaking, currently not available in certain areas where there is a single lane arrangement in each direction such as through Victoria Pass • would provide the shortest, quickest and preferred route for the majority of motorists across the Blue Mountains which would benefit road users.	
Safety	• would improve safety of the corridor for road transport users, including active transport users, by providing additional traffic lanes, overtaking opportunities, and potential separation of through traffic from local traffic • would alleviate congestion on the Great Western Highway and adjacent local roads by providing additional traffic lanes which may also improve safety • would address existing steep gradients, tight curves around mountains and clear zones (a roadside area free of objects where an out-of-control vehicle can traverse safely) that do not meet current safety standards.	●
Environment	• would avoid and/ or minimise impacts to the Blue Mountains National Park and Greater Blue Mountains World Heritage Area • would improve local amenity in the Blue Mountains townships located off the Great Western Highway by easing congestion.	●
Value for money	• would provide value for money considering costs and benefits.	●

3.3.5 Preferred strategic alternative

The Great Western Highway Upgrade Program strategic alternative best addresses the identified project need and best meets the project objectives. On this basis this strategic alternative was taken forward for further development.

3.4 Great Western Highway Upgrade projects

Following the selection of the Great Western Highway Upgrade Program as the preferred strategic alternative, the corridor between Katoomba to Lithgow was divided into nine segments in which various upgrade options were examined (as outlined in Table 3-5).

These nine segments were identified based on the characteristics of the road (e.g., separating areas comprising townships such as Blackheath and Medlow Bath from open road areas) and are shown in Figure 3-3. As part of the strategic business case for the Great Western Highway Upgrade Program, a viability assessment was carried out for these options. The shortlisted options identified for the nine segments through this viability assessment are summarised in Table 3-5.

Segments shortlisted for similar upgrade options (i.e., surface road upgrades and bypass tunnels) were consolidated into four separate projects including:

- Katoomba to Blackheath Upgrade
- Medlow Bath Upgrade (separated from the Katoomba to Blackheath Upgrade as this was identified as a priority section to progress to construction based on the viability assessment)
- the project
- Little Hartley to Lithgow Upgrade.

Table 3-5 Options considered for the Great Western Highway Upgrade

Section of Great Western Highway	Total number of options considered	Upgrade options considered by type				Shortlisted options
		Surface road upgrade	Road bypass	Tunnel bypass	Rail upgrade	
Katoomba to Medlow Bath	2	2	-	-	-	• surface road upgrade
Medlow Bath	1	1	-	-	-	• surface road upgrade
Medlow Bath to Blackheath	1	1	-	-	-	• surface road upgrade
Blackheath	17	5	4	6	2	• removal of level crossing and provision of rail underpass at Shipley Street • tunnel bypass
Blackheath to Mount Victoria	2	1	-	1	-	• surface road upgrade and tunnel bypass
Mount Victoria to Little Hartley	3	-	-	3	-	• bypass including five bridges and two tunnels
Little Hartley to River Lett	1	-	1	-	-	• surface road bypass
River Lett to Forty Bends	1	-	1	-	-	• surface road bypass
Forty Bends to Lithgow	1	1	-	-	-	• surface road upgrade

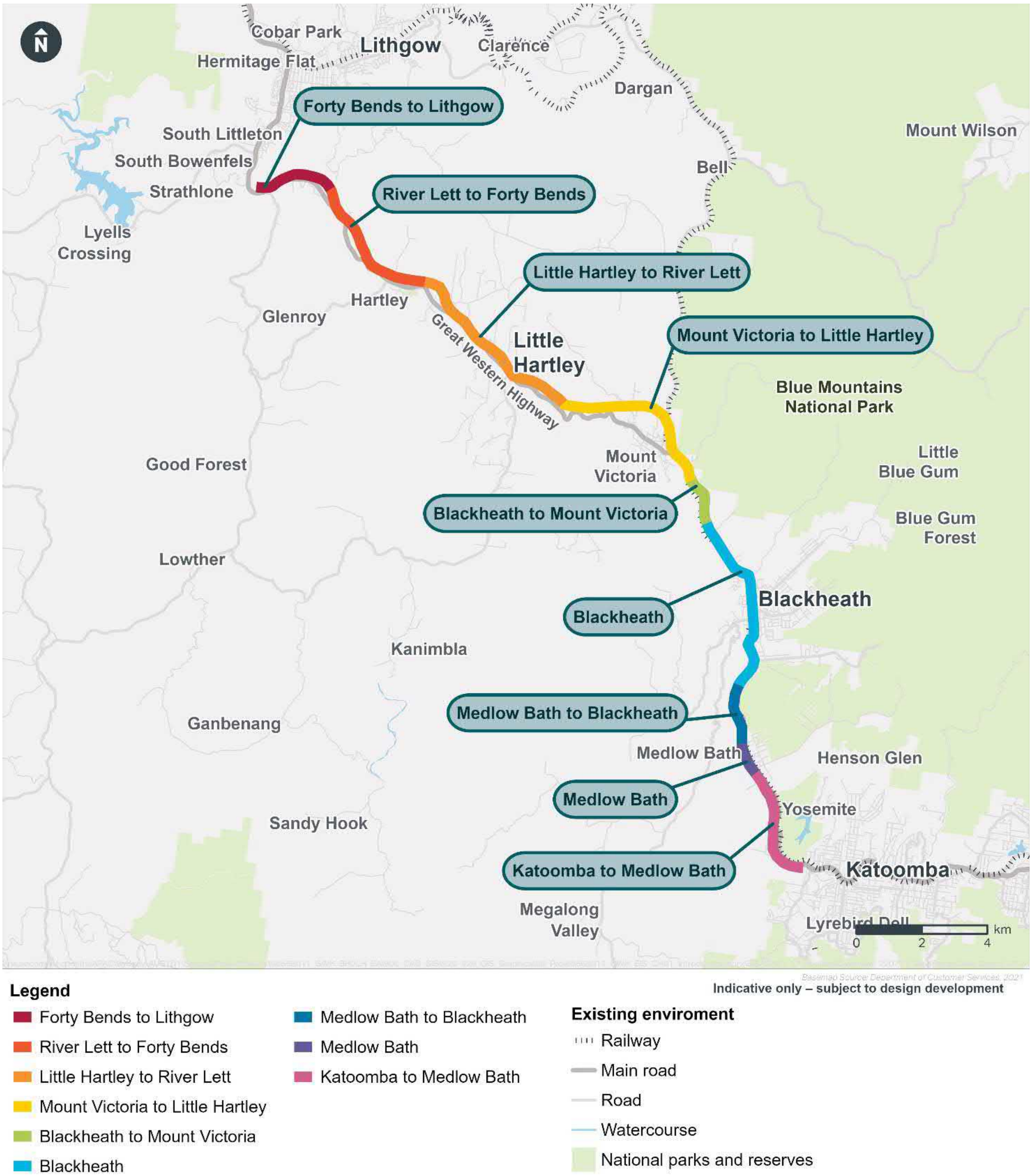


Figure 3-3 Sections considered for the Great Western Highway Upgrade

3.5 Project options considered

Four options were considered to support the preferred strategic alternative to upgrade the Great Western Highway between Blackheath and Little Hartley (the project) including:

- minimum scope (targeted minor road upgrades and intersection work)
- surface road upgrade (surface upgrade and bypass of Mount Victoria to provide two lanes in each direction)

- two tunnels (tunnel bypasses of Blackheath and Mount Victoria and a surface road upgrade between Blackheath and Mount Victoria)
- single tunnel (tunnel from Blackheath to Little Hartley).

The project options were assessed against the project objectives using the same traffic light rating system applied to strategic alternatives (refer to Section 3.3) to demonstrate strong alignment (green), some or neutral alignment (yellow) or limited or no alignment (red), as shown in Figure 3-4. A discussion of each of the project options considered, and their performance against the project objectives, is provided in the following sections.

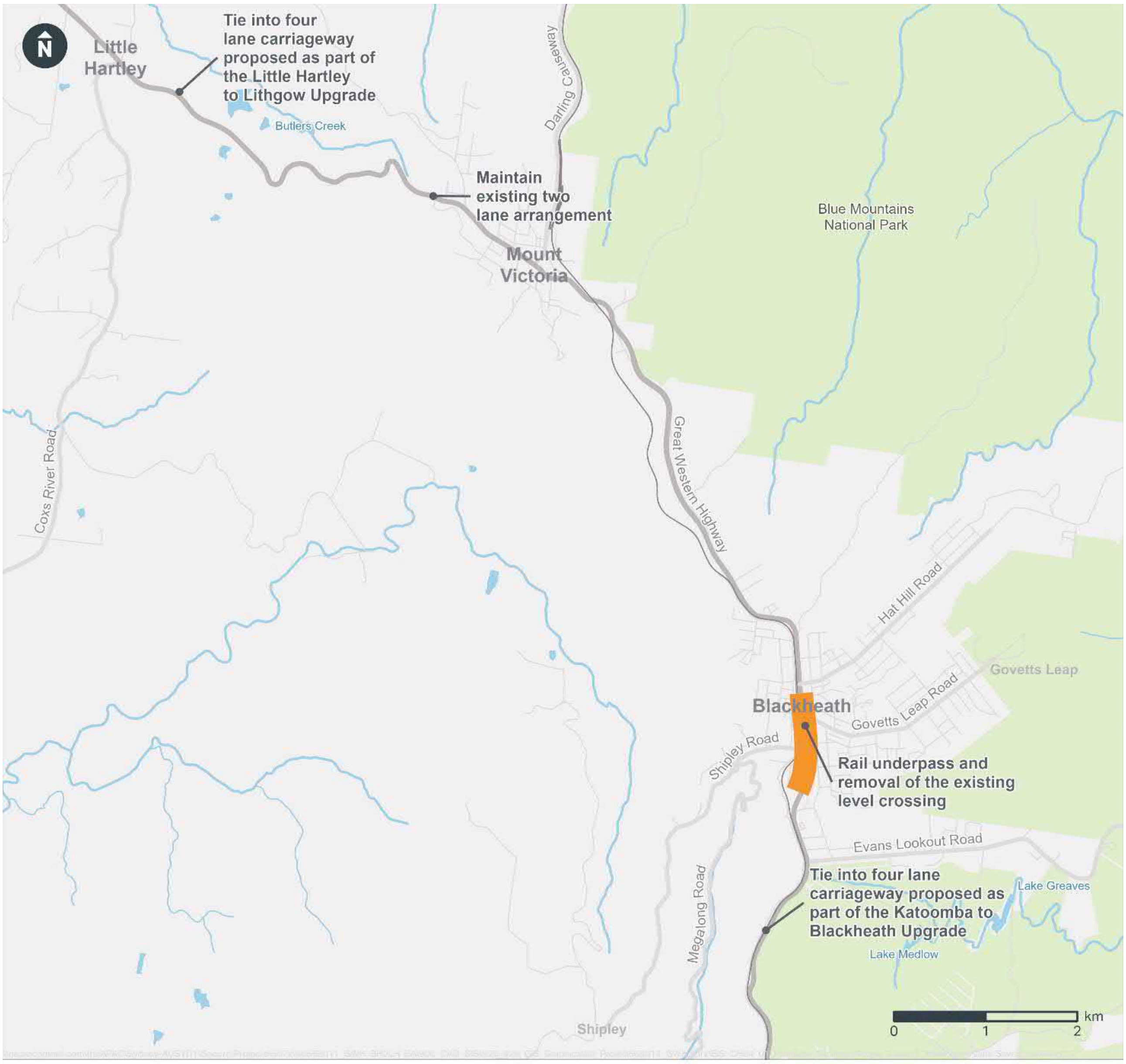
Figure 3-4 Assessment of project options against the objectives

3.5.1 Minimum scope

The minimum scope option would include targeted minor upgrades between Blackheath and Little Hartley. These targeted minor upgrades would integrate with the upgraded sections of the Great Western Highway between Katoomba and Blackheath and Little Hartley and Lithgow, which would be upgraded to a four lane surface carriageway.

Between Blackheath and Little Hartley this option would include a rail underpass and removal of the existing level crossing at Bundarra Street in Blackheath village to reduce substantial queuing that currently occurs at the intersection of Govetts Leap Road and the Great Western Highway. The minimum scope option is shown in Figure 3-5.

As summarised in Table 3-6, this option would not address the identified project need and is largely not consistent with the project objectives described in Chapter 2 (Strategic context and project need). As such this option was not progressed.



Basemap Source: Department of Customer Services, 2021

Legend

Existing environment

- Railway
- Main road
- Road
- Watercourse
- National Parks and Reserves

Figure 3-5 Minimum scope option overview

Table 3-6 Performance of the minimum scope option (between Blackheath and Little Hartley) against the project objectives

Objective	Project option performance against the project objectives	Rating
Economic development	• would not increase freight accessibility on the existing road network between Blackheath and Little Hartley, given that no additional traffic lanes would be provided.	🔴
Resilience	• would not improve resilience given no additional lanes, alternative route or separated carriageways between Blackheath and Little Hartley would be provided to enable overtaking opportunities, increased capacity, or safety opportunities, including in the event of an incident.	🔴
Transport network performance	• would not provide additional traffic lanes between Blackheath and Little Hartley and therefore would not increase road capacity • would improve congestion in a specific location as the rail underpass would help to alleviate significant queuing across the Great Western Highway at Govetts Leap Road • would likely result in a worsening of transport network performance, as the four lane arrangements east of Blackheath and west of Little Hartley would reduce to a two lane arrangement between Blackheath and Little Hartley.	🟡
Safety	• would not improve (and potentially worsen into the future) the safety of the corridor due to congestion and merging traffic east of Blackheath and west of Little Hartley • would not improve the steep grades traversed by the existing Great Western Highway at Mount Victoria • would improve safety in a specific location by alleviating significant queuing across the Great Western Highway at Govetts Leap Road.	🟡
Environment	• would limit the need for property acquisition and native vegetation removal • would only slightly improve liveability for locals by reducing the substantial queuing that currently occurs at the intersection of Govetts Leap Road and the Great Western Highway and providing a walkway for pedestrians to access the railway • would not improve (and potentially worsen) amenity between Blackheath and Little Hartley given there may be increased traffic noise and vehicle emissions from additional vehicles using and merging with the upgraded Great Western Highway east and west of this section • would be inconsistent with stakeholder feedback received indicating a preference for tunnel options, further described in Chapter 7 (Community and stakeholder engagement).	🟡
Value for money	• would minimise construction costs and materials required, however would not provide value for money with no additional transport capacity or improved freight accessibility provided between Sydney and the Central West and Orana regions.	🟡

3.5.2 Surface road upgrade

This option would include at-surface widening of the existing Great Western Highway or infrastructure upgrades to provide two lanes in each direction and would include:

- surface road widening from two to four lanes between Blackheath and Mount Victoria
- a bypass of Mount Victoria village and Victoria Pass via five bridges and twin tunnels (which would be up to around 1.4 kilometres long with two lanes in each direction)
- a rail underpass and removal of the existing level crossing at Bundarra Street in Blackheath village to reduce significant queuing that currently occurs at the intersection of Govetts Leap Road and the Great Western Highway
- a bypass of Mount Victoria township to Darling Causeway via northbound off-ramps and southbound on-ramps.

The surface road upgrade option is shown in Figure 3-6. This option would partially address the identified project need and project objectives described in Chapter 2 (Strategic context and project need). Following consideration of the factors summarised in Table 3-7 this option was not progressed.

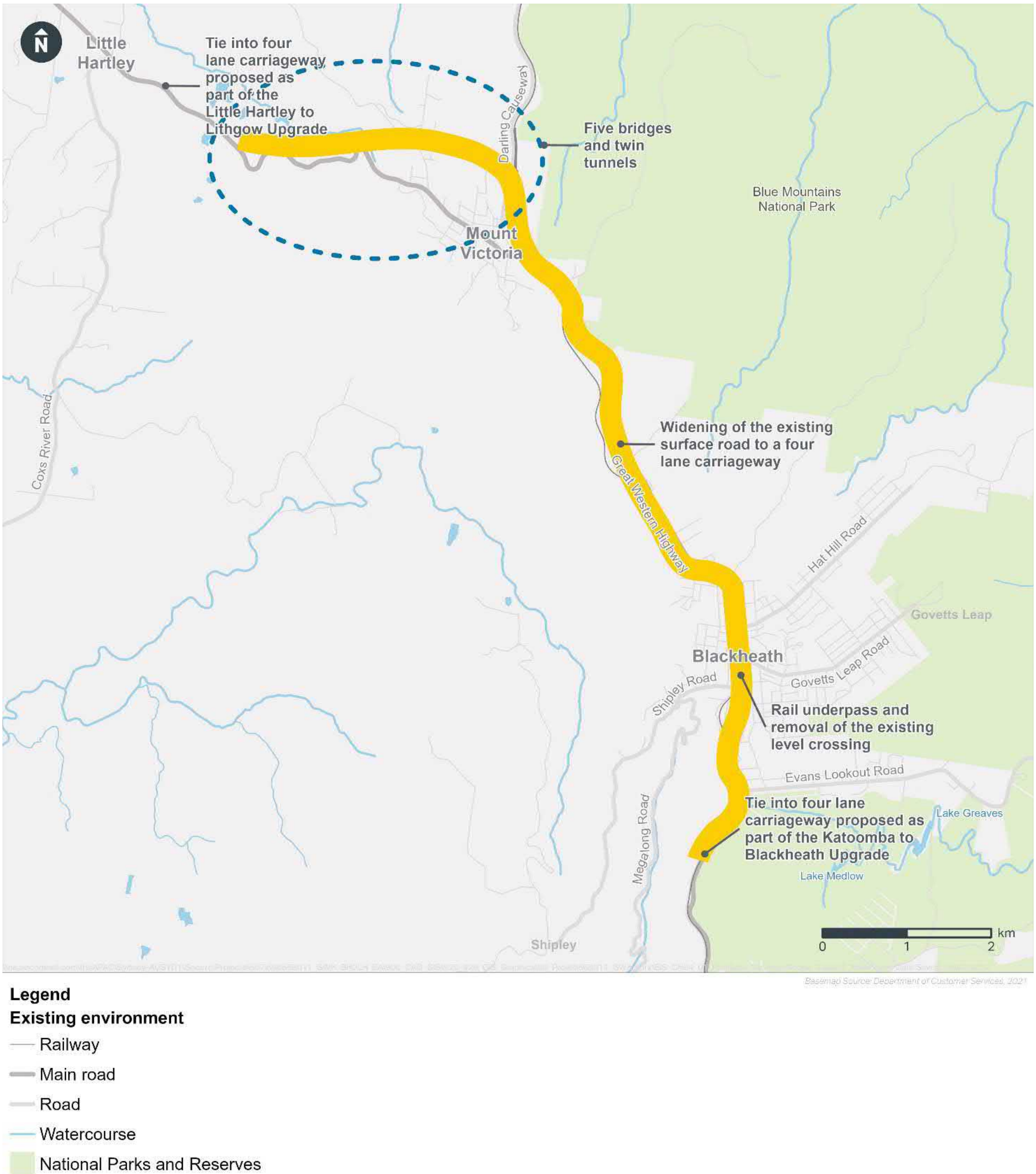


Figure 3-6 Surface road upgrade option overview

Table 3-7 Performance of the surface road upgrade option (between Blackheath and Little Hartley) against the project objectives

Objective	Project option performance against the project objectives	Rating
Economic development	• would provide additional transport capacity across the Blue Mountains and would enhance connection between the regions • would help to address the predicted 30 per cent rise in truck volumes on the Great Western Highway by 2036 (Transport for NSW, 2021d) • would not provide a separated carriageway for through (freight) traffic, which would continue to share the Great Western Highway with local traffic.	●
Resilience	• would enable increased capacity and safety opportunities given the road corridor would have an additional two lanes in each direction, allowing essential services better access to the area during vehicle incidents or extreme weather events • would not provide an alternative route in the event of road closure along the Great Western Highway.	●
Transport network performance	• additional transport capacity would alleviate current traffic queues for both private and commercial vehicles on the Great Western Highway which can be up to eight kilometres in length and incur delays of up to 80 minutes in peak periods (Transport for NSW, 2021d) • would allow opportunities for overtaking, currently not available in certain areas where there is a single lane arrangement in each direction such as through Victoria Pass • shared use of the Great Western Highway road network would not address current speed differences between through (freight) traffic and local traffic.	●
Safety	• would improve safety of the corridor for road transport users by providing additional traffic lanes, overtaking opportunities, and opportunities to separate private and commercial vehicles through measures such as heavy vehicle lane restrictions • would alleviate congestion on the Great Western Highway and adjacent local roads through additional traffic lanes which would likely result in less idling time • would address existing steep gradients and clear zones (a roadside area free of objects where an out-of-control vehicle can traverse safely) that do not meet current safety standards through the provision of additional road space, bridges and tunnels • would not address all tight curves around mountains, given the surface road upgrade would utilise the existing Great Western Highway alignment in most areas.	●

Objective	Project option performance against the project objectives	Rating
Environment	• would require more property acquisition when compared to a tunnel option • while utilising an existing road corridor, this option would require native vegetation removal where widening of the existing Great Western Highway would occur (which would encroach on the Blue Mountains National Park and the Greater Blue Mountains World Heritage Area) • would have comparatively greater environmental impacts from Mount Victoria to Little Hartley where large construction footprints would be required to construct the five bridges and twin tunnels • would involve increased traffic noise and vehicle emissions given the predominantly at-surface nature of the option • would be inconsistent with stakeholder feedback received indicating a preference for tunnel options, further described in Chapter 7 (Community and stakeholder engagement).	●
Value for money	• would result in cost savings associated with freight transportation efficiency, reduced congestion and would encourage goods production and agricultural trade between Sydney and the regions • would not be value for money given comparatively greater environmental and amenity impacts.	●

3.5.3 Blackheath and Mount Victoria tunnel bypasses

This option would include tunnel infrastructure and surface road upgrades between Blackheath and Little Hartley. It would include two separate tunnel bypasses (one of Blackheath and one of Mount Victoria) and surface road upgrades between these two locations. The two tunnels would be twin tunnels with two lanes in each direction. This option would include:

- twin tunnels underneath Blackheath from around Evans Lookout Road to around the existing Mount Boyce heavy vehicle safety station around 4.3 kilometres long (the Blackheath tunnel)
- twin tunnels from east of Mount Victoria to Little Hartley around 4.3 kilometres long (the Mount Victoria tunnel)
- surface road upgrades to provide four lanes along the existing Great Western Highway between the Blackheath tunnel and the Mount Victoria tunnel.

The Blackheath and Mount Victoria tunnel bypasses option is shown in Figure 3-7. A summary of how this option performs against the project objectives is provided in Table 3-8.

This option would address the project need and partially meet the project objectives and was therefore progressed for further consideration.

Ultimately this option was not selected as the preferred option for the project based on its performance compared with the Blackheath to Little Hartley tunnel option.

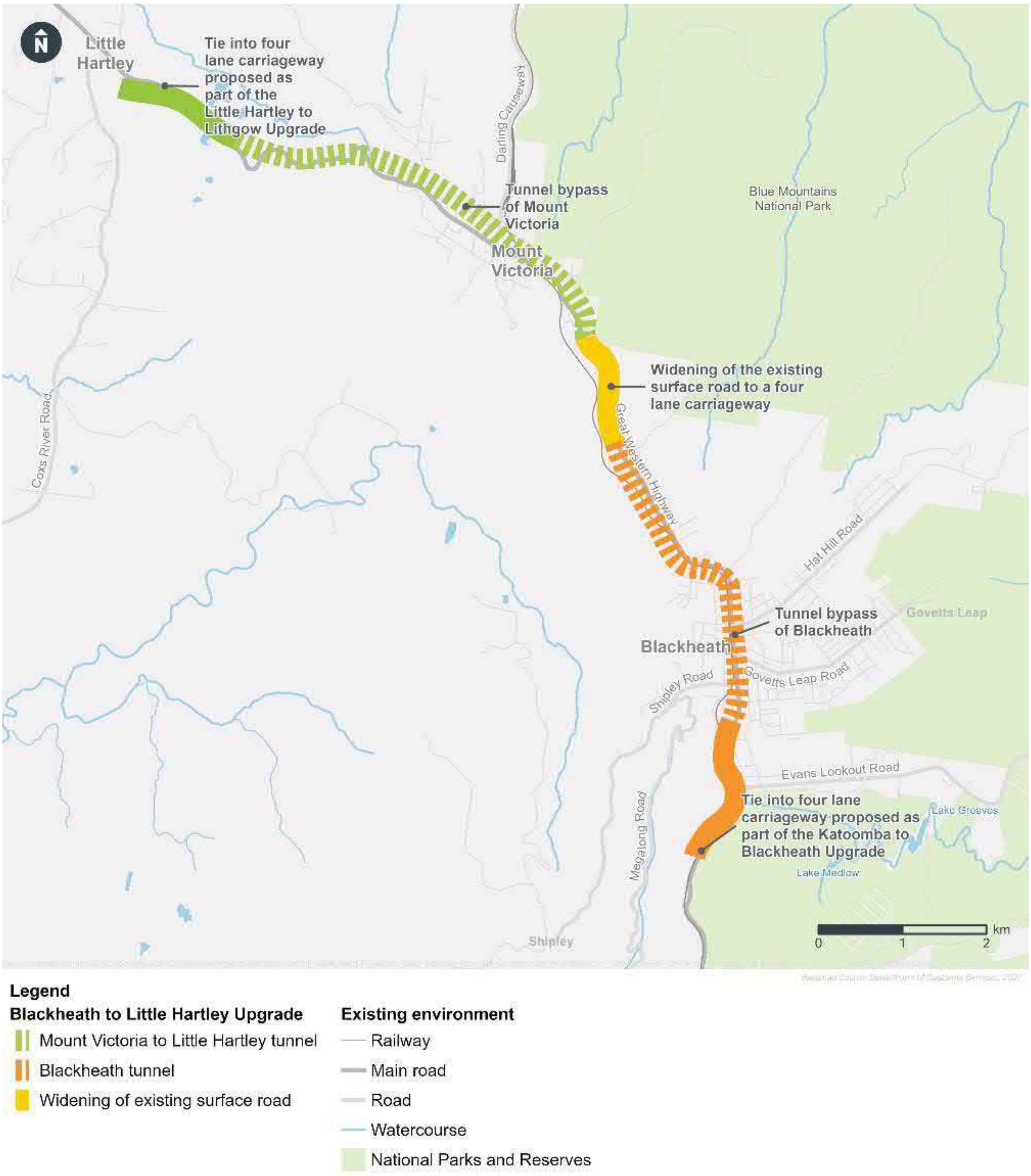


Figure 3-7 Blackheath and Mount Victoria tunnel bypasses option overview

Table 3-8 Performance of the Blackheath and Mount Victoria tunnel bypasses option against the project objectives

Objective	Project option performance against the project objectives	Rating
Economic development	• would provide additional freight transport accessibility across the Blue Mountains and would enhance connection between the regions • would improve freight accessibility by providing access for B-doubles and PBS level 2 vehicles up to 36 metres long • would help to address the predicted 30 per cent rise in truck volumes on the Great Western Highway by 2036 (Transport for NSW, 2021d).	●
Resilience	• would partially improve resilience through additional lanes which would enable increased capacity and safety opportunities, allowing essential services better access to the area during vehicle incidents or extreme weather events • would partially provide an alternative route, for those parts of the project in tunnels, in the event of road closure along the Great Western Highway. Merging with local traffic would continue to occur between the Blackheath and Mount Victoria tunnel portals.	●
Transport network performance	• would provide additional transport capacity by alleviating current traffic queues for both private and commercial vehicles on the Great Western Highway, which can be up to eight kilometres in length and incur delays of up to 80 minutes in peak periods (Transport for NSW, 2021d) • would allow opportunities for overtaking, currently not available in certain areas where there is a single lane arrangement in each direction, such as through Victoria Pass • would positively affect the local surface road network performance at Blackheath and Little Hartley, given through traffic would likely utilise the tunnel infrastructure. While the connection to Darling Causeway at Mount Victoria would cause some traffic impacts on the local surface road network, this option would perform better than the Blackheath to Little Hartley tunnel option with regards to connectivity and accessibility (creating a greater number of connections to local destinations).	●
Safety	• would improve the safety of the corridor for road transport users by providing additional traffic lanes, contributing to a reduction in congestion • would separate through (freight) traffic travelling at higher speeds, more likely to use the tunnel, from local traffic likely to use the existing Great Western Highway, apart from at Mount Victoria where the surface road would combine local and through traffic to provide a connection to Darling Causeway • would improve the safety of the road corridor at Victoria Pass with the tunnel bypassing steep grades and tight curves on the current highway alignment • would have a slightly steeper in-tunnel gradient, which would result in greater speed differences between the in-tunnel and the surface road network than the Blackheath to Little Hartley tunnel option.	●

Objective	Project option performance against the project objectives	Rating
Environment	• would require some property acquisition along the existing Great Western Highway, particularly around the four tunnel portal locations (Blackheath, Mount Victoria and Little Hartley) • would require comparatively greater native vegetation removal than the Blackheath to Little Hartley tunnel option to accommodate four portals (compared with two), additional construction sites and a surface road upgrade in Mount Victoria connecting the Great Western Highway to Darling Causeway. This would result in around an additional 300,000 square metres required for the surface construction footprint for this option with some of this potentially encroaching into the Blue Mountains National Park, and social and recreational facilities • would result in increased traffic noise and vehicle emissions at Mount Victoria due to the additional surface road capacity • would be generally consistent with stakeholder feedback received indicating preference for tunnel options, further described in Chapter 7 (Community and stakeholder engagement).	●
Value for money	• would be more expensive than the minimum scope and surface road upgrade options however would provide value for money given this option would perform better on the above project objectives • would be less expensive than the Blackheath to Little Hartley option, however, would have greater construction impacts, particularly at Blackheath and Mount Victoria due to a larger surface footprint, and greater construction duration and accessibility impacts given local roads would be significantly impacted by construction staging • would provide additional transport capacity and improve freight accessibility between Sydney and the Central West and Orana regions. This would result in cost savings associated with freight transportation efficiency and encourage goods production and agricultural trade between the regions.	●

3.5.4 Blackheath to Little Hartley tunnel

The Blackheath to Little Hartley tunnel option would include twin tunnels around 11 kilometres long between Blackheath and Little Hartley, connecting to the upgraded Great Western Highway at both ends.

This option was identified as the preferred project and is described in full in Chapter 4 (Project description). A summary of how this option performs against the project objectives is provided in Table 3-9.

Table 3-9 Performance of the Blackheath to Little Hartley tunnel option against the project objectives

Objective	Project option performance against the project objectives	Rating
Economic development	• would provide additional transport capacity across the Blue Mountains and enhances the connection of the regions • would improve freight accessibility by providing access for B-doubles and PBS level 2 vehicles up to 36 metres long • would help to address the predicted 30 per cent rise in truck volumes on the Great Western Highway by 2036 (Transport for NSW, 2021d).	●
Resilience	• would enable improved resilience through additional lanes which would enable increased road capacity and safety opportunities, allowing essential services better access to the area during vehicle incidents or extreme weather events • would provide an alternative route for transport and essential services between Blackheath and Little Hartley, in the event of road closure along the Great Western Highway.	●
Transport network performance	• would provide additional transport capacity by reducing current traffic queues for both private and commercial vehicles on the Great Western Highway which can be up to eight kilometres in length and incur delays of up to 80 minutes in peak periods (Transport for NSW, 2021d). This option would reduce congestion due to freight movement and weekend and peak holiday traffic to a greater extent than the Blackheath and Mount Victoria tunnel bypasses option • would not provide the same level of local connectivity as the Blackheath and Mount Victoria tunnel bypasses option • would allow opportunities for overtaking, currently not available in certain areas where there is a single lane arrangement in each direction, such as through Victoria Pass • would positively impact the local surface road network performance between Blackheath and Little Hartley, given through traffic would likely utilise the tunnel infrastructure.	●
Safety	• would improve safety of the corridor for road transport users by providing additional traffic lanes, reducing congestion • would separate through (freight) traffic travelling at higher speeds, more likely to use the tunnel, and local traffic likely to use the existing Great Western Highway • would improve the safety of the road corridor at Victoria Pass by bypassing steep grades and tight curves on the current highway alignment • would have improved in-tunnel gradient which would allow for a more consistent travel speed and lower speed differentials between the surface road and in-tunnel road networks as compared with the Blackheath and Mount Victoria tunnel bypasses option.	●
Environment	• would require the least surface property acquisition of all options except the do minimum option, given the majority of the duplicated road network would be located underground • would require less native vegetation removal than the Blackheath and Mount Victoria tunnel bypasses, given vegetation removal	●

Objective	Project option performance against the project objectives	Rating
	would be required at two portal locations and a reduced number of associated construction sites • would reduce amenity impacts for local residents and businesses, such as noise, vibration, visual impacts, given the predominantly underground nature of the option • would minimise impacts to groundwater dependent ecosystems as compared to the Blackheath and Mount Victoria tunnel bypasses option due to deeper excavation/tunnelling leading to less interaction with the perched aquifers the ecosystems rely on • would result in greater fuel efficiency for tunnel users and less greenhouse gas emissions given the lower in-tunnel gradient • would be generally consistent with stakeholder feedback received indicating preference for tunnel options, further described in Chapter 7 (Community and stakeholder engagement).	
Value for money	• would result in a slight reduction in vehicle travel times as compared to the Blackheath and Mount Victoria tunnel bypasses option due to reduced tunnel grades • would be slightly more expensive than the Blackheath and Mount Victoria tunnel bypasses option, however this would be value for money given this option would perform better on the above project objectives than all other options including a shorter construction duration, and less construction staging and associated accessibility impacts.	●

3.5.5 Preferred project option

The Blackheath to Little Hartley tunnel project option would address the identified project need and would best meet the project objectives. It was therefore selected as the preferred project option.

A discussion of how the project would meet ecologically sustainable development principles is provided in Chapter 25 (Justification and conclusion).

3.6 Further project development

Following identification of the preferred project option, further design development has been carried out. This has included indicative construction staging analysis and preliminary environmental assessments for traffic, drainage, flooding and urban design. Key areas of focus included the tunnel construction and ventilation system options. These are described further in this section.

3.6.1 Construction strategy

Tunnel excavation method alternatives

Alternative mainline tunnel excavation methods were considered during the development of the project, including tunnel boring machines (TBMs) and roadheader options. Indicative descriptions of TBM and roadheader construction methods are provided in Chapter 5 (Construction).

TBMs were identified as the preferred tunnelling methodology for the mainline tunnels as they can excavate at a faster rate than roadheaders and are able to install precast structural, waterproof tunnel lining progressively as they tunnel (i.e., tanked structures which prevent groundwater from entering the structure as opposed to a drained structure which captures, diverts and treats groundwater ingress). This tunnel construction method would minimise groundwater drawdown and potential impacts to groundwater dependent ecosystems. Tanked structures are also likely to reduce long-term settlement as groundwater drawdown is virtually eliminated due to the segment lining, although higher settlement may occur where the tunnel is shallowest near the Blackheath and Little Hartley portals. An assessment of settlement is provided in Chapter 20 (Business, land use and property). The effect of different tunnel lining in relation to groundwater ingress is shown in Figure 3-8.

To construct the mainline tunnels using roadheaders, a minimum of eight tunnel access points would be needed to support construction activities to maintain a similar construction program by comparison to TBMs. This would require multiple construction work sites at Blackheath, Soldiers Pinch and Little Hartley. Roadheader tunnelling from Blackheath in particular would add substantial numbers of heavy vehicles to local roads and the existing Great Western Highway corridor to transport spoil, shotcrete concrete and other construction materials to and from the work sites.

The option for roadheader tunnelling would have substantial, temporary impacts on the groundwater table, as the excavation would allow groundwater ingress until such time as a permanent, waterproof structural lining is constructed within the tunnel, which would take longer compared to progressive TBM lining. This drawdown could potentially affect groundwater dependent ecosystems reliant on groundwater seepage. Further discussion of potential impacts to groundwater and groundwater dependent ecosystems is provided in Chapter 13 (Groundwater and geology) and Chapter 12 (Biodiversity).

The selection of the TBM tunnel construction method would ensure that tunnel construction is sensitive to the unique environmental and cultural surroundings of the Blue Mountains. It would also provide a value for money and sustainable construction method, given the precast tunnel lining would add to the tunnel’s longevity.

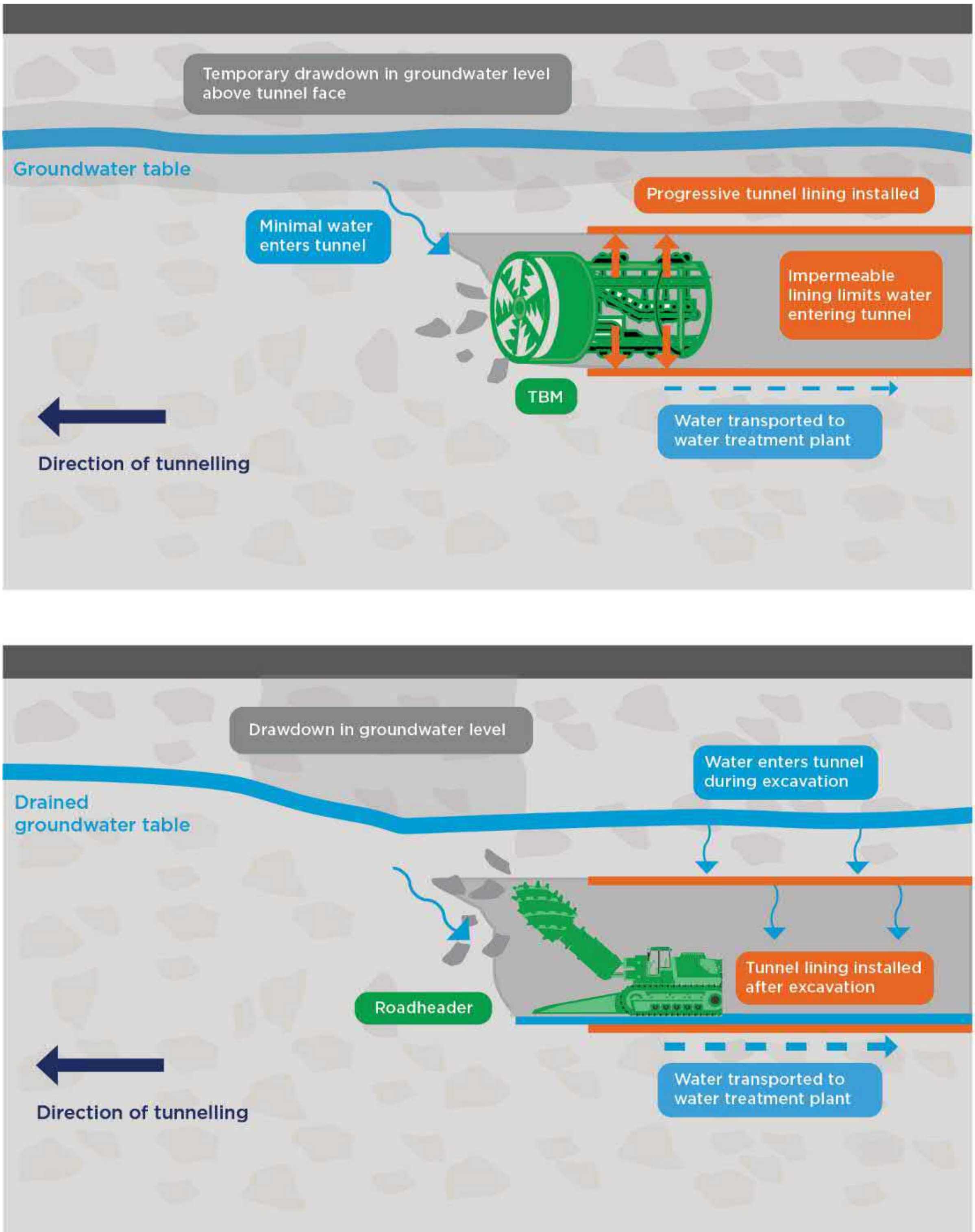


Figure 3-8 Comparison of TBM vs roadheader tunnelling methods on groundwater drawdown

Number of TBMs

The project considered scenarios using two and four TBMs to construct the tunnels. Using two TBMs launched from Little Hartley was identified as the preferred option to minimise impacts at the eastern portion of the project. A two TBM option, while resulting in a slightly longer construction program overall, would reduce the resource demand for labour and construction materials during the course of the tunnel construction, resulting in a considerably reduced number of daily vehicle movements within the construction corridor. Heavy vehicle traffic relating to tunnelling activities would be largely confined to the western end of the project (Little Hartley), minimising construction related impacts for Mount Victoria and Blackheath communities.

Under a four TBM scenario, two TBMs would be launched from Blackheath and two from Little Hartley, both tunnelling towards the mid-tunnel point. This option would require a larger construction footprint at Blackheath to provide a TBM launch site. A larger construction footprint at Blackheath would have had a greater impact on the community, including additional property acquisition and increased construction traffic, but would reduce the overall construction program. In addition, this option would require spoil haulage and increasing heavy vehicle movements including precast segment supply through Blackheath. As the heavy vehicle route including for spoil haulage would be primarily westbound from the project, the addition of heavy vehicles westbound on the Great Western Highway between Blackheath and Little Hartley would result in safety impacts due to potential conflicts with general traffic, particularly around the tight curves and steep grades at Victoria Pass. Additional heavy vehicle movements through Blackheath and Mount Victoria would also further impact the amenity of these localities.

Consideration was given to launching TBMs from the Soldiers Pinch construction footprint, however availability of land is constrained at this location, and a larger construction footprint at Soldiers Pinch would have potentially encroached into the Blue Mountains National Park and the Greater Blue Mountains World Heritage Area.

Using two TBMs would minimise potential traffic impacts at Blackheath and through the Blue Mountains during construction. It would also be sensitive to the unique environmental and cultural surroundings by minimising impacts to the Blue Mountains National Park and Sydney's drinking water catchment, avoiding direct impacts to the Greater Blue Mountains World Heritage Area and reducing amenity impacts to the community by minimising spoil haulage through Blackheath and Mount Victoria.

Spoil transport alternatives

The preferred spoil transport would be via road to minimise multiple handling of materials. Spoil transport via freight rail was considered as an alternative to reduce the number of heavy vehicles required on the roads. However, the use of rail would require multiple handling of the spoil with trucks required to move the material from the project to the railway loading area, and then again from an unloading area at the railway destination.

Analysis of haulage routes to potential railway loading / unloading points showed that the distance required to access these locations would be at least equivalent to the potential spoil reuse sites identified in Chapter 5 (Construction). Given the rail corridor is used by passenger and freight railway services, there may be capacity constraints or complex coordination required to achieve an effective rail spoil transport arrangement.

3.6.2 Ventilation design

Ventilation system design options

Tunnel ventilation systems provide a safe environment for tunnel users and adjacent receivers by regulating in-tunnel air quality, including the management of portal emissions, and emissions from any fire or other polluting incidents that may occur within the tunnel. There are a variety of tunnel ventilation system options that remove vehicle exhaust air from tunnels. The requirements for tunnel ventilation are determined by predicted vehicle emissions against pollutant limits set by regulatory authorities (described in Chapter 9 (Air quality)).

Table 3-10 outlines the advantages and disadvantages of the various ventilation systems. The project would be designed with longitudinal ventilation as shown in Figure 3-9. This is the preferred ventilation design given that:

- the length of the tunnel is too long for natural ventilation
- the concentration of in-tunnel pollutants would not require transverse or semi-transverse ventilation, which can require substantial amounts of energy to operate.

Table 3-10 Types of ventilation systems

Ventilation system	Description
Natural ventilation	Natural ventilation relies on the movement of vehicles, prevailing winds and differences in air pressure between the tunnel portals to move air without any mechanical assistance such as the assistance of ventilation fans. Natural ventilation is only suitable for short tunnels, typically less than one kilometre long. In longer tunnels vehicle emissions can build inside the tunnel if there is no mechanical assistance to move the air out of the tunnel. Natural ventilation would not achieve acceptable air quality within the tunnels given their length and therefore this ventilation option was not considered appropriate for the project.
Longitudinal ventilation	Longitudinal ventilation relies on the movement of vehicles, winds and differences in air pressure with mechanical assistance from jet fans. The in-tunnel air can be exhausted via the tunnel portals, or through an elevated ventilation outlet, usually above the tunnel. Most long road tunnels in Australia use longitudinal ventilation, including NorthConnex, which is around nine kilometres long, the WestConnex New M4 which is around 5.5 kilometres long, and the WestConnex M8 which is around nine kilometres long
Transverse ventilation	Transverse ventilation relies on provision of two ventilation ducts along the entire length of the tunnel with one providing fresh air and the other for expelling exhaust air with emissions via the tunnel portals, or through an elevated ventilation outlet. The fresh air ducts are located along the road surface, whilst exhaust air ducts are located along the roof of the tunnel. This type of ventilation system is more expensive to run due to the power required to manage air flows. These systems have been traditionally used in the past when emissions from vehicles produced greater concentrations of toxic pollutants than they do today.
Semi transverse ventilation	Semi-transverse ventilation relies on both longitudinal ventilation and transverse ventilation, with the provision of one ventilation duct along the length of the tunnel providing fresh air with emissions via the tunnel portals, or through an elevated ventilation outlet. The fresh air ducts are usually located along the road surface.
Air exchange stations	In the last decade an alternative to transverse ventilation systems for long and/or heavy trafficked road tunnels has been the use of air exchange stations. An alternative to reach the required air quality standards within the tunnel is to split a long tunnel into shorter sections, where air exchange is achieved through ventilation outlets or via the tunnel portals. A mid-point air exchange was considered however in-tunnel air quality modelling demonstrated that this was not necessary to achieve compliance with in-tunnel air quality criteria and would increase the construction and maintenance cost, and power consumption.

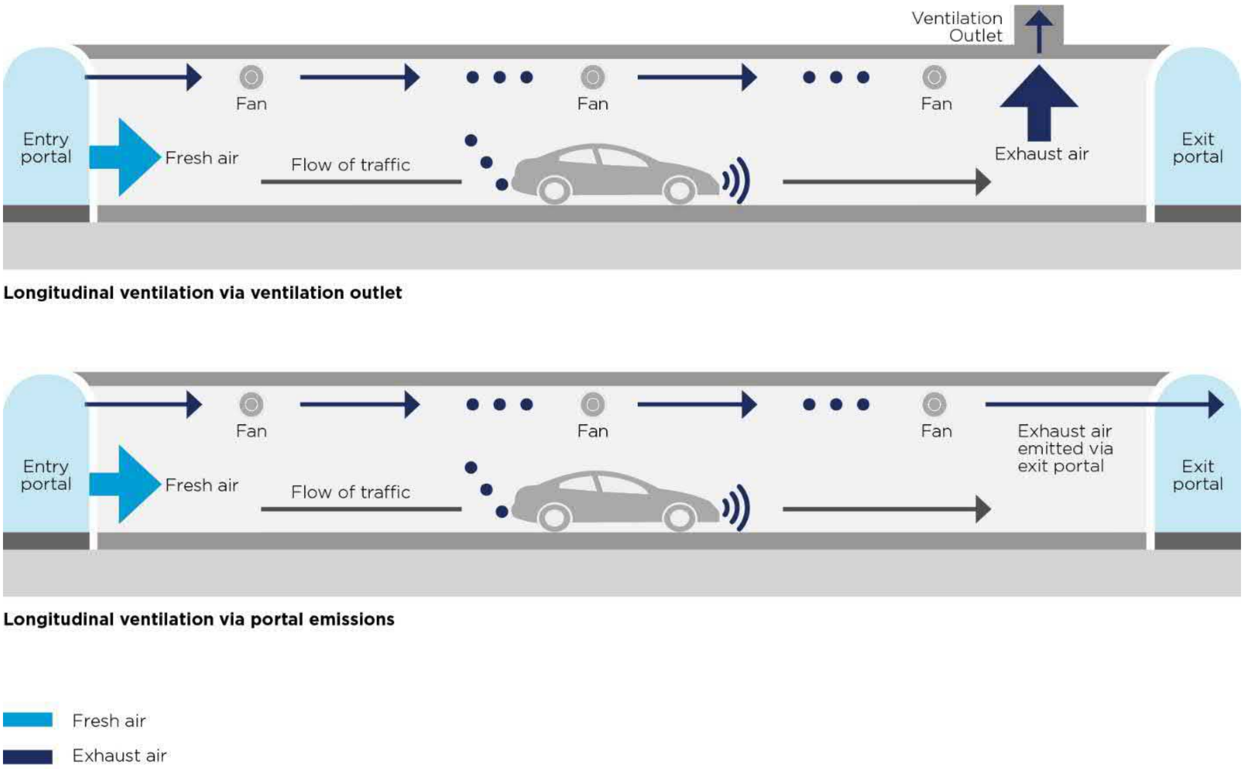


Figure 3-9 Ventilation system options being considered for the project

Tunnel emissions options

Two options for the management of tunnel emissions are being considered for the project including emissions via a ventilation building and outlet at each exit portal (ventilation outlet option) and portal emissions (portal emissions option). These options are described in Table 3-11.

Both tunnel emissions options have been assessed in this EIS, including potential impacts on air quality (Chapter 9 (Air quality)), human health (Chapter 10 (Human health)), noise and vibration (Chapter 11 (Noise and vibration)) and landscape and visual amenity (Chapter 18 (Landscape and visual)). A summary of the key differences in potential impacts from each tunnel emissions option is presented in Table 3-12. A decision on the preferred tunnel emissions option for the project will be made following the outcomes of further environmental assessment and consultation with key stakeholders and the community.

Table 3-11 Tunnel emissions options considered

Tunnel emissions option	Description
Ventilation outlet option	Ventilation outlets are usually used for longer tunnels, moving emissions release further away from ground level by pushing the air to a higher point in the atmosphere. Under this option, a ventilation building and outlet would be located at the Blackheath and Little Hartley portals. The ventilation buildings would be located underground to minimise visual impacts and integrate with the surrounding landform. Each ventilation outlet would be around 10 metres above the finished ground level.

Tunnel emissions option	Description
Portal outlet option	Portal emissions occur where tunnel emissions pass directly from the tunnel portals. The longitudinal ventilation system pushes emissions to the tunnel portals where they disperse. The potential benefits of portal emissions would include reduced operational power requirements and costs, reduced construction costs and durations, and neutral as opposed to adverse qualitative visual impacts (especially given the surrounding Greater Blue Mountains World Heritage Area). No ventilation buildings or outlets would be required under the portal emissions option.

Table 3-12 Key difference in operational impacts between tunnel emissions options

Potential impacts	Key differences between tunnel emissions options
Transport and traffic	Nil
Air quality	Compared to the ventilation outlet option for the typical daily traffic, the portal emissions option would result in: • 2.1% to 2.8% higher (as a percentage of the EPA criterion) 2030 annual average $PM_{2.5}$ (particulate matter equal to or less than 2.5 micrometres in diameter) concentrations for the most affected receptors • 3.6% to 4.4% higher (as a percentage of the EPA criterion) 2030 24-hour maximum $PM_{2.5}$ concentrations for the most affected receptors • 16% higher (as a percentage of the EPA criterion) 2030 maximum one-hour nitrogen dioxide concentrations for the most affected receptors, but yielding similar results by 2040 • 6.4% higher (as a percentage of the EPA criterion) 2030 annual average nitrogen dioxide concentrations for the most affected receptors.
Human health	Compared to the portal emissions option, the ventilation outlet option would result in: • a lower maximum localised/ individual particulate matter risk, potentially reducing the risk of adverse health outcomes associated with particulate matter such as cardiovascular and respiratory illness. However, both ventilation design options would result in localised impacts that are considered low and acceptable • more exceedances in noise management levels, however the differences are relatively minor. Where noise levels are mitigated during normal operations there would be no changes in noise that would result in adverse impacts to community health, such as annoyance or sleep disturbance which can lead to other long-term health effects.
Noise and vibration	Compared to the portal emissions option, the ventilation outlet option would exceed the noise criteria for: • two more receivers under normal traffic conditions at Blackheath • three more receivers under low flow traffic conditions at Blackheath • five more receivers under emergency conditions at Blackheath. These predicted noise exceedances can be reduced with the implementation of mitigation measures.
Biodiversity	Nil

Potential impacts	Key differences between tunnel emissions options
Groundwater and geology	Nil
Surface water and flooding	Nil
Soils and contamination	Nil
Aboriginal cultural heritage	Nil
Non-Aboriginal heritage	Nil (including nil difference in indirect visual impacts to the World Heritage listed area of the Blue Mountains National Park)
Landscape and visual	Compared to the portal emissions option, the ventilation outlet option would have the same overall impact rating (high to moderate) but would have an adverse qualitative rating (rather than a neutral qualitative rating) for the following landscape character zones: • landscape character zone 1b • landscape character zone 1c. Different visual impacts would be experienced at the following locations: • viewpoint 3 – both options would have the same overall impact rating (moderate) but the ventilation outlet option would have an adverse qualitative rating (rather than a neutral qualitative rating) • viewpoint 7– the ventilation outlet option would have a high (adverse) visual impact compared to the portal emissions option which would have a high to moderate (neutral) visual impact. All other landscape character zones and viewpoints assessed would experience the same visual impacts, irrespective of the ventilation design option selected for the project.
Social impacts	Nil
Business, land use and property	Nil
Resource use and waste management	Compared to the portal emissions option, the ventilation outlet option would require: • around 73,000 kWh/day of additional operational power supply • additional materials for the construction of the ventilation buildings and outlets.
Hazards and risk	Nil
Sustainability, climate change and greenhouse gas	Compared to the portal emissions option, the ventilation outlet option would produce (over the design life of the project (100 years)): • around 2,087,800 tonnes of carbon dioxide equivalent from additional scope 2 greenhouse gas emissions • around 187,370 tonnes of carbon dioxide equivalent from additional scope 3 greenhouse gas emissions.

3.7 Design refinements for impact avoidance and minimisation

Table 3-13 contains a summary of project design elements adopted to avoid or minimise potential environmental impacts. Ongoing design development would continue to consider opportunities to avoid and minimise environmental impacts.

Table 3-13 Environmental considerations during design development and refinement

Design development and refinement item	Environmental impact minimised and/or avoided
Construction	
Using TBMs as primary tunnel excavation method rather than roadheaders	• minimised construction duration due to faster rate of excavation compared to roadheaders • ability to progressively install precast structural, waterproof tunnel lining to minimise the extent of groundwater drawdown and potential impacts on groundwater dependent ecosystems • reduced number of tunnel excavation access points compared with using roadheaders, minimising the construction footprint and length of the spoil haulage route.
Excavating from west only rather than from both east and west	• minimised construction footprint at Blackheath, reducing native vegetation clearance, as the site would not need to accommodate TBM launch • reduced spoil haulage through Blackheath and Mount Victoria (including associated potential safety and amenity impacts), as spoil would primarily be hauled westbound from the Little Hartley construction footprint.
Optimised construction methodology which has reduced the construction footprint and number of construction sites	The project would repurpose the construction footprints used for the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade to minimise native vegetation clearance. Potential construction footprints at Browntown Oval and at the old Blackheath tip site were considered (and discounted) to support construction. Avoiding use of these sites would result in: • reduced amenity impacts for residents near Browntown Oval and the old Blackheath tip site associated with use of, and access to and from, these sites • avoidance of impacts to social infrastructure at Browntown Oval which would continue to be available for recreational purposes • reduced impacts to human and ecological health (by limiting the risk of exposure to contaminated lands and friable asbestos at the old Blackheath tip site) • minimised biodiversity impacts (to the observed wetland and Commonwealth listed threatened species (Gang-gang Cockatoos and Blue Mountains Water Skink) identified near the old Blackheath tip site) • minimised construction noise impacts and construction traffic impacts through Blackheath • shorter construction duration at Blackheath, and reduced construction impacts to the community.

Design development and refinement item	Environmental impact minimised and/or avoided
Revised tunnel alignment deviating from the existing Great Western Highway alignment to achieve a shorter and straighter tunnel	• less spoil, and shorter construction duration associated with a shorter tunnel length.
Operation	
Revised tunnel alignment deviating from the existing Great Western Highway alignment to achieve a shorter and straighter tunnel	• improved sustainability outcomes associated with reduced vehicle emissions from travelling along a shorter and straighter tunnel alignment • improved sustainability outcomes given the lower resource use and energy consumption associated with a shorter tunnel alignment • improved driver safety outcomes (minimising curvature and extending sight distance).
Reduced operational footprint at the Blackheath portal	• minimised visual impacts for road users, tourists and residents near the Blackheath portal • simplification of the Blackheath interchange and associated improved driver safety outcomes • increased opportunities for landscaping and better visual outcomes.
Physical separation of tunnel entry and exit portals at Blackheath and Little Hartley	• reduced localised air quality impacts if the portal emissions option is preferred • avoidance of portal emissions from the exit portal of one tunnel re-entering the entry portal of the adjacent tunnel • allows space for ventilation buildings and outlets for the ventilation outlet option (if identified as the preferred option), without requiring a change to the project footprint.
Use of portal emissions option instead of ventilation outlets option (if identified as the preferred option)	• minimised visual impacts as a result of removing the need for ventilation outlets • improved sustainability outcomes given the lower resource use, greenhouse gas emissions and energy consumption associated with operating under a portal emissions option.

4 Project description

This chapter describes the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The description of the project presented in this chapter is indicative and subject to ongoing design development.

4.1 Overview

The project would comprise new twin tunnels between Blackheath and Little Hartley, and would form part of the broader upgrade of the Great Western Highway between Katoomba and Lithgow to a four lane carriageway (the Upgrade Program).

The key components of the project are summarised in Table 4-1. An overview of the project is shown in Figure 4-1.

The existing Great Western Highway would be retained between Blackheath and Little Hartley and would continue to function as an alternative route for local and tourist traffic. It would also be an alternative route if there are planned or unplanned closures of the tunnels.

Table 4-1 Key components of the project

Key project component	Summary
Tunnels	Twin tunnels around 11 kilometres in length between Blackheath and Little Hartley, connecting to the upgraded Great Western Highway at both ends. Each tunnel would include two lanes of traffic and road shoulders and would range in depth from just below the surface near the tunnel portals, to up to around 200 metres underground at Mount Victoria.
Surface work	Surface road upgrade work would be required to connect the tunnels and surface road networks south of Blackheath and at Little Hartley. The twin tunnels would connect to the surface road network via: • mainline carriageways and on- and off-ramps at the Blackheath portal, located adjacent to the existing Great Western Highway and south of Evans Lookout Road • mainline carriageways at the Little Hartley portal, located adjacent to the existing Great Western Highway at the base of the western escarpment below Victoria Pass and southwest of Butlers Creek.

Key project component	Summary
Operational infrastructure	Operational infrastructure provided by the project would include: • a tunnel operations facility adjacent to the Blackheath portal • in-tunnel ventilation systems including jet fans and ventilation ducts connecting to the ventilation facilities • one of two potential options for tunnel ventilation currently being investigated, being: – ventilation design to support emissions via ventilation outlets; or – ventilation design to support emissions via portals • drainage and water quality infrastructure including sediment and water quality basins, an onsite detention tank at Blackheath and a water treatment plant at Little Hartley • fire and life safety systems, emergency evacuation and ventilation infrastructure and closed circuit television • lighting and signage including variable message signs (VMS) and associated infrastructure such as overhead gantries.
Utilities	Key utilities required for the project would include: • an electricity substation at Little Hartley for construction and operational power supply • a pipeline between Little Hartley and Lithgow for construction and operational water supply • other utility connections and modifications, including electricity substations in the project tunnels.
Other project elements	The project would also include: • integrated urban design initiatives • landscape planting.

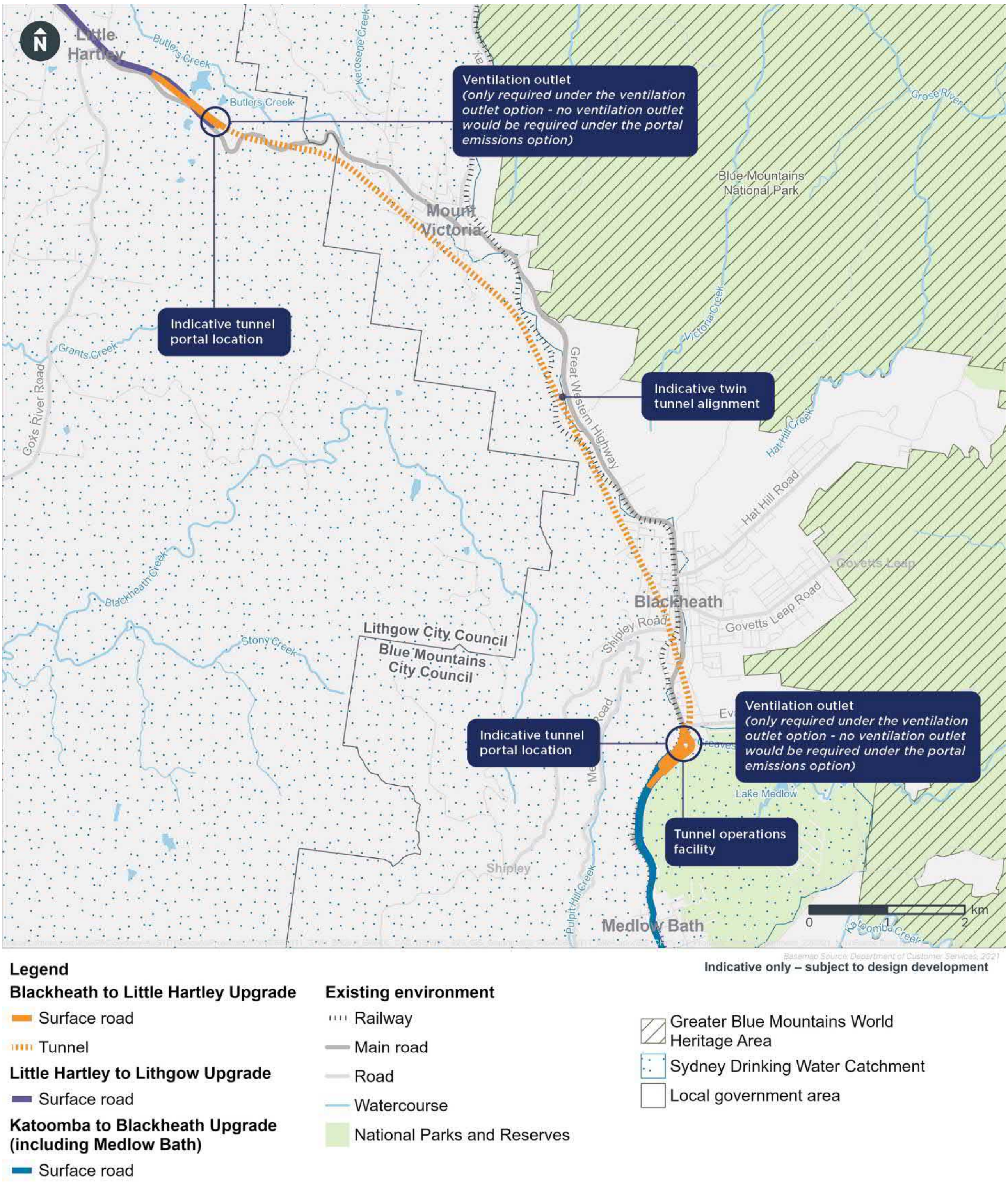


Figure 4-1 Overview of the project

4.2 Design process and evolution

4.2.1 Relevant policies and guidelines

The project design has been guided by several NSW Government policies and guidelines, including those developed by the Government Architect NSW. A summary of the relevant policies and guidelines relating to design, place and movement and how the project has considered these is provided in Table 4-2.

Table 4-2 Design, place and movement policies and guidelines relevant to the project

Policy / guideline	Project design response
Better Placed – An integrated design policy for built environment of New South Wales (Government Architect NSW, 2017)	The key objectives and project response include: • objective 1: Better fit – a design responsive to the landform, place and corridor context contributing to the richness of the area, views and vistas. The project design has taken a landscape led iterative design approach by placing the route below ground and by considering a portal emissions ventilation option, integrated with and supported by input from multiple technical disciplines and considers the surrounding heritage context including the Greater Blue Mountains World Heritage Area and Little Hartley valley • objective 2: Better performance – a design that provides an enduring purpose and amenity, responding positively to the environmental context to deliver enhanced economic and social outcomes • objective 3: Better for community – a design which supports the enhancement of place for local communities • objective 4: Better for people – a safe, user friendly design that enhances movement for all users and provides a place for the enjoyment and wellbeing of communities and end users • objective 5: Better working – a fit for purpose design that is innovative and practical, to ensure longevity of the tunnel and a world class transport asset • objective 6: Better value – a considered design that provides safer travel options and connectivity to places, as well as satisfying the existing social and economic needs of the community • objective 7: Better look and feel – an aesthetically pleasing and innovative design integrated into the surrounding landscape, adopting best practice place principles to minimise landscape and visual impacts.
Beyond the Pavement (Transport for NSW, 2020b)	Key design principles identified in Beyond the Pavement included in the project response: • principle 5: contributing to green infrastructure and responding to natural systems, and • principle 6: connecting with Country and incorporating heritage and cultural contexts into projects.

Policy / guideline	Project design response
Designing with Country (Government Architect NSW, 2020a)	Consultation with Aboriginal knowledge holders whose Country would be affected by the project has commenced so that Aboriginal culture and heritage is respected and integrated into the design. Feedback received to date highlights the importance of nature, language and connection. This feedback would continue to inform the design aspirations for the built form of the project and associated theming, balanced with other factors including potential visual and cumulative impacts on places of Aboriginal heritage significance, objects and cultural protocols. Transport is continuing to engage with Aboriginal knowledge holders with a view to incorporating Aboriginal culture and heritage into the design development of the project.
Connecting with Country Draft Framework (Government Architect NSW, 2020b)	The project as part of the Upgrade Program provides opportunities to improve connection to Country and connectivity through the Blue Mountains. The project would incorporate a visual interpretation of the cultural and physical identity of Country and has been designed in response to the following key principles for action in this policy: • respecting the rights of Aboriginal peoples through ongoing engagement mindful of their cultural and intellectual property with a goal to care for Country through considered and sensitive design • delivering an interpretive design that provides tangible and intangible benefits for current and future generations, with the Aboriginal people determining the representation of their cultural materials, customs and knowledge • prioritising consideration of the local, place specific cultural identities, supporting a reciprocal relationship with Country.
Aligning Movement and Place – Outline for understanding places in relation to movement infrastructure (Government Architect of NSW, 2019) Practitioner's Guide to Movement and Place (NSW Government, 2020a)	The project responds to the need to prioritise different customer groups based on their travel requirements, and to provide appropriate movement corridors, vibrant streets, local streets, and places for people. The project would reduce traffic volumes along the existing Great Western Highway between Blackheath and Little Hartley, leading to improved amenity on surface roads, particularly in and around Blackheath and Mount Victoria. Potential opportunities for placemaking and active transport initiatives would be subject to ongoing investigation and consultation with the relevant local councils. This would include consideration of opportunities to improve at-surface active transport infrastructure between Blackheath and Little Hartley, connecting to the active transport trails to be delivered by the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade. This active transport infrastructure would be subject to separate assessment and approval and may be delivered by others.

Policy / guideline	Project design response
Healthy Urban Development Checklist (NSW Health, 2009), section 10	The project is largely focused on improving vehicle and freight access. The project would however integrate with existing infrastructure being the Great Western Highway. While active transport infrastructure is not permitted within the tunnel, the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade would include active transport trails.
Creating Walkable Neighbourhoods (Active Living NSW, 2018)	
Sydney Green Grid – Spatial Framework and Project Opportunities (Tyrrell Studio and Office of the Government Architect, 2017)	The design of the project has considered and integrated the following objectives and principles in green infrastructure policy: • providing increased access to open spaces, while improving connections to nature • providing enhanced connectivity by reducing restrictions and barriers to movement of people and fauna • minimising potential biodiversity impacts • retaining remnant vegetation where possible • providing a net increase in tree numbers and canopy within proximity of the impacted areas to mitigate the heat island effect and replace lost biodiversity and ecological values. The project design responds to these principles by: • focusing on a landscape led design response that holistically integrates the design of the project with the landscape and reflects water sensitive urban design • minimising impacts to existing vegetated areas by locating the majority of project infrastructure underground within a tunnel • designing disturbed areas using ecological principles that integrate soil management and regeneration of vegetation communities.
Greener Places – Establishing an urban Green Infrastructure policy for New South Wales (NSW Government, 2020b)	
AS4970-2009 Protection of trees on development sites	
AS/NZS 4282:2019 Control of the obtrusive effects of outdoor lighting	Refer to Table 4-3.

4.2.2 Urban design

Six urban design objectives have been identified to guide the ongoing design development for the project. These objectives are shown in Figure 4-2, and:

- are consistent with key urban design guidelines and policies listed in Table 4-2
- outline the proposed direction of the urban design of the project
- govern the overall quality of the urban design outcomes.

A discussion of how the key project elements would consider urban design principles during design development is provided in Table 4-3. Further information regarding the urban design concept for the project is provided in Appendix N (Technical report – Urban design, landscape and visual).

Figure 4-2 Project urban design objectives

Table 4-3 Urban design principles for key project elements

Key project element	Urban design principles
Interchanges	• the design would be aesthetically simple and clean, applying the narrative and theming around connecting through and across Country • the urban design elements would contribute to a functional and legible design outcome, with increased user amenity • connectivity would be safe and visually appealing for the road users, guided by the consistent application of the established urban design objectives and principles • the materials, finishes and colours should respond to their immediate and diverse contexts in both locations in section and elevation.
Walls and dive structures	• walls would be consistent and continuous along the corridor and would relate to the surrounding context and place • materials would be considered for durability, weathering, vandal proof, graffiti and safety • the tops of the walls would run parallel to the road surface and would follow the road grade where possible • walls and dive structures would be designed in context as part of the visual experience and would be aesthetically consistent with the corridor design elements and tunnel experience.
Surface buildings	• surface buildings including the tunnel operations facility, water treatment plant, substation and maintenance and emergency facilities would be sustainable and used as expressions of place, identity and value • structures would be designed as high quality pieces of architecture sympathetic to and integrated as a best fit with the surrounding context • designs would attempt to reduce the visual impact of structures and buildings by locating them close to the tunnel • integrated art on surface buildings must be able to be appreciated at speeds of 80 kilometres per hour or more.
Ventilation outlets	Should ventilation outlets be identified as the preferred ventilation option, the ventilation outlet design would: • adopt a simple and refined design, responding to the surrounding rural character either in form and/or decoration • select colours to complement the bushland character, assist in the visual reduction of the form and provide visual calming where integrated with the portal structures • consider low maintenance planting cover to grow up and around the structure to assist in camouflaging the scale and providing a visually 'green' design • select outlet locations close to the portals and away from sensitive receivers and land uses.
Portals	The approach to design of the portals would consider: • avoiding signage including VMS in the vicinity of portals so the portals are clean, legible and free of distraction • avoiding large signage in the last 200 metres before the portal to avoid driver distraction and confusion.

Key project element	Urban design principles
	Design of the portals themselves would consider: • a distinctive portal design to mark the tunnel entrances and exits which is well considered and integrated into the surrounding environment, determined by existing landscape conditions and geomorphology • a simple, sculptural form, integrating the local landform against a background of vegetation, providing legibility and clarity of the journey experience • low maintenance and easily accessible landscape planting to soften the tunnel structure and integrated into the approach lanes to enhance the driving experience • framing views at the exit to continue the driver experience along the corridor.
Tunnels	• the tunnel design would create a narrative that references the surface features along the corridor through visual events in the tunnel • the tunnel design would include visual stimulation and movement with colour and feature panels relevant to the local context • the tunnel design would include features that add interest and variety and provide wayfinding cues and a smooth transition between inside and outside environments.
Lighting	Tunnel feature lighting would: • highlight the urban forms of walls, art and relevant signage structures to highlight the night-time experience • be low maintenance and energy efficient, integrated to meet functional requirements, and to meet general safety and amenity requirements.

4.2.3 Environment-led design

The project has been developed through an environment-led design process whereby preliminary environmental investigations, assessments and advice have informed the design to avoid where possible or otherwise minimise potential impacts to the sensitive environment and communities in this part of the Blue Mountains and Lithgow local government areas. Examples of design refinements adopted to minimise potential environmental and community impacts are discussed in Chapter 3 (Project alternatives and options).

This process has involved an integrated and collective approach to the project design, generated by collaboration across technical disciplines, the community, stakeholders and government agencies. This concept is presented in Figure 4-3.

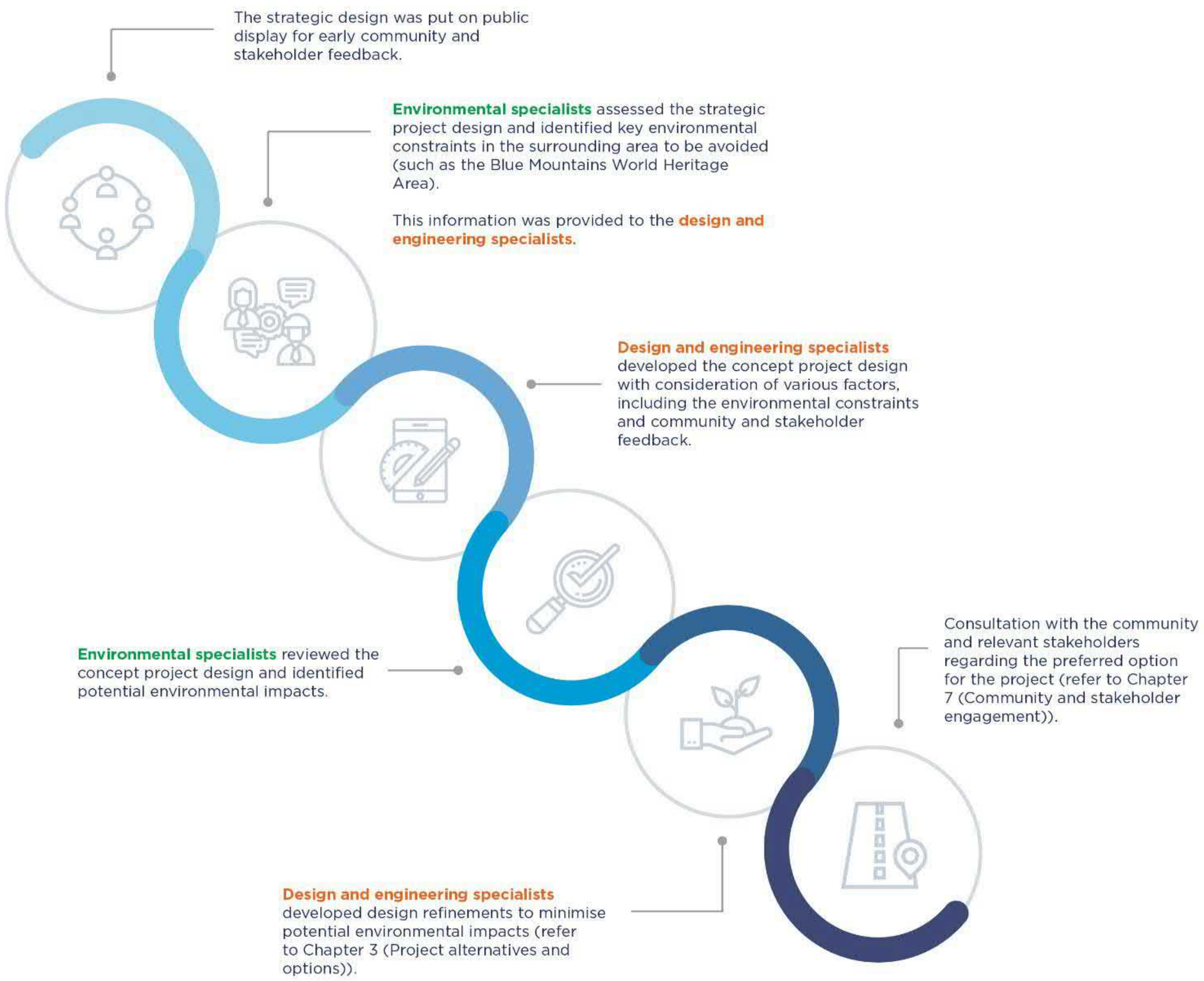


Figure 4-3 Environment-led design process

4.2.4 Connected with Country

The project travels across land which has been home to the Dharug, Deerubbin, Gundungurra and Wiradjuri Aboriginal cultural groups for thousands of years, who have an ongoing living culture and connection to Country. Everything starts with Country, connected through ceremony, living and ecological management.

The project would respond to place and movement through and across Country. Guidance documents prepared in consultation with Aboriginal people, of how to connect and design with Country, have guided the initial concept design and theming for the project. Representatives of the Dharug, Gundungurra and Wiradjuri peoples have been engaged with, and have led a process to provide a greater understanding of the cultural heritage and importance of connecting with and respecting Country. Transport is continuing this engagement as part of ongoing design development to provide stories to support and develop the design process further.

To integrate connection to Country, and Aboriginal culture and heritage into the project design, the following steps have commenced and will continue to be led by a specialist Aboriginal design and strategy consultant:

- engagement – initial engagement with identified Aboriginal stakeholders
- preliminary research and reporting – undertake desktop research to inform a preliminary Aboriginal narrative to identify cultural narratives and themes for the design of the project

- consultation – engagement with Aboriginal stakeholders to identify opportunities to deepen understanding of the Aboriginal context of the project
- reporting – provision of an Aboriginal Core Narrative Report incorporating stakeholder stories and culturally significant locations, to summarise processes and opportunities for consideration in design of the project
- design – develop designs that allow the themes identified in consultation to be expressed, including continued Aboriginal community consultation.

4.2.5 Landscape planting

Following construction, landscape planting would be carried out in areas subject to surface disturbance from the project (such as construction sites and surface road upgrades) consistent with the urban design concept presented in Appendix N (Technical report – Urban design, landscape and visual). Landscape planting for the project would be designed and implemented with the aim of:

- minimising the visual and landscape impacts of the project
- integrating the project into the surrounding visual catchment
- improving local and regional amenity
- providing a net increase in tree numbers and canopy within proximity of affected areas.

Areas of indicative landscape plantings for the project are shown in Figure 4-15 and Figure 4-19.

4.2.6 Ongoing design development process

As part of ongoing design development, the project design is being reviewed by the State Design Review Panel (SDRP). The SDRP is an independent panel established by the Government Architect NSW that provides a best-practice state-wide approach to the review of State significant projects, precincts and infrastructure. SDRP panellists are independent and highly qualified design professionals who bring a diversity of experience and insight. Panel members have cross disciplinary expertise in the areas of architecture, landscape architecture, urban design, Aboriginal and non-Aboriginal heritage and sustainability.

Transport has met with the SDRP to review the current project design and to seek advice and recommendations. Engagement with the SDRP would continue after public exhibition of this environmental impact statement (EIS) and as part of the ongoing design development process. Feedback received from the SDRP for the project to date relates to integrating engineering, design, and Country into a coherent approach that would have minimal impact on the landscape.

4.3 Tunnels

4.3.1 Tunnel design

The project would comprise twin tunnels around 11 kilometres long, connecting to the Great Western Highway at Blackheath and at Little Hartley.

Each tunnel would accommodate two lanes of traffic. The posted speed limit within the tunnel would be 80 kilometres per hour, and the tunnel on- and off-ramps at Blackheath would have an advisory speed of 25 kilometres per hour. During operation, each tunnel would have a carriageway width of around 10.5 metres (including two traffic lanes and shoulders) and a height clearance for vehicles of around 5.3 metres (total tunnel diameter inclusive of concrete segment lining would be around 14.8 metres). The tunnels would be designed to accommodate heavy vehicles including service and freight vehicles.

An indicative cross-section of the tunnels is shown in Figure 4-4.The lining for the tunnels would comprise precast concrete segments as described in Chapter 5 (Construction). The tunnel ventilation design is discussed in Section 4.5.2.

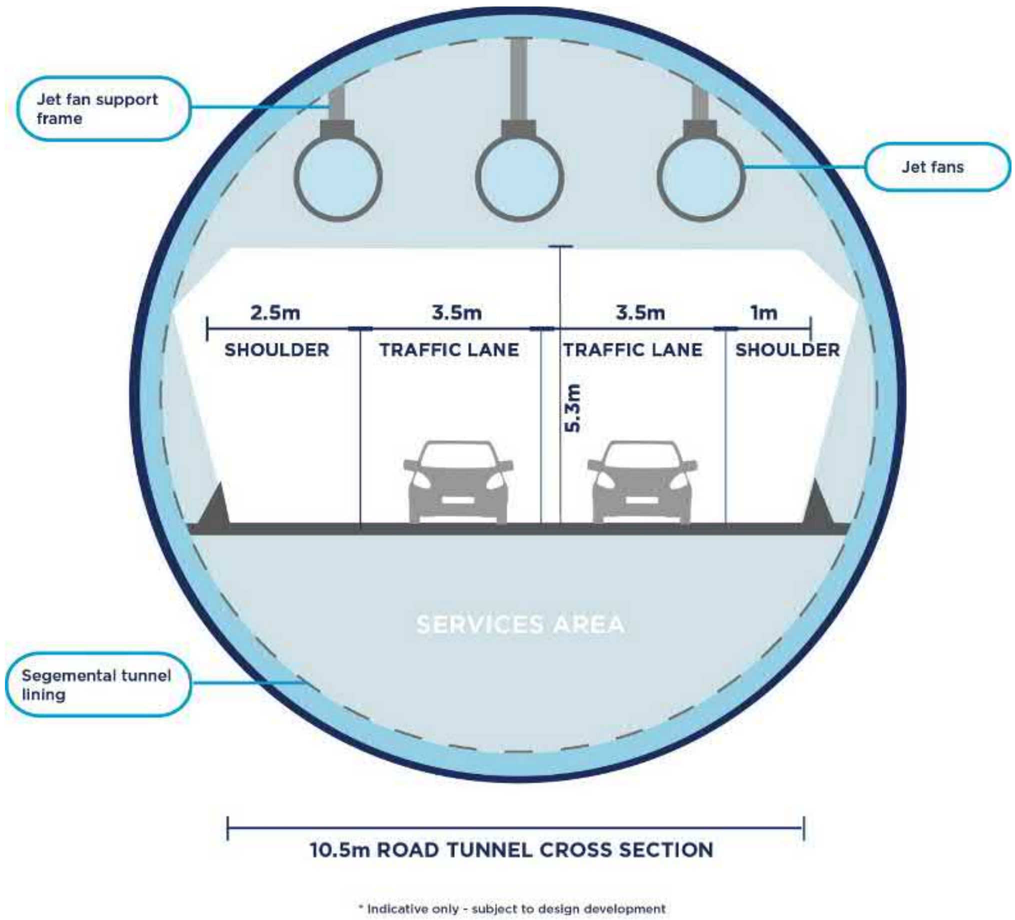


Figure 4-4 Indicative cross-section of the tunnel

4.3.2 Alignment

The horizontal alignment of the twin tunnels would generally be located to keep to the west of the existing Great Western Highway alignment as shown in Figure 4-1.

The tunnels would range in depth from just below the surface near the tunnel portals, to up to around 200 metres near Mount Victoria. The tunnels would provide a consistent grade of around 1.8 per cent in the eastbound (downgrade slope) and westbound (upslope) direction. The on- and off-ramps would vary depending on local topography and would have grades of between around 2.5 and six per cent.

A cross-fall would be incorporated into the design of the tunnel carriageways to allow for the collection and management of water in the tunnel as part of the tunnel water management system (see Section 4.5.3).

The indicative horizontal and vertical alignments of the twin tunnels are shown in Figure 4-5 to Figure 4-11 and would continue to be refined as part of design development. Depths presented in these figures are from the ground surface to the top of the tunnels.

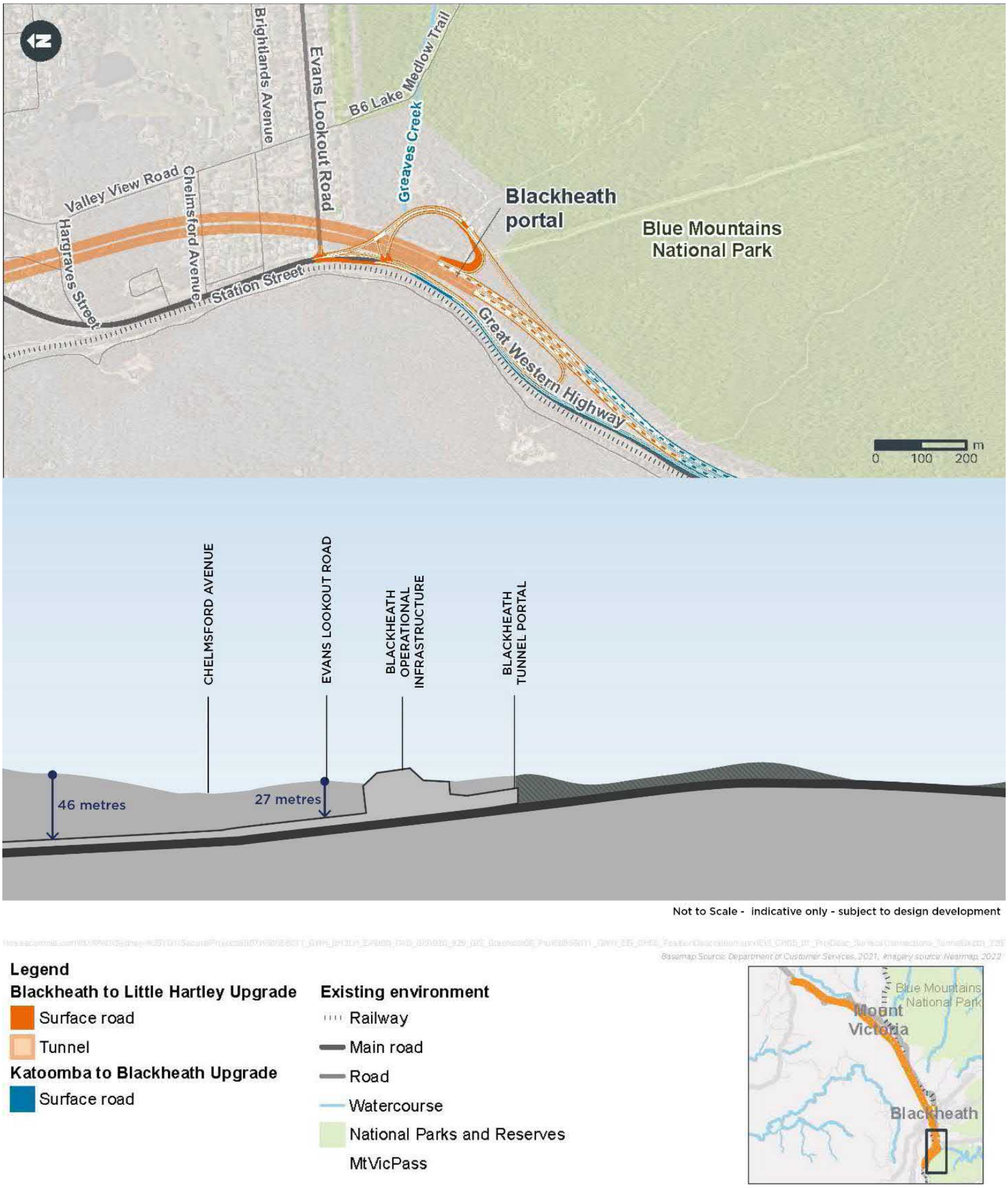


Figure 4-5 Horizontal and vertical alignments of the tunnels – map 1

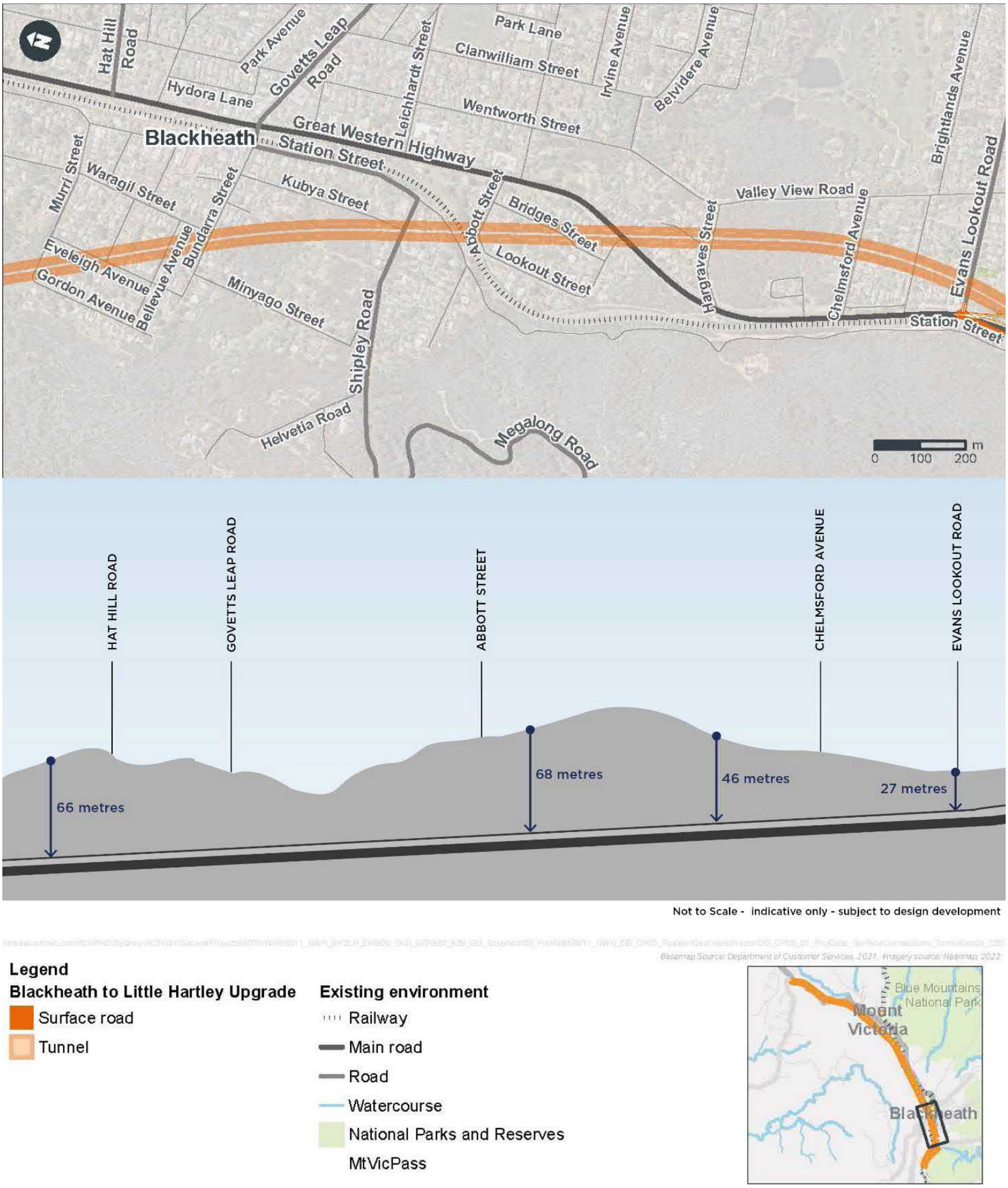


Figure 4-6 Horizontal and vertical alignments of the tunnels – map 2

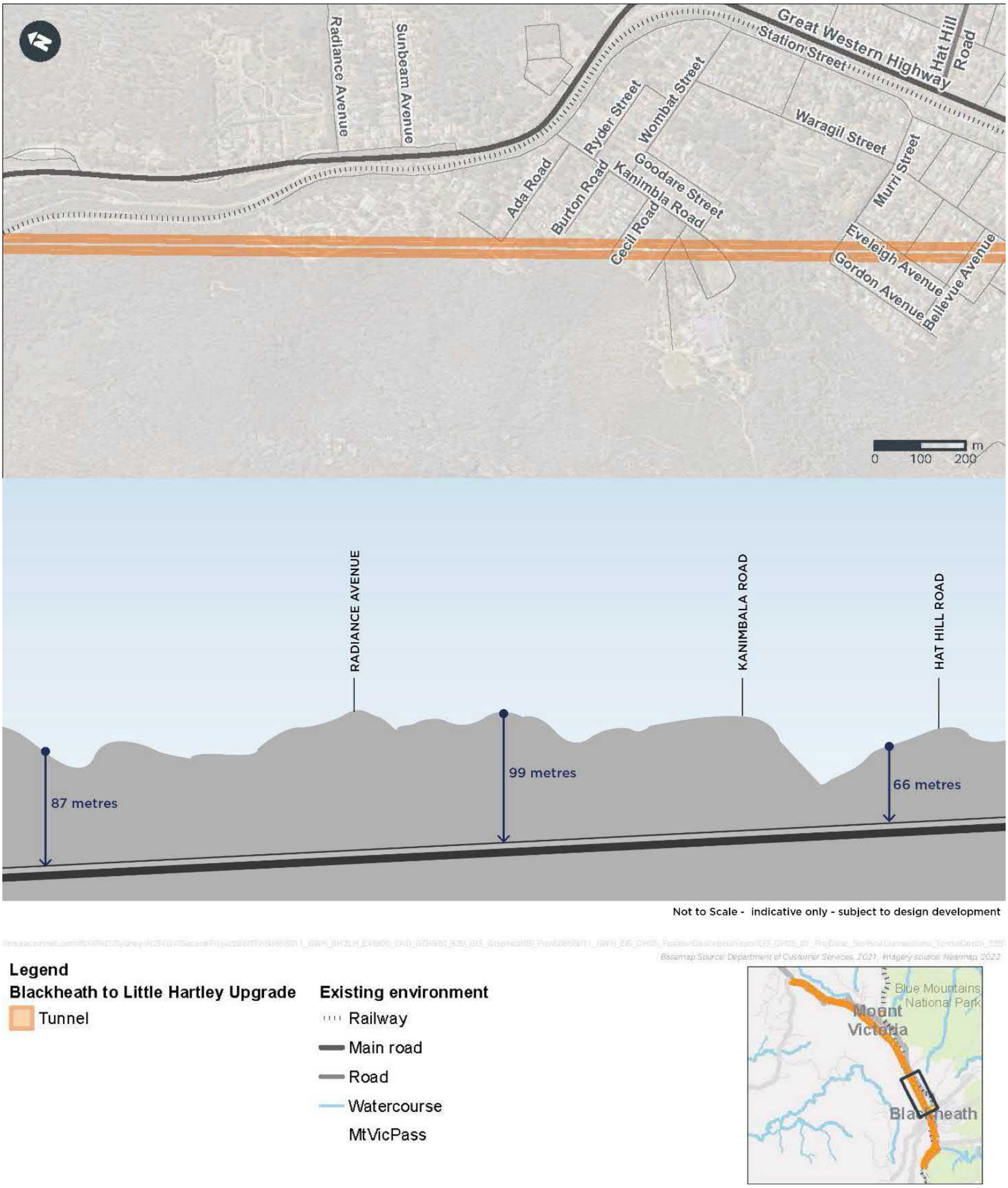


Figure 4-7 Horizontal and vertical alignments of the tunnels – map 3

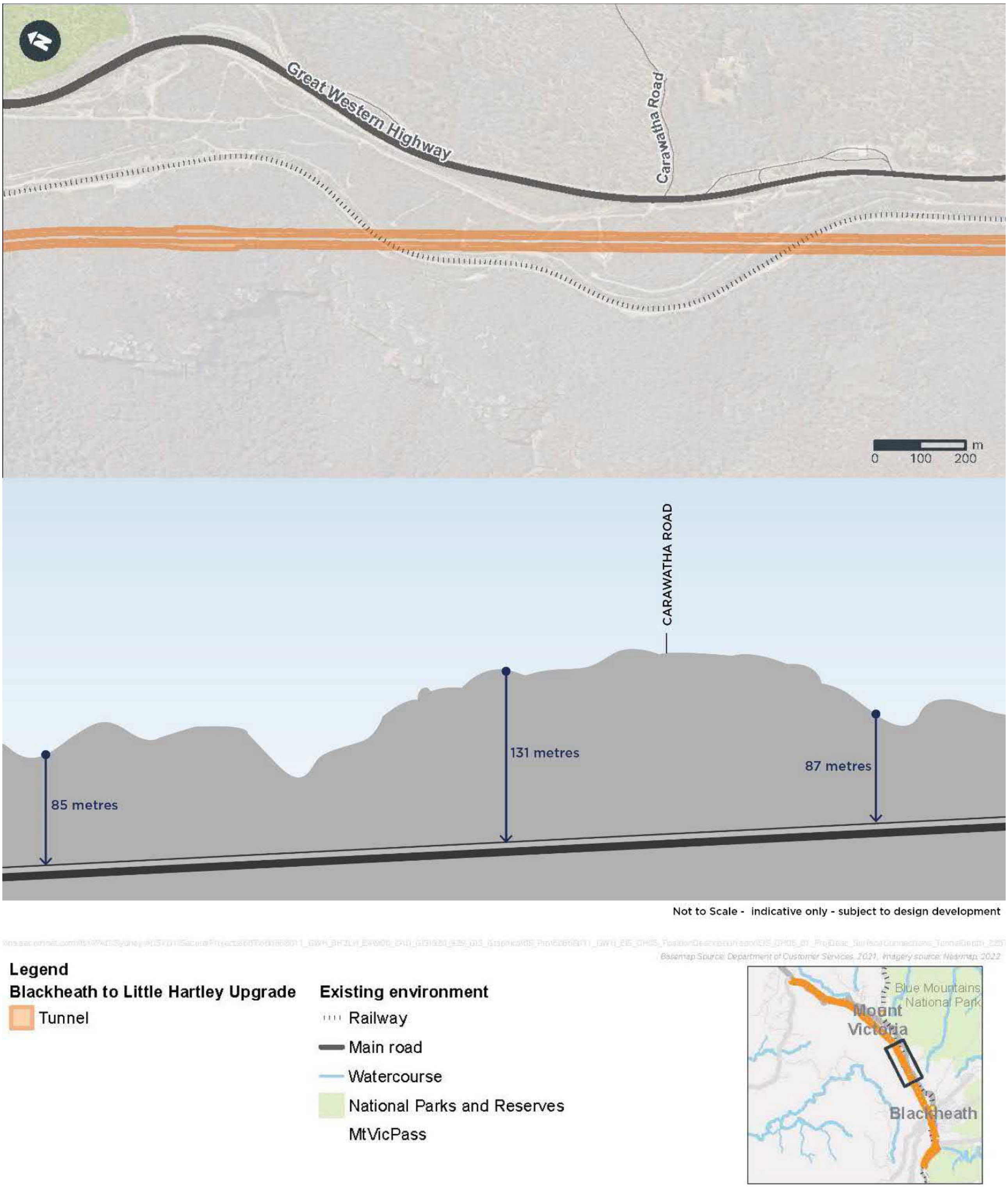


Figure 4-8 Horizontal and vertical alignments of the tunnels – map 4

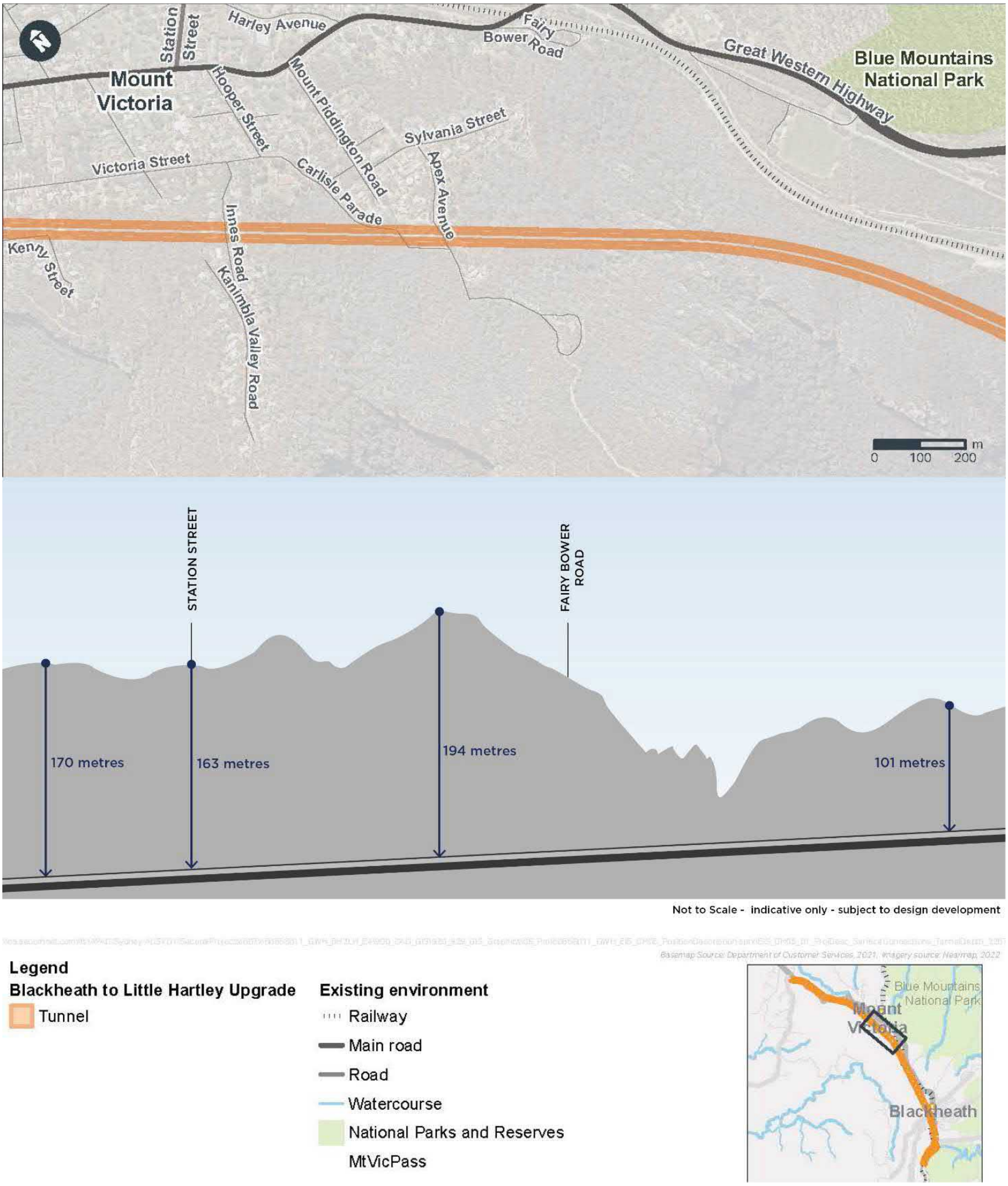


Figure 4-9 Horizontal and vertical alignments of the tunnels – map 5

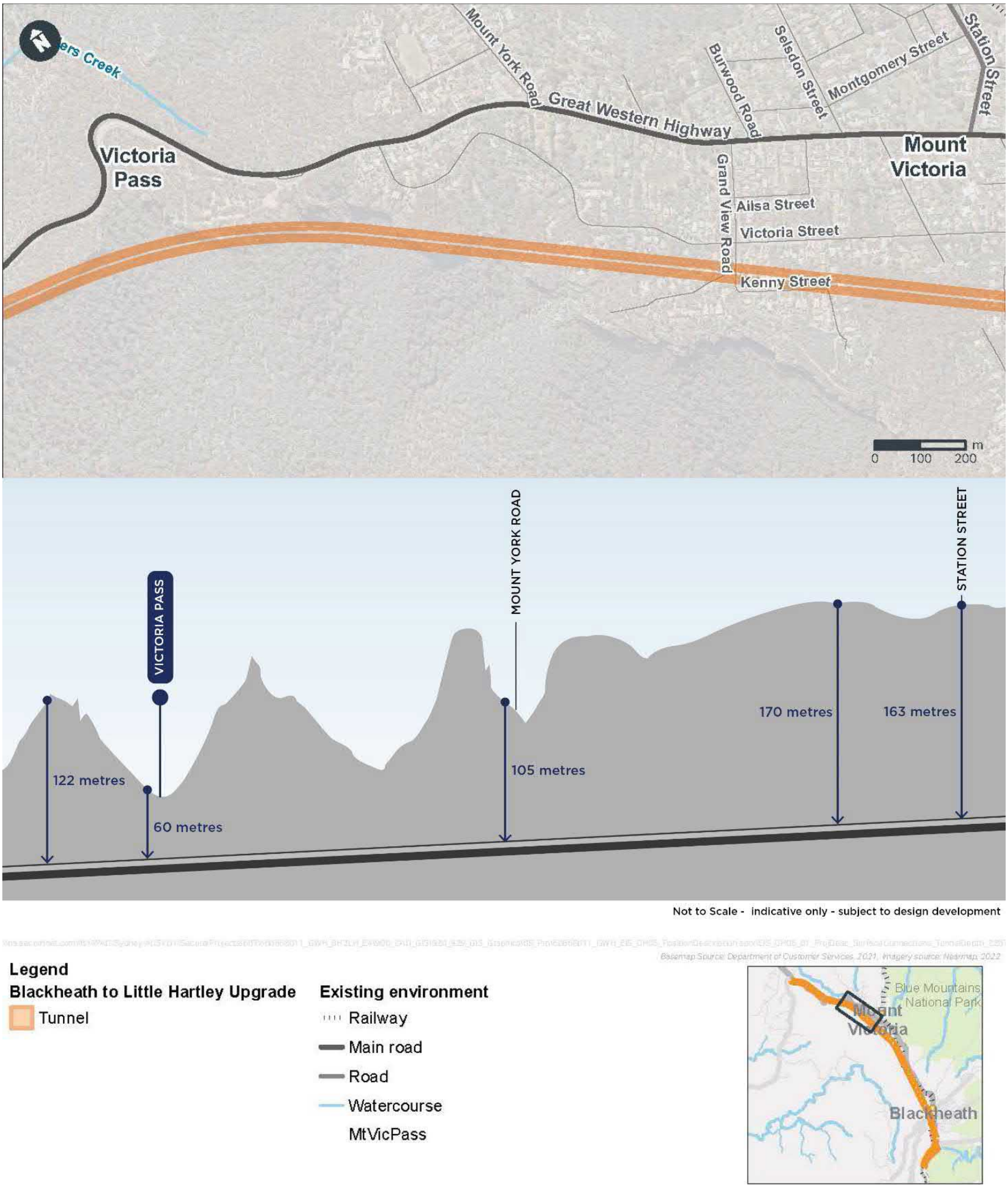


Figure 4-10 Horizontal and vertical alignments of the tunnels – map 6

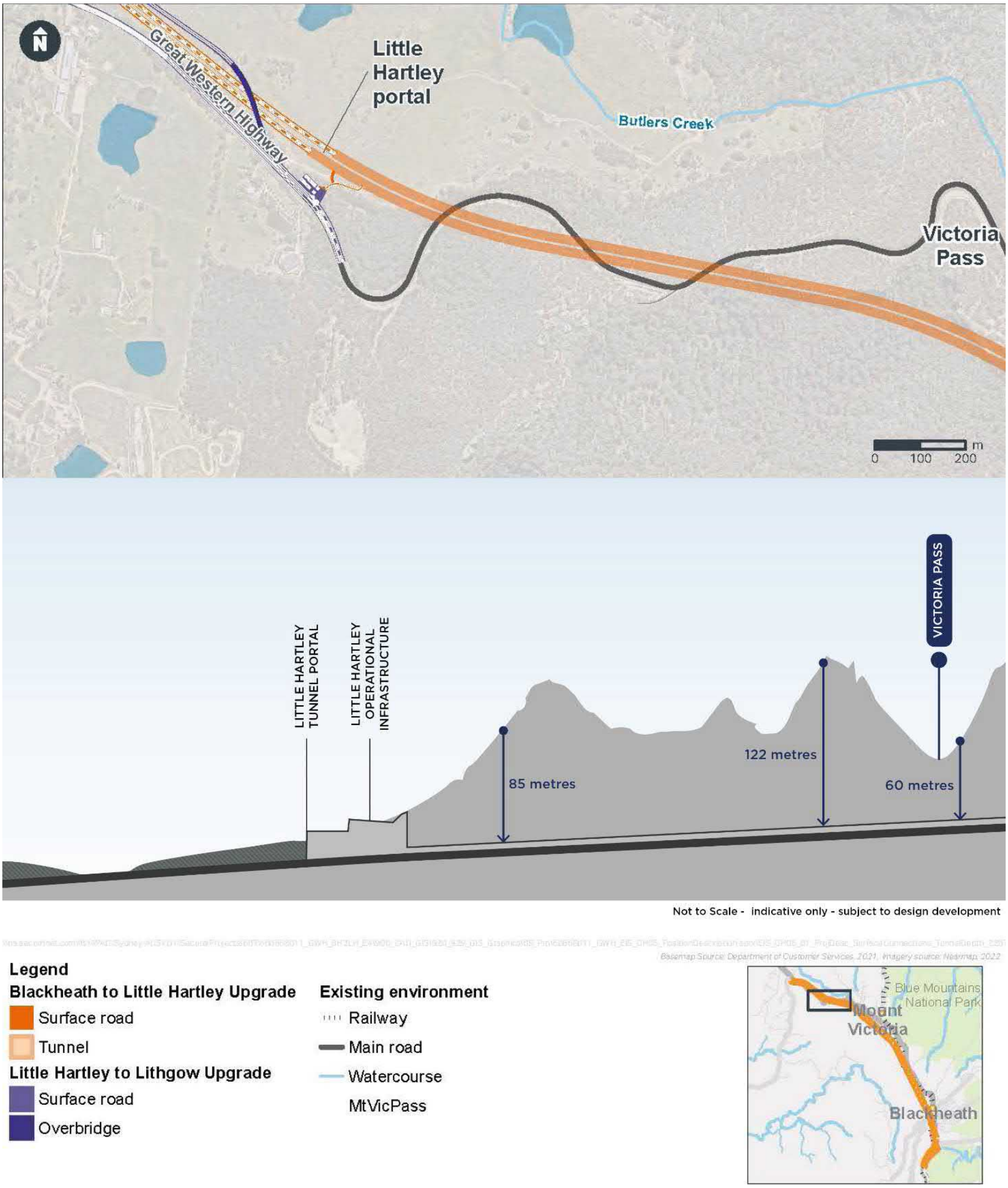


Figure 4-11 Horizontal and vertical alignments of the tunnels – map 7

4.3.3 Emergency breakdown facilities

The 2.5 metre shoulders provided in the tunnels would provide additional space for traffic, emergency personnel and operations crews in emergency situations or breakdowns. In addition, there would be a vehicle cross-passage between the tunnels for emergency service vehicles to switch between the westbound and eastbound tunnels around the tunnel mid-point. Further investigation into the need for this vehicle cross-passage is being carried out in consultation with relevant agencies, including emergency services. An indicative vehicle cross-passage layout is shown in Figure 4-12.

Pedestrian cross-passages would be provided at regular intervals around every 120 metres to allow for emergency pedestrian egress if an incident occurs in one of the tunnels. Investigations into the number and spacing of cross-passages within the tunnels are ongoing in consultation with relevant agencies, including emergency services.

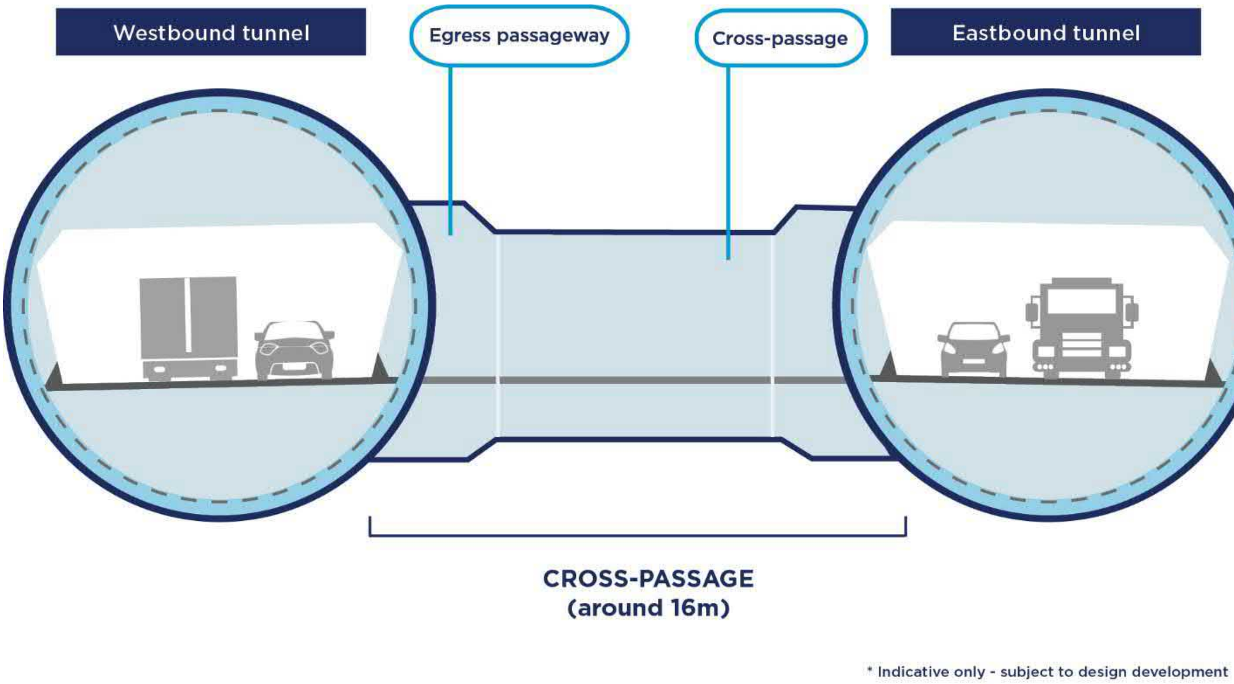


Figure 4-12 Indicative vehicle cross-passage layout

The tunnels would also include a breakdown and maintenance bay located around the midpoint of each tunnel. Further investigations into the need for these breakdown and maintenance bays are being carried out in consultation with the relevant agencies, including emergency services. An indicative layout of a breakdown and maintenance bay is shown in Figure 4-13.

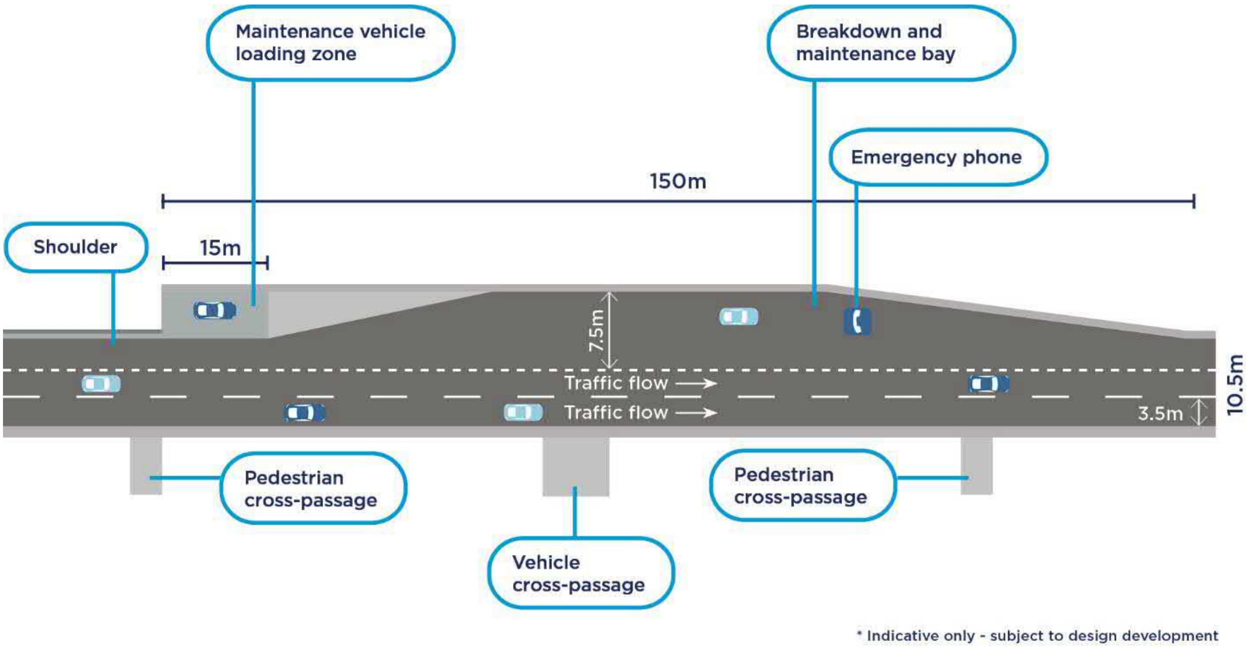


Figure 4-13 Indicative layout of a maintenance and breakdown bay

4.4 Surface work

The tunnels would be connected to the surface road network through portals and surface road upgrades located south of Evans Lookout Road in Blackheath and to the east of Little Hartley.

Dense grade asphalt has been adopted as the preferred road pavement surface type for the surface road works, and would be confirmed during detailed design.

4.4.1 Blackheath surface work

The Blackheath portal would be located to the east of the existing Great Western Highway alignment and south of Evans Lookout Road. Surface works at Blackheath would include tie-in works with the upgraded Great Western Highway as well as on- and off-ramps for all east and westbound movements and for access to Blackheath.

An artist's impression of the Blackheath portals showing an indicative visual concept of the project is presented in Figure 4-14. The requirement for the ventilation outlet presented in the artist's impression is subject to confirmation based on a decision on the preferred ventilation option.

The indicative operational configuration of the surface road network to be delivered as part of the project at Blackheath is shown in orange in Figure 4-15 and Figure 4-16. Figure 4-15 also shows how the project would connect to the Katoomba to Blackheath Upgrade. Operational infrastructure to be delivered as part of the Katoomba to Blackheath Upgrade is shown in blue and has been subject to separate assessment and approvals.

Connectivity at Blackheath is shown in Figure 4-17 and would include:

- mainline carriageway connection for vehicles heading westbound towards Lithgow via the new tunnel
- mainline carriageway connection for vehicles heading eastbound towards Katoomba via the upgraded Great Western Highway
- connection between the tunnel and the existing Great Western Highway at the Blackheath portal area, including:
  - westbound on-ramp into the tunnel from Blackheath town centre
  - eastbound connection from Blackheath onto the mainline carriageway
  - eastbound off-ramp from the tunnel to access Blackheath town centre
  - restricted access connections within the interchange to provide access from the east and the west to the operations facility, located south of Evans Lookout Road
- upgrade of the existing Great Western Highway / Evans Lookout Road intersection.

While active transport would not be permitted within the tunnel, the Katoomba to Blackheath Upgrade would include active transport connections to Blackheath as shown in Figure 4-15.

Figure 4-14 Indicative visual concept of the Blackheath portal looking westbound (subject to design development)

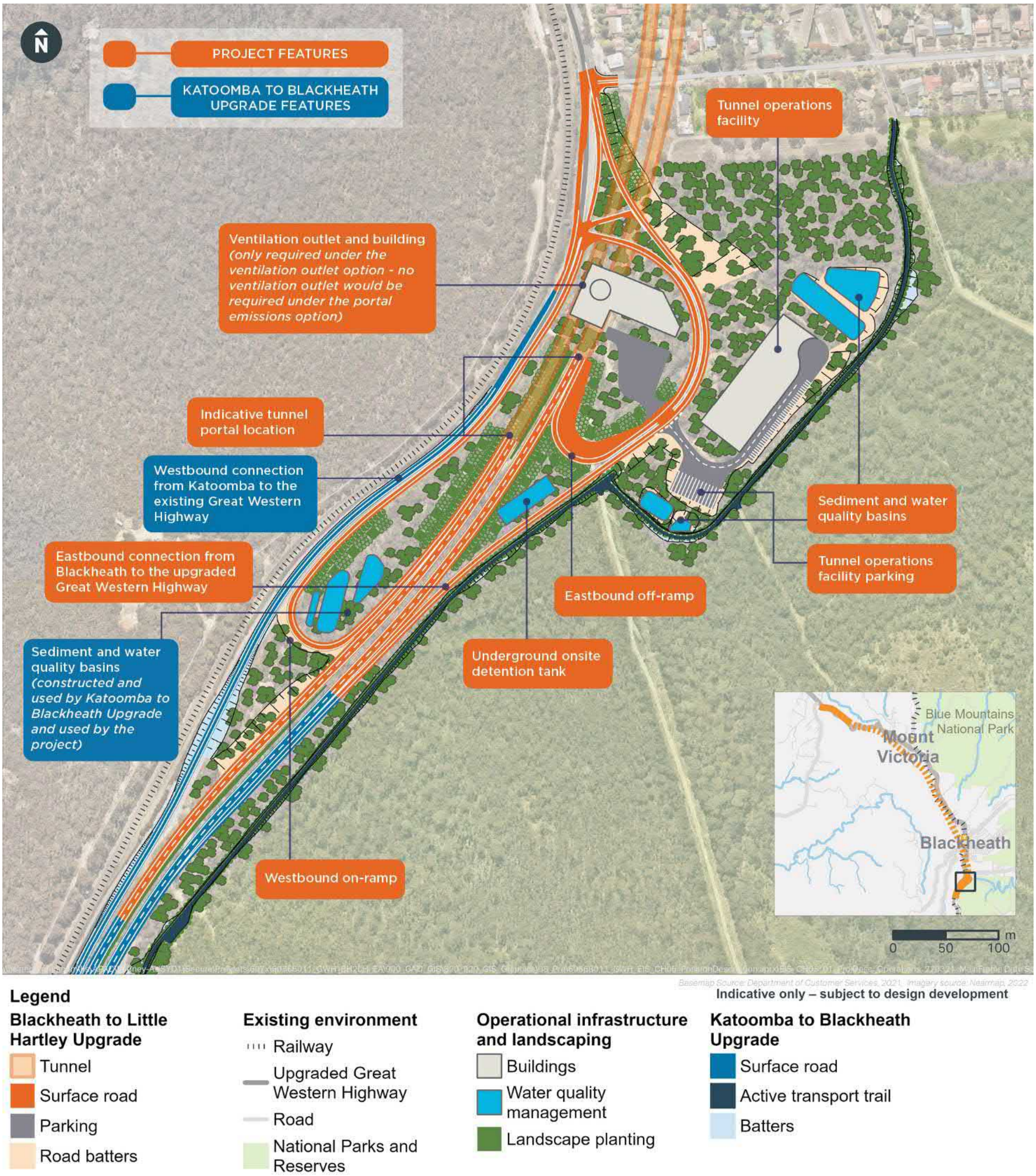
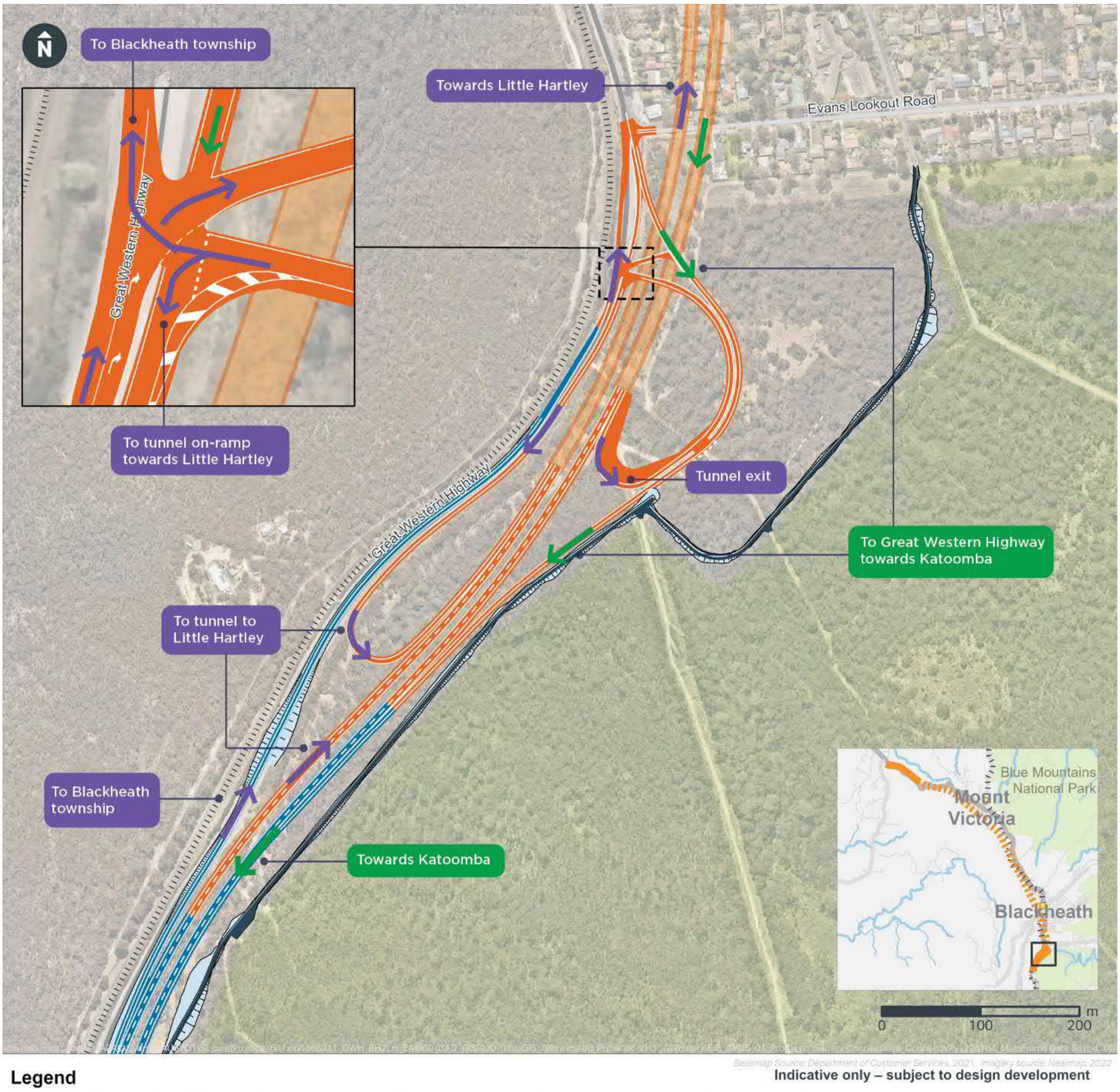


Figure 4-15 Indicative operational configuration at Blackheath

Figure 4-16 Indicative intersection details at Blackheath



Legend

Blackheath to Little Hartley Upgrade
- Surface road
- Tunnel

Katoomba to Blackheath Upgrade
- Surface road
- Active transport trail
- Road batters

Existing environment
- Railway
- Main road
- Road
- National Parks and Reserves

Direction of travel
- Eastbound travel
- Westbound travel

Figure 4-17 Indicative connectivity at Blackheath

4.4.2 Little Hartley surface work

The Little Hartley portal would be located at the base of the western Blue Mountains escarpment below Victoria Pass and southwest of Butlers Creek.

An artist's impression of the Little Hartley portal showing an indicative visual concept of the project is presented in Figure 4-18. The requirement for the ventilation outlet presented in the artist's impression is subject to confirmation based on a decision on the preferred ventilation option.

The indicative operational configuration of the surface road network at Little Hartley is shown in orange in Figure 4-19 and would include:

- mainline carriageway connection for vehicles heading eastbound towards Katoomba via the new tunnel
- mainline carriageway connection for vehicles heading westbound towards Lithgow via the upgraded Great Western Highway
- vehicle access to the tunnel ancillary site from Berghofer's Pass car park for operation and maintenance purposes.

Figure 4-19 also shows how the project would connect to the Little Hartley to Lithgow Upgrade. Operational infrastructure delivered by the Little Hartley to Lithgow Upgrade is shown in purple and has been subject to separate assessment and approvals.

While active transport would not be permitted within the tunnel, the Little Hartley to Lithgow Upgrade would include an active transport connection to Little Hartley as shown in Figure 4-19.

Figure 4-18 Indicative visual concept of the Little Hartley portal looking eastbound (subject to design development)

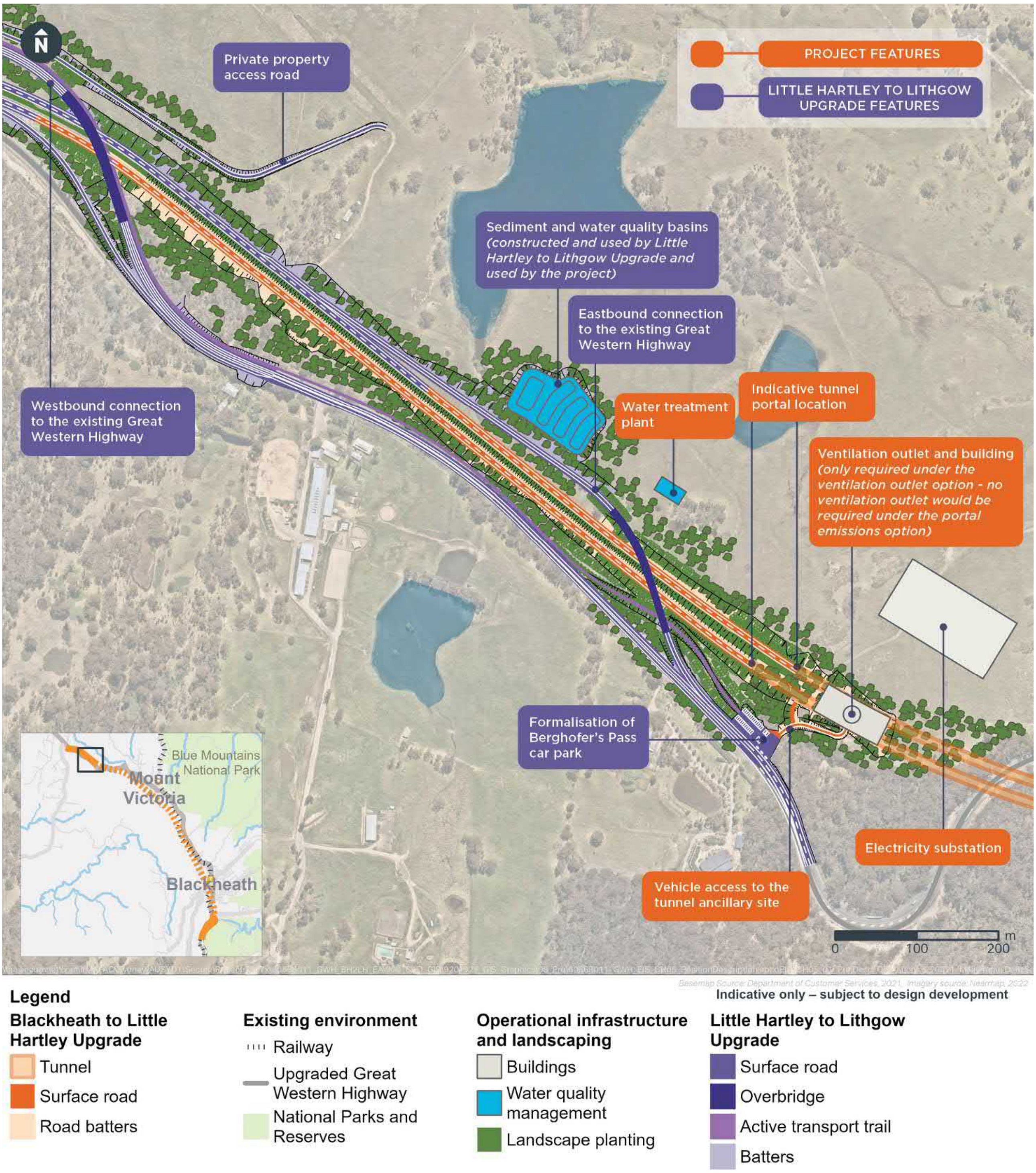


Figure 4-19 Indicative operational configuration at Little Hartley

4.5 Operational infrastructure

Operational infrastructure for the project would include:

- a tunnel operations facility at Blackheath
- in-tunnel ventilation systems including jet fans and ventilation ducts connecting to the ventilation facilities
- one of two potential options for tunnel ventilation currently being investigated including:
  - a ventilation building and ventilation outlet at Blackheath and another at Little Hartley (ventilation outlet option); or
  - portal emissions (portal emissions option)
- a new electricity substation at Little Hartley for construction and operational power supply (see Section 4.6.1)
- a new pipeline between Little Hartley and Lithgow is currently the preferred option for construction and operational water supply (see Section 4.6.2)
- water quality infrastructure including water quality basins at Blackheath and Little Hartley, an onsite detention tank at Blackheath and a water treatment plant at Little Hartley
- fire and life safety systems, emergency evacuation and ventilation infrastructure, closed circuit television and other intelligent transport systems
- lighting and signage including VMS and associated infrastructure such as overhead gantries.

This operational infrastructure is described further below. The indicative locations and arrangements of this infrastructure at Blackheath and Little Hartley are shown in Figure 4-15 and Figure 4-19 respectively.

4.5.1 Tunnel operations facility

The tunnel operations facility would be located adjacent to the Blackheath portal, south of Evans Lookout Road as shown in Figure 4-15.

The tunnel operations facility would operate 24 hours a day, seven days a week. It would be staffed to monitor and respond to conditions in the tunnels and on surface road connections.

Access to the tunnel operations facility would be via the eastbound off-ramp from the tunnel that connects to the existing Great Western Highway or via the eastbound connection from Blackheath to the upgraded Great Western Highway. Operational staff parking would be provided adjacent to the tunnel operations facility (see Figure 4-15).

4.5.2 Tunnel ventilation system

Tunnel ventilation systems are designed to prioritise the safety and health of motorists using the tunnel at all times (including during emergency conditions) and so that air inside and outside the tunnel meets the air quality criteria relevant to the project as described in Chapter 9 (Air quality).

The tunnel ventilation system would include:

- jet fans
- one of two potential options for tunnel ventilation design, being ventilation buildings and ventilation outlets (ventilation outlet option), or portal emissions (portal emissions option).

The ventilation system options being considered for the project are shown conceptually in Figure 4-20.

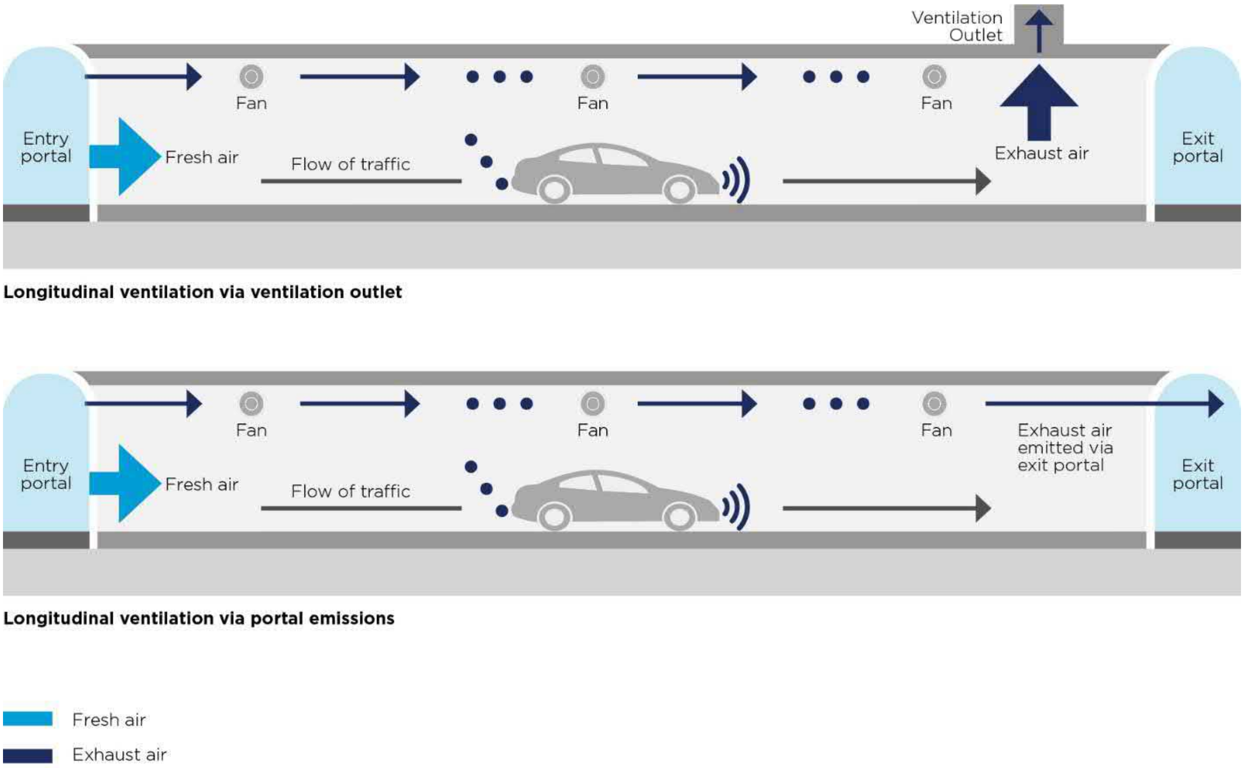


Figure 4-20 Overview of the two ventilation system options being considered for the project

Ventilation facilities

Ventilation infrastructure would be required for the project so that in-tunnel air quality and human health criteria can be achieved, and to manage fire and smoke in the event of an incident in the tunnels. Portal emissions would require the portals to be designed in a manner that potential smoke and tunnel emissions are not re-circulated from one tunnel into the other. Physical separation of the entry and exit portals at each end of the project as shown in Figure 4-14 and Figure 4-18 would minimise the potential for air re-circulation between the tunnels.

Two options for ventilation facilities are being considered for the project and have been assessed in the EIS. A summary of the differences in potential environmental impacts for both ventilation options is provided in Chapter 3 (Project alternatives and options).

A decision on the preferred ventilation option for the project will be made following the outcomes of further environmental assessment and consultation with key stakeholders and the community.

Ventilation outlet option

This option would include a ventilation building and ventilation outlet near the tunnel portals at Blackheath and at Little Hartley (shown in Figure 4-15 and Figure 4-19 respectively).

Each ventilation building would be located underground to minimise visual impacts and integrate with the surrounding landform. Each ventilation building would require an area of around 2,000 square metres. Each ventilation outlet would extend to around 10 metres above finished ground level. An artist’s impression showing an indicative visual concept of a ventilation outlet is presented in Figure 4-21.

Figure 4-21 Indicative visual concept of a ventilation outlet (subject to design development)

Depending on the traffic volumes in the tunnels, air would be moved through the tunnels by the movement of vehicles (the piston effect), or jet fans shown in Figure 4-20. If required, jet fans would be used to assist with the movement of tunnel air to maintain acceptable in-tunnel air quality. For this ventilation option, the air pressure inside the exit portals would be maintained below atmospheric pressure to avoid the release of tunnel air from the portals. This would be achieved by having the jet fans located close to the exit portals to move air from the portal into the tunnel and towards the ventilation outlet. The ventilation outlet option would require the use of high-powered radial fans (larger fans several metres in diameter) to draw the air from the tunnel up through the ventilation outlets (for dispersion), resulting in larger operational power requirements than the portal emissions option.

Portal emissions option

For this option tunnel emissions would be dispersed via the tunnel portals. Tunnel portal emissions would mean that underground ventilation buildings and the ventilation outlets are not required to disperse tunnel emissions. Instead, air would be moved through the tunnels by the movement of vehicles (the piston effect), or by jet fans shown in Figure 4-20 and dispersed from each tunnel exit portal. The adoption of portal emissions for the project would be the most sustainable and cost-effective system as it would not require the constant use of high-powered radial fans in ventilation buildings to push tunnel air through ventilation outlets.

Air quality monitoring

Air quality monitoring would be carried out during operation of the project to monitor:

- in-tunnel air quality
- ambient air quality.

Equipment for monitoring tunnel emissions for nitrogen dioxide (NO_2), carbon monoxide (CO), visibility, particulate matter and air speed would be installed at appropriate locations within the tunnels and ventilation outlets, to confirm that the project is operating within the emission limits set for the project. Consultation with the Department of Planning (DPE) and the Environment Protection Authority (EPA) regarding licensing and emissions limits for the project is ongoing.

Ambient air quality monitoring stations would be established to monitor for potential pollutants discharging from the tunnel. Ambient air quality monitoring locations would be confirmed as part of ongoing design development.

4.5.3 Groundwater and drainage management

An operational water treatment plant would be located at Little Hartley as shown in Figure 4-15. The water treatment plant would primarily provide treatment of:

- groundwater collected within the tunnel prior to its reuse or discharge to the environment
- water collected by the tunnel surface drainage system (which, for example, would include treatment of deluge water associated with the fire and life safety system).

Surface drainage for the project would include a combination of sediment and water quality basins, drainage pits and pipes, onsite detention tanks, drains and headwalls with scour protection delivered by the project as well as the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade. This infrastructure at Blackheath and Little Hartley (including which project would deliver this infrastructure) is shown in Figure 4-15 and Figure 4-19 respectively. A range of stormwater treatment options would be considered including gross pollutant traps, bioretention basins, swales and scour protection to minimise potential impacts to water quality during operation and to ensure a neutral or beneficial effect (NorBE) on runoff water quality in the Sydney drinking water catchment.

The project would also include an extension of the Rosedale Creek culvert crossing under the existing Great Western Highway at Little Hartley. The Lithgow to Little Hartley Upgrade will construct a portion of this culvert as part of those proposed works, including realignment of the existing culvert on the existing Great Western Highway. The remainder of the culvert will be constructed as part of this project.

4.5.4 Fire and life safety

The fire and life safety system would be designed to protect life and assets, control incidents and facilitate intervention by emergency services. The tunnel would include the following fire and life safety systems compliant with Australian Standard AS 4825:2011 Tunnel Fire Safety:

- fire and incident detection equipment, a closed circuit television monitoring system and automatic incident detection systems
- communications systems, public address system and radio re-broadcast, break-in system and emergency telephones
- fire suppression systems, including a deluge water suppression system, a fire hydrant system, emergency equipment points containing hydrants, water storage tanks, fire hose reels and fire extinguishers
- emergency lighting, smoke management and power systems
- tunnel emergency access including pedestrian cross passages between the mainline tunnels to provide safe access or exit in the event of a fire or other emergency
- tunnel closure system.

Operational ancillary facilities would be located and designed taking into account Planning for Bush Fire Protection (NSW Rural Fire Service, 2019) and AS3959-2018 guidelines which prescribe minimum setback distances for infrastructure near bushfire prone land

A decision on whether vehicles carrying dangerous goods would be allowed to travel through the tunnel would be made during ongoing design development in consultation with relevant stakeholders. The capacity of fire and life safety measures to manage potential dangerous good incidents would be confirmed at that time.

Consultation has occurred and would continue with emergency services regarding fire and life safety design, which would be considered during ongoing design development for the project.

4.5.5 Lighting

Lighting would be provided within the tunnel and along upgraded surface roads consistent with:

- Australian/New Zealand Standard AS/NZS 1158.5:2007: Lighting for roads and public spaces
- International Standard CIE 88-2004: International Commission of Illumination Publication Guide for the Lighting of Road Tunnels and Underpasses
- Australian Standard AS 4282-1977 Control of Obtrusive Effects of Outdoor Lighting.

Emergency lighting would also be provided in the tunnel including fixed direction exit signage and illuminated signage.

Lighting would be designed in accordance with the urban design principles outlined in Table 4-3. It would be installed for safety and security, and to minimise the potential for light spill and nuisance impacts.

4.5.6 Signage, closed circuit television and other traffic management systems

Traffic, locational, directional, warning and VMS would be required as part of the project in accordance with the applicable Australian Standards and guidelines published by Austroads and Transport. Project signage would be highly visible and would provide clear and unambiguous direction to motorists.

The project would include intelligent transport systems technology and traffic control infrastructure on the surface roads leading up to the tunnels including:

- VMS, including associated infrastructure such as gantries (an example of an overhead VMS is shown in Figure 4-22)
- lane use management systems
- variable speed limit signs
- a closed circuit television system and automatic incident detection systems
- motorists' emergency telephone system
- vehicle enforcement systems
- driver advisory signs and traveller information
- over height detection and response system.

To provide sufficient notice for drivers of any change in conditions or incidents, VMS and other infrastructure is often required around one kilometre from the tunnel. Indicative locations for VMS and associated infrastructure such as gantries that may be required are shown in Figure 4-23. The locations for this infrastructure would be confirmed during design development. Where this infrastructure is required beyond the construction footprint of the project (i.e. to the east and west of the project), the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade projects have made provision for the installation of this infrastructure within the road reserve.

Figure 4-22 Example image of an overhead VMS gantry

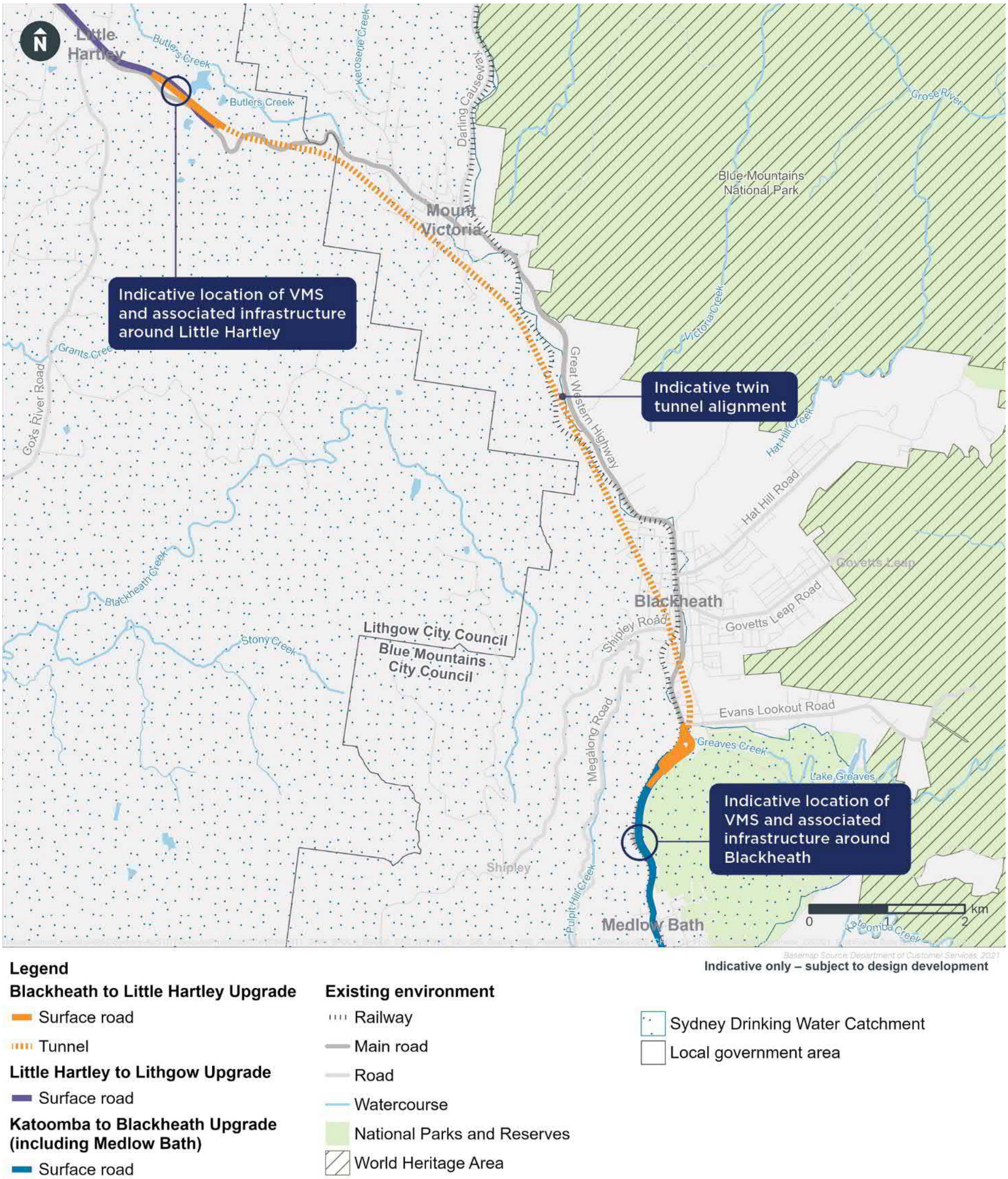


Figure 4-23 Indicative location of VMS and associated infrastructure

4.6 Utilities

The project would require the following utility works:

- installation of new utilities for the project, including communications, electricity and water
- connection to existing electricity, water and wastewater/ sewer utilities
- relocation, adjustment and/or protection of existing utilities, particularly within and around surface connections and surface road upgrades.

Utility works required for the project are further described in the sections below.

The location of existing utilities and any changes required would be confirmed during design development in consultation with the relevant utility provider.

4.6.1 Electricity

Electricity required to power the tunnel ventilation, lighting, signalling and communication systems would be supplied to the project from the existing electricity network via:

- a new aboveground substation at Little Hartley (see Figure 4-19)
- new underground substations along the length of the tunnels at around 1.5 kilometre intervals.

The aboveground substation at Little Hartley would connect to the existing electricity supply network and would be around 10 metres in height with a footprint of around 3,600 square metres.

Operational power requirements for the project are summarised in Chapter 21 (Resource use and waste management).

There is an existing 66kV Sydney Trains transmission line crossing the proposed Blackheath portal infrastructure. To avoid interference with construction machinery and activities, around one kilometre of this transmission line would be permanently adjusted as part of the project. This would also ensure access to this utility for Sydney Trains' maintenance.

4.6.2 Water

The project would be connected to the mains water supply network to provide water for essential services. Mains water would be used in cases where treated groundwater and rainwater harvesting are of insufficient quality or quantity to fully meet project needs.

During operation, water would be required for:

- cleaning and maintenance
- testing and operation of the tunnel fire suppression systems (which form part of the fire and life safety system)
- tunnel operational facilities including worker facilities
- landscape irrigation.

Operational water supply at Blackheath would be serviced via the existing network with upgrades to existing infrastructure carried out as required. The mains water supply network connection requirements, including connection location and design, would be determined in consultation with relevant local water supplier. Construction and operational water balances for the project are provided in Chapter 14 (Surface water and flooding).

Water to supply the tunnel hydrant and fire suppression systems would be stored with other operational ancillary infrastructure at Blackheath and Little Hartley (refer to Section 4.5). Operational water supply requirements are outlined in Chapter 21 (Resource use and waste management).

The currently preferred option for permanent water supply at Little Hartley would be via a water supply pipeline. This option is subject to design development in consultation with Lithgow City Council and would include around 14 kilometres of underground pipeline infrastructure with a corridor width of around 10 metres. The pipeline would primarily follow the alignment of the Great Western Highway and be located within the existing and/or new road reserve where possible.

The indicative alignment for the water supply pipeline is shown in Figure 4-24.

Key features of the water supply pipeline would include:

- installation of an underground pipeline between the Lithgow City Council potable water supply network at South Bowenfels and Little Hartley
- associated infrastructure which may include pumping stations and pressure valves
- connection of the pipeline to the Little Hartley tunnel supply point.

Investigations are ongoing to confirm the water supply option for the project and other options being investigated include the use of groundwater.

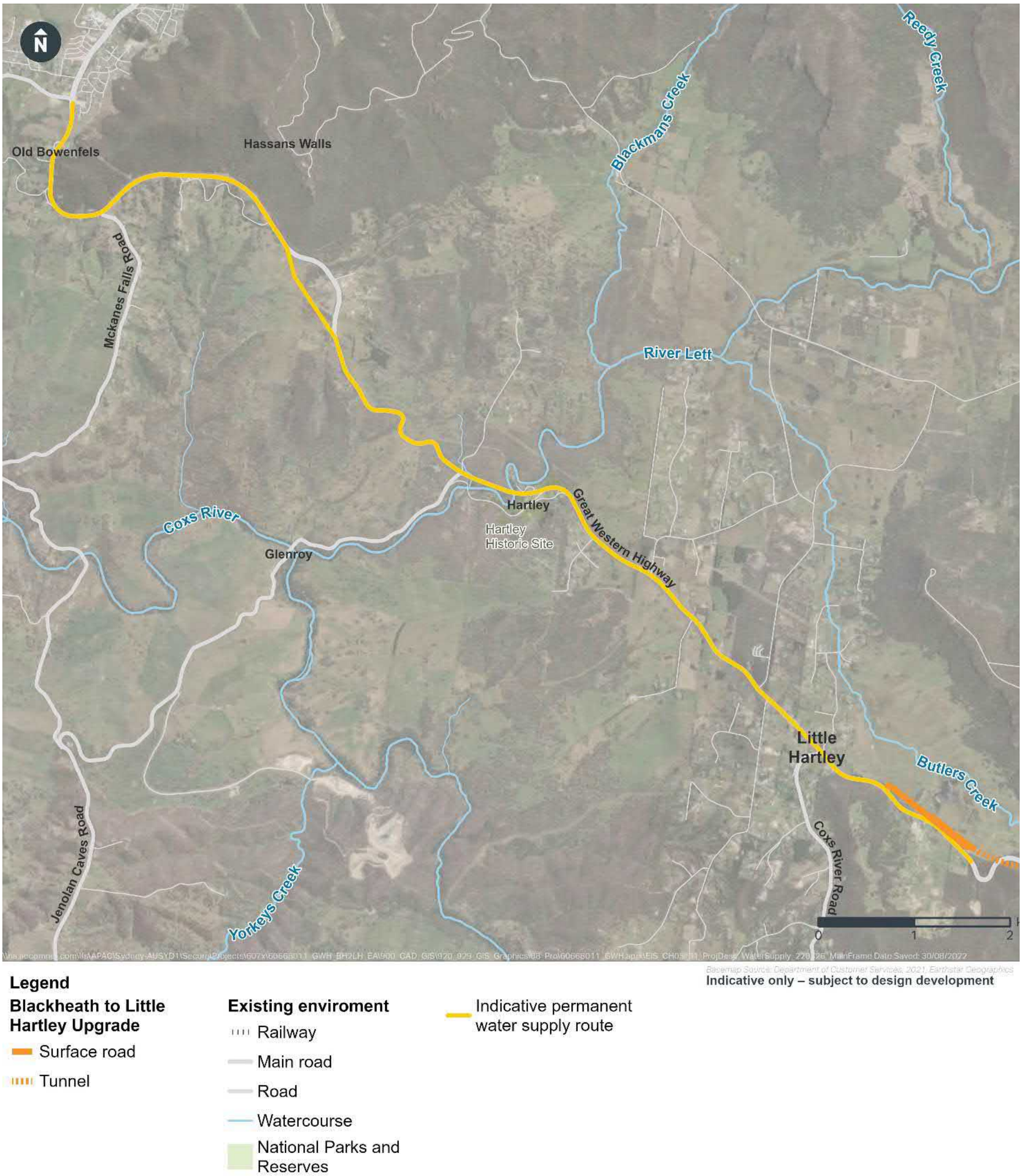


Figure 4-24 Indicative permanent water supply pipeline route

4.7 Project design uncertainties

The description of the project presented in this chapter is indicative and based on the current level of design. The project would continue to be refined as part of ongoing design development and where relevant, in response to feedback from the community and other stakeholders which may further minimise potential impacts.

Some flexibility has been provided in the design:

- so that proposed performance and technical requirements can be achieved
- to validate the feasibility and potential construction methodologies and techniques
- to identify key risks, constraints and potential environmental impacts and propose appropriate mitigation measures during construction and operation.

There remain some design uncertainties relating to the technical requirements of construction and operation of the project that would be resolved during further design development. A summary of the uncertainties that have the potential to impact on the environment, and how these would be resolved, is provided in Table 4-4.

Any changes to the project would be reviewed for consistency with the assessment contained in this EIS including relevant environmental mitigation measures, performance outcomes and any future conditions of approval.

Table 4-4 Resolution of project uncertainties

Project uncertainty	Proposed resolution	Timing	Where discussed
Tunnel ventilation	A decision on the preferred tunnel ventilation option for the project (ventilation outlet option or portal emissions option) would be made following the outcomes of further environmental assessment and consultation with key stakeholders and the community.	Design	Section 4.5.2
Configuration and detailed design of operational infrastructure	Refinement of the design and configuration for the ancillary infrastructure would be confirmed during ongoing design development. The design would be refined in accordance with performance requirements for elements such as the ventilation facilities, the urban design objectives and principles developed for the project, and the outcomes of community and stakeholder consultation.	Design	Section 4.5.1

Project uncertainty	Proposed resolution	Timing	Where discussed
Construction method and staging	Final construction methods (including selection of TBM type) and staging plans including road possessions would be prepared by the construction contractor, once appointed. The staging plans would be based on further design development and refinement of the construction method. The plans would describe how construction areas associated with road works would be established to safely maintain traffic flows in areas of reduced traffic capacity, and to minimise delays to motorists, public transport, pedestrians and cyclists.	Construction	Chapter 5 (Construction) Chapter 8 (Transport and traffic)
Off-site spoil reuse locations	Off-site spoil reuse locations would continue to be investigated during ongoing design development and confirmed by the construction contractor, once appointed. Spoil reuse locations would be located to the west of the project, avoiding the need to haul spoil eastbound from Little Hartley through the Blue Mountains.	Design	Chapter 5 (Construction) Chapter 21 (Resource use and waste management)
Requirement for the mid-tunnel access shaft and Soldiers Pinch construction footprint	Ongoing construction planning would confirm whether the mid-tunnel access shaft and Soldiers Pinch construction footprint is required to support construction of the project. Subject to managing construction-related issues, this infrastructure could be removed.	Construction	Chapter 5 (Construction)
Construction and operational water supply at Little Hartley	Ongoing investigation would confirm the construction and operational water supply for the project in consultation with relevant stakeholders.	Design	Chapter 4 (Project description) Chapter 5 (Construction)
Predicted groundwater drawdown impacts at the Blackheath portal	Additional groundwater data and further update of the numerical groundwater model for the project would occur to confirm potential groundwater impacts due to the project. Where potential impacts are different to those presented in the EIS, further environmental mitigation measures and/or design responses will be identified and applied where feasible and reasonable.	Design	Chapter 12 (Biodiversity) Chapter 13 (Groundwater) Chapter 14 (Surface water and flooding)

5 Construction

This chapter describes the approach to construction of the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The construction work described in this chapter is indicative, based on the current level of design. The construction methodology would continue to be refined as part of ongoing design development.

Detailed construction planning would be carried out before construction begins. This would include further refinement of specific construction methods, and the program, and would be developed by the construction contractor(s) when appointed. These refinements would likely be driven by factors such as updated geotechnical information, opportunities to further avoid and/or minimise environmental impacts, and opportunities to optimise the construction program.

5.1 Overview

An overview of the indicative construction program for the project is provided in Section 5.2. Section 5.3 provides an overview of the construction sites required for the project. The proposed construction activities required for the project are described in Section 5.4 and include:

- site establishment and enabling works
- tunnel portal construction
- tunnelling and associated works
- surface road upgrade works
- operational infrastructure construction and fit-out, including construction of operational environmental controls
- finishing works, testing and commissioning.

Other construction aspects such as spoil management, construction workforce and plant and equipment required for construction of the project are discussed in Section 5.5.

Construction working hours are outlined in Section 5.6 and Section 5.7 describes how construction works would be managed.

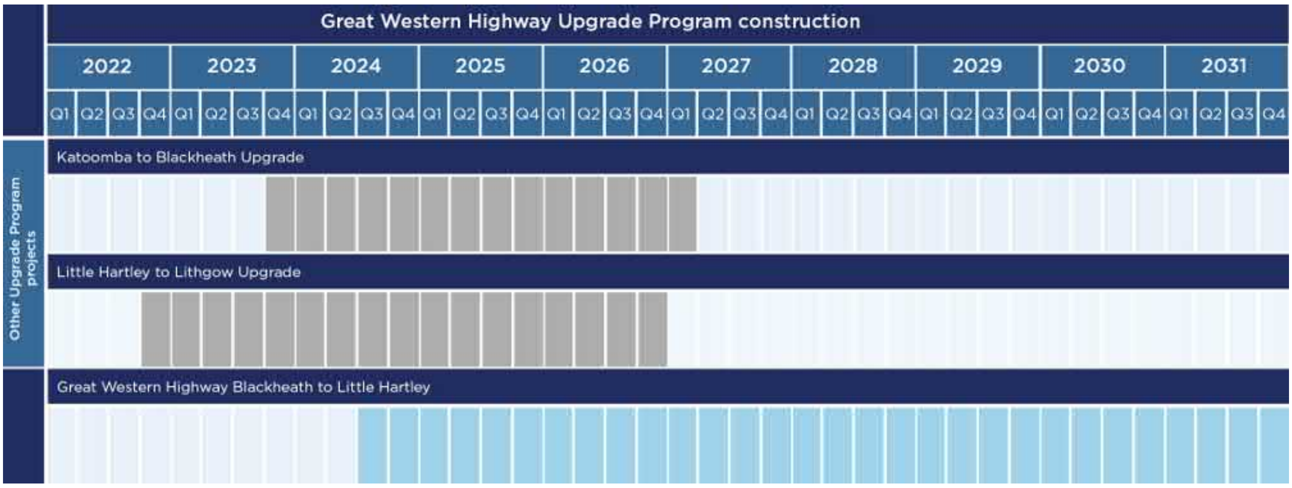
5.2 Construction program

Construction of the project is expected to take around eight years. Subject to planning approval, construction is planned to commence in 2024 and continue until 2031. The project is expected to open to traffic by 2030.

The indicative construction program for the project including the relationship with other components of the upgrade of the Great Western Highway between Katoomba and Lithgow (the Upgrade Program) is shown in Table 5-1. Construction activities proposed at each site are detailed in the following sections.

Opportunities to further minimise construction-related impacts would be investigated, including construction sequencing and staging to provide respite to receivers (refer to Chapter 24 (Cumulative impacts)).

Table 5-1 Indicative construction program



5.3 Construction footprint and sites

The construction footprint for the project is shown in Figure 5-1. The construction footprint comprises the following construction sites required to support construction of the project:

- Blackheath construction site
- Soldiers Pinch construction site
- Little Hartley construction site.

The indicative layouts and site access arrangements for these construction sites are discussed in Sections 5.3.1 to 5.3.4 and presented in Figure 5-5 to Figure 5-7.

Construction site locations are contingent on the project design and the need for access to key project components such as tunnel portals. The following amenity and environmental criteria were also considered when selecting construction site locations:

- avoiding direct impacts to the Blue Mountains National Park and Greater Blue Mountains World Heritage Area
- minimising impacts to areas of known contamination that would require remediation before use
- minimising impacts to areas of sensitive ecological communities
- minimising areas close to noise sensitive receivers
- minimising impacts to social infrastructure
- minimising areas close to known Aboriginal and non-Aboriginal heritage items.

Further detail regarding each construction site is provided below.

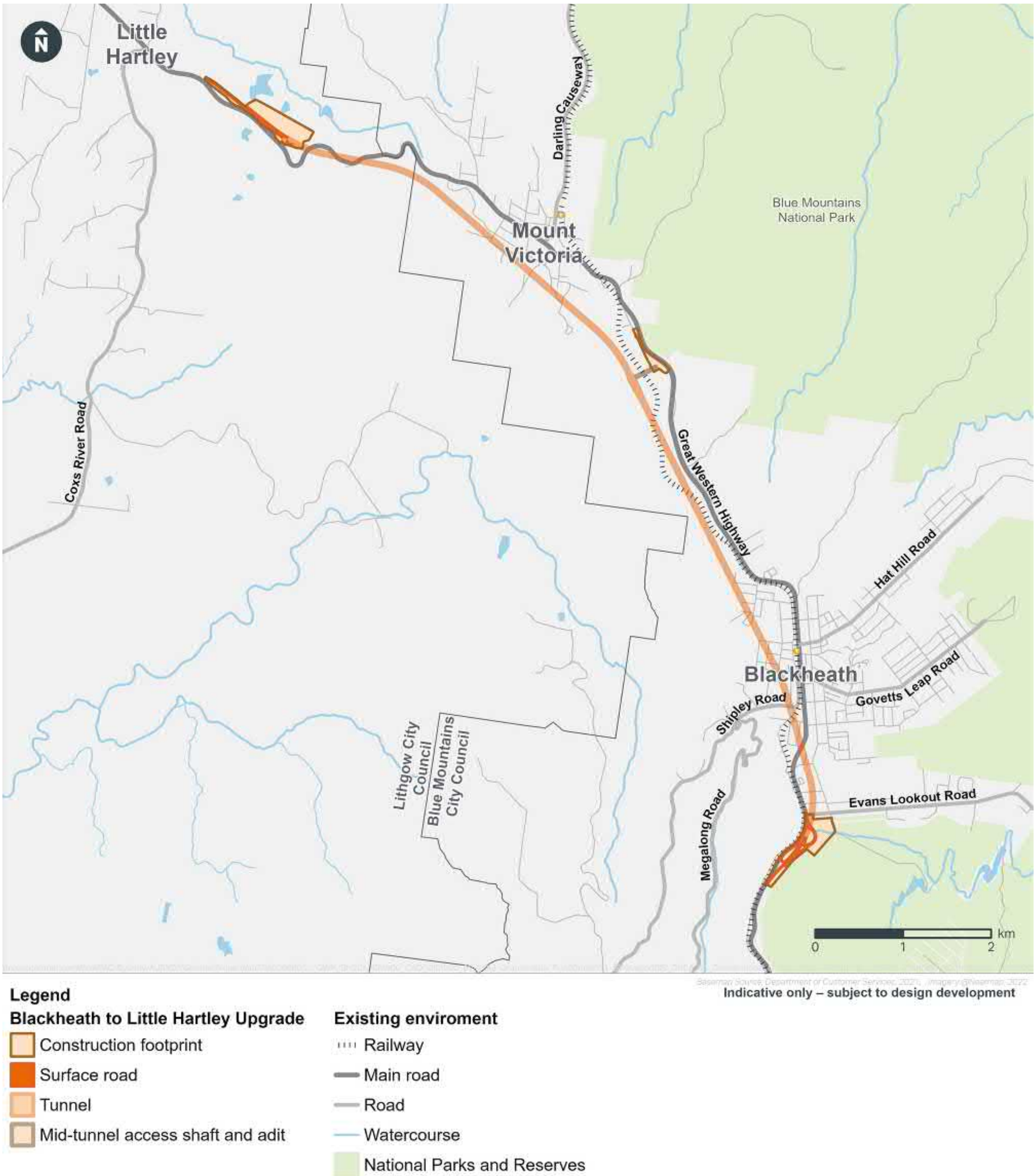


Figure 5-1 Construction footprint

5.3.1 Baseline environment

As shown in Table 5-1, the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade adjoining the project to the east and west respectively will be under construction when construction of the project commences. To minimise environmental impacts, parts of the construction sites used for the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade would be used to support construction of the project.

At these construction sites, the following activities would be carried out as part of the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade:

- vegetation would be cleared
- topsoil would be levelled and compacted
- site access tracks would be established
- water quality controls such as water quality and sediment basins would be installed.

The environmental impacts associated with these works have been assessed and approved as part of the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade. The construction footprints for these areas of both projects are shown in Figure 5-2 and Figure 5-4, and form the baseline environment for the project.

No work is proposed at Soldiers Pinch as part of the Katoomba to Blackheath Upgrade or the Little Hartley to Lithgow Upgrade and therefore in this location the existing environment forms the baseline environment for the project.

Figure 5-2 Indicative construction footprint at Blackheath

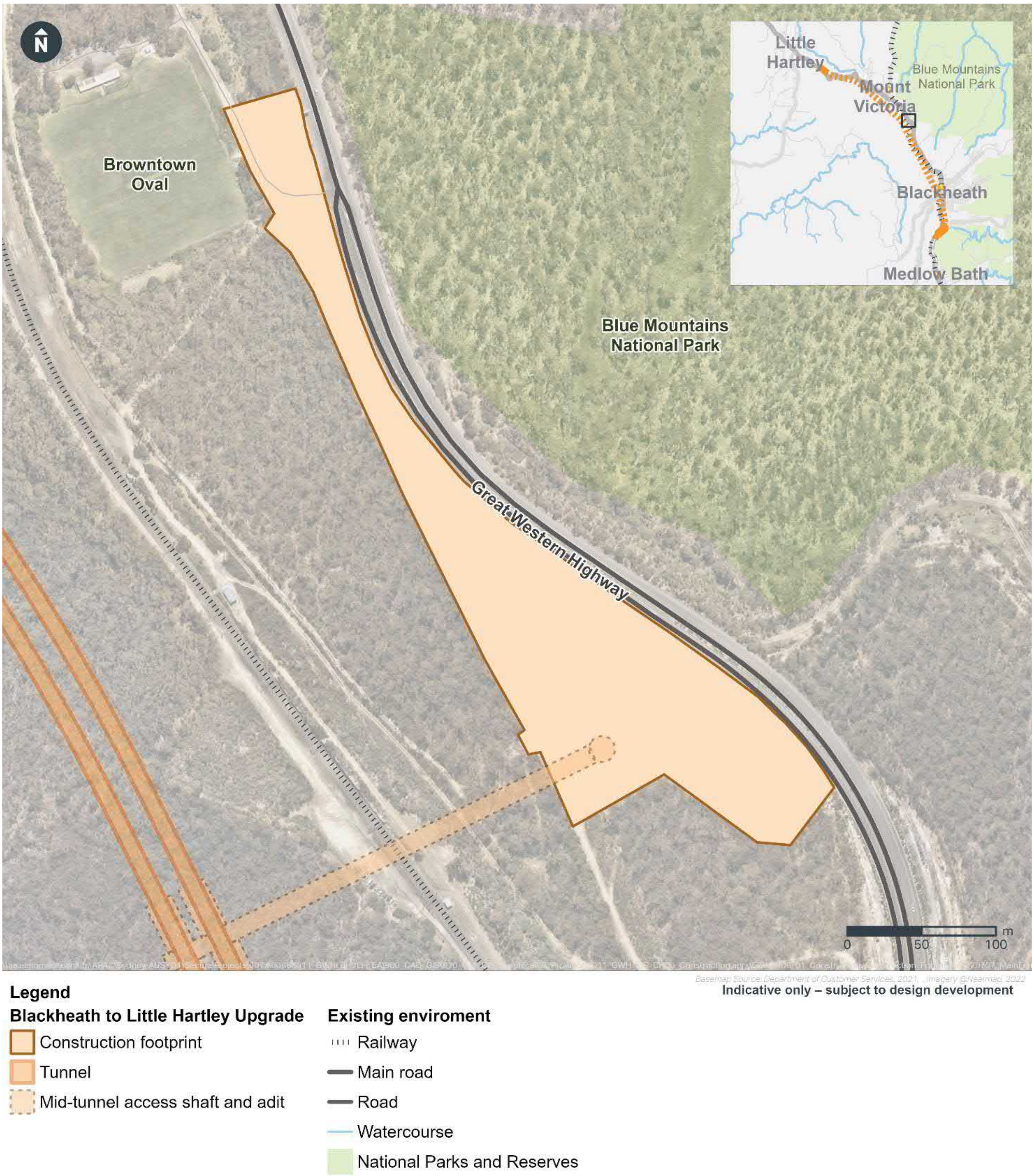
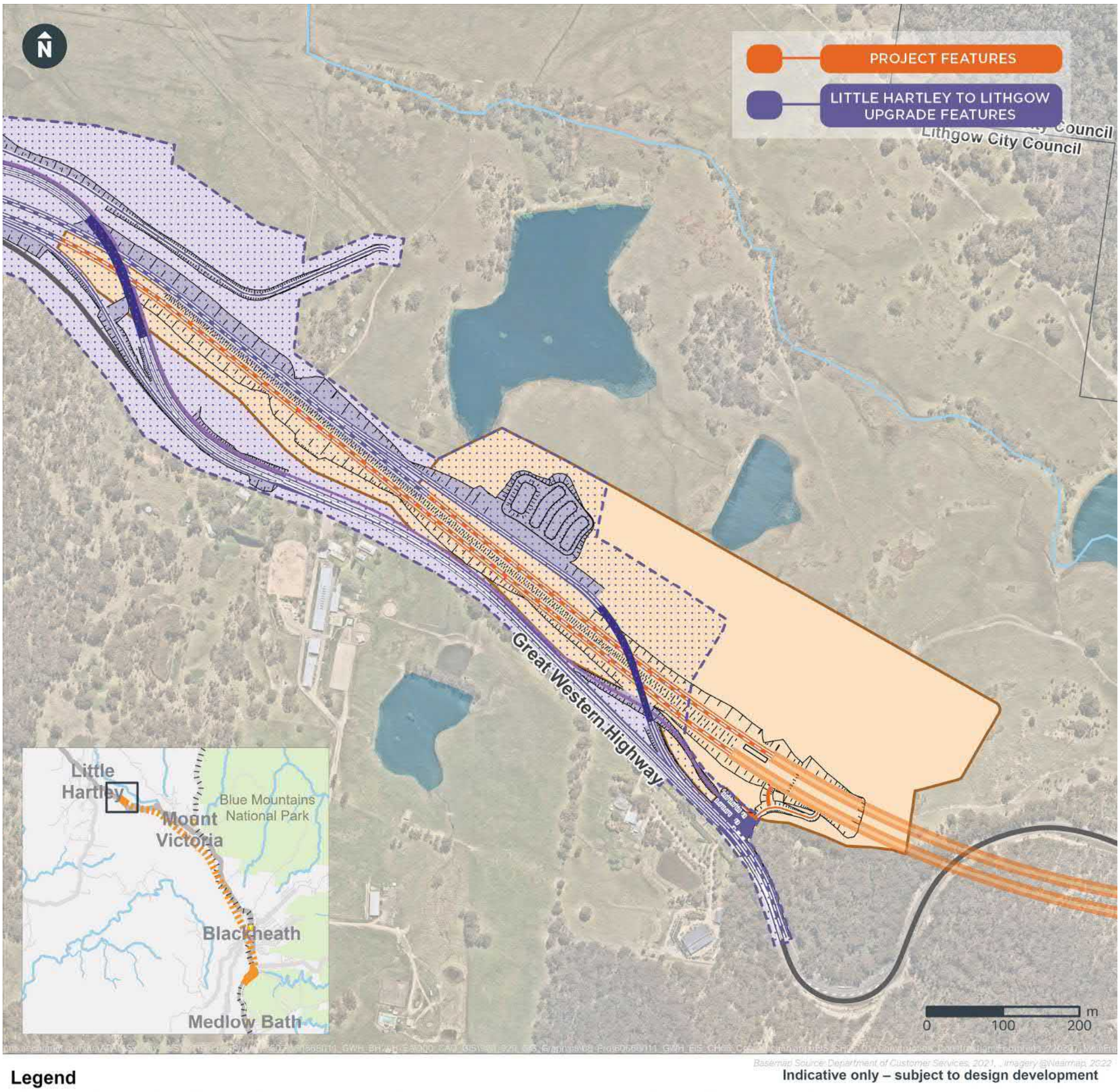


Figure 5-3 Indicative construction footprint at Soldiers Pinch



Indicative only – subject to design development

Legend

Blackheath to Little Hartley Upgrade
- Construction footprint
- Surface road
- Tunnel

Existing enviroment
- Main road
- Road
- Watercourse
- National Parks and Reserves
- Local government area

Little Hartley to Lithgow Upgrade
- Construction footprint
- Surface road
- Overbridge
- Active transport trail

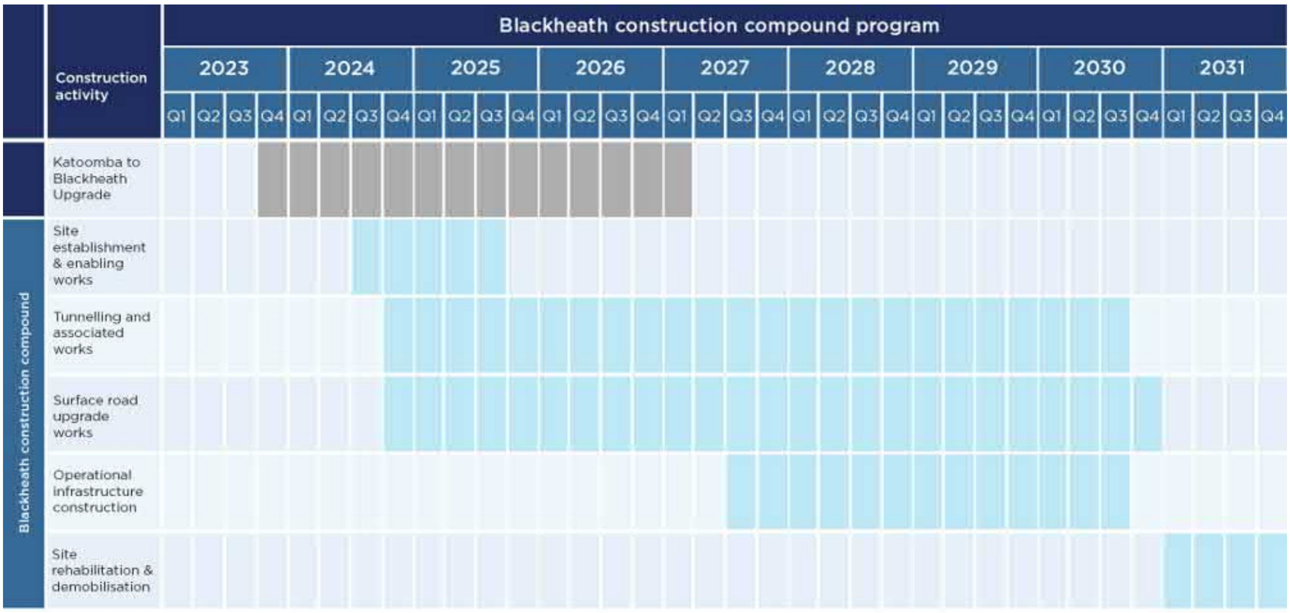
Figure 5-4 Indicative construction footprint at Little Hartley

5.3.2 Blackheath construction site

The Blackheath construction site would support tunnel portal construction, surface road work and establishment of operational ancillary infrastructure to support tunnel operations. The indicative construction program for work at Blackheath is shown in Table 5-2. The program presented in Table 5-2 provides an indication of the anticipated duration for the construction activities required at this location. These durations make allowance for appropriate staging/ phasing of activities to avoid or minimise interface with the Katoomba to Blackheath Upgrade and to minimise associated construction impacts.

The program in Table 5-2 reflects construction timing for the Katoomba to Blackheath Upgrade. It is anticipated that construction in the area surrounding the Blackheath construction site for the Katoomba to Blackheath Upgrade would be complete prior to commencement of construction activities for the project. Construction activities for the project are scheduled to be undertaken between late 2024 and early 2027 anticipated to be located further to the east. This would avoid concurrent construction activities for the two projects occurring in the same location.

Table 5-2 Indicative construction program – Blackheath



Construction activities required at the Blackheath construction site would include:

- localised utility adjustments (relocations/ connections) to support construction
- tunnel portal construction
- Tunnel Boring Machine (TBM) retrieval
- stockpile and spoil handling
- demolition of the temporary access arrangement installed by the Katoomba to Blackheath Upgrade
- surface road upgrade works including earthworks and landscaping
- construction worker amenities/ facilities and parking
- construction material and equipment storage
- construction water treatment plant
- installation and use of ventilation plant including clean air intake (fans and ducting)

- construction of:
  - tunnel operations facility
  - underground ventilation building and ventilation outlet (for the ventilation outlet option if progressed)
  - tunnel deluge system
  - permanent electricity substation
  - surface and tunnel drainage infrastructure (see Section 5.4.4)
- demobilisation and site rehabilitation.

Drainage infrastructure delivered as part of the Katoomba to Blackheath Upgrade would be used to manage surface water flows from this construction site alongside the additional drainage infrastructure noted above.

The construction footprint at the Blackheath construction site would remain consistent regardless of which tunnel ventilation option is progressed, however the ventilation outlet option would require additional construction activities to construct the ventilation building and ventilation outlet.

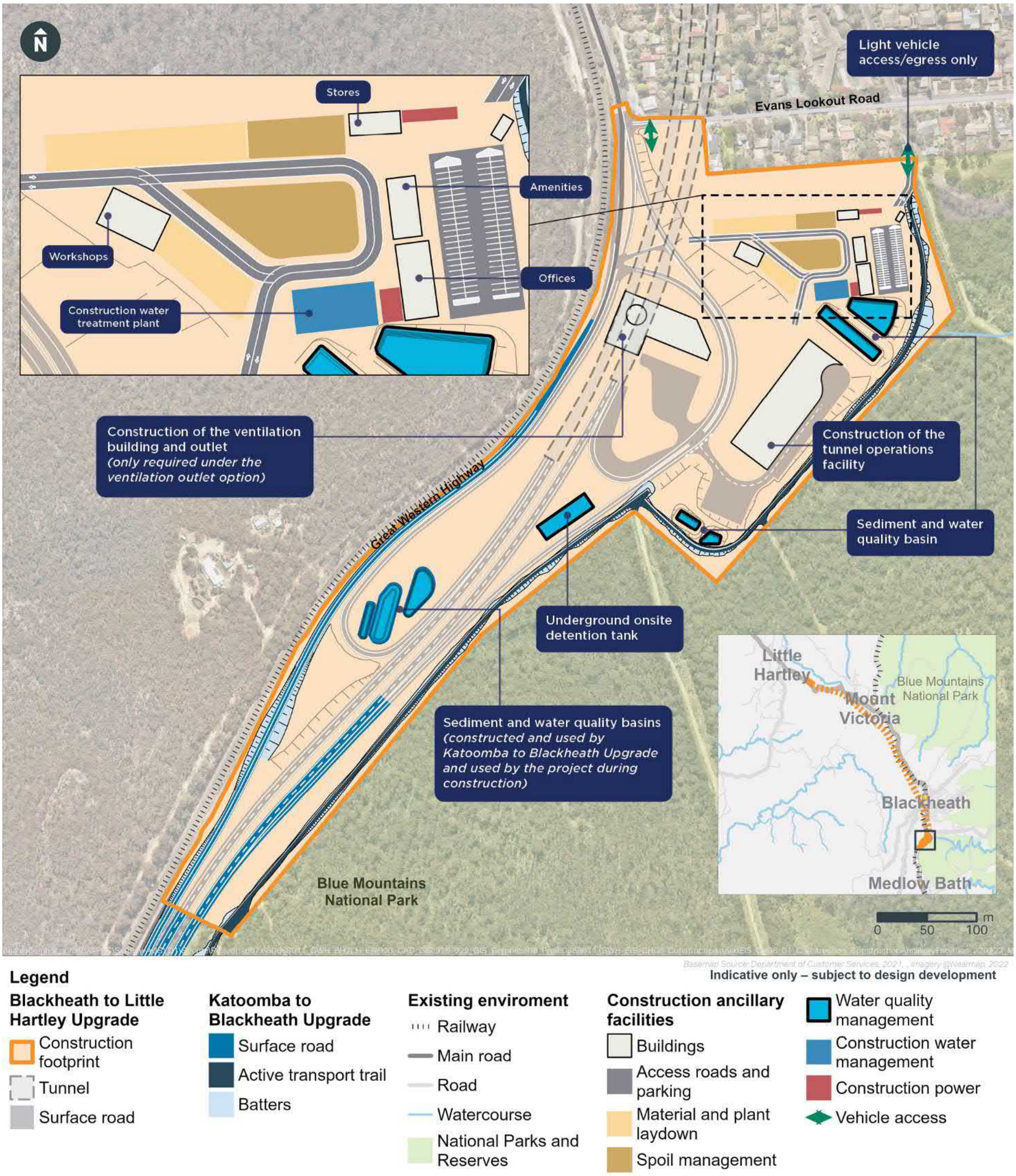


Figure 5-5 Indicative Blackheath construction site layout

5.3.3 Soldiers Pinch construction site

The Soldiers Pinch construction site would be located around the mid-point of the tunnel length. This construction site would be used to support TBM maintenance and construction of the mid-point vehicle crossover. This site would also be used to support tunnel fit-out and finishing activities. The indicative construction program for work at Soldiers Pinch is shown in Table 5-3.

Table 5-3 Indicative construction program – Soldiers Pinch

Construction activities required at the Soldiers Pinch construction site would include:

- mid-tunnel access shaft and adit construction
- access to carry out TBM maintenance
- installation and use of ventilation plant including clean air intake (fans and ducting) once tunnelling has progressed to Soldiers Pinch
- construction worker amenities/facilities and parking
- material and equipment storage
- construction water treatment plant
- support and access for in-tunnel civil finishing works and fit-out
- demobilisation and site rehabilitation.

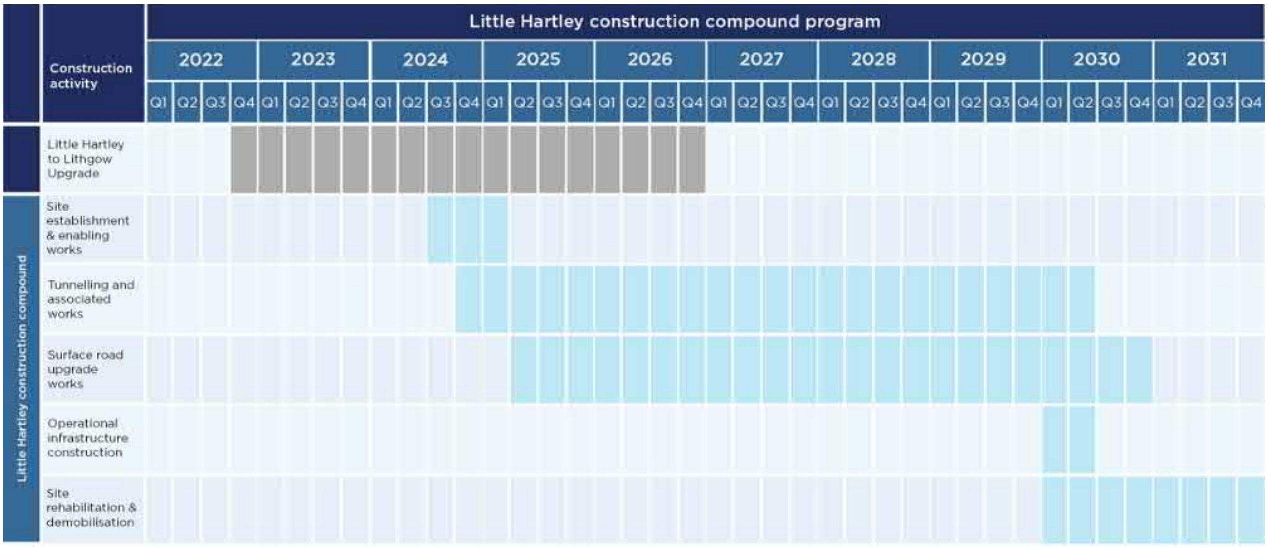
Figure 5-6 Indicative Soldiers Pinch construction site layout

5.3.4 Little Hartley construction site

The Little Hartley construction site would be the main site for tunnelling support activities, used to build and launch the TBMs, and manage spoil from TBM operation. The indicative construction program for work at Little Hartley is shown in Table 5-4.

The program presented in Table 5-4 provides an indication of the anticipated duration for the construction activities required at this location for the project and the Little Hartley to Lithgow Upgrade. These durations make allowance for appropriate staging/ phasing of activities to avoid or minimise interface with the Little Hartley to Lithgow Upgrade and to minimise associated construction impacts.

Table 5-4 Indicative construction program – Little Hartley



Construction activities required at the Little Hartley construction site would include:

- tunnel portal construction
- activities and infrastructure to support TBM operation, including, TBM assembly and launch, grout plant and bentonite silo, acoustic shed and tunnel segment storage
- stockpile and spoil handling
- surface road upgrade works including earthworks and landscaping
- construction ventilation plant including clean air intake (fans and ducting)
- construction worker amenities/facilities and parking
- material and equipment storage
- construction water treatment plant
- construction of:
  - underground ventilation building and ventilation outlet (for the ventilation outlet option if progressed)
  - operational water treatment plant
  - permanent electricity substation
  - surface and tunnel drainage infrastructure (see Section 5.4.4)
- demobilisation and site rehabilitation.

Drainage infrastructure delivered for the Little Hartley to Lithgow Upgrade would be used to manage surface water flows from this construction site alongside the additional drainage infrastructure noted above.

The construction footprint at the Little Hartley construction site would remain consistent regardless of which tunnel ventilation option is progressed, however the ventilation outlet option would require additional construction activities to construct the ventilation building and ventilation outlet.

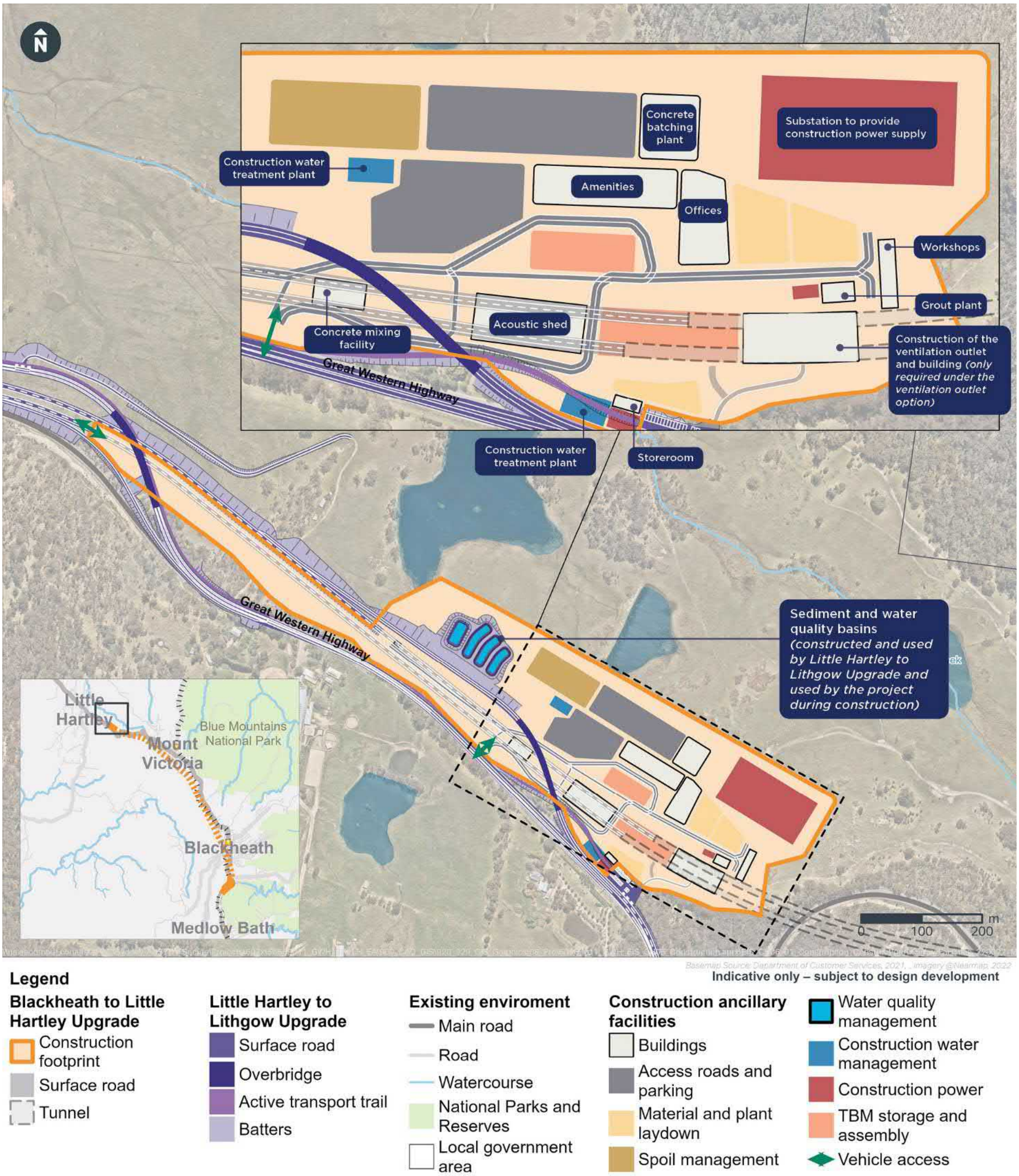


Figure 5-7 Indicative Little Hartley construction site layout

5.4 Construction activities

This section describes the key construction activities that would be required for the project.

5.4.1 Site establishment and enabling works

Site establishment and enabling works would generally occur prior to the commencement of the main construction works and would include:

- additional site investigations (such as archaeological, geotechnical and contamination)
- preparatory works (such as remediation and heritage salvage)
- utility relocation, adjustment and/or protection where the project may affect existing utilities, including relocation of the Sydney Trains 66kV line near Evans Lookout Road at Blackheath
- establishment of the electricity substation at Little Hartley for construction power (see Section 5.5.5)
- intersection upgrades to establish safe access to construction sites including:
  - upgrade of the Great Western Highway / Evans Lookout Road intersection to access the Blackheath construction site
  - upgrade of the Great Western Highway / Browntown Oval access road to access the Soldiers Pinch construction site
  - establishment of a temporary intersection on the Great Western Highway at Little Hartley to access the Little Hartley construction site
- vegetation clearing and earthworks to provide access to and level the construction sites in preparation for use
- site establishment of site facilities including amenities, site offices, acoustic shed, temporary ventilation, grout plant, site utilities
- establishment of construction water treatment infrastructure including sediment basins, where not already established by the Katoomba to Blackheath Upgrade or the Little Hartley to Lithgow Upgrade, and a water treatment plant
- establishment of temporary environmental and safety controls (including hoardings, noise attenuation measures and erosion and sediment controls)
- delivery of construction plant, equipment and materials
- establishment of traffic management controls, including adjustments to road signage (showing changes to traffic movements and speed limits).

5.4.2 Tunnel portal construction

Tunnel portals would adopt a ‘cut-and-cover’ construction method. Cut-and-cover is a tunnel excavation method that generally involves excavating downwards from the surface of the ground, with installation of a tunnel structure including a base, walls and a roof to support the surrounding soil and rock (where necessary), as shown in Figure 5-8. Cut-and-cover would be used to excavate the tunnels up to a distance of around 250 metres from the tunnel portals. Cut-and-cover is the preferred excavation method for this section as TBM excavation requires supports around the entire excavation face to advance. Supports around the entire excavation face would not be available towards the tunnel portals where depth of ground cover between the surface and the top of the tunnel reduces. In addition, the distance between the twin tunnels would narrow towards the Blackheath portal. Using an excavation method more precise than TBMs (i.e. cut-and-cover construction method) would be safer as the distance between the twin tunnels narrows.

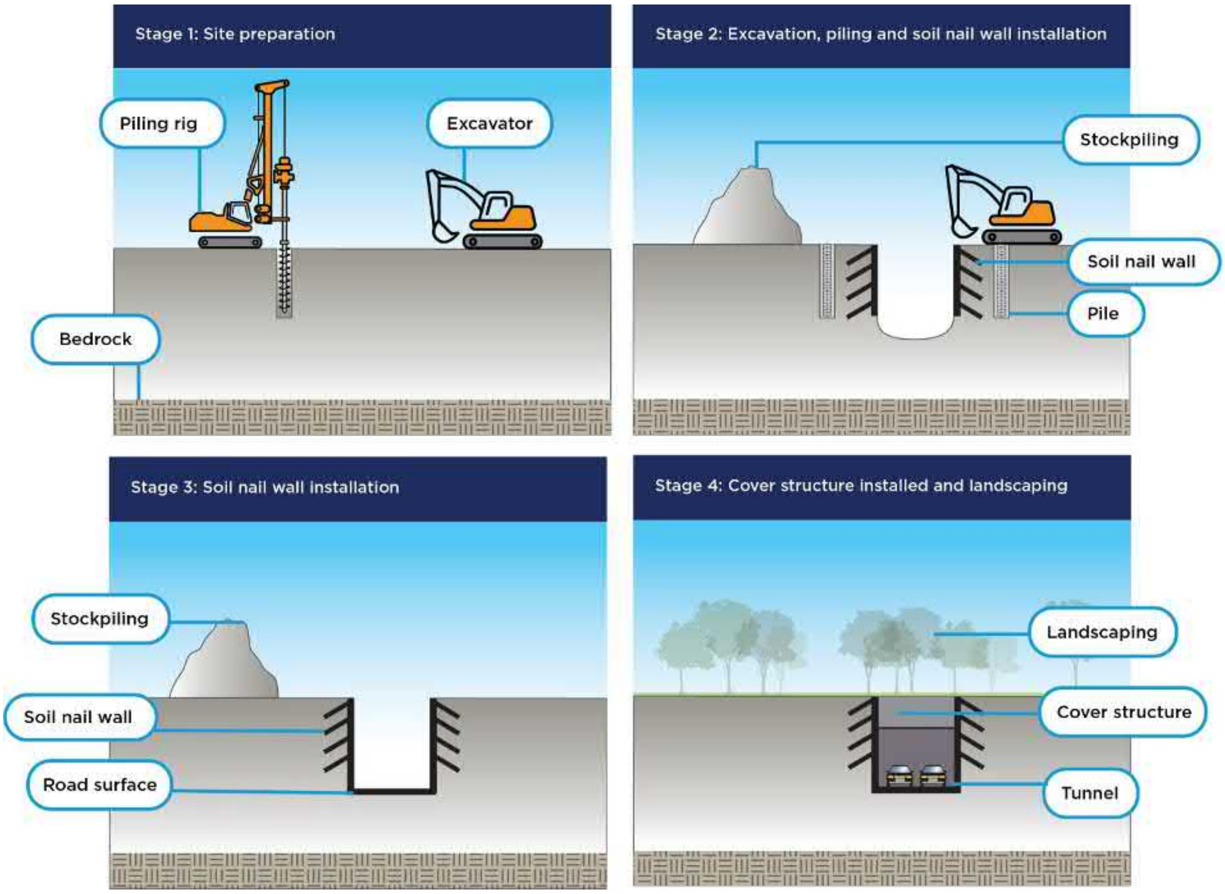


Figure 5-8 Indicative cut-and-cover construction methodology

Once the roof is in place, surface activity would resume as construction works continue below.

Construction activities associated with cut-and-cover structures would include:

- excavation
- piling works
- stabilisation and excavation support (retention systems) such as bored pile walls, soil nailing and rock anchoring
- construction of pile capping beams
- installation of roof slabs (including potential for precast roof)
- installation of permanent struts and form, reinforcement and pouring of horizontal beams used for bracing and support
- dewatering
- finishing works.

5.4.3 Tunnelling and associated works

Construction of the twin tunnels would occur towards the end of the tunnel portal works and would be largely located underground. These works would involve the following activities:

- excavation of TBM launch and retrieval sites
- delivery and assembly of the TBM machinery
- bored tunnel excavation and installation of tunnel segment lining
- excavation and structural lining of cross-passages and locations for in-tunnel substations

- excavation of mid-tunnel access shaft and caverns
- civil finishing works and fit-out
- testing and commissioning.

The tunnelling methodology described below is indicative and would be subject to refinement as part of detailed design and construction planning.

Bored tunnel excavation

TBMs include a front 'shield' with rotating cutterhead which can excavate through rock and soil (shown in Figure 5-9). Behind the cutterhead is a chamber where the excavated rock spoil is collected. Excavated material is transferred from the excavation chamber to a spoil conveyor within the TBM. The spoil is transported to the TBM launch site via a spoil conveyor. As the TBM moves forward, precast concrete segmental lining rings are installed in the excavated tunnel. The TBM is propelled forward by hydraulic jacks that push off the previously installed tunnel lining segments. Gaps between the excavated tunnel wall and the tunnel lining would be filled with cement-based grout.

Figure 5-9 Photo of a TBM used to construct the Sydney Metro Northwest Line

The twin tunnels would be constructed using two TBMs launched from Little Hartley, tunnelling eastbound on an uphill gradient at an average rate of around 70 to 90 metres per week. The TBMs would be retrieved at the Blackheath construction site. The indicative TBM tunnelling strategy is illustrated in Figure 5-10. The benefits associated with this tunnelling strategy compared to other tunnel construction options are described in Chapter 3 (Project alternatives and options).

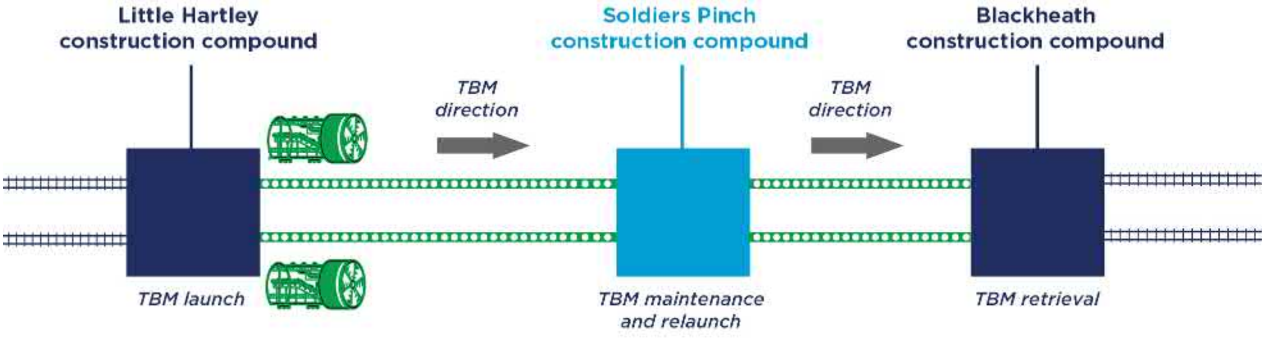


Figure 5-10 Indicative TBM tunnelling strategy

Enlarged tunnel caverns would be constructed at around the mid-point of the tunnels (mid-tunnel caverns) to support TBM refurbishment, including cutterhead maintenance or replacement. The mid-tunnel caverns would be constructed prior to the arrival of the TBMs.

The depth of the tunnels below ground level would vary according to localised geological conditions, with the deepest point of the tunnel crown (top of the tunnels) located around 200 metres below ground level near Mount Victoria, with shallower sections near the tunnel portals at Blackheath and Little Hartley. Indicative depths of the tunnels are shown in Chapter 4 (Project description).

Cross-passages linking the two mainline tunnels would be excavated using either roadheaders, excavators or a drill and blast method. A roadheader is specialised tunnelling equipment that excavates with picks mounted on a rotary cutterhead attached to a hydraulically operated boom. An excavator fitted with a rock breaker is used more generally in construction to break down concrete and rock.

As excavation advances, temporary or permanent ground support would be installed behind the excavation face followed by a waterproof membrane.

An example of a roadheader used for tunnel excavation is shown in Figure 5-11.

Figure 5-11 Photo of a roadheader used to construct the new M6 tunnels

Cross-passages would be located at around 120 metre intervals along the tunnels. Due to the hydrogeological conditions, the cross-passages would be lined with a waterproof lining (i.e. structures which prevent groundwater ingress) between Blackheath and the mid-point of the tunnel and drained (i.e. structures which capture, divert and treat groundwater ingress) between the mid-point and Little Hartley. Further design development and consultation with relevant stakeholders is occurring in relation to cross-passage design with opportunities being explored to reduce the number of cross-passages required for the project while meeting fire and life safety requirements. Excavation of cross-passages would occur concurrently with TBM excavation once the TBM has passed a cross-passage location.

Roadheaders or excavators fitted with rock breakers would likely be used to construct the mid-tunnel access shaft located at Soldiers Pinch. Roadheaders would be used to excavate the access adit from the base of the shaft to the tunnel (around 260 metres long) and the tunnel caverns required for vehicle crossover and breakdown bays. The access shaft would be tanked (waterproofed) for the top portion (around 50 metres) and drained for the bottom portion (around 50 metres) as illustrated in Figure 5-12. A cross section of the mid-tunnel access shaft is presented in Figure 5-13.

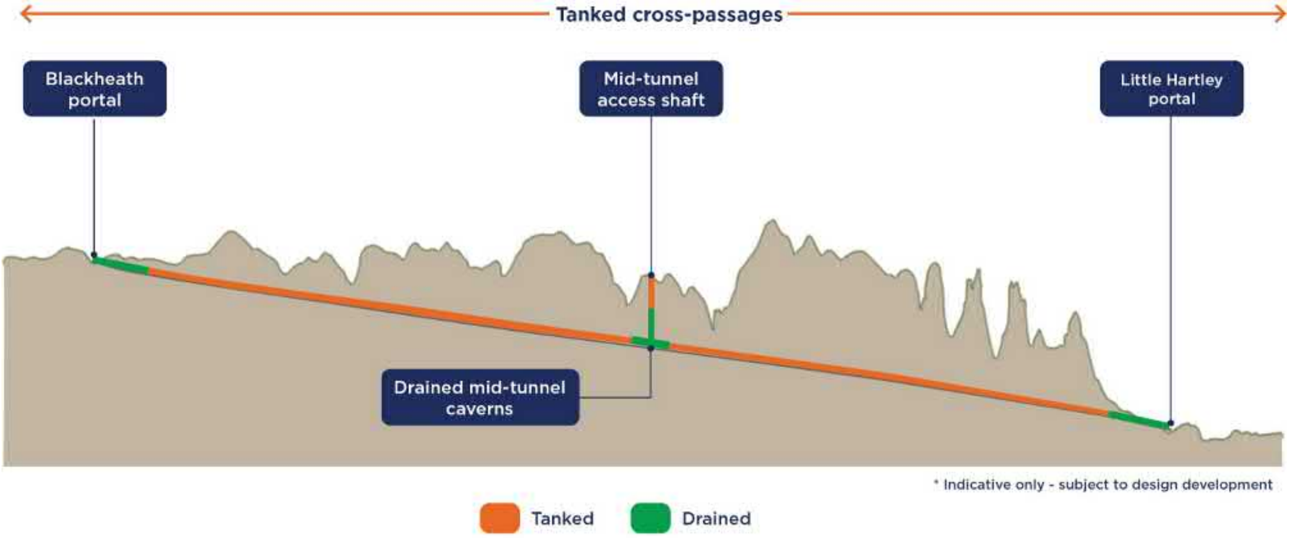


Figure 5-12 Tanked and drained sections of the tunnel and mid-tunnel access shaft

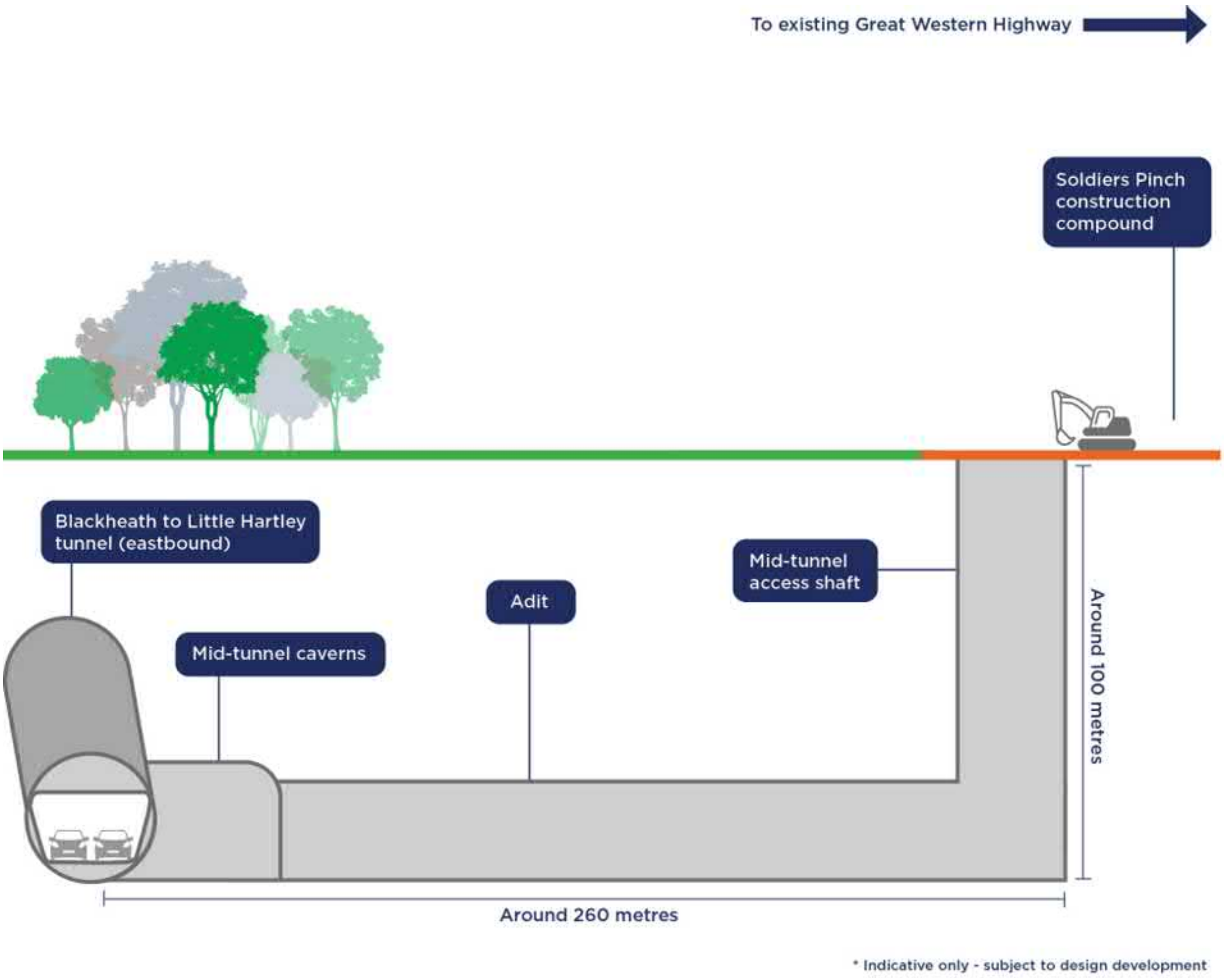


Figure 5-13 Cross section of the mid-tunnel access shaft

The lining for the TBM tunnels would consist of precast concrete segments, installed progressively as the TBM advances. The precast concrete segments would be manufactured at a precast segment manufacturing yard located west of the project. The establishment and operation of this facility would be subject to separate assessment and approvals. Heavy vehicle movements would be required along the Great Western Highway to transport the precast concrete segments to the Little Hartley construction site and have therefore been considered as part of relevant technical assessments for the project, including construction traffic (Chapter 8 (Transport and traffic)) and construction noise assessments (Chapter 11 (Noise and vibration)). Precast concrete segments would not be required to be transported to the Blackheath or Soldiers Pinch construction sites.

Tunnelling support activities

TBM operations would be 24 hours per day, seven days per week and would require surface construction areas for logistics support and material handling, including:

- TBM delivery, assembly and commissioning
- temporary storage of tunnel lining segments
- concrete batching plant and mixing facilities
- spoil handling and stockpiling areas and acoustic shed or other acoustic management measures
- construction water management including a construction water treatment plant and sediment and water quality basins
- workforce amenities, offices and parking.

The following would also be required to support TBM operations:

- high voltage power supply via the new electricity substation at Little Hartley
- construction water supply via the new pipeline from Lithgow to Little Hartley
- installation and operation of fresh air ventilation (fresh air ventilation fans would operate 24 hours per day, seven days per week during tunnelling).

An example of a TBM launch site is shown in Figure 5-14. Following launch of the TBMs, the Little Hartley construction site would provide the necessary support for the tunnelling operation.

Figure 5-14 Example of a TBM launch site

Coal seam gas draining and venting

Coal seams of varying thicknesses may be encountered during tunnel construction between Little Hartley and Mount Victoria. Coal seam or methane gas may be present in the surrounding geology. The presence of methane and carbon monoxide gases would be managed by the following types of activities:

- carrying out further investigations to characterise, quantify and map the extent of potential for coal seam gasses and identify areas of low, medium and high risk
- pre-installing gas drainage wells along the alignment prior to excavation if required and where possible
- forward probing from the excavation face to drain gases in advance of the excavation
- carrying out closed-mode TBM excavation in areas of high risk
- use of flameproof equipment
- ongoing monitoring of gases during tunnel construction.

Details relating to coal seam gas management are provided in Chapter 13 (Groundwater and geology) and Chapter 22 (Hazards and risks).

The requirement for installation of gas drainage wells would be confirmed during ongoing design development and reviewed during construction as tunnelling occurs and as additional information becomes available.

Civil finishing works and fit-out

On completion of the tunnel excavation works, there would be a variety of civil finishing works including:

- placement of invert backfill to the underside of road pavement
- installation of drainage systems, including sumps, pits and pipework
- installation of concrete barriers
- installation of service conduits and mechanical and electrical infrastructure including:
  - electrical and communication services and cable trays
  - lighting, power and surveillance systems
- installation of operational infrastructure including:
  - drainage infrastructure connecting to the operational water treatment plant at Little Hartley
  - underground substations at around 1.5 kilometre intervals along the tunnels to connect the operational power supply
  - in-tunnel ventilation systems
  - fire protection systems including deluge system
  - architectural panels
  - in-tunnel maintenance and breakdown bays at tunnel crossover.
- finishing of cross-passages
- road pavement construction, line marking and painting.

Once invert backfill has been placed and levelled in the excavated tunnel, concrete trucks would deliver concrete for laying of in-tunnel pavement via the Little Hartley construction site behind the TBM. Further investigations are being carried out into the use of the invert area below the road pavement. This area may also be used for trunk utilities, in-tunnel drainage or other infrastructure to support tunnel operations.

Testing and commissioning

Following tunnel civil finishing works and fit-out, all tunnel equipment and systems would undergo comprehensive testing and commissioning to validate the operation and integration of tunnel systems before the tunnels are opened to traffic.

5.4.4 Surface road upgrade works

Surface road upgrade works would connect and integrate the project tunnels with the adjacent road network. Surface road upgrade works would be required south of Blackheath and at Little Hartley.

Surface road upgrade work would involve the following activities:

- earthworks
- construction of stormwater drainage
- road pavement works
- construction of road furniture and line marking, lighting and signage
- surface finishing works (e.g., signage installation, revegetation and landscaping).

Earthworks

Earthworks would include bulk excavation, excavation for new pavement or pavement widening, placement and compaction of general fill and select fill. Earthworks for surface road upgrade works would include:

- vegetation clearing and topsoil stripping
- areas of new cut and fill, and widening of existing cuts and embankments, including construction of retaining walls and reinforced soil walls to design levels
- installation of drainage infrastructure.

Stormwater drainage

The project would provide new drainage infrastructure and alterations to existing drainage infrastructure, including:

- construction of new pits, pipes and culverts for the surface road sections
- adjustment of existing pits to suit new road alignments on existing surface roads.

Upgrade or capacity improvements of other cross drainage structures which are located underneath the existing road network may also be required.

The surface stormwater drainage system would generally consist of precast concrete pipes or culverts which would be placed in trenches that would then be backfilled with select material that meets relevant engineering specifications. Where pipes and culverts are to be installed under existing roadways they may be constructed via under-boring or pipejacking to minimise potential traffic impacts. These construction methods would be used where the work cannot be feasibly carried out in stages across existing carriageways.

Road pavement works

Dense grade asphalt has been adopted as the preferred road pavement type for the surface works, and would be confirmed during detailed design. The road pavement works would tie in with the existing road and would meet Transport for NSW (Transport) Specifications.

Existing road pavements would be modified to integrate with the project where required. This may require milling and resurfacing of the existing pavements to tie-in with new road surfaces. These works may need to be carried out at night when traffic numbers are lower to enable the required lane closures or traffic diversions.

A concrete batching plant would be used at the Little Hartley construction site for road pavement construction and other civil infrastructure requirements such as pipes, culvert segments, retaining wall elements and roadside barriers (see Figure 5-7).

Surface finishing works

Surface road finishing works would be carried out towards the completion of construction and would include:

- line marking of new road pavement
- installation of intelligent transport system devices including directional signage, variable message signs and associated infrastructure (such as gantries), traffic and other signage and other roadside furniture including lighting
- landscaping and revegetation work
- removal of construction sites
- site demobilisation and rehabilitation work.

The adjacent Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade projects would include space proofing provisions for infrastructure to support the project such as intelligent transport systems, variable message signs and power supply infrastructure.

5.4.5 Operational infrastructure construction and fit-out

Permanent operational infrastructure would be constructed for the ongoing management and operation of the project. The majority of the operational infrastructure would be located at Blackheath and Little Hartley, as described in Chapter 4 (Project description).

The typical construction method for the operational infrastructure is summarised in Table 5-5.

Table 5-5 Construction of operational infrastructure

Operational infrastructure	Construction method
Tunnel operations facility	Construction of the tunnel operations facility adjacent to the Blackheath portal, south of Evans Lookout Road would involve: • excavation, footing and base slab installation • erection of concrete columns, deck and roof • enclosure of buildings • external architectural treatments • internal fit-out of control rooms, computer rooms, amenities, offices and workshops • utilities connections including for power, potable water and sewerage • construction of a staff car park and installation of security fencing.
Tunnel ventilation systems	Construction of the tunnel ventilation systems would include: • installation and commissioning of jet fans at regular intervals along both tunnels • fit-out of the ventilation systems in the tunnels • construction of a ventilation building and ventilation outlet at Blackheath and Little Hartley (ventilation outlet option only) • internal fit-out of ventilation facilities, equipment installation and commissioning. Under the portal emissions option, there would be no ventilation buildings or ventilation outlets required.

Operational infrastructure	Construction method
Fire suppression systems	Construction of the tunnel fire suppression systems would include: • construction and fit-out of tunnel deluge systems along both tunnels • fit-out of manifolds and control systems in crossover passages • construction of water storage tanks and pump system near the Blackheath portal (the highpoint of the tunnels) • control equipment installation, testing and commissioning.
Water management and treatment controls and facilities	The operational water treatment plant would be constructed using prefabricated components which would be assembled as follows: • civil and mechanical assembly of operational water treatment plant components, including rising main from tunnel and discharge pipework • complete electrical connections between the operational water treatment plant components and incoming power supply • commissioning the operational water treatment plant • connection of the water treatment plant to the licensed discharge point.
Electricity substations	Construction of electricity substations required within the tunnel would include excavating a small room on the tunnel wall, installing waterproof lining, trenching and installing cabling, and installing a door and structural support backing. Construction of the permanent substation at Little Hartley is described in Section 5.5.5.

5.5 Construction resources

5.5.1 Spoil and waste management

The project is estimated to generate a total of around 7.8 million tonnes of spoil. It is expected that excavated material would consist of a combination of:

- virgin excavated natural material (VENM)
- roadbuilding materials from within existing road corridors, such as concrete and asphalt
- excavated natural material containing coal (see Section 5.4.3).

A portion of the tunnelling spoil may be used as backfill within the tunnel to provide a selected material zone and subgrade for the road pavement. Where possible, tunnelling spoil would also be stockpiled for future reuse as fill material for the surface road upgrade works to be constructed for the project. Opportunities to use excess spoil that cannot be reused for the project would be considered on adjacent or nearby Transport projects, including other parts of the Upgrade Program.

Excess spoil that cannot be reused within the project or for other parts of the Upgrade Program would be loaded directly into trucks and removed from site for appropriate reuse. The majority of spoil would come from TBM excavation. Haulage would involve truck movements westbound from the Little Hartley construction site. In addition, some spoil would be generated from excavation of the mid-tunnel access at Soldiers Pinch as well as from the Blackheath construction site. Spoil from these locations would be transported west via the existing Great Western Highway.

Disposal of spoil that cannot be reused would be highly dependent on the final classification of the spoil and the availability of sites that can accommodate both the class and volumes of spoil expected. Table 5-6 presents potential off-site spoil reuse sites that are being investigated for the project. Other appropriate spoil disposal sites to the west of the project may be identified during ongoing design development and construction planning.

Table 5-6 Off-site spoil reuse options

Site	Location	Approximate distance from Little Hartley (kilometres)
Little Hartley construction site (fill for surface road upgrade works)	Little Hartley	N/A
Little Hartley to Lithgow Upgrade	Little Hartley	Adjacent
Lidsdale/Kerosene Fly Ash Repository (associated with former Wallerawang power station)	Wallerawang, NSW	30
Hytec Austen Quarry	Hartley, NSW	15
Hanson Quarry	Clarence, NSW	25
Metromix	Marrangaroo, NSW	20
Invincible Colliery	Cullen Bullen, NSW	40
Cullen Valley Colliery	Cullen Bullen, NSW	40

Other waste streams which would be generated during construction include:

- demolition waste from existing road pavement
- contaminated soil and coal-bearing substrates (including acid sulfate rock) which may be encountered during construction
- general construction waste such as concrete, steel and timber formwork off-cuts
- vegetation waste from clearing and grubbing
- plant and vehicle maintenance waste such as oils and lubricants
- general office waste such as paper, cardboard, plastics and food waste
- sewage waste.

Details relating to construction waste management are provided in Chapter 21 (Resource use and waste management).

5.5.2 Construction workforce

The project is expected to support an indicative peak construction workforce of up to 1,100 full time equivalent jobs (direct employment) during the eight years of construction. This workforce would be primarily concentrated at the Little Hartley construction site (see Figure 5-15).

The construction workforce would comprise trades and construction personnel, subcontractor construction personnel and engineering, functional and administrative staff. The size of the workforce would vary depending on the construction activities being carried out. Construction workforce parking arrangements are outlined in Section 5.7.3.

Figure 5-15 Indicative construction workforce distribution

5.5.3 Plant and equipment

An overview of the indicative key plant and equipment that would be used during construction of the project is provided in Table 5-7. A detailed list of construction plant and equipment is included in Appendix G (Technical report – Noise and vibration). Plant and equipment required for each construction activity would be confirmed during ongoing design development and would be dependent on the final construction methodology developed by the construction contractor(s).

Table 5-7 Indicative construction plant and equipment

Construction activity	Indicative plant and equipment
Site establishment and enabling works	Grader, excavator, bulldozer, bobcat, chainsaw, small tools, light tower, franna crane, trucks, vibratory roller/compactor, water cart, off-road dump truck.
Tunnel portal construction	Grader, excavator, rock breaker, bobcat, small tools, forklift, elevated work platform, light tower, mobile crane, franna crane, light vehicles, concrete agitator, trucks, pavement laying machine, vibratory roller/compactor, generator, compressor, jackhammer, concrete saw, concrete pump/vibrator, piling rig, drilling rig, shotcrete rig, roadheader, dust scrubber, water cart, grout plant, water tanks.

Construction activity	Indicative plant and equipment
Tunnelling and associated works	Grader, excavator, rock breaker, bobcat, small tools, forklift, elevated work platform, light tower, mobile crane, franna crane, gantry crane, light vehicles, trucks, line marking truck, concrete agitator, pavement laying machine, vibrator roller/compactor, generator, compressor, jackhammer, rock crusher, concrete saw, concrete pump/vibrator, welding equipment, piling rig, drilling rig, shotcrete rig, roadheader, TBM, multi-service vehicle, dust scrubber, ventilation fan, water cart, road sweeper, grout plant, pug mill, water tanks.
Surface road upgrade works	Grader, excavator, rock breaker, bobcat, small tools, forklift, elevated work platform, light tower, mobile crane, franna crane, light vehicles, concrete agitator, trucks, line marking truck, pavement laying machine, vibratory roller/compactor, generator, compressor, jackhammer, concrete saw, concrete pump/vibrator, piling rig, drilling rig, shotcrete rig, dust scrubber, water cart, road sweeper, grout plant, water tanks.
Operational infrastructure construction and fit-out	Forklift, cranes, light vehicles, elevated work platform, light tower, concrete agitator, trucks, concrete pump/vibrator, shotcrete rig, dust scrubber, water cart, grout plant, water tanks.

5.5.4 Construction materials

Construction would require various resources and materials. The main construction materials required would include:

- general fill and select fill for earthworks (sourced from the project tunnel spoil where available and suitable)
- pavement materials, asphalt, cement, concrete and steel
- materials for lining drainage channels
- aggregate used for concrete and asphalt
- water
- precast concrete including for tunnel lining segments, pipes, culvert segments, retaining wall elements and roadside barriers
- structural steel
- plastics used for drainage, piping and conduits
- prefabricated steel and road furniture units
- wood for use in formwork and other temporary structures
- dangerous goods (refer to Chapter 22 (Hazards and risk)).

Construction materials would generally be sourced from off-site suppliers. Where feasible, local sources of construction materials would be preferred to minimise haulage distances. A full list of construction materials and indicative quantities required for construction is provided in Chapter 21 (Resource use and waste management).

5.5.5 Power supply

Temporary power supply

Power supply would be required for construction at the Blackheath, Soldiers Pinch and Little Hartley construction sites. In particular, high voltage power would be required at the Little Hartley construction site to power the TBMs for tunnelling.

The power supply for the Little Hartley construction site would be provided via a new substation which would connect to the existing electricity network. This is subject to a separate assessment. Power supply to Blackheath and Soldiers Pinch construction sites would be accommodated by connections to the existing local Endeavour Energy power supply network.

Indicative power supply requirements during construction of the project are provided in Chapter 21 (Resource use and waste management).

Permanent power supply

The construction power supply provided at Little Hartley would be sufficient to support operational power supply requirements. Construction of the substation at Little Hartley would include:

- earthworks, stormwater drainage installation, placement of hard surfaces (typically crushed rock) and access roads
- installation of security fencing and access gates
- substation installation, including installation of pits, conduits and pipes to support electrical cables, construction of buildings and other support infrastructure, installation of electrical switchgear, transformers and distribution boards in readiness to bring cables to the site
- connection to the existing power supply network.

Within the tunnels, substations spaced around 1.5 kilometres apart would be installed along the tunnels to supply the permanent power requirements of the project. These substations would provide operational power supply to the tunnel systems and services including lighting, ventilation, drainage, fire protection, communications and control systems.

5.5.6 Water supply

Water supply would be required to support tunnelling, earthworks, site facilities/ amenities, dust suppression, and concreting activities at each construction site. Quantities and sources of water required for each of these activities are provided in Chapter 21 (Resource use and waste management).

Construction of a water supply pipeline between Little Hartley and the potable water supply network at Lithgow is the currently preferred option for water supply to Little Hartley for the project. The water supply pipeline would be up to around 500 millimetres in diameter and located in a trench up to two metres in depth, subject to localised ground conditions, topography and geology. Ancillary infrastructure such as pumping station(s), pressure valves and other infrastructure may be required to support the pipeline with a slightly larger construction footprint required at these locations. If required, pumping station(s) would be connected to the local power supply network.

This option is subject to ongoing design development in consultation with Lithgow City Council and would include around 14 kilometres of underground pipeline infrastructure. The pipeline would be located within the construction footprint for the Little Hartley to Lithgow Upgrade and within existing and/or new road reserves. The indicative alignment for the water supply route is shown in Figure 5-16.

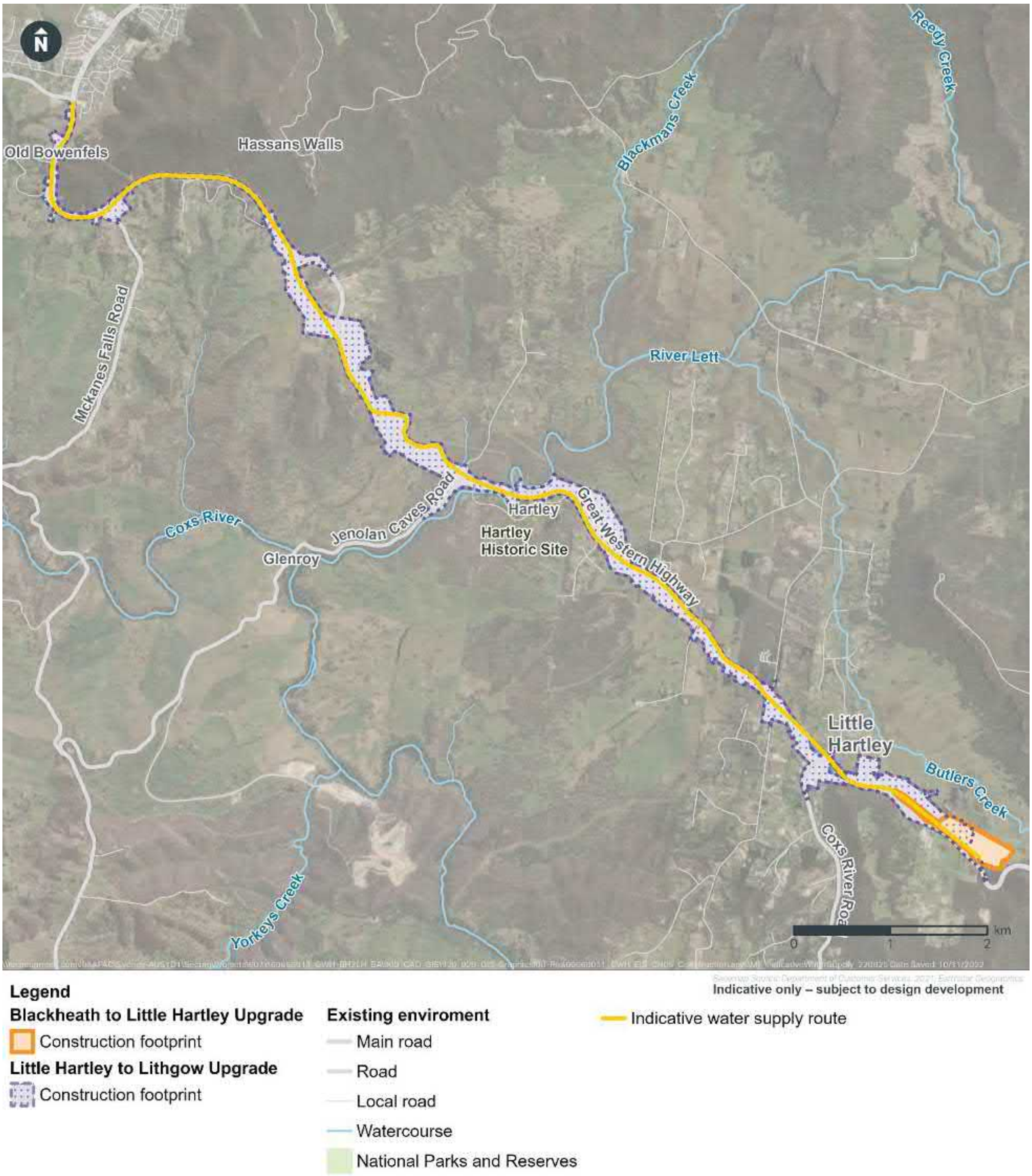


Figure 5-16 Indicative water supply pipeline route

Investigations are ongoing to confirm the water supply option for the project and other options being investigated include the use of groundwater.

Construction of the water supply pipeline would take up to around 18 months and would occur during standard working hours (see Section 5.6), however there may be some situations where out of hours work would be required (for example where partial or full road closures may be required to support construction activities for short periods). Where out of hours work is required, the out of hours works procedure developed as part of the Construction Noise and Vibration Management Plan would be followed. Construction of the pipeline would generally follow the alignment of the Great Western Highway and would largely be located within the construction footprint for the Little Hartley to Lithgow Upgrade where possible.

Construction activities would occur concurrently at several locations moving progressively along the pipeline route. The works are therefore not expected to be in one location for an extended period of time. Key construction activities would include:

- excavation of the pipeline trench, installation of pipeline and backfilling of the excavation
- concrete encasements works
- rehabilitation of disturbed and excavated areas
- connection to Lithgow water supply.

Construction would be staged where possible to occur in conjunction with activities being carried out for the Little Hartley to Lithgow Upgrade.

Open trenching would be adopted for the majority of the alignment and a less intrusive methodology (for example underboring or attachment to bridges) would be adopted where the pipeline interfaces with key features such as roads and riparian corridors. The pipeline would be designed to avoid environmental and heritage impacts, including avoiding and/ or minimising the need for native vegetation removal where possible.

Construction water supply at Blackheath and Soldiers Pinch would be serviced via the existing network with localised upgrades and/or connections to existing infrastructure carried out as required.

Where key water intensive construction activities commence prior to operation of the preferred water supply option, water may need to be trucked to the Little Hartley construction site temporarily until completion of the activities for the water supply option.

5.6 Construction hours

The project would seek to achieve a balance between the overall duration of construction activities and minimising potential construction impacts, including construction noise and traffic related impacts. Project construction hours have been developed in this context.

Where possible, above ground construction activities would be carried out during the recommended standard construction hours as defined by the Draft Construction Noise Guideline (NSW Environment Protection Authority, 2020c):

- 7am to 6pm Monday to Friday
- 8am to 1pm Saturdays
- no work on Sundays or public holidays.

Underground tunnelling activities, associated spoil handling and transport activities and other below ground construction activities would generally take place 24 hours per day, seven days per week. This would include access to the tunnel via the Little Hartley portal and the Soldiers Pinch mid-tunnel access shaft (once the TBMs have tunnelled past the mid-point of the tunnel), as well as material deliveries at these locations.

Construction hours for the project are outlined in Table 5-8.

Table 5-8 Construction hours

Work hours	Activity
24 hours a day, up to seven days a week	• underground construction, including TBM and roadheader tunnelling methodology and construction of roads and other infrastructure within tunnels • operation of TBM tunnelling support infrastructure (grout plants, ventilation, water treatment plant, spoil shed) and deliveries (precast concrete tunnel lining segments and other materials) • 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, if required.
Standard construction hours (Draft Construction Noise Guideline)	• general construction activities at construction sites • surface work including earthworks, stormwater drainage, road pavement and finishing work • construction of surface operational infrastructure • cut-and-cover construction • equipment delivery and waste removal • construction of the water supply pipeline and electricity substation.
Any time	The following activities may also be conducted outside standard construction hours where required, provided the local community has been notified of the work: • utility installations or relocations to minimise utility downtime or to prevent adverse impacts to the relevant utility, utility user or road network • activities as directed by a relevant authority • the occasional delivery of materials via oversized transport as required by the NSW Police or other authorities (including Transport) for safety reasons • work determined to comply with the relevant construction noise management levels at the nearest sensitive receiver • activities agreed with potentially affected receivers.

Tunnelling and associated works would be undertaken 24 hours per day, seven days a week as TBMs would typically operate continuously once commissioned. Delivery of the tunnel segments and other materials to Little Hartley construction site would be required 24 hours per day to ensure progressive installation can be maintained during TBM operations.

Excavation of portals and cross tunnels by road header would also need to operate on a 24 hour per day basis to enable efficient portal excavation and progressive fit-out of the tunnel.

Benefits of carrying out tunnelling and associated works 24 hours per day, seven days a week basis include minimising the duration of the project and associated construction impacts for local residents. It would also reduce the ongoing impacts to freight and light vehicles utilising the existing Great Western Highway by reducing heavy vehicle movements on the road network during the AM and PM peaks.

5.7 Construction environmental management

A Construction Environmental Management Plan(s) (CEMP) will be prepared for the project and may be developed as a series of complementary and coordinated CEMPs to address specific construction sites, construction activities or stages during the construction period. The CEMP(s) will detail the approach to environmental mitigation, management, monitoring and reporting during construction of the project. The CEMP(s) will provide a consolidated environmental management framework, supplemented by more detailed sub-plans and other documentation focused on key environmental issues during construction.

Further information related to the management of construction impacts is provided in Appendix R (Compilation of environmental mitigation measures).

5.7.1 Construction water management

A Construction Soil and Water Management Plan will be prepared to guide the management of water quality during construction. The excavation of the tunnels and mid-tunnel access caverns and shaft would require quantities of potable/ industrial water for:

- TBM coolant
- spoil conditioning
- wash-down and dust suppression
- firefighting
- mixing of grout and bentonite
- drilling.

Groundwater would also be encountered during tunnelling and this, in addition to construction wastewater from the above activities would result in the need to capture, treat and reuse, or discharge water. Treated water would be recirculated to the TBM cutting face or used for surface dust suppression. The reuse of treated water would be maximised during construction works. Other reuse options including use of treated water in nearby construction projects, would be investigated during construction planning.

Treated water that cannot be reused would be discharged from the construction sites via construction water treatment plants, as shown in Figure 5-5 to Figure 5-7. The construction water treatment plant would discharge treated water flows directly to the nearby environment at discharge locations which may include nearby farm dams or the project's sediment and water quality basins. Treated water that does not meet the relevant water quality criteria for discharge would be stored and transported offsite for disposal at an appropriately licensed facility or discharged into the Sydney Water sewer network (subject to an appropriate licence).

Water quality treatment criteria and erosion and sedimentation controls including scour protection and energy dissipation measures to prevent scour of existing channels are discussed in Chapter 14 (Surface water and flooding). Construction water requirements are outlined in Section 5.5.6.

5.7.2 Construction noise management

The potential construction noise impacts and mitigation measures to manage these impacts are discussed in Chapter 11 (Noise and vibration). A Construction Noise and Vibration Management Plan will be prepared in consultation with the relevant local councils. Measures to mitigate construction noise impacts on noise sensitive receivers would be confirmed during ongoing design development and detailed construction planning. Potential management and mitigation measures that would be considered include:

- community consultation
- training of construction workers related to potential noise and vibration impacts and mitigation measures

- use of acoustic sheds
- noise monitoring
- appropriate selection and maintenance of equipment
- scheduling of work for less sensitive time periods
- situating plant in less noise sensitive locations
- construction traffic management
- respite periods.

5.7.3 Construction traffic management and access

Temporary road network modifications

Some temporary modifications to the existing road network would be required during construction, to maintain the functionality of surrounding roads, and to protect the safety of all road users, including pedestrians, cyclists, motorists, public transport users and construction personnel.

Temporary traffic modifications would be staged to minimise impacts to traffic movements and to maintain a minimum of one lane in each direction of traffic movement. Traffic speed zones would also be adjusted to enhance safety around construction sites where required. Construction traffic impacts would be managed under a Construction Transport and Access Management Plan (CTAMP) developed for the project.

Temporary active and public transport network modifications

There are limited formal pedestrian or cyclist facilities near the proposed construction sites. Recreational access for hikers and cyclists near the Browntown Oval intersection may be temporarily impacted by the access to the Soldiers Pinch construction site.

Active transport links would be provided as part of the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade in the vicinity of Blackheath and Little Hartley respectively. These active transport links would be maintained during construction of the project. Where temporary modifications to existing pedestrian or cyclist facilities are required to facilitate construction, impacts would be managed through measures detailed within the CTAMP.

No impacts to public transport services are expected, including to train movements.

Access and vehicle routes and numbers

The indicative access points to the construction sites are shown in the site layout figures presented in Figure 5-5 to Figure 5-7. This would also include local access arrangements to assist with construction staging using both left and right in/out formations. Construction site access would be confirmed during detailed construction planning.

Heavy vehicles movements would be required for a range of construction activities including:

- transport of precast concrete segments to the Little Hartley construction site via the Great Western Highway (eastbound)
- transport of spoil from the construction sites to the off-site spoil reuse facilities considered in Table 5-6 via the Great Western Highway (westbound)
- material delivery and waste removal from all construction sites (westbound)
- deliveries of fuel, plant and equipment.

Indicative average light and heavy vehicle movements at each construction site (two-way) are outlined in Table 5-9. Around 75 per cent of construction workers have been assumed to travel to the project from the east, travelling westbound to the construction sites and eastbound to return home. The remaining 25 per cent of construction workers have been assumed to travel to the project from the west, travelling eastbound to construction sites and westbound to return home.

Peak traffic generating activities, including spoil haulage and TBM segment deliveries would be scheduled to avoid peak days such as weekends, public holidays and major events such as the Bathurst Super Car event where possible. The Little Hartley construction site would have capacity to store spoil and tunnel segments for around three days to accommodate these peak periods.

Table 5-9 Indicative site vehicle access and volumes

Construction site	Maximum vehicle movements in and out (per hour) [1]	Maximum vehicle movements in and out (per day)	Access/egress points
Blackheath	130	440 (270 light vehicles and 170 heavy vehicles)	• Great Western Highway around 950 metres southwest of Evans Lookout Road • intersection of Evans Lookout Road and Great Western Highway • intersection of Valley View Road and B5 Valley View Road Extension (light vehicle access/egress only).
Soldiers Pinch	105	395 (190 light vehicles and 205 heavy vehicles)	• intersection of Great Western Highway and Browntown Oval access road.
Little Hartley	905	3,325 (1,895 light vehicles and 1,430 heavy vehicles)	• Great Western Highway around 1.6 kilometres southeast of Coxs River Road • Great Western Highway around 750 metres southeast of Coxs River Road.

As identified in Section 5.5.1, several locations for spoil reuse are under consideration. The spoil haulage route for the project shown in Figure 5-17 would be westbound via the Great Western Highway and for the purposes of construction traffic and construction traffic noise assessments is assumed to extend to the intersection of the Great Western Highway and Castlereagh Highway. The majority of heavy vehicle movements would be westbound from Little Hartley transporting spoil, however some heavy vehicle movements would also occur westbound from Blackheath and Soldiers Pinch.

Construction workforce parking

The number of construction personnel requiring parking would vary over the duration of the construction program (see Figure 5-15). On-site parking for workers would be provided within the construction footprints, as shown in Figure 5-5 to Figure 5-7. Parking provided at each construction site would be sufficient for the associated worker demand, except for during worker shift changeover where specific measures would be implemented.

Nevertheless, construction workers may choose to use available on-street parking, particularly near the Blackheath construction site. On-site parking provisions for around 500 to 600 vehicles would be included at the Little Hartley construction site. Further discussion of potential parking impacts is provided in Chapter 8 (Transport and traffic).

[1] Maximum hourly construction vehicle movements would occur at around 6am coinciding with worker shift changeover (outside the AM peak hours on the road network). During the road network peak hours, construction vehicle movements would be around 90 vehicle movements per hour.

As part of the CTAMP, the construction contractor(s) would develop a parking and access measures and consider travel demand management measures to minimise the impacts of potential worker parking on nearby on-street parking and the residents and businesses that use these.

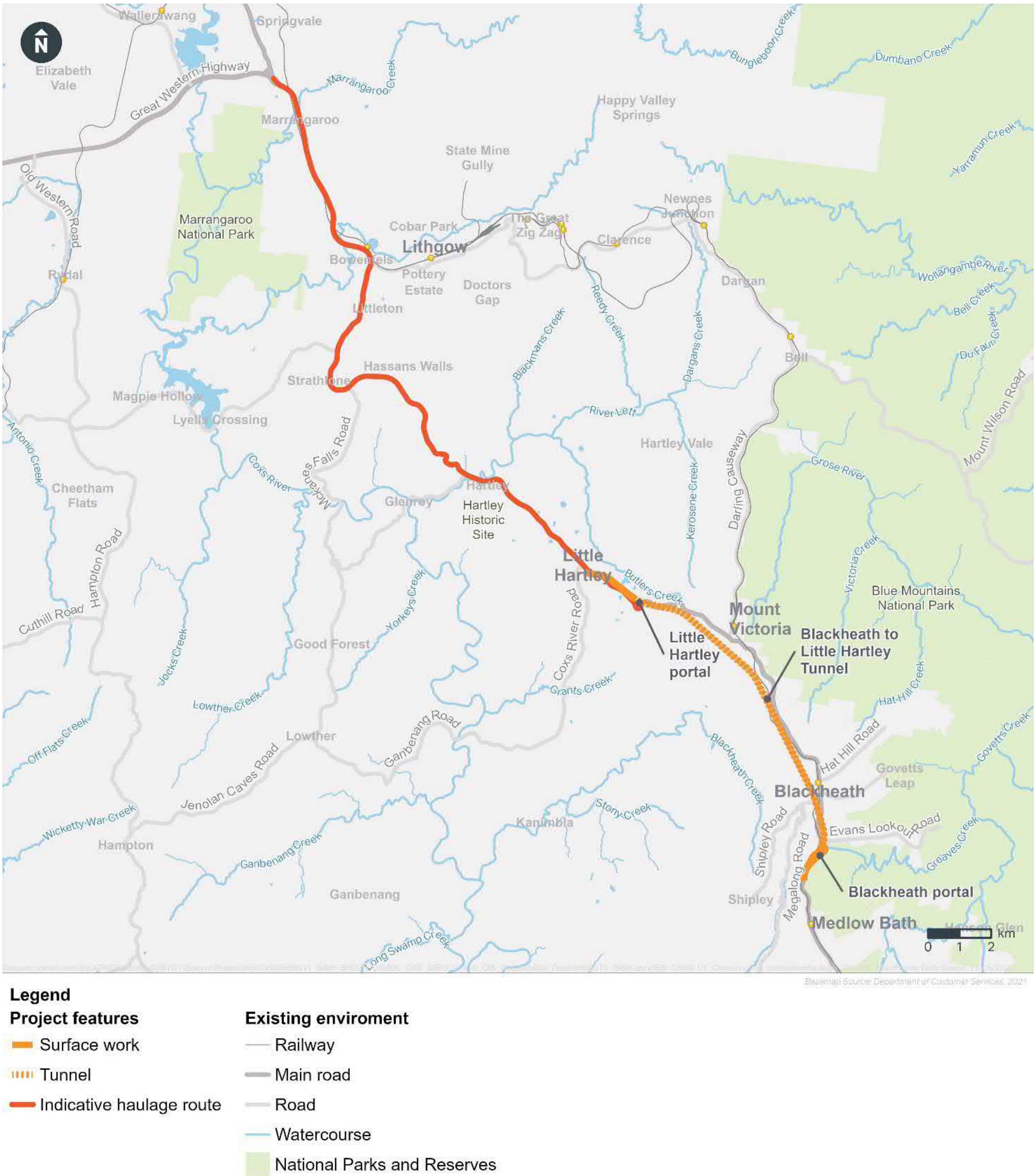


Figure 5-17 Indicative spoil haulage route

6 Statutory context

6.1 Overview

This environmental impact statement (EIS) has been prepared:

- to address the Secretary's environmental assessment requirements (SEARs) for the Great Western Highway Blackheath to Little Hartley Upgrade (the project)
- in accordance with Division 5, Part 8 of the Environmental Planning and Assessment Regulation 2021 (EP&A Regulation)
- having regard to the State Significant Infrastructure Guidelines, particularly Appendix B – preparing an environmental impact statement (Department of Planning, Industry and Environment, 2022) and the State Significant Project Technical Guidelines.

The assessment and approval process for the project under Division 5.2, Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) is shown in Figure 6-1.

The relevant statutory assessment requirements for the project and where they have been addressed in this EIS are identified in Appendix B (Statutory compliance).

6.2 Environmental Planning and Assessment Act 1979

6.2.1 Permissibility

Transport for NSW (Transport) is seeking approval to upgrade the Great Western Highway between Blackheath and Little Hartley (the project) under Division 5.2, Part 5 of the EP&A Act.

The project is defined under Section 2.108 of State Environmental Planning Policy (Transport and Infrastructure) 2021 (Transport and Infrastructure SEPP) as "road infrastructure facilities". On this basis, Section 2.108 of the Transport and Infrastructure SEPP makes the project permissible without consent on any land because it is development for the purpose of "road infrastructure facilities" being carried by or on behalf of a public authority (Transport).

Part of the project at the Blackheath portal traverses land that was previously reserved under the *National Parks and Wildlife Act 1974* as part of the Blue Mountains National Park. The national parks reservation for this area was revoked by the NSW Parliament in August 2022. As a result, the restrictions on permissibility of development on land reserved under the *National Parks and Wildlife Act 1974* presented in Section 2.109 of the Transport and Infrastructure SEPP do not apply to the project.

6.2.2 Power to grant approval

Transport for NSW is seeking State significant infrastructure and critical State significant infrastructure declaration for the project by the Minister for Planning.

As part of this declaration, Schedule 4 and 5 of the State Environmental Planning Policy (Planning Systems) 2021 (Planning Systems SEPP) will be amended to include the project. The Minister for Planning is the approval authority for development declared to the State significant infrastructure. Section 5.17 of the EP&A Act requires that Transport, as the proponent for the project, prepare an EIS for the project as per the process shown in Figure 6-1.

6.3 Other approvals

Other approvals required for the project would include:

- an Environment Protection Licence (EPL) for road construction and for road tunnel emissions under the *Protection of the Environment Operations Act 1997* (POEO Act)
- tenure arrangements under the *Crown Lands Management Act 2016*
- consent from Water NSW under the *Water NSW Act 2014.*

Further information is provided in Appendix B (Statutory compliance).

6.4 Commonwealth approval

The triggers for Commonwealth approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and consideration of the project against these triggers is provided in Appendix B (Statutory compliance).

An assessment of the project's potential impacts on threatened species, ecological communities and migratory species (as discussed in Chapter 12 (Biodiversity)), as well as the Blue Mountains World Heritage Area (as discussed in Chapter 17 (Non-Aboriginal heritage)) found that the project's potential impacts on Matters of National Environmental Significance (MNES) would not be significant. On this basis, approval under the EPBC Act would not be required. Notwithstanding, Transport has submitted a referral under the EPBC Act to the Department of Climate Change, Energy, the Environment and Water (DCCEEW). At the time of finalisation of this EIS there has been no decision on whether the project constitutes a controlled action or not.

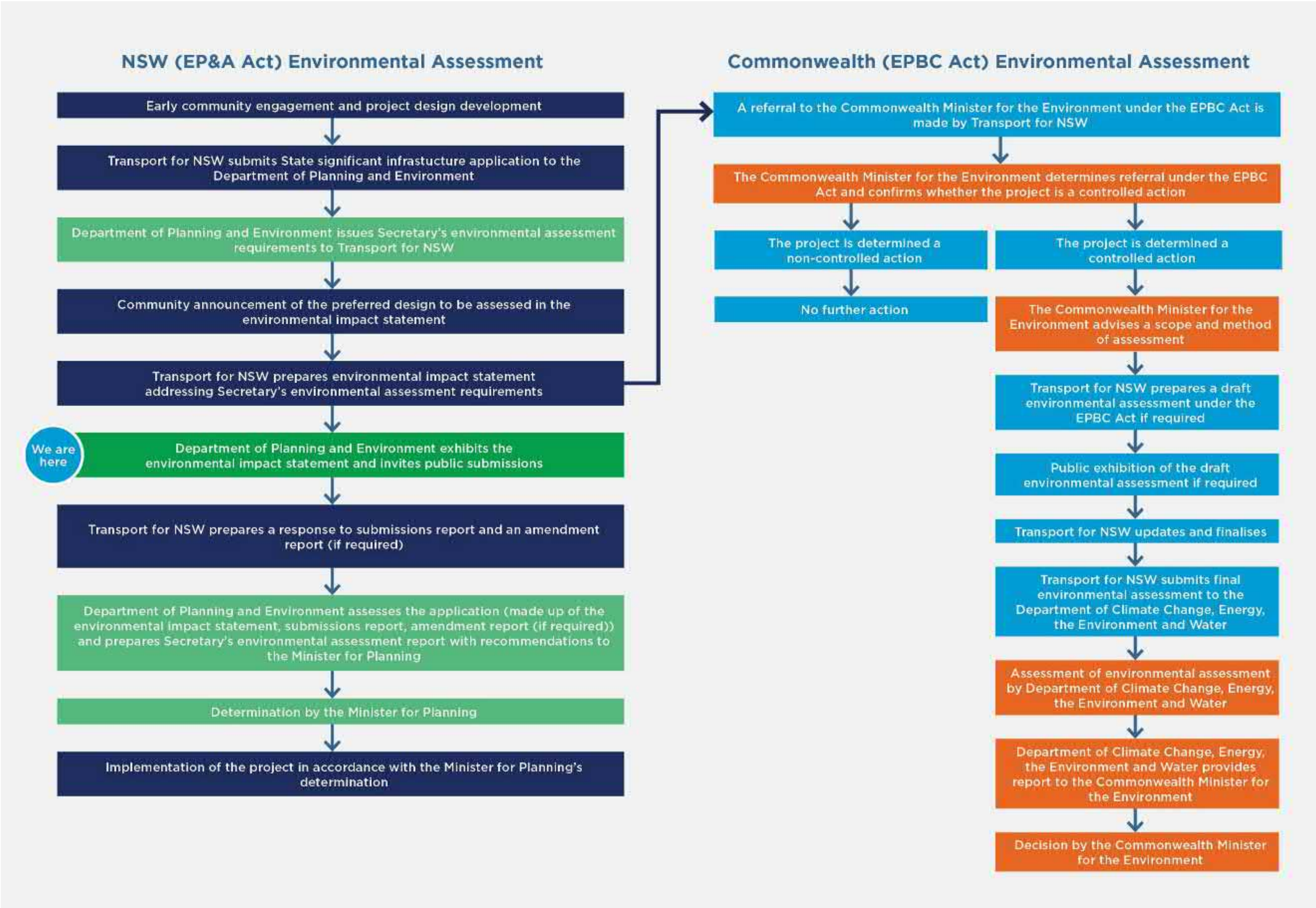


Figure 6-1 New South Wales and potential Commonwealth assessment and approvals processes for the project

7 Community and stakeholder engagement

7.1 Engagement strategy

As part of the broader upgrade of the Great Western Highway between Katoomba and Lithgow (the Upgrade Program), Transport for NSW (Transport) has established a Stakeholder Engagement Strategy (Transport for NSW, 2022h) to guide community consultation activities and communications for the Upgrade Program. A detailed stakeholder analysis has informed the Stakeholder Engagement Strategy.

The Stakeholder Engagement Strategy identifies key objectives and outcomes of engagement activities with the community, stakeholders, and government agencies. The engagement objectives are outlined in Figure 7-1.

The following sections outline the consultation that has been carried out specifically for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). Engagement for the project has been carried out consistent with the Undertaking Engagement Guidelines for State Significant Projects guideline (Department of Planning, Industry and Environment (DPIE), 2021c). For further information on community engagement for the Upgrade Program, refer to Transport's website: nswroads.work/gwhd.

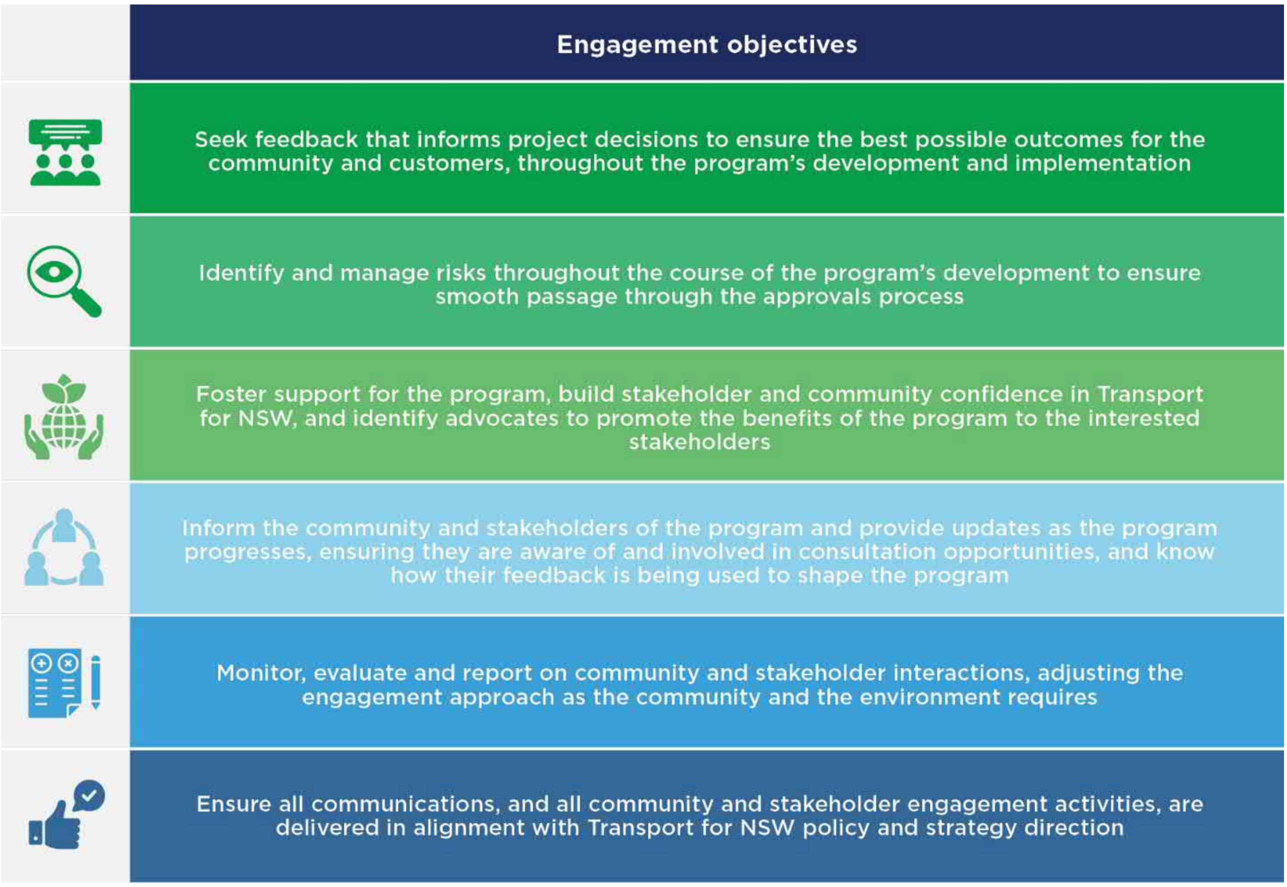


Figure 7-1 Engagement objectives of the Upgrade Program

7.2 Overview

Over the last decade, the NSW Government has progressively upgraded sections of the Great Western Highway between Emu Plans and Katoomba to make it safer and more reliable for all road users. The Upgrade Program will complete and realise the potential of decades of work in upgrading the Great Western Highway across the Blue Mountains.

Engagement with the community and broader stakeholders related to the Upgrade Program commenced in November 2019 and has continued through to the preparation of this environmental impact statement (EIS), including consultation specific to the project.

Consistent with the Undertaking Engagement Guidelines for State Significant Projects guideline (DPIE, 2021c), engagement on the Upgrade Program and the project was started as early as possible. Early engagement on a previous phase of investigation between Mount Victoria to Lithgow was carried out between 2008 and 2013, and focused mainly on consultation about a potential tunnel and viaduct bypass of Mount Victoria. As a result of this early engagement, a corridor for an early concept for a bypass of Mount Victoria was reserved under the Lithgow and Blue Mountains local environmental plans in 2013.

More recent and planned future engagement activities for the project have been described in this chapter in four main phases:

- engagement on the Upgrade Program relevant to early project development, strategic corridor options, route options and engagement with the Blackheath Co-Design Committee (see Section 7.3)
- engagement on the project during preparation of this EIS, including the public release of a preferred option in May 2022 (see Section 7.4)
- planned engagement during and following the public exhibition of this EIS, including the display of the EIS and the preparation of a submissions report and an amendment report (if required) (see Section 7.5)
- planned engagement during construction of the project, including how complaints would be handled (see Section 7.6).

A summary of the community and stakeholder engagement process and activities is shown in Figure 7-2.

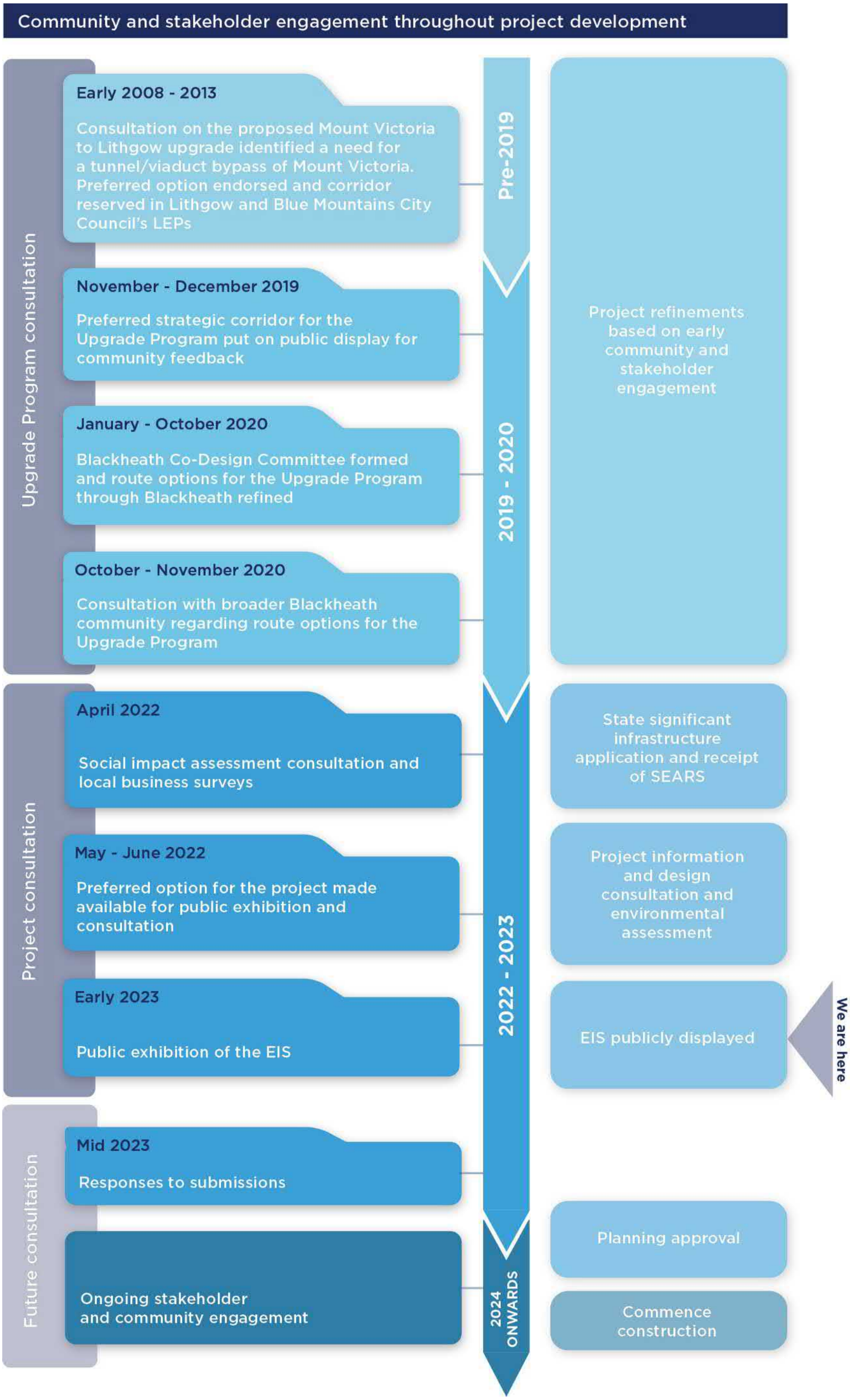


Figure 7-2 Completed and planned community and stakeholder engagement on the project

7.3 Engagement on the Upgrade Program

Key community and stakeholder engagement activities that have been carried out on the Upgrade Program are summarised in Figure 7-3. An overview of key issues raised during these engagement activities are shown in Figure 7-4. Appendix C (Community engagement) details where issues raised through engagement activities have been addressed in this EIS.

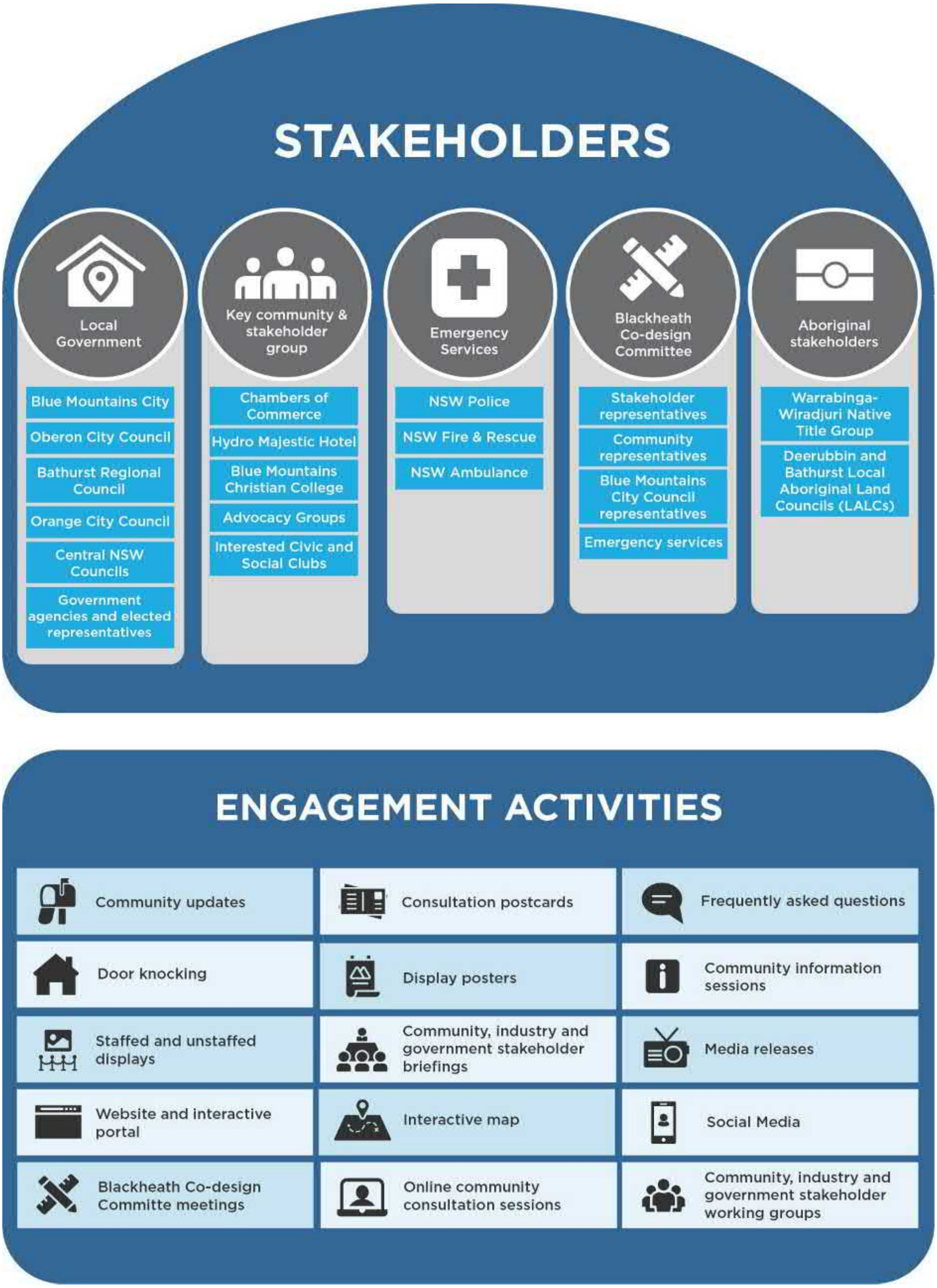


Figure 7-3 Stakeholders and engagement activities during Upgrade Program consultation

Figure 7-4 Key issues raised during engagement on the Upgrade Program

7.3.1 Engagement on the strategic corridor

Between November and December 2019, the preferred strategic corridor for the Upgrade Program was placed on public display and feedback was sought from the community and stakeholders. The strategic corridor presented a route to upgrade and duplicate the Great Western Highway from Katoomba to Lithgow. A wider 'strategic corridor study area' was presented at Blackheath for a route to be decided through further consultation with the community. During this public display period, feedback was collected about the key values and priorities of the community, along with questions or concerns the community had about the Upgrade Program.

Information on the Upgrade Program was displayed between Thursday 7 November and Monday 16 December 2019 at locations including Orange, Katoomba, Bathurst and Oberon libraries. Display locations and website links were included in advertisements in the Central Western Daily, Bathurst Western Advocate, Lithgow Mercury, Blue Mountains Gazette and Oberon Review. This information was also available on the NSW Roads Facebook page. Community information sessions were held in November and December 2019 in Katoomba, Medlow Bath, Blackheath, Mount Victoria, Hartley and Lithgow, and were attended by a total of 1,045 people.

7.3.2 Engagement with the Blackheath Co-Design Committee

As a result of feedback received during engagement on the strategic corridor, Transport established the Blackheath Co-Design Committee (BCC) in early 2020 to enable close collaboration with local stakeholders and community representatives. The BCC comprised various stakeholder group representatives, independently selected community representatives, Blue Mountains City Council and emergency services representatives. Transport sought to discuss and refine route options for upgrading the Great Western Highway through Blackheath early in the design evolution process. BCC's views were a key input into the decision-making process for a preferred route option and design through Blackheath.

The BCC assessed six broad route options, including options provided by the BCC, before unanimously preferring a tunnel bypass of Blackheath, with tunnel portals south of Evans Lookout Road and north of the existing Heavy Vehicle Safety Station at Mount Boyce. The BCC was disbanded following publication of the independent Blackheath Co-Design Committee: consultation process and outcomes report (KJA, 2020), however Transport has continued to engage with BCC members at key milestones of the project.

7.3.3 Engagement on route options

In October and November 2020, Transport consulted with the broader Blue Mountains community regarding route options including:

- the Blackheath to Little Hartley tunnel option, which would include twin tunnels around 11 kilometres long between Blackheath and Little Hartley, connecting to the upgraded Great Western Highway at both ends (long tunnel option)
- the Blackheath and Mount Victoria tunnel bypasses option, comprised of two separate tunnel bypasses (one of Blackheath and one of Mount Victoria) and surface road upgrades between these two locations (short tunnel option).

Engagement was conducted via a virtual engagement room and online webinars due to COVID-19 restrictions on face-to-face consultation. Community feedback was collected through the interactive online portal, online feedback forms, email, mail, phone, during engagement sessions and through hard copy forms placed at the Blackheath Area Neighbourhood Centre.

Results of this engagement process were summarised and high level responses were provided to submissions in the Blackheath Consultation Summary Report (Transport for NSW, 2021a).

In April 2021, Transport released the following consultation reports:

- the Community Consultation Summary Report (Transport for NSW, 2021h) which summarised the outcomes from the Blackheath route options consultation described above
- a Community Update for the preferred tunnel option (Transport for NSW, 2021i) presenting the Blackheath to Little Hartley tunnel as the preferred option for the project.

7.4 Engagement on the project during preparation of this EIS

Project information and feedback mechanisms have continued to be available during development and preparation of this EIS. These mechanisms were complemented with direct community and stakeholder engagement activities focused on:

- providing information and project updates at key stages during design development
- engagement with affected landowners and community groups about the project and key design decisions that may affect them
- engagement and coordination with Transport and other infrastructure providers, particularly around project interfaces and in relation to cumulative impacts at Blackheath and Little Hartley
- engagement with regulatory agencies to ensure a complete and robust EIS.

7.4.1 Social impact assessment consultation

Engagement activities for State significant projects should be proportionate to the scale, likely impacts and likely interest the community might have in the project (DPIE, 2021e). Along with the broader project consultation carried out during EIS preparation, residential interviews, business surveys and stopper surveys (surveys of pedestrians within shopping precincts near the project), were conducted during preparation of the EIS to inform the social impact assessment and business impact assessment for the project, detailed in Chapter 19 (Social impacts) and Chapter 20 (Business, land use and property) respectively. The outcomes of residential interviews, business surveys and stopper surveys are further described in Sections 4-6 of Appendix O (Technical report – Social).

Residential interviews

A total of 119 residences across Blackheath, Mount Victoria and Little Hartley were visited, and 46 respondents participated. The residential interviews were carried out in April 2022. Key findings from the residential interviews are summarised in Figure 7-5.

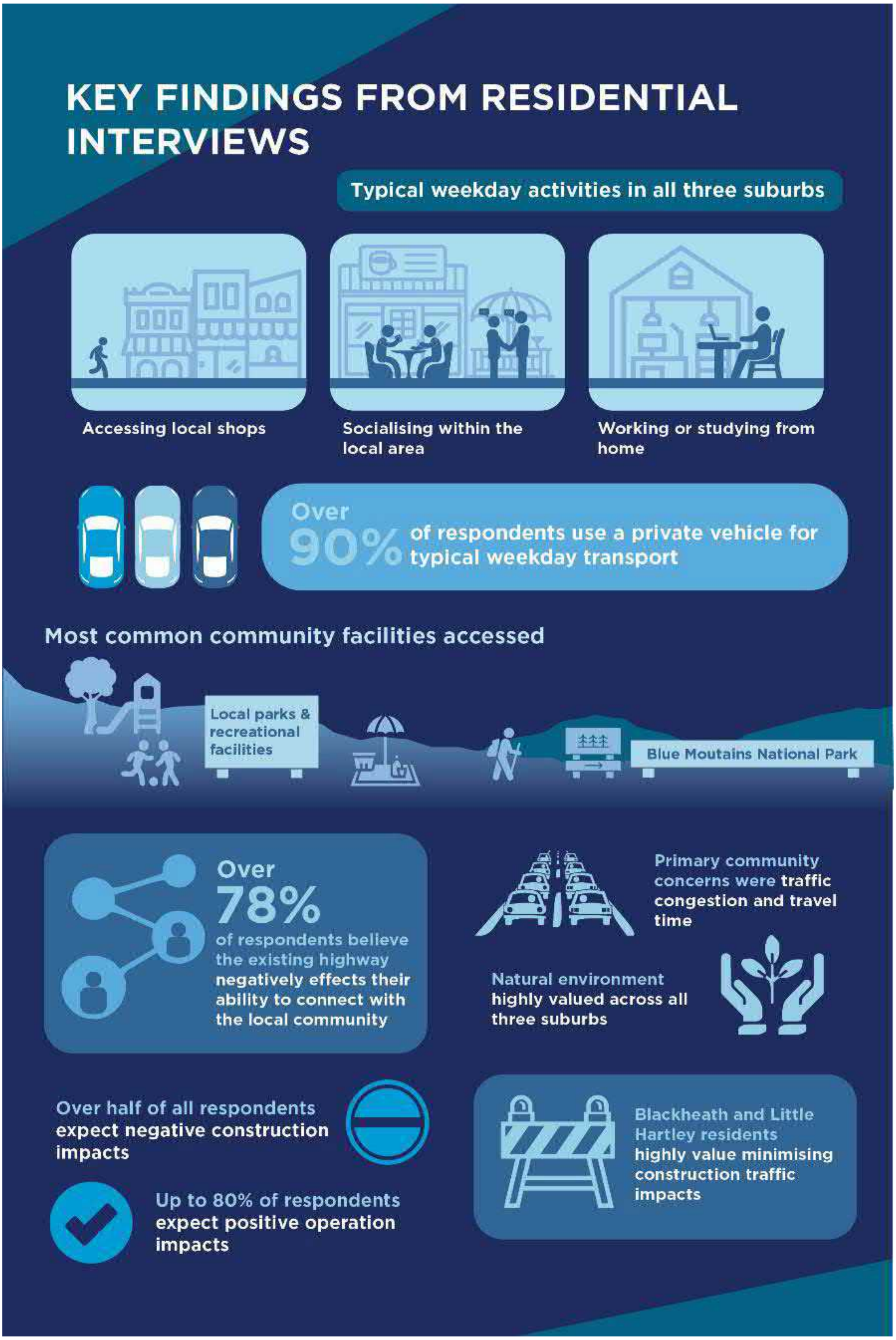


Figure 7-5 Key findings from residential interviews

Business surveys

A total of 45 businesses across Blackheath, Mount Victoria, Little Hartley, and other areas along the Great Western Highway were offered the opportunity to complete a survey, of which 35 businesses participated. The business surveys were carried out in April 2022. Key findings from the business surveys are summarised in Figure 7-6.

Figure 7-6 Key findings from business surveys

Stopper surveys

A total of 84 stopper surveys were conducted at various locations across Blackheath, Mount Victoria and Little Hartley. The stopper surveys were conducted during the NSW school holidays in April 2022. Key findings from the stopper surveys are presented in Figure 7-7.

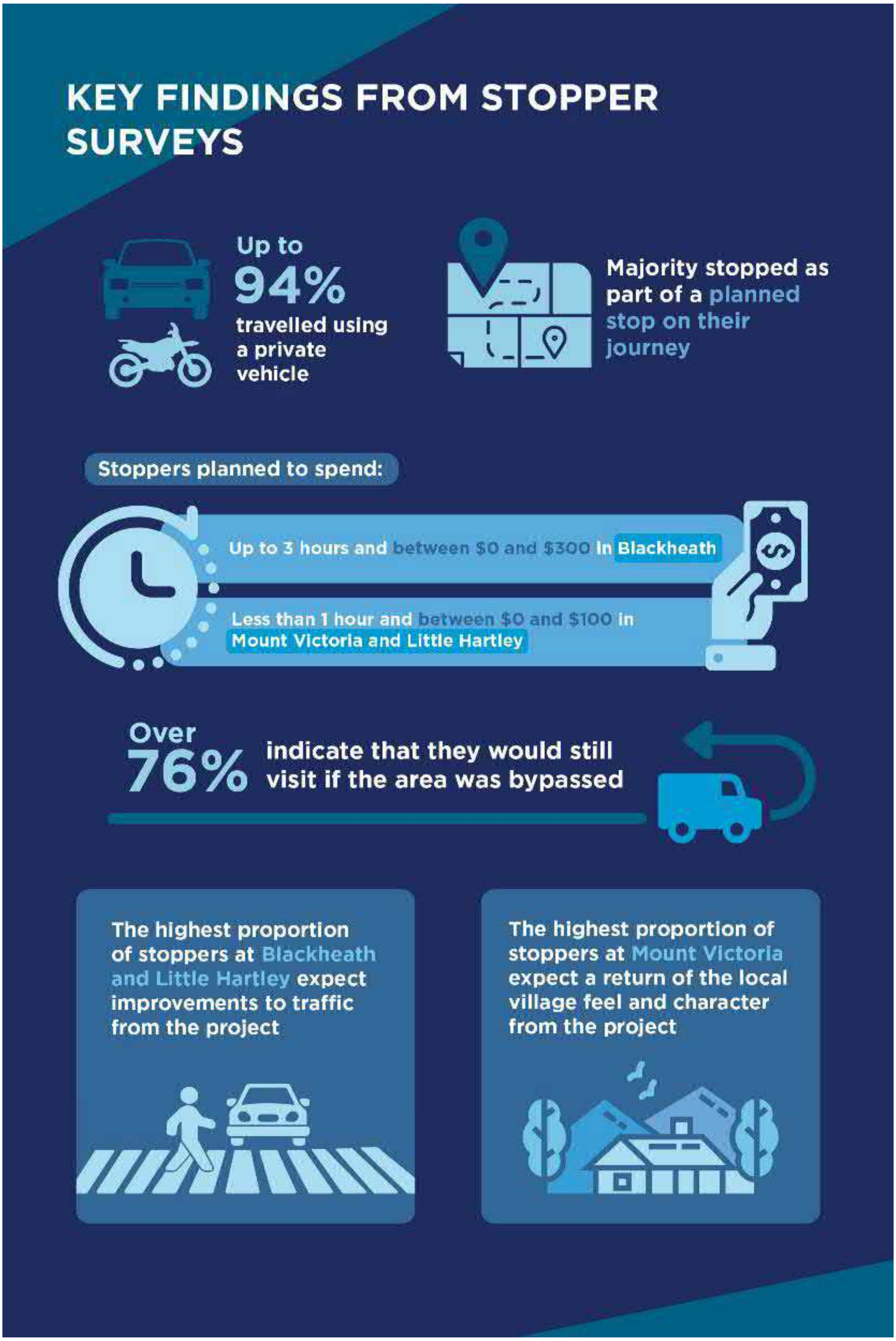


Figure 7-7 Key findings from stopper surveys

7.4.2 Engagement on the preferred option

Following announcement of the Blackheath to Little Hartley tunnel option (i.e. the long tunnel option) as the preferred option for the project by Transport in May 2022, a range of communication and engagement channels were used to inform the community. These included a community update, door knocks to 155 properties located above the tunnel alignment, e-newsletter, radio and newspaper announcements, phone calls to key stakeholders, stakeholder briefings, social media promotion and an interactive map and website. These engagement channels were used to:

- maximise the reach of the preferred option announcement
- provide more detail about the preferred option and why it was selected
- provide visual, easy to understand and non-technical information to the community
- enable detailed information to be provided on issues that matter to the community
- advertise the community drop in and online information sessions
- provide information to digital and non-digital communication platform users in the community.

In May and June 2022, Transport conducted briefings with key stakeholders and held face to face and online information sessions to present the preferred option to the community. These information sessions, along with the other engagement strategies detailed above explained why the preferred option was selected based on project objectives, design elements, potential environmental and community impacts, road user safety and efficiency, responses to community feedback, future proofing and cost.

Engagement with the community, key stakeholders and government agencies has continued during development of this EIS. Community engagement activities and key stakeholders relevant to the announcement of the preferred option are shown in Figure 7-8.

Feedback provided by government agencies, key stakeholders and the wider community was analysed and considered during the preparation of this EIS.

A summary of the key issues raised by the community on the preferred option in May and June 2022 is shown in Figure 7-9. The size of the circle for each issue reflects the relative level of interest raised.

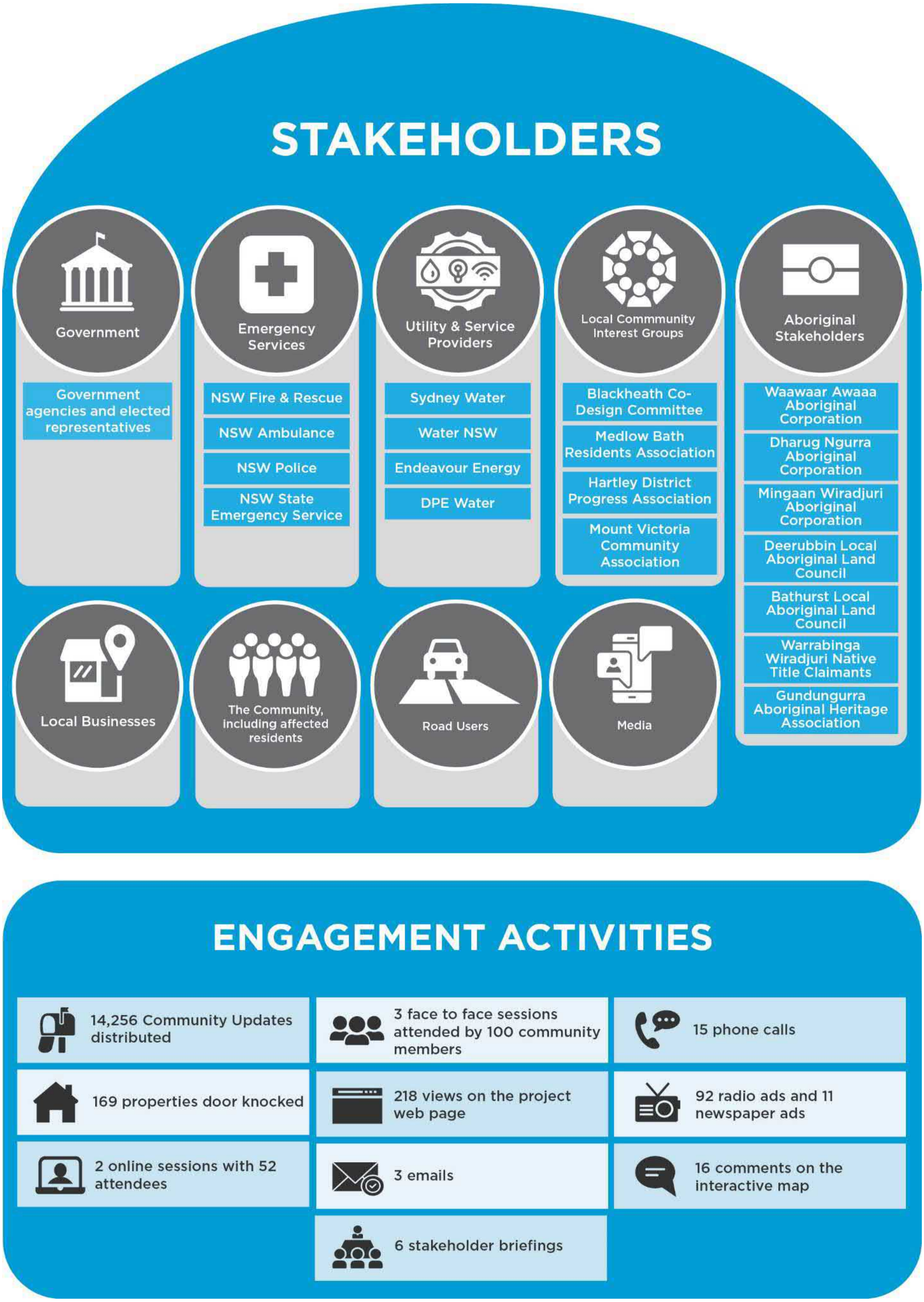


Figure 7-8 Stakeholders and engagement activities during the preferred option consultation

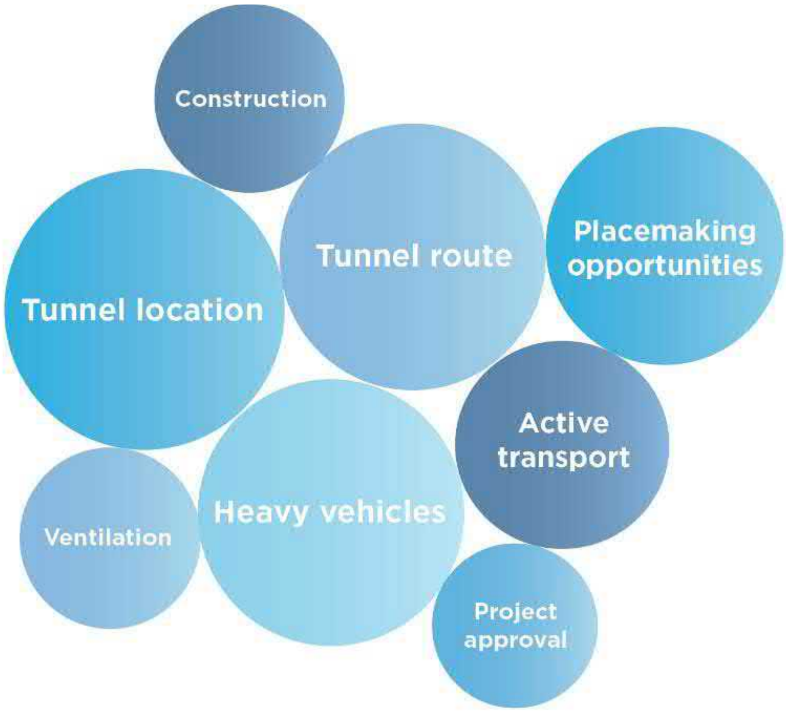


Figure 7-9 Summary of key issues raised by the community on the preferred option

7.4.3 Agency and stakeholder consultation

A summary of consultation carried out with government agencies and key stakeholders during preparation of the EIS is provided in Table 7-1.

Table 7-1 Government agency and key stakeholder consultation

Agency	Technical matter	Summary of consultation
NSW Department of Planning and Environment (DPE)	General	Transport provided an overview of the project and approach to the EIS as part of regular and ongoing consultation. The State significant infrastructure application and assessment process was discussed.
DPE and Commonwealth Department of Climate Change, Energy, the Environment and Water	Commonwealth matters (EPBC Act)	Transport provided an overview of the project and Commonwealth matters under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that have the potential to be affected by the project.
DPE	Biodiversity	Transport provided an overview of the project and the Secretary's environmental assessment requirements related to biodiversity. Transport also presented the survey work carried out to date to inform the existing environment and the proposed approach to the Biodiversity Development Assessment Report.
	Social impacts	Transport provided an overview of the project as well as the proposed assessment methodology and approach to the social impact assessment including consideration of the Engagement Guidelines (Department of Planning, Industry and Environment, 2021c) and Social Impact Assessment Guidelines

Agency	Technical matter	Summary of consultation
		(Department of Planning, Industry and Environment, 2021e), survey work, community consultation and the scope of the social impact assessment.
DPE, Health NSW and NSW Environment Protection Authority (EPA)	Noise and vibration	Transport provided an overview of the project and the Secretary's environmental assessment requirements related to noise and vibration. Transport also presented the proposed assessment methodology for the construction and operational noise and vibration assessment including the results of the noise monitoring and traffic surveys.
DPE, Health NSW, EPA, NSW Chief Scientist and Health Protection NSW	Air quality and human health	Transport provided an overview of the project and the Secretary's environmental assessment requirements related to air quality and human health. Transport also presented the two ventilation design options assessed in this EIS (ventilation outlets and portal emissions) and the proposed assessment methodology and approach to the air quality and human health assessments.
DPE and EPA	Contamination	Transport provided an overview of the project and the Secretary's environmental assessment requirements related to contamination. Transport also presented the proposed assessment methodology for the contamination assessment, potential areas of environmental interest and proposed timing for future detailed site investigations.
DPE Water	Groundwater	Transport provided an overview of the project as well as the geological setting of the project and design elements relevant to groundwater. Transport also presented the proposed approach to the conceptual hydrological model and the numerical model.
Blue Mountains City Council	General	Transport provided an overview of the project and approach to this EIS.
Lithgow City Council	General	Lithgow City Council was not available to join the briefing with the State Emergency Services discussed below related to potential flooding impacts at Little Hartley, however was provided with the presentation material and briefing minutes.
State Emergency Services	Flooding	Transport has engaged with the State Emergency Services on existing and proposed emergency management, evacuation and access and contingency measures and impacts the project may have on community emergency management arrangements and flooding.
State Design Review Panel (SDRP)	Urban design	Transport has met with the SDRP to review the current project design and to seek advice and recommendations. Further information on the SDRP process is provided in Section 4.2.6.

7.4.4 Summary of project community feedback

A summary of the key issues raised by the community on the project is provided in Table 7-2. Appendix C (Community engagement) outlines where in the EIS these key issues are addressed.

Table 7-2 Key issues raised by the community on the project

Theme	Key issues raised
Design of the project and any alternatives	
Project alternatives and options	**Strategic alternatives** • rail options should be considered as an alternative to upgrading the existing Great Western Highway through the townships and communities in the Blue Mountains • upgrade of the Bells Line of Road should have been considered as an alternative to the upgrade of the Great Western Highway between Katoomba and Lithgow (the Upgrade Program) • support for surface improvements to the existing Great Western Highway, rather than a tunnel • questions related to whether the project includes upgrade of the existing Great Western Highway • support for a tunnel to be built as part of the Upgrade Program consistent with a 2019 NSW Government election commitment • interest and support for the Upgrade Program providing a faster and safer connection through and between the Blue Mountains and Sydney.
	Tunnel options • support for a Blackheath to Little Hartley tunnel option, which would include twin tunnels around 11 kilometres long between Blackheath and Little Hartley, connecting to the upgraded Great Western Highway at both ends (long tunnel option) as part of 2020 consultation on Blackheath route options • support for a Blackheath and Mount Victoria tunnel bypasses option, comprised of two separate tunnel bypasses (one of Blackheath and one of Mount Victoria) and surface road upgrades between these two locations (short tunnel option) as part of 2020 consultation on Blackheath route options • concern that the route for the preferred option did not resemble previous options investigated.
	Ventilation options • request for further information regarding the type of ventilation outlet that would ensure safe operation of a tunnel.
Placemaking	• request for further information on the placemaking opportunities that would be delivered by the project • request for further information on the plans for Mount Victoria village.
Economic, environmental and social impacts	
Environment	**Heritage, the Blue Mountains National Park and Greater Blue Mountains World Heritage Area** • concern regarding protecting the cultural and historic heritage of the townships along the Great Western Highway • concern regarding potential impacts to the sense of community of the townships in the Blue Mountains and the Greater Blue Mountains World Heritage Area • request for further details regarding the potential impacts on the Blue Mountains National Park and the process for revocation of National Park land at Blackheath.

Theme	Key issues raised
	Air quality • concern relating to the location of potential ventilation outlets and how air pollution would be managed • concern relating to potential visual impacts of ventilation outlets.
	Noise and pollution • concern regarding noise and pollution during operation of the Upgrade Program.
	Biodiversity • concern regarding potential impacts of the project on local native flora and fauna • concern regarding potential impacts of the Upgrade Program on the surrounding natural environment.
	Water quality • concern regarding the potential impact of tunnelling on water systems and aquifers • concern regarding the potential impact of construction on groundwater and the Sydney drinking water catchment.
	General environmental assessment • request for more information regarding technical investigations, assessment, and studies for the Upgrade Program.
Transport and traffic	**Congestion and traffic volumes during operation of the Upgrade Program** • concerns regarding the safety of road users, including cyclists, as a result of increased heavy vehicles on the highway and the multiple speed limit changes • concern regarding increased traffic congestion in towns where congestion is already an issue • concern about traffic volumes and safety along the Great Western Highway.
	Freight and dangerous goods • queries related to road freight on the corridor, including consideration of wide loads • concern regarding the increased size of freight vehicles moving through communities and potential impacts to tranquillity and pollution • queries related to the transportation of dangerous goods in the tunnel • concern regarding heavy vehicles opting to use the surface road rather than the tunnel to access Darling Causeway at Mount Victoria.
	Speed • request that the speed limit should remain a consistent 100 km/h to support the current and future demand for an efficient connection from Sydney to the Central West region.
	Active transport • queries related to whether cycle paths will be provided by the project and how uptake will be encouraged as the current use of shared paths in the area is low.
Property and business	• request for information on the property acquisition process • concern regarding lack of certainty about route options for homes and businesses, particularly at Blackheath • concern from business owners that their livelihoods will be affected if their businesses are acquired or impacted by the project • concern regarding impacts to recreational opportunities which attract tourists to the region and provide economic benefit to local industry.

Theme	Key issues raised
Construction impacts	**Impacts on property and receivers** • concern regarding the impact of construction on the environment and existing properties • interest in the construction timeframe for the Upgrade Program • concern related to commuter congestion during construction of the Upgrade Program, including impacts on local roads • concern regarding construction noise and disruption from the project.
	Construction workforce • queries regarding local employment opportunities during construction.
	Spoil and waste • queries regarding how spoil management including removal, duration of work, reuse, and heavy vehicle movements would occur during construction.
	Hazards and risk • concerns regarding rock falls due to geological disturbance from construction of the tunnels.
Community engagement	
Community consultation	• interest in the 2020 co-design process for the Upgrade Program and how the community could be involved • request for a longer consultation period for the 2019 strategic corridor consultation, away from the Christmas holidays • request for extended consultation periods and face-to-face consultation methods, during 2020 consultation, as well as suggestions for future engagement.
Strategic context	
Business case and cost	• interest in the status and development of the Upgrade Program business case, cost benefit analysis and economic impact assessment • concerns the Upgrade Program would not provide a strong return on investment • queries around whether the project was supported by Infrastructure Australia.

7.5 Engagement during public exhibition of the EIS

7.5.1 Display of the EIS

DPE has placed this EIS on public exhibition. The EIS is available for viewing and download from the NSW Government major projects website (https://www.planningportal.nsw.gov.au/major-projects/projects/great-western-highway-blackheath-little-hartley).

During this exhibition period, government agencies, project stakeholders and community members can review the EIS and make a written submission to DPE for consideration in its assessment of the project.

Advertisements have been placed in newspapers to advise of the public exhibition and provide details on proposed community engagement activities and information sessions.

Transport has made copies of the EIS available for viewing for public convenience at the following locations:

- Blackheath Library, Blackheath
- Katoomba Library, Katoomba
- Lithgow Library, Lithgow

- Lithgow City Council building, Lithgow
- Blue Mountains City Council building, Katoomba
- Hartley Fresh & Café, Hartley.

A series of community engagement activities will be carried out during public exhibition of the EIS including innovative approaches via online engagement in line with Undertaking Engagement Guidelines for State Significant Projects guideline (DPIE, 2021c). These include:

- community update
- an interactive map on Transport's Upgrade Program website
- fact sheets which summarise the technical assessments in this EIS
- responses to frequently asked questions
- community information sessions (both in person and via online engagement tools)
- print, radio and social media advertising
- stakeholder briefings.

7.5.2 Preparation of the submissions report

Copies of submissions made during exhibition of the EIS would be provided from the Secretary of DPE to Transport as the proponent. The Secretary will then require Transport to respond to issues raised in submissions through a submissions report, and an amendment report (where required) to outline any proposed changes to the project. If an amendment report is required, DPE would make it publicly available if DPE considers significant changes are proposed to that assessed in this EIS.

DPE would prepare the Secretary's environmental assessment report and provide it to the Minister for Planning, who would then decide whether to approve the project. If approved, the Minister would identify a set of conditions of approval for Transport to adhere to during construction and operation of the project.

During the assessment process, Transport will continue to engage with the community and key stakeholders. Further details regarding the assessment and approval process following EIS exhibition can be found in Chapter 6 (Statutory context).

7.6 Engagement during construction of the project

If the project is approved, Transport would procure a construction contractor(s) to carry out design development and construction of the project. Communication and engagement with stakeholders and the community during project construction would be the responsibility of Transport and the construction contractor(s).

The objectives of engagement activities supporting construction of the project are:

- to keep the community and stakeholders informed about the project including construction activities, work programs and associated impacts
- to ensure opportunities to provide feedback or register complaints about the project and its impacts
- to provide a process for resolving complaints and issues raised.

The community and stakeholder engagement carried out during construction would include updates on planned construction activities and would respond to concerns and enquiries in a timely manner, seeking to minimise potential impacts where possible.

During construction, a dedicated community relations team would deliver:

- a community communications strategy to detail the processes and facilitate communication and feedback between Transport and the community

- notification letters and phone calls to residents and businesses affected by construction works notifying them of matters such as changes to traffic arrangements and out of hours works
- face to face meetings with landowners and community groups as needed
- regular community updates on the progress of the construction program
- regular updates to the project website
- media releases and project advertising in local and regional newspapers to provide the community with information on how to contact Transport
- site signage around construction and ancillary facilities
- a 24-hour, toll-free project information and complaints line, a dedicated email address and postal address.

A Social Impact Management Plan will also be prepared and implemented for the project. This plan will identify directly affected communities, businesses and stakeholders, document mitigation measures that will be implemented in response to the key social impacts identified for the project and document a feedback and complaints handling processes (refer to Chapter 19 (Social impacts)).

7.6.1 Coordinating engagement activities

Community engagement during construction of the project would potentially occur at the same time as engagement carried out for the other components of the Upgrade Program (i.e. upgrades to the Great Western Highway between Katoomba and Blackheath, and between Little Hartley and Lithgow), which would be under construction at the same time as the project.

The project communications team would participate in monthly inter-agency working group meetings to facilitate coordination with adjacent projects.

The indicative construction program for the project including the relationship with other components of the Upgrade Program is shown in Table 5-1 of Chapter 5 (Construction).

7.6.2 Managing complaints

Complaints received during project construction would be managed by:

- identifying complaints (including for other components of the Upgrade Program) that may also be relevant to the project and its construction sites
- analysing the cause and preparing a response to each complaint
- determining whether the project would result in similar or overlapping impacts with other projects, which are likely to result in a complaint.

A complaints management system would be implemented for the duration of construction. This would include recording complaints and how the complaint has been addressed (within a complaint register). Complainants would be contacted within 24 hours to follow up and respond to their complaint. An independent specialist would oversee the system and follow-up on any complaint where the public is not satisfied with the response.

Transport has built strong working relationships with the project teams for the other Upgrade Program projects to help identify stakeholders and community members who may be susceptible to complaint fatigue.

7.6.3 Managing consultation fatigue

Consultation fatigue occurs when a community is subject to a large number of engagement activities, either from a singular project or multiple projects occurring concurrently. This may occur given the development of the project has occurred over multiple years (as shown in Figure 7-2) and given the concurrent planning of other components of the Upgrade Program (as shown in

Figure 5-1 in Chapter 5 (Construction)). The impacts and extent of consultation fatigue during project construction would be assessed by:

- identifying stakeholders and community members potentially impacted by both previous and/ or current projects (including the project and other components of the Upgrade Program) to carry out more targeted, purposeful engagement
- analysing the type, extent, and timing of consultation – for the project and other components of the Upgrade Program – that has been or would be received by stakeholder and community members
- determining whether consultation for the project is likely to result in overload or disinterest for stakeholders and community members.

The project's community relations team would build a working relationship with the other Upgrade Program project teams to identify those persons or organisations who may be susceptible to consultation fatigue.

Transport would work to develop an integrated approach to contacting persons or organisations which may experience consultation fatigue and would determine which communication mechanisms stakeholders prefer.

7.6.4 Managing construction fatigue

Construction fatigue occurs when a community is subject to continued effects of construction, either from the longevity of a singular project's construction or multiple projects occurring concurrently. The impacts and extent of construction fatigue during project construction would be assessed by:

- identifying where the project would have sustained impacts to stakeholders or community members
- identifying whether the project would result in similar or overlapping impacts with other projects, to the same stakeholders or community members
- analysing whether the project would increase the magnitude and intensity of overlapping impacts on any stakeholders or community members
- analysing the duration of impacts for stakeholders or community members.

The cumulative assessment carried out for the project is provided in Chapter 24 (Cumulative impacts). This assessment identifies areas where construction of the project would overlap, coincide and/or be concurrent with construction of other Upgrade Program components, particularly at Blackheath and Little Hartley and how receivers would be affected including by construction fatigue. This assessment also outlines mitigation measures proposed to address these issues.

During construction of the project, the project's community relations team would build a working relationship with the other Upgrade Program project teams to identify stakeholders or community members who may be susceptible to construction fatigue. Transport would ensure the expectations of these stakeholders or community members for the project are managed.

8 Transport and traffic

This chapter summarises the transport and traffic assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full assessment is provided in Appendix D (Technical report – Transport and traffic).

8.1 Assessment approach

The methodology for assessing potential transport and traffic impacts from the project included:

- analysis of road network performance statistics which included:
  - review of the existing road network (see Section 8.2.1 to Section 8.2.5) and development of an operational traffic model based on strategic traffic forecasting (see Section 8.1.1 for the modelling approach)
  - analysis of construction and operational impacts of the project under various modelled scenarios (see Sections 8.3 and 8.4)
- review of existing local road access and parking arrangements (see Section 8.2.1) and analysis of construction and operational changes to existing parking arrangements (see Section 8.3.1 and Section 8.4.1 respectively)
- review of existing public transport routes and services (see Section 8.2.2) and analysis of construction and operational impacts to public transport (see Section 8.3.2 and Section 8.4.2 respectively)
- review of the existing active transport network (see Section 8.2.3) and analysis of the construction and operational impacts to active transport (see Section 8.3.3 and Section 8.4.3 respectively)
- identification of suitable mitigation measures to manage potential impacts (see Section 8.5.2).

8.1.1 Road network modelling approach

Traffic modelling was carried out using available data to determine existing traffic conditions, and to make realistic predictions about future traffic conditions. This included estimating travel demand and traffic volumes for the project and the surrounding road network during construction and operation. The potential for additional traffic to be attracted to the Great Western Highway during operation of the project was also considered, and it was concluded that the project would be unlikely to generate new trips that would not have otherwise occurred (induced demand). Higher productivity vehicles that can transport larger freight volumes that are not permitted to use the existing Great Western Highway would be able to use the tunnel and are likely to result in increased freight transport efficiency.

Predictions about future traffic conditions were used to assess the performance of the road network both with and without the project, and to determine potential impacts during construction and operation. The traffic scenarios that were considered are detailed in Table 8-1.

The Operational Travel Model was designed to assess the cumulative impacts and benefits of the Great Western Highway Upgrade Program – Katoomba to Lithgow (Upgrade Program). The following assumptions were made in the Operational Travel Model:

- while the Katoomba to Blackheath Upgrade, Medlow Bath Upgrade and the Little Hartley to Lithgow Upgrade would be constructed and in operation by 2026, these have not been included in the 'with project' construction year scenario (2026) given the Operational Travel Model only assesses cumulative impacts and benefits associated with the entire Upgrade Program during operation

- all Upgrade Program components would be operational during the operational scenarios and have been included in the Operational Travel Model for 2030 and 2040.

Table 8-1 Traffic modelling scenarios considered

Year	Scenario	Project inclusion	Upgrade Program inclusion	Description
2018	Base year scenario[1]	Without	None	A base year model developed to replicate the existing traffic conditions on the Great Western Highway between Katoomba and Lithgow, including the model domain (within which the study area is contained) as shown in Figure 8-2. This scenario was used to extrapolate traffic demands in the future year scenarios.
2026	Construction year scenario	With	None	A construction year model based on the peak year construction activities for the project and traffic forecasts for 2026.
		Without	None	A model based on an unchanged existing road network (the existing Great Western Highway without project construction activities) and traffic forecasts for 2026.
2030	Operational year scenario (at project opening)	With	All Upgrade Program components[2]	An operational year model based on the additional road network provided by the project and traffic forecasts for 2030 (the year the project is open to traffic).
		Without	None	A model based on an unchanged existing road network (the existing Great Western Highway without the project) and traffic forecasts for 2030.
2040	Operational year scenario (10 years after opening)	With	All Upgrade Program components[2]	An operational year model based on the additional road network provided by the project and traffic forecasts for 2040 (ten years after the project is open to traffic).
		Without	None	A model based on an unchanged existing road network (the existing Great Western Highway without the project) and traffic forecasts for 2040.

Table notes:
1. 2018 was selected as the base year scenario given the impacts of the COVID-19 pandemic on travel patterns between 2020-2022.
2. Assumes the Katoomba to Blackheath Upgrade, the Medlow Bath Upgrade and the Little Hartley to Lithgow Upgrade are all operational by 2027, 2024 and 2026 respectively.

In summary, traffic modelling was developed using a four-tier system, which included:

- tier 1 – application of Transport's Regional Travel Model as a strategic modelling basis, and previous analysis completed using the Regional Travel Model to forecast growth in private vehicle travel for the Upgrade Program

- tier 2 – supplementing the existing Regional Travel Model with Transport's Strategic Freight Model and previous analysis completed using the Strategic Freight Model to develop future freight forecasts for the Upgrade Program
- tier 3 – operational traffic modelling using an Operational Travel Model for the project which used traffic demand inputs to analyse the traffic conditions that would likely occur with and without the project
- tier 4 – intersection modelling using the SIDRA intersection software to assess the performance of intersections with and without the project.

The Regional Travel Model is based on land use assumptions and forecast population growth for NSW and the ACT and is typically used to analyse transport network changes on regional passenger transport demands. The future freight forecasts extrapolate freight movements for future years by applying annual growth rates from the Strategic Freight Model.

The modelling approach and assessment scenarios are shown in Figure 8-1 and described in detail in Section 3 of Appendix D (Technical report – Transport and traffic). The Operational Travel Model domain includes the project, the broader Katoomba to Lithgow corridor, and Bells Line of Road, as shown in the inset to Figure 8-2. The study area applied to assessment of transport and traffic impacts from the project, including the area for SIDRA modelling, is also shown in the figure.

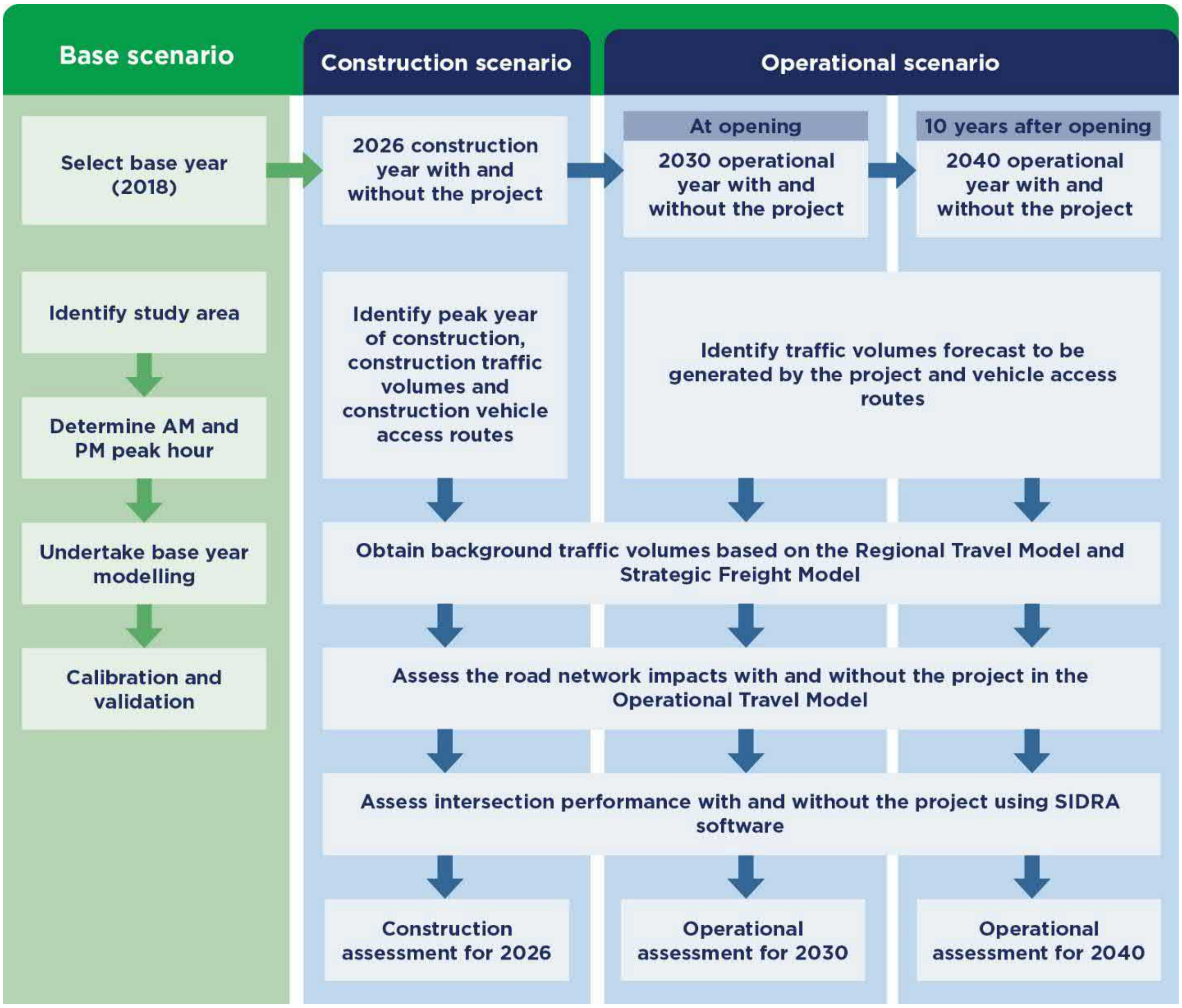


Figure 8-1 Summary of modelling approach and assessment scenarios

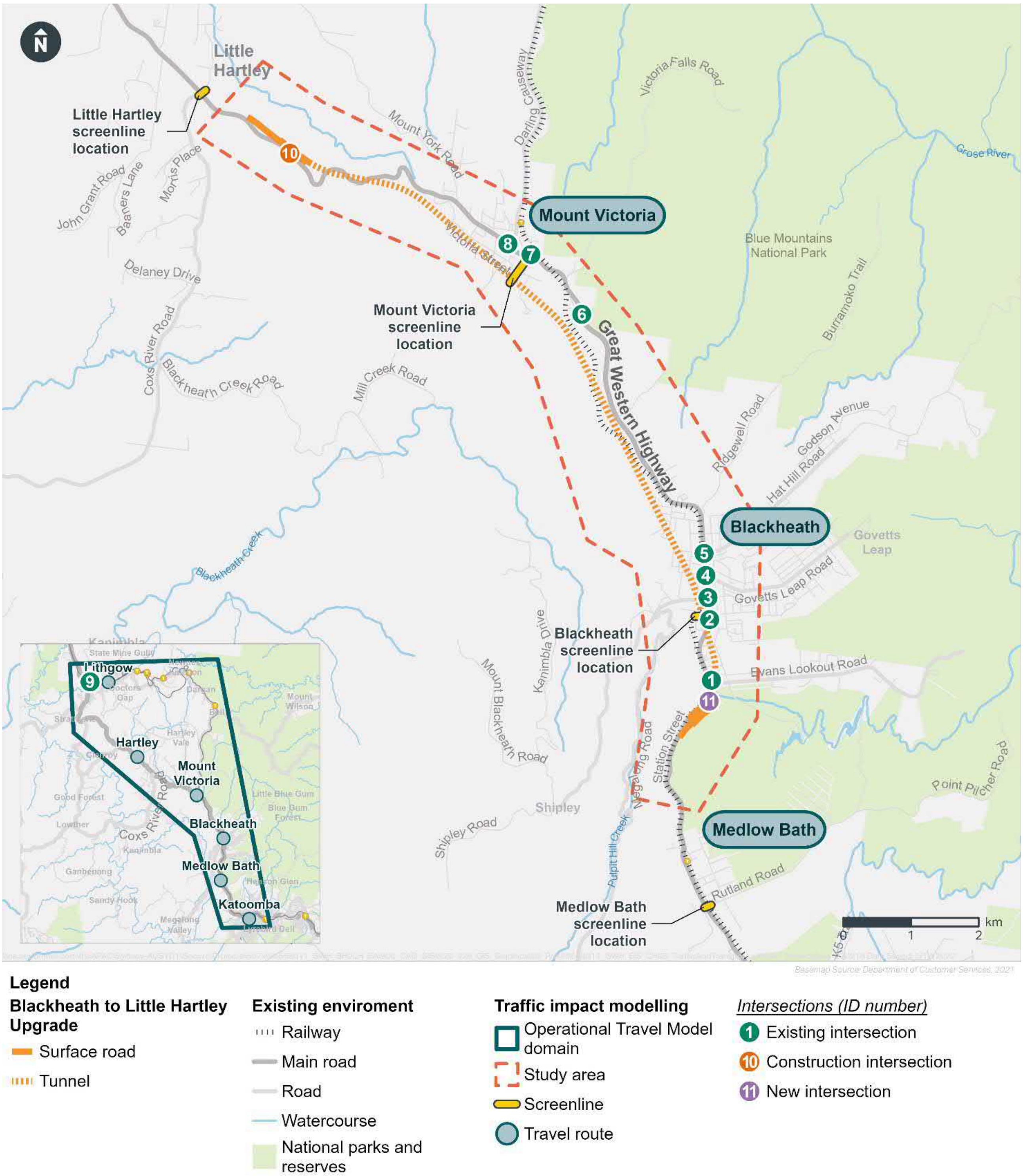


Figure 8-2 Study area, Operational Travel Model domain and screenline locations

The intersections listed in Table 8-2 were assessed for construction and operational traffic impacts. Most of the selected intersections are located within the study area and are anticipated to be most susceptible to traffic impacts due to the project. However, the Great Western Highway and Main Street and Caroline Avenue intersection (Intersection 9) is a signalised intersection located in Lithgow, to the west of the study area. This intersection has been included to assess the impacts of construction vehicles and spoil haulage to the west of the study area.

The traffic impact assessment carried out for the Little Hartley to Lithgow Upgrade (refer to Technical Working Paper – Traffic and transport (Jacobs and Arcadis, 2021) appended to the Review of Environmental Factors for that project) indicates that most other intersections along the Great Western Highway between the study area and Lithgow currently operate with spare capacity during the weekday AM and PM peak hours. The key exception is the intersection of the Great Western Highway, Coxs River Road and Ambermere Drive intersection which was identified in the traffic assessment for the Little Hartley to Lithgow Upgrade as operating near capacity in the PM peak hour. Based on current construction staging for the Upgrade Program, it is anticipated that this intersection would be upgraded to a grade separated intersection as part of the Little Hartley to Lithgow Upgrade prior to construction of the project[1]. This would address the existing capacity constraints at the intersection before the addition of project construction traffic.

Table 8-2 Intersection locations included in the construction and operational impact assessments

ID	Intersection	Signalling	Type
1	Great Western Highway and Evans Lookout Road, Blackheath	Unsignalised	Existing
2	Great Western Highway and Prince George Street, Blackheath	Unsignalised	Existing
3	Great Western Highway and Leichhardt Street, Blackheath	Unsignalised	Existing
4	Great Western Highway, Govetts Leap Road and Bundarra Street, Blackheath[1]	Signalised	Existing
5	Great Western Highway and Hat Hill Road, Blackheath	Unsignalised	Existing
6	Soldiers Pinch construction site intersection (to be used for access to the Soldiers Pinch construction site)	Unsignalised	Existing
7	Great Western Highway and Harley Avenue, Mount Victoria	Unsignalised	Existing
8	Great Western Highway and Station Street (Darling Causeway), Mount Victoria	Signalised	Existing
9	Great Western Highway and Caroline Avenue/ Main Street, Lithgow[2]	Signalised	Existing
10	Little Hartley construction site intersection (to be used for access to the Little Hartley construction site)	Unsignalised	New and temporary
11	New intersection at Blackheath[3] (to be used for access to the Blackheath ancillary facilities during operation)	Unsignalised	New and permanent

Table notes:

1. Intersection 4 performance considers the impacts of the adjacent level crossing
2. Intersection 9 is located outside the study area but is a major intersection located along the main construction haulage route and has therefore been analysed to assess potential construction impacts only
3. Intersection 11 would be a new intersection after the project is operational

[1] While it is anticipated that this intersection would be upgraded to a grade separated intersection as part of the Little Hartley to Lithgow Upgrade, this upgrade was not included in the 'with project' construction year scenario (2026) as part of the Operational Travel Model.

8.1.2 Assessment criteria

The assessment criteria used to evaluate the transport and traffic impacts of the project include:

- road network and intersection performance
- traffic volumes and patterns
- travel times
- road safety.

Assessment locations (shown in Figure 8-2) were used to evaluate these criteria under the scenarios described in Section 8.1.1 including:

- key intersections within the study area
- screenline locations to determine forecast traffic volumes at specific points in the modelled area
- travel route assessment locations to determine travel times and speeds between key travel locations.

For the project and the Operational Travel Model, the weekday AM peak hour was defined as between 8am and 9am, and the weekday PM peak hour was defined as between 3pm and 4pm. Although not used in the modelling, weekend peaks vary and are typically highest on a Saturday morning westbound and Sunday afternoon eastbound.

Common network performance indicators called levels of service (LoS) were also assessed. LoS is measured through a combination of parameters, such as total vehicle demand, kilometres travelled, average speed and time travelled. LoS indicators used for assessment of the project include:

- mid-block level analysis, showing travel time and travel speed changes to travel routes
- intersection level analysis, showing changes to the performance of intersections.

LoS is measured on a scale from A to F, with A representing optimal operating conditions and F representing worst operating conditions. When a road network performance falls to LoS D, investigations are generally initiated to determine if suitable remediation can be provided to improve the LoS rating. Further information about LoS ratings is provided in Figure 8-3.

During project development, design safety standards have been considered to avoid and minimise potential road safety impacts. To assess road safety, a qualitative assessment was conducted by analysing historical crash data and current traffic volumes, in conjunction with forecast changes in traffic volumes for the scenarios described in Section 8.1.1. The future benefits that the project would provide for road safety during operation were also considered in this assessment.

Intersection criteria			Mid-block criteria	
Average delay per vehicle (seconds per vehicle)	Traffic signals and roundabouts	Give way and stop sign		
Less than 14	Good operation	Good operation	LOS A	FREE FLOW Low volumes and no delays.
15 to 28	Good with acceptable delays and spare capacity	Good with acceptable delays and spare capacity	LOS B	STABLE FLOW Speeds restricted by travel conditions, minor delays.
29 to 42	Satisfactory	Satisfactory, but accident study required	LOS C	STABLE FLOW Speeds and manoeuvrability closely controlled because of higher volumes.
43 to 56	Near capacity	Near capacity, accident study required	LOS D	STABLE FLOW Speeds considerably affected by change in operation conditions. High density traffic restricts manoeuvrability; volume near capacity.
57 to 70	At capacity, at signals incidents will cause excessive delays	At capacity, requires other control mode	LOS E	UNSTABLE FLOW Low speeds; considerable delay; volume at or slightly over capacity.
Greater than 70	Extra capacity required	Extreme delay, major treatment required	LOS F	FORCED FLOW Very low speeds; volumes exceed capacity; long delays with stop-and-go traffic.

Figure 8-3 Level of service criteria for intersections and mid-block (traffic flow) (Transport, 2013; Austroads, 2020)

8.2 Existing environment

Ecological and heritage values associated with the Blue Mountains National Park and Greater Blue Mountains World Heritage Area, as well as topographical and engineering constraints have limited transport infrastructure development in the study area. In addition to a limited road and public transport network, the network also becomes congested during weekends, public holidays and event days and during emergencies such as flooding, bushfire, or vehicle crashes.

Figure 8-4 shows the weekday travel mode breakdown in the study area. The main travel mode is by private vehicle accounting for around 80 per cent of trips (as driver or passenger). The next most common mode is walking, followed by public transport use. On a typical weekday, travel in the Blue Mountains local government area (LGA) generally has a higher portion of travel for non-work related business, social/recreation and shopping when compared to the Sydney Greater Metropolitan Area (GMA)[2], and a lower proportion of travel for the purpose of commuting and education/childcare.

[2]as defined by the Australian Bureau of Statistics (ABS)

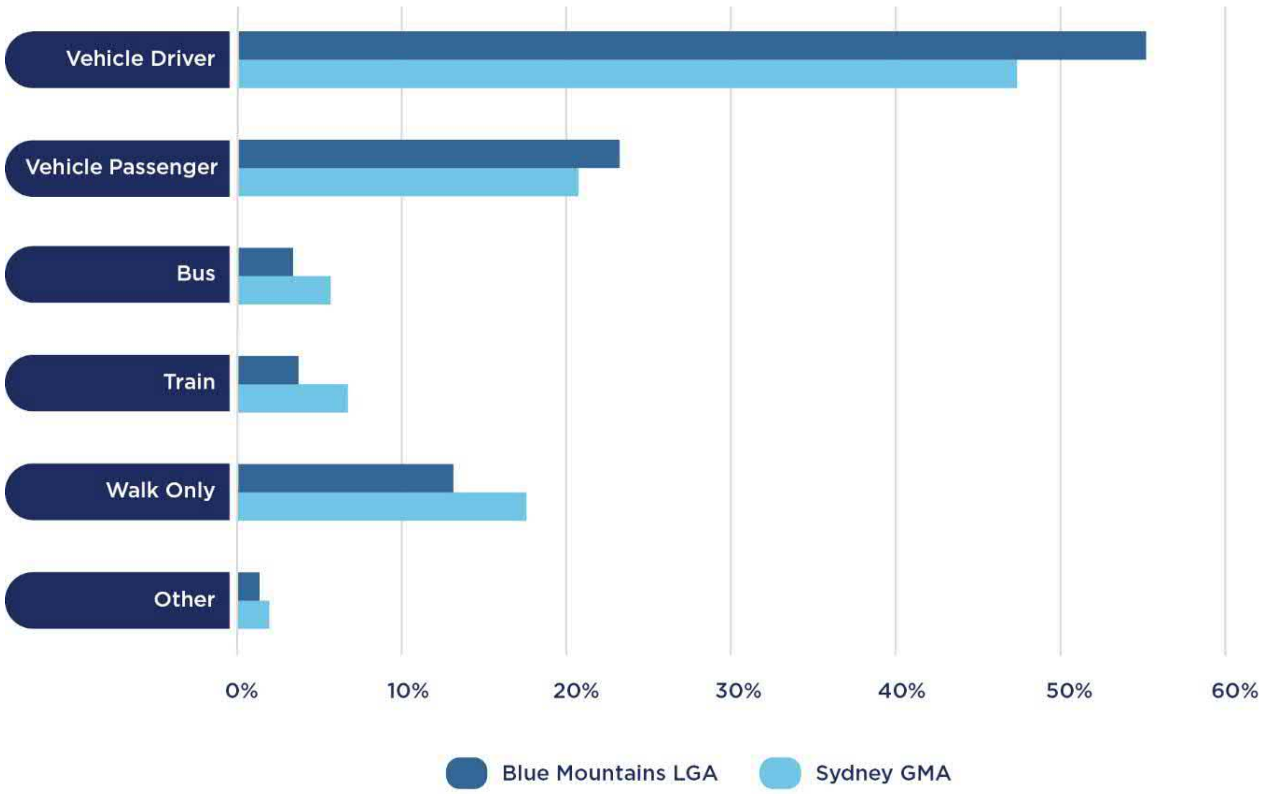


Figure 8-4 Average weekday travel mode share for the Blue Mountains LGA

8.2.1 Road network

The Great Western Highway is about 200 kilometres long and connects Bathurst, through the Central West and Orana regions, to Sydney. It spans the Great Dividing Range via the Blue Mountains. In the study area, the Great Western Highway is a generally undivided carriageway with one lane in each direction. Overtaking lanes and auxiliary lanes within the study area are limited. East of Katoomba, outside the study area, the Great Western Highway generally has two lanes in each direction.

The main functions of the Great Western Highway within the study area include:

- local access for residents of the adjacent townships and rural destinations located along the Great Western Highway
- major tourist route providing access to key destinations in the NSW Central West region
- major freight route accommodating vehicles up to 19 metres long carrying freight between Sydney and the Central West region.

Currently, the Great Western Highway typically has a posted speed limit of 60 kilometres per hour as it passes through townships and 80 kilometres per hour outside townships. Between Mount Victoria and Little Hartley, the 60 kilometre per hour posted speed limit continues for cars because of steep grades and a winding road alignment through Victoria Pass. Truck speeds are restricted to 40 kilometres per hour through this section.

The existing Great Western Highway has several sections with steep grades of more than 10 per cent, including Victoria Pass at 13 per cent. This is the steepest grade on any classified road or freight route in NSW.

Other components of the Upgrade Program have been approved and will deliver upgrades to the Great Western Highway, including:

- Medlow Bath Upgrade: upgrade and duplication of around 1.2 kilometres of the existing surface road corridor with intersection improvements and a new pedestrian bridge

- Katoomba to Blackheath Upgrade: upgrade, duplication and widening of around 5.8 kilometres the existing surface road corridor, with connections to the existing Great Western Highway east of Blackheath
- Little Hartley to Lithgow Upgrade: upgrade, duplication and widening of around 14 kilometres of the existing surface road corridor, with connections to the existing Great Western Highway at Little Hartley.

This approved infrastructure forms the baseline environment for the 2030 and 2040 'with project' scenarios in the transport and traffic assessment.

Crashes

Crashes on the Great Western Highway have increased over time. Between east of Blackheath and Little Hartley, 64 crashes have occurred between 2016 and 2020. Of these:

- one was a fatal crash
- 65 per cent resulted in an injury.

The following most common crash types occurred:

- nearly 35 per cent involved run-off road collisions, including nearly 30 per cent on bends
- nearly 35 per cent involved a rear-end collision
- nearly 20 per cent involved an intersection or opposing type crash, including nearly 15 per cent head-on collisions
- about five per cent of crashes involved a heavy vehicle.

Parking

On-street parking is generally provided along local roads within Blackheath and Mount Victoria, however on-street parking in Little Hartley is limited. There is an informal carpark used to access Berghofer's Pass at the base of Victoria Pass.

Within Blackheath and along the Great Western Highway, on-street parallel parking is provided on the eastbound side of the road between Evans Lookout Road and Hat Hill Road. Between Leichhardt Street and Gardiner Crescent, the on-street parking is time restricted to one hour. On-street parking is also provided on the westbound side of the Great Western Highway between Abbott Street and Murri Street and between the Station Street overbridge and Ridgewell Road.

One hour on-street parking is also provided along Govetts Leap Road between the Great Western Highway and Clanwilliam Street.

In Mount Victoria, on-street parking is generally provided along the eastbound side of the Great Western Highway between Harley Avenue and west of Mount York Road. Parking is permitted on the westbound side of the Great Western Highway in select locations in Mount Victoria.

On-street parking is not permitted along the Great Western Highway in Little Hartley. However, vehicles frequently park on a gravel area on the eastbound side of the Great Western Highway located at the bottom of Victoria Pass to gain access to Berghofer's Pass.

8.2.2 Public transport

Rail

The study area includes the Blue Mountains Line, which runs between Sydney and Lithgow / Bathurst via the Intercity Trains Network. The electrified rail line ends at Lithgow requiring most rail services to terminate at Lithgow or Mount Victoria. Within the study area, railway stations are provided at Blackheath and Mount Victoria as shown in Figure 8-5 and Figure 8-6. Commuter car parking is available at both stations, as well as bike lockers at Blackheath Station. Both stations have pedestrian facilities to enable crossing the Great Western Highway near the station. Rail patronage data shows that Blackheath Station has higher patronage than Mount Victoria Station.

The frequency of rail services on the Blue Mountains Line and within the study area includes:

- two express services in each direction between Sydney and Bathurst per day
- citybound services between 5:30am and 7:00am have a frequency of about 15 minutes at both stations, with an hourly service from 10am
- outbound services departing the Sydney CBD between 4:00pm and 6:30pm and stopping at both stations typically have a frequency of about 30 minutes, with an hourly service outside these times
- on weekends, one to two services typically stop at both stations per hour.

Bus services replace trains when the rail line is closed for maintenance works.

Bus services

The following bus services provided by Blue Mountains Transit operate near the project and service the Blue Mountains area:

- route 698 – Katoomba to Blackheath
- route 698V – Katoomba to Mount Victoria
- route 690K – Springwood to Katoomba (school bus)
- route 8710 – Wentworth Falls Public School to Blackheath (school bus).

Bus stops are located along the existing Great Western Highway, near Blackheath Station, and in Blackheath along Evans Lookout Road, Govetts Leap Road and Hat Hill Road. In Mount Victoria bus stops are located along the existing Great Western Highway, near Mount Victoria Station, on Victoria Street and on Mount York Road. No bus stops are provided in Little Hartley. Bus stops located close to the project are shown in Figure 8-5 and Figure 8-6.

8.2.3 Active transport

Pedestrian and cyclist facilities are limited near the Great Western Highway. Pedestrian infrastructure is generally limited to footpaths and a few signalised intersections in the Blackheath and Mount Victoria town centres.

There is a recreational trail used by hikers and cyclists that extends into the Soldiers Pinch construction footprint. Access to the trail is provided near the intersection of the Great Western Highway and Browntown Oval.

There are no footpaths or pedestrian crossings at Little Hartley. Active transport trails will be provided by the Katoomba to Blackheath Upgrade (near Blackheath) and the Little Hartley to Lithgow Upgrade (near Little Hartley) and will be completed prior to commencement of construction of the project. These trails are shown in Figure 8-5 and Figure 8-6.

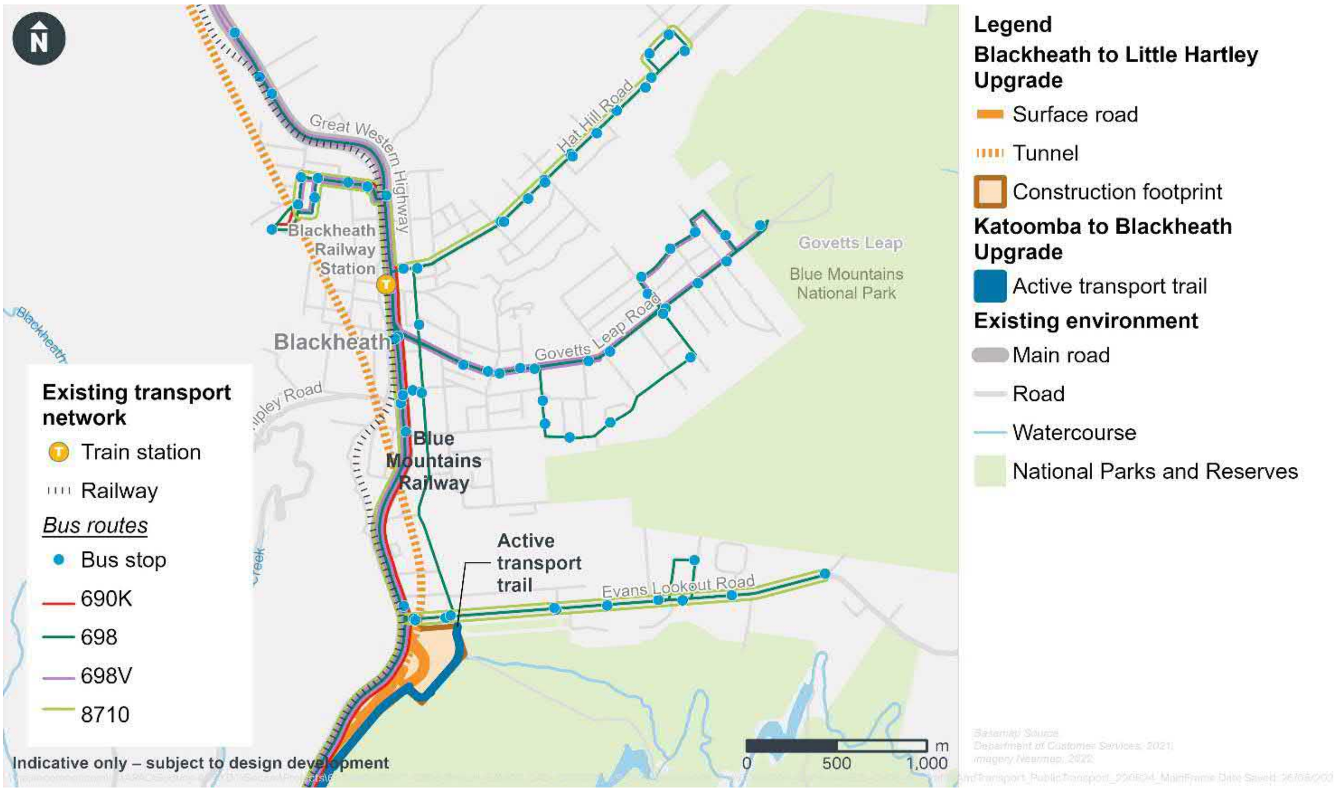


Figure 8-5 Existing and proposed public and active transport networks at Blackheath

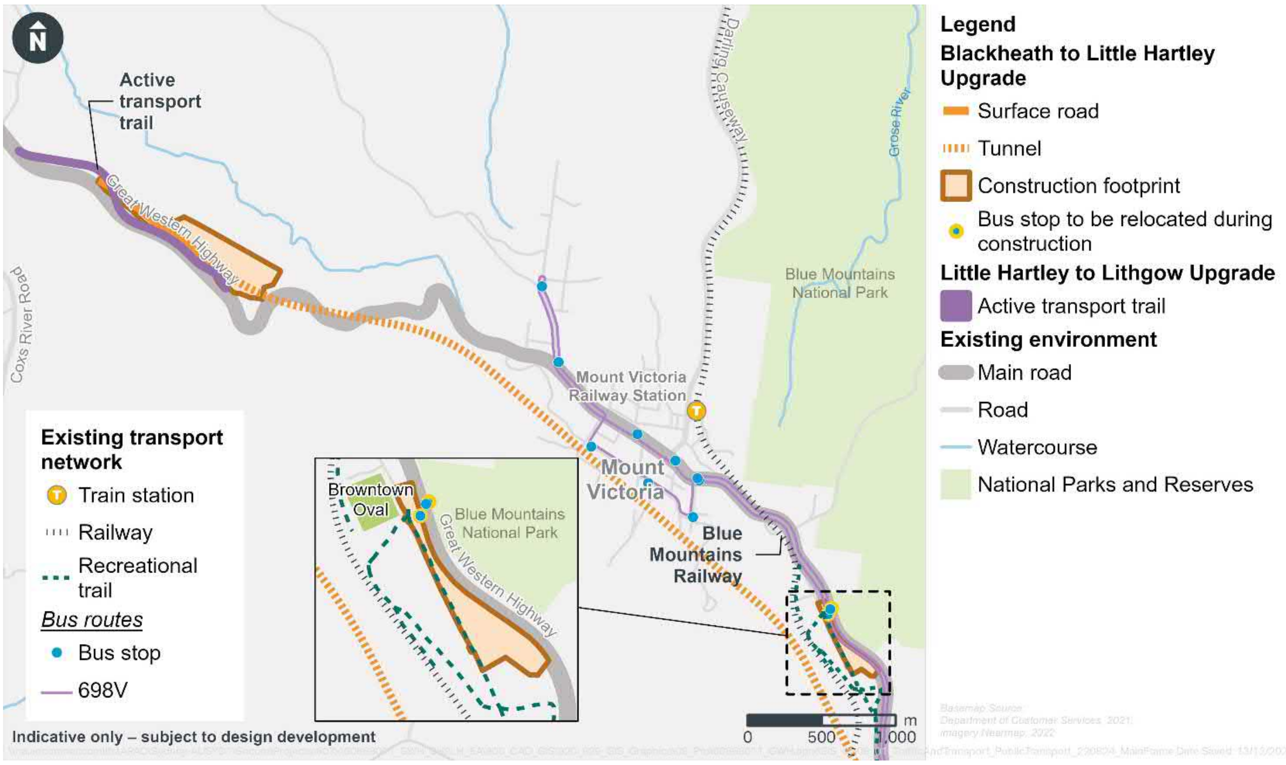


Figure 8-6 Existing and proposed public and active transport networks between Soldiers Pinch and Little Hartley

8.2.4 Traffic volumes and patterns

Hourly traffic volume data from counts conducted over 24-hours, seven days per week were used to estimate the weekday and weekend traffic volumes along the Great Western Highway and identify peak periods. The data shows that the road network is generally subject to higher weekend peaks than weekdays.

Table 8-3 presents the traffic volumes at traffic count locations in 2018:

- 800 metres north of Station Street and Railway Parade, Medlow Bath
- 450 metres south of Browntown Oval access, Blackheath
- 300 metres west of Mount York Road, Mount Victoria
- 500 metres east of Coxs River Road, Little Hartley.

Figure 8-7 shows typical weekday, weekend, and public holiday and special event traffic patterns, based on yearly traffic count data from 2018 from a count station just west of Mount Victoria[3].

Table 8-3 Traffic volumes counted in 2018

Location along the Great Western Highway	Two-way traffic volumes (vehicles per hour)		
	Weekday – AM peak	Weekday – PM peak	Sunday – peak hour
Railway Parade, Medlow Bath	1,260	1,490	1,910
Browntown Oval access, Mount Victoria	930	1,060	1,450
Mount York Road, Mount Victoria	780	880	1,300
Coxs River Road, Little Hartley	850	920	1,330
Average	**955**	**1,088**	**1,498**

Traffic count data from 2018 showed generally higher peaks of traffic on the weekends, as shown in Figure 8-8. These weekend peaks are generally around 700 vehicles in the early morning for Saturday westbound traffic, and around 900 vehicles between noon and early evening for Sunday eastbound traffic. These peaks could be indicative of recreational trips to or through the Blue Mountains from Greater Sydney at the start of the weekend (travelling westbound) and those returning to Greater Sydney at the end of the weekend (travelling eastbound). On weekdays there are two spikes of around 500 to 550 vehicles per direction associated with the weekday morning and afternoon peak periods at around 8am and 3pm, with a similar daily profile for eastbound and westbound traffic. This suggests that the Great Western Highway does not necessarily have peak directional flows.

For heavy vehicles, the traffic count data shows:

- during the weekday peak hour:
  - about 80 to 85 per cent of traffic is made up of light vehicles and light vehicles with trailers
  - about 15 to 20 per cent of the traffic count is made up of heavy vehicles (including rigid, articulated trucks such as semi-trailers and B-double vehicles)
- the highest proportions of heavy vehicles on a weekday occur late at night or in the early hours of the morning

[3] Statistics based on Transport's permanent count station 6188, Great Western Highway west of Mount Victoria

- over the weekday, the total heavy vehicle proportion of all traffic is about 20 per cent
- on a weekend, the total heavy vehicle proportion of all traffic is about five per cent.

While the Great Western Highway is used by through traffic to and from regions west of Lithgow, a large proportion of heavy vehicle traffic is generated between Katoomba and Lithgow, and accounts for around 30 per cent of road freight within the Blue Mountains.

Figure 8-7 Existing traffic volumes per day in 2018 west of Mount Victoria (count station: 6188)

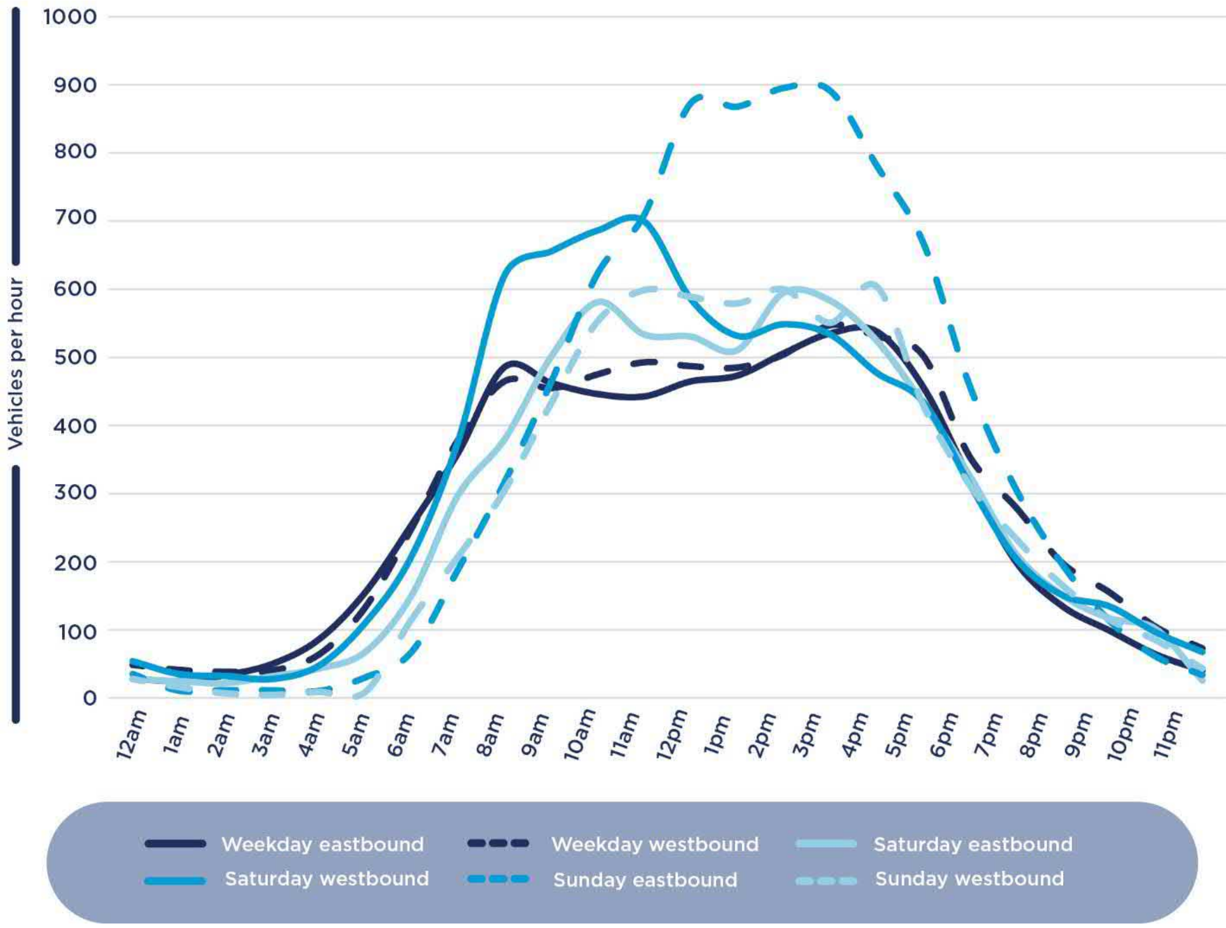


Figure 8-8 Great Western Highway average weekday, weekend and public holiday hourly traffic volume profiles

8.2.5 Road network performance

Network performance statistics

The road network performance statistics for all vehicles travelling through the study area was modelled for the 2018 base case scenario. The results show the following for weekday movements:

- vehicles travel through the model network with an average speed of around 55 kilometres per hour in the AM and PM peak periods
- the PM peak hour has a higher traffic demand than the AM peak hour (around 600 vehicles)
- both peak hours have similar total vehicles kilometres travelled and trip duration (PM peak hour is marginally higher)
- no unreleased vehicles were recorded (the number of vehicles unable to enter the study area due to congestion extending back into the study area's entry points), which suggests there is limited congestion on the road network.

Intersection performance

All existing intersections in the study area currently operate with an overall LoS C or better during the weekday AM and PM peak hour. The 2018 modelled intersection performance for the AM and PM peak hour is shown in Table 8-4. While not modelled, it is well known that lengthy delays and vehicle queuing frequently occurs on busy weekends and public holidays at the following intersections:

- local roads at the signalised intersections of the Great Western Highway
- Bundarra Street and Great Western Highway in Blackheath
- Govetts Leap Road and Great Western Highway in Blackheath
- Station Street and Great Western Highway in Mount Victoria.

Table 8-4 Level of service at existing intersections in the base year scenario (2018)

ID	Intersection	Intersection type	LoS	
			AM peak	PM peak
1	Great Western Highway/ Evans Lookout Road, Blackheath	Unsignalised	C	C
2	Great Western Highway/ Prince George Street, Blackheath	Unsignalised	B	B
3	Great Western Highway/ Leichhardt Street, Blackheath	Unsignalised	A	A
4	Great Western Highway/ Govetts Leap Road/ Bundarra Street, Blackheath[1]	Signalised	B	B
5	Great Western Highway/ Hat Hill Road, Blackheath	Unsignalised	A	A
6	Soldiers Pinch construction site intersection Blackheath[2]	Unsignalised	-	-
7	Great Western Highway/ Harley Avenue, Mount Victoria	Unsignalised	B	B

ID	Intersection	Intersection type	LoS	
			AM peak	PM peak
8	Great Western Highway/ Station Street (Darling Causeway), Mount Victoria	Signalised	A	A
9	Great Western Highway/ Caroline Avenue/Main Street, Lithgow[3]	Signalised	B	B

Table notes:

1. Intersection 4 performance considers the impacts of the adjacent level crossing
2. Intersection 6 is an existing intersection that would be used to access the Soldiers Pinch construction site. No existing traffic data is available and therefore this intersection has not been assessed in the existing environment
3. Intersection 9 is located outside the study area but is located along the proposed haulage route and has therefore been analysed to assess the project's construction impacts.

Travel times and speed

Travel time data for three key routes in the model domain was collected. The 2018 average AM and PM peak hour travel times and average speed for the three routes are summarised in Table 8-5. On peak days such as busy weekends and public holidays, vehicle times are substantially longer and vehicle speeds substantially lower than these averages.

When vehicles begin to queue eastbound at Mount Victoria during peak periods, Transport manages the traffic at the base of Victoria Pass in Little Hartley to prevent traffic congestion, breakdowns and start/stop movements up Victoria Pass, by:

- holding vehicles at the base of Victoria Pass in Little Hartley
- releasing vehicles in groups once there is enough storage capacity at the top of the Victoria Pass, allowing vehicles to travel up Victoria Pass in one smooth movement free from stopping.

Table 8-5 Base year scenario average travel times and speeds in the study area

Location	Average travel time (minutes)	Average travel speed (kilometres per hour)
Between Blackheath and Mount Victoria	7-8	50-55
Between east of Blackheath and Little Hartley	17-18	52-54
Between Katoomba and Lithgow	39-41	56-60

8.3 Potential impacts – construction

8.3.1 Road network performance

Construction vehicles and access

Temporary modifications to the existing road network such as construction site access arrangements, staged works and speed zone changes would be required during construction of the project. Construction vehicle access points and volumes at each construction site are outlined in Table 8-6. In this table, a vehicle entering a construction site constitutes one movement, and exiting the construction site would be another movement. Construction vehicle access points are shown in Figure 5-5 to Figure 5-7 in Chapter 5 (Construction).

Around 75 per cent of workers have been assumed to travel to the project construction sites from the east, travelling westbound to the construction sites and eastbound to return home. The remaining 25 per cent of construction workers have been assumed to travel to the project from the west, travelling eastbound to construction sites and westbound to return home.

Peak traffic generating activities, including spoil haulage and tunnel boring machine (TBM) segment deliveries would be scheduled to avoid peak days such as weekends, public holidays and major events such as the Bathurst Super Car event where possible. The Little Hartley construction site would have capacity to store spoil and tunnel segments for around three days to accommodate these peak periods.

While full road closures are not expected to be needed, the impacts of road closures would need to be assessed by the construction contractor(s) and measures to minimise and manage impacts would be identified in the Construction Transport and Access Management Plan (CTAMP).

Table 8-6 Construction site vehicle access and volumes[4]

Construction site	Maximum vehicle movements in and out				Access/egress points
	Per hour	Day time (6am-6pm)	Night time (6pm-6am)	Per day	
Blackheath	130	150 light vehicles and 160 heavy vehicles	120 light vehicles and 10 heavy vehicles	440 (270 light vehicles and 170 heavy vehicles)	• Great Western Highway around 950 metres southwest of Evans Lookout Road • intersection of Evans Lookout Road and Great Western Highway • intersection of Valley View Road and B5 Valley View Road Extension (light vehicle access/egress only).
Soldiers Point	105	120 light vehicles and 140 heavy vehicles	70 light vehicles and 65 heavy vehicles	395 (190 light vehicles and 205 heavy vehicles)	• intersection of Great Western Highway and Browntown Oval access road.
Little Hartley	905	1,230 light vehicles and 1,095 heavy vehicles	665 light vehicles and 335 heavy vehicles	3,325 (1,895 light vehicles and 1,430 heavy vehicles)	• Great Western Highway around 1.6 kilometres southeast of Coxs River Road • Great Western Highway around 750 metres southeast of Coxs River Road.

[4] Maximum hourly construction vehicle movements would occur at around 6am coinciding with worker shift changeover (outside the AM peak hours on the road network). During the road network peak hours, construction vehicle movements would be around 90 vehicle movements per hour

Traffic volumes and patterns

Outputs from the Operational Travel Model suggest that traffic along the Great Western Highway is anticipated to increase by 17 to 25 per cent between 2018 and 2026, without the project. The proportion of heavy vehicles along the Great Western Highway would remain relatively consistent between 2018 and 2026 and would constitute between 10 and 25 per cent of the weekday peak hour traffic volumes without the project.

As shown in Table 8-6, construction of the project is forecast to generate up to five per cent additional traffic compared to weekday peak hourly traffic volumes through Blackheath and Mount Victoria. At Little Hartley, construction traffic would increase traffic by up to 13 per cent of the weekday peak hourly traffic volume. The peak construction-related traffic volumes would occur during shift changeover at around 6am and between 5 and 7pm. As shown in Figure 8-8, average weekend traffic volumes along the Great Western Highway are typically much lower than weekday traffic volumes at 6am, but up to 20 per cent higher at 6pm.

Therefore, construction traffic is most likely to affect the performance of the Great Western Highway during the weekday AM peak and the weekend PM peak. Appropriate management measures would be developed and implemented through a CTAMP for the project.

The combination of reduced speed limits and additional construction traffic volumes would result in a minor increase to weekday peak hour travel times of about one minute for both directions along the Great Western Highway (between Katoomba and Lithgow). Potential construction traffic impacts on accessibility and connectivity to, businesses, town centres and schools is expected to be minimal (further discussed in Section 4.1.2 of Appendix P (Technical report – Economics and business) and Section 5.1 and Section 5.3 of Appendix O (Technical report – Social)).

Table 8-7 Forecast weekday peak hour traffic volumes at screenline locations with and without project construction

Screenline location	Peak hour	Base year scenario (2018) (vehicles/ hr)[1]	Construction year scenarios (2026)			
			Without project construction (vehicles/hr)	With project construction (vehicles/hr)	Overall change in traffic volumes (%)	With project construction (heavy vehicle %)
South of Medlow Bath	AM	1,330	1,540	1,570	2	16
	PM	1,440	1,810	1,810	0	16
Blackheath	AM	1,100	1,510	1,550	3	14
	PM	1,260	1,690	1,740	3	13
Mount Victoria	AM	990	1,190	1,210	2	17
	PM	1,040	1,340	1,360	1	16
Little Hartley	AM	860	960	1,050	9	29
	PM	890	1,050	1,190	13	22

Table notes:

1. The total heavy vehicle proportion of weekday traffic in 2018 was about 20 per cent

Network performance statistics and travel time

The additional construction traffic generated by the project would have a minor impact on the Great Western Highway network performance statistics. The combination of reduced speed limits and additional construction traffic volumes would result in a minor increase to weekday peak hour travel times through the study area of about one minute for both directions.

The modelled peak hour network performance between Blackheath and Little Hartley with and without construction is summarised in Table 8-8.

Table 8-8 Weekday peak hour network performance statistics between Blackheath and Little Hartley (with and without construction of the project)

Network performance statistic	Peak hour	Base year scenario (2018)	Construction year scenarios (2026)			
			Without project	With project	Change	Change (%)
All vehicles						
Total traffic demand (vehicles)	AM	4,350	4,825	4,931	106	2
	PM	4,961	5,384	5,493	109	3
Total kilometres travelled (kilometres)	AM	47,685	56,381	57,714	1,333	2
	PM	47,632	64,021	66,294	2,273	3
Total vehicle hours travelled (hours)	AM	864	1,047	1,091	44	4
	PM	871	1,177	1,247	70	6
Total vehicles arrived	AM	4,256	4,766	4,833	67	1
	PM	4,758	5,334	5,436	102	2
Total number of stops	AM	2,922	3,515	3,604	89	2
	PM	3,942	4,781	4,824	43	1
Average per vehicle in network						
Average vehicle kilometres travelled (kilometres)	AM	11	12	12	0	0
	PM	10	12	12	0	0
Average vehicle hours travelled (minutes)	AM	12	13	14	1	1
	PM	11	12	12	0	2
Average number of stops	AM	1	1	1	0	0
	PM	1	1	1	0	0
Average speed (kilometres per hour)	AM	55	54	53	-1	-2
	PM	55	54	53	-1	-2

Intersection performance

Forecast weekday peak hour levels of service (LoS) and average delays at existing and new intersections, with and without project construction, are summarised in Table 8-9. This data shows that:

- traffic growth between the base year (2018) and 2026 (without construction of the project) will lead to a deterioration in LoS at some existing intersections, namely:
  - Great Western Highway/ Evans Lookout Road, Blackheath – deterioration from LoS C to LoS F in both the AM and PM peak hours
  - Great Western Highway/ Govetts Leap Road/ Bundarra Street, Blackheath – deterioration from LoS B to LoS C in the PM peak hour
  - Great Western Highway/ Hat Hill Road, Blackheath – deterioration from LoS A to LoS C in the AM peak, and from LoS A to LoS D in the PM peak
- construction of the project would not materially affect average delays and would not affect the LoS at existing intersections, with the exception of a minor deterioration (from LoS C to LoS D) at the Great Western Highway/ Harley Avenue, Mount Victoria intersection in the PM peak hour
- the new, temporary intersection established to access the Little Hartley construction site, would operate at an acceptable LoS (LoS B during the AM peak hour, and LoS C during the PM peak hour)
- two intersections would operate at LoS F in the future, being the Great Western Highway/ Evans Lookout Road, Blackheath intersection and the Great Western Highway and Browntown Oval access intersection. Of these:
  - the Great Western Highway/ Evans Lookout Road, Blackheath intersection would operate at LoS F regardless of whether the project is constructed or not. This LoS F reflects delays to vehicles turning right from Evans Lookout Road to the Great Western Highway westbound
  - the LoS F forecast at the temporary intersection at the Great Western Highway/ Browntown Oval (access to the Soldiers Pinch construction site) would be restricted largely to construction vehicles turning right onto the Great Western Highway from the Soldiers Pinch construction site during weekday AM and PM peak hours. That is, the constraint at this intersection would affect mainly project construction traffic, rather than other road users.

Some intersections are predicted to perform better in the construction year scenarios (2026) than the base year scenario (2018). This is likely due to road network upgrades that have occurred since 2018, or that are planned to be completed prior to 2026, having been included in the Operational Travel Model (further described in Section 3.4.4 of Appendix D (Technical report – Transport and traffic)).

Access to public space and community facilities would not be directly affected during construction, however the above changes in anticipated level of service on the local road network may result in minor delays.

Access to Browntown Oval, which would remain open throughout the construction period, would be maintained via its existing intersection with the Great Western Highway. The project would include upgrade of the Great Western Highway / Browntown Oval access road to establish safe access to the Soldiers Pinch construction site. An increase in the number of heavy vehicles at the shared access point for the Soldiers Pinch construction site and Browntown Oval may impact on pedestrian and cyclist safety for those accessing the oval.

The oval includes a cricket pitch used for cricket matches and training in the summer months, and is used for archery practice on Sundays. The oval is also available for one-off events or seasonal bookings. Intersection improvements and/or traffic controllers could be used by the contractor to manage heavy vehicles turning in and out of the Soldiers Pinch construction footprint when the oval is in use. Mitigation measures would be confirmed during design development by the construction contractor(s).

Table 8-9 Forecast weekday peak hour level of service for existing and proposed intersections with and without construction of the project

ID	Intersection	Peak hour	Base year scenario (2018)	Construction year scenarios (2026)			
				Without construction		With construction	
			LoS	Average delay (seconds)	LoS	Average delay (seconds)	LoS
1	Great Western Highway/ Evans Lookout Road, Blackheath	AM	C	76	F	269	F
		PM	C	282	F	>300	F
2	Great Western Highway/ Prince George Street, Blackheath	AM	B	8	A	8	A
		PM	B	13	A	13	A
3	Great Western Highway/ Leichhardt Street, Blackheath	AM	A	8	A	8	A
		PM	A	12	A	12	A
4	Great Western Highway/ Govetts Leap Road/ Bundarra Street, Blackheath	AM	B	25	B	26	B
		PM	B	32	C	33	C
5	Great Western Highway/ Hat Hill Road, Blackheath	AM	A	29	C	30	C
		PM	A	45	D	49	D
6	Great Western Highway and Browntown Oval access intersection (Soldiers Pinch construction site)	AM	-	-	-	92	F
		PM	-	-	-	148	F
7	Great Western Highway/ Harley Avenue, Mount Victoria	AM	C	42	C	33	C
		PM	C	41	C	45	D
8	Great Western Highway/ Station Street (Darling Causeway), Mount Victoria	AM	A	9	A	8	A
		PM	A	5	A	5	A
9	Great Western Highway/ Caroline Avenue/ Main Street, Lithgow	AM	B	23	B	24	B
		PM	B	25	B	25	B
10	Little Hartley construction site intersection	AM	-	-	-	28	B
		PM	-	-	-	38	C

Public and road safety

The introduction of additional heavy vehicles onto the road network during construction has the potential to result in safety impacts to the public and other road users. This would be especially the case where there is an increased likelihood of interaction between heavy vehicles and other motorists, pedestrians and cyclists.

The design of the project (see Chapter 4 (Project description)) and construction planning (see Chapter 5 (Construction)) have sought to avoid or minimise the potential for road safety risks that may arise from project construction traffic. Importantly, the decision to construct the project tunnels with TBMs launched and spoil being hauled westward from the Little Hartley construction site means that:

- heavy vehicles hauling spoil from the Little Hartley construction site would not pass through Blackheath or Mount Victoria, avoiding interaction with pedestrians, cyclists and other vehicles in those areas
- heavy vehicles hauling spoil from the Little Hartley construction site would not need to use Victoria Pass, which frequently experiences heavy vehicle breakdowns due to steep grades.

Road safety risks from construction vehicles entering and exiting construction sites and increased heavy vehicle volumes using the Great Western Highway would be managed through the CTAMP.

Road safety is the main concern regarding transport and traffic related public safety issues, given the location of construction sites having limited interface with the public. Construction safety impacts on active transport are discussed in more detail in Section 8.3.3. The presence of construction sites and the construction workforce may result in changes to perceptions of public safety in an area, as discussed in Section 19.3 of Chapter 19 (Social impacts).

On-street parking impacts

On-street parking supply would generally be maintained during construction of the project.

On-site parking for workers would be provided at the project construction sites, as shown in Figure 5-5, Figure 5-6 and Figure 5-7 in Chapter 5 (Construction). This is likely to include parking for around 100 vehicles at Blackheath, around 70 vehicles at Soldiers Pinch and around 500 to 600 vehicles at Little Hartley[5]. Parking provided at each construction site would be sufficient for the associated worker demand, except for during worker shift changeover. Specific measures including staggering staff shift times to make parking available for incoming works and the use of carpooling or providing shuttle buses to workers will be investigated during detailed design to manage potential parking impacts during worker shift changeover. Further information about vehicle access and car parking during construction is provided in Section 5.10 of Appendix D (Technical report – Transport and traffic).

Nevertheless, construction workers may choose to use available on-street parking, particularly near the Blackheath construction site, which may impact the availability of on-street parking for nearby residents and visitors. A parking and access management plan would be developed as part of the CTAMP to minimise the impacts of potential worker on-street parking.

During construction, informal parking for around a 50-100 metre section of Evans Lookout Road near the Great Western Highway would be removed. This area accommodates space for up to five parked vehicles. This area would be required to facilitate heavy vehicles turning in and out of the Blackheath construction site at the intersection of Evans Lookout Road and the Great Western Highway.

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[5] Worker parking and supply to be confirmed during detailed design.

Construction of the project is not expected to directly impact access to private property. In the vicinity of Little Hartley, revised property access arrangements and property access roads would be provided as part of the Little Hartley to Lithgow Upgrade This revised access would be maintained during construction of the project. Further details on parking and access arrangements, including development of a parking and access management plan as part of the CTAMP.

8.3.2 Public transport

Buses that travel along the Great Western Highway in the study area would be affected by the minor impacts to road network performance outlined in Section 8.3.1. These minor impacts would include slight reductions in the performance of some intersections and increased travel times during construction of the project. Modifications to existing bus stops or bus routes would not be required during construction of the project.

Rail services within the study area would not be affected by construction of the project. However, rail replacement bus services are periodically used in the study area to replace rail services during planned and unplanned works to the rail line. These services would be subject to the same minor impacts as the passenger and school bus services discussed above.

8.3.3 Active transport

Use of the Soldiers Pinch construction site would impact a recreational trail used by hikers and cyclists during construction (see Figure 8-6). If required, the trail would be temporarily diverted around the Soldiers Pinch construction footprint to avoid the conflict between construction vehicles and the public, which would marginally increase walking or cycling travelling time and distance. Access would be maintained during construction and therefore this temporary impact would be negligible.

The active transport trails to be provided as part of the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade would be maintained during construction of the project. Where temporary modifications to existing pedestrian or cyclist infrastructure are required (such as at the Little Hartley construction site where construction vehicles would need to cross over the active transport trail), impacts would be managed under the CTAMP.

An increase in the number of heavy vehicles associated with construction may impact on pedestrian and cyclist safety near the project. This would be most prevalent around construction vehicle access points. There are also potential risks to pedestrian safety resulting from unauthorised access to construction areas. Removal of spoil westbound from the Little Hartley construction site would minimise potential impacts to pedestrian and cyclist safety, particularly in and around the Blackheath and Mount Victoria townships. Appropriate fencing and site security would be implemented at construction sites to minimise the risk of unauthorised access, in line with NSW workplace safety laws.

8.3.4 Emergency vehicle access

Emergency vehicles would potentially be subject to minor road network impacts such as increased traffic volumes, increased travel times and reduced intersection performance during construction of the project. Construction of the project may require temporary traffic modifications but would avoid full closures of the Great Western Highway. Therefore, emergency services access along the Great Western Highway would be maintained during the construction.

Access to the Sydney Drinking Water Catchment and Blue Mountains National Park at Blackheath via B6 Lake Medlow Trail (fire trail accessed via Valley View Road) would also be maintained during construction.

The CTAMP for the project would be developed in consultation with relevant emergency services, ensuring that procedures are in place to maintain safe, priority access for emergency vehicles through or around construction zones. In addition, local emergency services would be periodically updated on the staging and progress of construction works.

8.4 Potential impacts – operation

8.4.1 Road network performance

Light and heavy vehicle volumes and patterns

The project is forecast to attract additional traffic to the Great Western Highway to take advantage of the improved resilience, reduced travel time and increased road network capacity facilitated by the project. This additional traffic is forecast to be a combination of:

- travellers choosing more distant locations
- travellers switching travel modes
- travellers choosing to use the Great Western Highway instead of alternative routes (e.g. Bells Line of Road).

The project is not expected to generate new trips that would not have otherwise occurred (induced demand).

Weekday traffic volume estimates in both the eastbound and westbound direction are summarised in Table 8-10. The table compares traffic volumes without the project (i.e. traffic using the existing Great Western Highway only) for 2030 and 2040, and traffic volumes with the project (i.e. traffic using the existing Great Western Highway and project) for 2030 and 2040. These results show that there would be increases in traffic volumes on the Great Western Highway both with and without the project in both 2030 and 2040. However, the project would provide an additional two lanes in both eastbound and westbound directions that would support this additional traffic.

Table 8-10 Daily weekday traffic volume estimates in 2030 and 2040 with and without the project

Screenline location	Operational year scenario – total traffic volumes					
	2030			2040		
	Without the project	With the project	Change %	Without the project	With the project	Change %
Little Hartley (westbound)	6,090	6,870	13	6,500	8,730	34
Little Hartley (eastbound)	6,250	7,050	13	6,710	8,680	29
Mount Victoria (westbound)	7,270	7,900	9	7,770	9,810	26
Mount Victoria (eastbound)	7,620	8,180	7	8,150	9,960	22
Blackheath (westbound)	9,660	9,860	2	10,490	12,020	15
Blackheath (eastbound)	9,730	12,250	5	9,600	12,270	28
Medlow Bath (westbound)	9,730	10,250	5	10,470	12,480	19
Medlow Bath (eastbound)	10,490	10,970	5	10,550	12,980	23

Figure 8-9 compares the forecast weekday daily traffic volumes (total vehicles) passing through the Blackheath and Mount Victoria townships in 2030 and 2040, both with and without the project. With the project, weekday traffic volumes through the townships would be reduced by around 60 per cent in Blackheath and nearly 80 per cent in Mount Victoria. The large reduction in vehicle volumes along the existing Great Western Highway through Blackheath and Mount Victoria would noticeably improve the accessibility and amenity of these townships. Similarly, the expected traffic through these townships in 2030 and 2040 on weekends and on public holidays would be reduced with the project through removal of most through traffic.

Without the project (in 2030 and 2040) average traffic volumes on the existing Great Western Highway through Blackheath and Mount Victoria could reach 25,000 and 20,000 vehicles per day on public holidays. With the project (in 2030 and 2040) modelling indicates that these traffic volumes would reduce substantially to 11,000 and 5,000 vehicles per day respectively. These volumes would be less than recorded vehicle volumes from 2018.

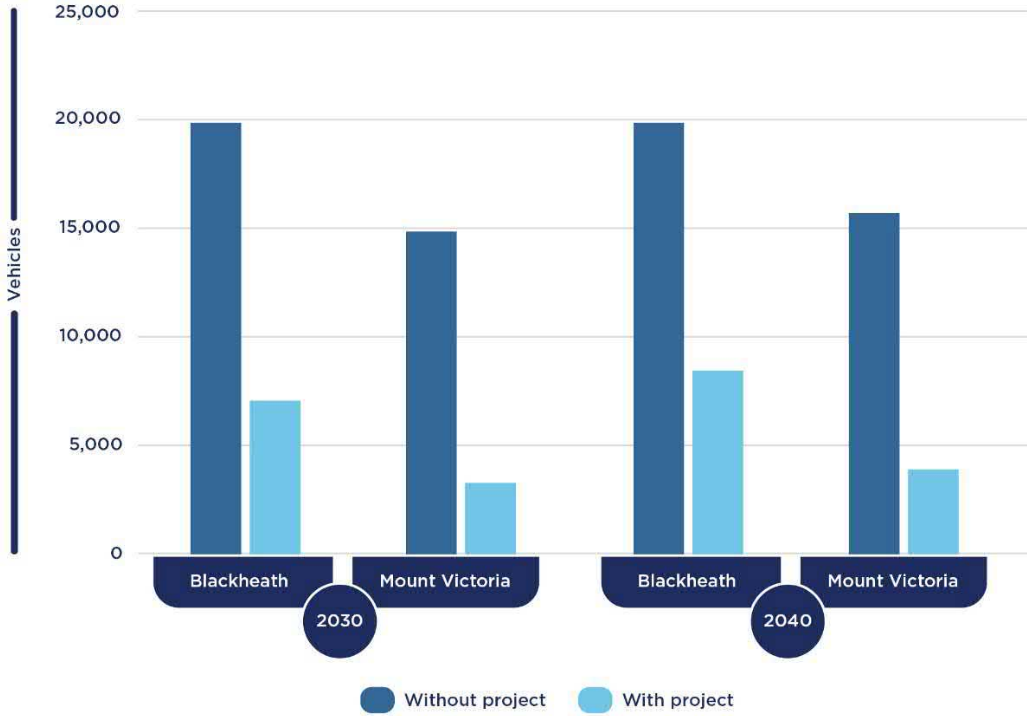

Figure 8-9 Comparison of daily weekday traffic volumes (total vehicles) travelling through Blackheath and Mount Victoria townships with and without the project in 2030 and 2040

Heavy vehicle volumes and patterns

Weekday eastbound and westbound heavy vehicle volumes are summarised in Table 8-11, including heavy vehicle volumes without the project (i.e. traffic using the existing Great Western Highway only) in 2030 and 2040, and heavy vehicle volumes with the project (i.e. traffic using the existing Great Western Highway and the project) in 2030 and 2040.

In 2030, the project would result in a slight increase in eastbound heavy vehicle volumes and a slight decrease in westbound heavy vehicle volumes when compared to the scenario without the project. In 2040, the project would result in a slight reduction in heavy vehicles travelling both eastbound and westbound when compared to the scenario without the project. This slight change in heavy vehicle volumes is due to the project providing a new connection for higher productivity freight vehicles longer than 20 metres between Blackheath and Little Hartley. Providing access to these higher efficiency vehicles would contribute to a total reduction in the current route for these vehicles by up to 100 kilometres between Sydney and Central West NSW (Transport for NSW, 2019).

Figure 8-10 compares the forecast weekday daily heavy vehicle volumes passing through the Blackheath and Mount Victoria townships in 2030 and 2040, both with and without the project. With the project, weekday heavy vehicle volumes through both townships would be reduced by around 80 to 85 per cent in 2030 and in 2040.

Table 8-11 Daily weekday heavy vehicle volume estimates in 2030 and 2040 with and without the project

Screenline location	Operational year scenario – heavy vehicle volumes					
	2030			2040		
	Without the project	With the project	Change (%)	Without the project	With the project	Change (%)
Little Hartley (westbound)	1,230	1,180	-4	1,370	1,300	-5
Little Hartley (eastbound)	1,170	1,190	2	1,300	1,270	-2
Mount Victoria (westbound)	1,370	1,300	-5	1,520	1,440	-5
Mount Victoria (eastbound)	1,340	1,380	3	1,490	1,490	0
Blackheath (westbound)	1,470	1,390	-5	1,670	1,580	-5
Blackheath (eastbound)	1,460	1,460	0	1,500	1,640	9
Medlow Bath (westbound)	1,570	1,470	-6	1,790	1,690	-6
Medlow Bath (eastbound)	1,680	1,680	0	1,770	1,820	3

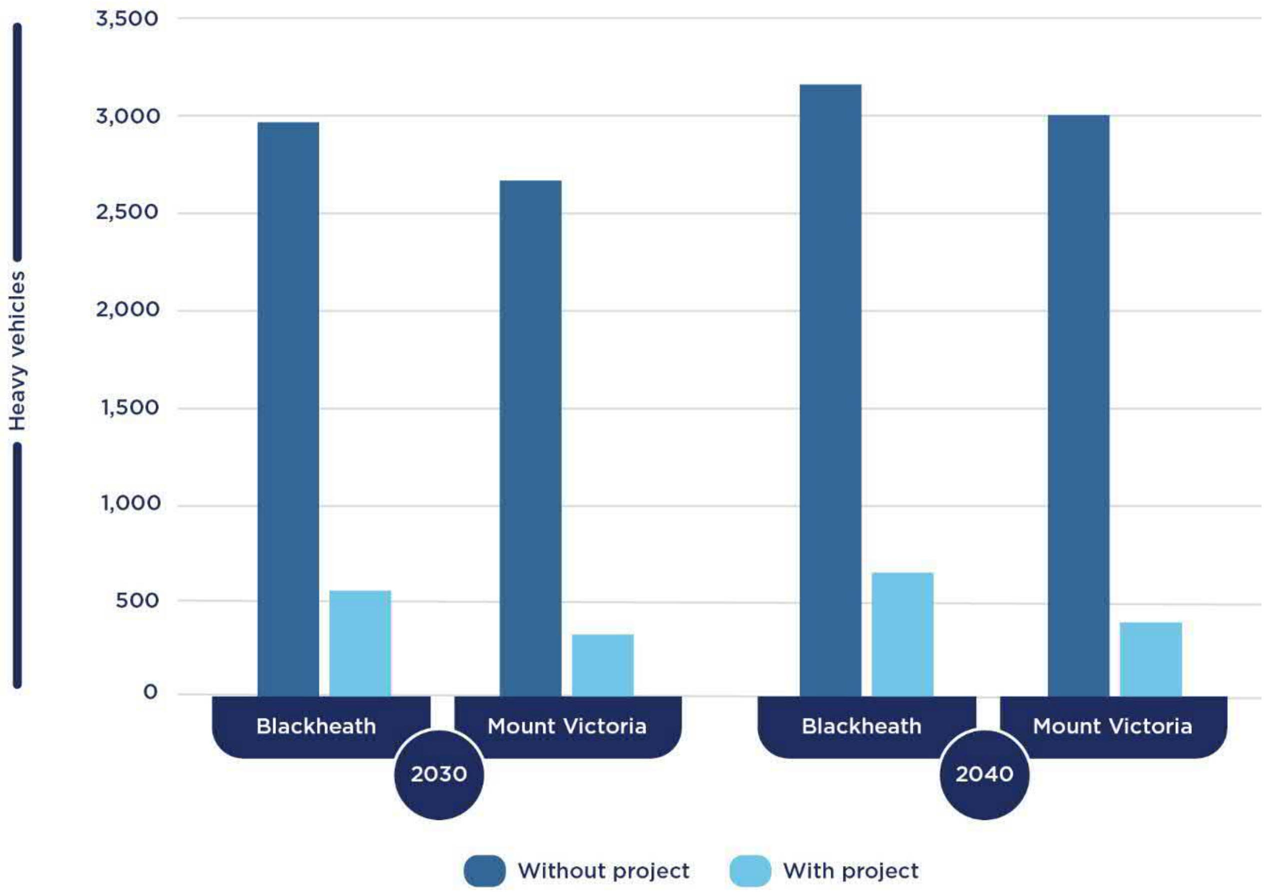

Figure 8-10 Comparison of daily weekday heavy vehicle volumes travelling through Blackheath and Mount Victoria townships with and without the project in 2030 and 2040

Network performance statistics and travel time

The modelled peak hour network performance between Blackheath and Little Hartley with and without the project in 2030 and 2040 is summarised in Table 8-12. A summary of peak hour travel times and speeds with and without the project in 2030 and 2040 are shown in Figure 8-11.

The project would provide the following traffic improvements between Blackheath and Little Hartley for the weekday AM and PM peak hours:

- average vehicle speeds would increase by up to 15 kilometres per hour with the project
- total vehicle hours travelled (VHT) would decrease by around 20 to 30 per cent during the weekday AM and PM peak hours
- total number of stops would decrease with the project
- between Medlow Bath and Hartley travel times would reduce from 23 and 24 minutes without the project in 2030 and 2040 respectively, to 14 minutes with the project (a reduction of around 40 per cent) providing substantial travel time savings for vehicles travelling through the study area
- between south of Blackheath and Little Hartley travel times would reduce from 18 and 19 minutes without the project in 2030 and 2040 respectively, to 10 minutes with the project (a reduction of around 45 per cent) providing substantial travel time savings for vehicles travelling through the study area
- between Leichhardt Street (Blackheath) and Station Street (Mount Victoria) via the existing Great Western Highway, travel times would reduce from eight and nine minutes without the project in 2030 and 2040 to seven minutes with the project
- in Blackheath and Medlow Bath local traffic would experience travel time savings of 15 to 40 per cent in 2030 and 2040 due to reduced traffic volumes using the existing Great Western Highway.

The project would also provide a connection for high productivity vehicles longer than 20 metres between Blackheath and Little Hartley, contributing to a total reduction in the current route for these vehicles by up to 100 kilometres between Sydney and the Central West region. Similar improvements to travel times are likely to occur on weekends and public holidays, due to the increased network capacity provided by the project. The Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade would also accommodate high productivity vehicles longer than 20 metres.

Table 8-12 Weekday peak hour network performance statistics in the base year (2018) and with and without the project (2030 and 2040)

Network performance	Peak hour	Base year scenario (2018)	Operational year scenarios							
			2030				2040			
			Without project	With project	Change	Change (%)	Without project	With project	Change	Change (%)
All vehicles										
Total traffic demand (vehicles)	AM	4,350	4,913	4,905	-8	0	5,159	5,172	+13	0
	PM	4,961	5,596	5,569	-27	0	5,784	5,920	+136	2
Total vehicle kilometres travelled (kilometres)	AM	47,685	59,454	56,588	-2,865	5	61,677	61,639	-38	0
	PM	47,632	66,222	64,043	-2,179	3	67,469	73,887	+6,418	9
Total vehicle hours travelled (hours)	AM	864	1,104	867	-237	21	1,224	928	-296	24
	PM	871	1,224	985	-239	20	1,344	1,135	-209	16
Total vehicles arrived	AM	4,256	4,877	4,843	-34	1	5,110	5,027	-83	2
	PM	4,758	5,510	5,427	-83	2	5,704	5,887	+183	3
Total number of stops	AM	2,922	3,582	3,455	-127	4	4,087	3,775	-312	8
	PM	3,942	4,861	4,427	-434	9	5,669	5,090	-579	10
Average per vehicle in network										
Average vehicle kilometres travelled (kilometres)	AM	11	12	12	0	0	12	12	0	0
	PM	10	12	12	0	0	12	13	+1	8

Network performance	Peak hour	Base year scenario (2018)	Operational year scenarios							
			2030				2040			
			Without project	With project	Change	Change (%)	Without project	With project	Change	Change (%)
Average vehicle hours travelled (minutes)	AM	12	14	11	-3	21	14	11	-3	21
	PM	11	13	11	-2	15	14	12	-3	14
Average number of stops	AM	1	1	1	0	0	1	1	0	0
	PM	1	1	1	0	0	1	1	0	0
Average speed (kilometres per hour)	AM	55	54	65	+11	20	50	66	+16	32
	PM	55	54	65	+11	20	50	65	+15	30

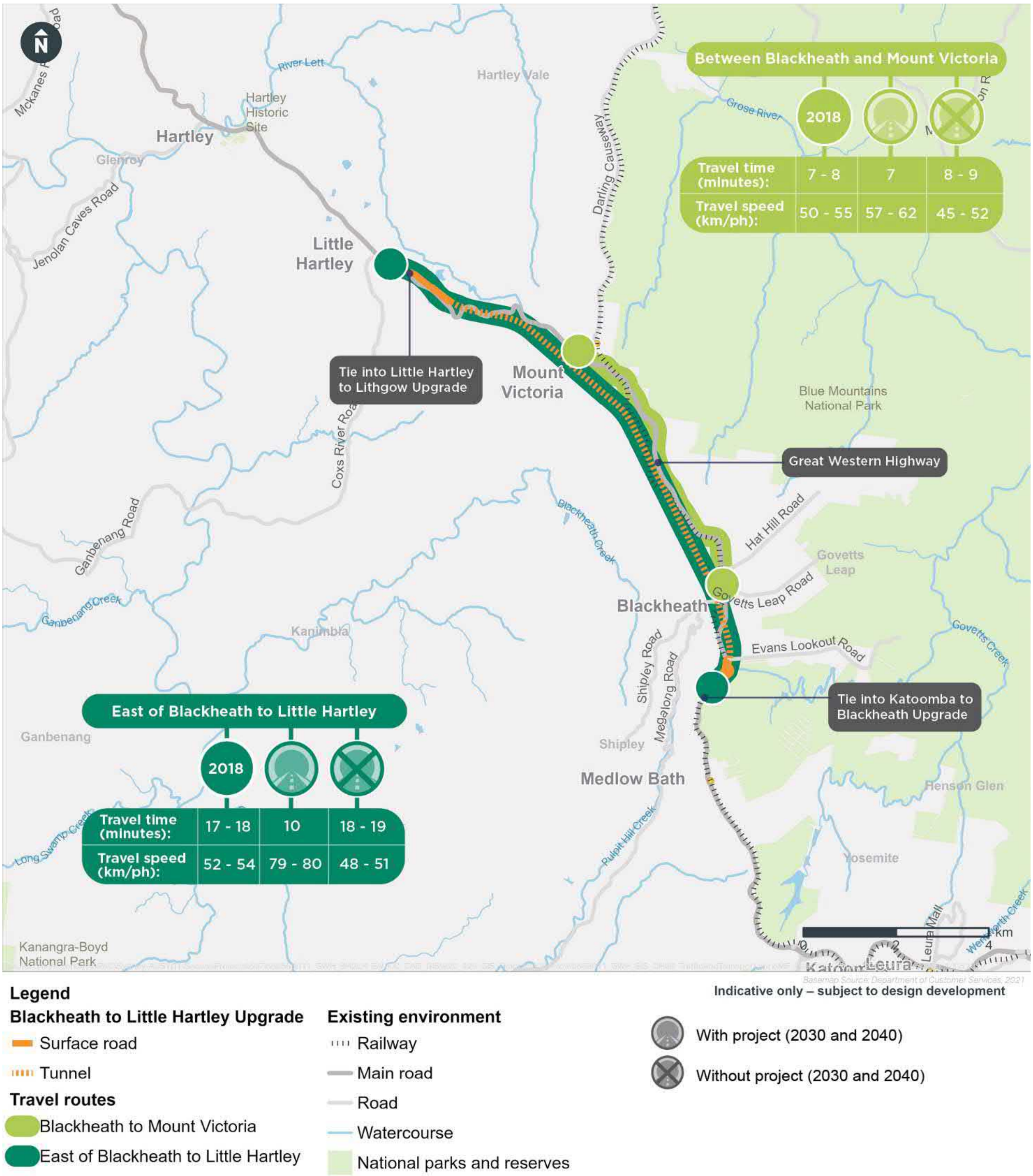

Figure 8-11 Peak hour average travel times and speed projections for the base year scenario (2018), and with and without the project in 2030 and 2040

Intersection performance

The modelled LoS for key intersections within the study area with and without the project for the 2030 and 2040 weekday AM and PM peak hours are summarised in Table 8-13. The model outputs indicate:

- with project in 2030 and 2040 all intersections would operate at LoS B or better
- with project in 2030 and 2040 there would be a substantial improvement in the performance of some intersections, particularly at:
  - Great Western Highway/ Evans Lookout Road, Blackheath – improvement from LoS F to LoS A in both the AM and PM peak hours in 2030 and 2040
  - Great Western Highway/ Govetts Leap Road/ Bundarra Street, Blackheath – improvement from LoS C to LoS B in the PM peak hour in 2030, and from LoS C to LoS B in both the AM and PM peak hours in 2040
  - Great Western Highway/ Hat Hill Road, Blackheath – improvement from LoS C in the AM peak hour and LoS E in the PM peak hour to LoS A in both the AM and PM peak hours in 2030 and 2040
  - Great Western Highway/ Harley Avenue, Mount Victoria – improvement from LoS C in the AM peak hour and LoS D in the PM peak hour to LoS A in both the AM and PM peak hours in 2030 and 2040
- intersection LoS would decline from 2018 to 2030 and 2040 without the project due to background traffic growth at the intersections listed above.

Table 8-13 Intersection performance during peak periods with and without the project in 2030 and 2040[6]

ID	Intersection	Intersection type	Peak hour	2030				2040			
				Without project		With project		Without project		With project	
				Average delay (seconds)	LoS	Average delay (seconds)	LoS	Average delay (seconds)	LoS	Average delay (seconds)	LoS
1	Great Western Highway and Evans Lookout Road, Blackheath	Unsignalised	AM	80	F	11	A	124	F	11	A
			PM	>300	F	13	A	>300	F	14	A
2	Great Western Highway and Prince George Street, Blackheath	Unsignalised	AM	8	A	5	A	9	A	5	A
			PM	14	A	6	A	14	A	7	A
3	Great Western Highway and Leichhardt Street, Blackheath	Unsignalised	AM	7	A	4	A	8	A	4	A
			PM	13	A	7	A	12	A	7	A
4	Great Western Highway, Govetts Leap Road and Bundarra Street, Blackheath	Signalised	AM	22	B	15	B	29	C	15	B
			PM	29	C	17	B	36	C	17	B
5	Great Western Highway and Hat Hill Road, Blackheath	Unsignalised	AM	32	C	7	A	40	C	8	A
			PM	68	E	8	A	70	E	8	A
7	Great Western Highway and Harley Avenue, Mount Victoria	Unsignalised	AM	33	C	9	A	36	C	9	A
			PM	49	D	9	A	49	D	9	A
8	Great Western Highway and Station Street (Darling Causeway), Mount Victoria	Signalised	AM	7	A	8	A	6	A	14	A
			PM	6	A	6	A	6	A	6	A
11	New intersection in Blackheath	Unsignalised	AM	-	-	7	A	-	-	7	A
			PM	-	-	8	A	-	-	8	A

[6] Intersections 6, 9 and 10 are not included in this discussion given they are only relevant to the construction assessment.

Heavy vehicle performance

The project would improve heavy vehicle performance by providing a consistent grade of around 1.75 per cent in the tunnel between Blackheath and Little Hartley and up to four per cent along the surface sections at Blackheath and Little Hartley. This compares to several existing sections of the Great Western Highway with steep grades of more than 10 per cent. It would also incorporate curves that are designed to be taken at higher speeds than curves on the existing Great Western Highway where advisory speed limits are as low as 45 kilometres per hour. The project would also have a positive impact on operational freight costs by reducing fuel consumption and the likelihood of breakdowns, as well as creating opportunities for increased freight efficiency via the use of larger freight vehicles in place of smaller freight vehicles.

Public and road safety

The project would result in the following road safety benefits:

- direct improvements to existing safety issues including:
  - separation of opposing traffic flows
  - wider lanes and improved sightlines
  - fewer intersections
  - reduced grades
  - separation of local and tourist traffic from through traffic (including heavy vehicles)
  - improved overtaking opportunities.
- improvements due to reduced traffic volumes and heavy vehicle traffic on the existing Great Western Highway resulting in:
  - substantially reduced local traffic through the Blue Mountains townships of Blackheath and Mount Victoria
  - improved safety and accessibility for pedestrians and cyclists using the existing road shoulder.

Investigations by Transport into the need for changed traffic signal phasing along the existing Great Western Highway in Blackheath and Mount Victoria may be considered after the project is completed, in consultation with the local councils and the local community.

8.4.2 Public transport

Existing public transport networks would be maintained with the project. The project does not include specific provision for additional public transport. However, buses would be permitted to use the tunnel which would result in travel time savings especially for longer trips. The project would also reduce congestion along the existing Great Western Highway which could result in improved travel times for local bus routes.

8.4.3 Active transport

The project does not include any specific provisions for active transport infrastructure, as pedestrians and cyclists would not be permitted to use the tunnel for safety reasons. Active transport trails to the east and west of the project provided as part of the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade would not be impacted during operation of the project.

Reductions in traffic volumes on the existing Great Western Highway would improve the amenity and safety for active transport users.

Investigations are ongoing in consultation with local councils into opportunities to improve at-surface active transport infrastructure between Blackheath and Little Hartley. This infrastructure would be subject to separate assessments and approvals and may be delivered by others.

8.4.4 Parking and access

The project is not anticipated to impact property access, business access or on-street parking during operation.

New access roads would be provided by the Little Hartley to Lithgow Upgrade to maintain access around the project at Little Hartley. The Little Hartley to Lithgow Upgrade would also include formalisation of the existing informal Berghofer's Pass car park to improve the safety and amenity of the car park for visitors.

8.5 Environmental mitigation measures

8.5.1 Performance outcomes

Performance outcomes for the project in relation to transport and traffic are listed in Table 8-14 and identify measurable performance-based standards for environmental management.

Table 8-14 Transport and traffic performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
Network connectivity, safety and efficiency of the transport system in the vicinity of the project are managed to minimise impacts. The safety of transport system customers is maintained. Impacts on network capacity and the level of service are effectively managed. The safety of transport system customers is maintained. Impacts on network capacity and the level of service are effectively managed.	Avoid or minimise adverse impacts to the performance of the existing road network, including with respect to level of service, travel times and road safety.	Construction and operation
Works are compatible with existing infrastructure and future transport corridors.	Coordinate and deliver the project as part of the integrated package of works comprising the Upgrade Program.	Construction and operation

8.5.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential transport and traffic impacts as a result of the project are detailed in Table 8-15. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 8-15 Environmental mitigation measures – transport and traffic

ID	Mitigation measure	Timing
TT1	A Construction Transport and Access Management Plan (CTAMP) will be prepared as part of the Construction Environmental Management Plan (CEMP) in consultation with the relevant local councils and emergency services. The CTAMP will include: • measures to minimise and manage construction traffic and road safety impacts on other road users, including pedestrians, cyclists and buses • planning to minimise the movement of construction heavy vehicles during the AM and PM peak hours, weekend peak hours and on peak weekends (such as the Bathurst Super Car event) and public holidays, where practicable • access management measures, including safety measures, for active transport interfaces with construction areas and construction sites • measures to provide safe and adequate access to residential premises and businesses during construction, particularly where construction activities affect existing property access arrangements • details of the types of temporary traffic management measures that would be required during construction, such as posted speed limit reductions, detours and full or partial road closures, and how these measures would be managed to minimise impacts on other road users • measures to periodically update local emergency services on the staging and progress of construction works, and to maintain safe adequate access for emergency services during the construction period • a framework for coordinating construction planning and traffic management with adjacent Great Western Highway upgrade projects to minimise potential cumulative construction traffic impacts.	Construction
TT2	Sufficient car parking spaces will be provided within the project construction sites to accommodate anticipated construction worker parking requirements. During detailed construction planning, opportunities to provide a shuttle bus or other initiatives to transfer construction workers from local hubs to construction sites will be investigated.	Design and construction
TT3	Opportunities to minimise the impacts of construction traffic on the level of service at the Great Western Highway/ Evans Lookout Road intersection and the Great Western Highway/ Browntown Oval intersection will be investigated during detailed construction planning.	Design and construction
TT4	The operational traffic performance of the project will be reviewed 12 months after commencement of operation. The review will aim to confirm the predicted positive effects of the project on the road network and, if relevant, identify adverse operational traffic impacts on road network performance. In the event that adverse operational traffic impacts on the road network are identified, opportunities to mitigate these impacts will be considered for implementation.	Operation

9 Air quality

This chapter summarises the air quality assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full air quality assessment is provided in Appendix E (Technical report – Air quality).

9.1 Key air quality issues for the project

Pollutants of interest from the project include those generated from both the combustion of fossil fuels and from non-combustion sources such as the generation of dust from the disturbance of soil during construction. The effect of these pollutants on human health and the environment is discussed in Chapter 10 (Human health) and Appendix E (Technical report – Air quality). The pollutants of interest assessed are:

- nitrogen dioxide (NO_2)
- carbon monoxide (CO)
- particulate matter less than 10 microns in diameter (PM_{10})
- particulate matter less than 2.5 microns in diameter ($PM_{2.5}$)
- volatile organic compounds (VOCs) including:
    - benzene
    - formaldehyde
    - toluene
    - acetaldehyde
    - ethylbenzene
    - xylene
    - 1,3 butadiene
- polycyclic aromatic hydrocarbons (PAHs).

The potential main sources of air emissions from the project addressed in this report are as follows:

- construction dust from demolition, earthworks, the concrete batching plant, the movement of vehicles on the construction site and spoil handling
- construction plant engine exhaust emissions
- odour emissions from earthworks during construction
- vehicle emissions from the operation of the project in relation to:
    - surface road emissions
    - in-tunnel emissions
    - the preferred tunnel ventilation design (ventilation outlet emissions or portal emissions) as discussed in Section 4.5 of Chapter 4 (Project description).

9.2 Air quality legislation, guidance and assessment criteria

9.2.1 Air quality legislation and guidelines

The relevant legislation and guidance documents for the regulation and assessment of air quality in NSW are:

- *National Environment Protection Council Act 1994* (Cth) which provides the relevant National Environment Protection Measures (NEPMs) relevant to air quality:
  - National Environment Protection (Ambient Air Quality) Measure (National Environmental Protection Council, 2021)
  - National Environment Protection (Air Toxics) Measure (National Environmental Protection Council, 2004)
- *Protection of the Environment Operations Act 1997* (NSW) (POEO Act) supported by the following regulations and guidance documents:
  - Protection of the Environment Operations (Clean Air) Regulation 2021
  - Approved Methods for the Modelling and Assessment of Air pollutants in NSW (Approved Methods) (NSW Environment Protection Authority (EPA), 2022a)
  - Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (NSW EPA, 2022b).

Further detail of these documents is provided in Section 3 of Appendix E (Technical report – Air quality).

Ventilation outlets are regulated by the EPA as a scheduled activity under the POEO Act. The project is not currently a listed road tunnel, but it is anticipated that the EPA would consider listing the project if it is approved and if the ventilation outlet option is pursued as the preferred ventilation option.

9.2.2 Air quality criteria and standards

An evaluation approach using multiple sets of assessment criteria has been used to assess the air quality impacts of the project. Since the project passes through areas with high ecological values, environmental impact criteria have been included in the assessment criteria. Neither the Approved Methods nor the NEPMs include environmental criteria for the assessment of impacts on ecological receptors, except for hydrogen fluoride. However, the EPA Victoria Guideline (EPA VIC, 2022) sets environmental criteria based on World Health Organisation standards and these have been adopted for the project.

Two ventilation options, emissions via ventilation outlets or portals (Chapter 4 (Project description)) have been assessed. Project impact descriptors for the assessment of portal emissions were developed and endorsed by Advisory Committee on Tunnel Air Quality (ACTAQ) (EMM Consulting, 2022). The methodology for the application of these descriptors is described in Section 3 of Appendix E (Technical report – Air quality).

In summary, four sets of assessment criteria were used for the assessment of air quality impacts from the project:

- air quality criteria prescribed in the Approved Methods, used to assess ground level concentrations (Table 9-1)
- project impact assessment descriptors endorsed by the ACTAQ (EMM Consulting, 2022) used to assess annual average NO_2 and $PM_{2.5}$ emissions from both portals and ventilation outlets (Table 9-2 and Table 9-3)
- environmental assessment markers used to assess potential air quality impacts on ecological receptors for NO_2, toluene and $PM_{2.5}$ (Table 9-4)

- assessment of in-tunnel air quality based on in-tunnel air quality criteria for NO_2 and visibility as detailed in the ventilation analysis (Section 8.4 of Appendix E (Technical report – Air quality)) (Table 9-6).

Air quality standards are typically a concentration limit for a given averaging period to address long-term, e.g. annual average, or short-term exposure, e.g. 24 hour or one hour average (see Section 3.4 of Appendix E (Technical report – Air quality)). These criteria are among the most stringent worldwide (see Annexure B of Appendix E (Technical Report – Air quality). In meeting these in-tunnel and ambient air quality criteria, the comparison with national and international air quality standards show that this tunnel is designed and would be operated consistent with international best practice.

Ambient air quality criteria

The ambient air quality criteria prescribed in the Approved Methods, (NSW EPA, 2022a; NSW EPA 2022b) were applied as shown in Table 9-1. A comparison of international ambient air quality criteria is shown in Section 1.3 (Table B-1) of Annexure B of Appendix E (Technical report – Air quality). An ambient air quality criterion relates to the background concentration of an air pollutant in the outdoor air.

Table 9-1 Ambient air quality criteria applied to the project

Pollutant	Averaging period	Criteria ($\mu g/m^3$)
Particulate matter (PM_{10})	24 hour maximum	25
	Annual average	8
Particulate matter ($PM_{2.5}$)	24 hour maximum	25
	Annual average	8
Nitrogen dioxide	1 hour maximum	164
	Annual average	31
Carbon monoxide	1 hour maximum	30,000
	8 hour maximum	10,000
Benzene (C_6H_6)	99.9th percentile 1-hour average	29
Formaldehyde	99.9th percentile 1-hour average	20
1,3-butadiene	99.9th percentile 1-hour average	40
Toluene (C_7H_8)	99.9th percentile 1-hour average	360
Ethylbenzene (C_8H_{10})	99.9th percentile 1-hour average	8,000
Xylene (C_8H_{10})	99.9th percentile 1-hour average	190
PAHs (as Benzo(a)pyrene)	99th percentile 1 hour	0.04

Project impact assessment descriptors

These descriptors have been applied to the assessment of emissions for both ventilation outlets and portal emission options to enable a comparison of both options. The pollutant concentration range and overall impact level are shown in Table 9-2 and Table 9-3.

Table 9-2 Project impact descriptors for annual average NO_2 at individual receptors

Total concentration at receptor for a given averaging period	Absolute change in concentration relative to air quality criterion				
	<0.5% (<0.16 μg/m^3)	≥0.5% to <1.5% (≥0.16 to <0.47 μg/m^3)	≥1.5% to <5.5% (≥0.47 to <1.71 μg/m^3)	≥5.5% to <10.5% (≥1.71 to <3.26 μg/m^3)	≥10.5% (≥3.26 μg/m^3)
≤75% of Air Quality Criteria (AQC) (≤23.3 μg/m^3)	Negligible	Negligible	Negligible	Slight	Moderate
>75% to ≤95% of AQC (>23.3 to ≤29.5 μg/m^3)	Negligible	Negligible	Slight	Moderate	Moderate
>95% to ≤103% of AQC (<29.5 to ≤31.9 μg/m^3)	Negligible	Slight	Moderate	Moderate	Substantial
>103% to ≤110% of AQC (>31.9 to ≤34.1 μg/m^3)	Negligible	Moderate	Moderate	Substantial	Substantial
≥110% of AQC (≥34.1 μg/m^3)	Negligible	Moderate	Substantial	Substantial	Substantial

Table 9-3 Project impact descriptors for annual average $PM_{2.5}$ at individual receptors

Total annual average concentration at receptor	Absolute change in concentration relative to air quality criterion				
	<0.5% (<0.04 μg/m^3)	≥0.5% to <1.5% (≥0.04 to <0.12 μg/m^3)	≥1.5% to <5.5% (≥0.12 to <0.44 μg/m^3)	≥5.5% to <10.5% (≥0.44 to <0.84 μg/m^3)	≥10.5% (≥0.84 μg/m^3)
≤75% of AQC (≤6.0 μg/m^3)	Negligible	Negligible	Negligible	Slight	Moderate
>75% to ≤95% of AQC (>6 to ≤7.6 μg/m^3)	Negligible	Negligible	Slight	Moderate	Moderate
>95% to ≤103% of AQC (<7.6 to ≤8.2 μg/m^3)	Negligible	Slight	Moderate	Moderate	Substantial
>103% to ≤110% of AQC (>8.2 to ≤8.8 μg/m^3)	Negligible	Moderate	Moderate	Substantial	Substantial
≥110% of AQC (≥8.8 μg/m^3)	Negligible	Moderate	Substantial	Substantial	Substantial

Ecological impact assessment criteria

Ecological receptors for the project have been assessed against the NO_2 annual average in the Victoria EPA Guideline (EPA VIC, 2022) for terrestrial vegetation as shown in Table 9-4. The endpoint represents the receptor or issue that the environmental air quality impact assessment criteria is protective of, if the endpoint is not relevant to a site, then the criteria does not apply.

Table 9-4 Victoria EPA environmental air quality impact criteria

Pollutant	Averaging period	Ecological endpoint	Environmental criteria (µg/m^3)
NO_2	Annual	Terrestrial vegetation	30
Toluene	Maximum 30 min	Environmental aesthetics	1,100
$PM_{2.5}$	10 hour	Terrestrial vegetation	50

Particulate emissions from vehicle exhaust are largely fine particulates within the $PM_{2.5}$ fraction. The effects of fine particulates on photosynthesis of vegetation are not well understood; and there is not currently an established criteria for assessment of ecological receptors with regards to $PM_{2.5}$ concentrations. To assess the potential $PM_{2.5}$ impacts on ecological receptors, the findings of the study 'The Response of Plant Photosynthesis and Stomatal Conductance to Fine Particulate Matter ($PM_{2.5}$) based Leaf Factors Analysing' (Li et.al. 2019) were used to define the assessment methodology.

Based on the findings of the study the most conservative threshold to assess ecological impacts would be a $PM_{2.5}$ µg/m^3 concentration of 50 µg/m^3 where photosynthetic rate and stomatal conductance is expected to decrease. The benchmark value of 50 µg/m^3 over a maximum 10-hour averaging period was adopted to assess predicted $PM_{2.5}$ concentration at ecological receptors.

In-tunnel air quality

In February 2016, the ACTAQ issued a document entitled 'In-Tunnel Air Quality (Nitrogen Dioxide) Policy' (ACTAQ, 2016). That document further consolidated the approach taken earlier for the NorthConnex, WestConnex New M4 and New M5 projects. The policy wording requires tunnels to be 'designed and operated so that the tunnel average nitrogen dioxide (NO_2) concentration is less than 0.5 ppm as a rolling 15-minute average'. This criterion compares favourably to the international in-tunnel criteria, shown in Table 9-5, which range between 0.4 and 1.0 ppm. Examples of in-tunnel NO_2 values for ventilation control from other projects internationally and in Australia are summarised in Table 9-5.

The criteria adopted for assessment of in-tunnel air quality are shown in Table 9-6. The NO_2 is a rolling average over the length of the tunnel as described in the In-Tunnel Air Quality (Nitrogen Dioxide) Policy (ACTAQ, 2016). The visibility criterion is a measurement of the scattering (extinction) of light by particles in the air, leading to low visibility in tunnels. The desired outcome for this criterion is to maintain clear air for good visibility within the tunnel.

Table 9-5 Comparative in-tunnel NO_2 limits (ACTAQ, 2016)

Jurisdiction/project	In-tunnel NO2 criteria	Design or compliance	Averaging period
NSW/NorthConnex[1]	0.5 ppm tunnel route average	Design and compliance	15-minutes
Brisbane City Council/Clem 7 (2007/Legacy Way (2010) tunnels	1 ppm average	Design and compliance	None given
Permanent International Association of Road Congresses	1 ppm tunnel average	Design only	None given
New Zealand	1 ppm	Design only	15-minutes
Hong Kong	1 ppm	Design only	5-minutes

Table notes:

1. Other projects have used these criteria including WestConnex projects (New M4, M4-M5, M8) and Western Harbour Tunnel.

Table 9-6 In-tunnel air quality criteria adopted for the assessment

Pollutant	Averaging period	Criteria
NO_2	15-min rolling average	0.5 ppm
Visibility (extinction co-efficient limit)	15-min rolling average	0.005 m^{-1}

9.3 Assessment approach

9.3.1 Construction assessment methodology

Dust emissions

A qualitative risk-based methodology was used to assess the impacts of dust given it is not possible to predict weather conditions during construction activities in future years. The majority of the works would be underground. The assessment follows the UK Institute of Air Quality Management's (IAQM) Guidance on the Assessment of Dust from Demolition and Construction (IAQM, 2014)[1]. The methodology is shown in Figure 9-1 and included:

- step 1: an initial screening to identify where there is a risk of significant construction dust impacts, including a review of the proposed work, plant and equipment, and potential emission sources and levels
- step 2A: categorise dust generating activities required for the project to reflect their potential impacts including demolition, earthworks, construction, tunnelling and track-out work
- step 2B: assess the risk of dust impacts during project construction through defining the potential magnitude of dust created by the activity, and the sensitivity of the area
- step 3: identification of mitigation measures for the potential impacts identified
- step 4: determine whether there are residual significant impacts after mitigation
- step 5: produce a dust assessment report that captured the approach, risks identified, mitigations required and significance of impacts.

[1] This assessment criteria has been adapted for use in NSW regarding ambient PM_{10} concentrations (being particulate matter less than or equal to 10 micrometres in diameter)

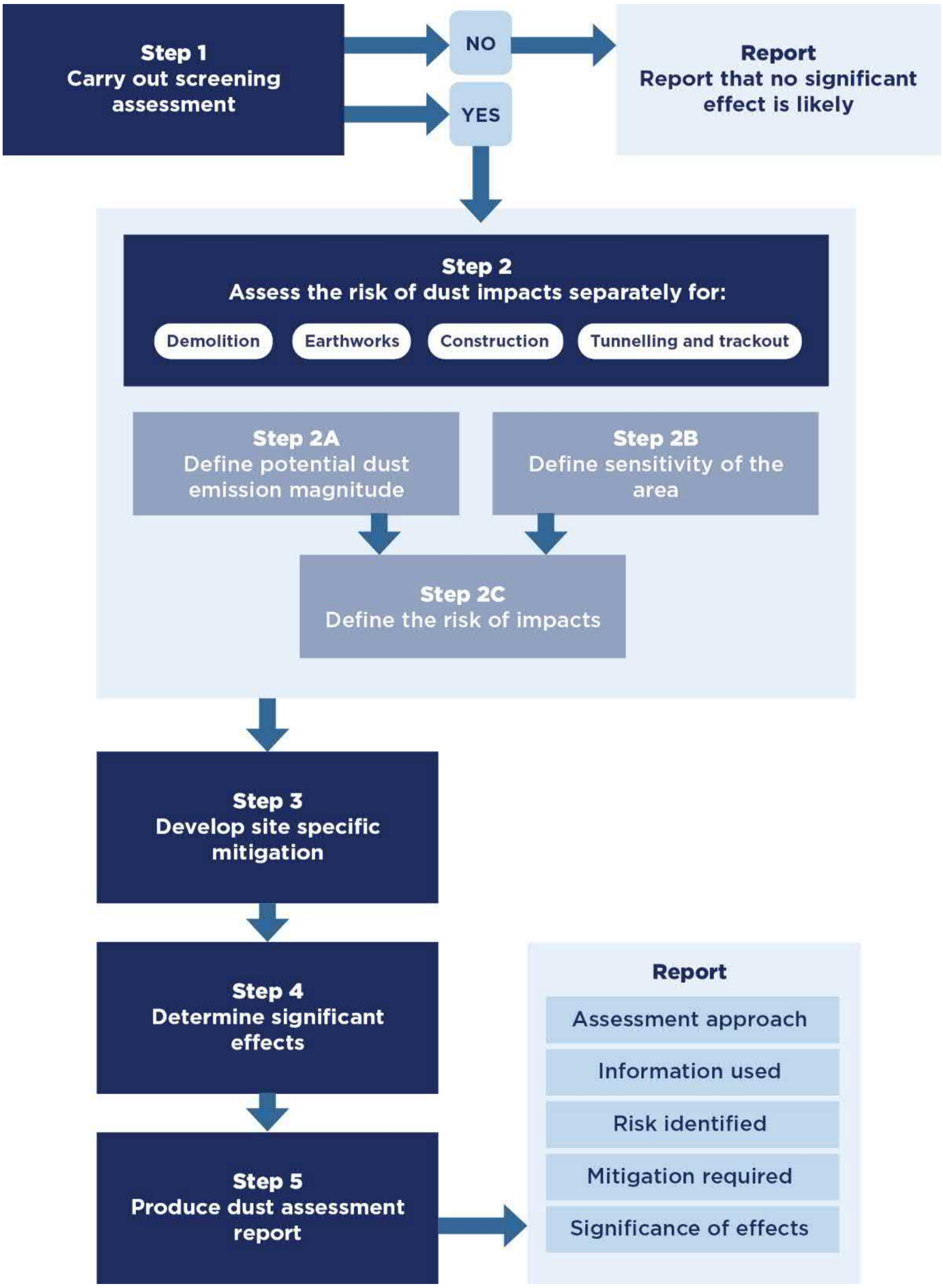

Figure 9-1 Construction dust assessment methodology

Exhaust emissions

Previous experience of assessing the exhaust emissions from onsite mobile and stationary equipment as well as construction traffic indicates that these emissions are unlikely to make a significant impact on local air quality (IAQM, 2014). Potential impacts from exhaust emissions from construction of the project were qualitatively assessed.

Assessment of odours

Potential sources of odour during construction would primarily be due to:

- the disturbance of acid sulfate soils or acid sulfate rock (ASR)
- contaminated soils during earthworks.

Acid sulfate occurs naturally in soils and rock that contains iron sulfides. When exposed to air, odorous compounds can be generated. The likelihood of encountering acid sulfate soils within the project area is low (see Chapter 15 (Soils and contamination)).

ASR is unweathered rock (i.e., rock that has not been exposed to water, wind, ice, plants, or changes in temperatures) which contains metal sulfide minerals. When exposed to either oxygen or water, oxidation of the sulphide within the ASR leads to the formation of iron oxides, sulfuric acid, sulfates, and salts.

Potential ASR deposits have been identified around the western half of the project alignment within Illawarra Coal Measures and Shoalhaven geological formations (see Chapter 13 (Groundwater and geology)). ASR may be exposed during tunnel excavation. An acid sulfate rock management plan would be implemented during construction.

Another potential minor source of odour emissions would be from asphalt during road pavement construction. Odour emissions from the laying of asphalt are from a complex mixture of hydrocarbons and VOCs. Potential odour impacts from this source would be minor and transitory in nature provided appropriate management measures for the project are applied as discussed in Section 9.7.

Given the low probability of odours occurring during earthworks and the transient nature of odours from the short lengths of surface roads on which pavement construction would occur, odours would be adequately managed by the measures in Section 9.7.

9.3.2 Operational assessment methodology

A quantitative assessment of operational air quality impacts was undertaken to determine the changes in air quality as a result of the project. The assessment process is outlined in Figure 9-2.

The first stage of an air quality impact assessment is the collection of a wide array of data, which is combined to make pollutant predictions using a dispersion model. The predicted pollutant concentrations are then assessed against the relevant air quality criteria (Section 9.2.2 and Section 9.6) and health criteria (see Chapter 10 (Human health)).

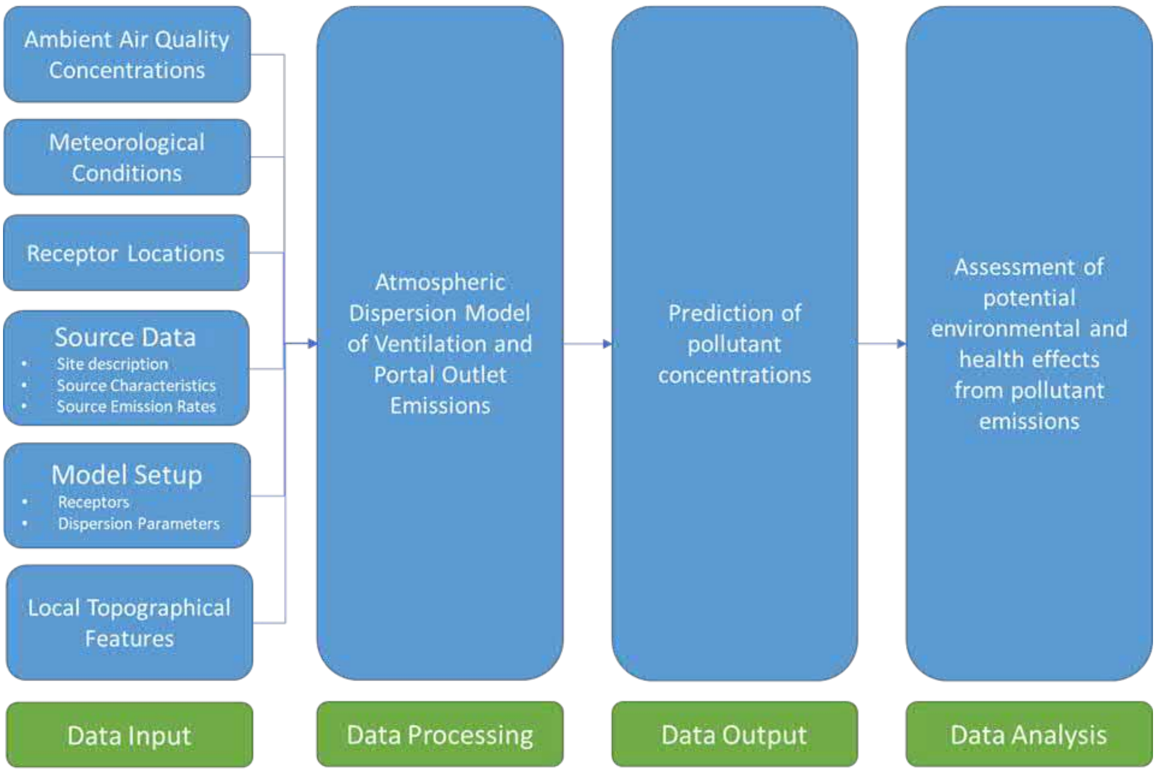

Figure 9-2 Stages of an air quality assessment

This assessment was carried in accordance with the Approved Methods for Modelling and Assessment of Air Pollutants in New South Wales, NSW Environment and Protection Authority (NSW EPA, 2022a) and other guidance documents as detailed in the Secretary's environmental assessment requirements and in Section 3 of Appendix E (Technical report – Air quality).

The future air quality in the year of project opening (2030) and ten years after project opening (2040) was predicted by modelling based on:

- forecast traffic volumes and type of vehicles for each of those years (see Chapter 8 (Transport and traffic))
- emissions from that traffic calculated based on known vehicle fleet emissions and future emissions standards (see Section 6.7 of Appendix E (Technical report – Air quality))
- existing air quality and meteorology of the project area
- the terrain, or topography of the project area and any buildings which may affect dispersion of emissions from the project.

Using the meteorological and dispersion models, pollutant concentrations are predicted at specific locations. These locations may be sensitive receptor locations or a point on a spatial grid within the modelled area used to produce contour plots of pollutant concentrations. The consideration of ecological receptors in this assessment recognises the values of the Blue Mountains National Park adjacent to the project area and the Greater Blue Mountains World Heritage Area.

The predicted concentrations of pollutants were then compared to the relevant criteria or impact descriptors. Further detail of the assessment process is provided in Section 5 and 6 of Appendix E (Technical report – Air quality).

Study area

The area of interest for the project spans a 13-kilometre-long section of surface road connecting the upgraded Great Western Highway between Blackheath and Little Hartley.

The project corridor was divided into five modelling domains as shown in Figure 9-3. A more detailed description of each domain has been provided in Annexure J of Appendix E (Technical report – Air quality). The domains include:

- the practical extent of the expected emission plumes around the tunnel outlets – preliminary modelling of the ventilation outlet and portal emissions options was used to test the extent of the modelling domains. The aim of the preliminary modelling was to ensure the peak concentration was identified and the closest relevant receptors were considered
- location of the receptors in proximity to the ventilation outlets
- project footprint – the domains need to cover the extent of the project footprint
- dispersion modelling grid size – as the project needs to consider complex topographical changes as part of the portal outlet modelling, fine scale modelling grid is required. A two metre resolution modelling grid was adopted to ensure the changes close to the portals were adequately characterised.

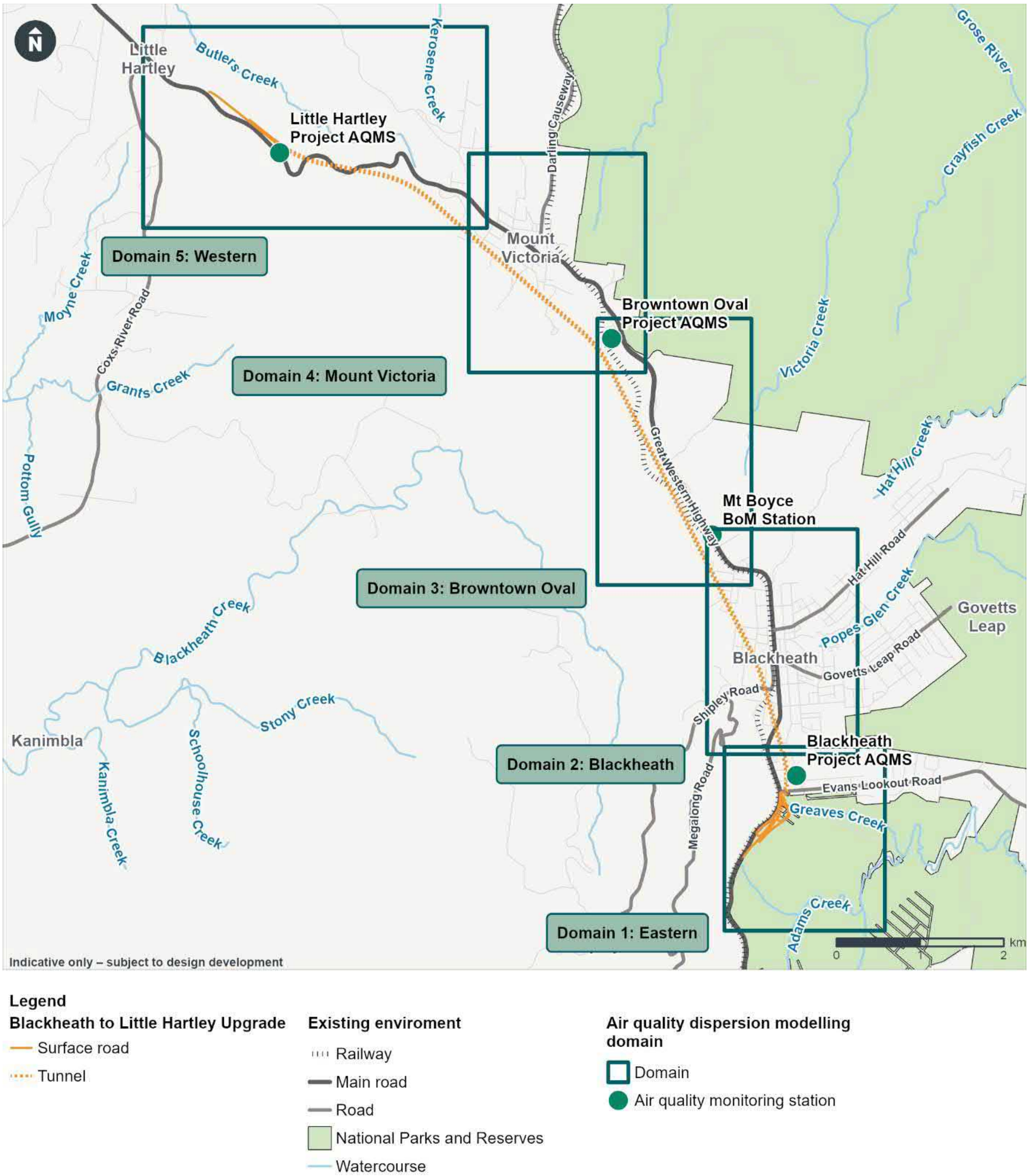

Figure 9-3 Dispersion modelling domains

Air quality modelling scenarios

Dispersion modelling scenarios define how emissions from surface roads, ventilation outlets or portals are combined for use in a dispersion model. Scenarios were developed considering three daily traffic emission profiles, expected from the tunnel including:

- typical daily traffic profile – the typical daily traffic profile reflects the expected hourly traffic numbers using the tunnel on a normal day (excluding peak traffic days such as Christmas, Easter, long weekend holidays and during special events such the Bathurst Super Car event). This profile is considered to provide the best indication of long-term impacts from the tunnel operations

- maximum daily traffic profile – the maximum daily traffic profile reflects traffic conditions that are only expected to occur for a small number of days per year e.g., during the Bathurst race weekend or at Christmas with high tourist numbers. As this is not expected to occur across many days per year, only short-term pollutant averaging periods have been considered for the assessment. This scenario best represents the tunnels worst-case short-term traffic conditions with the highest number of vehicles in the tunnel at any point in time, although with the mix of vehicles dominated by light (passenger) vehicles and lower numbers of heavy vehicles
- regulatory worst-case emissions profile – this reflects the theoretical maximum emissions concentrations modelled for every hour of one year. The tunnel emissions are equal to the emission concentrations that may be included in the tunnel environment protection licence (EPL), based on previous tunnel licences. Although licence conditions are not currently applicable to portal emissions, both ventilation outlet and portal emission options have been considered for the regulatory worst-case scenario.

In addition to the different operational emissions profiles outlined above, the assessment scenarios consider emissions from two different ventilation options. The two ventilation options consist of the ventilation outlet option and the portal emissions option, described in Section 4.5 of Chapter 4 (Project description).

The traffic scenarios considered future changes in the composition and performance of the vehicle fleet, as well as predicted traffic speeds, traffic volumes and the distribution of traffic on the road network (described in Chapter 8 (Transport and traffic)). For each expected traffic scenario, a spatial emissions inventory (emissions model) was developed. Greater uptake of alternate fuelled vehicles, in particular electric vehicles, are expected to reduce the NSW vehicle fleet emissions into the future. This expected reduction is difficult to quantify and is not included in the emissions inventory and model. Hence the vehicle emissions used are conservative for the future years 2030 and 2040.

The scenarios that were modelled are summarised in Table 9-7 and based on the traffic and transport modelling that include other components of the Great Western Highway Upgrade Program (Upgrade Program). Further detail on the traffic scenarios is provided in Section 8.1 of Chapter 8 (Transport and traffic). In the air quality assessment model, the following components were treated separately to take potential changes in traffic emissions across the road network into account:

- emissions from ventilation outlets
- emissions from exit portals
- emissions from the traffic on the existing surface road network, and new surface roads associated with the project.

Two traffic conditions were used to understand in-tunnel air quality conditions:

- typical traffic
- worst-case traffic.

Table 9-7 Modelled air quality scenarios for operation of the project

Ventilation option	Traffic scenario modelled (year)	Emission profile			
		Upgrade Program inclusion	Typical daily traffic	Maximum daily traffic	Regulatory worst case
None	Base year scenario (2018[1])	No	✔	✔	x
	Operational year scenario (2030) without the project	No	✔	✔	x

Ventilation option	Traffic scenario modelled (year)	Emission profile			
		Upgrade Program inclusion	Typical daily traffic	Maximum daily traffic	Regulatory worst case
	Operational year scenario (10 years after opening) (2040) without the project	No	✔	✔	x
Ventilation outlet option	Operational year scenario (2030) (at project opening)	All Upgrade Program components[2]	✔	✔	✔
	Operational year scenario (2040) (10 years after opening)	All Upgrade Program components[2]	✔	✔	✔
Portal emissions option	Operational year scenario (2030) (at project opening)	All Upgrade Program components[2]	✔	✔	✔
	Operational year scenario (2040) (10 years after opening)	All Upgrade Program components[2]	✔	✔	✔

Table notes:

1. 2018 was selected as the base year scenario given the impacts of the COVID-19 pandemic on travel patterns between 2020-2022.
2. Assumes the Katoomba to Blackheath Upgrade, the Medlow Bath Upgrade and the Little Hartley to Lithgow Upgrade are all operational.

GRAMM/GRAL modelling system

The atmosphere is a complex physical system, and the movement of air in a given location is dependent on a number of variables, including temperature, topography and land use, as well as larger-scale weather patterns. Dispersion modelling is a method of simulating the movement of air pollutants in the atmosphere using mathematical equations.

The operational assessment methodology involved combining the use of a meteorological model (Graz Mesoscale Model (GRAMM)) and a dispersion model (Graz Lagrangian Model (GRAL)) as illustrated in Figure 9-4. The GRAMM/GRAL models have been used on all recent Sydney road tunnel environmental impact assessments. Further detail of the GRAMM/GRAL modelling system is presented in Section 6.5 of Appendix E (Technical report – Air quality).

The GRAL dispersion model predicts potential ground-level pollutant concentrations by simulating the movement of individual 'particles' of a pollutant emitted from an emission source in a three dimensional wind field. The main project-specific inputs to the GRAL model are shown in Figure 9-4.

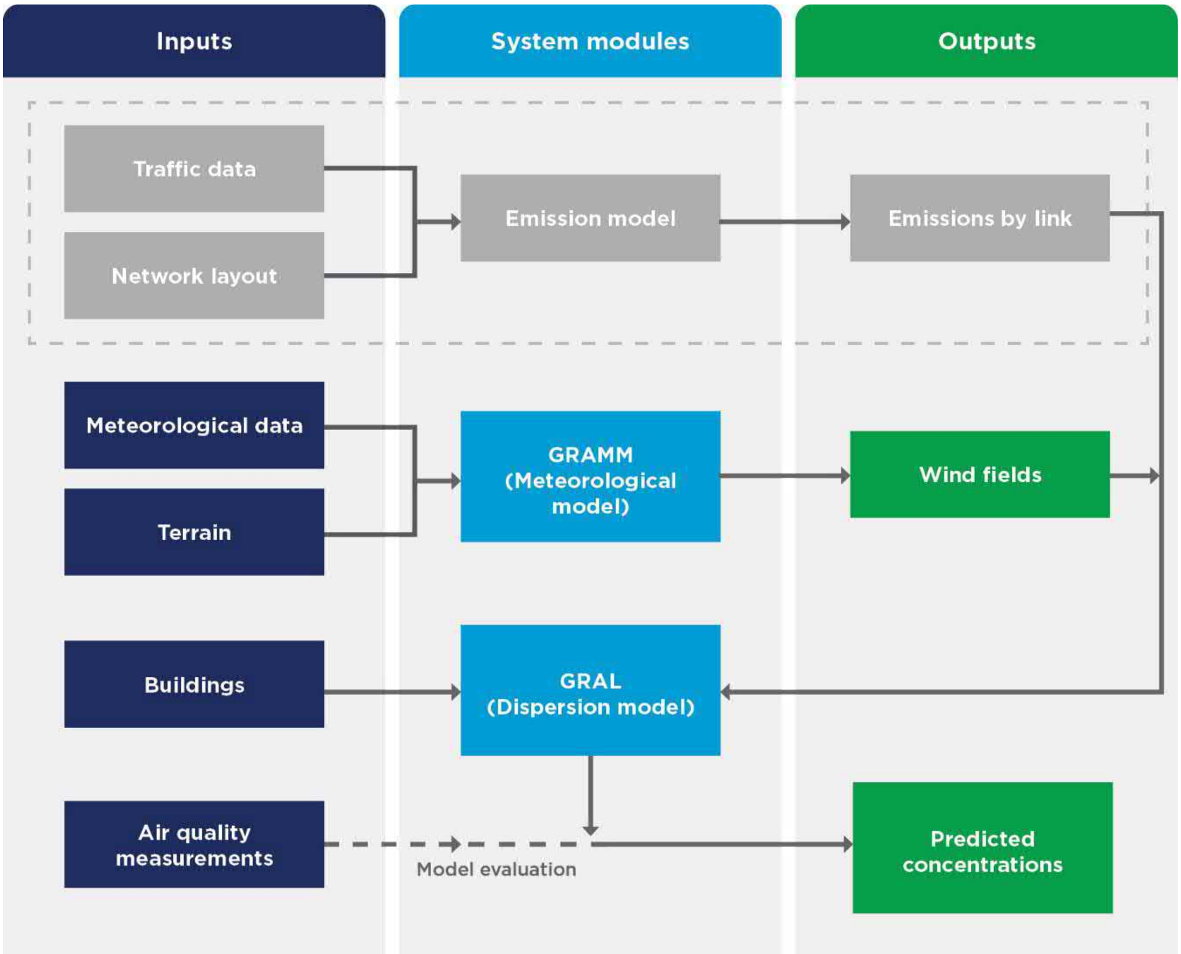

Figure 9-4 Overview of the operational air quality model

Air quality concentrations

The concentration of a pollutant at a given location includes contributions from various sources. The following sources were used to describe the concentration of a pollutant at a specific location or receiver (as depicted in Figure 9-5).

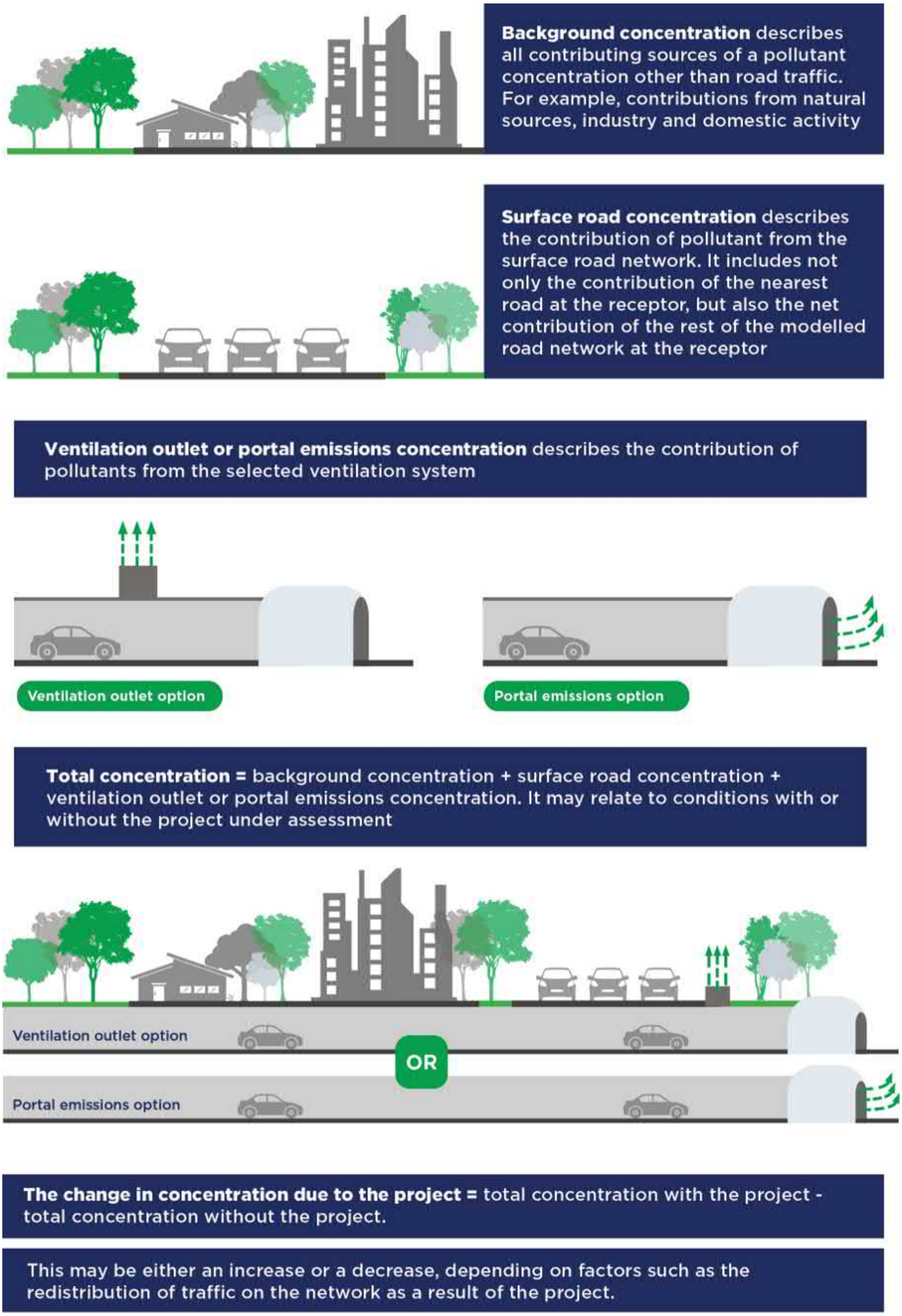

Figure 9-5 Components of air quality concentrations

In-tunnel air quality

In-tunnel air quality modelling was carried out using IDA Tunnel software which has been used on previous Sydney road tunnel assessments. The modelling considered traffic volumes and speeds, tunnel air flow, vehicle emission levels and temperature in the following scenarios:

- typical traffic – 24-hour operation of the project ventilation system under day-to-day conditions of expected traffic demand in 2030 and 2040
- worst-case traffic – the most onerous traffic conditions for the ventilation system (refer below).

The operational worst-case traffic scenarios represent the theoretical maximum pollutant concentrations for all potential traffic operations in the tunnel as well as vehicle breakdown situations. The operational worst-case scenarios are very conservative and would result in pollutant emission concentrations that are much higher than those that could occur under foreseeable operational conditions in the tunnel. Two scenarios were considered, including:

- the worst-case for traffic variable speeds
- the worst-case in the event of a breakdown or major incident.

The worst-case (variable speed) traffic operation scenario represents the upper limit of daily ventilation system operations in the tunnels, regardless of the year of operation, and is based on the traffic flows for the predicted traffic peak periods with the mainline tunnels reaching a theoretical maximum lane capacity traffic flow. The worst-case scenario was considered for average speeds for lane capacity for 20 to 80 kilometres per hour.

At an average traffic speed of 20 kilometres per hour through the tunnel jet fans would be operated to assist the longitudinal flow of air through the tunnel as the piston effect would be reduced by the slow-moving traffic and the volume of traffic passing through the tunnel is reduced. The likelihood of average traffic speed throughout the tunnel being less than 20 kilometres per hour is very small, likely less than one per cent, based on monitoring of traffic through the M5 East tunnel (see Annexure D of Appendix E (Technical report – Air quality)).

Traffic management plans would be developed during design development to provide capability to further reduce the likelihood of slow-moving traffic. Maintaining the traffic speed above 20 kilometres per hour in any section of the tunnel is also a safety measure to minimise the chance of rear end crashes at the end of a line of stopped or slow-moving traffic, which could result in a fire, and to allow vehicles in front of a fire to drive out of the tunnel without being over-run by smoke.

At an average speed of 80 kilometres per hour the traffic is free flowing with twice the volume of vehicles passing through the tunnel and no jet fans are required to assist the air flow through the tunnel.

The worst-case (breakdown or major incident) operation scenario assesses the most onerous traffic case, where congestion that occurs as a result of a breakdown affects the longest possible queue length within the tunnel. The air flow would be reliant on jet fans.

9.4 Existing environment

9.4.1 Terrain features

Terrain features include both the topographical changes and land use characteristics within a study area.

Topography along the project corridor is dominated by the western escarpment of the Blue Mountains plateau and the lower elevations in the Little Hartley valley. The majority of the Great Western Highway within the project corridor is situated along the Blue Mountains plateau at an elevation of about 1,025 to 1,091 metres above sea level. The elevation drops significantly as the Great Western Highway moves from Mount Victoria to Little Hartley valley, dropping from about 1,075 metres at Mount Victoria to about 830 metres in Little Hartley. The topographical changes observed between Mount Victoria and Little Hartley would be expected to affect the local meteorological conditions and, being close to the location of the western end of the tunnel, would affect the dispersion pattern for emissions from the tunnel.

Terrain changes are minor in the vicinity of the Blackheath portal and as such terrain is likely to have a limited effect on plume dispersion.

Detailed analysis of the terrain is provided in Section 4 of Appendix E (Technical report – Air quality).

9.4.2 Land use

Land use is a semi-rural to rural environment that includes some urban residential development scattered between areas of natural vegetation and rural communities. The natural vegetation in the area consists of several reserves as well as the Blue Mountains National Park. Areas of urban development occur at Blackheath and Mount Victoria.

Blackheath includes a mix of low to medium density residential and tourist accommodation, with a small commercial town centre and several public recreational areas including a golf course close to the Blackheath portal. On the outskirts of Blackheath are areas zoned for environmental living as well as several recreational reserves.

Mount Victoria has a small commercial town centre surrounded by low density residential and some public recreational areas. The land use surrounding the Mount Victoria township consists of areas zoned for environmental living as well as several recreational reserves and conservation areas.

The Little Hartley valley is rural residential, agricultural, and low-density residential land surrounded by areas of native vegetation.

These land use patterns have been included in the dispersion model.

9.4.3 Existing ambient air quality

Background air pollution in NSW is typically characterised by either ambient monitoring data collected from a project specific monitoring program or through the use of data measured at DPE monitoring locations throughout NSW. A full year of data from all seasons is typically considered the minimum amount of data needed to enable the thorough analysis of all likely existing pollutant concentrations, although having several years of data is also useful to understand longer term changes in pollutant concentrations.

For the purposes of dispersion modelling and impact assessment, ambient monitoring data needs to be from the same 12 month period as the meteorological data used for the dispersion modelling, in accordance with the Approved Methods (NSW EPA, 2022b). The meteorological year used for the dispersion modelling was 2018[2], hence an ambient air pollutant data set for 2018 was required.

Ambient air quality monitoring locations within the Blue Mountains region were reviewed, firstly to establish whether there were relevant monitoring stations close enough to the project area that could be used to characterise background air pollution levels and secondly, whether sufficient data is available to enable a seasonal pollutant analysis and contemporaneous meteorological analysis. All stations considered are discussed in Section 4 of Appendix E (Technical report – Air quality). Of these, the Katoomba DPE monitoring data provided some data that was representative of the background air quality. However, once the data from the 2019-2020 ‘Black Summer’ bushfires was removed, there was insufficient data for a full 12 month data set. To overcome this limitation, three project specific monitoring stations were commissioned by Transport within the project corridor. Further information based on 12 months of monitoring data would be provided in future planning stages for the project.

[2] Existing year of 2018 was selected due to that year being the most recent full calendar year unaffected by either COVID travel restrictions conditions or the black summer bushfires in 2019. Traffic data was also available for that calendar year.

Project monitoring data

Three project specific monitoring stations have been installed at the following locations:

- Little Hartley adjacent to the Great Western Highway (operational since February 2022)
- Browntown Oval (operational since October 2021)
- Blackheath (operational since September 2021).

A summary of the data compared to the NSW EPA ambient air quality criteria is shown in Table 9-8.

Table 9-8 Project air pollutant monitoring station data summary

Pollutant	Averaging period	Units	Katoomba (Apr19-Jun20)	Blackheath (Nov21-Jun22)	Browntown Oval (Nov21-Jun22)	Little Hartley (Feb22-Jun22)	Synthetic data (Jan18-Dec18)	Criteria
NO_x	1 hour max	µg/m³	58.9	106.5	114.0	211.6	159.9	-
	All hours average[1]	µg/m³	3.8	9.1	7.1	23.4	11.2	-
NO_2	1 hour max	µg/m³	56.4	27.1	26.0	29.3	49.8	164
	All hours average[1]	µg/m³	2.7	3.3	1.9	5.5	6.3	31[2]
CO	1 hour max	µg/m³	1035	2114	1182	1333	1392	30000
	8 hour max	µg/m³	1021	1559	1099	1282	721	10000
PM_{10}	24 hour max	µg/m³	45.0	22.3	16.1	22.5	24.4	50
	All hours average[1]	µg/m³	6.7	6.8	6.3	6.7	8.4	25[2]
	No. exceedances	-	0	0	0	0	0	NA
$PM_{2.5}$	24 hour max	µg/m³	38.2	22.2	19.6	11.8	17.8	25
	All hours average[1]	µg/m³	3.8	3.9	3.7	3.5	5.2	8[2]
	No. exceedances	-	1	0	0	0	0	NA

Table notes:

1. Annual average cannot be calculated as less than 12 months of data was collected. All hours average has been used as a proxy for annual average
2. Criteria for annual average has been included for reference only as less than 12 months of data has been collected for each calendar year
3. This is not a criterion, more of an expectation for good airshed air quality

Unified monitoring data

The limited data availability prevented the use of a single representative observational data set for the background pollutant levels for the project corridor. To address this issue a unified monitoring data set was developed using observed data from the project monitoring stations and historical data from the Katoomba station. The methodology used to develop the unified monitoring data set is provided in Section 4.3 of Appendix E (Technical report – Air quality).

A comparison between the final unified data set, the project monitoring data and the Katoomba monitoring station data set is provided in Section 4.3 of Appendix E (Technical report – Air quality) with a summary of the unified data. The comparison showed a good correlation between the observed data while generally remaining conservative. On this basis the unified data set was considered appropriate for use when calculating the impacts of the project.

9.4.4 Meteorology

The dispersion model uses regional meteorological data to predict the direction of travel and degree of dispersion for a pollutant from the point of emission, whether that be the road, a ventilation outlet or a portal. Analysis of the meteorological data also considers how representative the dispersion modelling meteorology is of the local conditions. This is particularly relevant given the elevation difference between Blackheath and Little Hartley. Meteorological monitoring data was available from Lithgow, Wallerawang, Katoomba and Mount Boyce.

An analysis of the data available from these stations was undertaken, with the focus on data representativeness, quality and availability. The monitoring station data evaluation showed that only the Mount Boyce station was considered acceptable for use in the project (despite it being representative of the Blackheath to Mount Victoria area only)[3]. Monitoring data from the project stations located at Blackheath, Browntown Oval and Little Hartley did not have a full 12 months of data that could be used for the dispersion meteorology but have been used for verification purposes as discussed in Annexure E of Appendix E (Technical report – Air quality).

Given the limited data availability across the project corridor, the Mount Boyce meteorological data was used along with detailed topographical information and land use data to produce a refined GRAMM 'Match To Observation' meteorological data file for use in GRAL dispersion modelling.

The GRAMM model considers variable topographical and land use features across a modelling domain which enables the model to account for the expected differences between the Blackheath and Mount Victoria areas and the Little Hartley valley. This characteristic of the model means that although the Mount Boyce observation data is not representative of Little Hartley, the refined 'Match To Observation' GRAMM flow field data will take into account the significant differences between the top and bottom of the Blue Mountains and produce meteorology that is more reflective of conditions in the Little Hartley valley. The modelled data showed that calm (low wind speed conditions) percentages at Little Hartley were 10.6 per cent higher than calms observed at the top of the Blue Mountains, which is consistent with expectations for the region and consistent with limited observations undertaken at Little Hartley to date (additional detail on the Little Hartley measured data comparison is provided in Appendix E (Technical report – Air quality)).

Several additional verification analyses have been presented in Annexure E of Appendix E (Technical report – Air quality). All analyses show that the dispersion meteorology produced by GRAMM provides a good representation of the expected conditions in Little Hartley and at Blackheath and that the GRAMM data is acceptable for use in the assessment.

A detailed outline of the dispersion meteorology and discussion of its representativeness has been provided in Section 6.5 of Appendix E (Technical report – Air quality).

9.4.5 Sensitive receptors

The term "receptor" refers to a location where pollutant predictions are calculated by a dispersion model. Receptors can be either "sensitive" receptor locations or "gridded" receptors, which are locations on a spatial grid primarily used to generate pollutant concentration contours. Sensitive receptors are defined as "A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area." (NSW EPA, 2022a).

The eastern and western modelling domains (corresponding to the southern Blackheath residential area and the Little Hartley and western Mount Victoria areas), included sensitive receptor locations at all identified residential dwellings and commercial developments. Sensitive receptor locations were also placed at all residential and commercial developments within about 200 metres of the Great Western Highway between the Blackheath and Mount Victoria townships and in Little Hartley. These are the areas in which most development occurs and would be influenced by changes in air quality due to the project.

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[3] Noting that Mount Boyce is considered representative of the project corridor meteorology at the top of the Blue Mountains. It is not considered representative of conditions at Little Hartley.

All sensitive receptor locations included in the dispersion model are shown in Figure 9-6.

No hospitals or retirement homes were identified for this assessment. Educational facilities (schools and pre-school) are shown in Table 9-9. Gridded receptors were included for all modelling domains at a two metre resolution. These receptors were used as the basis for the generation of concentration contours along the Great Western Highway and around the tunnel portals.

Table 9-9 Educational facilities in the project area

Receptor name	Address
Kookaburra Kindergarten	9/11 Park Ave, Blackheath
Blue Gum Montessori	95 Wentworth St, Blackheath
Blackheath Public School	Leichhardt St, Blackheath
Blue Mountains Christian School	60 Thirroul Ave, Blackheath
Possum's Patch Childcare Centre	107 Great Western Hwy, Mount Victoria
Mount Victoria Public School	105-107 Great Western Hwy, Mount Victoria
One School Global NSW	84 Great Western Hwy, Mount Victoria

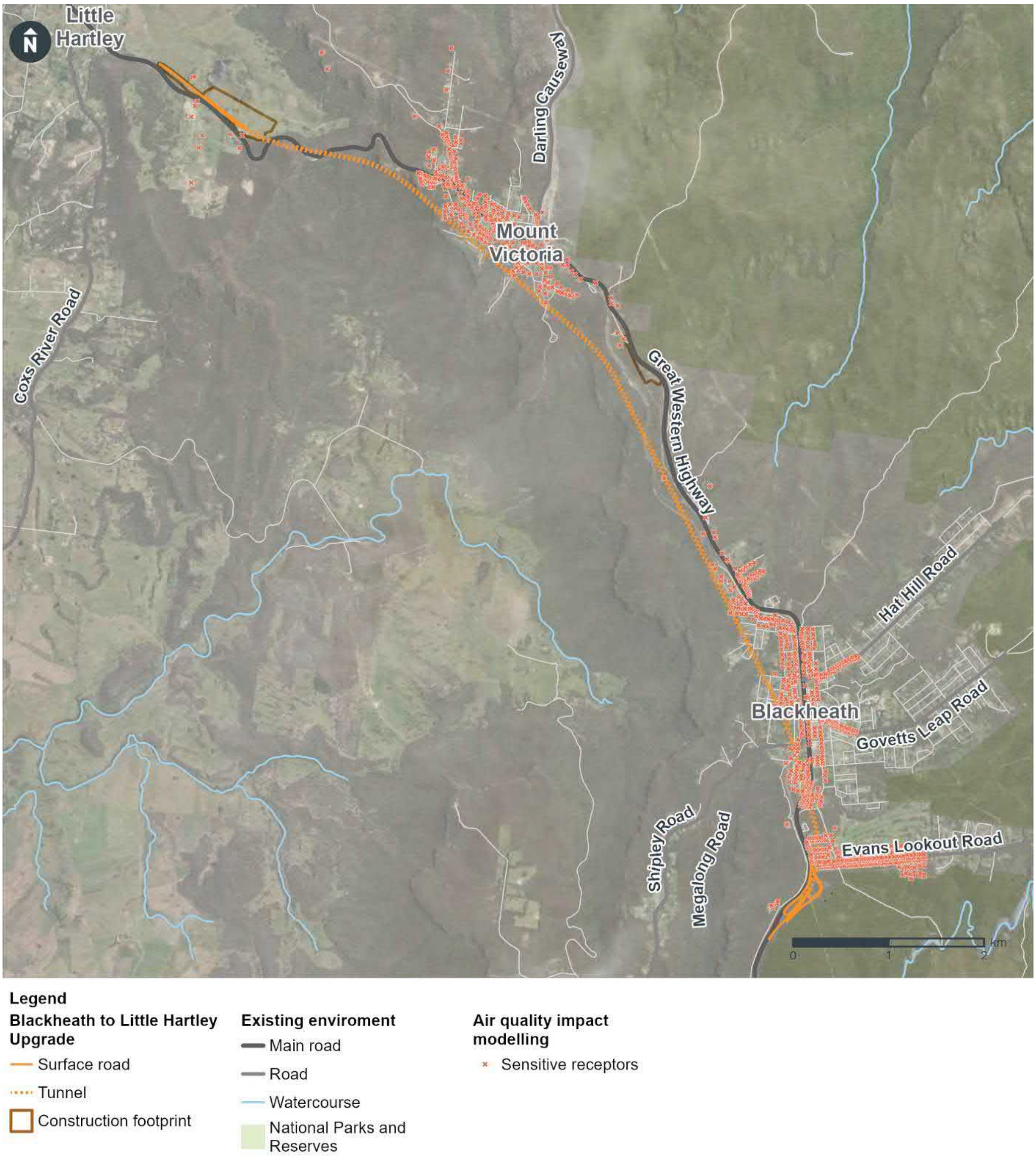


Figure 9-6 Sensitive receptor locations

9.4.6 Ecological receptors

Ecological receptors are areas of ecological significance. This can include areas such as national parks, state conservation areas, nature reserves and endangered ecological communities or species. Ecological receptors can also include agricultural activities that might be vulnerable to air emissions such as fruit and vegetable farms, flower farms or vineyards.

Increased concentrations of atmospheric pollutants have the potential to affect sensitive habitats and plant communities. For example:

- high levels of prolonged dust deposition may lead to plant physical stress, reduced photosynthesis, respiration, and transpiration through smothering

- chemical changes to soils or watercourses may lead to a loss of plants or animals, for example via changes in acidity
- exposure to elevated NO_2 concentrations may result in changes to leaf chlorophyl and mineral ion content and changes to essential enzyme activity in vegetation
- physiological changes to vegetation because of increased pollutant concentrations may also have indirect effects such as increased susceptibility to stresses such as pathogens.

The assessment of ecological impacts associated with the project is provided in Chapter 12 (Biodiversity). Due to the ecological significance of the area surrounding the project, both construction and operational air quality impacts from the project were assessed.

9.5 Potential impacts – construction

9.5.1 Dust impact assessment

Construction of the project is anticipated to take around eight years. Potential dust impacts during the construction period have been determined based on the IAQM construction dust assessment guidance and the expected scale of the of construction activities outlined in Section 9.3.1.

Stage 1: screening stage assessment

An initial screening assessment was undertaken in line with the IAQM construction dust assessment guidance for each of the three construction sites defined in Chapter 5 (Construction) to identify whether there are any:

- human receptors within 350 metres of the construction sites
- ecological receptors within 50 metres of the construction sites
- human or ecological receptors within 50 metres of the construction haul route on public roads up to 500 metres from the construction sites.

Screening lines of 50 metres and 350 metres were drawn around the construction sites as shown in Figure 9-7 to Figure 9-9. The figures show that there are both human and ecological receptors within 350 metres and 50 metres respectively from the construction sites which trigger the requirement for a Stage 2 assessment.

In addition to the 50 metres and 350 metres screening lines, Figure 9-7 to Figure 9-9 show additional buffer zones of 20 metres, 100 metres and 200 metres. These distances have been used to estimate receptor sensitivity for the Stage 2 assessment.

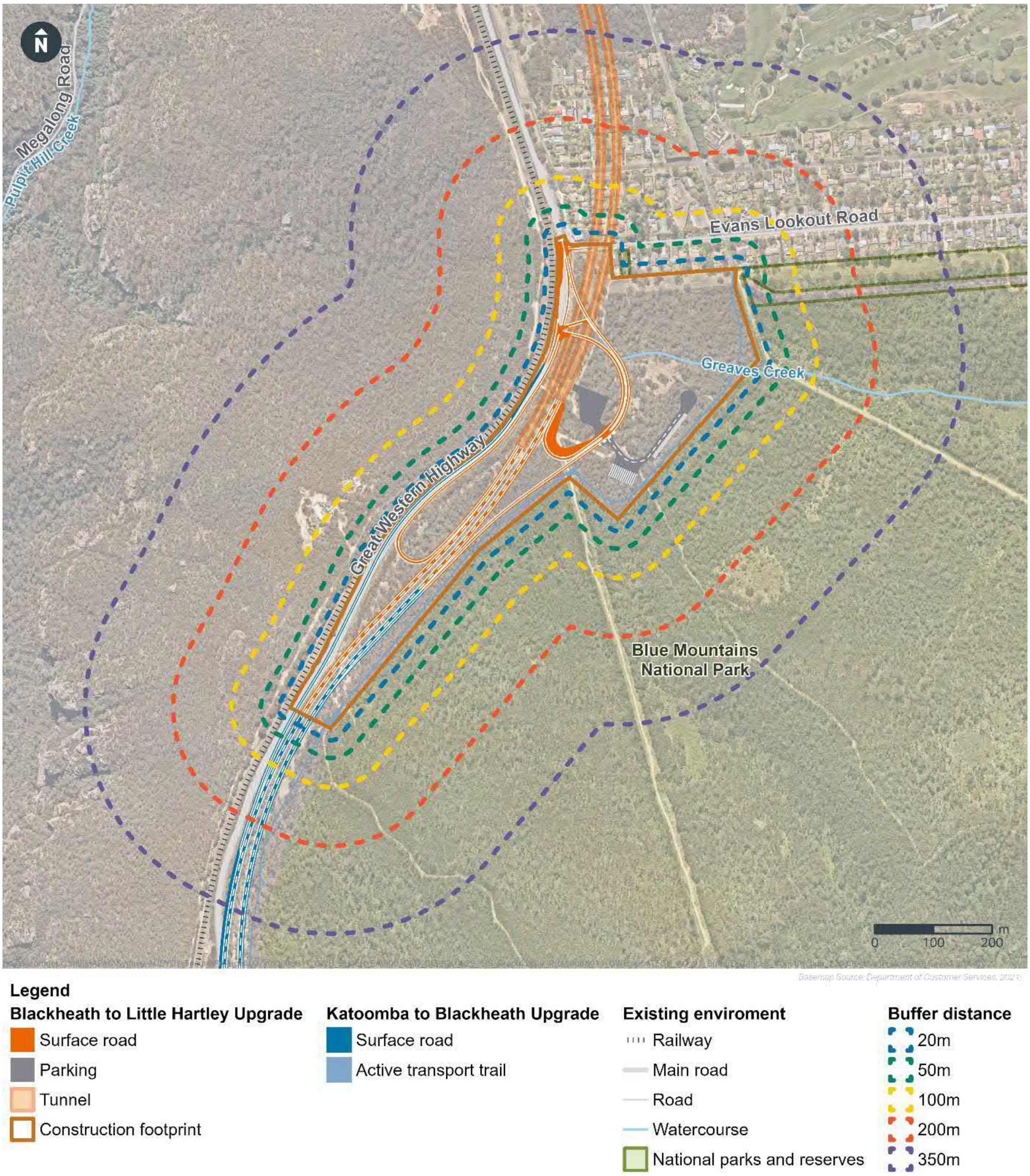


Figure 9-7 Buffer distances for Blackheath construction site

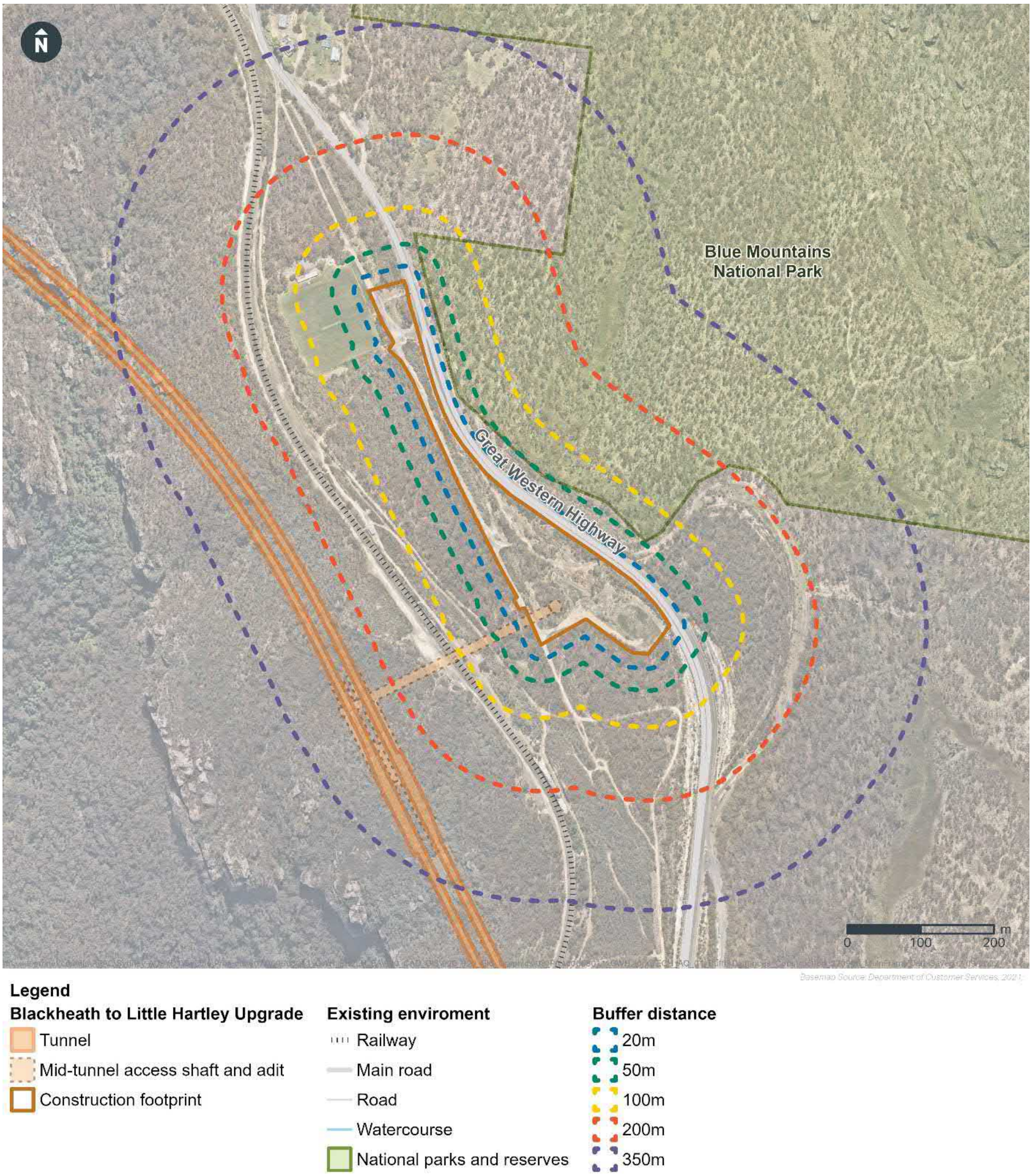


Figure 9-8 Buffer distances for Soldiers Pinch construction site

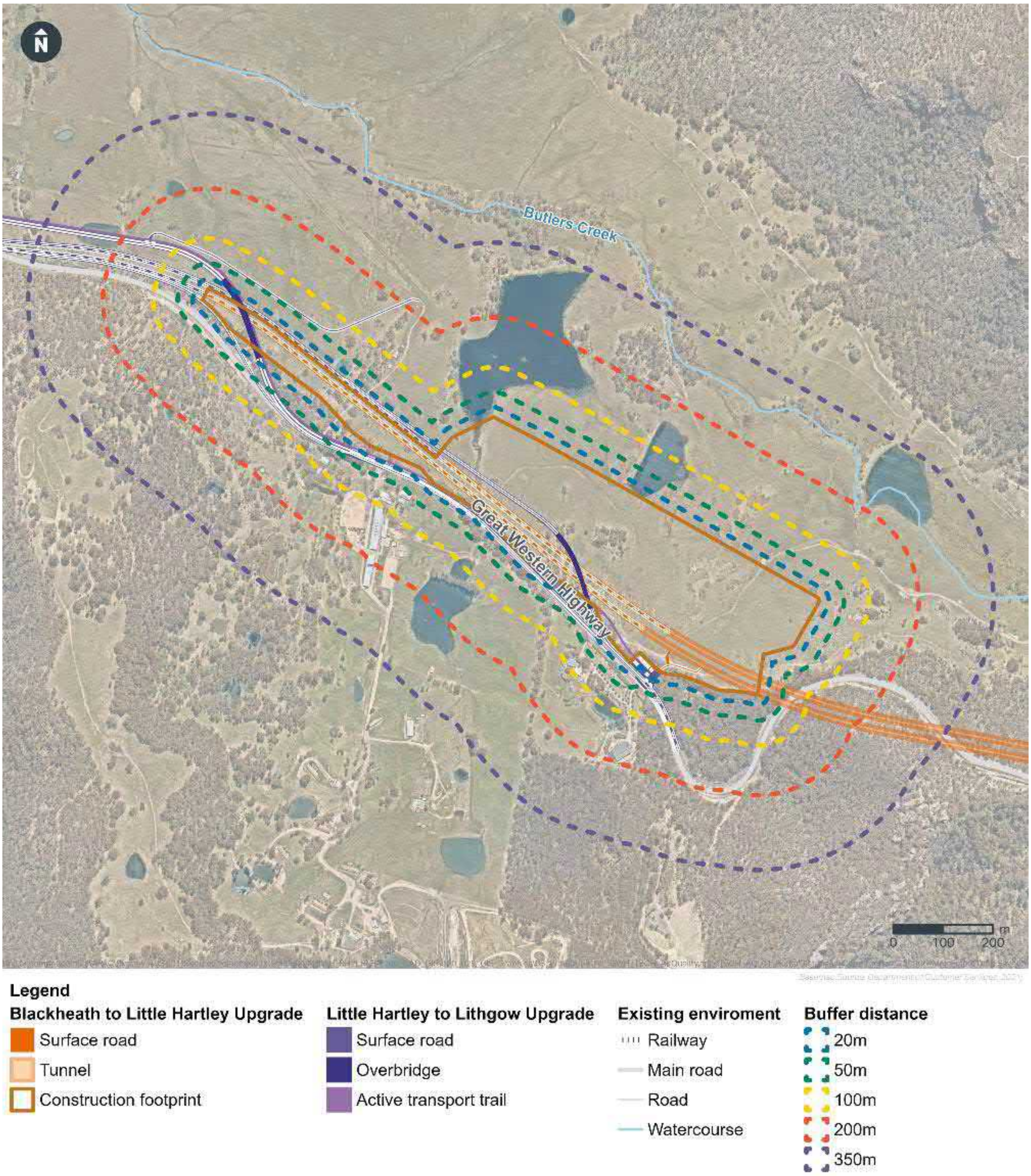


Figure 9-9 Buffer distances for Little Hartley construction site

Stage 2: Dust impact assessment by construction activity

Step 2A: Magnitude of construction activity

The magnitude of construction activity at each construction site is described in Chapter 5 (Construction) and assessed in relation to potential for generation of dust, as described in Section 5 of Appendix E (Technical report – Air quality). A summary of the assessment is presented in Table 9-10.

Table 9-10 Stage 2: IAQM screening assessment for construction zones

Construction site	Construction activity magnitudes			
	Demolition	Earthworks	Construction	Track-out
Blackheath	Medium	Large	Large	Large
Soldiers Pinch	Small	Large	Large	Large
Little Hartley	Medium	Large	Large	Large

Step 2B: Sensitivity to dust

The sensitivity of receptors to dust has been examined for each of the construction buffer zones and are shown in Table 9-11. Dust risk ratings are determined by the highest risk rating attributed to a construction buffer zone and have been estimated based on IAQM guidance and surrounding land use as discussed in Section 9.3.1.

Table 9-11 shows that:

- at Blackheath the risk of dust is high due to the proximity of highly sensitive residential receptors on the border of the construction footprint
- at Soldiers Pinch the risk of dust is low due to the presence of a single low sensitivity recreational receptor
- at Little Hartley the risk of dust is low due to limited proximity of highly sensitive rural receptors.

Table 9-11 Assessment of sensitivity of the areas in construction buffer zones to dust

Construction site	Receptor sensitivity	Distance from construction site boundary			
		< 20 m	< 50 m	< 100 m	< 350 m
Blackheath	High	10-100 (High)	10-100 (Medium)	10-100 (Low)	>100 (Low)
	Medium	>1 (Medium)	>1 (Low)	>1 (Low)	>1 (Low)
	Low	>1 (Low)	>1 (Low)	>1 (Low)	>1 (Low)
Soldiers Pinch	High	No receptors identified	No receptors identified	No receptors identified	No receptors identified
	Medium	No receptors identified	No receptors identified	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified	>1 (Low)	>1 (Low)
Little Hartley	High	No receptors identified	No receptors identified	1-10 (Low)	1-10 (Low)
	Medium	No receptors identified	No receptors identified	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified	No receptors identified	No receptors identified

Sensitivity to exposure to dust for human receptors

Sensitivity to dust (as PM_{10}) for human receptors has been assessed for each of the construction sites. Results of the analysis are detailed in Table 9-12. Dust health impacts ratings for human receptors are determined by the highest sensitivity rating attributed to a construction buffer zone and have been estimated based on IAQM guidance, using the background annual average PM_{10} of less than 8.4 μg/m^3 (see Table 9-8) and surrounding land use.

An assessment of potential human health risks from construction dust is provided in Chapter 10 (Human health).

From the results in Table 9-12 it was concluded that the risk of health impacts from PM_{10} emissions is low at all construction sites due to the low PM_{10} background concentrations and the limited number of sensitive receptors at Little Hartley and Soldiers Pinch.

Table 9-12 Assessment of sensitivity of the area to human health impacts from PM_{10}

Construction site	Receptor sensitivity	Distance from construction site boundary				
		< 20 m	< 50 m	< 100 m	< 200m	< 350 m
Blackheath	High	10-100 (Low)	10-100 (Low)	10-100 (Low)	10-100 (Low)	10-100 (Low)
	Medium	1-10 (Low)	>10 (Low)	>10 (Low)	>10 (Low)	>10 (Low)
	Low	≥1 (Low)	≥1 (Low)	≥1 (Low)	≥1 (Low)	≥1 (Low)
Soldiers Pinch	High	No receptors identified	No receptors identified	No receptors identified	No receptors identified	No receptors identified
	Medium	No receptors identified	No receptors identified	No receptors identified	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified	≥1 (Low)	≥1 (Low)	≥1 (Low)
Little Hartley	High	No receptors identified	No receptors identified	1-10 (Low)	1-10 (Low)	1-10 (Low)
	Medium	No receptors identified	No receptors identified	No receptors identified	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified	No receptors identified	No receptors identified	No receptors identified

Sensitivity to exposure to dust for ecological receptors

The sensitivity of ecological receptors to dust have been examined for each of the construction sites and are reported in Table 9-13. Dust risk ratings for ecological receptors are determined by the highest risk rating attributed to a construction footprint area and have been estimated based on IAQM guidance and the ecological value of the land around the construction sites.

Results in Table 9-13 show the following:

- Blackheath and Soldiers Pinch construction sites are considered to have a high sensitivity to dust due to their proximity to the Blue Mountains National Park; regarded as a highly sensitive ecological receptor due to its World Heritage and National Heritage listings
- the Little Hartley construction site is surrounded primarily by agricultural land of low ecological sensitivity but does contain some adjacent remnant native vegetation and is therefore considered of medium sensitivity.

Table 9-13 Assessment of sensitivity of the area to ecological impacts

Construction site	Receptor sensitivity	Distance from construction site boundary	
		< 20 m	20 - 50 m
Blackheath	High	High sensitivity	Medium sensitivity
	Medium	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified
Soldiers Pinch	High	High sensitivity	Medium sensitivity
	Medium	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified
Little Hartley	High	No receptors identified	No receptors identified
	Medium	Medium sensitivity	Low sensitivity
	Low	Low sensitivity	Low sensitivity

Step 2C: Overall dust risk ratings

The potential risks for the overall project were found to range from negligible to high, as summarised in Table 9-14.

Specifically, for human receptors the risk of unmitigated dust was medium to high at Blackheath due to the proximity of sensitive receptors to the north, while dust risks at Soldiers Pinch and Little Hartley were low. Unmitigated dust human health risks were considered low across all sites, largely attributed to the low existing PM_{10} background levels as well as low density of sensitive receptors.

The unmitigated risks of dust impacts to ecological receptors at Blackheath and Soldiers Pinch were largely considered high risk due to the proximity of the Blue Mountains National Park and its high ecological sensitivity. Unmitigated ecological risks at Little Hartley were rated medium risk.

Table 9-14 Assessment of unmitigated dust risks for construction activities

Construction area	Activity	Step 2A: Potential for dust emissions	Step 2B: Sensitivity of area			Step 2C: Risk of unmitigated dust impacts		
			Dust	Human health	Ecology	Dust	Human health	Ecology
Blackheath	Demolition	Medium	High	Low	High	Medium	Low	Medium
	Earthworks	Large	High	Low	High	High	Low	High
	Construction	Large	High	Low	High	High	Low	High
	Trackout	Large	High	Low	High	High	Low	High
Soldiers Pinch	Demolition	Small	Low	Low	High	Negligible	Negligible	Medium
	Earthworks	Large	Low	Low	High	Low	Low	High
	Construction	Large	Low	Low	High	Low	Low	High
	Trackout	Large	Low	Low	High	Low	Low	High
Little Hartley	Demolition	Medium	Low	Low	Medium	Low	Low	Medium
	Earthworks	Large	Low	Low	Medium	Low	Low	Medium
	Construction	Large	Low	Low	Medium	Low	Low	Medium
	Trackout	Large	Low	Low	Medium	Low	Low	Medium

Given the unmitigated risk ratings which range from negligible to high for the project, specific activity-based mitigation measures would be implemented to reduce the likelihood of dust being generated. These mitigation measures are outlined in Section 9.7 and would be implemented throughout construction works.

9.5.2 Assessment of impacts of combustion emissions

The source of combustion emissions during the project construction phase would be from combustion of petrol and diesel fuel by light and heavy vehicles travelling to and from site as well as onsite, mobile construction equipment and stationary equipment such as diesel generators.

Construction access is expected to primarily occur from the existing Great Western Highway with access routes shown in Chapter 5 (Construction). Given the existing volume of traffic using the Great Western Highway, combustion emissions from construction traffic on the Great Western Highway are unlikely to result in a notable deterioration in ambient air quality at nearby sensitive receptors.

Combustion emissions from diesel operated mobile equipment as listed in Chapter 5 (Construction) would also result in air pollutant emissions. Stationary diesel generators may be used to provide onsite power to construction ancillary facilities and equipment where access to the electricity grid may not be readily available.

Given the existing volume of traffic utilising the Great Western Highway, it is unlikely that emissions from construction traffic and use of mobile and stationary plant would make a significant impact on local air quality. Typical mitigation and maintenance measures for operation of construction vehicles and plant equipment would be included in the Construction Environmental Management Plan (CEMP) and when applied, adverse air quality impacts from the operation of construction vehicles and plant equipment are expected to be minimal.

9.5.3 Odour emission impact assessment

Potential odour impacts from the site during construction would be temporary in nature. Potential sources of odour would primarily occur from the disturbance of acid sulfate soils or ASR or contaminated soils during earthworks.

Given the extremely low to low probability for intercepting acid sulfate soils across the study area, potential odour risks associated with the project are not considered significant. In the event ASR is encountered during excavation works, measures outlined in the ASR management plan would be implemented. Potential impacts and management measures for ASR are further discussed in Chapter 15 (Soils and contamination).

During tunnel construction between Mount Victoria and Little Hartley coal seam gas or methane gas, which is an odorous gas, may be encountered. See Chapter 13 (Groundwater and geology) for a further discussion on the presence of coal seams in the surrounding geology. Mitigation measures for prevention of gas build-up in the event that coal seam or methane gas is present is discussed in Chapter 13 (Groundwater and geology). The requirement for installation of gas drainage wells would be confirmed during ongoing design development and during construction as tunnelling occurs. Another potential minor source of odour emissions would be from volatile organic compounds (VOCs) released during road pavement construction. Odour emissions from the laying of asphalt are from a complex mixture of hydrocarbons and VOCs and are anticipated to be minor in nature provided appropriate management measures outlined in the CEMP for the project are applied.

9.6 Potential impacts – operation

The ground level concentrations of pollutants from both the ventilation outlet option and the portal emissions option were modelled separately to provide a clear comparison of their respective impacts on local air quality. The emissions from each of these sources was also combined with the background (existing) pollution levels and the emissions from traffic on surface roads to predict total pollutant concentrations and the total change in pollutant concentrations with and without the project.

9.6.1 Assessment of operational impacts of ventilation outlets

NSW EPA criteria

A summary of highest predicted air pollutant ground level concentrations for the 'with project' and 'without project' scenarios and for the 2018 base year is shown in Table 9-15. Results are compared with NSW EPA criteria from the Approved Methods (NSW EPA, 2022a; NSW EPA, 2022b).

Predicted contributions from the ventilation outlets and total concentrations (project contribution and background) for NO_2 and $PM_{2.5}$ for the project in 2030 and 2040 were below the EPA criteria. There were some exceedances of the EPA maximum one-hour and annual average NO_2 criteria for the base year 2018 scenario and the 'without project' scenarios in 2030 and 2040. The results of the modelling indicate a reduction in ground level pollutant concentrations from the project in 2030 as shown in Figure 9-10 to Figure 9-13. This improvement in air quality would be due to the improved traffic flow and reduced traffic volumes along the existing Great Western Highway as a result of traffic diverting to the tunnel, and the reduced gradient in the tunnel compared to the existing Victoria Pass, as well as improved emissions standards.

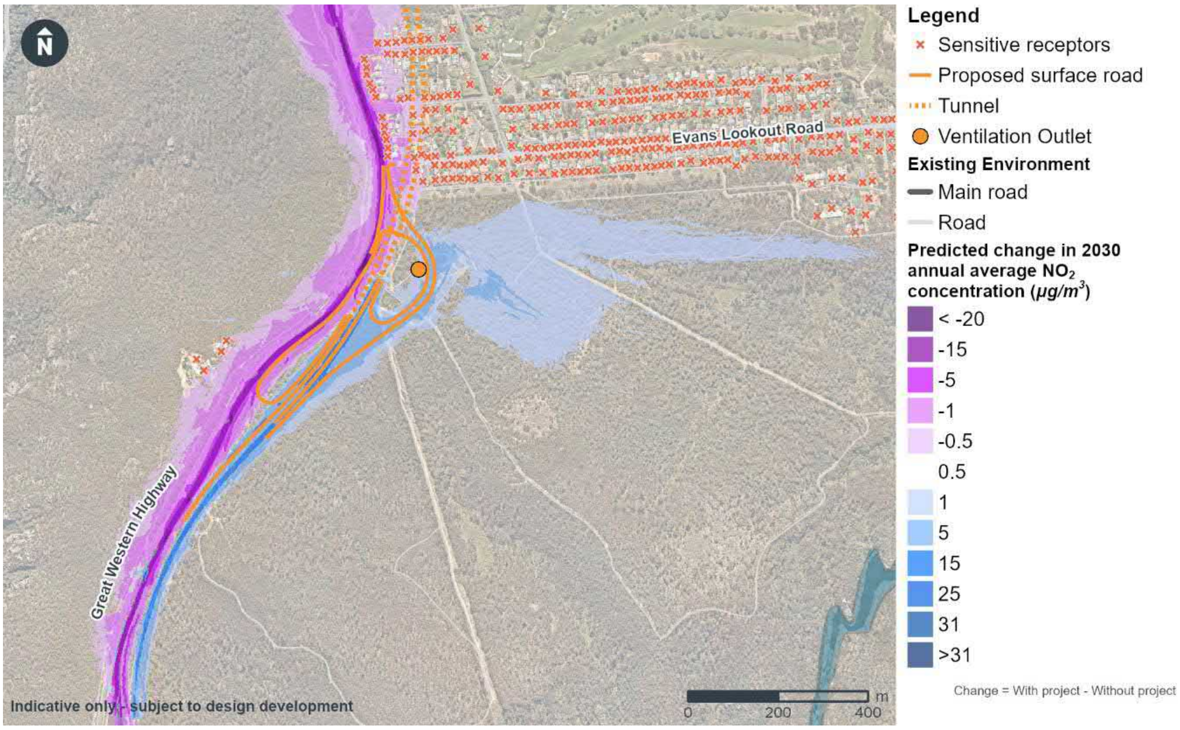


Figure 9-10 Annual average NO_2 concentration change contour for ventilation outlet option in 2030 at Blackheath

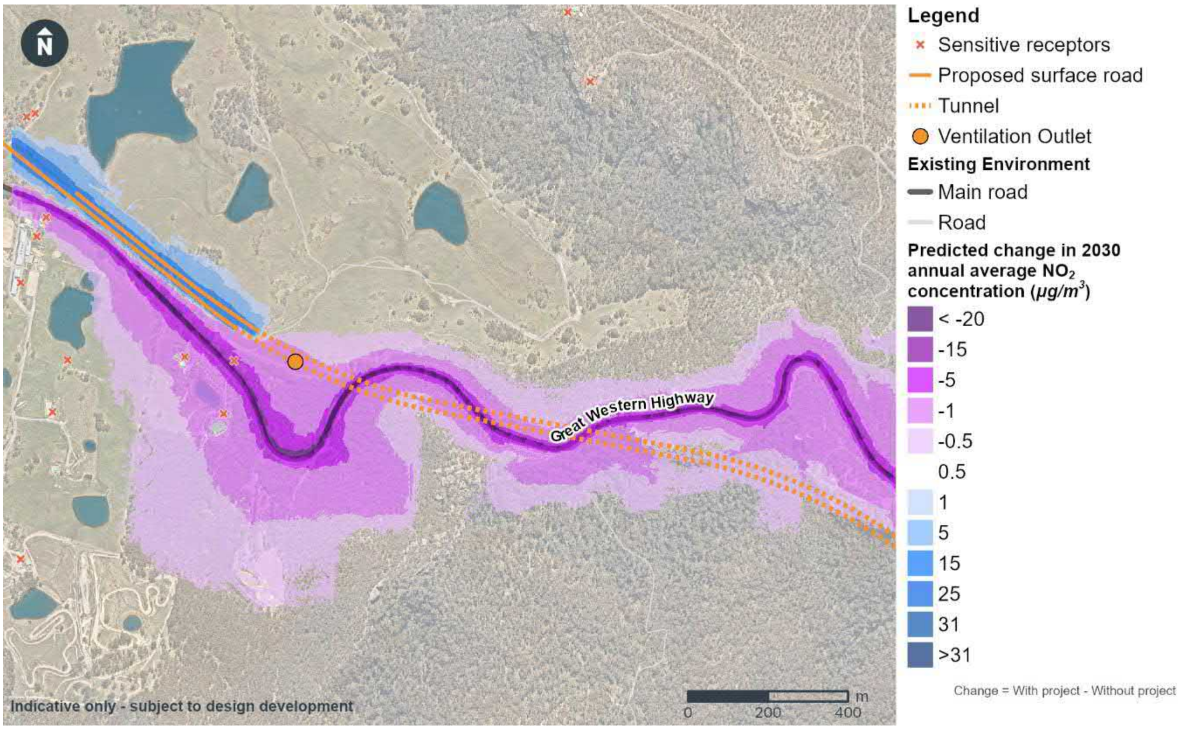


Figure 9-11 Annual average NO_2 concentration change contour for ventilation outlet option in 2030 at Little Hartley

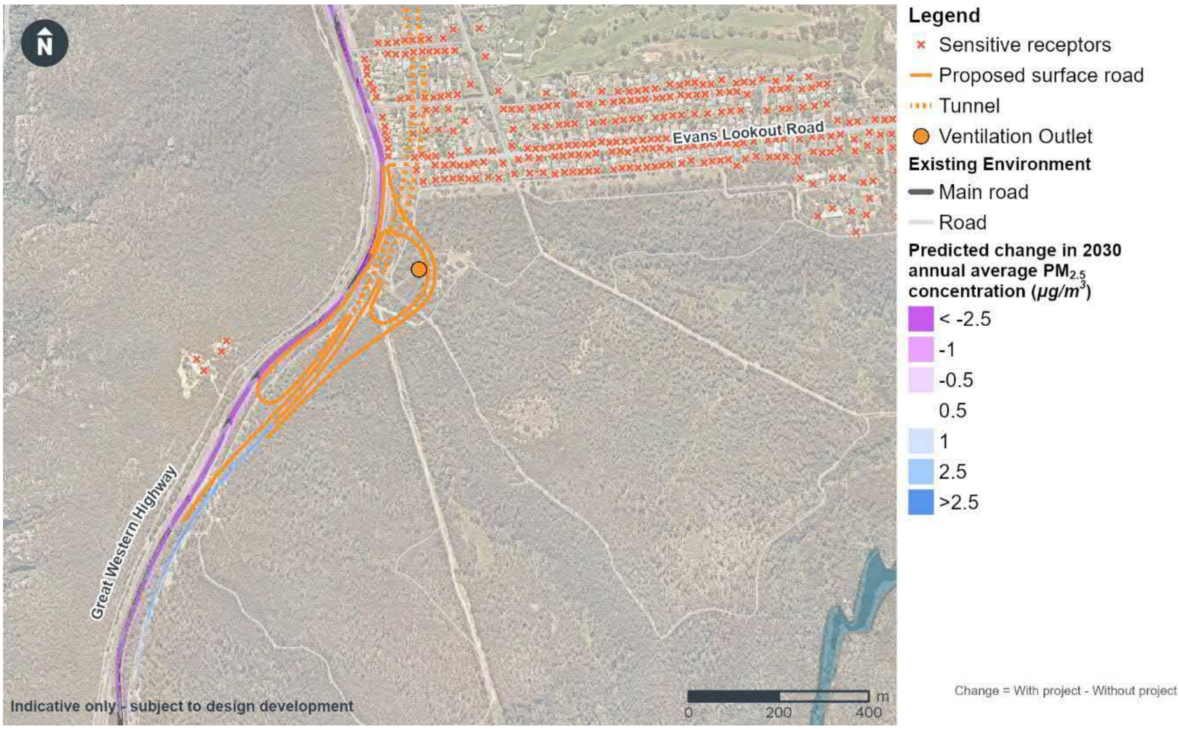


Figure 9-12 Annual average $PM_{2.5}$ concentration change contour for ventilation outlet option in 2030 at Blackheath

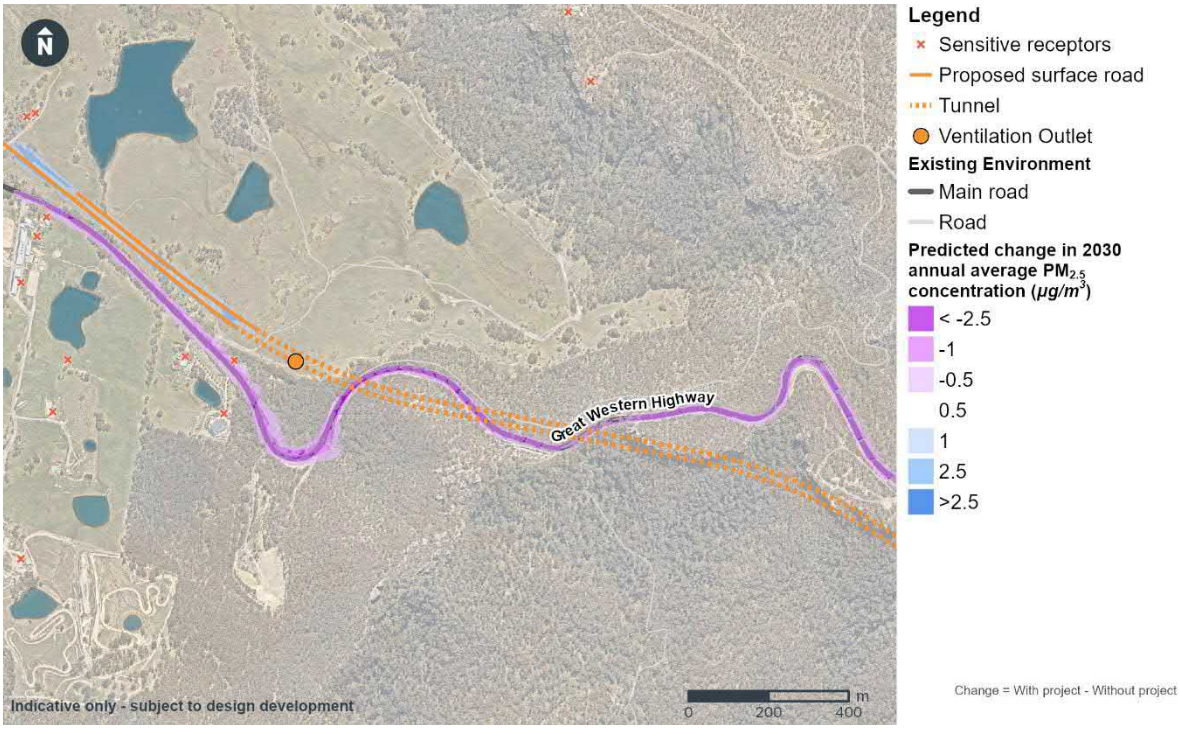


Figure 9-13 Annual average $PM_{2.5}$ concentration change contour for ventilation outlet option in 2030 at Little Hartley

Table 9-15 shows the highest predicted $N0_2$ and $PM_{2.5}$ ground level concentrations for the ventilation outlet option. Both the 2030 and 2040 ‘without project’ scenarios concentrations were lower than the 2018 base year. The difference in concentrations between the base year and future ‘without project’ scenarios is largely attributed to improved emission standards for vehicles between 2018 and 2030 and between 2030 and 2040. Increased uptake of electric vehicles would further reduce emissions although the future percentage of electric vehicles in the NSW vehicle fleet cannot be reliably predicted at this time and is not included in the emission modelling, hence the results presented are conservative. In 2020, the percentage of electric vehicle new car sales in the NSW was 0.68 per cent (NSW Government, 2021c). The NSW Government has developed an Electric Vehicle Strategy to increase the number of electric vehicles in NSW which are projected to make up 52 per cent of new car sales in 2030-31 (NSW Government, 2021c).

Table 9-15 Highest predicted NO_2 and $PM_{2.5}$ ground level concentrations for the ventilation outlet option

Pollutant	Averaging period	Background concentration (µg/m³)	Baseline (2018) (µg/m³)	Design opening year (2030) (µg/m³)		Ten years after opening (2040) (µg/m³)		Criteria (µg/m³)*
			Without Project	Without project	With Project	Without project	With Project	
Project only concentrations – ventilation outlet and surface road contribution without background concentrations								
NO_2	Annual Average	NA	19.6	19.5	5.9	12.1	4.7	31
$PM_{2.5}$	24 Hour Maximum	NA	5.8	4.3	0.9	3.5	0.9	25 (20)
	Annual Average	NA	1.9	1.4	0.2	1.1	0.2	8 (7)
Total pollutant concentrations – ventilation outlet and surface road contribution with background concentrations								
NO_2	1 Hour Maximum	49.8	144.5	144.5	136.6	144.5	130.9	164
	Annual Average	6.3	25.9	25.8	12.1	18.4	11.0	31
$PM_{2.5}$	24 Hour Maximum	17.8	21.8	20.7	18.1	20.1	18.1	25 (20)
	Annual Average	5.2	7.1	6.6	5.4	6.3	5.4	8 (7)

Table notes:

1. Criteria in parenthesis represent maximum 24 hour and annual average 2025 $PM_{2.5}$ NEPM goal

In addition to the predicted highest ground level concentrations at a receptor reported above, Table 9-16 provides a summary of predicted cumulative NO_2 and $PM_{2.5}$ concentrations at SHR receptors. Predicted total annual average NO_2 and $PM_{2.5}$ concentrations were below the EPA criteria (and below the 2025 annual average NEPM goal for $PM_{2.5}$) for all modelled scenarios.

About 79 per cent of receptors would experience a decrease in concentration of annual average NO_2 and about 76 per cent of all receptors would experience a decrease in annual average $PM_{2.5}$.

In 2030, less than 21 per cent of the 1,092 receptors would experience a very minor increase of up to 0.5 µg/m³ in annual average NO_2 and up to 0.1 µg/m³ in annual average $PM_{2.5}$. These changes in concentration are unlikely to be discernible from measured background concentrations.

As such no significant air quality impacts are predicted for the project for the ventilation outlet option.

Table 9-16 Predicted total annual NO_2 and $PM_{2.5}$ concentrations at local educational facilities for the ventilation outlet option

Sensitive receptor	Base year (2018) (µg/m³)	Design opening year (2030) (µg/m³)		Ten years after opening (2040) (µg/m³)	
		Without project	Project	Without project	Project
Predicted total annual average NO_2 concentrations					
Kookaburra Kindergarten	9.7	9.7	9.3	9.4	9.3
Blue Gum Montessori	9.6	9.5	9.5	9.4	9.4
Blackheath Public School	9.2	9.2	9.3	9.2	9.2
Blue Mountains Christian School	9.2	9.2	9.4	9.2	9.2
Possum's Patch Childcare Centre	10.1	10.1	9.4	9.6	9.3
Mount Victoria Public School	12.6	12.4	10.0	10.8	9.7
One School Global NSW	9.8	9.7	9.3	9.4	9.2
Criteria (µg/m³)	31				
Predicted total annual average $PM_{2.5}$ concentrations					
Kookaburra Kindergarten	5.2	5.2	5.2	5.2	5.2
Blue Gum Montessori	5.2	5.2	5.2	5.2	5.2
Blackheath Public School	5.2	5.2	5.2	5.2	5.2
Blue Mountains Christian School	5.2	5.2	5.2	5.2	5.2
Possum's Patch Childcare Centre	5.3	5.3	5.2	5.2	5.2
Mount Victoria Public School	5.5	5.4	5.3	5.4	5.3
One School Global NSW	5.2	5.2	5.2	5.2	5.2
Criteria (µg/m³)	8 (7)				

Table notes:

1. Criteria in parenthesis represent maximum 24 hour and annual average PM2.5 2025 NEPM standard

Figure 9-14 and Figure 9-15 illustrate the spatial distribution of the plume under the ventilation outlet option at Blackheath and Little Hartley respectively, for typical daily traffic in 2030. The shading represents the concentrations resulting from the ventilation outlet contribution to the annual average $PM_{2.5}$ ground level concentrations.

Modelled results for other pollutants compared against the NSW EPA criteria, including results for maximum daily traffic and regulatory worst case ventilation emission profiles are reported in Section 8 of Appendix E (Technical report – Air quality).

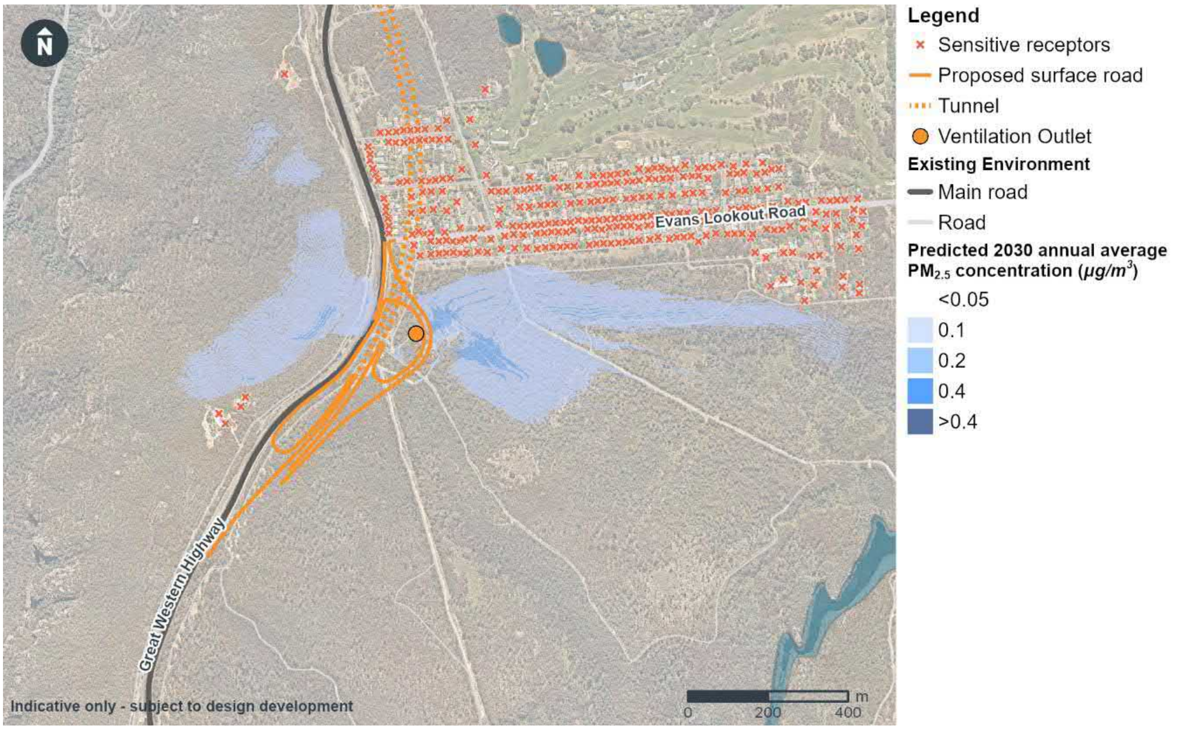


Figure 9-14 Contribution to annual average $PM_{2.5}$ concentrations at Blackheath for the ventilation outlet option (typical daily traffic in 2030)

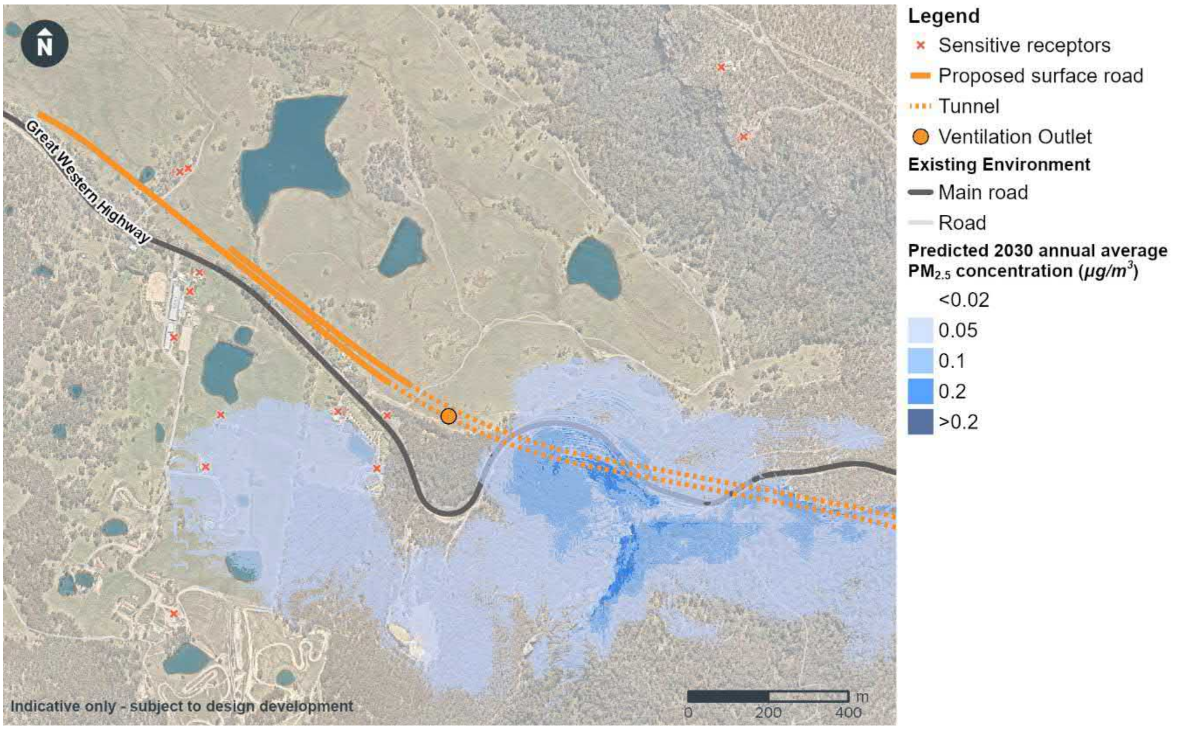


Figure 9-15 Contribution to annual average $PM_{2.5}$ concentrations at Little Hartley for the ventilation outlet option (typical daily traffic in 2030)

Modelled results for other pollutants compared against the NSW EPA criteria, are reported in Section 8 of Appendix E (Technical report – Air quality).

9.6.2 Assessment of operational impacts from portal emissions

The predicted modelling results for portal emissions indicate a reduction in ground level pollutant concentrations from the project as shown in Figure 9-16 to Figure 9-19. This improvement in air quality would be due to the improved traffic flow and reduced traffic volumes along the existing Great Western Highway as a result of traffic diverting to the tunnel, and the reduced gradient in the tunnel compared to the existing Victoria Pass, as well as improved emissions standards.

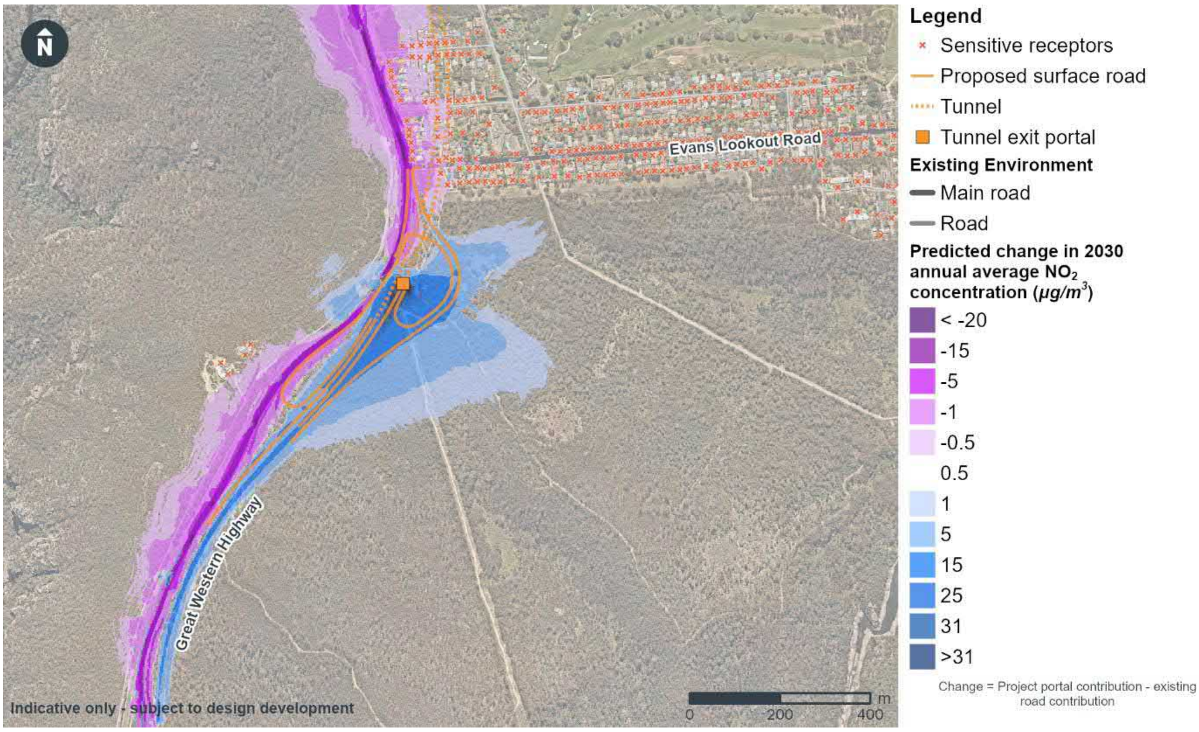


Figure 9-16 Annual average NO_2 concentration change contour for portal emissions option in 2030 at Blackheath

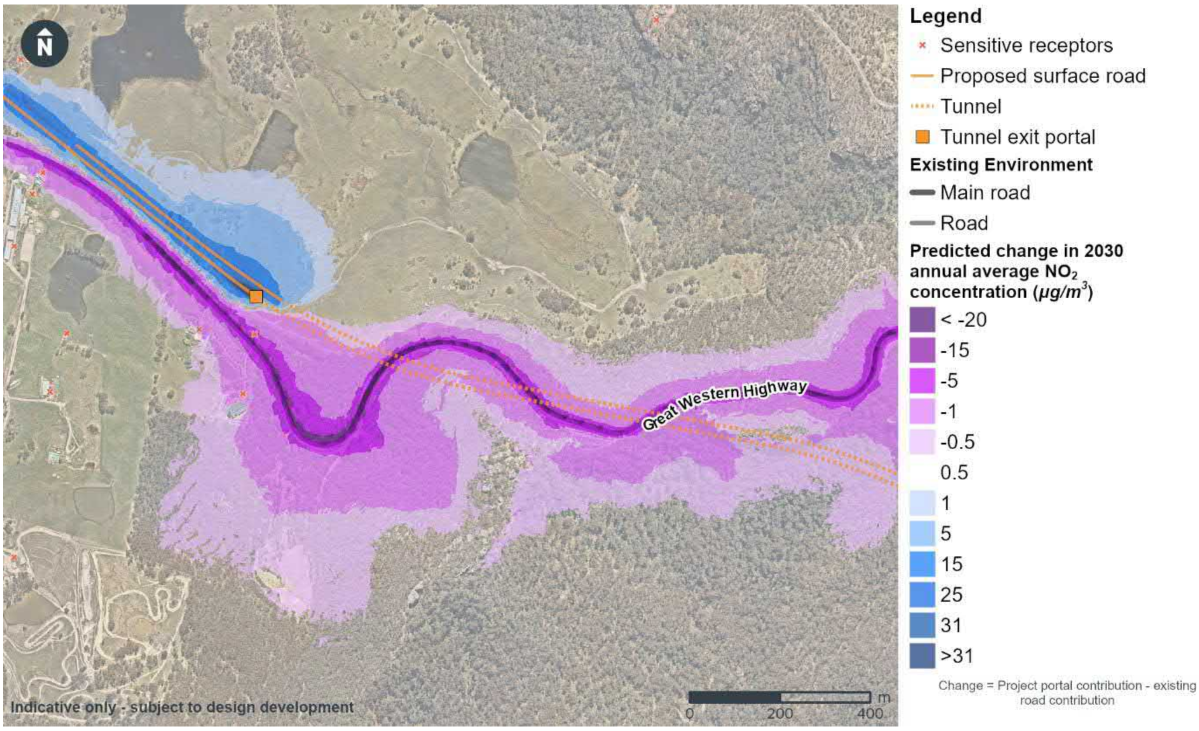


Figure 9-17 Annual average NO_2 concentration change contour for portal emissions option in 2030 at Little Hartley

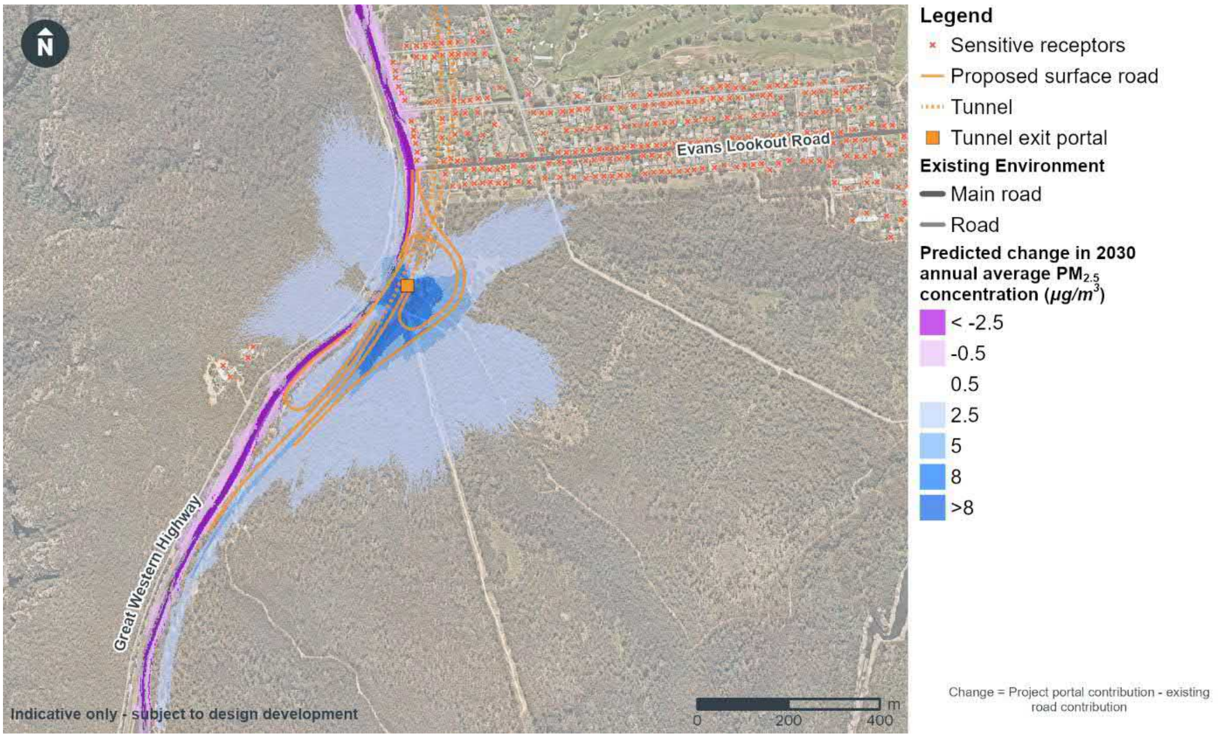


Figure 9-18 Annual average $PM_{2.5}$ concentration change contour for portal emissions option in 2030 at Blackheath

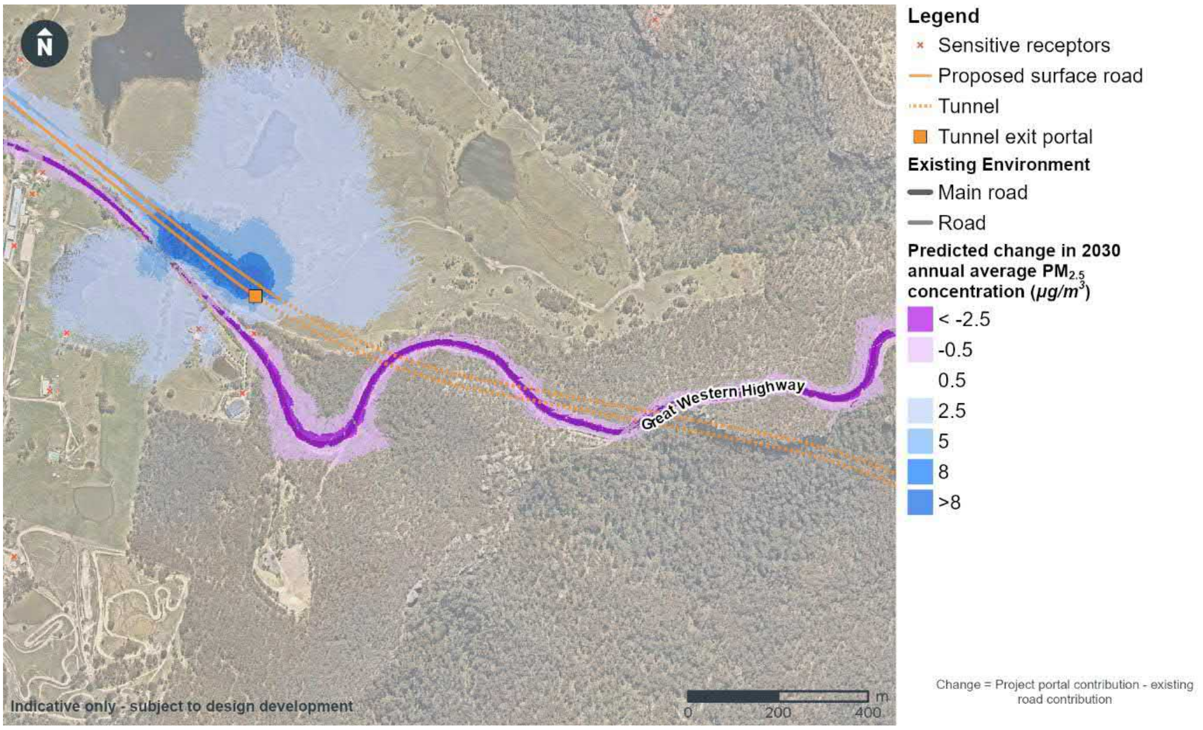


Figure 9-19 Annual average $PM_{2.5}$ concentration change contour for portal emissions option in 2030 at Little Hartley

NSW EPA criteria

A summary of the highest ground level pollutant concentrations from portal emissions for all traffic scenarios (Blackheath and Little Hartley receptors combined) is provided in Table 9-17.

Table 9-17 Predicted highest NO_2 and $PM_{2.5}$ concentrations for the portal emissions option

Pollutant	Averaging period	Background concentration	Base year 2018	2030 Without project	2030 Project	2040 Without project	2040 Project	Criteria
		(µg/m³)						
Project pollutant concentration – all project sources in isolation from background								
NO_2	Annual Average	NA	19.6	19.5	7.8	12.1	5.0	31
$PM_{2.5}$	24 Hour Maximum	NA	5.8	4.3	1.5	3.5	1.7	25 (20)
	Annual Average	NA	1.9	1.4	0.5	1.1	0.6	8 (7)
Total pollutant concentrations – all project sources including background								
NO_2	1 Hour Maximum	49.8	144.5	144.5	142.3	144.5	131.8	164
	Annual Average	6.3	25.9	25.8	14.1	18.4	11.3	31
$PM_{2.5}$	24 Hour Maximum	17.8	**21.8**	**20.7**	18.6	**20.1**	18.7	25 (20)
	Annual Average	5.2	**7.1**	6.6	5.7	6.3	5.8	8 (7)

Table notes:

1. Criteria in parenthesis represent the maximum 24 hour and annual average $PM_{2.5}$ NEPM goals proposed for 2025.
2. Bold entries denote exceedances of the proposed NEPM goal. Note the only exceedances are without the project.

In addition to the predicted highest ground level concentrations at a receptor reported above, Table 9-18 provides a summary of predicted total NO_2 and $PM_{2.5}$ concentrations at identified sensitive receptors. Predicted total annual average NO_2 and $PM_{2.5}$ concentrations were below the EPA criteria (and below the 2025 annual average NEPM goal for $PM_{2.5}$) for all modelled scenarios. As such no significant air quality impacts are predicted for the project under the portal emission option for the specific sensitive receptors.

Table 9-18 Predicted total annual NO_2 and $PM_{2.5}$ concentrations at local educational facilities for the portal emissions option

Sensitive Receptor	Base year (2018) (µg/m³)	Design opening year (2030) (µg/m³)		Ten years after opening (2040) (µg/m³)	
		Without project	Project	Without project	Project
Predicted total annual average NO_2 concentrations					
Kookaburra Kindergarten	9.7	9.7	9.3	9.4	9.3
Blue Gum Montessori	9.6	9.5	9.5	9.4	9.4
Blackheath Public School	9.2	9.2	9.2	9.2	9.2
Blue Mountains Christian School	9.2	9.2	9.2	9.2	9.2
Possum's Patch Childcare Centre	10.1	10.1	9.4	9.6	9.3
Mount Victoria Public School	12.6	12.4	10.0	10.8	9.7
One School Global NSW	9.8	9.7	9.3	9.4	9.2
Criteria (µg/m³)	31				
Predicted total annual average $PM_{2.5}$ concentrations					
Kookaburra Kindergarten	5.2	5.2	5.2	5.2	5.2
Blue Gum Montessori	5.2	5.2	5.2	5.2	5.2
Blackheath Public School	5.2	5.2	5.2	5.2	5.2
Blue Mountains Christian School	5.2	5.2	5.2	5.2	5.2
Possum's Patch Childcare Centre	5.3	5.3	5.2	5.2	5.2
Mount Victoria Public School	5.5	5.4	5.3	5.4	5.3
One School Global NSW	5.2	5.2	5.2	5.2	5.2
Criteria (µg/m³)	8 (7)				

Table notes:

1. Criteria in parenthesis represent maximum 24 hour and annual average PM2.5 NEPM standard that may be adopted by NSW EPA in the future.

Figure 9-20 and Figure 9-21 illustrate the spatial distribution of the plume from the portal emission option at Blackheath and Little Hartley respectively, for typical daily traffic in 2030. The shading represents the concentrations resulting from the ventilation outlet contribution to the annual average $PM_{2.5}$ ground level concentrations.

Modelled results for other pollutants compared against the NSW EPA criteria, are reported in Section 8 of Appendix E (Technical report – Air quality).

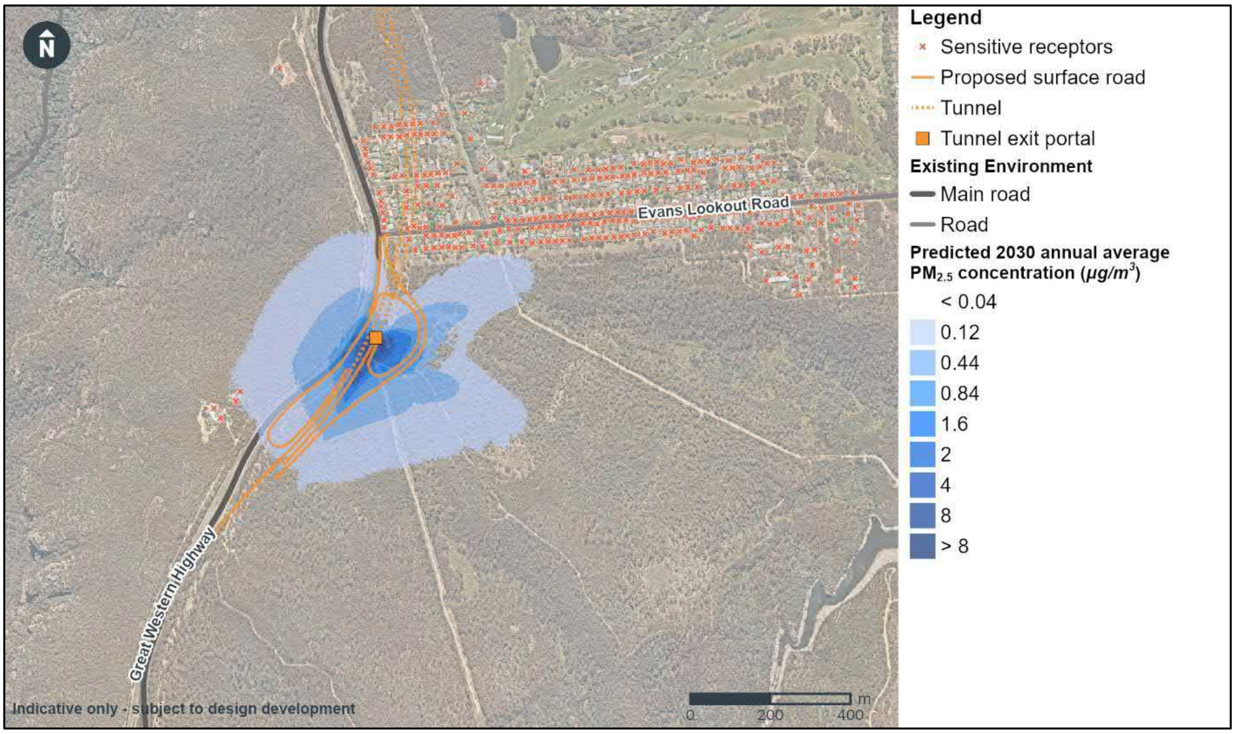


Figure 9-20 Contribution to annual average $PM_{2.5}$ concentrations at Blackheath for the portal emissions option (typical daily traffic in 2030)

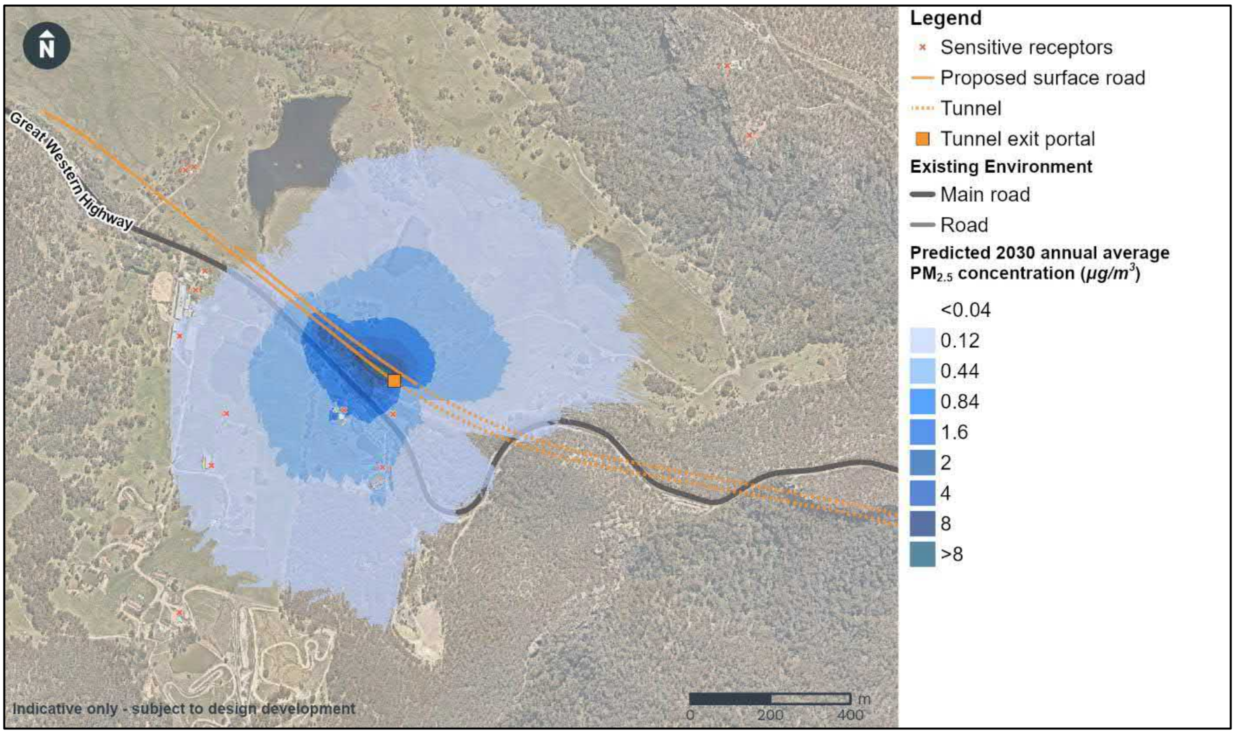


Figure 9-21 Contribution to annual average $PM_{2.5}$ concentrations at Little Hartley for the portal emissions option (typical daily traffic in 2030)

9.6.3 Comparison of ventilation options

This comparison is based on the typical daily traffic and for the annual average NO_2 and $PM_{2.5}$ for 2030 and 2040. Results for the maximum daily traffic and regulatory worst case are provided in Section 8 of Appendix E (Technical report – Air quality).

Figure 9-22 shows the incremental contributions of each ventilation option for NO_2 and $PM_{2.5}$ comparing the highest ground level concentrations for 2030 and 2040. The figure shows:

- for NO_2 in 2030 the maximum one-hour concentrations at the highest receptor concentration was around 16 per cent higher for the portal emissions option as a percentage of the EPA criteria and around 6.4 per cent higher for the annual average. The predicted one-hour maximum and annual average concentration at the receptor with the highest NO_2 concentration were within two per cent of each other for the ventilation options for 2040
- for $PM_{2.5}$ both the 24-hour maximum and annual average concentrations are slightly higher for the portal option. A difference of 2.1 to 2.8 per cent of the EPA criteria was predicted for the 24-hour maximum and 3.6 to 4.4 per cent of the EPA criteria was predicted for the annual average.

Both ventilation options meet the criteria for NO_2 and $PM_{2.5}$ under all averaging periods. Further comparison of operational air quality impacts associated with different ventilation options is provided in Section 8.4 of Appendix E (Technical report – Air quality).

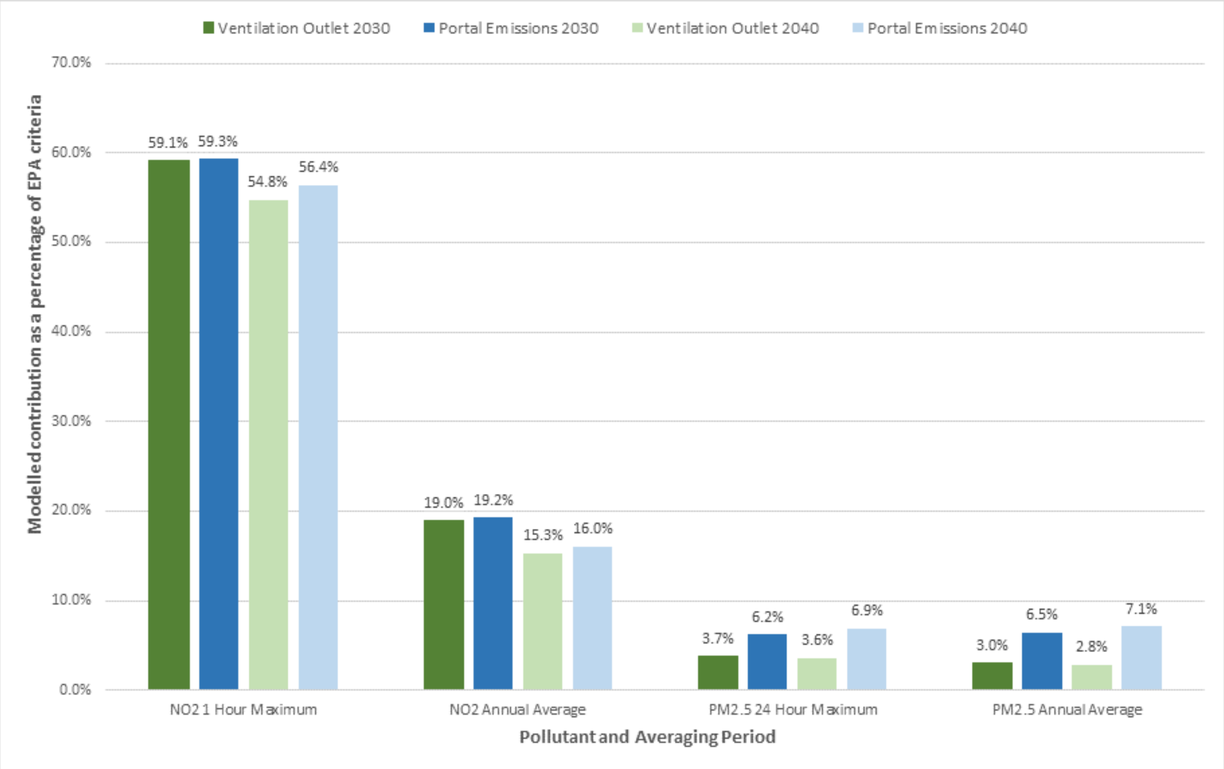


Figure 9-22 Comparison of highest NO_2 and $PM_{2.5}$ receptor concentrations (ventilation outlet and portal options only)

Annual average NO_2 concentrations

Predicted differences in annual average NO_2 concentrations between ventilation options are relatively small when compared to the EPA criteria of 31µg/m^3.

While slightly higher annual average NO_2 concentrations are generally predicted for the portal emissions option, the difference in predicted contributions for the ventilation option and portal emissions option at receptors are unlikely to be discernible from background air quality concentrations.

Annual average $PM_{2.5}$ concentrations

Predicted differences in annual average $PM_{2.5}$ concentrations between ventilation options are small when compared to the EPA criteria of 8µg/m^3.

Comparison of ventilation options using project impact descriptors

Ventilation options have been analysed against the specific project impact assessment descriptors endorsed by ACTAQ (EMM Consulting, 2022) for annual average NO_2 and $PM_{2.5}$ as discussed in Section 9.2.2.

Comparison of predicted annual average absolute changes in concentration and impact descriptors at sensitive receptors for NO_2 and $PM_{2.5}$ for 2030 and 2040 using typical daily traffic are summarised here and reported in more detail in Appendix E (Technical report – Air quality).

Given most receptors modelled along the Great Western Highway will experience a decrease in concentration (with vehicle numbers on the surface roads decreasing), the data has been compared showing whether there is an associated decrease or increase in concentration for each descriptor classification.

Annual average NO_2

Results of the comparison indicate that:

- there is no material difference in air quality outcomes for the two ventilation options, with predicted pollutant concentration increases at all receptors rated 'negligible' for each ventilation option
- slight, moderate, or substantial beneficial impacts are predicted at a similar number of receptors for each option.

Annual average $PM_{2.5}$

Results of the comparison indicate that:

- for both ventilation options, changes in concentrations are negligible; with all predicted adverse impacts assigned a negligible impact rating, with exception of one receptor at Little Hartley for the portal emissions option predicted to experience a slight adverse impact in 2030 and moderate adverse impact in 2040
- some slight to moderate beneficial impacts were observed for some receptors for both ventilation options. Differences between the number of sensitive receptors that were predicted to experience a slight or moderate decrease in annual average $PM_{2.5}$ for each ventilation option were very small.

Results of the comparison indicate there is no material difference in air quality outcomes for the two ventilation options; with predicted pollutant concentration increases at all receptors rated 'negligible' for each ventilation option. Slight to moderate beneficial impacts predicted at a similar number of receptors for each option.

Summary of operational air quality impacts for both ventilation options

Typical daily traffic

Comparison of predicted modelling results for the two ventilation options showed some differences in spatial distribution of pollutants, but no material difference in potential air quality impacts when all sensitive receptors are considered.

The results of the air quality impact assessment for both ventilation options show that for typical daily traffic:

- most (76-79 per cent) sensitive receptors would be expected to experience a decrease in pollutant concentrations. The largest decreases in ground level pollutant concentrations would be expected along the existing Great Western Highway due to the reduced traffic volumes as traffic would divert to the tunnel
- the total ground level concentrations for NO_2, CO, PM_{10} and $PM_{2.5}$ at all sensitive receptors were below the EPA criteria
- predicted contributions from both ventilation options were generally low when compared to existing background pollutant levels, the EPA criteria and NEPM goals

- predicted contributions from both ventilation options and surface roads were below the relevant EPA criteria for VOCs and PAHs at less than one per cent of the criteria. Based on the low-level concentrations for toluene, acetaldehyde and xylene, no odour impacts from vehicle exhausts are anticipated.

Maximum daily traffic

The maximum daily traffic profile reflects traffic conditions that are only expected to occur for a small number of days per year; identified as peak days where the total bi-directional traffic flow is above 1,300 vehicles per hour. Results of the modelling for the maximum daily traffic profile indicated that, for both the ventilation outlet and portal emissions options:

- there are no predicted exceedances of the EPA criteria for all pollutants under all averaging periods in 2030 and 2040
- predicted concentrations as a result of the project for all pollutants are higher for the 2030 modelled scenario than the 2040 scenario, which is consistent with observations made in relation to the typical daily traffic scenario and is a result of improved emissions from the vehicle fleet
- predicted ground level pollutant concentrations for all modelled scenarios were lower than the equivalent daily average traffic emission profile scenarios. This was attributed to the traffic mix being a higher proportion of light passenger vehicles with a much lower proportion of heavy vehicles expected on the small number of days characterised by the maximum daily traffic profile.

Regulatory worst case

The regulatory worst case emission profile reflects the potential emission concentrations that could theoretically occur when tunnel emissions are equal to the emission concentration limits set by the EPA under the EPL for the project. Predicted ground level concentrations at sensitive receptors for the regulatory worst-case scenarios for both ventilation options were found to be compliant with relevant EPA criteria for all pollutants examined. This indicates that operation of either the ventilation outlet option or the portal emissions option would operate under the proposed emission limits and within the limits of the EPA criteria. Further detail of assessment for all pollutants during operation is reported in Section 8 of Appendix E (Technical report – Air quality).

9.6.4 Assessment of odour impacts

The following provides an assessment of potential odour impacts from vehicle emissions associated with the project. Potential odour impacts have been assessed based on individual odorous air pollutants for VOCs ethylbenzene, toluene, acetaldehyde and xylene.

Table 9-19 provides a summary of one-hour 99.9th percentile ground level concentrations at the worst affected sensitive receptor for ethylbenzene, toluene, acetaldehyde, and xylene for all modelled scenarios for the typical daily traffic emission profile. Additional information for peak day and regulatory worst-case scenarios is discussed in Section 8 of Appendix E (Technical report – Air quality).

Predicted one-hour 99.9th percentile ground level concentrations at the worst affected receptors in Table 9-19 are well below the air quality assessment criteria for all pollutants at less than one per cent of the criteria, for all modelled scenarios. The change in concentration at the worst affected receptors was negligible for both ventilation outlet and portal emissions options for 2030 and 2040. The predicted minor reduction in VOC concentrations is the same for both options indicating the worst affected receptor was largely influenced by changes to surface road emissions.

Given the very low predicted ground level concentrations for individual odorous pollutants; and predicted changes in concentration with and without the project were less than one per cent of the relevant criteria, no noticeable odour impacts from vehicle emissions are anticipated from operation of the project.

Table 9-19 Predicted 1-hour 99.9th percentile concentrations for individual odours VOCs

Pollutant	1-hour 99.9th percentile concentration (µg/m³)					Criteria (µg/m³)	Change in concentration (µg/m³)	
	Existing	2030		2040			2030	2040
		Without project	With project	Without project	With project			
Ventilation outlet								
Ethylbenzene	0.2	0.06	0.01	0.03	0.01	8000	-0.04	-0.02
Toluene	1.08	0.32	0.08	0.17	0.04	360	-0.25	-0.13
Acetaldehyde	0.12	0.04	0.01	0.02	<0.01	42	-0.03	-0.01
Xylene	0.81	0.24	0.06	0.13	0.03	190	-0.18	-0.10
Portal emissions								
Ethylbenzene	0.20	0.06	0.02	0.03	0.01	8000	-0.04	-0.02
Toluene	1.08	0.32	0.09	0.17	0.04	360	-0.23	-0.13
Acetaldehyde	0.12	0.04	0.01	0.02	<0.01	42	-0.03	-0.01
Xylene	0.81	0.24	0.07	0.13	0.03	190	-0.17	-0.10

9.6.5 Assessment of ecological impacts

Assessment of ecological impacts has been undertaken for the project in 2030 and 2040 for the typical daily traffic emission profile and a summary of the assessment for both ventilation options is provided below. Evaluation of ecological impacts for both ventilation options was undertaken by visually examining predicted modelled contribution contours at ecological receptors and comparing the concentrations to the identified ecological impact assessment markers.

Predicted cumulative impacts (project contribution plus background concentrations) for both ventilation options were found to be below the environmental assessment markers for ecological receptors, with no material difference between the options. Predicted cumulative concentrations at ecological receptors are as follows:

- the modelled annual average NO_2 contribution when added to a background concentration of 6.3 µg/m³ and compared to the assessment criteria of 30 µg/m³ were:
  - below 9.7 µg/m³ for the ventilation outlet option
  - below 12.8 µ/m³ for portal emissions option
- for the maximum 30-minute toluene modelled contributions when compared to the assessment criteria of 1,100 µg/m³ were:
  - below 0.1 µg/m³ for the ventilation outlet option
  - below 0.1 µ/m³ for portal emissions option
- for the maximum 10-hour $PM_{2.5}$ modelled contributions when added to a background concentration[4] of 35.3 µg/m³ when compared to the assessment criteria of 50 µg/m³ were:
  - below 36.8 µg/m³ for the ventilation outlet option
  - below 45.3 µ/m³ for portal emissions option.

Based on the predicted cumulative concentrations for all examined pollutants, no significant air quality related ecological impacts are anticipated from the project for either ventilation option.

[4] The 10-hour maximum $PM_{2.5}$ background concentration was derived from the unified data set as described in Appendix E (Technical report – Air quality).

9.6.6 In-tunnel air quality

Figure 9-23 and Figure 9-24 show the predicted in tunnel air 15-minute average NO_2 concentrations and visibility (based on in-tunnel $PM_{2.5}$ emissions) for the project for 2030 and 2040. The results of the ventilation analysis show that both predicted NO_2 concentrations and visibility are well below the in-tunnel air quality criteria for eastbound and westbound typical daily traffic in 2030 and 2040.

The analysis and results for maximum daily expected traffic and worst case scenarios, are provided in Annexure D of Appendix E (Technical report – Air quality).

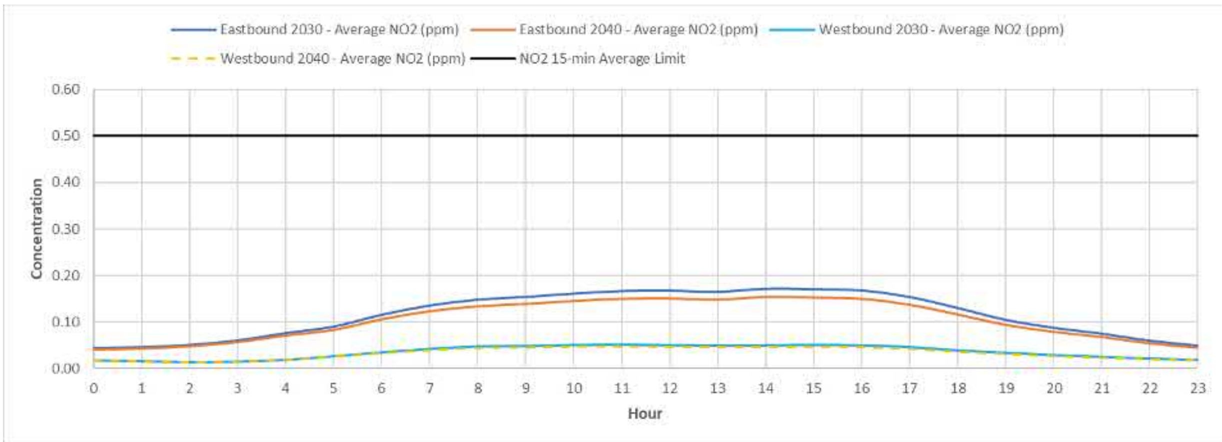


Figure 9-23 Predicted 15-min average NO_2 concentrations (ppm) for typical daily traffic operations for 2030 and 2040 (Stacey Agnew, 2022)

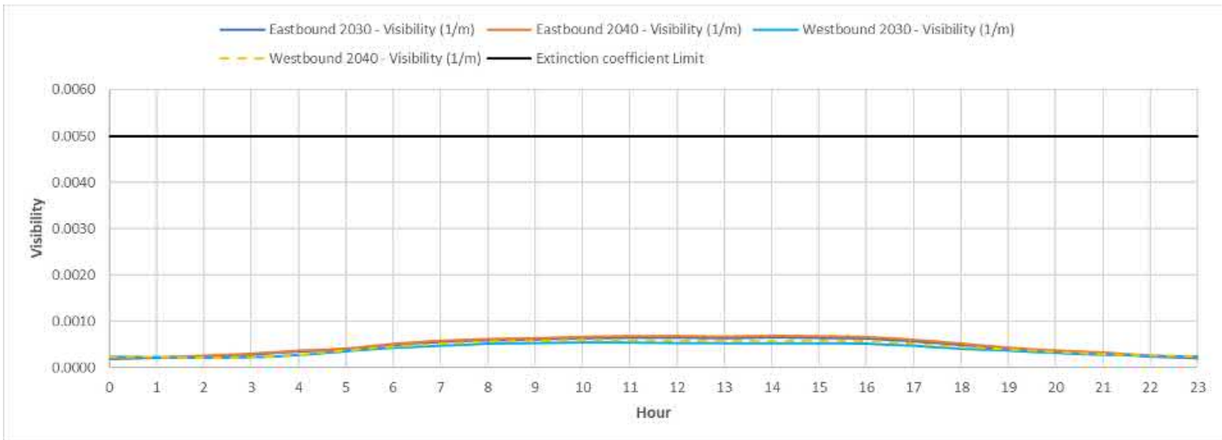


Figure 9-24 Predicted 15-min average visibility (1/m) for expected traffic operations for 2030 and 2040 (Stacey Agnew, 2022)

9.7 Environmental mitigation measures

9.7.1 Performance outcomes

Performance outcomes for the project in relation to air quality are listed in Table 9-20 and identify measurable performance-based standards for environmental management.

Table 9-20 Air quality performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
The project is designed, constructed and operated in a manner that minimises air quality impacts (including nuisance dust and odour) to minimise risks to human health and the environment to the greatest extent practicable.	Design, construct and operate the project to achieve applicable amenity and human health based in-tunnel and ambient air quality criteria, including in relation to nuisance dust and odour.	Design, construction and operation

9.7.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential air quality impacts as a result of the project are outlined in Table 9-21. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 9-21 Environmental mitigation measures – air quality

ID	Mitigation measure	Timing
AQ1	Construction activities will be managed to minimise the emission of visible dust beyond the construction footprint. Measures to minimise the generation and emission of dust will be detailed in the Construction Environmental Management Plan (CEMP), and applied to relevant construction locations and construction activities. Dust mitigation measures for each location/ activity may include one or more of the following: • visual inspection of construction sites to identify sources of dust emissions, taking into account weather conditions (particularly dry and windy conditions) and the scale, nature and intensity of construction activities • scheduling of dust generating activities to minimise potential for elevated cumulative dust generation • location and management of dust generating stockpiles away from sensitive human and ecological receptors • application of measures to minimise dust generation from surfaces and stockpiles, such as sealing (or other treatment), application of water sprays, covers and enclosures, dust barriers or similar • progressive site rehabilitation or stabilisation to minimise the potential for and duration of dust generation from disturbed areas • implementation of speed limits on unsealed roads and other trafficked surfaces.	Construction
AQ2	Air emissions from construction plant and equipment will be minimised by: • using mains electricity or battery powered equipment instead of diesel- or petrol-powered generators where practicable • switching off vehicles, plant and equipment when not in use • using lower emissions plant and equipment where feasible and reasonable.	Construction

ID	Mitigation measure	Timing
AQ3	Dust emissions from construction vehicles travelling to or from the construction footprint will be minimised by: • covering dust generating loads where practicable • implementing a wheel washing system at relevant construction site access points (with rumble grids to dislodge accumulated dust and mud prior to leaving the site) where practicable • using water-assisted sweepers or similar on access roads around the construction footprint to remove any material tracked onto those roads by construction traffic.	Construction
AQ4	The existing air quality monitoring program will be reviewed in consultation with relevant stakeholders and updated and implemented to confirm the in-tunnel air quality and ambient air quality performance of the project during the first two years of operation.	Operation
AQ5	The tunnel walls will be cleaned as part of routine maintenance to reduce concentrations of small particles.	Operation
AQ6	If required, in-tunnel air quality will be managed by temporary in-tunnel traffic management measures. These temporary measures will be communicated to tunnel users using a range of methods including traffic lights, barriers, variable message signs, radio broadcasts and public address systems (used in emergencies).	Operation

10 Human health

This chapter summarises the human health assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full human health assessment is provided in Appendix F (Technical report – Human health).

10.1 Assessment approach

The methodology for the human health impact assessment is shown in Figure 10-1 and involved:

- review of other technical assessments prepared to support this environmental impact statement (EIS) including Appendix D (Technical report – Transport and traffic), Appendix E (Technical report – Air quality), Appendix G (Technical report – Noise and vibration), Appendix I (Technical report – Groundwater), Appendix J (Technical report – Surface water and flooding), Appendix K (Technical report – Contamination), Appendix O (Technical report – Social), Appendix P (Technical report – Economics and business) and Chapter 22 (Hazards and risk)
- identification of sensitive receivers within potentially impacted communities surrounding the project
- establishment of the baseline community health for the population relevant to the project
- assessment of the potential benefits and impacts to community health during construction and operation of the project
- identification of appropriate mitigation measures to manage potential impacts.

The human health assessment has focused on health-related impacts associated with the potential impacts of other studies shown in Figure 10-1. The assessment has not addressed occupational exposures during construction or operation of the project. Occupational health and safety aspects of the project would be managed separately under current occupational health and safety regulations and guidelines in accordance with the *Work Health and Safety Act 2011* and Work Health and Safety Regulations 2011 as enforced by SafeWork NSW.

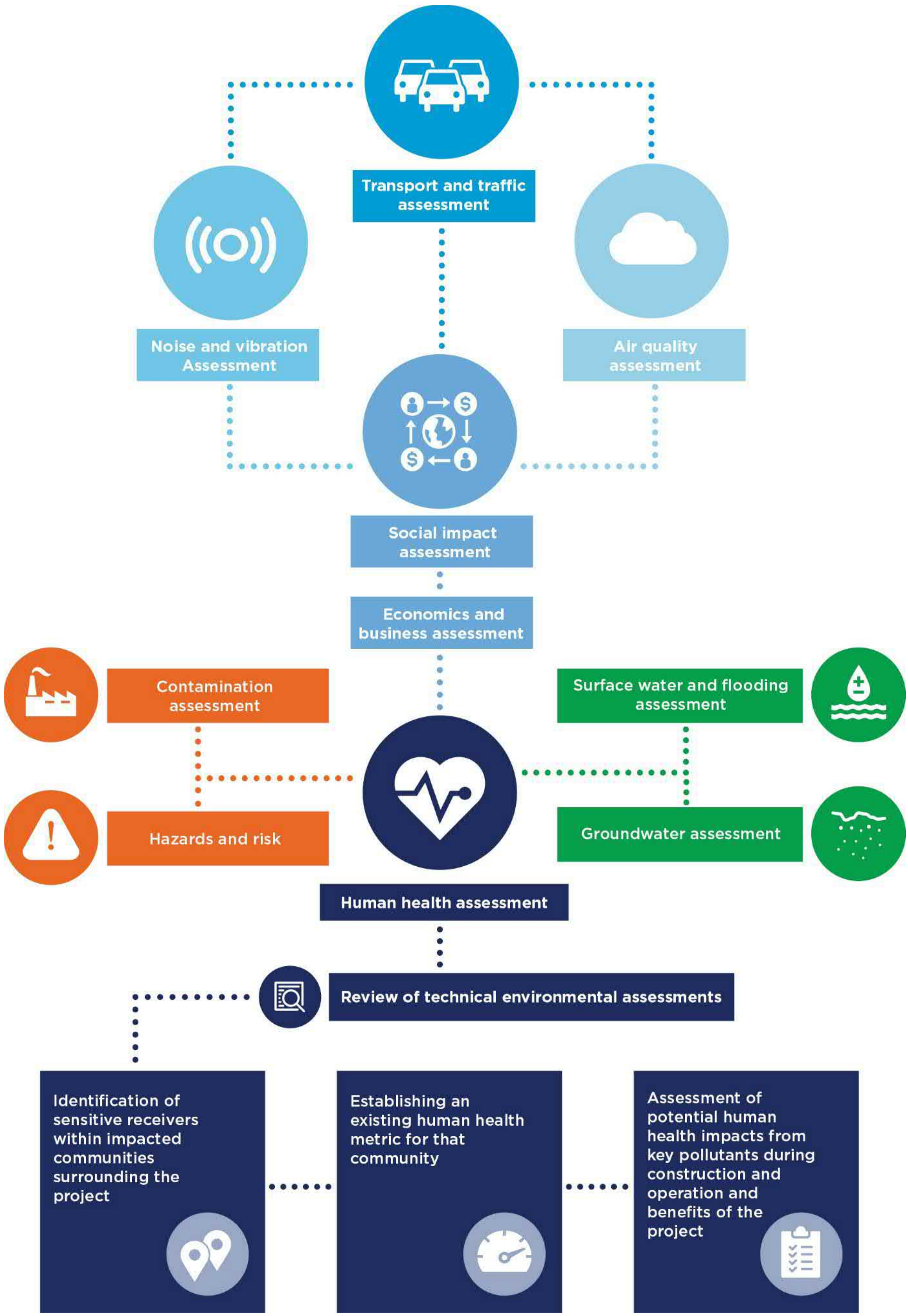


Figure 10-1 Assessment approach for the human health impact assessment

10.1.1 Assessment approach – air quality

Construction

The assessment of construction air quality health impacts was carried out using a qualitative assessment approach for dust, emissions, and odour impacts (refer to Section 9.3.1).

Operation (ambient air quality)

The assessment of operational air quality impacts considered a range of scenarios that includes the operation of the project in 2030 (year of opening) and 2040 (ten years after opening) both with the project and without the project. For further details on the scenarios considered, refer to Chapter 9 (Air quality).

The assessment considered emissions from:

- a typical daily traffic profile reflecting expected annual hourly traffic numbers using the tunnel
- a maximum daily traffic profile reflecting traffic conditions only expected to occur for a small number of days per year
- a regulatory worst case scenario, reflecting the tunnel full of vehicles such that the emissions from the ventilation outlets or portal emissions are at the maximum level. This is not a realistic scenario, however it is used to demonstrate compliance with regulatory assessment requirements.

Potential health-related air quality impacts outside the tunnel have been assessed for nitrogen dioxide (NO_2), particulate matter (PM), carbon monoxide and air toxins (including benzene, toluene, xylenes, 1,3-butadiene, formaldehyde and polycyclic aromatic hydrocarbons). Further information on these compounds including their potential health related impacts and relevant toxicity and health guidelines is provided in Section 5.5 of Appendix F (Technical report – Human health).

The tunnel and ventilation system have been designed to control the concentration of pollutants discharged to the external environment regardless of whether the ventilation outlet or portal emissions option is selected as the preferred design option.

Operation (in-tunnel air quality)

Health related in-tunnel air quality impacts during operation have been assessed for NO_2, carbon monoxide and PM. This includes cumulative exposures to NO_2, carbon monoxide and PM for frequent users of the tunnels.

The tunnel ventilation system, regardless of whether designed for portal emissions or ventilation outlet emissions, has been designed to meet operational in-tunnel air quality standards (refer to Section 9.2.2).

10.1.2 Assessment approach – noise and vibration

Potential noise related health impacts have been assessed against NSW criteria that have been established on the basis of the relationship between noise and health impacts.

Noise guidelines and criteria are generally established based on noise annoyance, which is a more sensitive impact that precedes physiological impacts. As a result, these guidelines are designed to be protective of all adverse health impacts (refer to Section 7.3.1 of Appendix F (Technical report – Human health). Specific health impacts such as sleep disturbance are based on other guidelines for the assessment of night-time noise.

Where the guidelines cannot be met then there is the potential for adverse health impacts to occur in the community adjacent to the project.

10.1.3 Assessment approach – social

The assessment of potential human health impacts associated with social impacts considers changes in traffic, access and connectivity, public safety and contamination, property acquisitions, visual amenity, impacts on green space, equity issues, economic impacts, construction fatigue, and both the long and short-term impacts of stress and anxiety arising from construction and operation of the project. These aspects have been considered qualitatively.

10.2 Study area

The study area is shown in Figure 10-2 and identifies the area over which sensitive receivers have the potential to experience human health impacts.

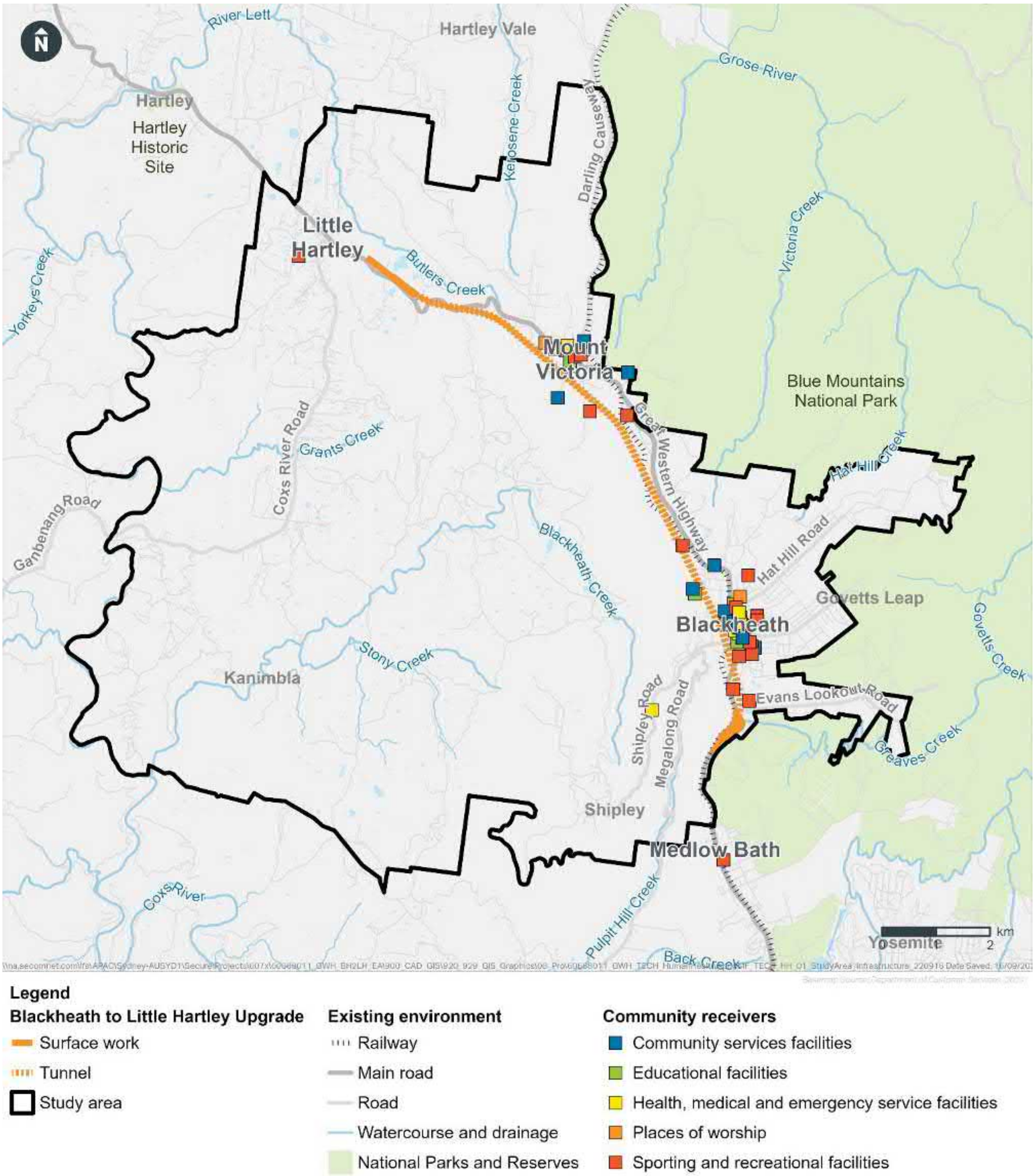


Figure 10-2 Human health impact assessment study area and key sensitive receivers

10.3 Incorporation of health issues into the project design

The project has sought to minimise impacts on the community, including health and wellbeing, through:

- an optimised construction methodology which has reduced the construction footprint and number of construction sites, limiting exposure to contaminated land and friable asbestos at the old Blackheath tip site, reducing amenity impacts for residents near Browntown Oval and the old Blackheath tip site reducing noise impacts and construction traffic impacts through Blackheath, and avoiding impacts to social infrastructure at Browntown Oval
- excavating from Little Hartley in an eastbound direction thereby reducing the spoil haulage through Blackheath and Mount Victoria including associated safety and amenity impacts, as spoil would primarily be hauled westbound from the Little Hartley construction footprint
- physical separation of tunnel portals, reducing localised air quality impacts if portal emissions is identified as the preferred option.

Further detail on design refinements for impact minimisation is discussed in Chapter 3 (Project alternatives and options).

10.4 Existing environment

This section outlines the existing environment as it relates to human health including:

- the current health status of the communities surrounding the project
- sensitive and potentially impacted receivers within these communities.

The existing air quality, noise and vibration, and social environment is described in the following chapters:

- Chapter 9 (Air quality)
- Chapter 11 (Noise and vibration)
- Chapter 19 (Social impacts).

10.4.1 Health status of the community

Community health is influenced by a range of factors including age, socio-economic status, social networks, behaviours, beliefs and lifestyle, life experiences, country of origin, genetic predisposition and access to health and social care.

The community relevant to the project is located within the Nepean Blue Mountains local health district. A summary of the health status of the community is provided in Figure 10-3.

Further information on the health-related behaviours and health indicators for the study area is provided in Section 4.5 of Appendix F (Technical paper – Human health).

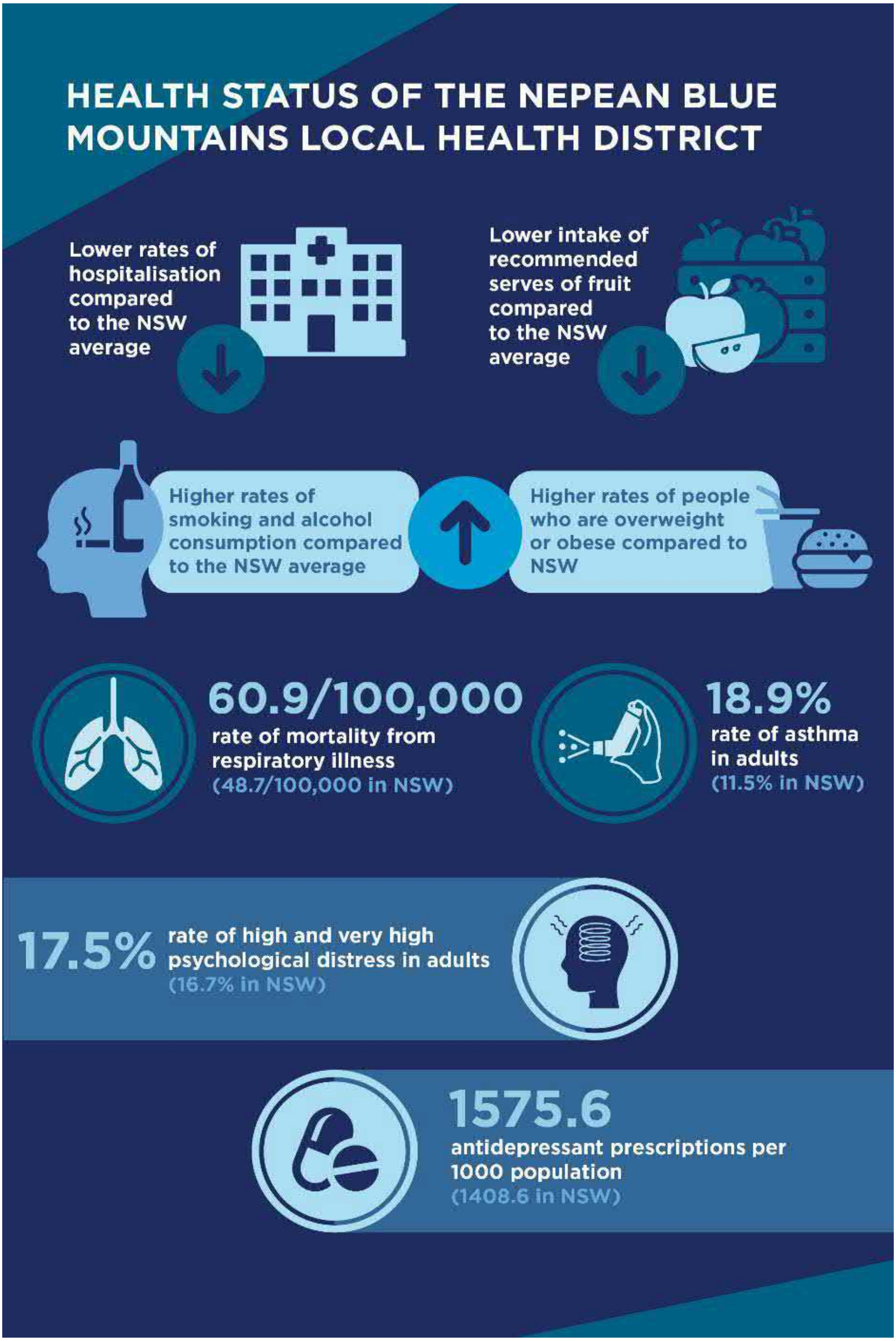


Figure 10-3 Health status of the Nepean Blue Mountains local health district (Australian Bureau of Statistics Census, 2021)

10.4.2 Sensitive receivers and potentially impacted communities

The potentially impacted communities considered in the assessment include those who live or work within the vicinity of the tunnel operations facility, water treatment plant, landscaping, surface road structures, portals, ventilation outlets (if this ventilation design option is selected), and other operational infrastructure associated with the project.

This includes community receivers including hospitals, child-care facilities, schools and aged care facilities, and sensitive receivers such as residential, workplace and recreational receivers. The assessment of noise impacts also identified places of worship and community areas as a sensitive receiver.

Key receivers identified in the study area are listed in Table 4-1 of Appendix F (Technical report – Human health).

10.5 Potential impacts – construction

10.5.1 Health related air quality impacts

Dust can directly affect health including eyes and respiratory systems. The deposition of dust can also increase levels of stress and anxiety as the community perceives the presence of substantial visible amounts of dust as potentially affecting their health. Furthermore, some odours are noxious and can make the community feel unwell.

The assessment of potential air quality impacts during construction presented in Chapter 9 (Air Quality) determined that unmitigated dust impacts pose a low risk to community health. Odours are also not expected to be of significance during construction works. Dust and odour mitigation is proposed during construction. Implementation of these measures would minimise dust related impacts and the potential for associated health impacts such as stress and anxiety. Health related air quality impacts during construction are further discussed in Section 5.4 of Appendix F (Technical report – Human health).

10.5.2 Health related noise and vibration impacts

The distribution of potential construction noise impacts on residential buildings is discussed in Section 7.4.1 of Appendix F (Technical report – Human health).

Movement of construction vehicles

Increases in road traffic noise of greater than two decibels (dBA) (the criterion adopted in accordance with the NSW Road Noise Policy (DECCW, 2011)) have been identified for the Great Western Highway to the west of the Little Hartley construction footprint for the night-time peak construction traffic volume scenario. Daytime construction traffic movements are predicted to increase noise levels by up to 1.7 dBA during peak construction works. The peak construction traffic volumes are a worst-case scenario indicative of peak activities occurring at the same time which is highly unlikely. In the unlikely event that peak construction activities occur at the same time, it is anticipated that it would be for a short duration. Construction footprints have been designed such that heavy vehicles would travel via existing major roadways with use of local roads limited to light vehicles using Evans Lookout Road. The tunnelling methodology for the project whereby spoil is removed westbound from Little Hartley would also minimise the number of heavy vehicles travelling eastbound through Mount Victoria and Blackheath. As these peak noise exceedances are unlikely to occur, the potential for health impacts from individual road noise events, such as sleep disturbance, are low to moderate. Health impacts from construction vehicle noise are further discussed in Section 7.6.2 of Appendix F (Technical report – Human health).

Air-borne construction noise

Chapter 11 (Noise and vibration) identifies residential receivers that are predicted to experience exceedances in noise levels above noise management levels, in the absence of mitigation measures. In some instances, maximum noise levels prior to mitigation are also predicted to exceed the sleep disturbance screening level and awakening reaction levels at a number of receivers.

Where criteria cannot be met with the application of reasonable and feasible mitigation measures, there is the potential for adverse health impacts such as sleep disturbance and annoyance to occur for the receivers in the vicinity of construction footprints, or where noise increases of greater than five dBA occur in the long-term (over a year or more).

Exceedances of the noise management level and the number of impacted residential receivers would vary over the duration of construction. For example, the predicted air-borne noise levels are only likely to occur when works are at the closest point to each receiver building. However, for many work areas, construction activities are mobile and would move around the construction sites, so construction noise impacts may be lower than predicted. Mitigation measures to manage potential noise impacts are identified in Chapter 11 (Noise and vibration) would be implemented to minimise potential health-related impacts related to noise on the surrounding community. This includes noise management approaches for works that would occur outside of standard construction hours.

Mitigation measures would be detailed in a Construction Noise and Vibration Management Plan (CNVMP) which would detail a range of mitigation measures that would result in noise reductions up to 15 decibels (refer to Section 7.6 of Appendix G (Technical paper – Noise and vibration). Monitoring would also be carried out periodically throughout all stages of construction to check that noise and vibration impacts are being appropriately managed, and to review the effectiveness of implemented mitigation and management measures. Where mitigation measures are implemented, the potential for health impacts such as sleep disturbance or annoyance from air-borne construction noise would be low to moderate. Health impacts from air-borne construction noise are further discussed in Section 7.6.2 of Appendix F (Technical report – Human health).

Ground-borne construction noise

Ground-borne noise would occur as a result of tunnel boring machine (TBM) and roadheader tunnelling at a discrete number of locations within the tunnel including at cross passages. A number of receptors are predicted to experience exceedances in ground-borne noise levels. All but one of these receptors (located near the Little Hartley construction footprint) would be located at Blackheath. These exceedances are due to the tunnel becoming shallower closer to the portals.

Tunnelling is proposed to 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 the exceedance 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 increase and decrease respectively. All reasonable and feasible mitigation measures would be implemented to manage noise impacts and to minimise potential health impacts where the recommended noise management levels cannot be achieved. The potential for health impacts such as sleep disturbance and annoyance from ground-borne construction noise would be low to moderate. Health impacts from ground-borne construction noise are further discussed in Section 7.6.2 of Appendix F (Technical report – Human health).

Construction vibration

Some items of equipment to be used during construction have the potential to cause vibration that results in human discomfort and/or damage to structures. Managing the potential for such vibration to cause discomfort, annoyance or structural damage at sensitive receiver locations is based on selecting site-specific suitable plant and methods as well as providing suitable separation distances between the equipment and receiver locations.

The management of human comfort related vibration impacts involves monitoring of the predicted impacts, advising the community of impacts and offering respite periods to affected residents where human comfort levels are to be exceeded for an extended period of time during any one day. Health impacts from construction vibration are discussed in Section 7.4.2 of Appendix F (Technical report – Human health).

10.5.3 Health related social impacts

Changes in traffic, public transport, access and connectivity

Changes in traffic, access and connectively during construction are presented in Chapter 8 (Transport and traffic). During construction, the following changes to the transport network may disrupt people's ability to get around their local area:

- there would be a need for temporary modifications to the existing road network to maintain the functionality of surrounding roads and to protect the safety of all road users, including pedestrians, cyclists, motorists, public transport users and construction personnel. Temporary traffic modifications would be staged so as to not impact traffic movements unnecessarily and to maintain a minimum of one lane in each direction of traffic movement
- additional construction traffic using the Great Western Highway where construction haul routes and construction site access points are proposed. Use of the Great Western Highway would minimise the presence of heavy vehicles on local roads.

Social infrastructure including schools, childcare, health care facilities and recreation areas are mainly located within town centres. Access to these facilities is unlikely to be substantially disrupted as the construction footprint avoids these areas, including Browntown Oval which is adjacent to the Soldiers Pinch construction site and may be impacted by movement of heavy construction vehicles, worker parking and equipment storage. Works would be designed to manage these impacts. Potential health impacts associated with changes in access and connectivity, such as stress and anxiety, are therefore considered negligible.

Construction works have been focused in areas away from the major town centres to minimise interaction between heavy vehicles and pedestrians or cyclists. While there are limited formal pedestrian or cycling paths in the areas further from the town centres where the works would occur, the adjacent projects to upgrade the Great Western Highway would include active transport trails around Blackheath and Little Hartley. Changes to existing road shoulders where people walk or ride would be temporary and their implementation and management would be included in the Construction Transport and Access Management Plan. Potential impacts to the health benefits provided by pedestrian and cycle access, including improved mental health status and maintaining a healthy weight, would therefore be low. Health related impacts from changes in traffic, public transport, access and connectivity are further discussed in Section 9.2 of Appendix F (Technical report – Human health).

Public safety and contamination

Potential hazards during construction are discussed in Chapter 22 (Hazards and risk) and include bushfires, rock falls and the use of dangerous goods. None of the hazards that have been identified during construction have the potential to result in material safety risks to the community.

Known and potentially contaminated sites and potential contamination impacts are discussed in Chapter 15 (Soils and contamination). Contamination risk issues to the community would be associated with the construction phase of the project, when there is a risk of disturbing existing contaminated soil or groundwater during construction activities. In addition, there is a risk of disturbing existing contaminated soil or groundwater sources during construction activities, which could result in exposure of construction workers to contamination. Mitigation measures to manage potential contamination impacts are discussed in Section 15.5.2 and include additional detailed site investigations for areas of potential contamination risk as well as an unexpected finds procedure to be implemented if contamination is identified during construction.

Provided the proposed management measures are adopted, it is expected that there would be negligible impacts to human health in the event that contamination exposures occur during project construction. Health related public safety and contamination impacts are further discussed in Section 8 of Appendix F (Technical report – Human health).

Property acquisitions

Property acquisitions, including substratum acquisition, are presented in Chapter 20 (Business, land use and property).

As primarily a tunnel, the project has been designed to minimise the need for property acquisition by locating the majority of infrastructure below ground. Wherever possible, construction footprints have been designed to minimise property acquisition requirements, as well as impacts on heritage items and ecologically sensitive areas.

The potential for project property acquisition to disrupt social networks and affect health and wellbeing due to raised levels of stress and anxiety is considered low.

The project would also require the acquisition of land below the surface of the ground to accommodate the tunnels (substratum acquisition). Residents in areas directly above the tunnel alignment may potentially experience elevated levels of stress and anxiety associated with acquisition below their properties.

Impacts associated with property acquisition would be managed through a range of measures including a counselling service, a community relations support toll-free telephone line, and a property acquisition factsheet. All acquisition would be carried out in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991,* Property Acquisition – A guide for residential owners (NSW Government, 2021a) and Property Acquisition – A guide for residential tenants (NSW Government, 2021b). Health impacts from property acquisition are discussed further in Section 9.3 of Appendix F (Technical report – Human health).

Loss of green space

Green space within urban areas includes green corridors (paths, rivers and canals), grassland, parks and gardens, outdoor sporting facilities, playing fields and children's play areas. Epidemiological studies have been undertaken that show a positive relationship between green space and health and wellbeing (de Vries et al., 2003; Health Scotland, 2008; Kendal et al., 2016; Maas et al., 2006; Mitchell & Popham, 2007).

The health benefits of green space in urban areas include:

- protection of people from environmental exposures associated with flooding, air pollution, noise and extreme temperature
- reduced morbidity and mortality
- improved opportunities for physical activity and exercise.
- improved mental health and feelings of wellbeing, particularly lower stress levels and the perception of restorative effects
- improved opportunities for social interactions.

The project has largely avoided impacts to recreational facilities and parks and the project would not have direct impacts on public open space. Access to the Soldiers Pinch construction footprint would temporarily impact access to Browntown Oval which would need to be managed during construction, however the proposed works would not impact on recreational use of the oval. Given the extensive size of the surrounding Blue Mountains National Park, conservation and nature areas, the changes due to the project are not expected to impact on green space or the passive and active recreational use of green space in the study area. Hence no adverse impacts on health are expected.

Visual amenity

Landscape and visual impacts are presented in Chapter 18 (Landscape and visual).

Visual amenity can be described as the pleasantness of the view or outlook of an identified receptor or group of receptors (e.g. residences, recreational users). Visual amenity is an important part of an area's identity and offers a wide variety of benefits to the community in terms of quality of life, wellbeing and economic activity. Located in the Blue Mountains, the project is within an area known for its natural beauty and high level of visual amenity.

During construction, visual amenity has the potential to be affected by factors such as vegetation removal and the visual appearance of construction footprints.

For some individuals, changes in visual amenity can increase levels of stress and anxiety and may affect the use of outdoor spaces for walking and cycling. These impacts, however, are typically of short duration as most people adapt to changes in the visual landscape. As a result, most changes in visual impacts are not expected to have a material impact on the health of the community. Health impacts from changes to visual amenity are further discussed in Section 9.4 of Appendix F (Technical report – Human health).

Equity issues

The health effects associated with impacts related to transport projects are not typically equally distributed across the community. Groups at higher risk, or more sensitive to impacts, include the elderly, infants and young children, and individuals with pre-existing health conditions, disabilities, or who live in areas of higher levels of air or noise pollution.

The surface works for the project are located in areas where few people live or work – i.e. in areas between the townships along the highway. This means the majority of the impacts during construction are not in the centre of areas of social disadvantage. As such, groups that are at higher risk or more sensitive to health impacts are unlikely to experience an accumulation of health impacts as a result of the project. Health impacts associated with equity issues are discussed in Section 9.6 of Appendix F (Technical report – Human health).

Economic impacts

Business and economic impacts are presented in Chapter 20 (Business, land use and property).

The project would result in a substantial increase in economic activity (including economic stimulus benefits into the local, regional and state economies). Ongoing or improved economic vitality is a key factor that beneficially influences the health of a community. Employment opportunities would grow in the region through the potential increase in business customers and through the increase in demand for construction workers.

Economic impacts during construction as a result of the project, including gross output (market value of goods and services produced) and value added (market value of goods and services produced after deducting the cost of goods and services used) are shown in Figure 10-4.

Figure 10-4 Economic impacts during construction (2024 to 2031)

Potential access and connectivity impacts including road closures, impacts on evacuation routes during emergencies and property and business access during construction may negatively affect local business. However, this is expected to be a short-term impact and is not expected to have a substantial impact on the overall activity of local businesses.

Construction expenditure for the project would result in a substantial increase in economic activity, and the project would support a large number of additional jobs a year over the construction period. Increased employment and improved economic vitality are of considerable benefit to human health. For further discussion on health related economic impacts during construction, refer to Section 9.7.1 of Appendix F (Technical report – Human health).

Construction fatigue

Construction fatigue relates to receivers that experience construction impacts from a long construction period, as well as a variety of projects over an extended period of time with few or no breaks between construction periods. Construction fatigue typically relates to traffic and access disruptions, noise and vibration, air quality, visual amenity and social impacts from project that have overlapping construction phases or are back-to-back.

The assessment of construction fatigue includes the following projects that may overlap with the construction phase of the project:

- Great Western Highway Upgrade – Medlow Bath (Medlow Bath Upgrade)
- Great Western Highway East – Katoomba to Blackheath (Katoomba to Blackheath Upgrade)

  Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade).

As outlined in Chapter 24 (Cumulative impacts), the areas of greatest potential for cumulative impacts are at Little Hartley and Blackheath construction sites. All projects considered in the cumulative impact assessment would be required to implement mitigation measures to minimise noise and dust impacts. Mitigation measures to address construction fatigue related to the project are outlined in Chapter 24 (Cumulative impacts). Where all projects implement such measures the potential for cumulative impacts to be sufficiently elevated to impact on health is considered low (for air quality) to moderate (for noise).

10.6 Potential impacts – operation

10.6.1 Overview of health related ambient air quality impacts

Nitrogen dioxide

Potential health impacts associated with NO_2 consider both comparison with guidelines for both acute and chronic cumulative exposure (background concentrations plus the project) and an assessment of incremental impacts on health (associated with changes in air quality from the project alone) and are discussed in Table 10-1. Potential health impacts associated with NO_2, are discussed in Section 5.7 of Appendix F (Technical report – Human health).

The redistribution of nitrogen dioxide concentration shows that nitrogen dioxide concentrations adjacent to existing surface roads where traffic volumes are predicted to decrease, with some localised increases adjacent to the ventilation outlet to portals. The locations of maximum increases in nitrogen dioxide are in areas where there are no sensitive receptors (refer to Section 5.7.3 of Appendix F (Technical report – Human health)).

Table 10-1 Potential health impacts from nitrogen dioxide exposure during operation

Exposure type	Potential health impacts
Cumulative exposures	The assessment of acute and chronic health exposures found that under the previous National Environmental Protection Council (NEPC) and NSW Environment Protection Authority (EPA) standards, there are no exceedances predicted for NO_2 in air from the project relevant to the assessment of acute and chronic exposures. Under the current NEPC standards, the assessment of acute inhalation exposures exceeds air quality standards for both the with project and without project scenarios. The with project scenario provides a benefit in reducing peak acute health impacts of NO_2 in the community compared to the without project scenario. The assessment of chronic inhalation exposures exceeds the current NEPC standards for the without project scenario. The with project scenario would reduce NO_2 exposures and result in compliance with the current NEPC standards. While there are some exceedances of the current NEPC standards, no substantial adverse health impacts associated with NO_2, such as potential respiratory illnesses, are expected in the community, noting that the project reduces short and long-term exposures to NO_2 in the community.
Incremental exposures	Population health impacts: • consistent with the predicted reduction in total NO_2 concentrations in the study area, exposures to NO_2 for the population evaluated in the study area would decrease with the project, regardless of whether the design utilises portal emissions or ventilation outlet emissions. These reductions in NO_2 indicate the project would provide some health benefit to the population by reducing the risk of developing respiratory illnesses associated with NO_2 exposure. Localised health impacts • all calculated risks are less than the risk management action level of 1 x 10^{-4}, indicating that maximum changes in NO_2 in the local community as a result of the project are considered to be low and acceptable, and the project would not increase the risk of potential respiratory illnesses associated with NO_2 exposure. This outcome is the same for both ventilation design options.

Particulate matter

Potential health impacts associated with particulate matter are discussed in Table 10-2. Further discussion is provided in Section 5.8 of Appendix F (Technical report – Human health).

The redistribution of $PM_{2.5}$ shows that $PM_{2.5}$ concentrations adjacent to existing surface roads where traffic volumes are predicted to decrease, with some localised increases adjacent to the ventilation outlet to portals (refer to Section 5.8.5 of Appendix F (Technical report – Human health)).

Table 10-2 Potential health impacts from particulate matter exposure during operation

Exposure type	Potential health impacts
Cumulative exposures	The NEPC has proposed standards for air quality including particulate matter concentrations for the year 2025. Maximum 24-hour average concentrations of $PM_{2.5}$ have the potential to just exceed the NEPC goal of 20 for the year 2025 in the without project scenario. In the with project scenario, total concentrations of $PM_{2.5}$ are lower and would comply with the NEPC goal, regardless of ventilation design option. Maximum 24-hour average PM_{10} concentrations meet the NEPC standards for both the with and without project scenarios. Concentrations are lower in the with project scenario, regardless of whether the project is constructed with portal emissions or ventilation outlet emissions. The project would provide potential health benefits by potentially reducing the risk of adverse health outcomes, such as cardiovascular and respiratory illnesses, associated with PM_{10}. Annual average concentrations of $PM_{2.5}$ and PM_{10} meet the NEPC standards and goals, noting that concentrations would be lower with the project, regardless of the portal emissions or ventilation outlet emissions design options. On the basis of the above, the project would result in lower levels of exposure to $PM_{2.5}$ and PM_{10}, which has the potential for some health benefit to the population in the study area reducing the risk of adverse health outcomes associated with particulate matter such as cardiovascular and respiratory illnesses.
Incremental exposures	Population health impacts: • for the population evaluated in the study area, exposures to $PM_{2.5}$ would decrease with the project, regardless of the portal emissions or ventilation outlet emissions design options. This is consistent with the predicted reduction in total $PM_{2.5}$ concentrations in the study area. These reductions in $PM_{2.5}$ indicate the project would provide some health benefit to the population by reducing the risk of adverse health outcomes associated with particulate matter such as cardiovascular and respiratory illnesses. Localised health impacts: • all calculated maximum individual risks are less than the risk management action level of 1×10^{-4}, indicating that maximum changes in $PM_{2.5}$ in the local community as a result of the project are considered to be low and acceptable. This outcome is the same for both ventilation design options. However, it is noted that the calculated maximum individual risks are lower for the ventilation outlet option, compared with portal emissions. The localised health impacts from changes in $PM_{2.5}$ as a result of the project are considered low and acceptable.

Carbon monoxide

The assessment of potential health impacts associated with carbon monoxide indicate that the concentrations of carbon monoxide for both the with and without project scenarios are below the relevant NEPC health-based standards. Carbon monoxide concentrations would be below the NEPC standards regardless of the ventilation design option. As a result, no adverse health impacts such as increases in potential cardiovascular mortality are expected in relation to exposures to carbon monoxide in the local area surrounding the project. For further discussion of carbon monoxide impacts related to human health, refer to Section 5.6 of Appendix F (Technical report – Human health).

Air toxins

Potential health impacts associated with air toxins are discussed in Table 10-3. Further discussion can be found in Section 5.5 of Appendix F (Technical report – Human health). Based on the information in this table, no chronic health risk issues of concern are predicted in the local community associated with air toxics or diesel particulate matter from the project.

Table 10-3 Potential health impacts from air toxins exposure during operation

Exposure type	Potential health impacts
Acute and chronic exposure	The assessment indicates that the total hazard index predicted for acute exposures to volatile organic compounds (VOCs) and chronic exposures to VOCs and polycyclic aromatic hydrocarbons (PAHs) would be less than one for the with project and without project scenarios for 2030 and 2040. Health issues associated with exposure to VOCs and PAHs include respiratory irritation, nausea and headaches, and damage to the kidney and central nervous system. Based on this assessment, there would be no acute or chronic health issues predicted in the local community as a result of the project.
Incremental lifetime carcinogen risk (enHealth, 2012)	The calculated lifetime cancer risks associated with the maximum change in benzene, 1,3-butadiene and carcinogenic PAHs (as benzo(a)pyrene TEQ) are less than $1x10^{-6}$ in relation to all impacts associated with emissions from the project irrespective of the ventilation design option chosen. In addition, the maximum calculated lifetime cancer risk associated with exposure to diesel particulate matter are equal to $1x10^{-5}$ (considered acceptable) for portal emissions and $1x10^{-6}$ for ventilation outlet emissions (considered negligible). Where the more realistic traffic scenario emissions estimates are considered in the assessment of diesel particulate matter, the risk would be lower. On this basis, the calculated carcinogenic risks are considered low and acceptable.

10.6.2 Health related in-tunnel air quality impacts

Further discussion on potential health related in-tunnel air quality impacts can be found in Section 6 of Appendix F (Technical report – Human health).

Nitrogen dioxide

The NO_2 concentrations in-tunnel during normal operations in 2030 and 2040 are forecast to be well below the in-tunnel limit of 0.5 parts per million (ppm). Where operating at capacity the maximum average concentration equals the in-tunnel air limit but does not exceed the limit. As discussed in Section 10.6.1, exposure to NO_2 potentially increases the risk of developing respiratory illnesses. NO_2 concentrations inside vehicles travelling in the tunnels would be lower with windows up and ventilation on recirculation. Therefore, the potential for adverse health impacts for users of the tunnel are considered to be low.

Carbon monoxide

The adopted in-tunnel air quality limit of 50 ppm for a 15-minute rolling average and 150 ppm as a peak value is lower than the available health based guidelines for exposure from the World Health Organisation (2010). As discussed in Section 10.6.1, exposure to carbon monoxide potentially increases the risk of cardiovascular mortality. Forecast in-tunnel concentrations for carbon monoxide for the project are substantially lower than the adopted limits (refer to Section 6 of Appendix F (Technical report – Human health)). Therefore, the in-tunnel air quality limits are considered to be adequately protective of the health of tunnel users in relation to carbon monoxide exposure.

Particulate matter

No guidelines are currently available to evaluate health impacts of very short-duration exposures to particulates. However, keeping vehicle windows closed and switching ventilation to recirculation has been shown to reduce particulate exposures inside the vehicle by up to 80 per cent (NSW Health, 2003). Adopting such measures, as is suggested for other tunnels in NSW, would minimise exposures to motorists within the tunnel, reducing potential adverse health impacts associated with particulate matter exposure.

10.6.3 Health related noise and vibration impacts

Road noise

The operational noise assessment identified that 30 receptors are expected to experience noise in excess of the adopted noise criteria. However, for the majority of these receptor buildings, exceedance of the noise criteria is a result of existing noise levels, rather than due to the project. For the majority of receptor buildings within the noise catchment areas, the change in noise levels is less than two dBA due to the project, which is unlikely to be discernible or impact on human health.

Noise levels are predicted to increase by more than two dBA at one sensitive receiver.

There are two receivers at Little Hartley where noise levels are predicted to equal or exceed the cumulative limit of three dBA. These receivers would be eligible for the consideration of feasible and reasonable noise mitigation measures such as at-property noise mitigation. Noise walls were not considered reasonable given the low number of receivers in this area.

Overall, two properties would experience increases in noise at levels that may be of concern to health as a result of the project. Where noise mitigation measures proposed are implemented, no substantial health impacts are expected for these properties. For the majority of the community road noise impacts would be reduced as a result of the project by reducing traffic on the existing Great Western Highway, resulting in some health benefits by reducing the potential for annoyance and sleep disturbance. For further discussion on health related road noise impacts from operation, refer to Section 7.6.3 of Appendix F (Technical report – Human health).

Fixed facility noise

For both ventilation options, noise impacts during normal and low flow traffic conditions relate to the operation of jet fans near the portal exits. Under the portal emissions option, there is potential for one receptor at Blackheath to experience increased levels of noise that exceed the adopted noise criteria during normal and low flow traffic conditions. During emergency conditions and prior to the application of noise attenuation, 14 receptors at Blackheath may experience increased levels of noise from operation of the fire pump. No exceedances are predicted at Little Hartley.

Under the ventilation outlet option, there is potential for up to four receptors at both Blackheath and Little Hartley to experience increased levels of noise that exceed the adopted noise criteria during normal and low flow traffic conditions. During emergency conditions, 19 receptors at Blackheath may experience increased levels of noise from the operation of the fire pump. No exceedances are predicted at Little Hartley.

Where noise levels are mitigated during normal operations there would be no changes in noise that would result in adverse impacts to community health, such as annoyance or sleep disturbance which can lead to other long-term health impacts. For further discussion on health-related fixed facility noise impacts from operation, refer to Section 7.6.3 of Appendix F (Technical report – Human health).

10.6.4 Health related social impacts

Changes in traffic, public transport, access and connectivity

Changes in traffic, access and connectively during operation are presented in Chapter 8 (Transport and traffic).

Operation of the project would divert a substantial proportion of through traffic from the existing Great Western Highway into the tunnels. This means the existing Great Western Highway would mostly cater to local users and tourist traffic which would substantially improve local access and movements. By improving traffic access and connectivity during operation, the project could reduce motorist stress and fatigue, reducing adverse health impacts for the community.

Access to social infrastructure is likely to be improved as a result of the project with less traffic congestion on the surface roads. No specific impacts on public transport are expected, other than benefits due to decreased travel times for buses on surface roads and/or within the tunnel for through trips. By maintaining access to social infrastructure and public transport, the project would avoid potential adverse health impacts associated with feelings of isolation, helplessness and dependence. The project may provide potential health benefits by decreasing travel times for buses on surface roads and/or within the project tunnel, and reducing feelings of isolation, helplessness and dependence.

Reduced traffic congestion on surface roads as a result of the project would improve the safety of these roads for use by cyclists. Opportunities to improve at-surface active transport trails between Blackheath and Little Hartley are also being considered as part of ongoing investigation and consultation with relevant councils for potential placemaking initiatives, subject to separate planning approval. By improving pedestrian and cyclist safety during operation, the project would enhance the health benefits associated with providing pedestrian and cyclist access, which include maintaining a healthy weight and improved mental health status.

During operation of the project, the reduction in traffic congestion along the surface roads would improve amenity for residents living in Blackheath and Mount Victoria due to reduced travel times when travelling locally and when using the tunnel, potentially resulting in health benefits associated with decreased levels of stress and anxiety. Health related impacts from changes in traffic, public transport, access and connectivity are further discussed in Section 9.2 of Appendix F (Technical report – Human health).

Public safety

A range of potential hazards have been identified that have the potential to affect public safety during the operation of the project, including traffic accidents and subsidence. The subsidence analysis did not identify any residential properties where estimated settlement was not in compliance with relevant guidelines. With the implementation of recommended mitigation measures, these hazards are unlikely to result in substantial safety risks to the community.

Operation of the project would divert a substantial proportion of through traffic from the existing Great Western Highway into the tunnels, improving public safety on the existing Great Western Highway. By reducing traffic on the existing Great Western Highway, the project would provide potential health benefits by potentially reducing crash rates and improving pedestrian and cyclist safety. Health related public safety impacts are further discussed in Section 8 of Appendix F (Technical report – Human health).

Green space

The project has largely avoided impacts to recreational facilities and parks and the project would not have direct impacts on public open space. The project would not impact on areas of green space during operation, and therefore no adverse impacts to health are expected. The project would provide potential health benefits by improving access and connectivity to areas of green space and social infrastructure. The project would not result in a loss of green space.

Visual amenity

The operation of the project would include changes to the local landscape and visual amenity due to the presence of new project infrastructure (including the tunnel operations facility, water treatment plant, landscaping, surface road structures and ventilation outlets (if this ventilation design option is selected)). The water supply pipeline would be below ground or integrated with other infrastructure (such as bridge) and not visible during operation.

Changes in visual amenity have the potential to increase levels of stress and anxiety, however, most people adapt to changes in the visual landscape. Where long term visual impacts would be adverse, mitigation measures including landscape screening would be utilised where feasible to reduce these impacts. Design development has been influenced by urban design principles that have been established for the project including integrating the project elements and infrastructure into the surrounding environment. A detailed review and finalisation of architectural treatment of the project operational infrastructure would be carried out during further design development including input from the State Design Review Panel.

As a result, most changes in visual impacts would have a negligible impact on the health of the community or increase levels of stress and anxiety. Health impacts from changes to visual amenity are further discussed in Section 9.4 of Appendix F (Technical report – Human health).

Economic impacts

Business and economic impacts are presented in Chapter 20 (Business, land use and property). It is expected that there would be ongoing economic impacts/benefits to the regional economy via the three drivers shown in Figure 10-5.

Figure 10-5 Key economic impact drivers during operation of the project

In the first ten years of operation, it is estimated that the project would result in the economic impacts identified in Figure 10-6. This impact would be largely driven by the productivity uplift associated with business and freight related benefits and increased tourism spend within the regional area. This uplift is expected to be partly offset by a modest decline in passing trade activity, due to a reduction in local through traffic.

Figure 10-6 Economic impacts during operation (2030 to 2040)

It is also expected that traffic congestion and travel times between Blackheath and Little Hartley would improve for through traffic and local traffic once the project is operational. This would likely improve productivity for local businesses and may also improve access to jobs for local residents due to ease of travel.

Reducing the level of traffic on the existing Great Western Highway by diverting traffic to the tunnels has the potential to improve land value over time due to improved amenity around the project. This may also attract new businesses to move to the areas being bypassed including Blackheath and Mount Victoria.

As stated in Section 10.5.3, increased employment and improved economic vitality are of considerable benefit to human health. The ongoing economic benefits provided by the project, including increase business productivity and increased tourism spend in the area, would provide considerable community health benefits. For further discussion on health-related economic impacts during operation, refer to Section 9.7.2 of Appendix F (Technical report – Human health).

10.7 Environmental mitigation measures

10.7.1 Performance outcomes

Performance outcomes for the project in relation to human health are listed in Table 10-4 and identify measurable performance-based standards for environmental management.

Table 10-4 Human health performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
The project avoids or minimises adverse health impacts arising from the project.	Design, construct and operate the project to achieve applicable human health based in-tunnel and ambient air quality criteria, and human health based noise and vibration criteria.	Design, construction and operation
The project avoids, to the greatest extent possible, risk to public safety.	Design, construct and operate the project to comply with applicable road design and road safety standards, guidelines and policies.	Design, construction and operation

10.7.2 Mitigation measures

Environmental mitigation measures identified to manage potential human health related impacts as a result of the project are provided in other technical environmental assessment chapters. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

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 Heritage structures German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures (DIN 4150) Non-heritage structures Evaluation and Measurement for Vibration in Buildings Part 2, (British Standard (BS) 7385: Part 2-1993) (BS 7385) Human comfort (tactile vibration) Assessing Vibration: A Technical Guideline (AVATG)1 (Department of Environment and Conservation, 2006) Human comfort (ground-borne noise) 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.

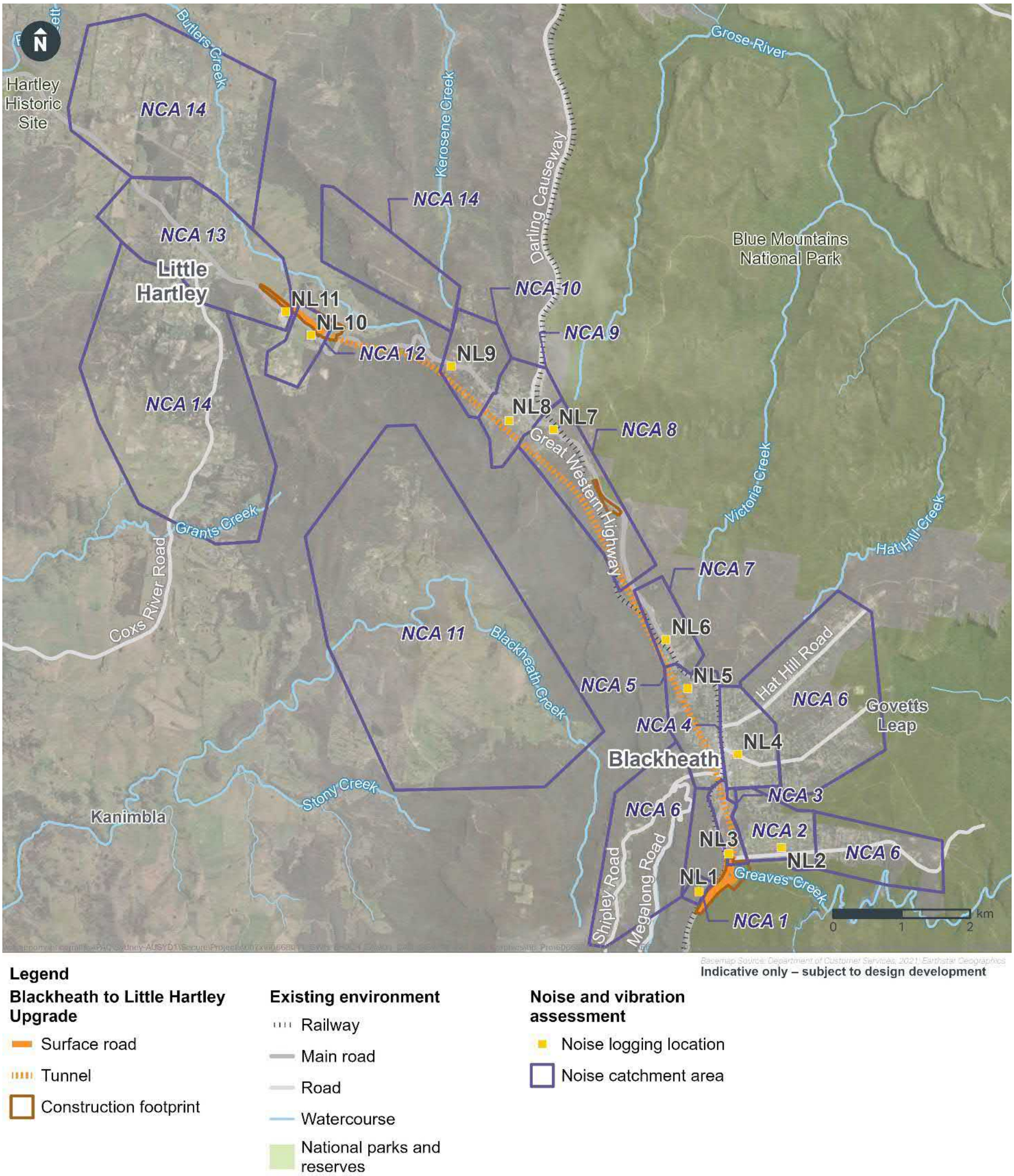


Figure 11-1 Noise catchment areas (NCAs) and monitoring locations (NLs)

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.

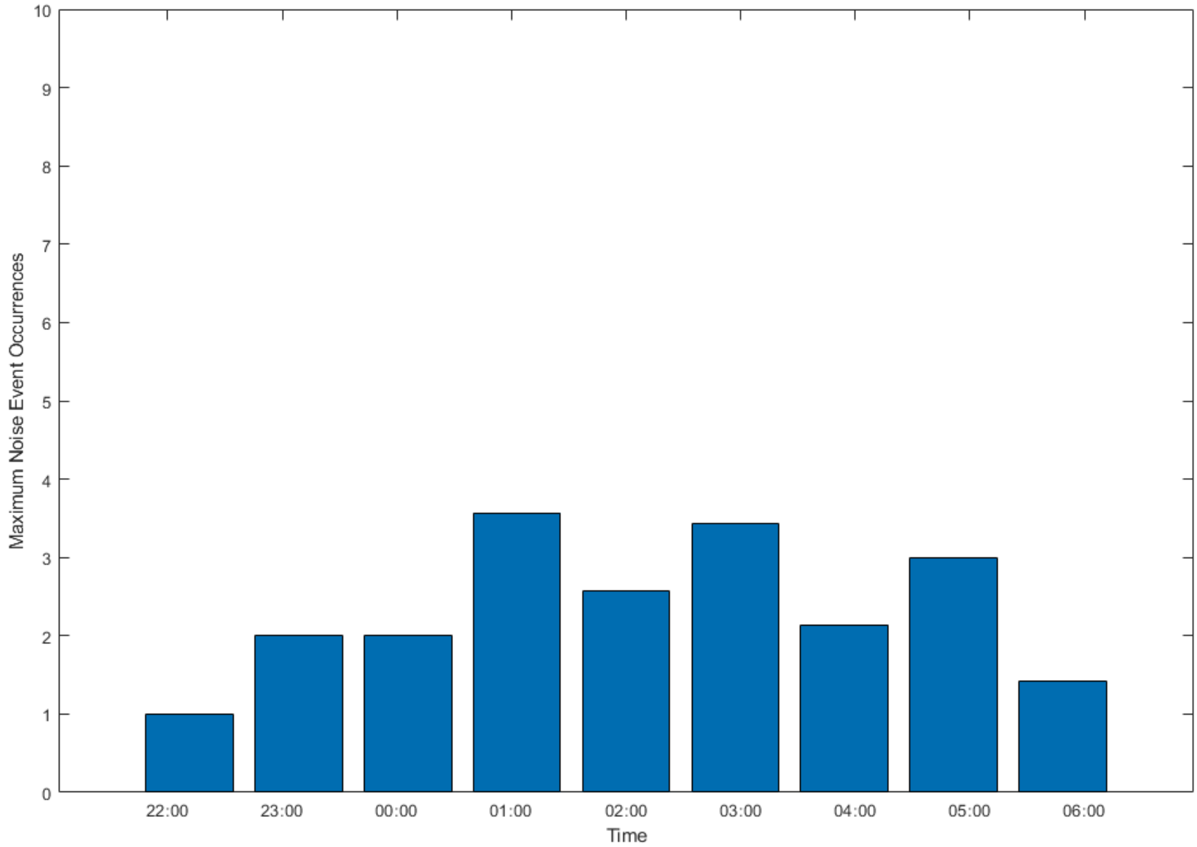


Figure 11-2 Existing maximum noise level events – 89 Great Western Highway, Blackheath

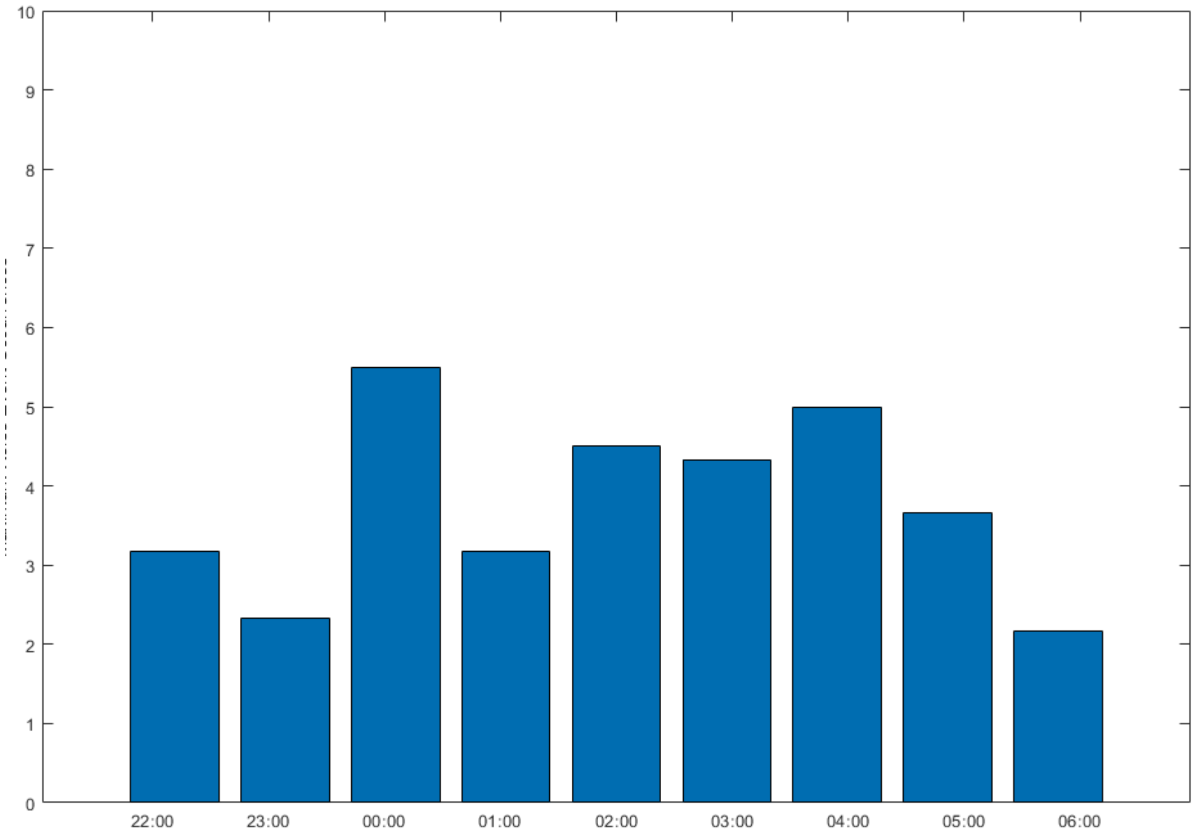


Figure 11-3 Maximum noise level events – 2133 Great Western Highway, Little Hartley

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

<table>
<tr><th>SEARs desired performance outcome</th><th>Project performance outcome</th><th>Timing</th></tr>
<tr><td rowspan="3">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.</td><td>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.</td><td>Construction</td></tr>
<tr><td>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.</td><td>Construction</td></tr>
<tr><td>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.</td><td>Design</td></tr>
</table>

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

12 Biodiversity

This chapter summarises the biodiversity assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full Biodiversity Development Assessment Report (BDAR) has been prepared in accordance with the Biodiversity Assessment Method (BAM) and is provided in Appendix H (Technical report – Biodiversity).

12.1 Assessment approach

The biodiversity assessment for the project comprised the following three areas shown in Figure 12-1 and described in Table 12-1.

Table 12-1 Biodiversity assessment areas

Area	Extent and description
Development footprint[1]	Represents the three areas of direct impacts associated with the project's construction. This area comprises the project's construction footprint, minus the areas that are being assessed as part of the Great Western Highway East – Katoomba to Blackheath Upgrade (Katoomba to Blackheath Upgrade) and the Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade) projects.
Assessment area	Represents the area considered for prescribed and indirect impacts. This area includes the development footprint and the area of land within a 1500m buffer zone surrounding the development footprint. It also includes the area within a 500m buffer zone (taken from the centre line) of the tunnel alignment.
Study area	Represents the area subject to biodiversity field investigations to inform the existing environment.

Table notes:

1. This term is specific to the biodiversity assessment and has therefore been used in this chapter for consistency with the BDAR

The biodiversity assessment involved:

- a search of relevant databases to identify the existing biodiversity and natural environment features, such as landscape features, plant community types (PCTs), threatened and migratory species and their habitats previously recorded or predicted to occur and aquatic ecosystems in the assessment area
- a review of reports relevant to the project, including biodiversity assessments for the Great Western Highway East – Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade projects
- field surveys to:
  - verify the presence and determine the condition of vegetation within the assessment area (either as high, moderate or low), and targeted threatened species surveys to determine the presence of threatened species that could be potentially impacted by the project (carried out between November 2021 and May 2022)
  - validate the presence of aquatic and riparian ecosystem constrains identified in the desktop review, and to provide condition assessments of riparian habitats (carried out between August and September 2022)

- assessment of potential biodiversity impacts from the project including direct, indirect, serious and irreversible, and prescribed impacts in accordance with the BAM (DPIE, 2020a)
- identification of environmental mitigation measures and offsets required to manage these impacts.

Further detail regarding the biodiversity assessment methodology is provided in Appendix H (Technical report – Biodiversity). Further detail regarding the aquatic ecology assessment methodology is provided in Annexure H of Appendix H (Technical report – Biodiversity).

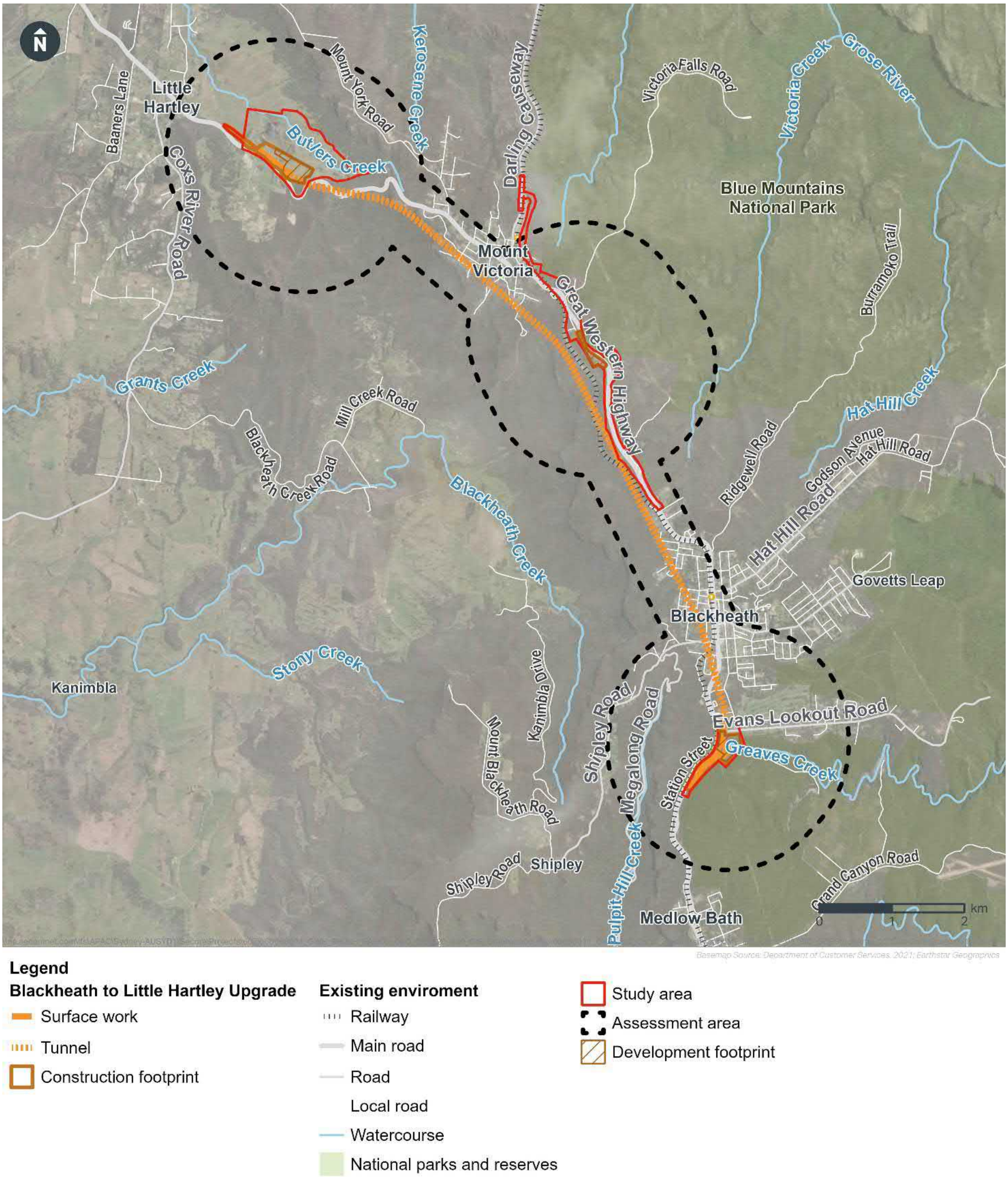


Figure 12-1 Biodiversity assessment area

12.2 Existing environment

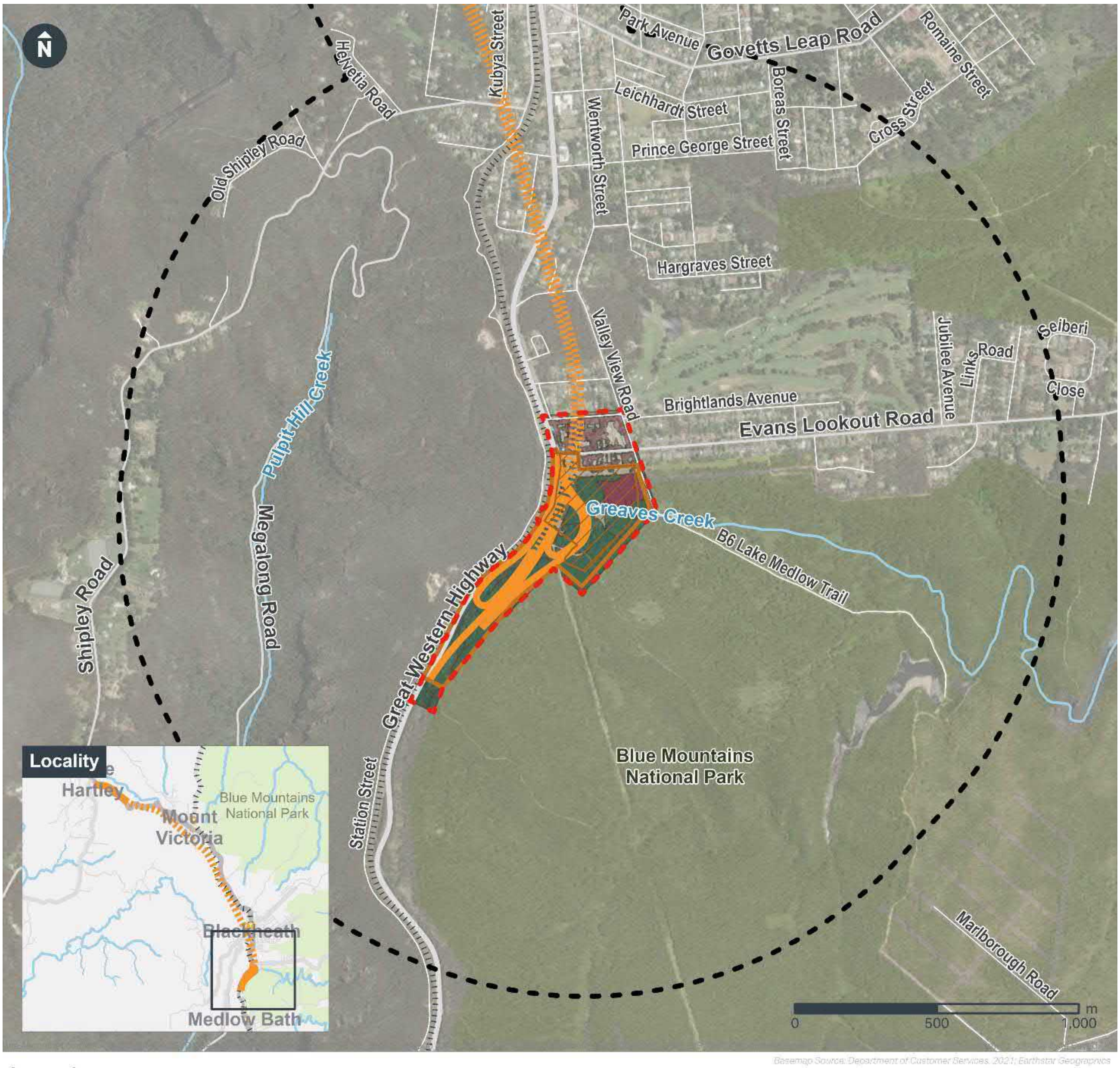
This assessment considers a baseline environment, where the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade adjoining the project to the east and west respectively, are under construction and associated construction sites have been cleared of vegetation (see Figure 12-2 to Figure 12-4).

12.2.1 Landscape context and connectivity

The influence of landscape context on habitat suitability and connectivity (biodiversity links that connect different areas of habitat) for threatened species in the study area is described in Table 12-2.

Table 12-2 Assessment area landscape context and connectivity

Location	Landscape context	Connectivity
Blackheath construction site	Native vegetation is present in high condition and forms a dense woodland directly connected to the Blue Mountains National Park. Predominantly remnant bushland and covers a total of 26.85 ha.	Connectivity in this area is high allowing for unrestricted movement of terrestrial and arboreal (living in trees) fauna. Watercourses and drainage lines in this area also allow for the movement of amphibious species.
Soldiers Pinch construction site	Predominantly existing road infrastructure and patches of native bushland and covers a total of 67.25 ha.	Within this area there is substantial pre-existing fragmentation associated with the existing Great Western Highway road corridor, Browntown Oval and several dirt access tracks that pass through and are located directly adjacent to the construction footprint.
Little Hartley construction site	Predominantly cleared agricultural land for cattle grazing that covers a total of 106.02 ha.	Butlers Creek runs in an east-west orientation across this area and facilitates movement for aquatic and amphibious species with several native frog species detected during field investigations. The Blue Mountains Western Escarpment wildlife corridor also traverses the assessment area between Mount Victoria and Little Hartley providing valuable connectivity.



Legend

Blackheath to Little Hartley Upgrade
- Surface work
- Tunnel
- Construction footprint

Existing enviroment
- Railway
- Main road
- Road
- Watercourse
- National parks and reserves

Biodiversity assessment
- Assessment area
- Study area
- Development footprint

Threatened ecological community
- Threatened ecological community

Plant community types
- Urban Native/Exotic
- 708
- 1248

Figure 12-2 Biodiversity assessment area at Blackheath

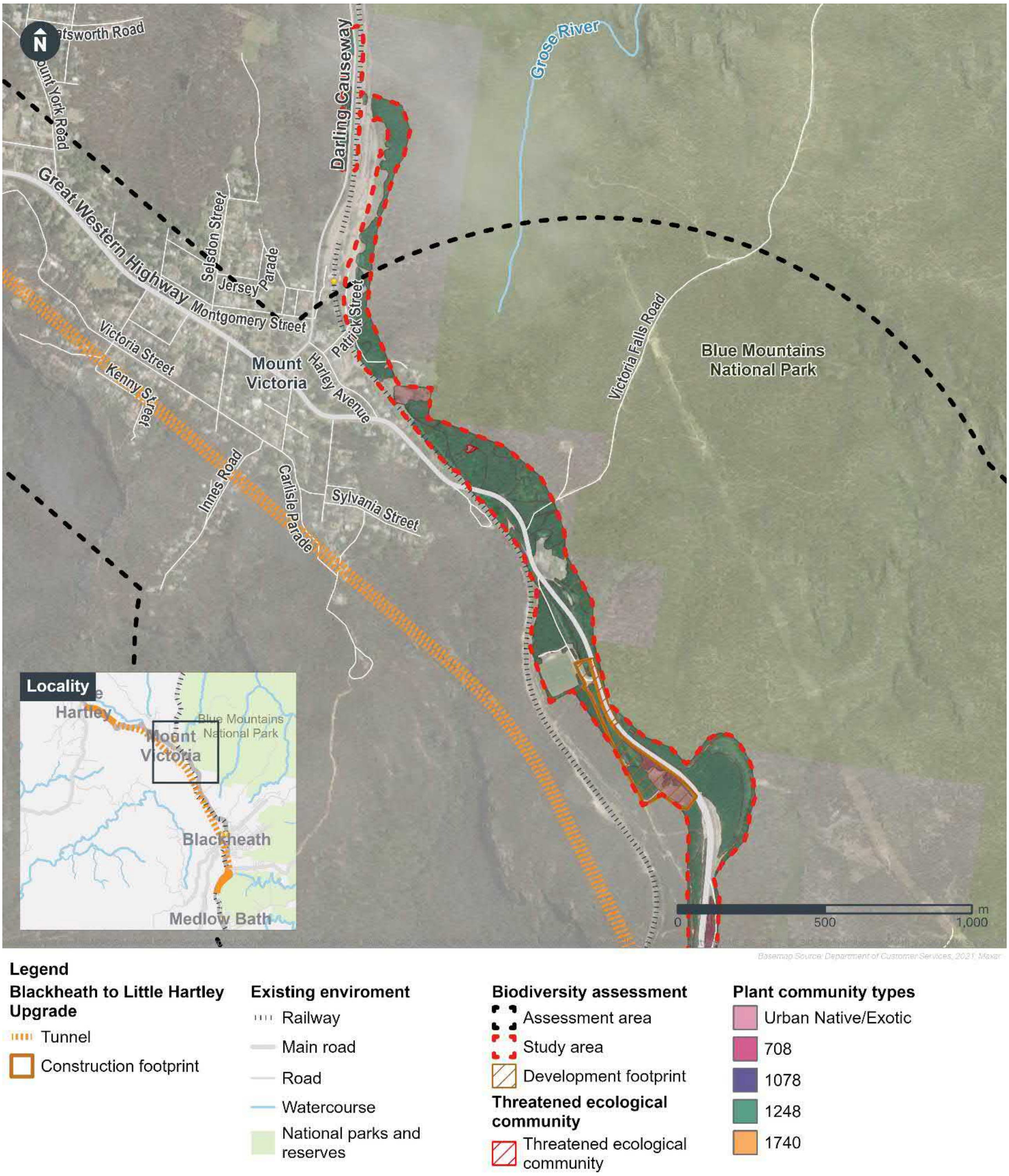


Figure 12-3 Biodiversity assessment area at Soldiers Pinch

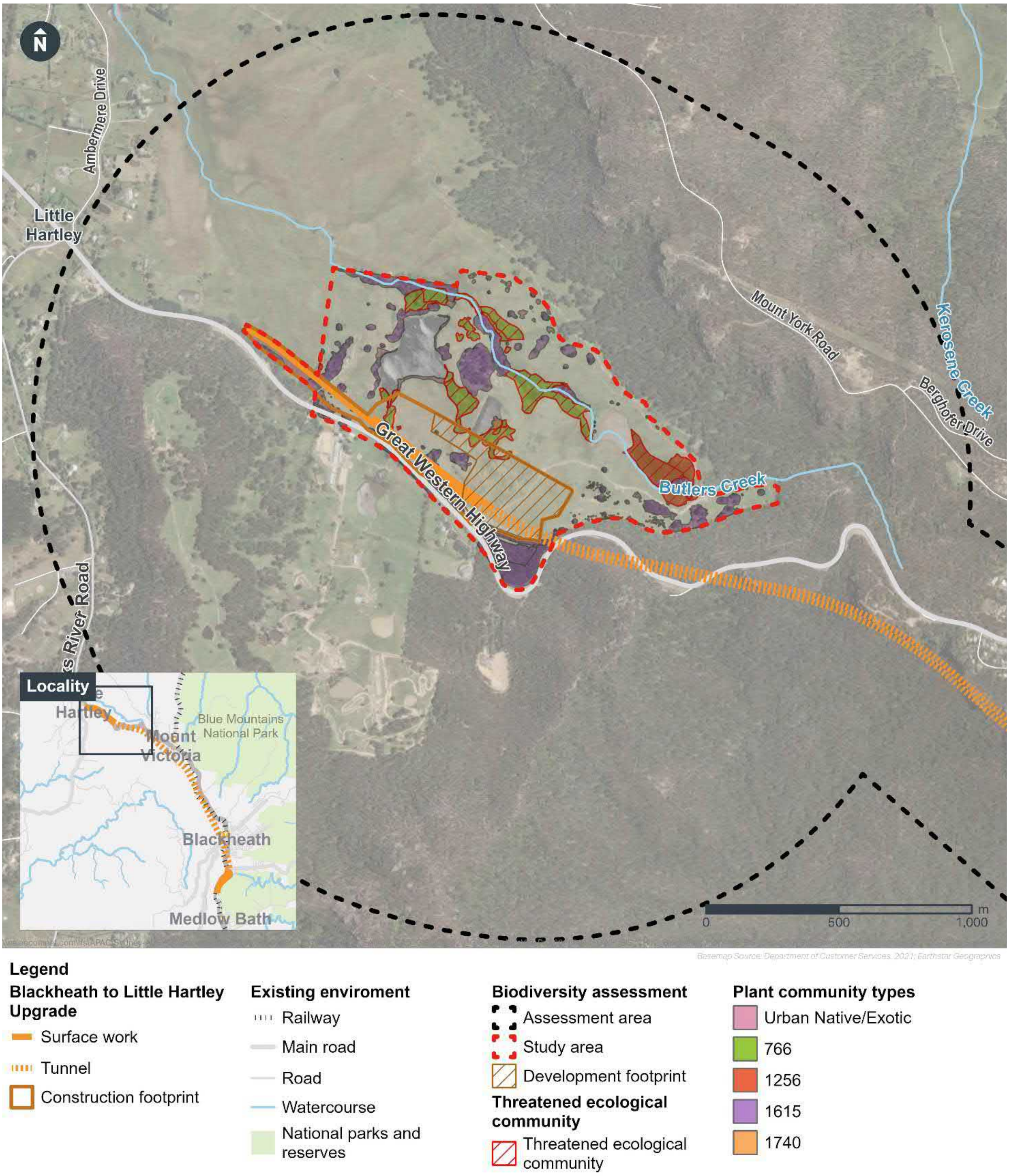


Figure 12-4 Biodiversity assessment area at Little Hartley

12.2.2 Native vegetation and threatened ecological communities

Seven PCTs were recorded in the study area. These seven PCTs meet the relevant criteria for two Threatened Ecological Communities (TECs) listed under the NSW *Biodiversity Conservation Act 2016* (BC Act) and one TEC listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). A summary of each PCT, associated TEC and listing is provided in Table 12-3.

Details of how each PCT meets each element of the scientific determination, including geographical location, characteristic species, soils and geology can be found in Section 4 of Appendix H (Technical report – Biodiversity).

The extent and distribution of the PCTs within the study area is shown in Figure 12-2 to Figure 12-4. Section 4.1 of Appendix H (Technical report – Biodiversity). These are shown in Figure 12-7 to Figure 12-9.

Table 12-3 Assessment area PCTs and associated TECs

PCT	Associated TEC
PCT 708 Blue Mountains Mallee Ash - Dwarf Casuarina heath of the upper Blue Mountains, Sydney Basin Bioregion	Nil
PCT 1078 Prickly Tea-tree - sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion	• Blue Mountains Swamps in the Sydney Basin Bioregion listed as vulnerable under BC Act
PCT 1248 Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion	Nil
PCT 1256 Tableland swamp meadow on impeded drainage sites of the western Sydney Basin Bioregion and South Eastern Highlands Bioregion	• Temperate Highland Peat Swamps on Sandstone (THPSS) listed as endangered under the EPBC Act • Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions listed as endangered under the BC Act
PCT 1615 Monkey Gum - Eucalyptus blaxlandii shrubby open forest on basalt of the Sydney Basin	Nil
PCT 1740 Tall Spike Rush freshwater wetland	Nil
PCT 766 Carex sedgeland of the slopes and tablelands	• Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions listed as endangered under the BC Act

12.2.3 Threatened flora

No threatened flora species were found during field surveys or considered likely to occur within the development footprint.

12.2.4 Threatened fauna

Field surveys carried out for the project identified two threatened fauna species within the development footprint. Another threatened species, the Purple Copper Butterfly, was identified as having a high likelihood of occurrence within the development footprint based on habitat assessment, despite not being identified during field surveys.

Table 12-4 lists the threatened fauna species known or likely to occur within the development footprint.

Table 12-4 Threatened fauna species known or likely to occur in the development footprint

Species	Common name	BC Act[1]	EPBC Act[1]	Likelihood of occurrence
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Detected via call detection. Areas of suitable habitat are associated with PCTs in the development footprint and are within two kilometres of rocky areas containing caves, overhangs, escarpments, outcrops, or crevices, or within two kilometres of old mines or tunnels.
Petauroides volans	Greater Glider	-	E	Detected during spotlighting surveys. Areas of suitable habitat align with PCT 1248 which include hollow-bearing trees within connected vegetation.
Paralucia spinifera	Purple Copper Butterfly	E	V	Areas of suitable habitat align with areas of *Bursaria spinosa* or within 40m of *Bursaria spinosa* within PCT 1248.

Table notes:

1. V = Vulnerable, E = Endangered under the EPBC Act

12.2.5 Groundwater dependent ecosystems

Three PCTs within the study area at Little Hartley are associated with high probability GDEs:

- PCT 766 Carex sedgeland of the slopes and tablelands
- PCT 1256 Tableland swamp meadow on impeded drainage sites of the western Sydney Basin Bioregion and South Eastern Highlands Bioregion
- PCT 1615 Monkey Gum - Eucalyptus blaxlandii shrubby open forest on basalt of the Sydney Basin.

The remaining PCTs within the study area at Blackheath, Soldiers Pinch and Little Hartley are likely to use groundwater but are not considered dependent on it.

An additional high probability GDE is mapped outside of the Little Hartley study area but within the assessment area at Little Hartley, along with several moderate probability GDEs. Several medium probability GDEs have also been mapped either directly above the tunnel alignment or within the surrounding assessment area.

Some GDEs within the assessment area are classified as THPSS and are listed as endangered under the EPBC Act including:

- headwater swamps (formed near catchment divides at the headwaters of streams where gradients are shallow)
- valley infill swamps (occur on steeper gradients in the valleys of larger waterways)
- hanging swamps (occur in steep valley walls where there is groundwater seepage).

A conceptual representation of the dependency of GDEs such as THPSS on groundwater is illustrated in Figure 12-5 and Figure 12-6.

GDEs within the study area and assessment area are shown in Figure 12-7 to Figure 12-9.

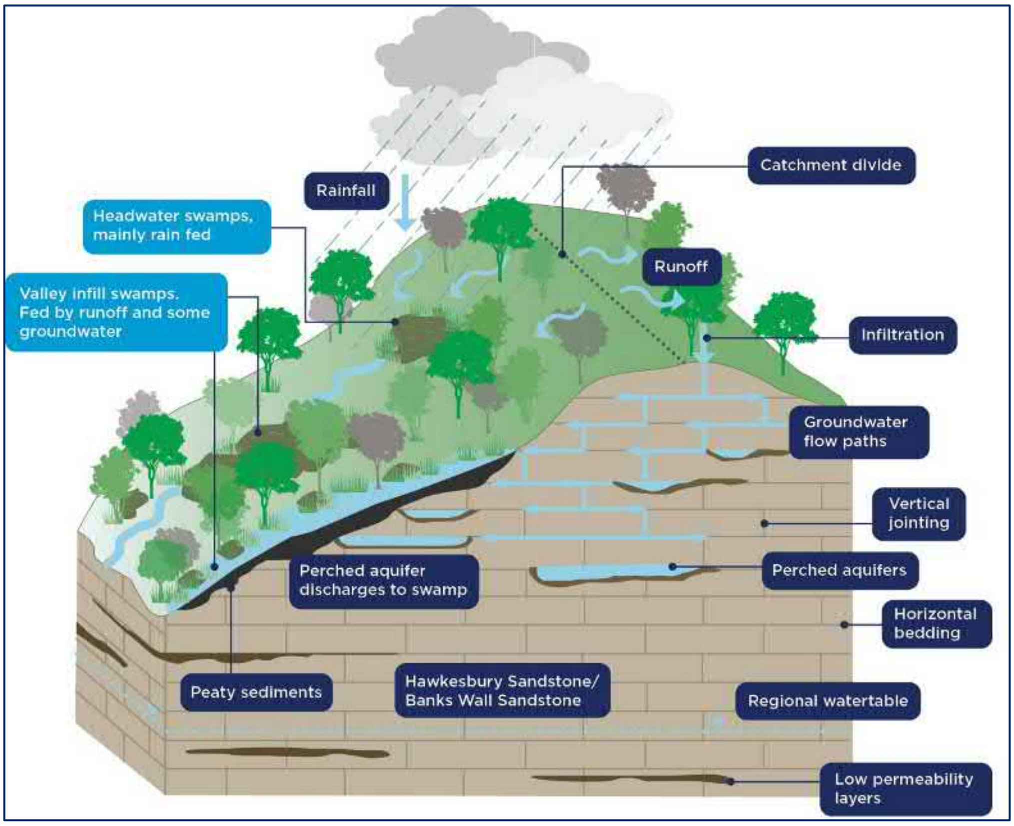


Figure 12-5 Conceptual diagram showing THPSS groundwater relationship (headwater swamps and valley infill swamps)

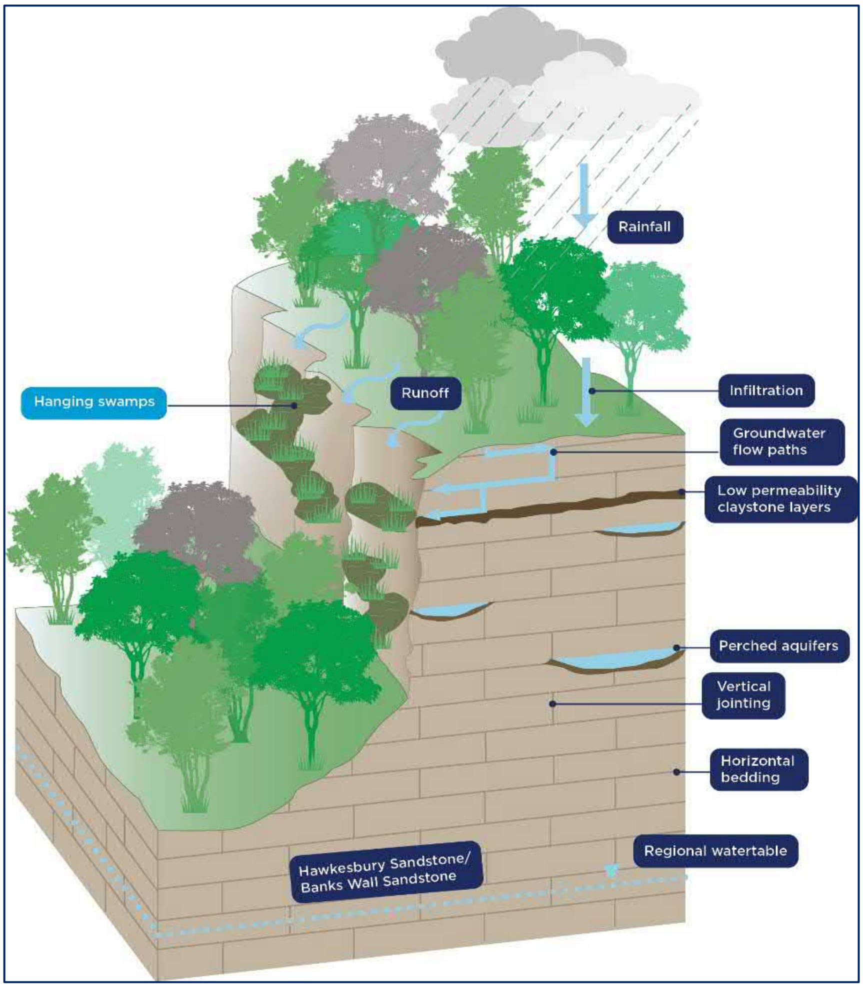


Figure 12-6 Conceptual diagram showing THPSS groundwater relationship (hanging swamps)

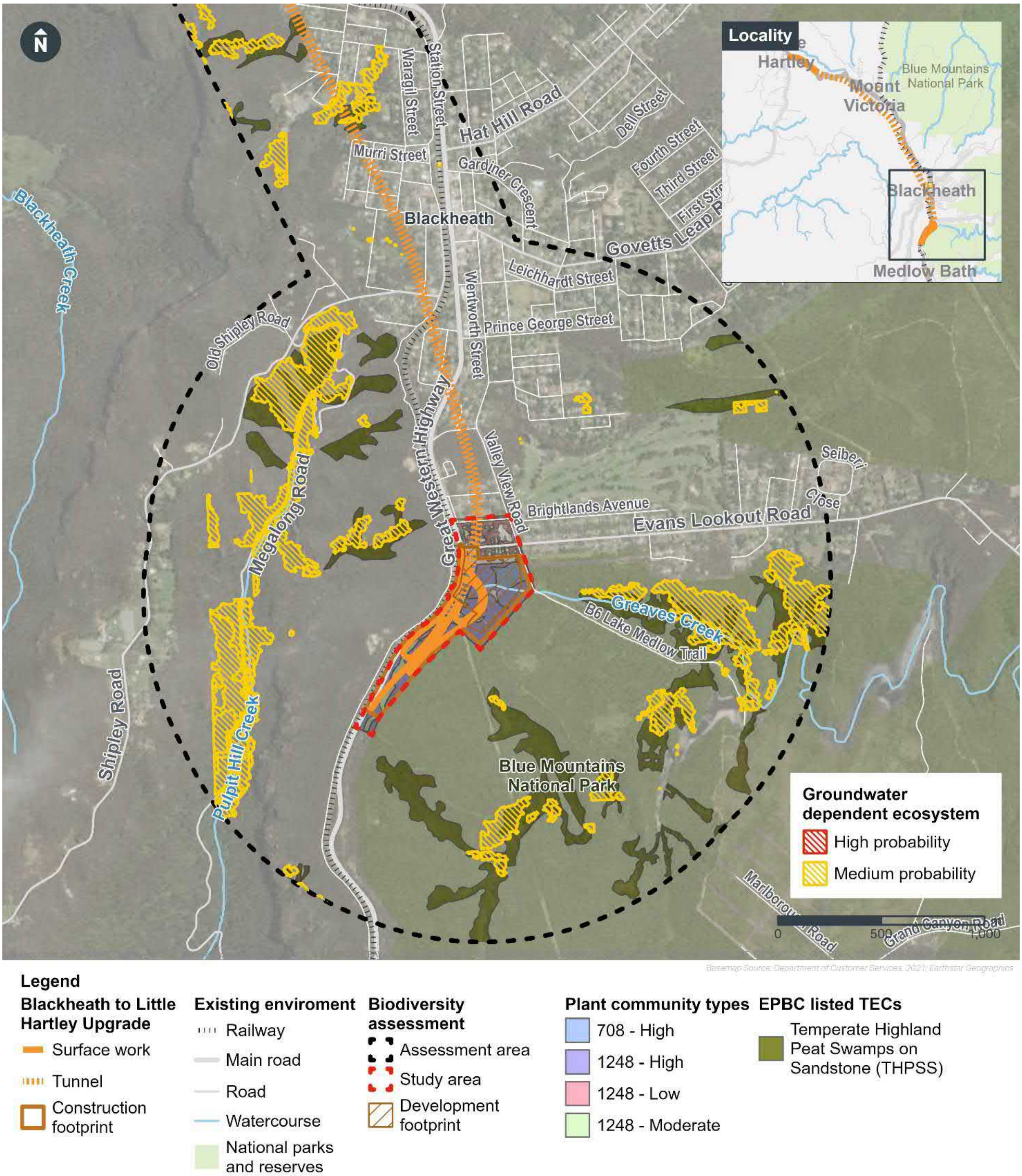


Figure 12-7 Distribution of groundwater dependent ecosystems within the assessment area at Blackheath

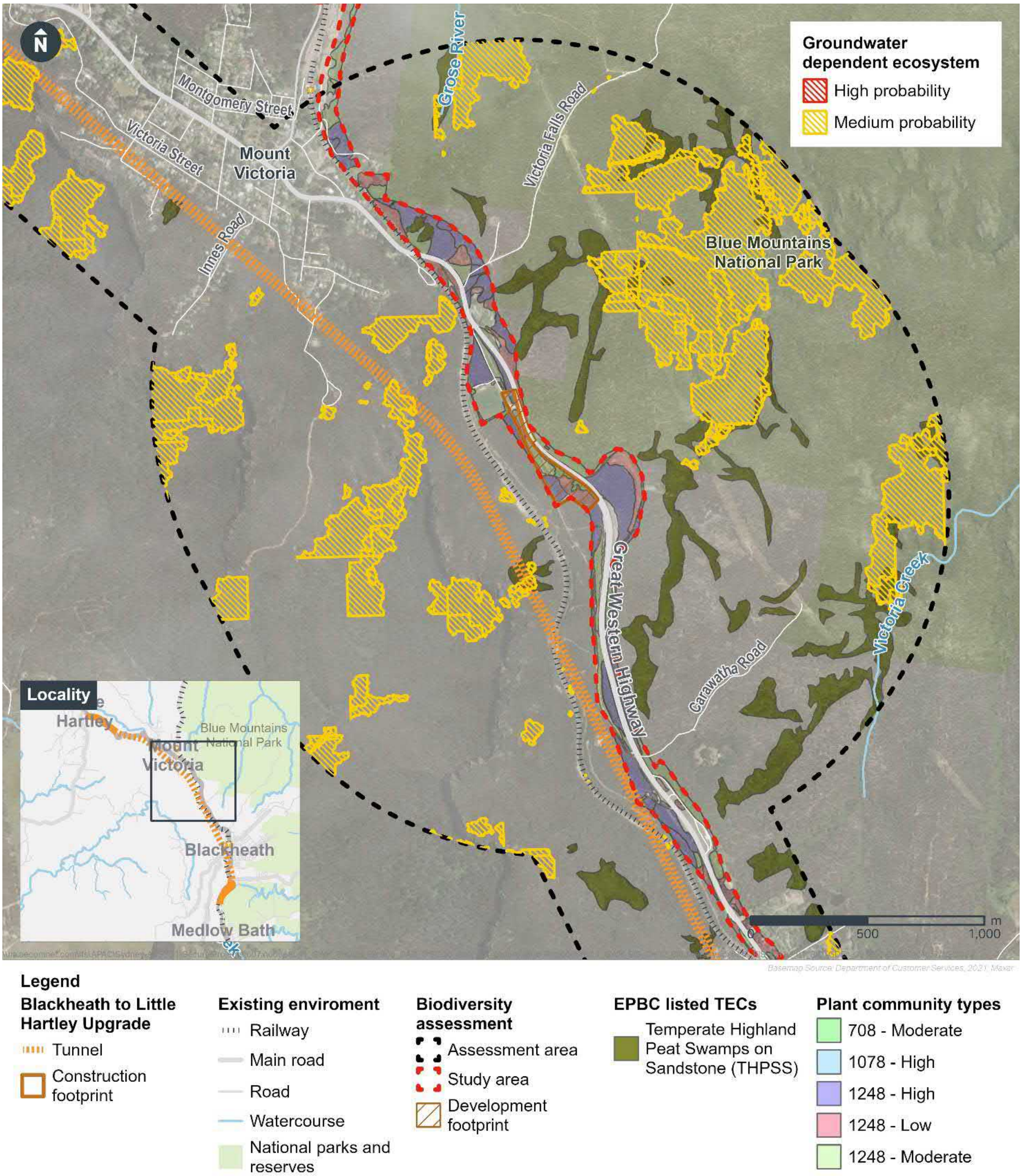


Figure 12-8 Distribution of groundwater dependent ecosystems within the assessment area at Soldiers Pinch

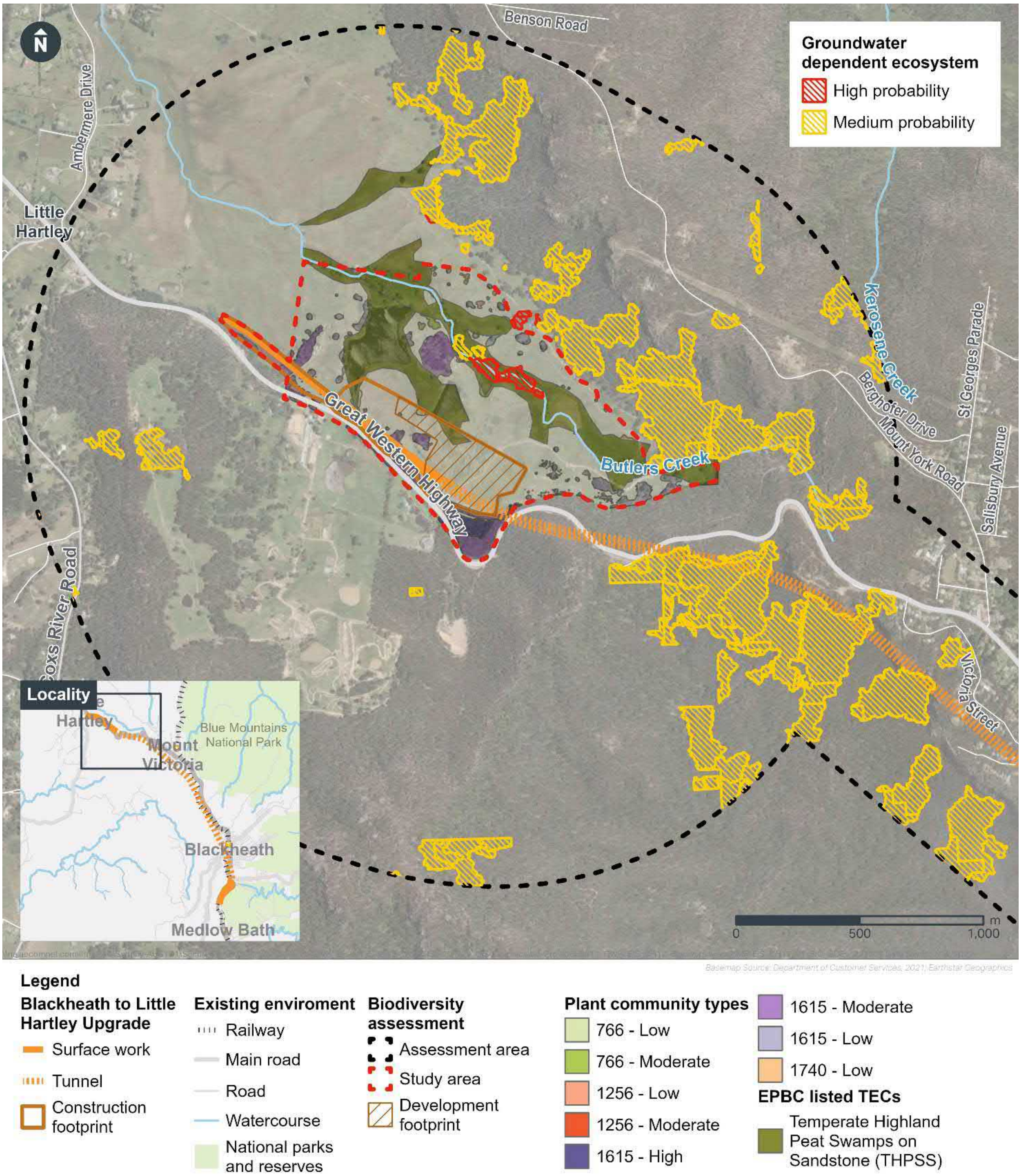


Figure 12-9 Distribution of groundwater dependent ecosystems within the assessment area at Little Hartley

12.2.6 Existing aquatic environment

The project is located within the Hawkesbury catchment with the closest river-mouth being the Parramatta River located around 98 kilometres south-east of the project.

Several waterways originate from the assessment area. These waterways and their Strahler stream order, along with Key Fish Habitat (KFH) as mapped by the NSW Department of Primary, are shown in Figure 12-10 (Department of Primary Industries (DPI), 2022).

The ecological condition of these waterways ranges from 'poor' to 'excellent', with the majority of waterways considered to be in 'excellent' condition. At Butlers Creek, upstream areas are categorised as 'excellent', whereas downstream areas that approached pasture grassland are considered 'poor'.

Waterways originating from the assessment area are not considered habitat for threatened species or endangered populations listed under the *Fisheries Management Act 1994* (FM Act) and there are no records of threatened aquatic species. However, the waterways do flow into the Grose River and Coxs River, which are mapped as habitat for the Macquarie Perch (*Macquaria australasica*), listed as endangered under the EPBC Act and FM Act.

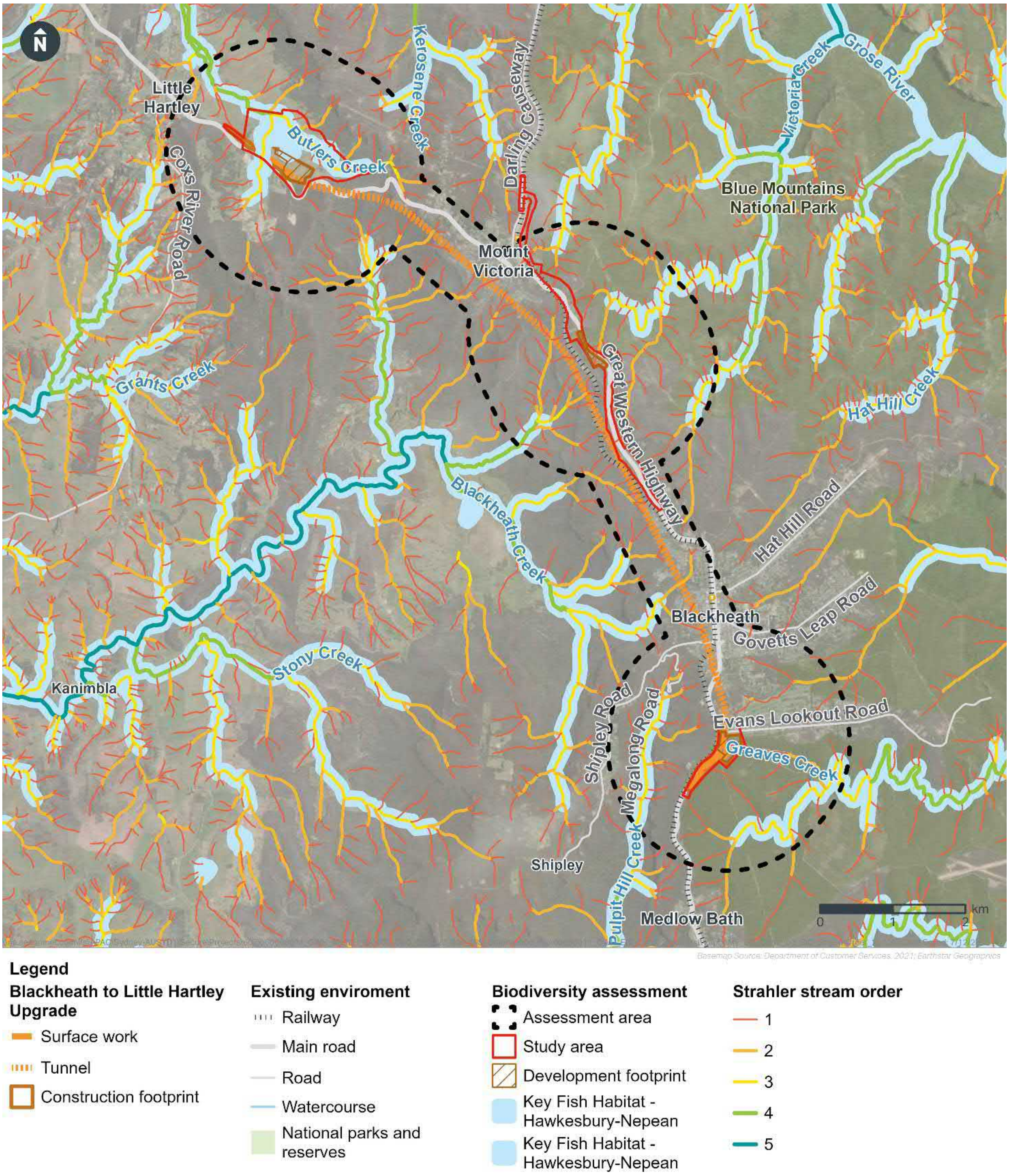


Figure 12-10 Strahler order and key fish habitat of waterways near the project

12.2.7 Wetlands of international importance

No wetlands of international importance occur within the development footprint or assessment area. The nearest wetland is the Pitt Town Lagoon, located 53 kilometres to the east of the project. The project lies approximately 93 kilometres north-west of the nearest Ramsar wetland of international importance, being Towra Point Nature Reserve south of Sydney. The project would not drain to this catchment.

12.2.8 Matters of national environmental significance

The following matters of national environmental significance (MNES) under the EPBC Act are relevant to the project:

- two threatened fauna species listed under the EPBC Act have been recorded (Large-eared Pied Bat and Greater Glider) and a further eight are considered likely to have potential habitat within the development footprint, including Regent Honeyeater, Gang-gang Cockatoo, Large-eared Pied Bat, Spotted-tailed Quoll, Broad-headed Snake, Swift Parrot Purple Copper Butterfly, Greater Glider, Koala and Grey-headed Flying Fox
- one threatened ecological community (THPSS) listed as endangered under the EPBC Act
- the potential to support migratory species (but no areas considered significant habitat for migratory species)
- the Greater Blue Mountains Area listed on the World Heritage List and Australia's National Heritage List
- the Greater Blue Mountains Area – Additional Values nominated for inclusion on Australia's National Heritage List.

12.3 Potential impacts – construction

12.3.1 Avoidance and minimisation of impacts

The project has been designed to minimise impacts on biodiversity in the following ways:

- a tunnel option between Blackheath and Little Hartley minimising surface impacts including vegetation clearance
- design and location of the Blackheath and Little Hartley construction sites have been minimised and partially located within the footprints of the Katoomba to Blackheath and Little Hartley to Lithgow Upgrades, already cleared for construction of these projects, minimising the total impact to vegetation
- the water supply pipeline between the Little Hartley construction footprint and Lithgow would be located wholly within the existing and/or new road reserves and the indicative alignment thereby avoiding vegetation clearing or direct impacts to biodiversity.

While the water supply pipeline would cross waterways, a less intrusive methodology (for example underboring or attachment to bridges) would be adopted in these locations to minimise direct impacts on riparian corridors or Key Fish Habitat.

Further detail on efforts to avoid and minimise impacts on biodiversity values is described in Chapter 3 (Project alternatives and options) and Appendix H (Technical report – Biodiversity).

12.3.2 Direct impacts

As stated in Section 12.2, the assessment considers a baseline environment, where the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade adjoining the project to the east and west respectively, are under construction and associated construction sites have been cleared of vegetation. As a result, the project's direct impacts have been determined with reference to the construction footprint required by the project, minus the overlapping areas that are being assessed by the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade (referred to as the development footprint).

Potential direct impacts arising from the project include:

- removal of native vegetation and flora and fauna habitats
- removal of known habitat for threatened fauna species.

Direct impacts to native vegetation arising from the project includes the removal of:

- 7.40 hectares of high condition native vegetation
- 1.54 hectares of moderate condition native vegetation
- 0.77 hectares of low condition native vegetation
- at least 20 hollow-bearing trees.

Direct impacts would also occur to 0.43 hectares of Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions as a result of the project. No direct impacts would occur to mapped areas of Blue Mountains Swamps in the Sydney Basin Bioregion or THPSS.

This vegetation removal will require an offset in accordance with the BAM and the Commonwealth EPBC Act Environmental Offsets Policy (Department of Sustainability, Environment, Water, Population and Communities, 2012), described in Section 12.5.3. Areas of retained native vegetation within the assessment area are known and predicted to support the same native vegetation and TECs as those being directly impacted by the project. In the context of native vegetation retained and impacts to the Greater Blue Mountains World Heritage Area avoided, direct impacts to native vegetation are considered minor.

Direct impacts to threatened species relate to impacts to their habitat. Given that the areas of retained native vegetation adjacent to the construction footprint are known and predicted to support the same native vegetation and TECs as those being directly impacted, direct impacts to threatened species are considered minor.

Table 12-5 provides a summary of direct impacts to threatened species credit species (threatened species requiring targeted surveys or expert reports to confirm their presence) arising from the project.

Table 12-5 Summary of direct impacts on threatened species credit species

Species name	Common name	BC Act	EPBC Act	Sensitivity to gain class	Serious and irreversible impact entity?	Habitat or individuals to be impacted
Chalinolobus dwyeri	Large-eared Pied Bat	Vulnerable	Vulnerable	Very high	Yes	9.13 ha
Petauroides volans	Greater Glider	-	Endangered	High	No	0.35 ha
Paralucia spinifera	Purple Copper Butterfly	Endangered	Vulnerable	High	No	7.33 ha

12.3.3 Indirect impacts

Table 12-6 provides a summary of the potential indirect impacts arising from construction of the project.

Table 12-6 Potential indirect impacts of project construction

Indirect impact	Relevance to the project
Inadvertent impacts on adjacent habitat or vegetation	Inadvertent impacts on adjacent habitat or vegetation have the potential to occur as a result of non-targeted vegetation clearance during construction. With the implementation of the environmental mitigation measures outlined in Section 12.5, impacts to adjacent habitat or vegetation as a result of the project would be minimised.
Reduced viability of adjacent habitat due to edge effects	Habitats adjacent to the construction footprint are currently subject to a high degree of edge effects (such as introduction of weeds, erosion and sedimentation, and increased noise, dust and light), due to their close proximity to the existing Great Western Highway. An increase in edge effects is therefore not expected to occur as a result of construction with the exception of the potential for weed spread, which would be minimised or prevented through the implementation of the environmental mitigation measures in Section 12.5. Remaining areas of native vegetation within a 50 metre buffer surrounding the construction footprint have also been assessed for their potential to be impacted by edge effects. Areas of vegetation that would become isolated patches (i.e. less than 0.25 hectares in size), or which are currently unfragmented or undisturbed and would be subsequently impacted by a new edge, have had an offset credit calculated. The full process of calculating these offset credits for indirect credits is detailed in Section 9 of Appendix H (Technical report – Biodiversity).
Reduced viability of adjacent habitat due to noise, dust or light spill	Elevated levels of noise, lighting and dust are expected as a result of construction of the project. Vehicle movements during construction, particularly during earthwork, spoil handling, stockpiling and spoil transportation, are likely to generate dust. Noise and light from the project are expected during construction works, and light is expected during night works and other works which require lighting. Noise and light from construction may attract insects as food for microbats. Adverse impacts from noise, dust or light spill would be minimised or prevented through the implementation of the environmental mitigation measures outlined in Section 12.5.
Transport of weeds and pathogens from the site to adjacent vegetation	Increased transport of pathogens and weeds from construction is unlikely to occur as the construction footprint already occurs adjacent to the existing Great Western Highway. Potential impacts from the transport of weeds and pathogens would be managed through the environmental mitigation measures outlined in Section 12.5.
Increased risk of starvation, exposure and loss of shade or shelter	The habitat present in the development footprint represents potential habitat for native species, including the Large-eared Pie Bat, Purple Copper Butterfly and Greater Glider. Due to the small area of threatened species habitat proposed for removal and large areas of equivalent habitat in areas directly adjacent the project, the project would not result in an increased risk of starvation, exposure and loss of shade or shelter.
Loss of breeding habitats	Breeding habitat for the Greater Glider would be impacted by the project. However, retained vegetation in adjacent areas provides higher quality habitat and would not be reduced by the project.

Indirect impact	Relevance to the project
Trampling of threatened flora species	No threatened flora species were found or are considered likely to occur within the development footprint. Therefore, the trampling of threatened species is unlikely. Unexpected finds are to be managed in accordance with Guide 1: Pre-clearing process of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Maritime Services, 2011b).
Inhibition of nitrogen fixation and increased soil salinity	Excavation or soil disturbance at the surface would be restricted to the construction footprints. Tunnelling excavation would reach a depth of up to around 200 metres below the surface at the deepest point, which is unlikely to affect surface nitrogen fixation. Changes to groundwater could potentially lead to impacts on soil salinity. Groundwater seepage into the tunnel would be redirected to a treatment plant, and surface water would be redirected to discharge points which would include bioretention filtration.
Fertiliser drift	No fertiliser is proposed to be used and therefore there are no indirect impacts proposed from fertiliser drift expected as part of the project.
Rubbish dumping	The construction footprint already occurs adjacent the existing Great Western Highway where levels of rubbish dumping from passing traffic are most likely moderate, particularly in the township areas. Standard environmental controls for the project would help to minimise potential rubbish dumping.
Wood collection	Construction of the project is unlikely to increase access to retained vegetation beyond current access capacity. Based on future use of the project, members of the public are not expected to undertake wood collection within the retained vegetation and landscaping around portal entrances. If wood collection does occur adjacent to portal entrances, it is unlikely to occur at a level that would have a detrimental effect.
Bush rock removal and disturbance	Bush rock may be removed within the development footprints. Removal of bush rock would be managed via mitigation measures outlined in the project construction environmental management plan (CEMP), including re use of bush rock, where possible.
Increase in predatory species populations	Portions of the construction footprint already occur within a semi-urbanised setting with pets. The vegetation clearance proposed by the project is unlikely to exacerbate predatory species populations. There may be temporary effects to predatory species such as Red Fox *Vulpes vulpes* associated with construction if rubbish is not adequately controlled. Lighting during construction of the project has the potential to attract predators and/or prey, however it is not expected that this would occur to a level that is detrimental. Indirect impacts from rubbish dumping and light spill during construction would be managed through the environmental mitigation measures outlined in Section 12.5.
Increase in pest animal populations	There is potential for an increase in pest animal populations during construction if general rubbish is not adequately controlled around construction footprints. Waste disposal management measures would be implemented during construction and would reduce resources available for pest species, preventing an increase in these species.

Indirect impact	Relevance to the project
Increased risk of fire	The project may result in an increased risk of fire during construction due to an increase in the use of machinery within the construction footprint. Appropriate fire suppressions and mitigation measures would be required at all construction sites. Mitigation measures to reduce the risk of construction work starting a bushfire and to manage the impact of bushfire events are provided in Chapter 22 (Hazards and risks).
Emissions	Construction of the project would result in emissions from construction plant and equipment and construction traffic. Measures to mitigate adverse emissions from the project are presented in Chapter 9 (Air quality).
Disturbance to specialist breeding and foraging habitat	No breeding habitat for assessed species credit species occurs within the development footprint. It is unlikely that the project would result in indirect impacts to breeding habitat for threatened species, such as Purple Copper Butterfly and Greater Glider.
Fragmentation of movement corridors	Movement corridors are currently not restricted in width and availability through the area, as there are large tracts of intact vegetation adjacent to sections of the Great Western Highway. The project would result in the removal of native vegetation from the development footprint that fringes retained native vegetation, to allow for the construction sites. The removal of vegetation is unlikely to fragment movement corridors, as extensive remnant vegetation adjacent to the construction footprint would remain intact and would not be fragmented.

12.3.4 Serious and irreversible impacts

No serious and irreversible impacts (SAII) are expected as a result of the project. Though the Large-eared Pied Bat is considered to meet the principles for SAII outlined in Clause 6.7 of the Biodiversity Conservation Regulation 2017, no breeding habitat is present for the Large-eared Pied Bat within the development footprint, and therefore there are no mapped areas of SAII for this species.

12.3.5 Prescribed impacts

Table 12-7 provides a summary of the potential indirect impacts arising from construction of the project.

Table 12-7 Summary of prescribed biodiversity impacts during construction

Prescribed biodiversity impact	Nature	Extent
Areas of geological significance	Cliff lines and crevices within the rocky mountainous region of the Greater Blue Mountains represent potential habitat for native fauna, particularly for microbats, the Brush-tailed Rock Wallaby and the Broad-headed Snake.	Impacts to areas of geological significance may occur within the areas directly above the tunnel alignment. There is one cliff line to the south of the Soldiers Pinch construction footprint that crosses into the modelled settlement zone of influence and may be affected by settlement in excess of 5 millimetres Updated settlement modelling will be carried out based on further design development, to confirm the anticipated levels of settlement beneath areas of geological significance (including cliff lines and GDEs). Where updated modelling indicates settlement may be more than 20 millimetres (consistent with the settlement threshold applied to sensitive structures), a before after control impact design monitoring program is recommended within these areas to detect and mitigate impacts accordingly.
Human-made structures and non-native vegetation	Human made structures and non-native vegetation may provide habitat to threatened or non-threatened fauna species.	No human made structures providing habitat to threatened or non-threatened fauna species occur within the development footprint. Around 11.02 hectares of the project's direct impact to vegetation is located in non-native vegetation, considered to provide negligible habitat beyond foraging opportunities for common kangaroo and wallaby species.
Habitat connectivity	Movement corridors are currently not restricted in width and availability as there are large tracts of intact vegetation adjacent to sections of the Great Western Highway.	The removal of vegetation for construction of the project is unlikely to fragment movement corridors for threatened fauna, as extensive remnant vegetation adjacent to the construction footprint would remain intact and not be fragmented.
Water bodies, water quality and hydrological processes	Reductions in water quality and increased flows can be detrimental to the natural environment as they can reduce available habitat for sensitive fauna, cause structural changes in creek lines, swamps and wetland ecosystems, and cause alterations in floristic diversity.	Groundwater seepage from tunnel excavation would be treated prior to discharge/re-use to avoid negative impacts to receiving environments. Surface water runoff would be managed via bioretention systems, flood retarding basins, flow spreaders and energy dissipation methods to limit potential impacts to receiving environments. Impacts to GDEs from groundwater drawdown are discussed in Section 12.3.6 and 12.3.7.

Prescribed biodiversity impact	Nature	Extent
Vehicle strikes	Increased vehicle movements, in particular heavy vehicles, have the potential to increase vehicle strikes with fauna species. Vehicle strikes on threatened fauna are of particular concern.	The potential for vehicle strikes would be reduced via construction of fauna exclusion fencing around the construction site, driver awareness training, and on-site measures such as reduced speed limits and signage.

12.3.6 Impacts on groundwater dependent ecosystems

Around 0.23 hectares of high priority GDEs and 3.92 hectares of medium priority GDEs occur within the assessment area at Little Hartley. As these areas are located outside of the development footprint there are no direct impacts to these areas.

However, indirect impacts have the potential to occur as a result of changes to water quality and hydrological processes, as outlined in Section 12.3.3. In particular, the increased runoff volumes from discharge locations are likely to result in increased inundation of the GDEs surrounding the largest of the three dams near the Little Hartley construction footprint. This has the potential to impact these communities as well as GDEs located downstream of the dam. Medium probability GDEs east of the Blackheath construction footprint would not be directly impacted but may also be subject to indirect impacts due to changes in surface water runoff volumes from discharge locations, and potential groundwater drawdown impacts.

Based on initial groundwater modelling (refer to Chapter 13 (Groundwater and geology)), potential reductions in baseflow are predicted at Greaves Creek from construction of the Blackheath portal, with the potential to impact medium probability GDEs to the east of the Blackheath construction footprint during dry periods. During design development and prior to construction, the numerical groundwater model will be updated and the existing groundwater monitoring network will be reviewed and maintained around the project to characterise the hydrogeological environment along and around Greaves Creek and associated GDEs. Subject to the outcomes of further consideration of potential impacts on GDEs, options to avoid and/ or minimise anticipated impacts will be identified and implemented if reasonable and feasible. Potential impacts to THPSS are discussed in Section 12.3.7.

12.3.7 Impacts on aquatic ecology

Impacts to aquatic ecology during construction are related to potential impacts on water quality and subsequent impacts on key fish habitat, and potential impacts to THPSS from groundwater drawdown.

As discussed in Chapter 14 (Surface water and flooding), the project would result in limited changes to the volume and quality of water discharged into receiving waterways. Populations of Macquarie Perch in the Coxs River and Grose River would therefore remain unaffected by the project.

As discussed in Section 12.3.6, potential dewatering and changes to baseflow are predicted within the Greaves Creek sub-catchment during construction of the project. During dry years, this could lead to impacts to THPSS mapped to the east of the Blackheath portal, including:

- the drying of swamp margins leading to a reduction in the area of the swamp
- changes to plant community type and structure
- increased susceptibility to erosion from surface water or stream flows
- increased susceptibility to bushfire.

As discussed in Section 12.3.6, a groundwater monitoring network will be established and maintained around the project to characterise the hydrogeological environment along and around Greaves Creek and associated GDEs, and options to avoid and/ or minimise anticipated impacts will be identified and implemented if reasonable and feasible.

12.3.8 Key threatening processes

A Key Threatening Process (KTP) is a process that threatens or may have the capability to threaten the survival or evolutionary development of species, populations or an ecological community. The direct impacts identified in Section 12.3.2 are likely to contribute to the KTPs identified in Table 12-8.

Table 12-8 Relevant Key Threatening Processes

Relevant Key Threatening Process	Statutory listing	Likelihood of the project contributing to the KTP
Land clearance	EPBC Act	Clearing of land would occur
Bush rock removal	BC Act	Bush rock may be removed within the development footprint
Clearing of native vegetation	BC Act	Clearing of native vegetation would occur
Loss of hollow-bearing trees	BC Act	At least 20 hollow-bearing trees are expected to be removed
Removal of dead wood and dead trees	BC Act	Dead wood and dead trees may be removed as part of native vegetation clearing

12.3.9 Matters of national environmental significance

The project has the potential to directly impact the following MNES under the EPBC Act:

- six threatened fauna species, including Large-eared Pied Bat, Spotted-tailed Quoll, Broad-headed Snake, Purple Copper Butterfly, Greater Glider, and Koala
- a place nominated on the National Heritage List, namely the Greater Blue Mountains Area – Additional Values at Blackheath and Soldiers Pinch.

The following MNES have the potential to be indirectly impacted by the project:

- TECs, specifically potential changes in hydrology impacting THPSS (see Section 12.3.6 and 12.3.7)
- World Heritage areas, specifically potential changes in hydrology impacting the Greater Blue Mountains World Heritage Area (see Section 12.3.3).

Significant Impact Assessments have been completed for the threatened fauna species and TECs for which the project has the potential to impact. These assessments found that no significant impact is likely for these species, TECs and places as a result of the project. The project's potential impacts to threatened fauna is discussed in Section 12.3.2.

Biodiversity values related to the Greater Blue Mountains Area – Additional Values include high condition native vegetation. Given the areas of retained native vegetation near the project are known and predicted to support the same native vegetation, and no threatened flora or TECs have been identified in the development footprint, impacts to the Greater Blue Mountains Area – Additional Values are considered negligible.

12.4 Potential impacts – operation

The main impacts on biodiversity during operation would be:

- inadvertent impacts on adjacent vegetation and habitat during operation
- impacts on adjacent vegetation and habitat arising from a change in land-use patterns
- impacts on aquatic ecology due to changes in hydrology and water quality
- impacts on GDEs, including THPSS during operation
- prescribed biodiversity impacts during operation.

Operational impacts are considered likely to extend beyond the development footprint. Biodiversity impacts during operation are summarised in Table 12-9.

Table 12-9 Operational biodiversity impacts

Operational biodiversity impact	Nature	Extent
Inadvertent impacts on adjacent habitat or vegetation	Inadvertent impacts to adjacent vegetation have the potential to occur during the operation of the project as a result of non-targeted vegetation clearance.	Areas associated with retained vegetation adjacent the project. With the implementation of the environmental mitigation measures outlined in Section 12.5.2, impacts to adjacent habitat or vegetation as a result of the project can be minimised or prevented.
Reduced viability of adjacent habitat due to noise, dust or light spill	Habitats adjacent to the construction footprint are currently subject to a high degree of edge effects due to their close proximity to the existing Great Western Highway.	Areas associated with the use of lighting, and operational noise around tunnel portals. Given the project largely comprises subsurface infrastructure, habitat adjacent to the existing Great Western Highway may experience a decrease in noise, dust or light spill during operation. Potential noise, dust or light spill impacts near the portals would be managed with the implementation of the environmental mitigation measures outlined in Section 12.5.2.
Increase in predatory species populations	Lighting during operation of the project has the potential to attract predators and/or prey.	Areas associated with the use of lighting around tunnel portals and operational facilities. It is not expected that lighting from operation would attract predators and/or prey to a level that is detrimental. Indirect lighting during operation can be managed through the environmental mitigation measures outlined in Section 12.5.2.
Increased risk of fire	During operation of the project, the risk of fire may decrease adjacent to the project as use of underground tunnels increases, and surface traffic is reduced adjacent to retained vegetation.	Areas associated with retained vegetation adjacent to the project. The use of fire prevention and control systems during operation would minimise the risk of fire during operation.

Operational biodiversity impact	Nature	Extent
Water bodies, water quality and hydrological processes	Reductions in water quality and increased flows can be detrimental to the natural environment as they can reduce available habitat for sensitive fauna, cause structural changes in creek lines, swamps and wetland ecosystems, and cause alterations in floristic diversity.	Areas associated with waterways and water bodies. Groundwater seepage from tunnel operation would be treated prior to discharge to minimise impacts to receiving environments. Surface water runoff would be managed via bioretention systems, flood retarding basins, flow spreaders and energy dissipation methods to limit potential impacts to receiving environments.
	Groundwater drawdown can be detrimental to the natural environment as reduced groundwater availability may lead to the drying out of the fringes of waterways or swamps which can alter the plant community type extent and floristic structure and associated aquatic habitat.	Based on initial groundwater modelling (refer to Chapter 13 (Groundwater and geology)), the majority of groundwater dependent ecosystems are at low risk of experiencing impacts associated with operational groundwater drawdown. The majority of THPSS locations are not predicted to be affected by groundwater drawdown during operation. Drawdown at GDEs from construction (see Section 12.3.6) are predicted to decline during operation due to tanking of the tunnels and cross passages. The numerical groundwater model will be updated as part of ongoing design development. Where updated groundwater modelling confirms the likelihood of material impacts on Greaves Creek baseflows, then further consideration should be given to design-related mitigation measures with a focus on reducing groundwater drawdown around the Blackheath portals.
Vehicle strikes	Increased vehicle movements, in particular heavy vehicles, have the potential to increase vehicle strikes with fauna species.	The potential for vehicle strikes is likely to decrease during operation as traffic volumes on the existing Great Western Highway through Blackheath and Mount Victoria are projected to decrease due to operation of the tunnel.

12.5 Environmental mitigation measures

12.5.1 Performance outcomes

Performance outcomes for the project in relation to biodiversity are listed in Table 12-10 and identify measurable performance-based standards for environmental management.

Table 12-10 Biodiversity performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity.	Design the project to minimise adverse impacts on native terrestrial and aquatic flora and fauna.	Design
The offsets and/or biodiversity conservation actions are assured and are equivalent to any residual impacts of project construction and operation.	Secure a biodiversity offset and/ or carry out a conservation action equivalent to no less than the impacts of the detailed design of the project on biodiversity as assessed using the NSW Biodiversity Assessment Method (BAM) (2020).	Construction and operation

12.5.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential biodiversity impacts as a result of the project are outlined in Table 12-11. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 12-11 Environmental mitigation measures – biodiversity

ID	Mitigation measure	Timing
B1	The project will be designed and implemented to minimise the removal of native vegetation and to minimise impacts to threatened species and their habitats.	Design and construction
B2	The project will be designed and constructed to minimise disturbance and impacts, including indirect impacts, to watercourses, riparian areas, aquatic habitats and threatened aquatic species, where feasible and reasonable.	Design and construction
B3	A Construction Flora and Fauna Management Plan (CFFMP) will be prepared as part of the Construction Environmental Management Plan (CEMP) in consultation with DPE. The CFFMP will be prepared in accordance with Biodiversity Guidelines: Protecting and Managing Biodiversity on RTA Projects (RMS 2011b) and Policy and Guidelines for Fish Habitat Conservation and Management Update 2013 (DPI, 2013), including: • a procedure for planning and carrying out clearing, including preclearance surveys, management of vegetation clearance, removal of bush rock and other habitat features, and a specific protocol for the identification and removal of hollow-bearing trees • delineation of the construction footprint and areas within it where vegetation will be retained in accordance with Guide 2 of the Biodiversity Guidelines: Protecting and Managing Biodiversity on RTA Projects (RMS, 2011b) • procedures for establishing and maintaining tree protection zones, including with reference to Australian Standard 4970-2009 Protection of Trees on Development Sites	Construction

ID	Mitigation measure	Timing
	• procedures for managing and appropriately handling fauna that may be located within the construction footprint or affected by construction activities, and protocols for managing injured fauna in accordance with Guide 9: Fauna handling of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (RMS, 2011b) • requirements for the installation of traffic signage and construction driver education on the risk of fauna related vehicle strikes, and procedures for removal of road carrion • measures for managing the presence of unexpected threatened species • procedures for re-establishing native vegetation, taking into account ecological values, opportunities to enhance habitat connectivity and landscaping requirements of the project, and replacing or re-installing habitat features such as woody debris, bushrock, and tree hollows • protocols for managing weeds and pathogens in accordance with Guide 6: Weed management and Guide 7: Pathogen management of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (RMS, 2011b) • measures to protect aquatic habitat and riparian areas, including runoff and water quality management (refer to measure SW1), in accordance with Guide 10: Aquatic habitats and riparian zones of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (RMS, 2011b) and section 3.3.2 Standard precautions and mitigation measures of the Policy and guidelines for fish habitat conservation and management (DPI, 2013).	
B4	Rehabilitation and landscaping of the construction footprint following completion of construction will seek to maximise the use of locally endemic native species and to enhance habitat connectivity across the Great Western Highway corridor where feasible and reasonable, consistent with the landscape plan for the project.	Design and construction
B5	Consideration will be given to the design of culverts under surface roads to act as potential fauna crossing points and habitat resources for microbat species.	Design
B6	Native vegetation cleared from the construction footprint will be mulched and reused in site rehabilitation, stabilisation and landscaping where appropriate.	Construction
B7	Potential lighting/ overshadowing effects from the project on flora and fauna will be minimised where reasonable and feasible, including design and implementation of lighting during construction and operation taking into account: • minimum lighting requirements and design standards to maintain safety during construction and safety for operational traffic • guidance on the management of obtrusive lighting effects in AS4282-1997: Control of the Obtrusive Effects of Outdoor Lighting • guidance on good lighting principles provided in Part 4 of Dark Sky Planning Guideline (DPE, 2016a).	Design and construction

ID	Mitigation measure	Timing
B8	Opportunities to minimise the risk of fauna strikes during construction and operation of the project will be considered during further design development and construction planning. This may include the installation of temporary fencing or other barriers near construction sites.	Design and construction
B9	The Biodiversity Assessment Method (BAM) will be used to review and update biodiversity offset requirements based on the final detailed design for the project. Biodiversity offsets for the project will be secured in accordance with the NSW Biodiversity Offset Scheme (BOS).	Design
B10	Based on the updated numerical groundwater model for the project (refer to environmental mitigation measure GW1), and groundwater and surface water monitoring data (refer to environmental mitigation measures GW2 and SW2), further consideration of the potential impacts of the project on groundwater dependent ecosystems along Greaves Creek as a consequence of groundwater drawdown and/ or reduction in watercourse baseflow will be carried out during further design development. Subject to the outcomes, options to avoid and/ or minimise anticipated impacts will be identified, and implemented if reasonable and feasible.	Design
B11	Swamp extent and PCT mapping will be carried out for the *Biodiversity Conservation Act 2016* (NSW) and *Environmental Protection and Biodiversity Conservation Act 1999* listed peat swamps (GDEs) on Greaves Creek and Butlers Creek prior to the commencement of construction, followed by seasonal swamp extent mapping and species composition assessment to assess change in swamp dynamics for a period of two years post-construction.	Design and operation
B12	Ground settlement predictions will be considered based on further design development. If cliff top areas are identified as potentially experiencing settlement of 20 millimetres or more, monitoring and management measures will be identified based on a Before After Control Impact (BACI) approach.	Design, construction and operation
B13	Interruptions to water flows associated with groundwater dependent ecosystems will be minimised through the use of design features such as bioretention systems and flow spreaders.	Design
B14	Bioretention systems will be unlined to allow infiltration of treated stormwater directly into the surrounding soils and will also include usage of engineered filter media augmented with organic carbon to provide appropriate pH buffering. The bioretention system will be planted with native flora species that are representative of the surrounding PCTs.	Design

12.5.3 Biodiversity offset requirements

Residual impacts that are not able to be avoided or managed through mitigation measures would be offset in accordance with the BAM based on the BAM calculator calculations for both TECs (ecosystem credits) and threatened species (species credits). Further detail on the calculations for the project's offset obligation is provided in Appendix H (Technical report – Biodiversity).

The project offset obligation has been calculated to require the following biodiversity credits:

- 279 ecosystem credits
- 510 species credits.

The biodiversity offset strategy for the project comprises three options:

- identifying the required ‘like for like’ credits in the market through the biodiversity offset scheme public registers, then purchasing the appropriate number of credits using biodiversity offset scheme transaction forms
- generating the required number of credits from a suitable Biodiversity Stewardship Site
- utilising the offsets payment calculator to determine the cost of the credit obligation, and paying this amount into the Biodiversity Conservation Fund. The Biodiversity Conservation Trust is then responsible for identifying and securing the credit obligation.

The obligation may be refined as further field work is undertaken and design development reduces the impacts of the project.

13 Groundwater and geology

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

13.1 Assessment approach

13.1.1 Groundwater assessment

The groundwater assessment approach for the project included:

- identification of a study area comprising a five kilometre radius around the project
- characterisation of the existing environment including climate, topography, geology, groundwater resources including groundwater occurrence, recharge and discharge processes, quality and use, and groundwater dependent ecosystems (GDEs)
- review of previous assessments and previous tunnelling projects with similar geologies in NSW
- geotechnical field investigations including drilling, permeability testing, monitoring bore installation and water level and quality monitoring
- development of a conservative conceptual hydrogeological model and numerical groundwater model
- groundwater modelling to simulate the assumed tunnelling and construction activities for the project and predict groundwater tunnel inflows and drawdown extent
- assessment of potential groundwater-related construction and operational impacts
- development of mitigation measures for ongoing groundwater monitoring and to manage potential impacts and risks including recommendations for monitoring to validate mitigation measures as appropriate.

Geotechnical field investigations to establish baseline groundwater monitoring was carried out simultaneously with the preparation of this assessment and as a result not all monitoring data was available to inform this assessment. As groundwater data becomes available, this would be considered before construction of the project in an updated groundwater numerical model as discussed in Section 13.5. Baseline data used for the groundwater assessment is provided in Section 2.3 of Appendix I (Technical report – Groundwater).

Key assumptions have been made to inform the groundwater assessment including those relating to characterisation of the existing environment and monitoring and these are provided in Section 3 of Appendix I (Technical report – Groundwater).

13.1.2 Settlement (ground movement) assessment

A ground movement assessment has been carried out to identify infrastructure such as buildings (including heritage items), railways and utilities that may be affected by potential ground movement associated with the project. Ground movement refers to a localised lowering of the ground level typically associated with either:

- immediate settlement caused by tunnel excavation (during construction)
- settlement caused by groundwater drawdown (during construction and/or operation).

The settlement assessment methodology included:

- calculation of the zone of influence for settlement and identification of buildings located in areas where maximum settlement levels are exceeded (see Table 13-1)
- calculation of the maximum slope of ground and maximum settlement for the identified buildings. These values were compared against criteria specified in conditions of approval for recent large tunnel projects in NSW
- numerical modelling and structural assessment for those buildings that exceed the settlement criteria or have an assessed damage category that exceeds 'slight' (see Table 13-2).

Table 13-1 Settlement criteria (adopted from recent large tunnel projects in NSW)

Structure/facility	Maximum settlement	Maximum slope of ground
Buildings – one storey or non-sensitive properties such as carparks	30 mm	1:350
Buildings – high or sensitive properties such as heritage items	20 mm	1:500
Roads and parking areas	40 mm	1:250
Parks	50 mm	1:250

Table 13-2 Building damage category and corresponding tensile strain limits (Mair et al, 1996; Rankin, 1988)

Damage category	Description	Maximum building settlement	Maximum building slope
0	Negligible	<10 mm	<1:500
1	Very slight	10 mm	<1:500
2	Slight	50 mm	1:200
3	Moderate	75 mm	1:50
4-5	Severe to very severe	>75 mm	>1:50

13.2 Existing environment

13.2.1 Geology

The project would interact with geological formations from the Mid-Late Permian era (Shoalhaven Group and Illawarra Coal Measures) and Early-Mid Triassic era (Narrabeen Group). Geological formations around the project are described in Table 13-3 and shown in Figure 13-1 to Figure 13-3.

Table 13-3 Geological formations underlying the project

Geological formation	Description
Narrabeen Group – Banks Wall Sandstone	Up to 115 m thick and comprised of quartz-lithic sandstone, claystone and ironstone. Clearly visible as outcroppings and cliffs throughout the Blue Mountains.
Narrabeen Group – Mount York Claystone	Up to 13 m thick and comprised of claystones or claystones split by narrow sandstone layers.
Narrabeen Group – Burra-Moko Head Sandstone	Around 30-112 m thick and comprised of quartz-lithic sandstone with irregular pebbly bands and thin shales.
Narrabeen Group – Caley Formation	Around 27-43 m thick and comprised of siltstone, claystone, shale, and fine-grained sandstone.
Illawarra Coal Measures – Farmers Creek Formation and Gap Sandstone	Around 0.3-12 m thick and comprised of coal, claystone, sandstone, band chert and torbanite.
Illawarra Coal Measures – State Mine Creek Formation, Watts Sandstone, Denman Formation, Glen Davis Formation, Newnes Formation, Irondale Coal, Long Swamp Formation	Around 1.2-27 m thick and comprised of claystone, sandstone, siltstone and torbanite.
Illawarra Coal Measures – Lidsdale Coal, Blackmans Flat Formation, Lithgow Coal, Marrangaroo Formation	Around 0.9-16 m thick and comprised of coal, quartz-lithic sandstone and conglomerate.
Illawarra Coal Measures – Gundangaroo Formation, Coorongooba Creek Sandstone and Mount Marsden Claystone	Around 5-25 m thick and comprised of lithic sandstone, siltstone, shale, coal, torbanite, limestone, dolomite and claystone.
Shoalhaven Group – Berry Formation	Up to around 210 m thick, found in valleys and comprised of sandy, micaceous siltstone.

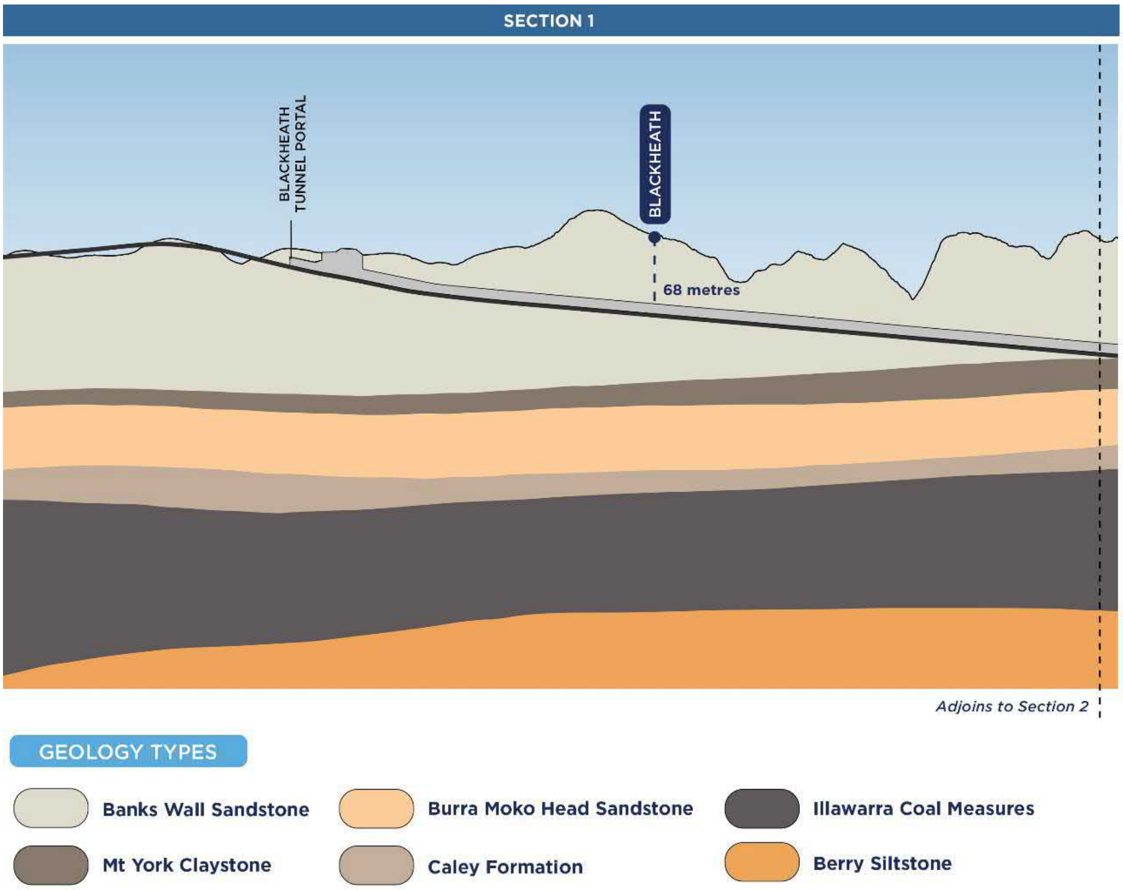


Figure 13-1 Indicative geological formations around the project (section 1 of 3)

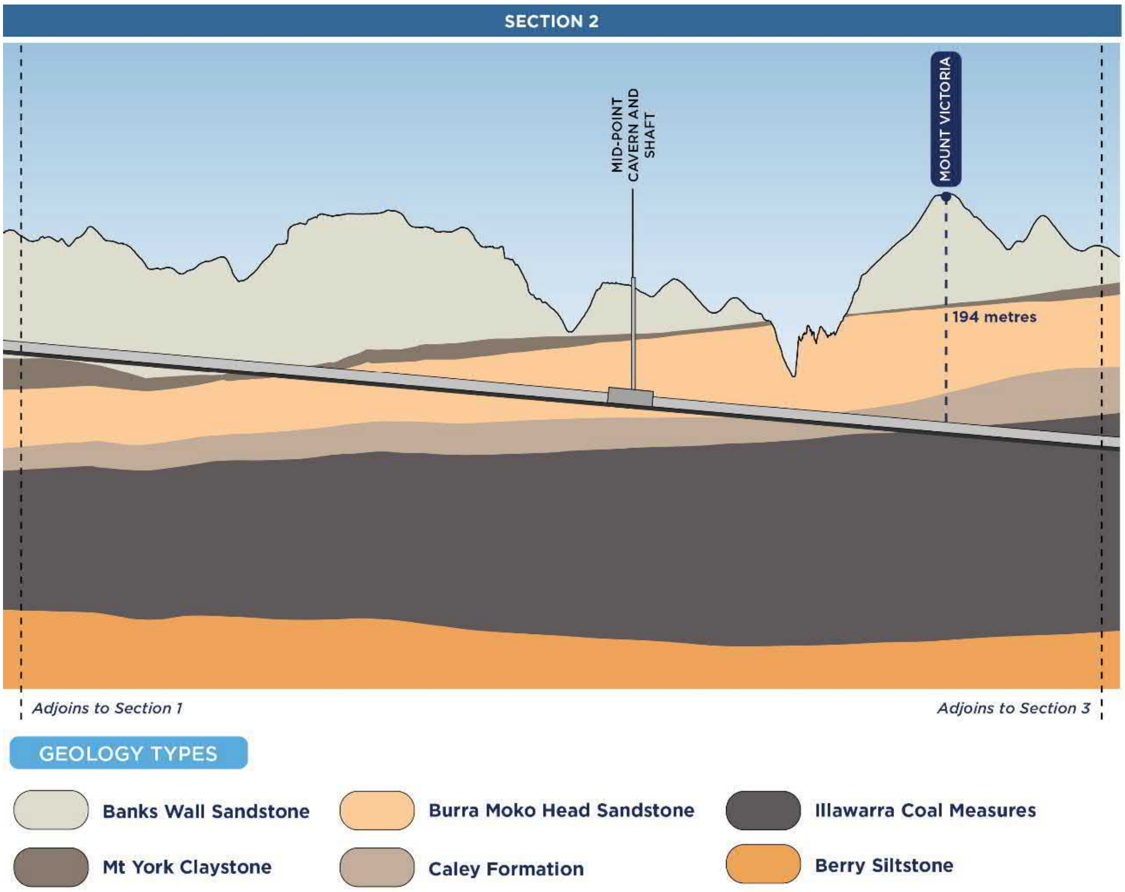


Figure 13-2 Indicative geological formations around the project (section 2 of 3)

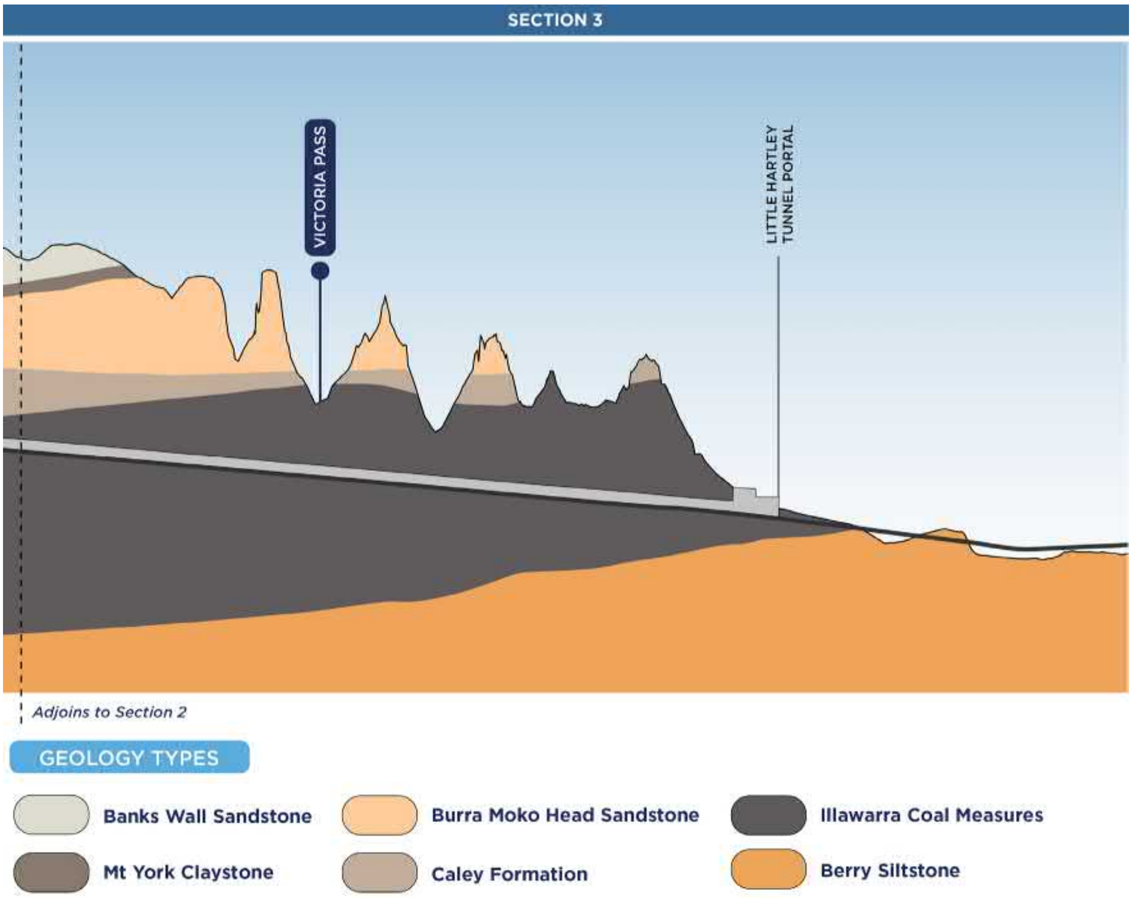


Figure 13-3 Indicative geological formations around the project (section 3 of 3)

Geological structural features

The dominant geological structures around the project include faults (fractures caused by movement of tectonic plates), joints (fractures caused by accumulation of soil and rock on top of existing units that, over time, causes rocks to break apart) and lineaments (linear features in the landscape as a result of an underlying geological structure such as a fault). These features are shown in Figure 13-4 and mainly comprise:

- faults at right angles trending north-northwest to east-northeast
- lineaments trending north to south and north-northeast to south-southwest.

Surface water flow is strongly influenced by these features, with many streams flowing north-northwest and some longer streams following the north-northeast, south-southwest structural features.

Coal seams

Coal seams within the Illawarra Coal Measures geological group may be present around the project. Coal seam gas is a natural gas found in coal deposits. Figure 13-1 to Figure 13-3 show where tunnelling activities for the project would intersect with the Illawarra Coal Measures geological group, which likely contains coal seams.

Acid sulfate rock

Acid sulfate rock (ASR) is unweathered rock (i.e. rock that has not been exposed to water, wind, ice, plants, or changes in temperatures) which contains metal sulfide minerals. When exposed to either oxygen or water, oxidation of the sulfide within the ASR leads to the formation of iron oxides, sulfuric acid, sulfates, and salts.

Potential ASR deposits have been identified around the western half of the project alignment within Illawarra Coal Measures and Shoalhaven geological formations, which are shown in Figure 13-1 to Figure 13-3.

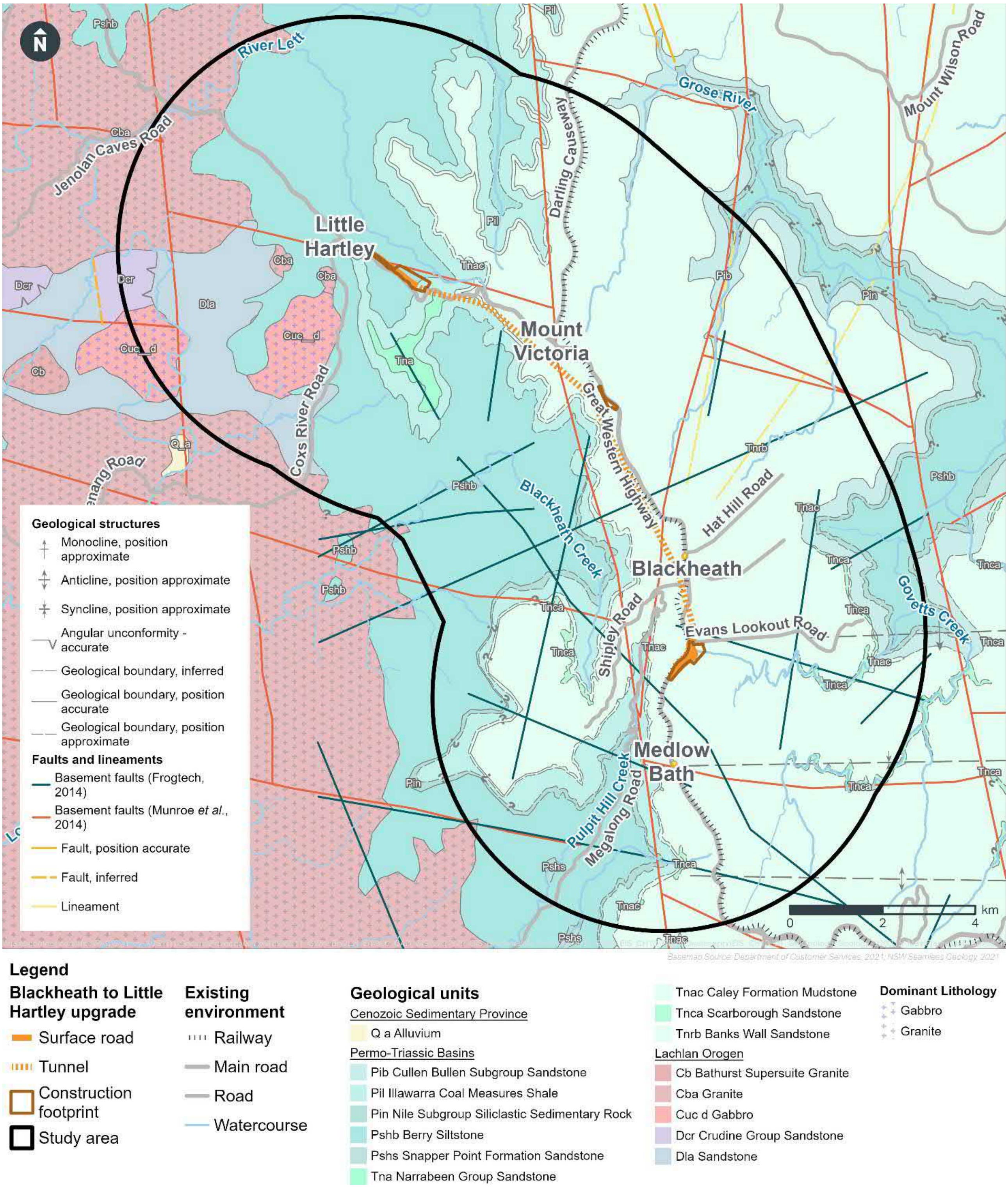


Figure 13-4 Geological structures and units near the project

13.2.2 Groundwater

Groundwater levels and movement

Groundwater near the project is divided into a shallow flow system in Banks Wall Sandstone and a deep flow system between the Mount York Claystone and the Berry Siltstone. In both aquifers, vertical groundwater flow is primarily controlled by structural features such as faults and joints, and horizontal groundwater flow is primarily controlled by topography.

In addition to these aquifers, perched aquifers have been identified near the project (see Figure 12-5 and Figure 12-6 in Chapter 12 (Biodiversity)). Perched aquifers occur when there are small areas of low permeability geological units within a higher permeability unit. The low permeability rock does not allow water to flow down to the natural water table, and groundwater is instead trapped.

The conceptualised groundwater recharge and discharge mechanisms of each aquifer system within the study area are outlined in Table 13-4. The simulated regional groundwater balance is included in Annexure B of Appendix I (Technical report – Groundwater).

The existing groundwater elevation (water table) around the project is shown in Figure 13-5.

Table 13-4 Groundwater recharge and discharge mechanisms

Groundwater system	Geological unit	Recharge mechanisms	Discharge mechanisms
Perched aquifer in unconsolidated sediment	Unconsolidated sediments and fill material	• primarily via seasonal rainfall infiltration • irrigation of land (Little Hartley only) • seepage from surface water drainage features • leakage from stormwater, water distribution and sewerage systems.	• discharge to surface water including swamps • leakage to the underlying shallow groundwater system • evapotranspiration.
Shallow groundwater flow system	Banks Wall Sandstone	• infiltration of rainfall where the unit outcrops • seepage of water from overlying perched groundwater systems • seepage of water from surface water storage dams (e.g. Lake Greaves at Blackheath) • seepage from surface water drainage features • leakage from stormwater, water distribution and sewerage systems.	• discharge to surface water flows and swamps either side of the plateau, with greater discharges expected to the swamps of the eastern escarpment • leakage to or through the underlying discontinuous Mount York Claystone aquitard or where missing leakage to other aquifers within the deep aquifer system • evapotranspiration • groundwater abstraction (licensed and unlicensed bores).

Groundwater system	Geological unit	Recharge mechanisms	Discharge mechanisms
Aquitard (i.e. low permeability geological unit)	Mount York Claystone	• infiltration of rainfall where the unit outcrops • vertical seepage of water from the overlying groundwater systems.	• facilitates horizontal flow (on top of unit) resulting in discharge to surface water flows and swamps either side of the plateau, with greater discharges expected to the swamps of the eastern escarpment • evapotranspiration (hanging swamps of the escarpments) • leakage to aquifers within the deep aquifer system.
Deep groundwater flow system	Burra-Moko Head Sandstone, Caley Formation, Illawarra Coal Measures	• infiltration of rainfall where geological units outcrop (mostly to the north and east of the project) • vertical seepage from the overlying groundwater systems • irrigation of land (Little Hartley only).	• discharge to surface water systems on either side of the plateau, with greater discharges expected to the eastern escarpment • leakage to aquifers within the deeper aquifer system • groundwater abstraction (licensed and unlicensed bores), most likely from the Burra-Moko Head Sandstone.

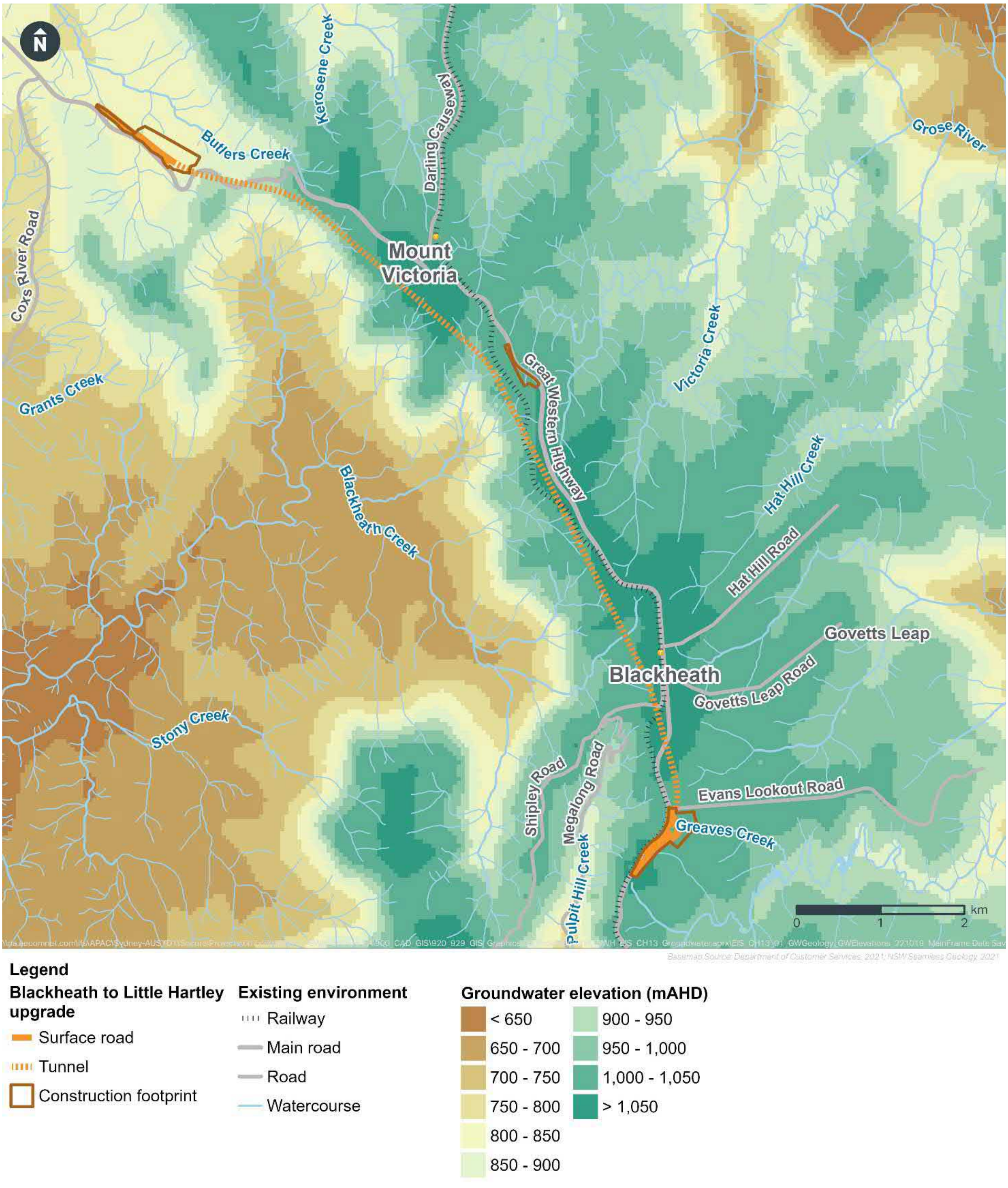


Figure 13-5 Simulated existing groundwater elevations (water table)

Groundwater quality

Groundwater investigations were completed in May and August 2011 for the Great Western Highway Little Hartley to Lithgow Upgrade (Mount Victoria to Lithgow Alliance, 2011). Groundwater quality was tested at 11 locations within the regions of Mount Victoria and Little Hartley with the results summarised in Table 13-5.

Table 13-5 Groundwater quality characteristics

Geological group	Total dissolved solids (mg/L)[1]	Salinity (µS/cm)[2]	pH	Manganese (mg/L)	Iron (mg/L)
Narrabeen Group	46-146	69-185	4.7-5.8	0.032-0.094	<0.05-0.07
Illawarra Coal Measures	80-711	114-1093	5.9-6.9	0.078-1.52	<0.05-6.93
Shoalhaven Group	400-3209	644-4088	5.1-7.4	0.183-1.88	0.34-40.6

Table notes:
1. mg/L = milligrams per litre
2. µS/cm = micro siemens per centimetre (a measure of electrical conductivity used as a proxy for measuring water salinity)

Shallow groundwater in the Narrabeen Group contains low salinity and low dissolved metal concentrations (hence likely recently recharged by rainfall and surface water infiltration) and is slightly acidic. Groundwater within the Illawarra Coal Measures is slightly less acidic but has a relatively high level of total dissolved solids. Groundwater samples taken for the Shoalhaven Group varied widely, however, all samples exceeded the Australian and New Zealand Environment and Conservation Council (ANZECC) guideline levels for salinity. Dissolved manganese concentrations in both Illawarra Coal Measures and Shoalhaven Group exceeded human health levels under the Australian Drinking Water Guidelines.

Areas of potential contamination that may affect groundwater underlying the project, including the potential for dissolved gases, are discussed in Chapter 15 (Soils and contamination).

Groundwater dependent ecosystems (GDEs)

GDEs are communities of plants and animals whose extent and life processes are dependent on groundwater, such as through wetlands or springs. An assessment of the project's potential impacts on GDEs, including groundwater-related biodiversity impacts, is provided in Chapter 12 (Biodiversity).

Groundwater users

Searches of WaterNSW and Bureau of Meteorology databases indicated that there are 112 registered groundwater bores located within the study area (Bureau of Meteorology, 2022; (WaterNSW, 2022). These bores are shown in Figure 13-6 and are generally used for:

- household water supply
- irrigation
- groundwater monitoring
- livestock water supply
- township water supply.

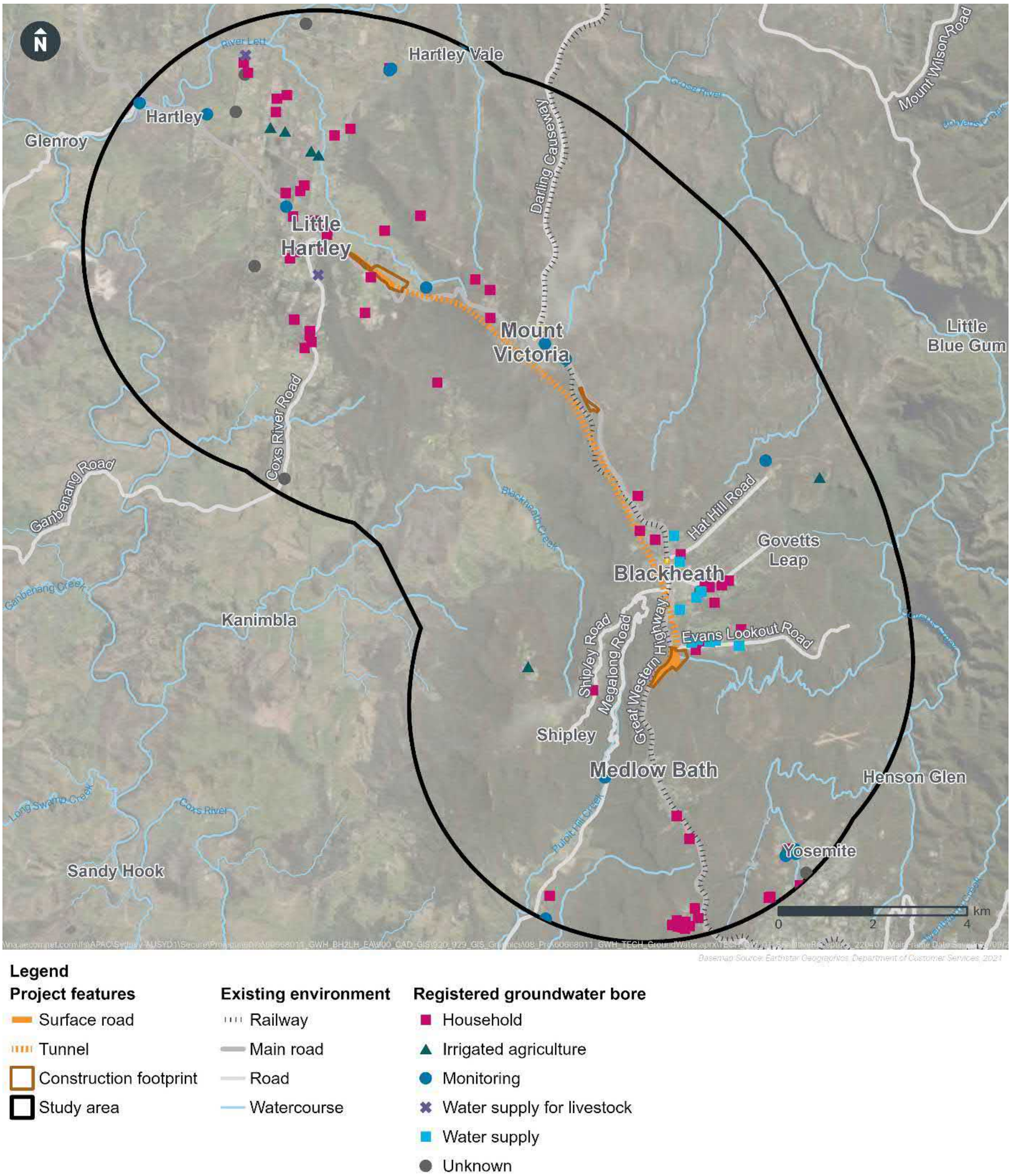


Figure 13-6 Registered groundwater users in the study area

13.3 Potential impacts – construction

During construction ground disturbing activities such as tunnelling are expected to have the largest influence on groundwater. A key design decision for the project is the use of tunnel boring machines (TBMs) rather than roadheaders for the mainline tunnels, which would minimise groundwater impacts through progressive lining of the tunnel (to immediately provide a waterproof barrier).

Temporary groundwater inflow and drawdown is expected to be greatest where the TBM is used in single shield mode (where there is a gap between the cutterheads and the tunnel lining installed, allowing groundwater ingress). A summary of groundwater impacts modelled to occur during construction is provided below. Further information on tunnelling methodologies is provided in Chapter 5 (Construction).

13.3.1 Tunnel groundwater inflow

Groundwater inflow has been estimated using numerical groundwater modelling. Given the data limitations and assumptions made as explained in Section 13.1, groundwater modelling was carried out for a variety of scenarios. To account for the level of uncertainty in the model, results are discussed in terms of a range, considering:

- total inflow according to the 50th percentile of modelling results, which represents the median value of all results (the likely case)
- total inflow according to the 95th percentile of modelling results, which represents a conservative upper end value (the likely worst-case).

Estimated groundwater inflows for the project during construction are provided in Table 13-6, based on modelled average and maximum groundwater inflows. The 50th percentile and 95th percentile values for model runs are presented for the average and maximum groundwater inflows.

Due to the conservative modelling approach, the total estimated construction inflow rate may be substantially lower in practice. The maximum predicted tunnel groundwater inflow volume during construction would peak at around 750 to 1850 cubic metres per day (8.7 to 21.4 litres per second) over the total length of the tunnel. Given the depth and length of the tunnel, as well as its location in hydrological structures within various geological strata, groundwater inflows during construction are likely to be higher than other NSW tunnel projects. Further investigation would be carried out during design development to refine the groundwater model and validate modelling outputs, with the aim of minimising groundwater inflow volumes.

Construction and design assumptions have been made to inform groundwater modelling for the purposes of this assessment, such as where certain TBM modes would be used (refer to Section 4.2 of Appendix I (Technical report – Groundwater). The construction methodology and construction sequencing would be subject to ongoing design development and construction planning and further detailed groundwater modelling would be carried out as part of that process.

As shown in Figure 13-7 maximum predicted tunnel groundwater inflow volumes are predicted to:

- peak during construction of the tunnel (between the mid-tunnel cavern and Blackheath when the TBM switches to earth pressure balance mode), and during construction of the tunnel cross-passages
- decrease around 2029 once construction of these elements is complete, with the cross-passages and twin tunnels being tanked (i.e. structures which prevent groundwater from entering the structure as opposed to a drained structure which captures, diverts and treats groundwater ingress)
- stabilise after construction given most infrastructure would be tanked.

Tunnel groundwater inflow would be pumped to construction water treatment plants at Blackheath, Soldiers Pinch and Little Hartley where it would be treated to levels consistent with water quality requirements before being reused or discharged. Treated water would be discharged to the environment or transported to a suitable disposal facility.

Measures to limit groundwater ingress during construction would be implemented where excessive or greater than predicted inflows are encountered, to reduce the potential impact on the surrounding environment for example pre-grouting of cross-passage if required. Inflow rates during construction may have some impacts on groundwater drawdown, recharge and flow, groundwater users, surface water/groundwater interactions or settlement (discussed in Sections 13.3.2 to 13.3.6).

Table 13-6 Summary of modelled groundwater inflows during construction (mid-2024 to 2030)

Project feature	Tanked or drained structure	Indicative inflow volumes (m^3/day)			
		Average inflow over construction period		Maximum inflow over construction period	
		50th percentile of model runs	95th percentile of model runs	50th percentile of model runs	95th percentile of model runs
Blackheath portal	Drained (unsealed)	21.0	45.4	61.4	144.4
Little Hartley portal	Drained (unsealed)	5.6	16.2	20.6	61.8
Mid-tunnel caverns	Drained (unsealed)	2.5	11.9	18.8	52.9
Mid-tunnel adit	Drained (unsealed)	1.1	12.5	6.8	46.5
Mid-tunnel access shaft	Tanked (sealed) and drained (unsealed)[1]	1.2	8.9	9.9	29.6
Cross-passages	Tanked (sealed)	76.5	222.1	724.6	1,756
Tunnel (between Blackheath and mid-tunnel caverns)[2]	Tanked (sealed)	26.6	82.4	704.3	1,702.3
Tunnel (between mid-tunnel caverns and Little Hartley)[3]	Tanked (sealed)	0.0	0.0	0.0	0.0
Total[4]		**107.8**	**317.2**	**756.2**	**1,847.2**

Table notes:

1. the mid-tunnel access shaft would be tanked (sealed) from the ground surface to the Mount York Claystone and drained (unsealed) from the Mount York Claystone to the shaft depth. See Chapter 5 (Construction) for further description of the mid-tunnel access shaft
2. for the purposed of the groundwater assessment, the TBM would operate in single shield mode between the mid-tunnel caverns and Blackheath, which would possibly allow groundwater ingress as captured by the modelled outputs in the table above
3. the tunnel between Little Hartley and the mid-tunnel caverns would be excavated using TBMs in earth pressure balance mode whereby the tunnel face is stabilised to limit groundwater ingress, resulting in no modelled groundwater ingress
4. total inflow volumes are not the sum of the inflow from each project element, as when each of these inflows occur would depend on construction stage. The total inflow volumes have been estimated based on modelled construction staging (refer to Annexure B of Appendix I (Technical report – Groundwater).

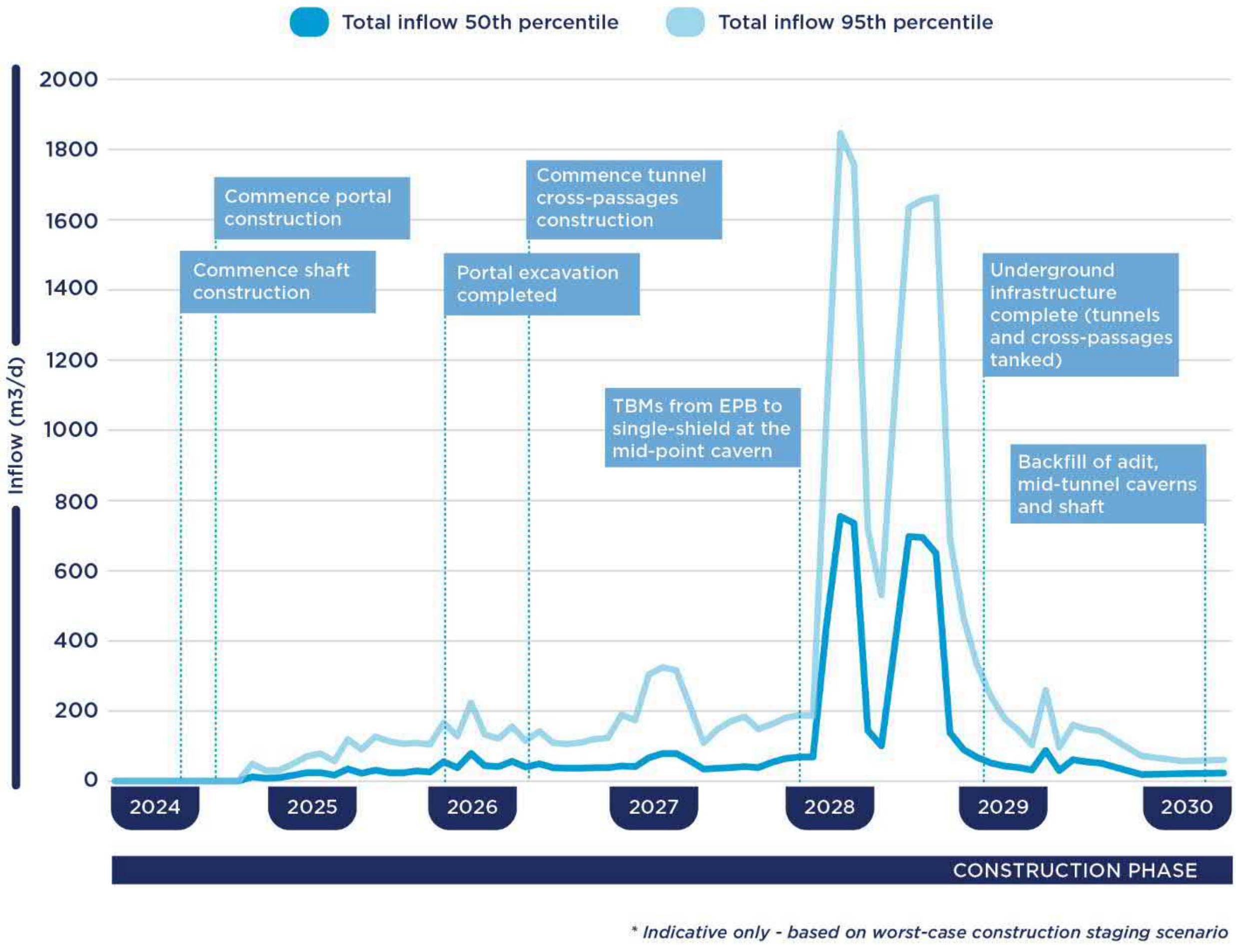


Figure 13-7 Rate of tunnel groundwater inflow during construction

13.3.2 Groundwater drawdown, recharge and flow

The maximum groundwater drawdown during construction of the project has been modelled for the water table and the five geological units above or through which the project would pass (as shown in Figure 13-1 to Figure 13-3):

- Banks Wall Sandstone
- Mount York Claystone
- Burra-Moko Head Sandstone
- Upper Caley Formation
- Marangaroo or Gundangaroo Formation (Illawarra Coal Measures).

The maximum groundwater drawdown (depth of drawdown) during construction modelled for the 50^{th} and 95^{th} percentile is summarised in Table 13-7. The spatial extent of modelled groundwater drawdown during construction is shown in Figure 13-8 (50^{th} percentile within the water table). The spatial extents of drawdown in other geological units are shown in Section 4.4 of Appendix I (Technical report – Groundwater). Drawdown predictions, at different locations, may occur temporarily or may be ongoing during varying stages of construction. These modelled maximum drawdown values are conservative and may not eventuate in practice.

Table 13-7 Modelled groundwater drawdown during construction

Geological unit	Groundwater drawdown
Water table	Maximum drawdown from the 50th percentile of modelling results would be: • between 5.1 and 20 metres at the Blackheath portal • between 5.1 and 20 metres at the Little Hartley portal • between 5.1 and 20 metres at the mid-tunnel caverns • between 2.1 and 5.0 metres at a regional fault east of the Little Hartley portal. Potential drawdown impacts to registered water supply bores and GDEs during construction are further discussed in Section 13.3.4 and Section 12.3 of Chapter 12 (Biodiversity) respectively. The two metre drawdown contour from the (more conservative) 95th percentile model prediction of maximum drawdown occurs around the same features as the 50th percentile, but extends to around double the radius.
Banks Wall Sandstone	Maximum drawdown from the 50th percentile of modelling results would be between 5.1 and 20 metres and would occur due to the construction of cross-passages that intercept the Banks Wall Sandstone near the tunnel surface, at geological structures between the mid-tunnel caverns and at the Blackheath portal. The cross-passages would be tanked (sealed) upon construction completion and therefore groundwater drawdown would be temporary and would recover after construction. An additional 0.1 to 0.3 metres maximum drawdown would occur at the regional fault through this geological unit (refer to Figure 13-4). Potential drawdown impacts to registered water supply bores and GDEs are further discussed in Section 13.3.4 and Section 12.3 of Chapter 12 (Biodiversity) respectively. The two metre drawdown contour from the (more conservative) 95th percentile model prediction of maximum drawdown occurs around the same features as the 50th percentile, but extends to around double the radius.
Mount York Claystone	Maximum drawdown from the 50th percentile of modelling results would be between 0.3 and 0.5 metres at the tunnel cross-passages and the near-surface twin tunnels south (towards Blackheath) of the mid-tunnel caverns. No registered water supply bores or GDEs are known within the extent of drawdown within these locations. The two metre drawdown contour from the (more conservative) 95th percentile model prediction of maximum drawdown occurs around the same features as the 50th percentile, but extends to around four times the radius.
Burra-Moko Head Sandstone	Maximum drawdown from the 50th percentile of modelling results would be between: • 5.1 and 20 metres, at the access shaft • 2.1 and 5.0 metres at the tunnel caverns • 2.1 and 5.0 metres at geological structures north of the mid-tunnel cavern. No registered water supply bores or GDEs are known within the extent of drawdown within these locations. The two metre drawdown contour from the (more conservative) 95th percentile model prediction of maximum drawdown occurs around the same features as the 50th percentile, but extends to around four times the radius and presents at a northwest-southeast trending geological structure located south of the mid tunnel caverns.

Geological unit	Groundwater drawdown
Upper Caley Formation	Maximum drawdown from the 50th percentile of modelling results would be between: • 5.1 and 20 metres at the geological structures north of the mid-tunnel caverns • 0.6 and 2.0 metres east of the Little Hartley portals • 0.3 and 0.5 metres south of the mid-tunnel caverns. No registered water supply bores or GDEs are known within the extent of drawdown within these locations. The two metre drawdown contour from the (more conservative) 95th percentile model prediction of maximum drawdown occurs around the same features as the 50th percentile, but extends to around double the radius and presents at a northwest-southeast trending geological structure located south of the mid tunnel caverns.
Marangaroo or Gundangaroo Formation	Maximum drawdown from the 50th percentile of modelling results would be between: • 5.1 and 20 metres at Little Hartley portal • 5.1 and 20 metres at the geological structure north of the mid-tunnel caverns • 0.1 and 0.3 metres south of the mid-tunnel caverns. Potential drawdown impacts to GDEs are further discussed in Section 12.3 of Chapter 12 (Biodiversity). No registered water supply bores are known to be screened within this unit within the extent of drawdown. The two metre drawdown contour from the (more conservative) 95th percentile model prediction of maximum drawdown occurs around the same features as the 50th percentile, but extends to around four times the radius and presents at a northwest-southeast trending geological structure located south of the mid tunnel caverns.

Groundwater in the study area is recharged primarily through direct rainfall which infiltrates through the soil and rock profile. The project would only result in a minor increase in impervious surfaces compared to the overall extent of the recharge area, and would therefore have a negligible impact on existing recharge rates.

Impacts to groundwater flow, including mounding on the side of the tanked tunnels, during construction may include localised changes to flow rates and drawdown near the Blackheath portal and mid-tunnel access shaft, adit and caverns. Given the low magnitude and localised spatial extent of groundwater drawdown, the project would have a low impact on regional groundwater flow patterns.

The introduction of the tanked tunnels and other tanked infrastructure has the potential to alter groundwater flow during construction. Groundwater flow direction is inferred from east to west, towards the western escarpment. Groundwater flow impacts during construction could result in a reduction of baseflow at hanging swamps, which occur on steep valley sides where there is groundwater seepage. Potential impacts to hanging swamps, including due to reductions in groundwater flow during construction, are discussed in Chapter 12 (Biodiversity).

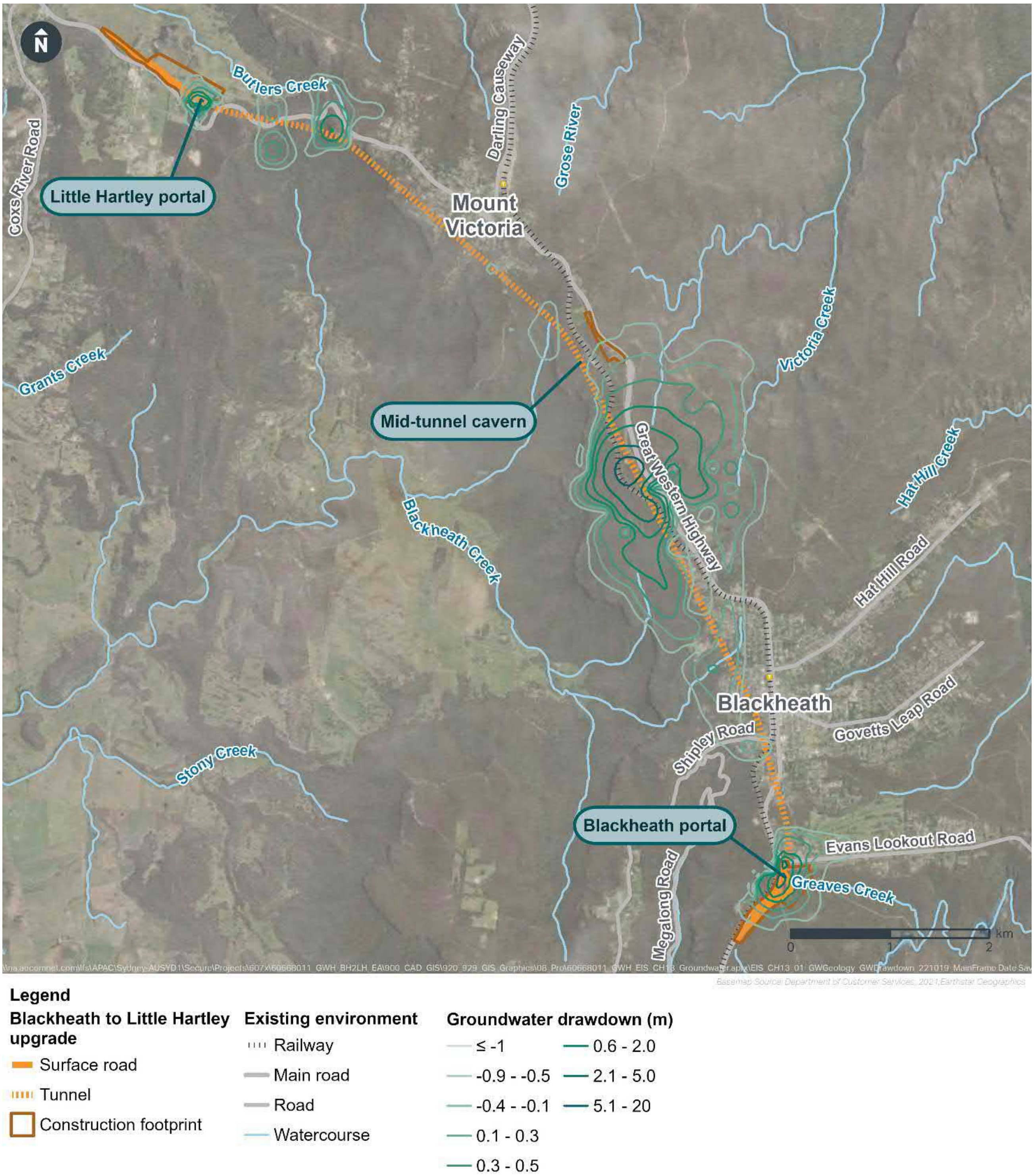


Figure 13-8 Predicted groundwater drawdown in the water table during construction (50th percentile modelling outputs)

13.3.3 Groundwater quality

Potential impacts to groundwater quality during construction could arise from:

- leaks or spills of fuels, oils, or lubricating fluids used for construction machinery
- excavated acid sulfate rock and/or coal seams within the Illawarra Coal Measures seeping into uncontaminated groundwater at the source or once excavated (contamination risks are addressed in Chapter 15 (Soils and contamination))

- construction materials used for construction of underground structures, including:
  - drilling/cutting fluids that may be required for the TBMs and roadheaders
  - particulate matter from tunnelling activities leading to increased total suspended solids
  - cement pollution arising from shotcrete application, grouting or in-situ concrete casting.

Groundwater collected during construction would be treated at construction water treatment plants at Blackheath, Soldiers Pinch and Little Hartley before discharge. With the application of standard construction environmental management and mitigation measures, these activities would be low risk and impacts to groundwater quality during construction of the project would be unlikely.

13.3.4 Groundwater users

Groundwater drawdown during construction of the project would potentially affect 31 registered bores near Blackheath, as shown in Figure 13-9. Predicted groundwater drawdown at Mount Victoria and Little Hartley does not impact existing groundwater users as drawdown is minimal and limited in spatial extent. The potentially impacted bores near Blackheath comprise six monitoring bores, 21 bores used for water supply, two bores used for unknown purposes (assumed to be used for water supply purposes), and two abandoned water supply bores.

No registered water supply bores had a median (50^{th} percentile) maximum predicted drawdown greater than two metres. Two registered water supply bores within Blackheath had a 95^{th} percentile maximum predicted drawdown greater than two metres (GW100157 and GW102214), where there was predicted to be around 3.14 metres and 4.76 metres of drawdown respectively. The frequency that these bores would have drawdown greater than or equal to two metres is relatively low (predicted at around 12.1 per cent at GW100157 and around 22.5 per cent at GW102214).

There is a low frequency (less than four per cent of model realisations) that drawdown would be greater than or equal to two metres at four registered water supply bores (GW058193, GW058236, GW059737, and GW102030). At all other bores, predicted drawdown was less than two metres in all model realisations.

Although there are registered groundwater bores within Mount Victoria and Little Hartley, predicted groundwater drawdown within these areas do not impact these groundwater users as drawdown is minimal and limited in lateral extent.

Detailed groundwater modelling would be carried out as part of further design development and construction planning that would incorporate additional baseline groundwater data, as discussed in Section 7.2 of Appendix I (Technical report – Groundwater). Where this modelling identifies potential for drawdown at registered bores of greater than two metres, a baseline assessment of each at-risk registered bore (including GW100157 and GW102214) would be carried out prior to commencing construction activities. Groundwater monitoring during construction would also validate model predictions.

If drawdown at registered bores is found to exceed two metres, measures would be implemented to 'make good' the impact based on the location of the impacted bores and in consultation with the affected licence holder as discussed in Section 13.5. Results of the initial modelled groundwater levels during construction at each registered groundwater bore location are provided in Appendix I (Technical report – Groundwater).

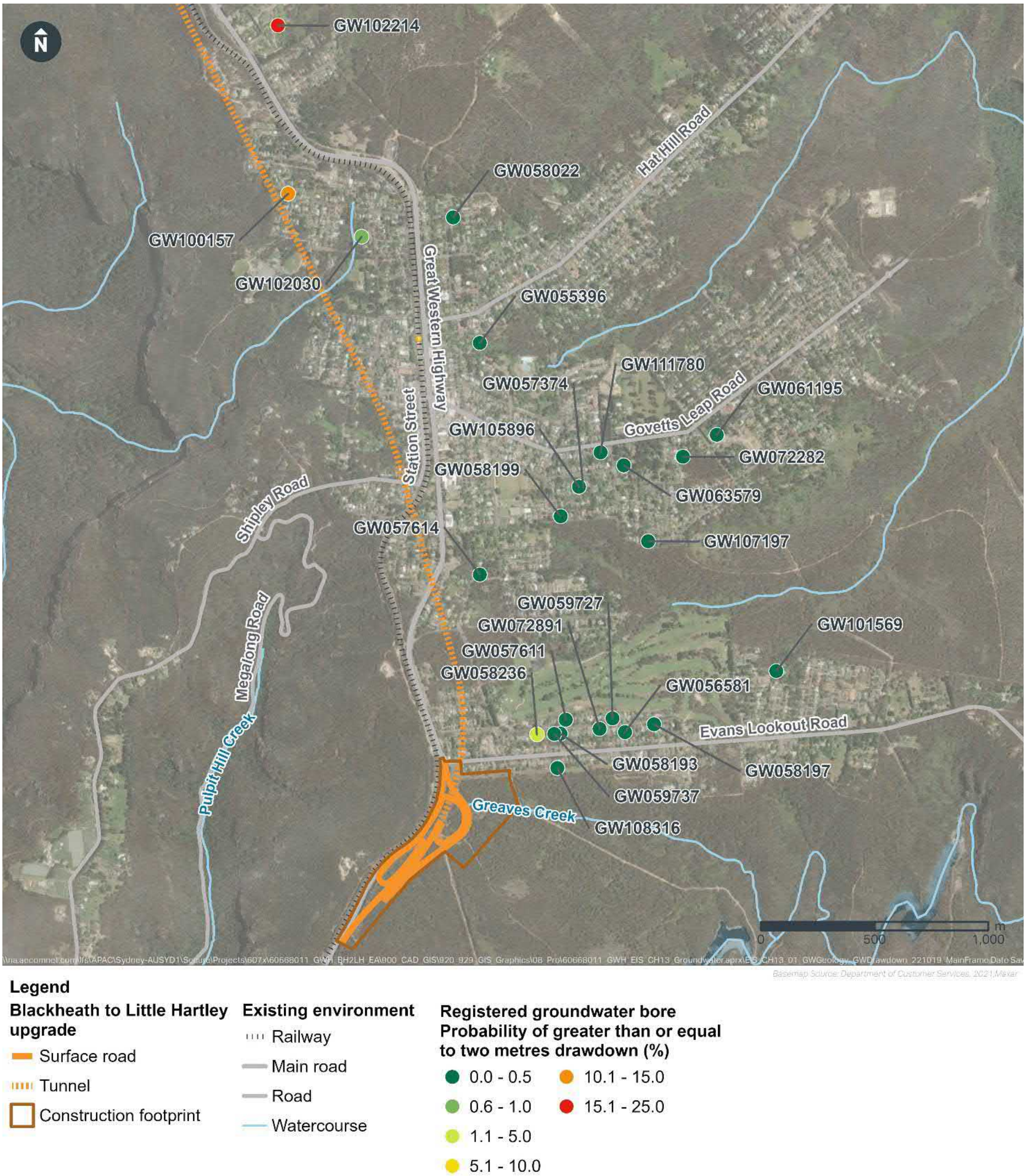


Figure 13-9 Predicted maximum groundwater drawdown (95th percentile) at registered groundwater bores during construction at Blackheath

13.3.5 Surface water/groundwater interaction

Surface water features that are partially or wholly reliant on groundwater to sustain baseflow (regular flow patterns) can be affected by changes to groundwater via:

- groundwater depressurisation or drawdown in the groundwater system connected to a stream
- changes to the gradient of the water table resulting in an increase or decrease in groundwater entering a stream

- installation of segmental tunnel lining as part of TBM excavation which can result in a barrier to groundwater flow between recharge and discharge locations (see Section 13.3.2).

Groundwater modelling and assessment of potential changes to surface water baseflow during construction indicate that dewatering due to construction activities would have the largest impact on baseflow within the Fairy Bower sub-catchment, which is located immediately west of the mid-tunnel caverns, adit and access shaft (refer to Section 4.5.5 of Appendix I (Technical report – Groundwater)). The Fairy Bower sub-catchment has been modelled to experience a predicted maximum baseflow reduction of 5.6 per cent for the 95th percentile modelling outputs.

The impact to this location would be low given the greatest predicted baseflow reduction would be during periods of higher rainfall. During these periods of higher rainfall, the sub-catchment would have higher streamflow contributions from rainfall runoff, which would likely lessen the effects of the baseflow reduction. A full discussion of potential changes to baseflow rates from surface water infiltration during other rainfall periods is provided in Sections 4.5.4 and 4.5.5 of Appendix I (Technical report – Groundwater). Further information about potential impacts to surface water is provided in Chapter 14 (Surface water and flooding).

13.3.6 Settlement (ground movement)

The main cause of settlement relevant to the project would be tunnel excavation. Initial modelling has predicted that settlement due to groundwater drawdown would be low to negligible across the project with the maximum settlement predicted to be around 1.8 millimetres. Given the perched groundwater tables are mainly confined to the rock mass and that overlying fills and clays are typically shallow in depths, long term settlement due to groundwater drawdown would not be a key concern for the project.

Settlement due to tunnel excavation has been evaluated as part of the development of the project design. Settlement calculations indicate that:

- the maximum settlement due to the project is predicted to be up to 30.1 millimetres, and is predicted to occur in areas away from development (including houses and structures)
- a total of 34 buildings and structures are predicted to experience settlement greater than five millimetres, including:
  - all residential and commercial buildings are predicted to experience settlement less than the 30 millimetre criterion for buildings. The most affected building is predicted to experience settlement of 17.8 millimetres
  - all heritage items are predicted to experience settlement less than the 20 millimetre criterion for sensitive buildings, with the most affected heritage item (Tree Tops and garden (Blue Mountains LEP BH065)) predicted to be affected by up to 16.8 millimetres. Further discussion of settlement impacts on heritage items is provided in Chapter 17 (Non-Aboriginal heritage)
  - the Megalong Reservoir and water booster pump is predicted to experience settlement of up to 6.0 millimetres, which is less than the 20 millimetre criterion
- maximum slope and tensile strain criteria is not predicted to be exceeded at any building, structure or infrastructure.

This analysis indicates that the predicted settlement values are within the acceptable criteria and therefore potential settlement impacts would be negligible. Mitigation measures to monitor potential settlement and minimise potential settlement impacts are provided in Section 13.5. Further discussion of potential settlement impacts to properties is provided in Chapter 20 (Business, land use and property).

13.4 Potential impacts – operation

During operation the Little Hartley and Blackheath portals and the mid-tunnel caverns (drained (unsealed) features) are expected to have the largest influence on the groundwater environment.

13.4.1 Tunnel groundwater inflow

Operational groundwater inflow rates are predicted to reach a steady state between the years 2030 and 2100 following completion of the construction phase, with some slight variations due to weather conditions. As shown in Table 13-8, the maximum predicted tunnel groundwater inflow volumes (associated with the Blackheath portal) are predicted to peak at around 21.2 to 42.1 cubic metres per day (0.2 to 0.5 litres per second). Over time, this would steadily decline and would stabilise. Minor leakage may occur in localised areas in the tanked (sealed) sections of the project tunnels, however these are expected to be relatively small and not anticipated to result in measurable impacts to groundwater.

Groundwater inflows captured during operation would be pumped to the operational water treatment plant at Little Hartley and would be treated to levels consistent with water quality requirements before being reused or discharged.

Table 13-8 Summary of modelled groundwater inflows during operation (2030 to 2130)

Project feature	Tanked or drained	Indicative inflow volumes (m^3/day)			
		Average during operation		Maximum during operation	
		50th percentile	95th percentile	50th percentile	95th percentile
Mid-tunnel caverns	Drained (unsealed)	2.0	14.0	2.0	14.9
Little Hartley portal	Drained (unsealed)	4.2	12.8	4.6	13.6
Blackheath portal	Drained (unsealed)	18.2	37.7	21.2	42.1
Estimated peak during operation		**24.4**	**64.5**	**27.7**	**70.4**

13.4.2 Groundwater drawdown, recharge and flow

During operation, groundwater drawdown would occur at permanently drained (unsealed) structures, being the Blackheath and Little Hartley portals and above the mid-tunnel caverns. Maximum groundwater level drawdown for long-term operation (2130) has been modelled for the water table and the five geological units above or through which the project would pass (as shown in Figure 13-1 to Figure 13-3).

The maximum groundwater drawdown during operation modelled for the 50th and 95th percentile is summarised in Table 13-9. The spatial extent of modelled groundwater drawdown during operation is shown in Figure 13-10 (50th percentile within the water table). The spatial extents of drawdown in other geological units are shown in Section 5.3 of Appendix I (Technical report – Groundwater). The modelled maximum drawdown values are conservative and may not eventuate in practice.

Table 13-9 Long-term modelled groundwater drawdown (year 2130)

Geological unit	Groundwater drawdown
Water table	Maximum drawdown from the 50th percentile of modelling results would be: • between 5.1 metres and 20 metres at the Blackheath portal • between 2.1 metres and 5.0 metres at the Little Hartley portal, including areas with mapped GDEs to the north. Minor drawdown would be between 0.3 and 0.5 metres at geological structures that intersect the operational footprint due to reduced recharge to these units. At Blackheath, drawdown would be marginally greater than during the construction phase at this location, given the portals would be permanently drained (unsealed). At Little Hartley, drawdown would be similar to that experienced during construction. Potential drawdown impacts to registered water supply bores and GDEs during operation are further discussed in Section 13.4.4 and Section 12.4 of Chapter 12 (Biodiversity) respectively. The two metre drawdown contour from the (more conservative) 95th percentile model prediction of maximum drawdown occurs around the same features as the 50th percentile, but extends to around double the radius.
Banks Wall Sandstone	Maximum drawdown from the 50th percentile of modelling results would be between 0.1 metres and 0.3 metres around the regional fault through this geological unit (refer to Figure 13-4), due to the drained (unsealed) structure of the Blackheath portal. Drawdown is predicted to be less than during the construction phase as the cross-passages and twin tunnels would have been tanked (sealed) prior to operation. The spatial extent of predicted drawdown around the Blackheath portals would be marginally greater than during construction, given the portals would be permanently drained (unsealed), extending to areas of registered water supply bores (see Section 13.4.4).
Mount York Claystone	Maximum drawdown from the 50th percentile of modelling results would be between 0.3 metres and 0.5 metres as a result of the mid-tunnel caverns. Minor drawdown would also potentially occur around regional faults located near the north of the Blackheath portal (around 0.1 to 0.3 metres), as a result of groundwater inflows at this location. Drawdown would not extend to where the unit outcrops and therefore is not predicted to impact GDEs. No registered water supply bores are known within the extent of drawdown in these locations. The two metre drawdown contour from the (more conservative) 95th percentile model prediction of maximum drawdown occurs around the same features as the 50th percentile but extends to around double the radius.

Geological unit	Groundwater drawdown
Burra-Moko Head Sandstone	Maximum drawdown from the 50th percentile of modelling results would be between 5.1 metres and 20 metres at the mid-tunnel caverns. The extent of drawdown would be less than during construction as the mid-tunnel access shaft and adit would be infilled at the end of the construction phase and no longer be drained (unsealed)[1]. Minor drawdown would also potentially occur around regional faults located north of the mid-tunnel caverns and Blackheath portals (around 0.1-0.3 metres), as a result of groundwater inflows at these locations. Drawdown would not extend to where the unit outcrops and therefore is not predicted to impact GDEs. No registered water supply bores are known within the extent of drawdown in these locations. The two metre drawdown contour from the (more conservative) 95th percentile model prediction of maximum drawdown occurs around the same features as the 50th percentile but extends to around double the radius.
Caley Formation	Maximum drawdown from the 50th percentile of modelling results within this unit would be largely due to drawdown associated with the mid-tunnel caverns due to the project intercepting geological structures. Drawdown would be 0.1 metres to 0.3 metres at the mid-tunnel caverns. Minor drawdown of 0.1 metres to 0.3 metres would also potentially occur around geological structures located north of the Blackheath portals and north of the mid-tunnel caverns as a result of groundwater inflows to these locations. Drawdown would not extend to where the unit outcrops and therefore is not predicted to impact GDEs. The two metre drawdown contour from the (more conservative) 95th percentile model prediction of maximum drawdown occurs around the same features as the 50th percentile but extends to around double the radius.
Marangaroo or Gundangaroo Formations	Maximum drawdown from the 50th percentile of modelling results would be around 5.1 metres to 20 metres around the Little Hartley portal. Minor drawdown of 0.1 metres to 0.5 metres would also potentially occur around geological structures located north of the Blackheath portal and east of the Little Hartley portal, as a result of groundwater inflows at these locations. Drawdown would not extend to where the unit outcrops and therefore is not predicted to impact GDEs. No registered water supply bores are known within the extent of drawdown in these locations. The two metre drawdown contour from the (more conservative) 95th percentile model prediction of maximum drawdown occurs around the same features as the 50th percentile but extends to around double the radius.

As the project would result in a minor increase in impervious surfaces for surface road upgrades and operational ancillary facilities, operation of the project would have a negligible impact on regional groundwater recharge.

Groundwater throughflow within geological structures (listed in Table 13-9) near the tunnel post construction is anticipated to revert back to its existing flow from east to west, towards the western escarpment of the Blue Mountains. Impermeable underground infrastructure within the geological units, such as the mostly tanked (sealed) tunnels, have the potential to create mounding on the up-gradient side of the tanked twin tunnels and drawdown on the down-gradient side of the tunnels. Estimated groundwater drawdown and changes to flow during operation within the water table are

[1] The modelling has assumed that the infilled mid-tunnel access shaft and adit would have hydraulic properties not distinctly different to the host rock and therefore groundwater flow would generally return to pre-construction conditions during the operational phase.

shown in Figure 13-10. Given the low magnitude and spatial extent of groundwater mounding and / or drawdown, the project's impact on regional groundwater flow patterns is considered to be low.

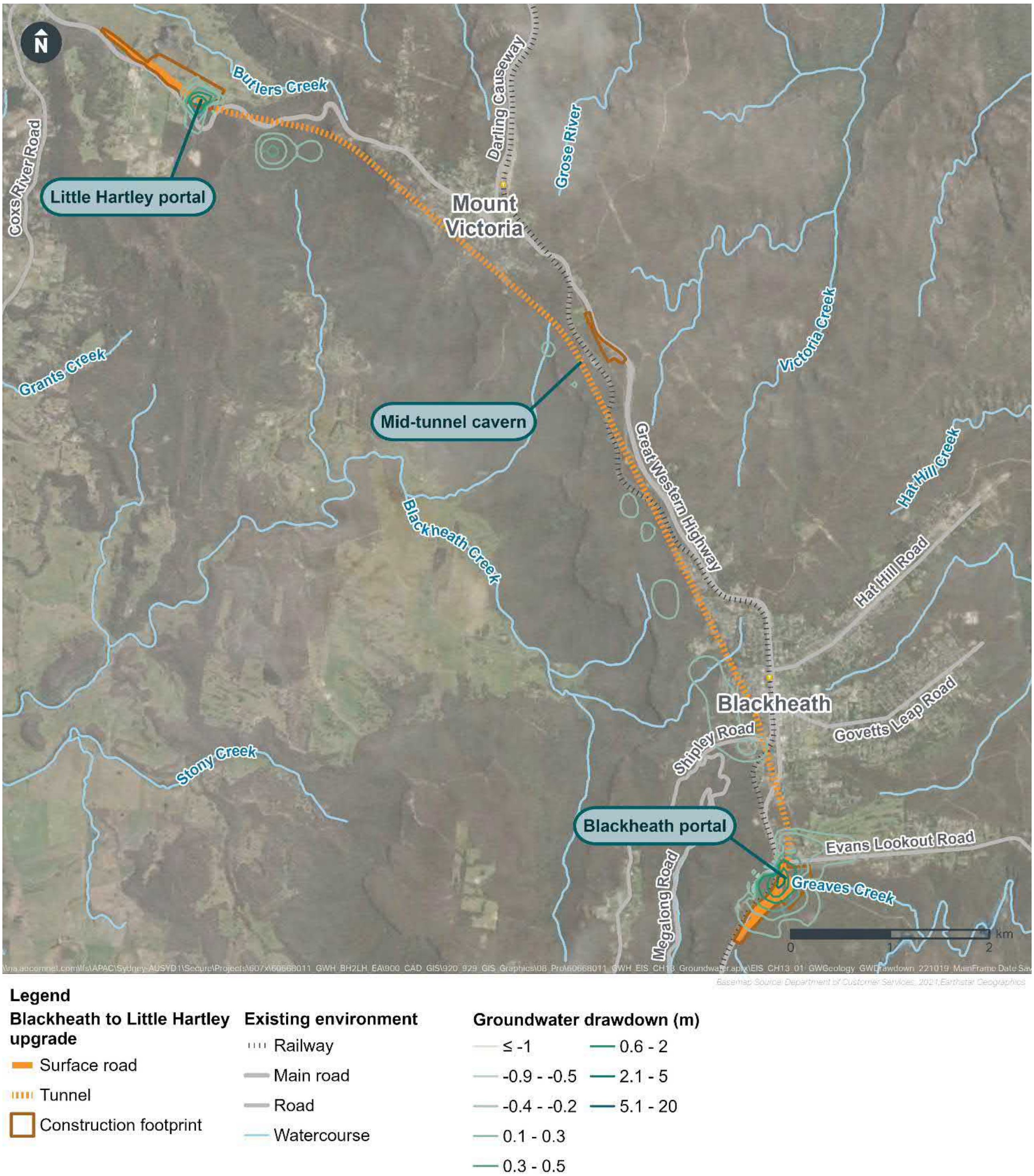


Figure 13-10 Predicted groundwater drawdown in the water table during operation (using 50th percentile modelling outputs)

13.4.3 Groundwater quality

Potential impacts to groundwater quality during operation would arise from:

- leaks or spills of fuels, oils, or lubricating fluids used by vehicles using the tunnels
- groundwater seepage from potential acid sulfate rock (at the Little Hartley portal)

- firefighting system deluge and testing (including vehicle fires if accidents occur within the tunnels).

Groundwater collected during operation would be treated at the water treatment plant at Little Hartley before reuse and/or discharge. With the application of standard mitigation measures, these activities would be low risk and impacts to groundwater quality during operation of the project would be unlikely. Further information on water quality treatment and procedures for spills management, such as spill containment facilities, is provided in Chapter 14 (Surface water and flooding). Consideration of the impact of spills on aquatic receiving environments is addressed in Chapter 12 (Biodiversity). Information about risks from potential acid sulfate rock and firefighting systems is provided in Chapter 15 (Soils and contamination).

13.4.4 Groundwater users

Groundwater drawdown would potentially affect 34 registered bores screened within the Banks Wall Sandstone, Caley Formation or the Shoalhaven Group during operation (2030 to 2130) as shown in Figure 13-10. The higher number of affected registered bores during operation compared with construction relates to groundwater drawdown seepage and spread over time over a larger extent. These bores comprise four monitoring bores, 26 bores used for water supply, two bores used for unknown purposes (assumed to be used for water supply purposes), and two abandoned water supply bores. Long-term (year 2130) impacts are predicted at 23 of these bores, including 20 bores used for water supply, two bores used for unknown purposes (assumed to be used for water supply purposes), and one abandoned water supply bore.

Modelling results indicate that no registered water supply bores would experience a maximum drawdown greater than two metres during operation of the project in the long-term (year 2130). Maximum drawdown during operation would be minimal, around 1.66 metres and is not projected to increase (the long-term maximum predicted groundwater drawdown is around 1.21 metres).

A very low likelihood of drawdown being equal to or greater than two metres was observed in the model at four registered water supply bores in years between 2030 and 2130 (GW058193, GW058236, GW059737, and GW102214) and at one registered supply bore (GW058236) in the year 2031. Results of the modelled groundwater levels during operation at each registered groundwater bore location are provided in Section 5.4.3 of Appendix I (Technical report – Groundwater). Monitoring pre-construction, during construction and during operation will be used to verify model predictions, with model refinements made if required (see Section 13.5).

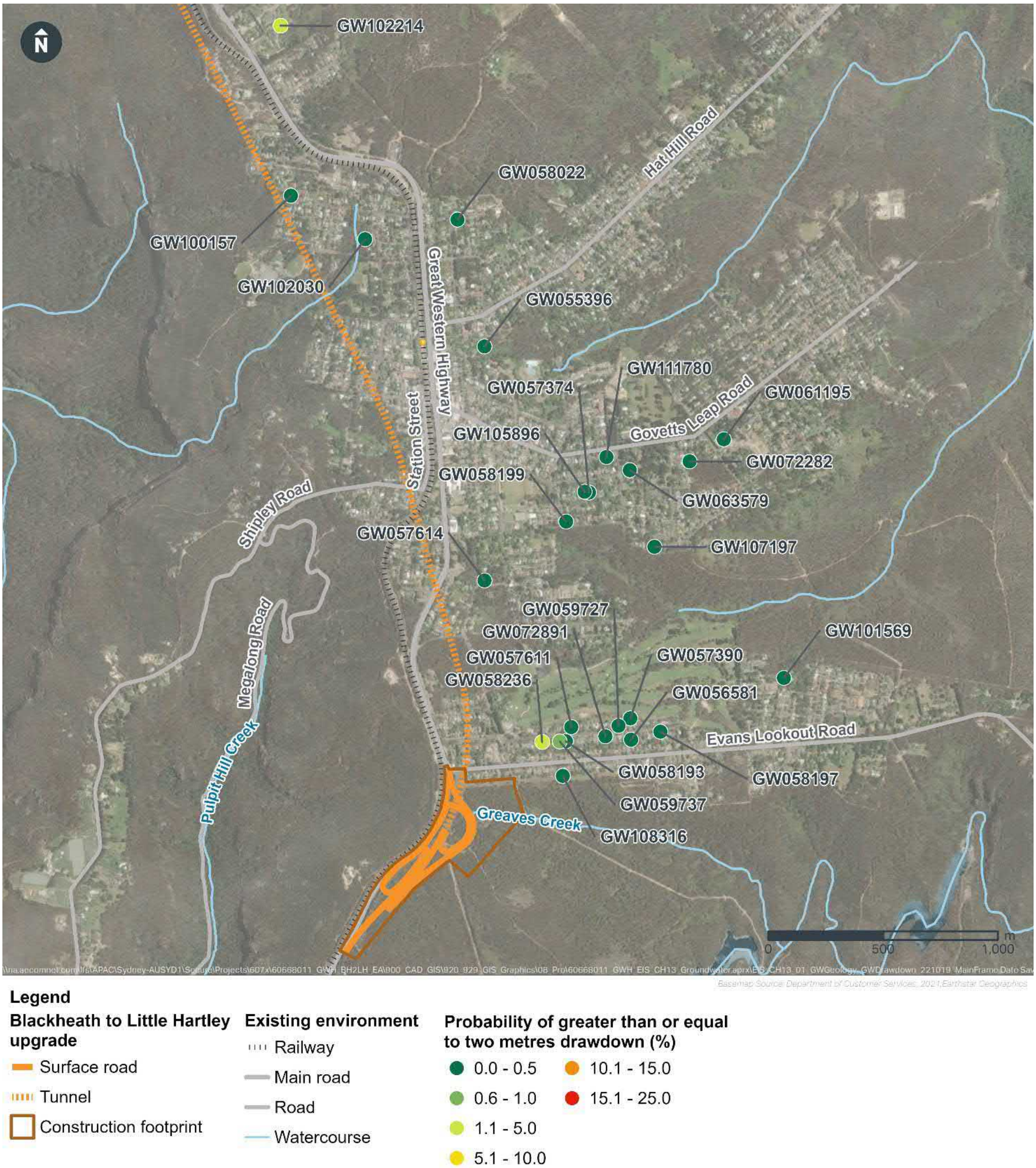


Figure 13-11 Predicted maximum groundwater drawdown (95th percentile) at registered groundwater bores during operation at Blackheath

13.4.5 Surface water/groundwater interaction

Surface water features may be impacted during operation of the project due to continued groundwater inflow to the drained features of the project (portals and mid-tunnel caverns), potentially causing some long-term reduction in stream baseflow at surface water features.

Groundwater modelling and potential changes to surface water baseflow during operation are presented in Section 5.4.5 of Appendix I (Technical report – Groundwater) and indicate that the largest impact on baseflow reduction would be within the Greaves Creek sub-catchment which is located immediately east of the Blackheath portal and flows east towards Greaves Lake.

Lake Medlow and Lake Greaves would be located around 1.3 kilometres and 1.9 kilometres, respectively, from the Blackheath portals and within the Blackheath portion of the Blue Mountains Special Area, listed under Schedule 1 of the Water NSW Regulation 2020. This Special Area forms part of the water supply network for the populations of Medlow Bath, Blackheath and Mount Victoria. Modelling results for these two lakes indicate that a loss (95th percentile model prediction) from the lakes would be 0.06 cubic metres per day (60 litres per day) for Lake Medlow and 0.07 cubic metres per day (70 litres per day) for Lake Greaves. The combined reduction of baseflow for these catchments during dry periods could contribute to reduced water volumes available for water supply purposes, however the loss is predicted to be minimal in the context of surface water flows.

Reduction in baseflows (which would vary across different rainfall seasons) could also affect GDEs, including a threatened ecological community listed under the *Environment Protection and Biodiversity Conservation Act 1999* – Temperate Highland Peat Swamps on Sandstone (THPSS) at Greaves Creek. The loss of baseflow from Greaves Creek and potential impacts on associated GDEs have been assessed as not having a significant impact on the THPSS community. Further information and assessment of potential impacts to surface water bodies and GDEs is provided in Chapter 14 (Surface water and flooding) and Chapter 12 (Biodiversity).

Further investigation into the impacts of baseflow reductions on watercourses and swamps will be undertaken during design development, including field hydrogeological investigations and revised modelling as required.

If revised modelling determines that a reduction in baseflow to the valley floor infill swamps of Greaves Creek is likely and that there is a risk of detrimental impacts to these ecosystems as a result, then further mitigation measures would be investigated. Performance outcomes for the mitigation measures would be developed and agreed upon by subject matter experts, and mitigation actions including design responses such as lining the Blackheath tunnel portal would be assessed for their effectiveness in addressing the risk.

In the instance that residual risk is predicted, monitoring would continue during construction for the hydrogeology, geomorphology and vegetation community likely to be impacted. Observations would be assessed against set triggers, trigger thresholds, and responses developed for observed impacts. Monitoring methods would be developed with reference to supporting justification.

13.4.6 Settlement (ground movement)

Settlement is most likely to occur during construction. It is unlikely that settlement would be an ongoing issue during operation, given the tunnel would be tanked.

Further discussion of potential settlement impacts to properties is provided in Chapter 20 (Business, land use and property).

13.5 Environmental mitigation measures

13.5.1 Performance outcomes

Performance outcomes for the project in relation to groundwater and geology are listed in Table 13-10 and identify measurable performance-based standards for environmental management.

Table 13-10 Groundwater and geology performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised.	Design and operate the project to minimise adverse long term impacts on surface water and groundwater, and related environmental values, including: • minimising the volume and rate of groundwater inflow to the project during operation • minimising the magnitude and extent of groundwater drawdown around the project during operation • minimising the reduction in baseflow volumes in watercourses affected by groundwater drawdown around the project during operation • surface water discharge from the project, including site runoff and water treatment plant discharges, achieves a neutral or beneficial effect on the receiving watercourse and catchment, taking into account relevant Water Quality Objectives.	Design, construction and operation
The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved).		
Consideration of tunnel boring methods to minimise groundwater drawdown impacts and dewatering.	Design and construct the project to minimise groundwater inflow and groundwater drawdown around the project during construction and operation.	Design, construction and operation
The project is designed, constructed, and operated to protect the NSW Water Quality Objectives where they are currently being achieved, and contribute towards achievement of the Water Quality Objectives over time where they are currently not being achieved, including downstream of the project to the extent of the project impact including estuarine and marine waters (if applicable).	Manage surface water discharges from the project during construction and operation, including collection and treatment where necessary, to achieve a neutral or beneficial effect on the receiving watercourse and catchment, taking into account relevant Water Quality Objectives.	Design, construction and operation

13.5.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential groundwater and geology impacts as a result of the project are detailed in Table 13-11. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 13-11 Environmental mitigation measures – groundwater and geology

ID	Mitigation measure	Timing
GW1	The numerical groundwater model for the project will be updated as part of ongoing design development, will consider the construction schedule and methodology, and will take into account relevant additional geotechnical and groundwater monitoring data. Anticipated groundwater impacts will be confirmed and if required inform the development of detailed groundwater mitigation and management measures. The updated numerical groundwater numerical model will be calibrated against groundwater monitoring data collected during the construction phase. If observed groundwater level responses identified through monitoring markedly differ from predictions made by the updated numerical groundwater model, including extent of drawdown and timing, the model will be further refined and calibrated against the observed groundwater conditions.	Design
GW2	Where the updated groundwater model predicts groundwater impacts or related baseflow reductions in surface water resources that markedly differ from predictions presented in the EIS, further environmental mitigation measures and/or design responses will be identified and applied where feasible and reasonable. Design responses could include the review of tanked or drained infrastructure elements, pre-grouting of cross-passages and/or the treatment and discharge of treated groundwater into the affected creeks to address baseflow reductions.	Design
GW3	As part of detailed design, the existing groundwater monitoring network will be reviewed and maintained in consultation with relevant government agencies, and monitoring data will be made available to those agencies upon request, to: • continue to gather representative groundwater monitoring data to inform ongoing project design development, and the updated numerical groundwater model for the project • characterise the hydrogeological environment along and around Greaves Creek and associated groundwater dependent ecosystems in more detail • monitor groundwater prior to, during, and after construction of the project • complement the surface water monitoring network for the project (refer to environmental mitigation measure SW2). A suitably qualified person, such as a hydrogeologist and/or an environmental scientist will undertake periodic reviews of the groundwater monitoring data, and advise on potential groundwater impacts and appropriate mitigation and management measures prior to, during and after construction of the project for up to two years.	Design

ID	Mitigation measure	Timing
GW4	Registered groundwater bores identified as being potentially impacted by two or more metres of drawdown in the updated numerical groundwater model, will be inspected in consultation with the relevant groundwater licence holders. The inspection will aim to confirm the current viability of the bores. If the bores are identified to be viable, they will be monitored and if a material loss of yield occurs as a consequence of the project, make good provisions will be offered to the relevant groundwater licence holders.	Design
GW5	An updated assessment of potential ground settlement as a consequence of tunnel construction activities will be carried out as part of further design development at appropriate locations above the tunnel alignment. Where the assessment or monitoring data identifies an exceedance, or potential for an exceedance, of the acceptance criteria for settlement for buildings/ structures, heritage items and other sensitive buildings, or critical infrastructure, additional mitigation measures will be identified, which may include design and construction measures, and/ or reparatory works to affected buildings, structures or infrastructure.	Construction

14 Surface water and flooding

This chapter summarises the surface water and flooding assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full surface water and flooding assessment is provided in Appendix J (Technical report – Surface water and flooding).

14.1 Assessment approach

14.1.1 Surface water and hydrology

The approach to the surface water and hydrology assessment included:

- review of previous water quality reports to understand the existing environment and water quality conditions within the study area (see Figure 14-1)
- identification of project-specific environmental values and assessment criteria including the neutral or beneficial effect (NorBE) criteria (required for projects within Sydney's Drinking Water Catchments)
- qualitative assessment of potential water quality impacts during construction
- quantitative modelling of potential operational impacts using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC)
- consideration of whether the project has a NorBE on water quality (i.e., a 10 per cent reduction in total suspended solids, total phosphorus and total nitrogen, and gross pollutant loads equal to or less than the existing loads)
- development of a surface water balance for construction and operation of the project (see Sections 14.3 and 14.4)
- identification of mitigation measures to avoid or minimise potential impacts.

The surface water quality objectives for the project are outlined in Section 2.2.4 of Appendix J (Technical report – Surface water and flooding).

14.1.2 Flooding

The approach to the flooding assessment included:

- review of historic flooding information and flood assessments
- identification of project-specific criteria for operational impacts
- flood modelling of existing and proposed flooding conditions including for the five per cent annual exceedance probability (AEP), two per cent AEP, one per cent AEP, 0.2 per cent AEP (climate change) and probable maximum flood (PMF) events[1]
- qualitative assessment of potential temporary construction flooding impacts
- quantitative assessment of potential operation flooding impacts based on flood modelling
- identification of mitigation measures to avoid or minimise potential impacts.

The flood management objectives for the project are outlined in Section 2.2.3 of Appendix J (Technical report – Surface water and flooding).

[1] The full range of listed flooding events was considered at Little Hartley. Only the PMF event was considered at Blackheath due to the low flood risk identified at this location. Soldiers Pinch is unlikely to be affected by flooding given the high elevation of the site, upstream catchments and localised flow paths directing water toward the Grose River.

14.2 Existing environment

14.2.1 Sensitivity of the receiving environment

The project is located adjacent to the Blue Mountains National Park and the Greater Blue Mountains World Heritage Area. This sensitive and unique environment comprises important views, rugged tablelands, sheer cliffs, deep, inaccessible valleys and swamps supporting a diverse ecosystem. There are a number of sensitive ecological receptors and water bodies near the project, including threatened species and groundwater dependent ecosystems (GDEs) as well as water bodies supporting Sydney's drinking water catchment. The area is largely undeveloped and remains largely in its natural form. The integrity of the Greater Blue Mountains World Heritage Area depends upon the complexity of its geological structure, geomorphology and water systems, which have created the conditions for the evolution of its outstanding biodiversity.

14.2.2 Catchments and waterways

Catchments

The project is located within the Hawkesbury-Nepean River catchment, which has an area of around 22,000 square kilometres. Runoff from the project would ultimately drain to the Hawkesbury River via:

- Grose River– proposed work at Blackheath and Soldiers Pinch, given the natural ridgeline and modelling which suggests runoff would drain to the east, would be located within the Grose River sub-catchment and would drain to Grose River via a series of tributaries located immediately downstream of the existing Great Western Highway
- Coxs River– proposed work at Little Hartley and the majority of the tunnels would be located within and beneath the Coxs River sub-catchment and would drain to Coxs River via Butlers Creek and River Lett.

The indicative locations of these sub-catchments are shown on Figure 14-1 which lie within the larger Hawkesbury-Nepean River catchment.

The majority of the project would be located within or beneath the mid-Coxs River catchment, which forms part of the Sydney Drinking Water Catchment eventually draining to the Warragamba Dam. This would include most of the project tunnels and the surface works at Little Hartley.

The project east of the existing Great Western Highway, including the Soldiers Pinch construction site, is within the Grose River sub-catchment and is not associated with a drinking water catchment.

The project at Blackheath would be located within the Blue Mountains Special Area, listed under Schedule 1 of the *Water NSW Regulation 2020*. The Blue Mountains Special Area forms the surface water catchment for Lake Medlow and Lake Greaves, which supply water (along with supply from the Cascade dams) to the Cascade water filtration plant for subsequent supply to the populations of Medlow Bath, Blackheath and Mount Victoria. Public access to this area is restricted to protect water quality and create a buffer of land around essential water storage.

Land within drinking water catchments, as shown in Figure 14-2 to Figure 14-4, plays an important role in capturing drinking water. Further detail on relevant legislation pertaining to the drinking water catchments is provided in Section 2.1 of Appendix J (Technical report – Surface water and flooding).

The project is also located within two water sources which form part of the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011:

- Upper Nepean and Upstream Warragamba Water Source
- Hawkesbury and Lower Nepean Rivers Water Source.

These water sources include all water naturally occurring on the surface of the ground, and in rivers, lakes estuaries and wetlands.

Watercourses

There are 21 waterways within proximity to the project as listed in Section 3.5 of Appendix J (Technical report – Surface water and flooding). Of these, 17 are ephemeral streams (i.e., only flow after rainfall) and four streams are intermittent (i.e., stop flowing when groundwater levels are low).

Rosedale Creek and an unnamed creek at Little Hartley are third and first order streams (as defined by Strahler) respectively and the only watercourses characterised as key fish habitats. All other waterways within the study area are first order streams and do not comprise key fish habitat.

Waterways in proximity to the construction footprint are shown in Figure 14-2 to Figure 14-4.

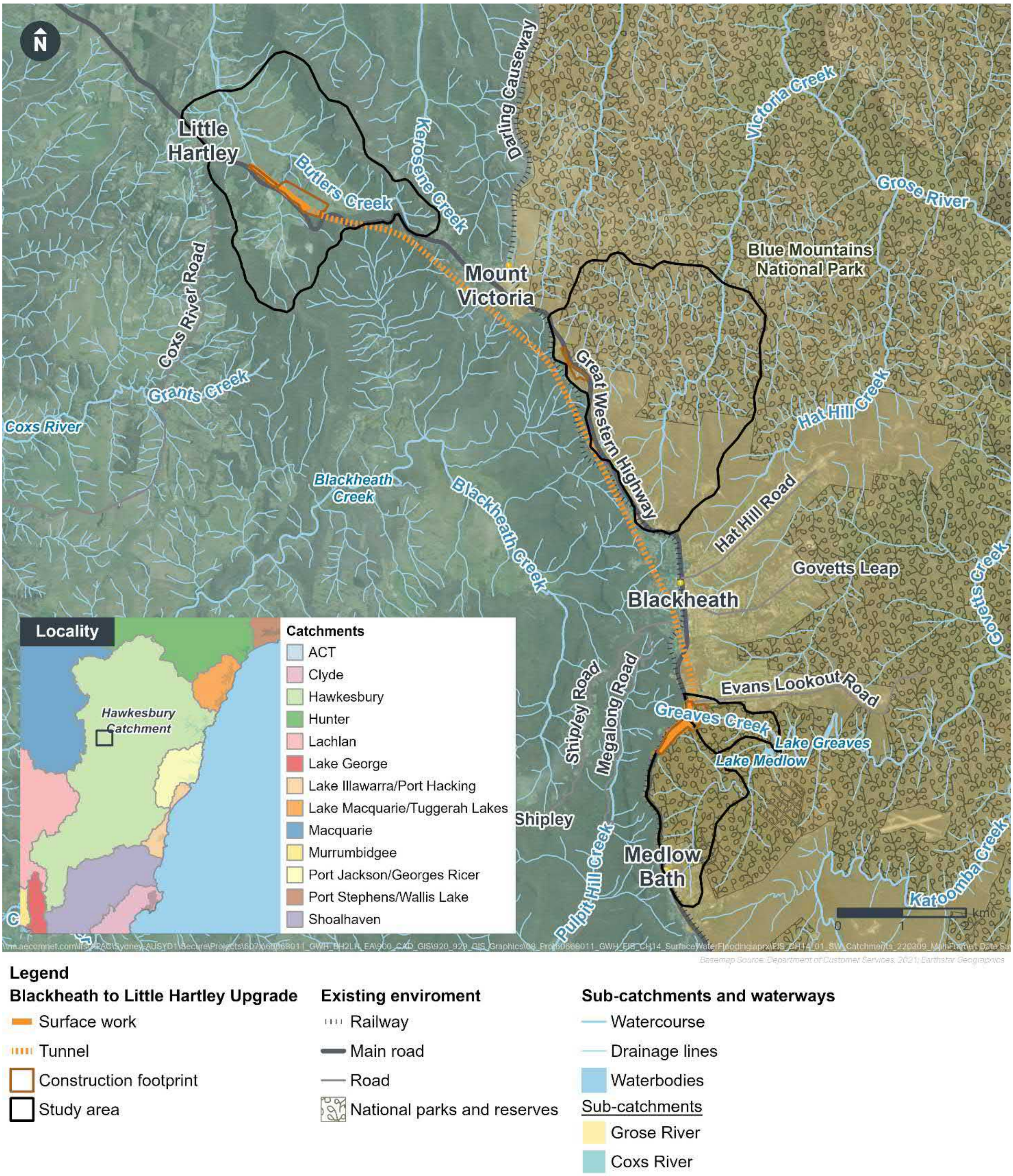


Figure 14-1 Overview of the surface water study area, sub-catchments and waterways[2]

[2]Data for the boundaries of sub-catchments was not available. Indicative boundaries shown have been adapted from Figure 1 of the 'Hawkesbury-Nepean Valley Flood Management Review Stage One' (Department of Primary Industries, 2014)

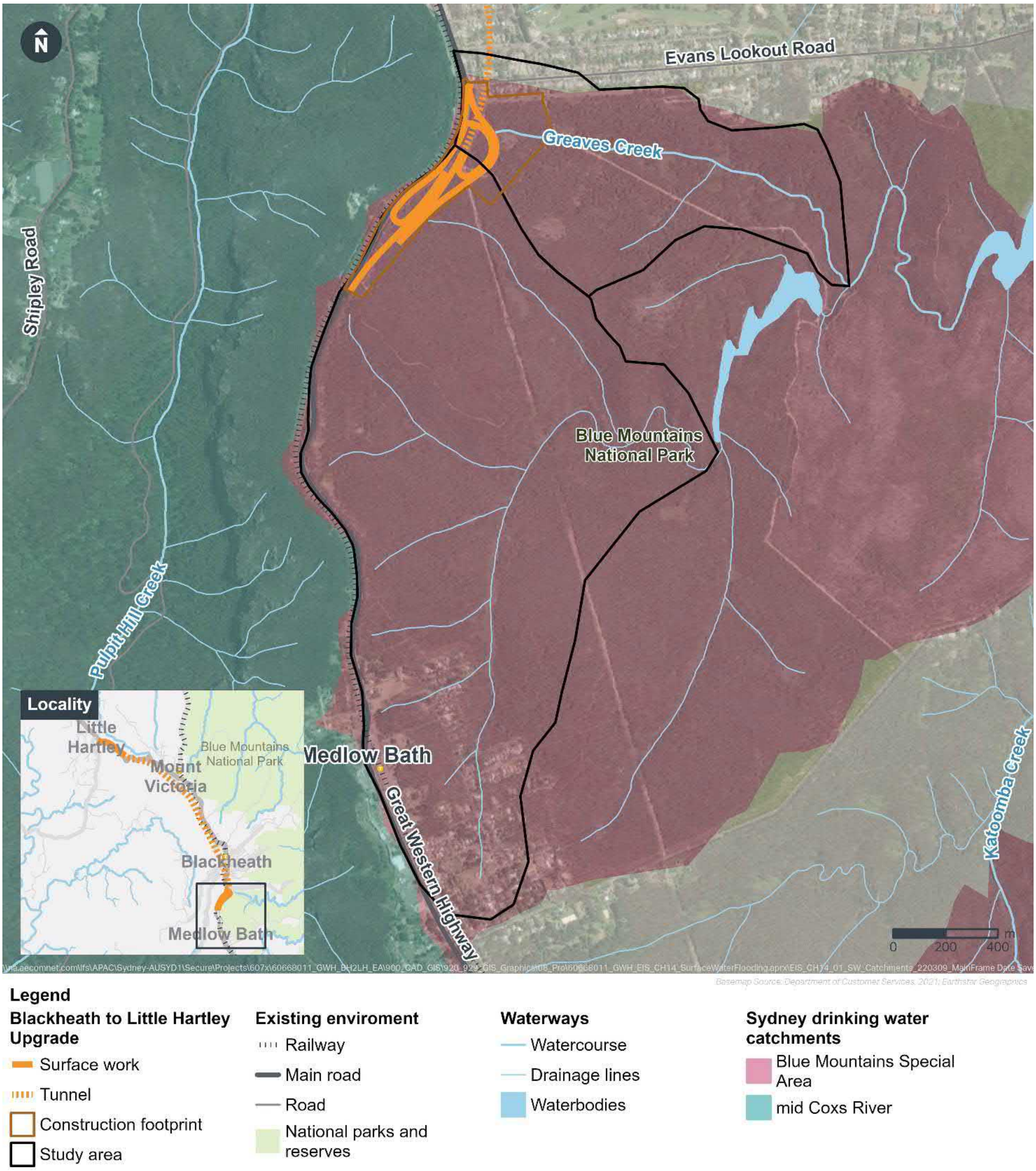


Figure 14-2 Sydney Drinking Water Catchments and waterways near the Blackheath study area

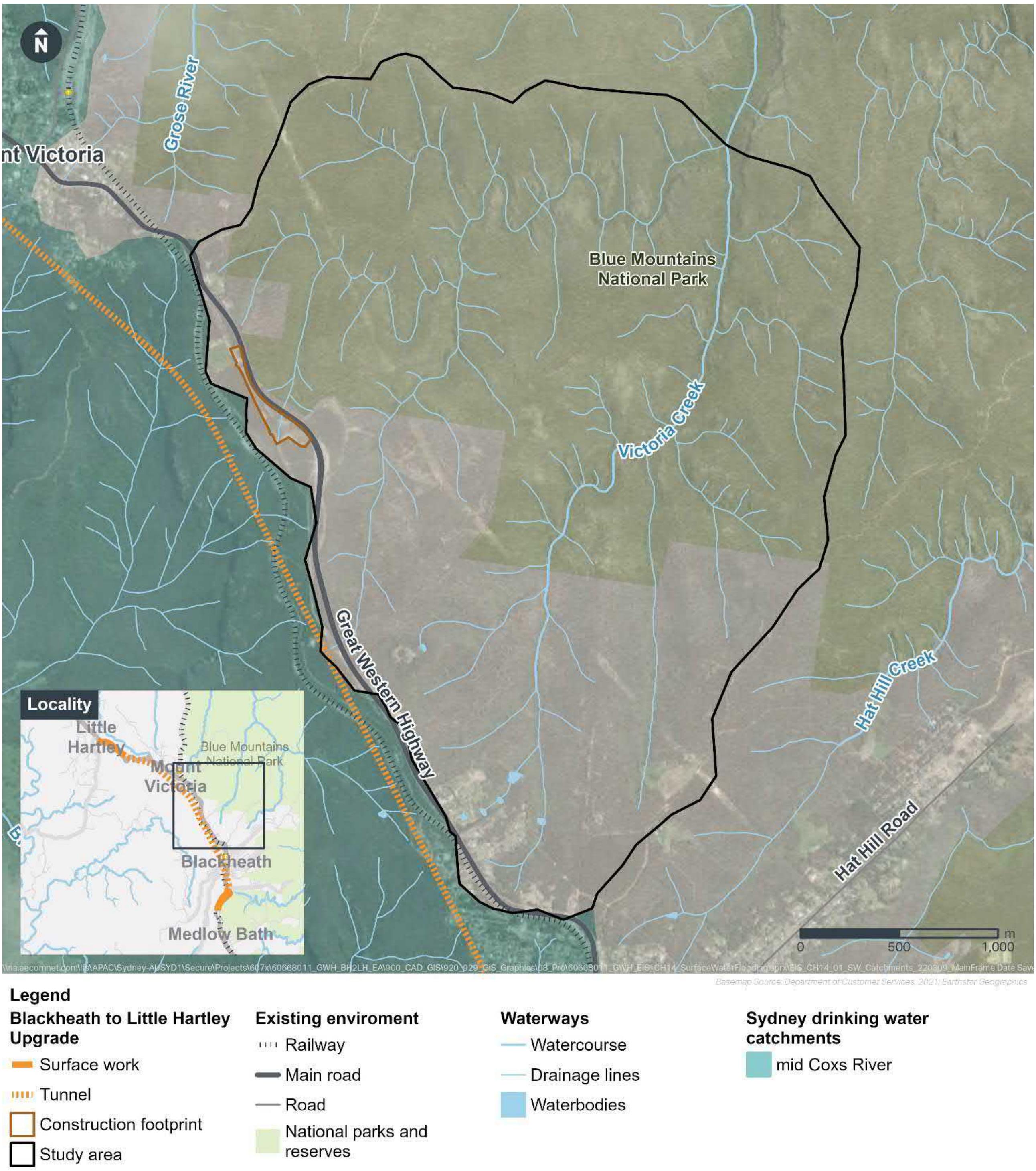


Figure 14-3 Sydney Drinking Water Catchments and waterways near the Soldiers Pinch study area

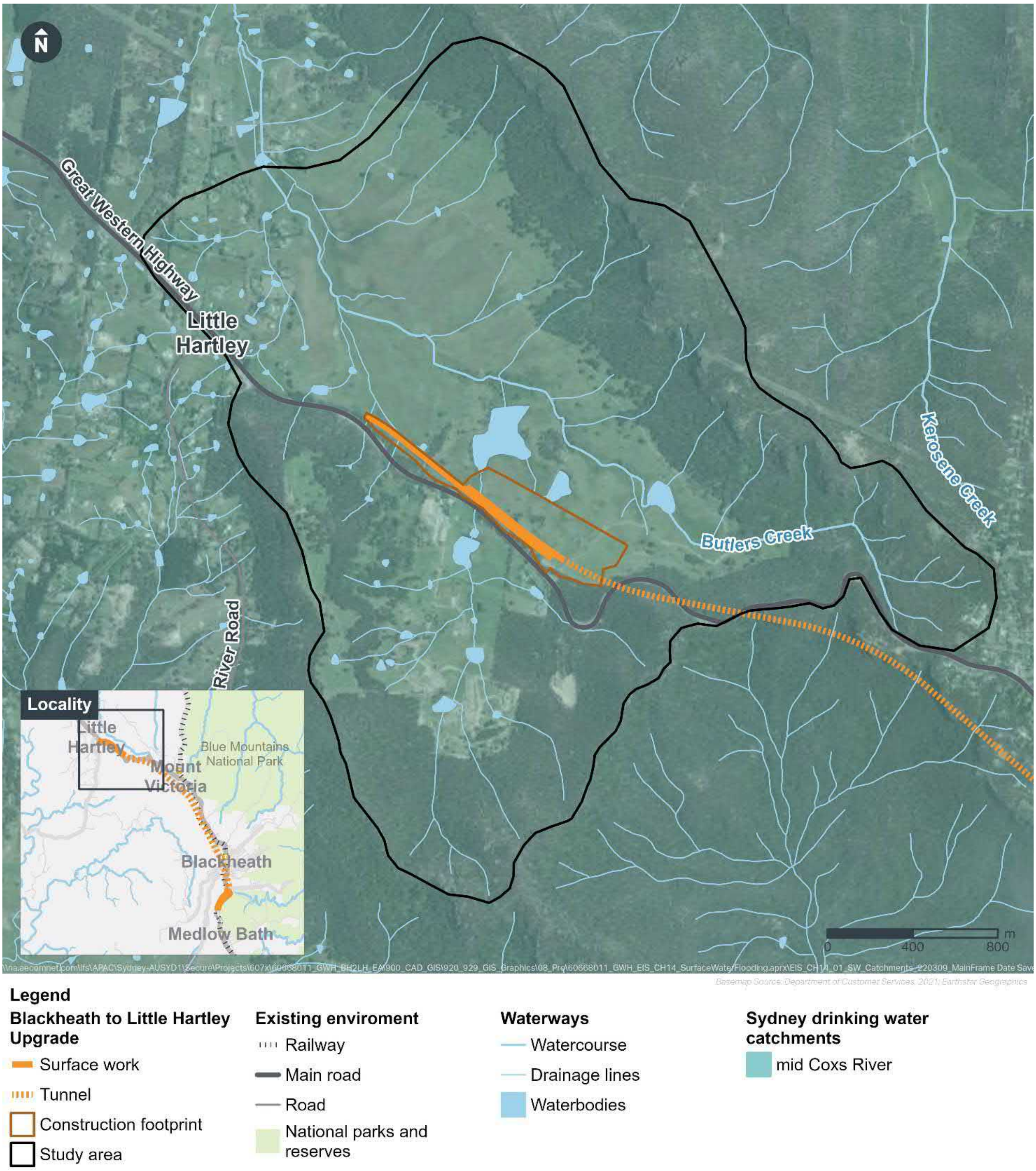


Figure 14-4 Sydney Drinking Water Catchments and waterways near the Little Hartley study area

14.2.3 Surface water and water quality

Available water quality reporting suggests that the water quality of the surrounding watercourses and broader catchments relevant to the project vary from good to poor (see Table 14-1). The water quality in mid Coxs River was found to be mostly compliant with Australian and New Zealand Environment and Conservation Council (ANZECC) Water Quality Guideline values. Greaves Creek sub-catchment (which sits within the Blue Mountains Special Area) was mainly found to be non-compliant with guideline values. Previous reports used to characterise the existing water quality environment are summarised in Section 2.2 of Appendix J (Technical report – Surface water and flooding).

To understand the existing water quality conditions, 22 in situ-sites nearby the project were sampled, with a summary of the results provided in Table 14-2. Further information on water quality sampling is provided in Section 3.6 of Appendix J (Technical report – Surface water and flooding).

Table 14-1 Existing water quality relevant to the project

Report or Study	Relevant catchment/waterway	Overall assessment of water quality in relation to the project
Sydney Drinking Water Catchment Audit 2019 (Eco Logical Australia, 2020)	Little Hartley (mid Coxs River catchment)	Water quality found to be mostly compliant, with the following parameters outside the recommended range: • pH • electrical conductivity • total aluminium. These results are similar to previous audit findings.
Annual Water Quality Monitoring Report 2020-21 (WaterNSW, 2021)	Blackheath (Lake Greaves – Greaves Creek sub-catchment)	Parameters outside the recommended range included: • pH • total aluminium. The Greaves Creek sub-catchment was found to be prone to increases in metals, nitrogen and phosphorus post-rainfall which can cause sustained algal growth.
Waterways Health Report 2017 (Blue Mountains City Council, 2017)	Blackheath (Adams Creek, Govetts Leap Brook, and Pulpit Hill Creek) and Soldiers Pinch (Grose River tributary)	The following health ratings were given to the waterways close to the study area: • Pulpit Hill Creek (Coxs River Catchment) – excellent/good health • Grose River Tributary – good health • Adams Creek – good health • Govetts Leap Brook – good health. A rating of good health suggests that data collected was mostly in compliance with guidelines and reference data.

Table 14-2 Summary of in-situ water quality sampling results

Sample	ANZECC Water Quality Guidelines Range	Percentage of sites within ANZECC Water Quality Guidelines Range	Notes
Dissolved oxygen (% saturation)	90-110	36%	Considerably low oxygen readings at the upper Relton Creek and upper Greaves Creek sites are likely due to sites being at the headwaters of the creeks with very little flow, resulting in only small, oxygen poor pools of water present.

Sample	ANZECC Water Quality Guidelines Range	Percentage of sites within ANZECC Water Quality Guidelines Range	Notes
Electrical conductivity (mS/cm)	30-350	72%	All of the sites not within the range were below the lower limit. It is noted that the ANZECC guidelines do not accurately reflect the true geochemical nature of Blue Mountains streams which are typically dilute.
pH	6.5-8	9%	The lowest pH was recorded at the middle Greaves Creek site which had a pH of 4.74. As with electrical conductivity, the ANZECC guidelines do not reflect the naturally acidic nature of Blue Mountains streams and results such as this are typical of Blue Mountains creeks with minimally disturbed catchments.
Turbidity (NTU)	2-25	81%	The sites that were not within the guideline range were below the lower limit, which reflects the relatively clear and dilute sandstone derived waters.
Total suspended solids (TSS) (mg/L)	No range stated. The Blue Book (Landcom, 2004) states < 50 mg/L	Results between <5 to 538 mg/L	The upstream of most watercourses showed an increase in TSS compared to most downstream watercourses. Butlers Creek (at Little Hartley) is an exception to this, likely resulting from the transition from minimally disturbed upper reach to an agricultural land use.

14.2.4 Drainage infrastructure

The existing drainage environment surrounding the project is described in Table 14-3.

Table 14-3 Existing drainage infrastructure

Location	Description
Blackheath	• limited underground drainage with a one-way crossfall, directing stormwater runoff towards the low side of the Great Western Highway • roadside swales.
Soldiers Pinch	• no existing formal drainage at Solders Pinch • surface water appears to sheet off the existing road into the surrounding environment • surface water paths appear to have formed within some of the road corridors due to erosion of the existing unsealed road.

Location	Description
Little Hartley	• piped drainage along kerbed sections of the Great Western Highway • inlet pits which transfer surface flows into the existing underground drainage network, which then discharge to an existing channel, watercourse and/or transverse culvert • surface road runoff sheets directly off the road at un-kerbed sections of the Great Western Highway.

For the purposes of the environmental impact statement, it has been assumed that the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade and associated drainage, flooding and water quality infrastructure have been assessed, approved and are operational prior to construction of the project. This infrastructure would be used to manage surface water related impacts from the construction and operational phases of the project. The baseline scenario represents an environment where:

- downstream drainage infrastructure has been sized and constructed so that it can accommodate discharges from the project without affecting the drainage performance of adjacent projects that are part of the Upgrade Program. This includes designing the sizing of pipes and attenuation basins in the adjacent projects to accommodate the predicted flows from all Upgrade Program projects. The Little Hartley to Lithgow Upgrade will construct a section of the Rosedale Creek culvert crossing to accommodate the project, as well as upgrading and realigning the culvert on the existing Great Western Highway at Rosedale Creek
- treatment devices to manage the quality of stormwater runoff include flow diversions, treatment systems, flow spreaders and infiltration areas. These have all been designed to accommodate runoff from the adjacent east and west projects where necessary in addition to runoff from this project. These treatment devices would be in place when this project is constructed. Treatment targets for water quality for this project would be met by integrating design of this project with treatment systems provided by the adjacent projects.

The water quality controls for the project are described in Chapter 4 (Project description). Figure 4-15 and 4-19 in Chapter 4 (Project description) show water quality control infrastructure to be delivered by the project and adjacent projects as part of the Upgrade Program.

14.2.5 Sensitive receiving environments

Vegetation communities

Aquatic ecosystems within stream environments may be sensitive to changes in surface runoff. Temperate Highland Peat Swamps on Sandstone community (THPSS) is listed as an endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and listed as endangered under the *Biodiversity Conservation Act 2016* (NSW) (BC Act). The project is in close proximity to THPSS, and surface runoff from the project would be discharged to waterways that contain THPSS.

Several swamp communities listed under the BC Act make up the THPSS community including:

- Blue Mountains Swamps in the Sydney Basin Bioregion (Vulnerable, BC Act and Endangered, EPBC Act)
- Newnes Plateau Shrub Swamp in the Sydney Basin Bioregion (Endangered, BC Act)
- Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions (Endangered, BC Act).

Further discussion of potential impacts to swamp communities, including THPSS, is provided in Chapter 12 (Biodiversity).

14.2.6 Flooding

Flood modelling for the project and previous flooding studies for the Great Western Highway Upgrade Program – Katoomba to Lithgow have determined the existing flood behaviour for the study area.

Blackheath

Based on the existing PMF depth, major flooding is considered unlikely to occur at the Blackheath portal. This area is located on a natural ridgeline and therefore the majority of water would flow away from the Great Western Highway to the east or west. Existing PMF depths at Blackheath show three overland flow paths within the construction footprint where flood depth is up to 0.75 metres (locations 1, 2 and 3 in Figure 14-5), and one location where localised ponding occurs above 1.2 metres, however this does not overtop the railway line (location 4 in Figure 14-5). In other locations flood depths are generally below 0.2 metres.

Based on PMF modelling results, areas of higher velocity are associated with existing flow paths (identified above) downstream of the existing Great Western Highway including Relton Creek, an unnamed tributary of Adams Creek and Greaves Creek downstream of the existing Great Western Highway. Peak flood velocities in these flow paths range from 1.5 to 2.5 metres per second. Peak velocity levels are shown in Figure 3-15 of Appendix J (Technical report – Surface water and flooding).

The Katoomba to Blackheath Upgrade would be under construction when construction of the project commences. There is expected to be some flood risk due to temporary blockage or diversion of waterways and drainage lines due to construction activities. These temporary impacts are expected to be minor and would be managed through the implementation of standard construction techniques.

Soldiers Pinch

Solders Pinch is located at a high point in the landscape and is unlikely to experience major flooding given the elevation profile. While Soldiers Pinch is located around eight metres below the existing Great Western Highway, water passes under the highway downstream west to east. A natural drainage channel runs through the construction footprint and towards the Grose River. There may be some localised ponding at depressions along and around the natural drainage channel, however, modelling suggests that the channel conveys flows downstream towards Grose River before any major ponding occurs.

Little Hartley

Under baseline conditions for all modelled scenarios, deep water ponding above two metres occurs at the Rosedale Creek crossing (location 3 in Figure 14-8) for the one per cent AEP. Across different flood events, there are five other locations where the existing Great Western Highway overtops. The existing one per cent AEP flood depth and flood hazard maps are shown in Figure 3-17 and Figure 3-18 in Appendix J (Technical report – Surface water and flooding).

The existing one per cent AEP peak flood velocities for Little Hartley identify areas of higher velocity associated with Rosedale Creek and unnamed tributaries of Butlers Creek. Flood velocities in these flow paths generally peak at between 2.0 and 2.5 metres per second but are generally less than 1.5 metres per second. Within the construction footprint, the highest velocities are experienced downstream of the existing Rosedale Creek culvert crossing, which reaches 2.1 metres per second for the one per cent AEP event. Peak flood velocities in these flow paths range from 1.5 to 2.5 metres per second.

During the one per cent AEP, the flood hazard for the upstream and downstream ends of the culvert crossing at Rosedale Creek has a flood hazard rating of H5 (unsafe for people or vehicles with all buildings vulnerable to structural damage).

The Little Hartley to Lithgow Upgrade would be under construction at the time of project construction. The Little Hartley to Lithgow Upgrade will construct a section of the Rosedale Creek culvert crossing to tie into the project and assist in managing existing the flood hazard at this location.

Emergency management

No formal emergency management, evacuation and access and contingency measures were identified for Little Hartley. Existing emergency evacuation routes are assumed to be eastbound and westbound via the Great Western Highway.

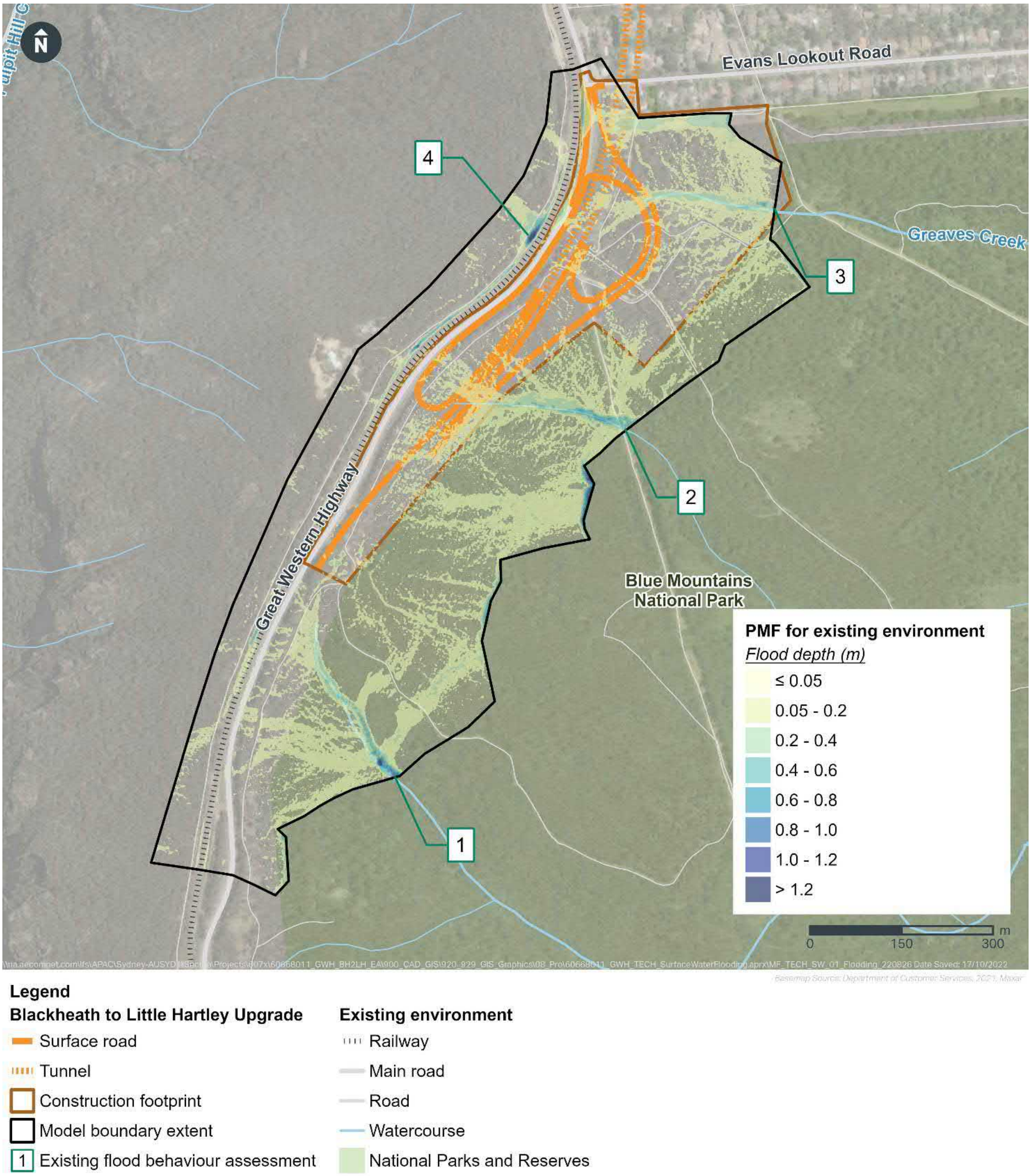


Figure 14-5 Baseline modelled flood depth for the PMF at Blackheath

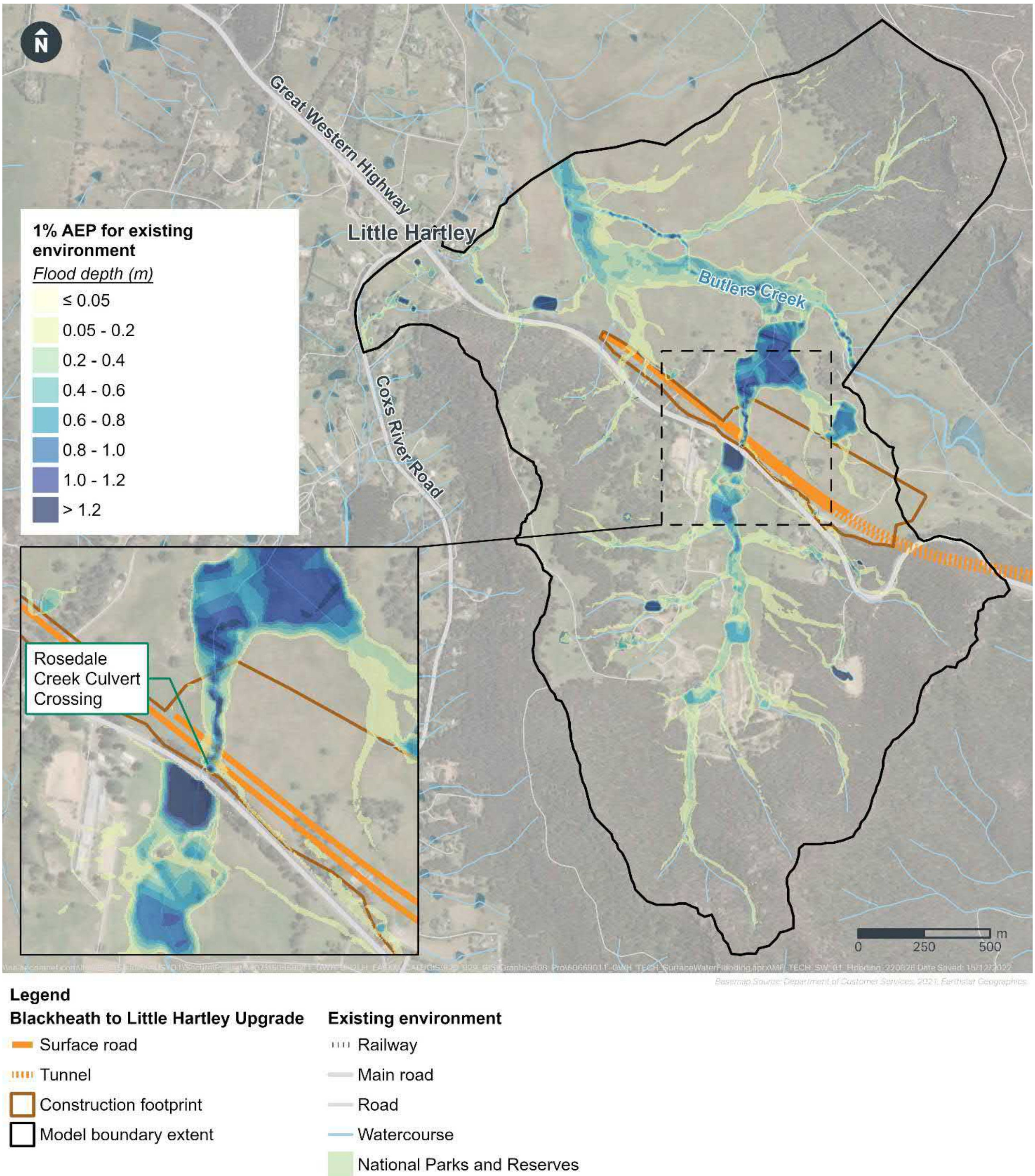


Figure 14-6 Baseline modelled flood depth for a one per cent AEP event at Little Hartley

14.3 Potential impacts – construction

14.3.1 Surface water and hydrology

Surface activities

The construction of the project has the potential to temporarily impact the water quality of waterways within the study area and areas downstream of the project as outlined in Table 14-4, if not properly managed.

Table 14-4 Potential water quality impacts during construction (before mitigation measures)

Construction activity	Potential impact
• clearing of vegetation and exposure of soils could result in mobilisation and release of sediment laden runoff from construction areas or stockpiles of soil • direct disturbance of waterway bed and/or banks as a result of earthworks could result in soil and bank erosion and mobilisation of sediments into receiving waterways, particularly at Rosedale Creek (a key fish habitat) • loading and transporting of building materials, stockpiling, earthworks, and demolition of structures could result in dust, litter and other pollutants being mobilised by wind and stormwater runoff into waterways • vehicle movement across construction footprints may loosen soils and transport sediment onto public roads and into the waterways either by runoff carrying sediment from loosened soils or through sediments attached to the vehicles traversing drainage lines.	• sediments could smother receiving waterways impacting aquatic ecosystems • increased turbidity, lower dissolved oxygen levels, and increases in toxicant concentrations could impact aquatic ecosystems • nutrients associated with sediments could lead to algal blooms and aquatic weed growth, which could impact aquatic ecosystems, recreation, irrigation, livestock, and aquatic foods • reduced visual amenity could result from turbid water and visible gross pollutants, impacting recreation and visual amenity • potential for pollution and impacts described above to impact peat swamps identified at Blackheath and Little Hartley, as well as the Blue Mountains Special Area at Blackheath.
• leakage or spills of oils, fuel and/or chemicals from machinery or equipment, during refuelling or accidental spill could potentially result in pollutants being conveyed to downstream waterways.	• oil sheen on water surface could impact amenity or recreation • increased toxicant concentration could lead to fish kills and other aquatic ecosystem impacts, livestock and aquatic foods impacts, including impacts to peat swamps identified at Blackheath and Little Hartley, as well as the Blue Mountains Special Area at Blackheath.
Concreting could result in: • accidental runoff of concrete washout water into waterways • chemicals used in treatment and curing of concrete and mobilisation of concrete dust through wind and runoff could impact waterways • spills of excess or waste concrete could be discharged into stormwater systems.	• increased alkalinity and toxicant concentration could lead to impacts to aquatic ecosystems such as fish kills and undesirable impacts to livestock • increased turbidity could impact aquatic ecosystems, amenity and recreation • changes in alkalinity and toxicity also have the potential to impact peat swamps identified at Blackheath and Little Hartley • pollution of surface water within the Blue Mountains Special Area at Blackheath.

Construction activity	Potential impact
Earthworks and changes to the site resulting in concentrated flows that have potential to disrupt existing surface water flow paths, scour the earth and increase sediment loads carried by surface waters.	• increased turbidity, lower dissolved oxygen levels and increased nutrients could lead to algal blooms and aquatic weed growth which could impact aquatic ecosystems • increased toxicant concentration • reduced visual amenity (turbidity) • localised ponding could occur creating drainage/flooding issues within nearby properties and surrounding downstream environment • erosion affecting channel geomorphology and bank stability • potential for pollution and impacts described above to impact peat swamps identified at Blackheath and Little Hartley, as well as the Blue Mountains Special Area at Blackheath.
Activities related to discharges from the project include: • dewatering open excavations following periods of rainfall, which may contain sediments and other pollutants mobilised by the rainfall • increased baseflow rate to receiving waterways due to continuous discharge from construction water treatment plants, causing a potential for increased erosion and scouring of waterways due to increased discharged volumes • impacts to ambient water quality as a result of poorly treated discharges from the construction water treatment plants.	• increased alkalinity and toxicant concentration could lead to fish kills and other undesirable impacts to aquatic ecosystems, livestock, and aquatic foods • increased turbidity, lower dissolved oxygen levels and nutrients could lead to algal blooms and aquatic weed growth, which could impact aquatic ecosystems, amenity, recreation, irrigation, livestock, and aquatic foods • potential for pollution and impacts described above to impact peat swamps identified at Blackheath and Little Hartley, as well as the Blue Mountains Special Area at Blackheath.
Oxidation and/or runoff stockpiles comprising acid sulfate rock (ASR) at Little Hartley during construction excavation, earthworks and tunnelling.	• sulfuric acid production resulting in more aggressive conditions and increased acidity of surface water impacting water quality • reduction in pH of downstream receivers can stress aquatic fauna and flora • reduction in pH can increase solubility of metal pollutants which can negatively impact aquatic organisms.

Erosion and sedimentation management measures and water treatment plant maintenance procedures would be detailed in the Construction Environment Management Plan (CEMP) for the project. These measures would be implemented in accordance with Managing Urban Stormwater – Soils and Construction, Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008), commonly referred to as the ‘Blue Book’. Compliance with the Blue Book requirements would meet NorBE requirements for the construction phase of the project.

No public access to the Blackheath Special Area would be permitted as the construction site would be appropriately secured.

With the implementation of these controls, potential construction related erosion and sedimentation impacts would be appropriately managed and would be negligible.

Water treatment

As described in Section 14.2.4, the water quality controls and drainage infrastructure such as sediment basins at the Blackheath and Little Hartley construction sites would have been previously established by the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade project respectively.

These basins and drainage infrastructure would be appropriately sized to manage and mitigate the pollutants generated and convey flow volumes during construction, meeting the required criteria for the projects.

Water use requirements during construction of the project, including measures to avoid and minimise water consumption, particularly of potable water are outlined in Chapter 21 (Resource use and waste management). An indicative total for water required during construction is estimated at around 758,000 kilolitres. An indicative construction water balance for the project is outlined in Figure 14-7.

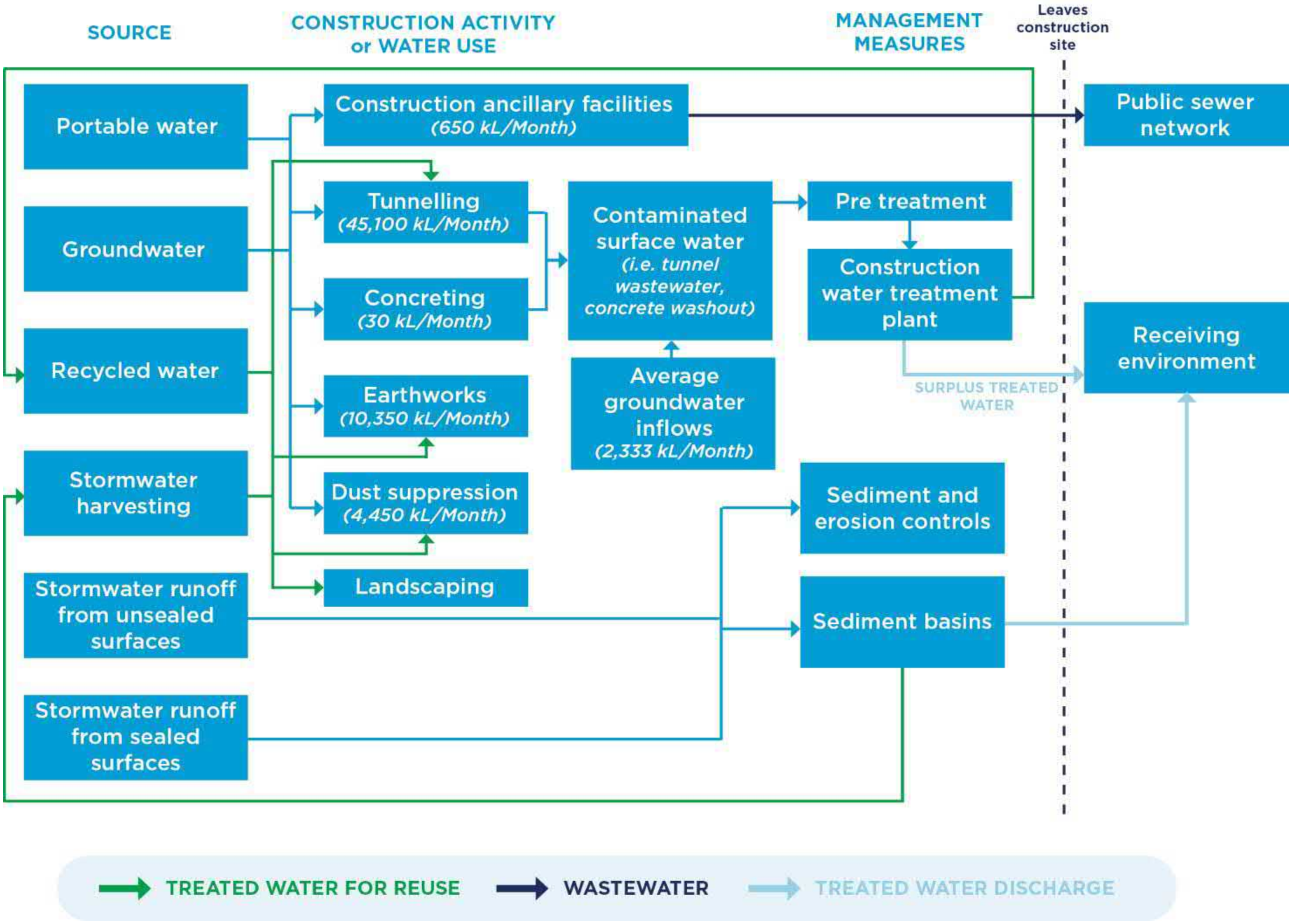


Figure 14-7 Indicative construction water balance[3]

[3] Recycled water and stormwater harvesting would make up at least 33 per cent of construction water demand

Water generated during construction would vary depending on the types of construction activities being carried out and the stage of construction. The majority of water generated during construction would be through tunnelling followed by earthworks. The new water supply pipeline at Little Hartley, described in Chapter 4 (Project description), would supply water to the Little Hartley construction site to support construction activities including the tunnel boring machines (TBMs).

A description of how construction water would be managed is provided in Chapter 5 (Construction).

As outlined in Section 13.3.1, predicted tunnel groundwater inflow volumes are predicted to:

- peak during construction of the tunnel (between the mid-tunnel cavern and Blackheath when the TBM switches to earth pressure balance mode), and during construction of the tunnel cross-passages
- decrease around 2029 once construction of these elements is complete, with the cross-passages and twin tunnels being tanked (i.e. structures which prevent groundwater from entering the structure as opposed to a drained structure which captures, diverts and treats groundwater ingress)
- stabilise after construction given most infrastructure would be tanked.

Water generated during construction including groundwater encountered during tunnelling would be captured and treated and either reused or discharged. The anticipated generation of water during construction would be greater than the potential for reuse. Therefore, treatment of surplus construction water and off-site discharge would be required. The water generated from tunnel construction would be tested and treated at construction water treatment plants at each construction site prior to reuse or discharge. Where surplus treated groundwater needs to be discharged, it may be discharged to the local stormwater system or to a surrounding local watercourse.

Treatment and discharge of water that cannot be reused would be carried out in accordance with the Environment Protection Licence for the project. Construction water would be treated so it meets the requirements for discharge to the Sydney Drinking Water Catchment in accordance with Part 6.61 of the State Environmental Planning Policy (Biodiversity and Conservation) 2021 which requires that developments have a NorBE on water quality.

Baseflow changes

Aquatic ecosystems may be sensitive to changes in groundwater quantity and quality. Some surface water features that are partially or wholly reliant on expressed groundwater to sustain baseflow can be affected by changes to groundwater. The surface water/groundwater relationship, including analysis of potential changes in baseflow to surface water environments as a result of the project are discussed in Chapter 13 (Groundwater and geology).

Tunnelling activities as part of the project would result in groundwater inflows and drawdown of groundwater which in turn has potential to reduce baseflows to surface watercourses. Groundwater modelling undertaken for the project indicates minor losses in baseflow along the tunnel alignment as a result of tunnelling activities. The most notable predicted reduction is at Greaves Creek, which is located immediately east of the proposed unlined (drained) Blackheath portal. This would be in the order of one per cent baseflow loss. Predicted impacts as a result of baseflow reduction at Greaves Creek and associated GDEs including THPSS are further discussed in Chapter 12 (Biodiversity).

Reductions in baseflow during construction are expected to be of short duration (less than six months) given majority of the project tunnel would be progressively lined during construction. This would be unlikely to impact the survival of plant communities as the small amount of baseflow reduction would be within the plant tolerance limits for seasonal variability. The risk to the swamp communities identified around Greaves Creek would continue to be assessed and refined as part of further design development (further discussed in Section 14.4.1).

14.3.2 Flooding

Potential flooding impacts identified during construction that could occur without the implementation of appropriate management measures may include:

- inundation and damage to construction sites, machinery, equipment and stockpiles and delays to construction programming
- safety risk to construction workers
- blockage of existing drainage infrastructure due to mobilisation of sediment
- increased flow rates in receiving drainage lines downstream of the construction footprint due to vegetation clearing and increased impervious areas
- increased velocity and ponding potentially restricting access to construction sites
- obstruction of floodwaters and overland flow paths due to temporary works, such as site sheds and stockpiles, leading to exacerbated flooding conditions in and outside the construction footprint.

Blackheath

As discussed in Section 14.2.6, Blackheath is unlikely to be affected by flooding. There is expected to be some overland flows during construction due to temporary blockage or diversion of waterways and drainage lines due to construction activities. Flood modelling has identified three overland flow paths, and these convey flows from west to east during the PMF event. It can be expected that smaller flow depths may be experienced through these locations during smaller events such as the five per cent AEP and one per cent AEP events. The following maximum flow depths were modelled for a the PMF event:

- 0.46 metres for overland flow
- 0.65 metres for localised ponding
- 0.75 metres within the existing channel within the project area to Greaves Creek.

Potential flooding impacts during construction would be considered during design development and detailed construction planning. This would include consideration of the Blackheath construction site layout (especially stockpile locations) so flows are effectively diverted or unimpeded. With the implementation of standard mitigation measures (in accordance with the Blue Book) and other controls, the potential impacts to surrounding properties, for flood hazard, hydraulic functions, downstream velocity and scour potential would be expected to be temporary and minor.

Without appropriate management of stormwater, there is potential for overland flow to impact the tunnel portals during construction. Construction sequencing should be considered in the CEMP to manage and direct flow paths away from both tunnel portals. Where this is not possible, bunding (or similar) would be used to divert flow paths. However, the overland flow would likely have a minimal impact on the tunnel entries during the construction phase since they are located at the ridge line with no upstream catchment and there is no flooding present in the existing PMF.

Additionally, the topography (and the project design) generally slopes downhill away from the tunnel portal. Hence, overland flow would not be directed toward the tunnel at any stage of the construction phase.

Soldiers Pinch

As discussed in Section 14.2.6 Soldiers Pinch is unlikely to be affected by flooding. Localised ponding may occur at lower elevations within this site and therefore stockpiles located in low points of the site have the potential to obstruct floodwater and alter flow paths. The layout of the Soldiers Pinch construction site, including the placement of construction plant and equipment, site offices and stockpiles relative to overland flow paths would be considered during design development and detailed construction planning.

The flood results for the five per cent AEP event have been used to guide the construction impact assessment and for the selection and layout of construction sites including areas of stockpiling and chemical storage. High level calculations estimate that the flow rate through the existing channel during the five per cent AEP event would be around 0.3 cubic metres per second. If the five per cent AEP peak flow can be conveyed within the channel, then stockpiles would be located at least above the identifiable banks of the channel. During design development and construction planning it would be determined if catch drains or bunding at locations upstream of stockpiles would be necessary to prevent water ponding from minor overland flow paths.

The proposed sediment basin would be located in the path of the channel and adequately sized to minimise downstream impacts of potential scour and erosion due to changes in surface water behaviour as a result of construction.

Little Hartley

An assessment of potential flood impacts during construction at Little Hartley has considered the full range of flood events (refer to Annexure A of Appendix J (Technical report – Surface water and flooding). The existing five per cent AEP flood results have been used to guide the construction impact assessment and for the selection and layout of construction sites including stockpiling and chemical storage. The existing five per cent AEP extent with observations in relation to flow conveyance, storage areas and flood hazard summarised in is summarised in Table 14-5 and presented in Figure 14-8. The Little Hartley construction site would be largely located outside the five per cent AEP flood extents.

Flood management measures and site planning as part of the CEMP would manage conveyance of overland flow to minimise potential flooding and scour impacts during construction. This would minimise the potential for impacts to surrounding properties including localised flooding, flood hazard, hydraulic function, downstream velocity and scour potential. These impacts are expected to be temporary and minor.

In the five per cent AEP event, overland flow was not observed near the Little Hartley portal. The topography in this area generally slopes downhill, away from the portal. However construction sequencing would be considered to manage and direct flow paths away from the tunnel entries.

Existing emergency evacuation routes are assumed to be eastbound and westbound via the Great Western Highway, and these would be retained throughout the construction phase.

Table 14-5 Construction flood impact assessment for Little Hartley – five per cent AEP event

Location (Figure 14-8)	Impact assessment	Mitigation
1 – eastern extent at tunnel portals	During the 5% AEP event the flood depth reaches up to 0.8 metres. A small area is classified with a flood hazard rating of H3 (unsafe for vehicles, children and the elderly).	Detailed construction planning would develop site layouts that avoid placement of construction plant and equipment, site offices and material stockpiles within the modelled extent of the 5% AEP event.
2 – immediately west of tunnel portals	Based on the 5% AEP flood hazard there are no restrictions at this location. There are some flow paths and flood extents during the 5% AEP event.	Detailed construction planning would develop site layouts that avoid placement of construction plant and equipment, site offices and material stockpiles within the modelled extent of the 5% AEP event.

Location (Figure 14-8)	Impact assessment	Mitigation
3 – Rosedale Creek	During the 5% AEP event the flood depth is modelled to exceed 1.2 metres. The flood hazard rating is H5 (unsafe for people and vehicles). The concentrated flow contributes to the high flood hazard risk (a safety threat to construction workers).	A dedicated floodway zone (avoid placement of construction plant and equipment, site offices and material stockpiles) would be established using the 1% AEP flood mapping during construction planning.
4 – western extent	Based on the 5% AEP flood hazard there are no restrictions. There are some flow paths and flood extents during the 5% AEP event.	Detailed construction planning would develop site layouts that avoid placement of construction plant and equipment, site offices and material stockpiles within the modelled extent of the 5% AEP event

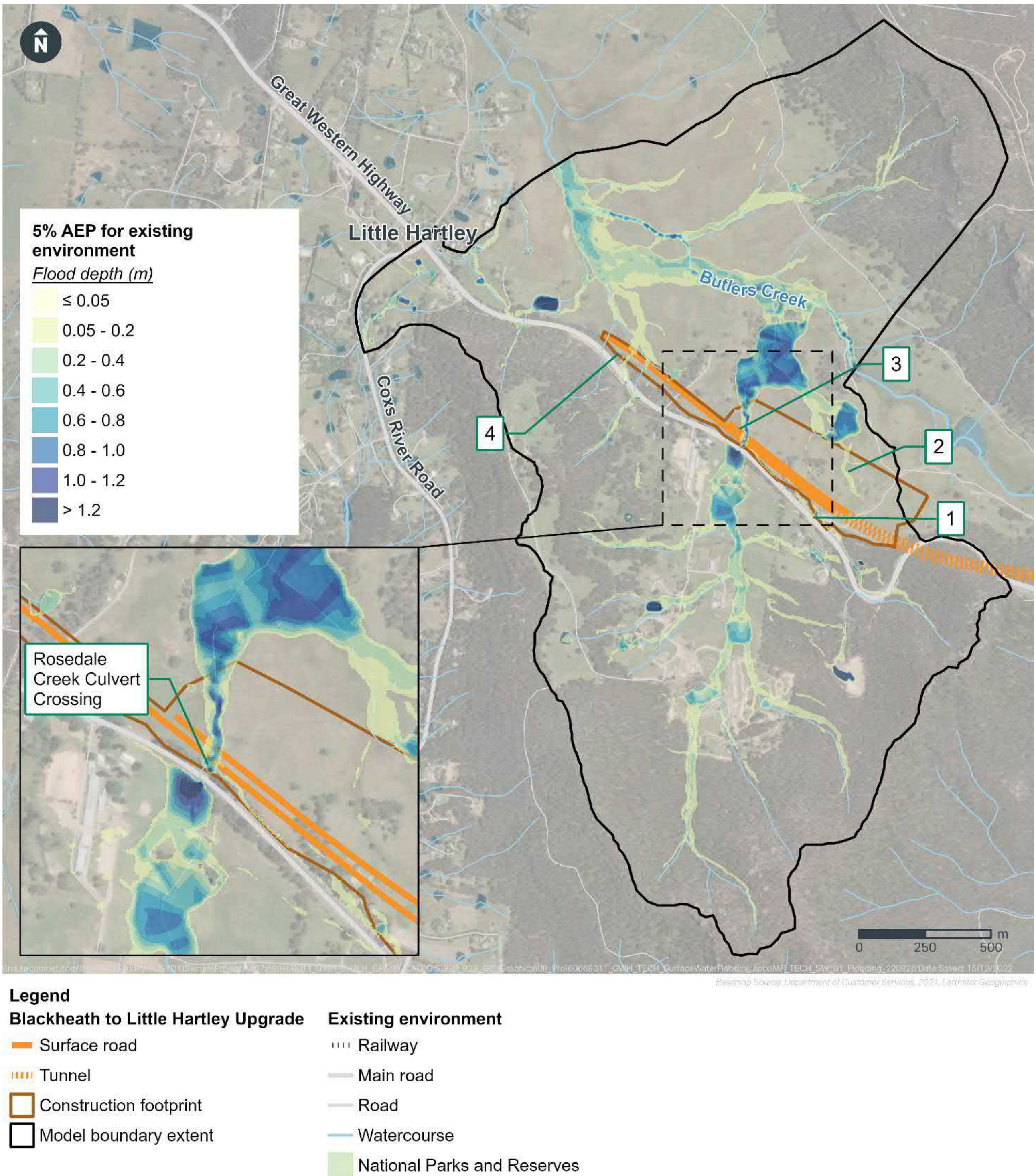


Figure 14-8 Modelled flood depth under a five per cent AEP event at Rosedale Creek (near Little Hartley construction site)

14.4 Potential impacts – operation

14.4.1 Surface water and hydrology

Surface water runoff

During operation of the project, there is potential for the following impacts if not managed appropriately:

- increased sedimentation which could affect receiving waterways impacting aquatic ecosystems
- increased turbidity, lower dissolved oxygen levels, and increases in toxicant concentrations could impact aquatic ecosystems and livestock
- nutrients in runoff could lead to algal blooms and aquatic weed growth, which could impact aquatic ecosystems, recreation, irrigation, livestock, and aquatic foods
- reduced visual amenity could result from turbid water and visible gross pollutants, impacting recreation and visual amenity
- potential for pollution and impacts described above to adversely affect peat swamps identified at Blackheath, Soldiers Pinch and Little Hartley, as well as the Blue Mountains Special Area at Blackheath
- increase in scour and erosion potential due to increase in impervious surface, mitigated by the proposed stormwater treatment devices
- increased acidity of surface water impacting quality from potential changes to pH levels from untreated ASR which could impact aquatic ecosystems
- alkalisation of surface water from runoff during rainfall periods, which could impact aquatic ecosystems.

To mitigate potential surface water quality impacts, stormwater treatment opportunities would be considered, including:

- flow splitters (a device designed to divert the flow of water into two or more directions)
- gross pollutant traps
- bioretention basins or filtration devices
- vegetated buffers and swales
- detention basins
- scour protection, energy dissipation devices and/or flow spreaders (structures that disperse the energy of concentrated flows).

The potential surface water runoff impacts would be largely mitigated by the proposed stormwater treatment devices and procedures for spills management. Therefore, the project would not be expected to impact the environmental values and water quality objectives of the receiving environment.

NorBE assessment

The annual pollutant loads of TSS, total phosphorus, total nitrogen and gross pollutants leaving the study area under both existing environment and project operation conditions are summarised for Blackheath and Little Hartley in Table 14-6. A NorBE assessment is not required for the Soldiers Pinch construction site as this temporary site would be used during construction only.

Stormwater treatment measures that would be located at each discharge location would include a range of onsite detention basins, sediment basins, water quality basins and flow spreaders. The indicative locations of these treatment measures are shown in Section 5.3 of Appendix J (Technical report – Surface water and flooding). The results of the NorBE assessment indicate that with the implementation of these treatment measures, the project would successfully achieve the

NorBE criteria in relation to annual pollutant loads by demonstrating pollutant load reductions of at least 10 per cent. Future design development could identify alternative treatment options that could be implemented to achieve the same outcomes.

Table 14-6 Operational NorBE assessment

Location	Criteria	Annual pollutant load (kg/year)			
		TSS	Total phosphorus	Total nitrogen	Gross pollutants
Blackheath (Sydney Drinking Water Catchment, Greaves Creek sub-catchment, tributary of the Grose River)	Existing environment	38,400	29	145	1,440
	Unmitigated	26,000[1]	44	220	2,460
	Mitigated	3,250	21	125	0
	Improvement compared to existing environment	92%	29%	14%	100%
	NorBE target met?	**Yes**	**Yes**	**Yes**	**Yes**
Little Hartley (Sydney Drinking Water Catchment, Butlers Creek sub-catchment, tributary of the Coxs River)	Existing environment	14,000	25	140	824
	Unmitigated	285,000	47	235	2,660
	Mitigated	1,330	15	106	0
	Improvement compared to existing environment	91%	42%	24%	100%
	NorBE target met?	**Yes**	**Yes**	**Yes**	**Yes**

Table notes:

1. TSS is greater for the pre-development case compared to the post-development (unmitigated) case at Blackheath as there is a greater percentage of unsealed roads in the pre-development case compared to the post-development case. An unsealed road produces approximately four times as much TSS as sealed road.

Water treatment

Water use requirements during operation of the project, including measures to avoid and minimise water consumption, particularly of potable water are outlined in Chapter 21 (Resource use and waste management). During operation, impacts to surface water availability and flows are expected to be minimal and would be minimised through the variety of treatment measures including those mentioned above and described further below.

An indicative operational water balance for the project is provided in Figure 14-9. Connection to and supply of mains water would be confirmed during design development. A new water supply pipeline between Lithgow and Little Hartley would provide operational water supply for the project at Little Hartley (noting that use of recycled water sourced from the project would be prioritised).

The tunnels would include drainage infrastructure to capture groundwater and stormwater, spills, maintenance water, fire deluge and other potential water sources. The tunnel drainage may contain a variety of pollutants (such as fuel, oil grease, and fire suppressants) requiring different treatment before discharge. Due to the potentially saline nature of the groundwater that may be encountered within the project locality (particularly from within coal seams), groundwater would also be treated prior to reuse/ discharge to minimise water quality impacts to the receiving environments. A permanent water treatment plant at Little Hartley would treat water to an adequate quality prior to reuse or discharge. All deluge flows, including those from the tunnel, would be stored and pumped to the water treatment plant with no untreated flows directly discharged into the receiving environment.

Surplus treated water would be directed to the environment. Indicative water quality treatment measure locations to meet NorBE requirements and discharge locations for Blackheath and Little Hartley are shown in Figure 5-4 and 5-5 of Appendix J (Technical report – Surface water and flooding), respectively. Engineered treatment measures would be located at each discharge location to treat stormwater runoff from the project. Several of these treatment measures would be constructed by the adjacent projects (Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade), and therefore are considered in the baseline environment for the project's surface water and flooding assessment.

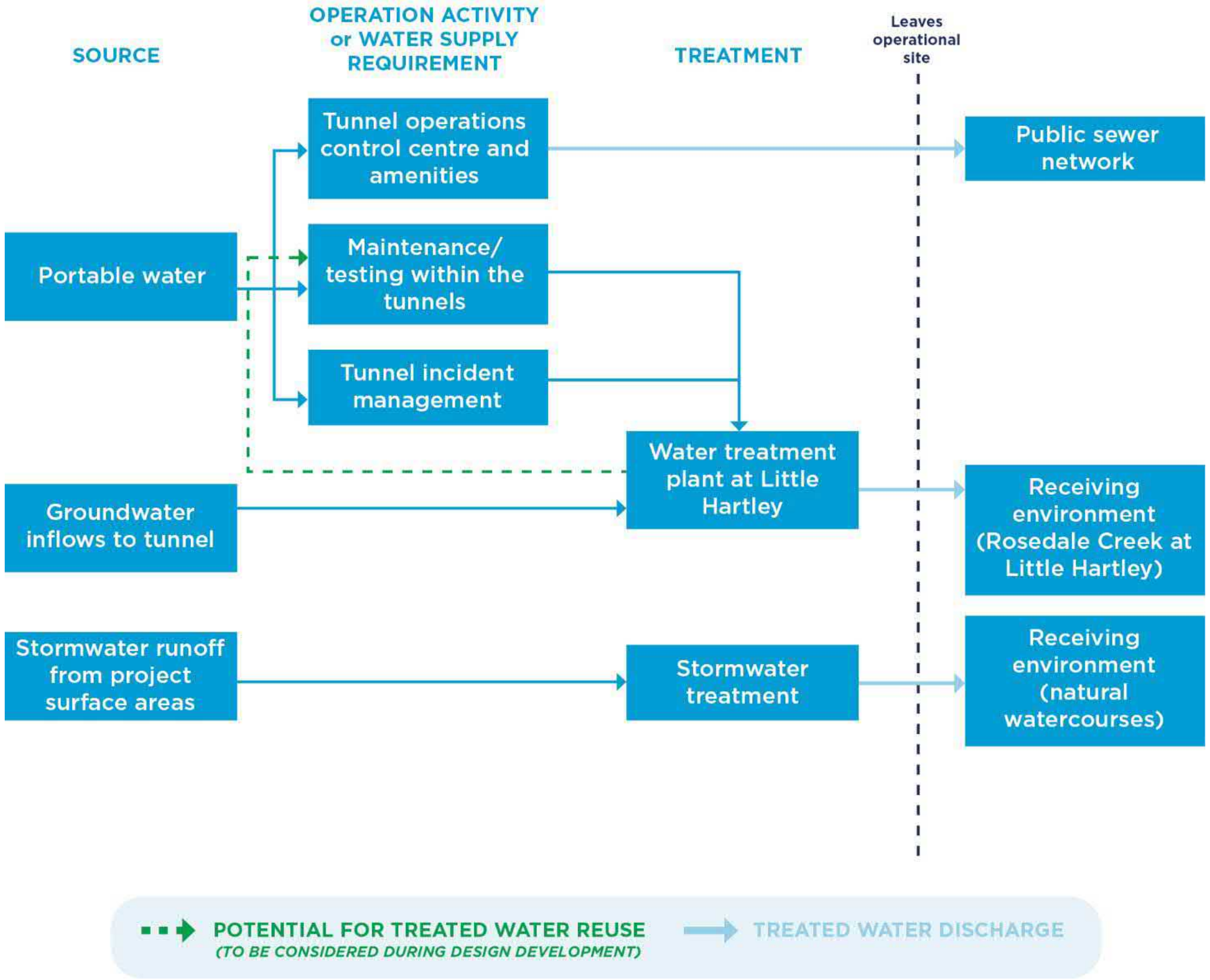


Figure 14-9 Indicative operation water balance

Baseflow changes

Changes in water quality and flows can be detrimental to the natural environment as they can:

- reduce the area of available habitat for sensitive fauna (such as native frog species)
- cause structural changes in creek lines, swamps and wetland ecosystems due to flow induced changes in geomorphology, or hydrological changes to the wetting and drying regimes of peat, which can affect the integrity of the peat
- cause alterations in the floristic diversity e.g. change in species density and vegetation community structural composition, increases in exotic species due to water quality changes.

Surface water features may be impacted during operation as a result of continued potential reduction in stream baseflow. Reductions in stream baseflows can negatively impact the valley floor infill swamps by reducing the water supply that these plant communities rely upon. Potential changes to stream baseflows are discussed in Chapter 13 (Groundwater and geology).

Reductions in baseflow of around 15 to 17 per cent (for a 95th percentile year (dry year)) are predicted at Greaves Creek near the Blackheath portal. In drier years there may be impacts to peat swamps. Potential impacts related to a reduction in baseflows and management measures are further discussed in Chapter 12 (Biodiversity).

Further investigation into the impacts of baseflow reductions on watercourses and swamps will be undertaken during design development. Future investigations would include field hydrogeological investigations to provide more accurate, site-specific parameters that can be used in predictive groundwater modelling. Modelling would then be revised for this catchment to enable more accurate predictions of the likely impact of the Blackheath portal on baseflow reductions.

If revised modelling determines that a reduction in baseflow to the valley floor infill swamps of Greaves Creek is likely and that there is a risk of detrimental impacts to these ecosystems as a result, then further mitigation measures would be investigated. Performance outcomes for the mitigation measures would be developed and agreed upon by subject matter experts, and mitigation actions including design responses such as lining the Blackheath tunnel portal would be assessed for their effectiveness in addressing the risk.

In the instance that residual risk is predicted, monitoring would continue during construction for the hydrogeology, geomorphology and vegetation community likely to be impacted. Observations would be assessed against set triggers, trigger thresholds, and responses for observed impacts. Monitoring methods would be developed with reference to supporting justification where appropriate.

14.4.2 Flooding

The operational flooding assessment considered proposed surface components of the project at Blackheath and Little Hartley as these have the potential to obstruct or alter the path of surface water flows. As no operational ancillary facilities would be located at Soldiers Pinch, this site has not been considered in the operational assessment.

Potential flooding impacts during operation, if not adequately managed may include:

- changes in peak flood level within the study area
- increases in velocity and scour potential
- increase in flood hazard
- impacts to adjacent property and infrastructure due to changes in flood behaviour.

Generally operational flooding impacts are expected to be minimal with the implementation of appropriate mitigation measures. Drainage infrastructure delivered as part of the Little Hartley to Lithgow Upgrade would also result in increased flood immunity through the addition of drainage infrastructure described in Section 14.2.4, therefore improving the existing and baseline flooding environment at Little Hartley.

Blackheath

As discussed in Section 14.2.6 Blackheath is unlikely to be affected by flooding. Flood modelling for the existing environment PMF event, as shown in Figure 14-5, indicates that the overland flow is expected to have minimal impact on the proposed tunnel portal locations. Water currently flows east away from the Blackheath portal due to the project's location on a natural ridgeline.

Flood immunity of the tunnel portals at Blackheath would also be achieved. The surface drainage infrastructure would direct all surface road runoff around or away from the Blackheath tunnel portal towards the nearest drainage outlet and after treatment, be reused or discharged to the closest waterway. Surface drainage infrastructure (including pits, pipes, detention basins and on-site detention tanks) at Blackheath have been designed to capture and convey all flows up to and including the 0.05 per cent AEP event (1 in 2000 year flood event). Therefore this design provides flood immunity for the highway and tunnel portals at Blackheath.

Based on the surface drainage system design, the project is not expected to adversely impact existing flood characteristics (including flood hazard, hydraulic functions, downstream velocity and scour potential) or surrounding properties and infrastructure. The drainage design would effectively convey stormwater flows, not increase scour and erosion potential in receiving waterways and manage localised flooding. As the project would not impact any residential, commercial or industrial dwellings, or result in an increase in peak flood velocity, the flooding criteria would be met (described in Section 2 of Appendix J (Technical report – Surface water and flooding)).

Little Hartley

Flood modelling for one per cent AEP event at Little Hartley is shown in Figure 14-6. The remaining flood scenarios are shown in Annexure A of Appendix J (Technical report – Surface water and flooding).

Various flood events were modelled for Little Hartley including the five per cent AEP, two per cent AEP, one per cent AEP, 0.2 per cent AEP[4] (climate change) and PMF events. The following potential operational flooding potential impacts were observed based on modelling results:

- during the one per cent AEP event:
  - with the introduction of the proposed realigned culvert at Rosedale Creek as part of the Little Hartley to Lithgow Upgrade, no overtopping of the upgraded Great Western Highway is observed at this location (see Figure 14-6)
  - overtopping of the upgraded Great Western Highway occurs at location one, resulting in a six metre flow width and high flood velocity (around 2.5 metres per second) which is not compliant with the flood immunity criteria. Drainage design, such as lowering and refining the design of the swale, would be investigated during design development to mitigate overtopping of the existing highway
  - immediately downstream of the Rosedale Creek culvert, a localised high flow velocity of around eight metres per second for the one per cent AEP is estimated due to a change in elevation at this location. The high velocity may lead to increased scour potential at this location, therefore scour protection would be included at this location. Design refinement would include using energy dissipation, erosion and sediment control measures at all drainage outlets to minimise these impacts
  - due to the proposed drainage design for the project, conveyance of surface water under the Great Western Highway, particularly at Rosedale Creek, is improved. Upstream of the culvert would generally experience a reduction in flood level, since the proposed culvert would convey more water downstream. Immediately downstream of the culvert, a flood level increase of up to 700 millimetres is predicted. At the existing dam downstream of the Rosedale Creek culvert there would be an increase in influx of 10 to 15 millimetres.

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[4] In accordance with ARR 2019 guidelines and "Technical Guide Climate Change Adaptation for the Road Network" provided by Transport, the 0.2 per cent AEP was adopted to represent the climate change scenario of the one per cent AEP flood event

Downstream of the project, modelled flood level increases are less than 100 millimetres with no adverse flood impact or flood damage to surrounding residential areas, commercial areas or agricultural land expected, thereby complying with the flooding criteria used for this project (further described in Section 2 of Appendix J (Technical report – Surface water and flooding))

  - locations which exceed a flood hazard rating of H2 (unsafe for small vehicles) are confined to existing concentrated flow paths and water bodies, with no detrimental changes to flood hazard predicted during operation

- during the 0.2 per cent AEP event (climate change):
  - the only change to flood behaviour would be a localised flood level increase upstream of the Rosedale Creek culvert crossing. The flood depth would increase from around 2.8 to 3.2 metres for the 0.2 per cent AEP compared to the one per cent AEP. Downstream of the Rosedale Creek culvert crossing, the flood depth would increase from around 1.5 to 1.8 metres for the 0.2 per cent AEP compared to the one per cent AEP. Therefore the predicted effects of climate change are not expected to materially change the flood risk of the project
- during the PMF event:
  - both tunnel portal entries would achieve the flood immunity criteria as there is no overland floodwater flowing from the floodplain that reaches the portals. Based on the localised topography, any floodwater conveyance flows away from the tunnel portals.

The proposed surface road drainage is designed to convey up to the 10 per cent AEP event for the underground drainage system and flood immunity is designed up to the one per cent AEP for overland flow. The drainage design would effectively manage localised flooding based on criteria.

Flood modelling indicated an increase in velocity in a number of locations. Increases in velocity greater than one metre per second at locations downstream of the project are associated with transverse drainage structures and upstream of the project are associated with a proposed swale (described above). These exceedances would be managed as part of further design development and residual increases would be managed with measures detailed in Section 14.5 such as energy dissipation and flow control measures to minimise impacts of erosion and scour.

The potential flooding impacts above are not expected to impact transport corridors or nearby properties during operation. The Great Western Highway, as the primary road network and emergency evacuation route, would benefit from project related flood immunity improvements at Little Hartley improving community emergency management arrangements. The project would also provide an additional emergency access capacity in the event of flooding events which may affect the Great Western Highway.

Consultation with Lithgow City Council and the State Emergency Services was undertaken to review the flood behaviour and the evacuation management route for the project, which also concluded that with appropriate stormwater management measures, no impacts would be expected. Consultation with Blue Mountains City Council was not undertaken as no flood impacts are anticipated within the Blue Mountains local government area.

14.5 Environmental mitigation measures

14.5.1 Performance outcomes

Performance outcomes for the project in relation to surface water and flooding are listed in Table 14-7 and identify measurable performance-based standards for environmental management.

Table 14-7 Surface water and flooding performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
Flooding The project minimises adverse impacts on existing flooding characteristics.	Design and construct the project to minimise adverse effects on existing flooding characteristics, to meet relevant standards, guidelines and policies and meet the flood design criteria developed for the project.	Design and construction
Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure.	Design and construct the project to achieve flood immunity consistent with design standards, guidelines and policies for road and tunnel infrastructure and meet the flood design criteria developed for the project.	Design and construction
Water – Hydrology Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised. The environmental values of nearby, connected and affected water sources, including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved).	Design and operate the project to minimise adverse long term impacts on surface water and groundwater, and related environmental values, including: • minimising the volume and rate of groundwater inflow to the project during operation • minimising the magnitude and extent of groundwater drawdown around the project during operation • minimising the reduction in baseflow volumes in watercourses affected by groundwater drawdown around the project during operation • discharging surface water from the project, including site runoff and water treatment plant discharges, to achieve a neutral or beneficial effect on the receiving watercourse and catchment, taking into account relevant Water Quality Objectives.	Design, construction and operation
Sustainable use of water resources.	Design, construct and operate the project to minimise the volume of water and rate of water consumption required during construction and operation. Subject to quality and volume requirements, maximise the reuse and recycling of water within the project.	Design, construction and operation

SEARs desired performance outcome	Project performance outcome	Timing
Water – Quality The project is designed, constructed and operated to protect the NSW Water Quality Objectives where they are currently being achieved, and contribute towards achievement of the Water Quality Objectives over time where they are currently not being achieved, including downstream of the project to the extent of the project impact including estuarine and marine waters (if applicable).	Manage surface water discharges from the project during construction and operation, including collection and treatment where necessary, to achieve a neutral or beneficial effect on receiving watercourses and catchments, taking into account relevant Water Quality Objectives.	Design, construction and operation

14.5.2 Mitigation measures

Mitigation measures that would be implemented to manage potential surface water and flooding impacts of the project are listed in Table 14-8. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 14-8 Environmental mitigation measures – surface water and flooding

ID	Mitigation measure	Timing
SW1	A Construction Soil and Water Management Plan (CSWMP) will be prepared as part of the Construction Environmental Management Plan (CEMP) in consultation with relevant government agencies and local councils. The CSWMP will be prepared and implemented to detail measures to minimise erosion and sedimentation, manage surface water and flooding, and protect local water quality during construction, including the potential impacts of high risk construction activities to the Sydney Drinking Water Catchment and the Blue Mountains Special Area. The CSWMP will include: • erosion and sediment control measures prepared by or in consultation with a soil conservationist to be applied to each construction site, consistent with the guidance in *Managing Urban Stormwater – Soils and Construction (4th Edition)* (Landcom, 2004). Specific control measures may include: - diversion of runoff from undisturbed areas of the catchment around project disturbance areas - diversion of existing drainage lines disturbed by construction, or establishment of an alternative drainage line - construction and commissioning of sediment and water quality basins before major earthworks. Where projects overlap, the sizing of basins would account for the concurrent construction catchments and common discharge locations shared between the east, central and west projects, and sizing would be modified as required to accommodate the construction catchments. - use of sediment management devices such as fencing, sandbags, coir logs and graded or lined earth or sandbag diversion bunds and banks	Construction

ID	Mitigation measure	Timing
	- measures to divert or capture and filter water prior to discharge, such as drainage diversion channels to flush and sediment sumps or traps - scour protection and energy dissipaters at locations of high erosion risk - location and storage of construction materials, fuels, and chemicals, including controls where possible to minimise the risk of leaks, spills and other unintended releases - storage of materials clear of frequently flooded low-lying areas - stabilisation of the surface of batters and drains, including temporary works and diversions - regular inspections and responsive adaptive management to improve erosion and sedimentation control practices as required to achieve the outcomes of the Blue Book. This will include inspections at regular intervals and after large rainfall events. • planning and management of stockpile areas in accordance with *Stockpile Site Management Guideline* (RMS, 2011a) • progressive and timely stabilisation and rehabilitation of disturbed areas, taking into account the ultimate requirements of the Place Design and Landscape Plan (PDLP) for the project (refer to environmental mitigation measure LV1) • a spill management procedure to minimise the risk of release of construction materials, fuels, and chemicals from construction sites. The procedure will include: - management of chemicals, fuels and potentially polluting materials - any specialised containment, security and bunding requirements (refer to environmental mitigation measure HR02) - maintenance of plant and equipment - emergency management, including notification, response, and clean-up procedures • measures to manage construction activities in areas prone to flooding or inundation, particularly around Rosedale Creek, including: - daily monitoring of weather conditions, including rainfall forecasts, to provide advance warning of potential flooding or inundation - cessation of relevant works and site security and stabilisation requirements in the event of a severe weather warning - site clean-up and recovery measures in the event of flooding or inundation • measures to manage acid sulfate rock, consistent with the Acid Sulfate Rock Management Plan (ASRMP) for the project (refer to environmental mitigation measure SC3).	

ID	Mitigation measure	Timing
SW2	A surface water monitoring network will be maintained for the project to: • continue to gather baseline surface water monitoring data to inform ongoing design development, and the updated numerical groundwater model for the project • characterise the hydrological environment along and around Greaves Creek and associated groundwater dependent ecosystems • monitor surface water, including surface water quality, prior to, during and for two years after completion of construction of the project • complement the groundwater monitoring network for the project (refer to environmental mitigation measure GW3). The surface monitoring network will be developed in consultation with relevant government agencies, and monitoring data will be made available to those agencies upon request. A qualified hydrologist or environmental scientist or equivalently experienced professional will be engaged to periodically review surface water monitoring data, and to advise on potential surface water impacts and appropriate mitigation and management measures prior to, during and after construction of the project.	Design, construction and operation
SW3	Batters constructed as part of the project will be designed and implemented to minimise risk of exposure, instability, and erosion, and to support long-term, on-going best practice management, in accordance with *Guideline for Batter Surface Stabilisation using Vegetation* (RMS, 2015).	Design and construction
SW4	Construction wastewater, including water from each construction site and groundwater ingress collected during tunnel works, will be treated to a suitable standard prior to reuse and/ or discharge to the environment. Water quality criteria for discharges to the environment will be developed in consultation with relevant government agencies, and will be based on the need to achieve a neutral or beneficial effect on sensitive receiving waters and drinking water catchments.	Construction
SW5	Operational wastewater will be treated via a mix of water quality control basins and a wastewater treatment plant at Little Hartley to a suitable standard prior to reuse and/ or discharge to the environment as part of routine operations. Water quality criteria for discharges to the environment will be developed in consultation with relevant government agencies, and will be based on the need to achieve a neutral or beneficial effect on sensitive receiving waters and drinking water catchments.	Operation
SW6	Further design development will be carried out to minimise flooding impacts and to meet flood criteria identified for the project.	Design

15 Soils and contamination

This chapter summarises the soils and contamination assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full contamination assessment is provided in Appendix K (Technical report – Contamination).

15.1 Assessment approach

The following steps were followed to inform the soils and contamination assessment:

- review of available desktop information to provide context for the existing environment including:
  - previous and relevant site contamination reports
  - topographical and geological context, soil landscapes, salinity and acid sulfate soil potential for the region
  - soil and groundwater data collected from geotechnical investigations for the project
  - relevant Lotsearch reports, historical aerial photographs, historical titles and/or section 10.7 certificates (formerly section 149 certificates)
- a site inspection in December 2021 to investigate the existing environment
- development of a preliminary conceptual site model to provide the framework for identifying how receivers may potentially be exposed to contamination from contamination sources
- qualitative risk rating of contamination related construction and operational impacts of the project using the following categories:
  - low risk: a complete pollutant linkage would be unlikely
  - medium risk: a complete pollutant linkage may potentially be present, however the likelihood and consequence would be medium
  - high risk: a complete pollutant linkage would be likely.
- identification of suitable mitigation measures to manage the potential soils and contamination impacts of the project.

Further details of the methodology undertaken for the contamination assessment are provided in Section 2 of Appendix K (Technical report – Contamination).

15.2 Existing environment

15.2.1 Sensitivity of the receiving environment

The project would be located adjacent to the Blue Mountains National Park and the Greater Blue Mountains World Heritage Area. This sensitive and unique environment comprises important views, rugged tablelands, sheer cliffs, deep, inaccessible valleys and swamps supporting a diverse ecosystem. There are a number of sensitive ecological receivers and water bodies near the project, including threatened species and groundwater dependent ecosystems as well as water bodies supporting Sydney's drinking water catchment. The area is largely undeveloped and remains largely in its natural form.

15.2.2 Soils

Topography

The project would be located along a ridgeline. The land to the east is generally similar or at higher elevation and land to the west follows a moderately steep slope down towards the Megalong Valley. There are numerous mountain peaks in the area, including Mount Boyce to the west and Mount Victoria to the north. The land closest to the eastern and western ends of the project are the lowest and flattest and the land with greatest elevation is located near Mount Victoria at around 1,000 to 1,100 metres Australian Height Datum.

Soil landscapes

Nine soil landscapes are located across the area of the project. Soil landscapes within one kilometre of the project are mapped in Figure 15-1. A summary of the erosion hazard of each soil landscape is outlined in Table 15-1.

Table 15-1 Erosion hazards of soil landscapes near the project

Soil landscape	Erosion hazard
Lithgow (li)	Slight erosion hazard in wind and non-concentrated (slower, low power) stream flows. Moderate-high erosion hazard in concentrated (faster, higher power) stream flows.
Cullen Bullen (cb)	Moderate-high erosion hazard in concentrated and non-concentrated flows. Slight wind erosion hazard.
Medlow Bath (mb)	Moderate erosion hazard in non-concentrated flows. Moderate to high erosion hazard in concentrated flows. Slight-moderate wind erosion hazard.
Hassans Walls (hw)	Very high-extreme erosion hazard in concentrated and non-concentrated flows. Slight wind erosion hazard.
Warragamba (wb)	Very high-extreme erosion hazard in concentrated and non-concentrated flows. Slight wind erosion hazard.
Wollangambe (wo)	High-extreme erosion hazard in concentrated and non-concentrated flows. Slight wind erosion hazard.
Deanes Creek (dc) and Deanes Creek variant a (dca)	Slight-moderate erosion hazard in non-concentrated flows. Very high-extreme erosion hazard in concentrated flows. Slight wind erosion hazard.
Mount Sinai (ms)	High-extreme erosion hazard in concentrated and non-concentrated flows. Slight-moderate wind erosion hazard.
Disturbed terrain (xx)	Erosion hazard is variable according to site characteristics. Disturbed terrain was identified near the project at Berghofer's Pass (see Figure 15-1).

Soil salinity

Salinity refers to the salt content of soil or water and is caused by the build-up of salt in surface soil or water. The risk of salinity impacts can be increased by clearing vegetation, irrigation or other activities that can lead to a temporary rise in the groundwater table, which then leaves salt behind as it recedes. Based on searches of the National Assessment Dryland Salinity data, there are no areas of soil salinity recorded near the project. The overall salinity hazard along the project alignment is identified as 'very low' by the Hydrogeological Landscapes of New South Wales and the Australian Capital Territory (Department of Planning and Environment, 2016b).

Acid sulfate soils and rock

Acid sulfate soils are naturally occurring soils containing iron sulfides, which on exposure to air, oxidise and create sulfuric acid. Disturbance of acid sulfate soils and/or potential acid sulfate soils can result in adverse impacts on surface and groundwater quality, flora and fauna, and degradation of habitats.

Acid sulfate soil risk maps from the Australian Soil Resource Information System (ASRIS) database[1] have been reviewed for areas surrounding the project to determine the risk of acid sulfate soils being present. The acid sulfate soil probability near the project is shown in Figure 15-2. The project would be located within land mapped as low (six to 70 per cent chance of occurrence) and extremely low (one to five per cent chance of occurrence with occurrences in small, localised areas) probability for acid sulfate soil risk.

Acid sulfate rock (ASR) is unweathered rock (i.e. rock that has not been exposed to water, wind, ice, plants, or changes in temperatures) which contains metal sulfide minerals. When exposed to either oxygen or water, oxidation of the sulfide within the ASR leads to the formation of iron oxides, sulfuric acid, sulfates, and salts. Potential ASR deposits have been identified around the western sections of the project alignment, as shown in Figure 13-1 in Chapter 13 (Groundwater and geology).

[1] Acid sulfate soils have been verified using ASRIS data as class data derived from local environmental plan mapping is not available for this area.

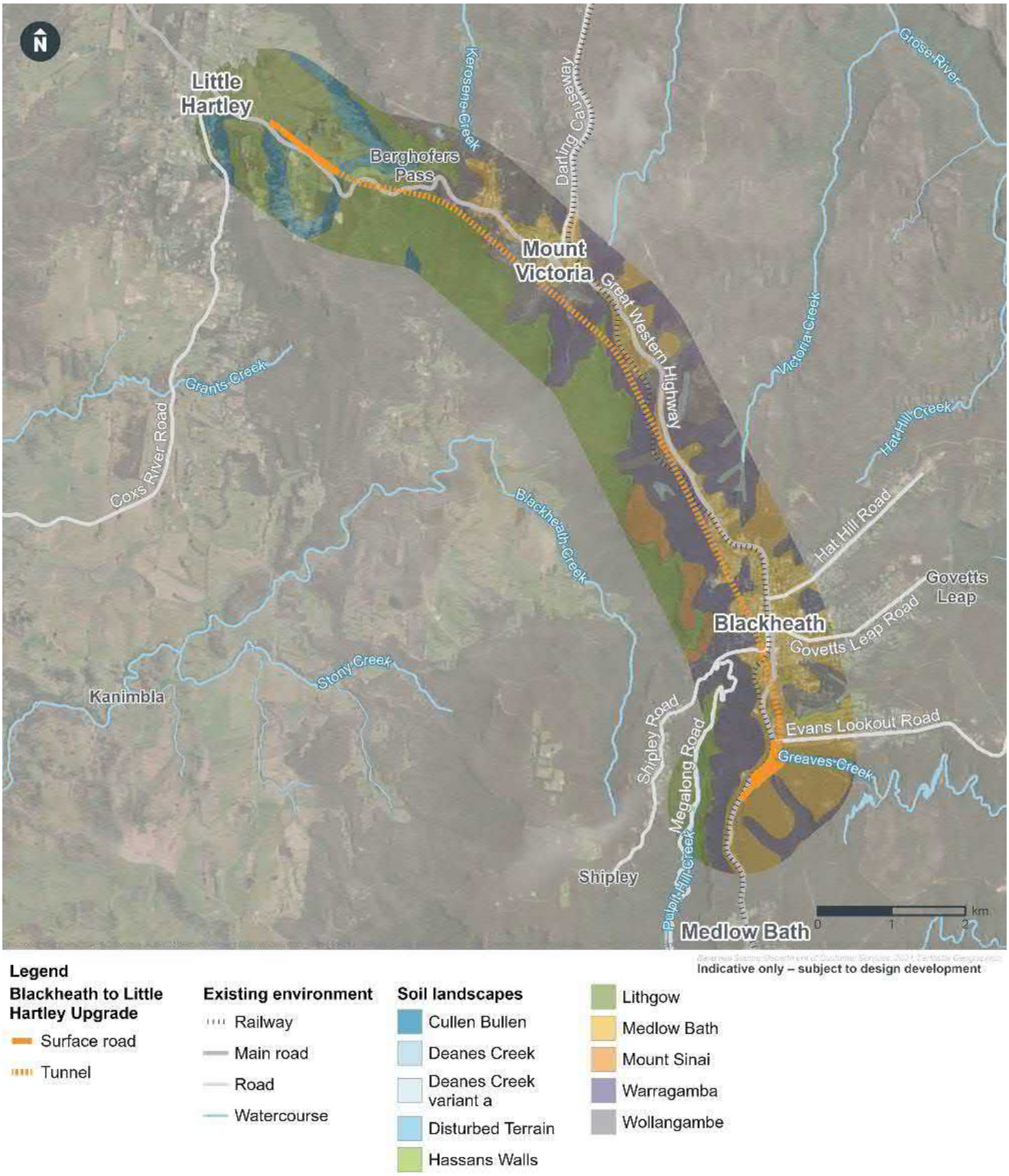

Figure 15-1 Soil landscapes within one kilometre of the project

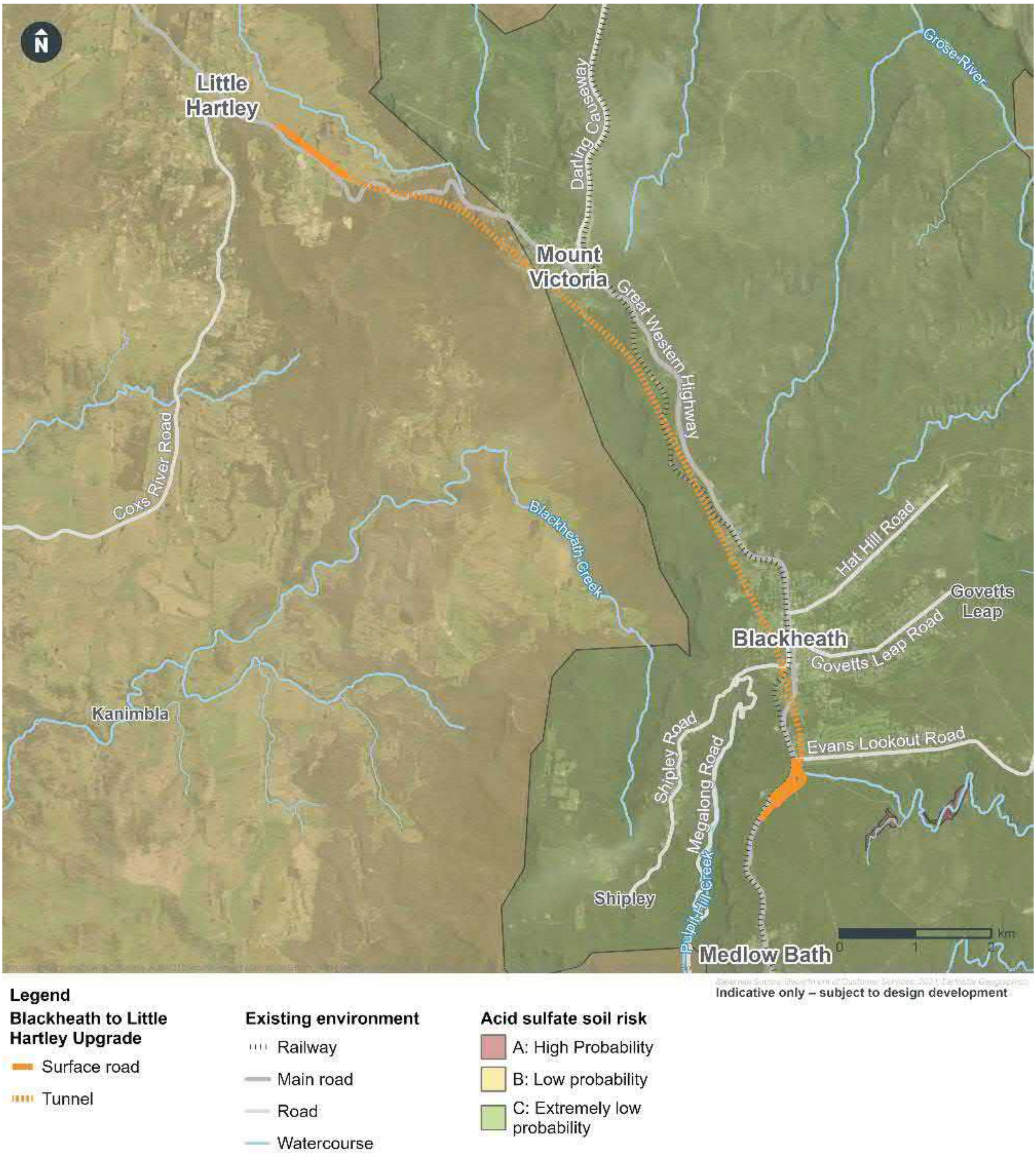

Figure 15-2 Acid sulfate soil risk near the project

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15.2.3 Contamination

The areas of environmental interest (AEIs) and contaminants of potential concern identified near the project are summarised in Table 15-2 and the AEIs are shown in Figure 15-3 to Figure 15-5. Some AEIs, including vehicle crashes and spills, coal seam gas and potential acid forming rock, could be encountered at various locations and are therefore not always indicated on figures (referred to as general areas of environmental interest in Figure 15-3 to Figure 15-5).

Table 15-2 Areas of environmental interest and potential contaminants of concern near the project

ID	Areas of environmental interest	Contaminants of potential concern
AEI-1	Mount Victoria rail maintenance yard	Heavy metals, polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPHs), total recoverable hydrocarbons (TRHs), asbestos and volatile organic compounds (VOCs) including benzene, toluene, ethylbenzene, xylenes and naphthalene.
AEI-2[1]	Railway lines and rail compounds	Heavy metals, PAHs, TPHs, TRHs, asbestos and VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene.
AEI-3	Current and former service stations, garages and service centres in Blackheath, Little Hartley and Mount Victoria	Heavy metals, PAHs, TPHs, TRHs, asbestos, per- and poly-fluoroalkyl substances (PFAS) and VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene.
AEI-4	Two fire stations in Blackheath and two fire stations in Mount Victoria	Heavy metals, PAHs, TPHs, TRHs, asbestos, PFAS and VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene.
AEI-5	Electricity substations at Blackheath and Mount Victoria	Heavy metals, PAHs, TPHs, TRHs, asbestos, PFAS, polychlorinated biphenyls (PCBs), semi-volatile organic compounds (SVOCs) and VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene.
AEI-6	Blackheath Laundrette	Heavy metals, PAHs, TPHs, TRHs, SVOCs and VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene.
AEI-7	Mount Victoria Sewerage Treatment Plant and effluent outflow area	Heavy metals, PAHs, TPHs, TRHs, SVOCs including phenols and organochlorine pesticides (OCPs), nutrients, PFAS and VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene.
AEI-8	Covered stockpiles adjacent to Valley View Road Blackheath	Heavy metals, PAHs, TPHs, TRHs, SVOCs including phenols and OCPs, nutrients, asbestos (bonded/friable), PCBs, PFAS and VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene.

ID	Areas of environmental interest	Contaminants of potential concern
AEI-9	Areas of possible historical landfilling in Blackheath Tip (yet to be remediated), Blackheath Oval/Jubilee Park, Eltham Park, Mountain Christian College	Heavy metals, PAHs, TPHs, TRHs, SVOCs including phenols and OCPs, nutrients, asbestos (bonded/friable), PCBs, PFAS and VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene.
AEI-10	Weber's Nursery, Mount Boyce and Wood You Believe Firewood	OCPs, organophosphorus pesticides (OPPs), herbicides, termiticides (arsenic) and nutrients (ammonia, nitrate, nitrite, phosphorous).
AEI-11[1]	Areas of possible historical landfilling adjacent to Soldiers Pinch, Browntown Oval and Great Western Highway roadworks/cut and fill areas	Heavy metals, PAHs, TPHs, TRHs, SVOCs, phenols, OCPs, nutrients, asbestos (bonded/friable), PCBs, PFAS and VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene.
AEI-12[1]	Illegal dumping	Heavy metals, PAHs, TPHs, TRHs, PFAS, asbestos and VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene.
AEI-13	Lolly Bug Little Hartley former service station	Heavy metals, PAHs, TPHs, TRHs, PFAS, asbestos and VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene.
AEI-14[1]	Vehicle crashes and spills	Heavy metals, PAHs, TPHs, TRHs, VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene, PFAS, asbestos.
AEI-15[1]	Previously demolished historical buildings	Lead and asbestos.
AEI-16	Former Little Hartley airfield	Heavy metals, PAHs, TPHs, TRHs, PFAS and VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene.
AEI-17[1]	Historical use of pesticides and herbicides	OCPs, OPPs, herbicides, termiticides (arsenic) and nutrients.
AEI-18[1]	Coal seam gas	Dissolved methane.
AEI-19[1]	Potential acid forming rock, towards the western section of the project alignment	Low pH.
AEI-20	CSR building products clay/shale, structural clay mine	Heavy metals, PAHs, TPHs, TRHs, VOCs including benzene, toluene, ethylbenzene, xylenes and naphthalene, PFAS and asbestos.

Table notes:

1. General AEIs

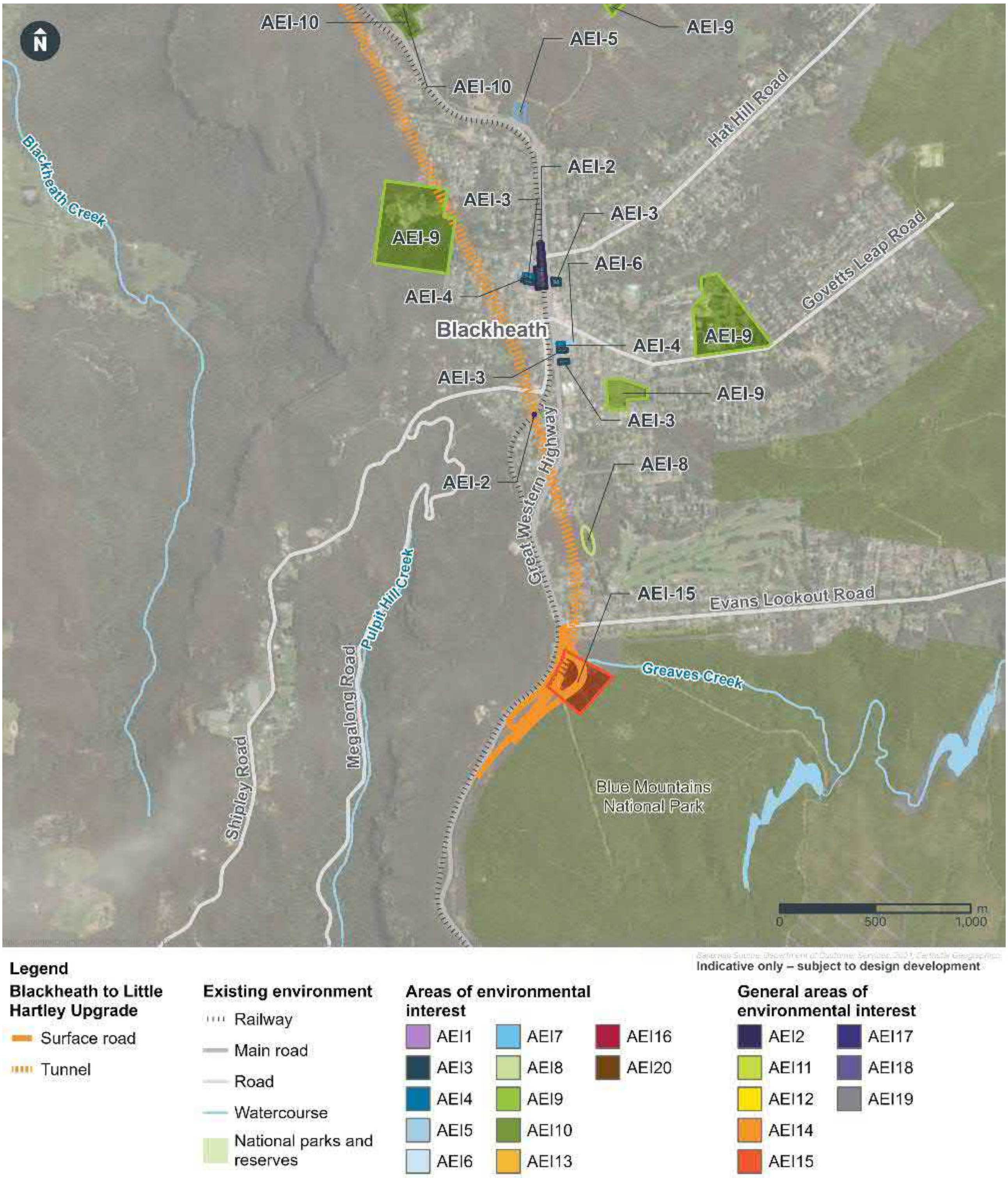


Figure 15-3 Areas of environmental interest near the project at Blackheath

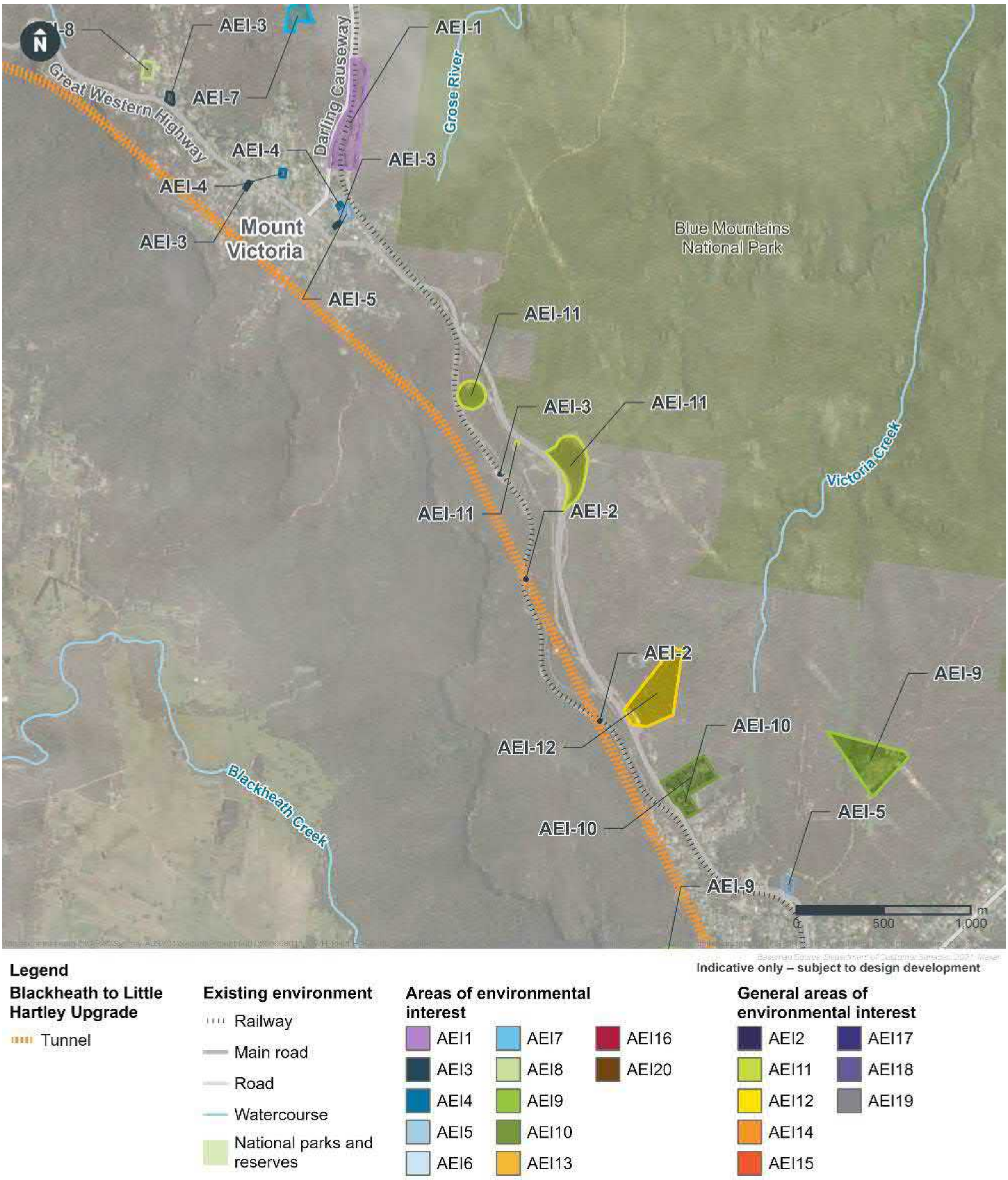


Figure 15-4 Areas of environmental interest near the project at Mount Victoria

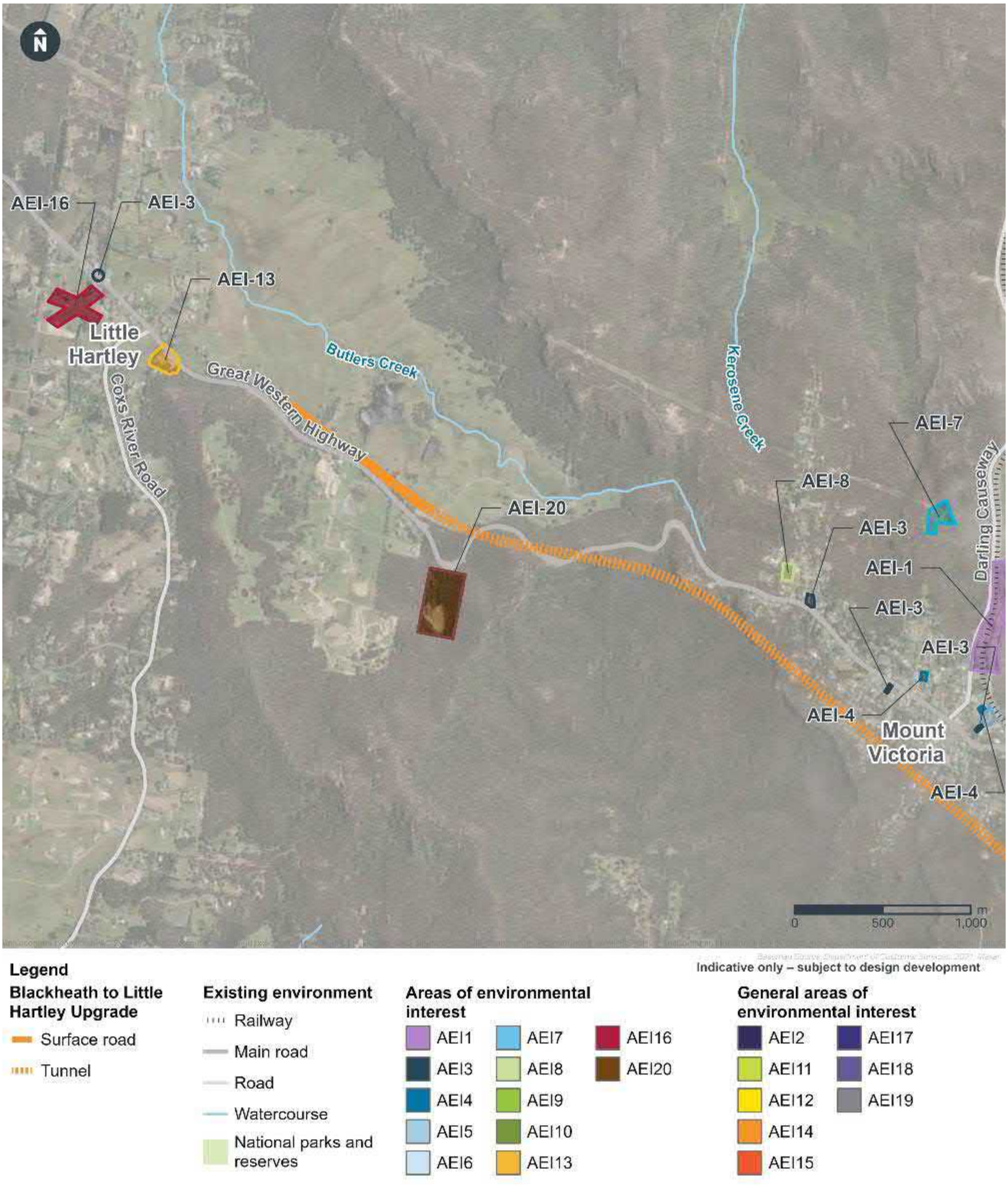


Figure 15-5 Areas of environmental interest near the project at Little Hartley

15.3 Potential impacts – construction

15.3.1 Soils

Construction of the project would temporarily expose the natural ground surface and subsurface through the removal of vegetation and excavation and compaction of topsoil. The temporary exposure and stockpiling of soil to water runoff and wind could increase soil erosion potential. There is the potential that exposed soils and other unconsolidated materials (such as spoil, sand and other aggregates) could be transported from the construction footprint into surrounding waterways via stormwater runoff.

Erosion controls would be implemented and managed in accordance with relevant guidelines to manage this risk.

It is unlikely that saline or acid sulfate soils would be encountered during construction. Unexpected saline or acid sulfate soils encountered during construction would be managed under the unexpected finds procedure that would be developed and implemented as part of the project.

Impacts from potential ASR are limited to potential water quality impacts from oxidation of inadequately treated ASR around Little Hartley. Further information on surface water impacts can be found in Chapter 14 (Surface water and flooding).

15.3.2 Contamination

Surface work

Construction work could result in potential soil, surface water or groundwater contamination from the following activities if unmitigated:

- spills of oils, fuels or chemicals from plant and equipment in the construction footprint
- accumulation of potentially contaminated sediments in sediment ponds and water treatment plant
- importing or backfilling of excavations with potentially contaminated spoil
- stockpiling of potentially contaminated spoil.

In addition, there is a risk of disturbing existing contaminated soil or groundwater sources during construction activities, which could result in:

- exposure of project workers and surrounding human receptors to contamination
- generation of contaminated surface water runoff from contaminated soils which could discharge to waterways or surrounding land
- generation of solid or liquid waste requiring disposal to landfill or a liquid waste facility.

Based on historical land use and currently available information, there is a pre-mitigation risk rating of medium for the construction sites at Blackheath, Soldiers Pinch and Little Hartley as shown in Figure 15-6. Construction activities in these locations would include excavation and temporary stockpiling. Potential contamination pathways could be through:

- direct contact, ingestion and inhalation by construction workers
- off-site transport via dust, vehicle/plant movements
- surface water runoff and discharge to receiving environment
- groundwater extraction and discharge to receiving environment.

Areas identified as having a medium risk of potential contamination during construction are presented in Table 15-3 and would be subject to targeted site investigations during ongoing design development. No high risk areas were identified, and areas identified as low risk would be managed through standard mitigation (refer to Section 7 of Appendix K (Technical report – Contamination)). Risk ratings would be reduced through the implementation of appropriate mitigation measures as detailed in Section 15.5. This includes detailed site investigations for areas of environmental interest within the construction footprint identified as posing a medium or greater risk and preparation of a Remedial Action Plan if required.

Table 15-3 Potential contamination issues during construction

Construction site	Potential contamination issue	Risk rating
Blackheath	• AEI-10 areas of possible historical landfilling • AEI-11 illegal dumping • AEI-13 vehicle crashes and spills • AEI-14 previously demolished historical buildings • AEI-16 historical use of pesticides and herbicides	Medium
Soldiers Pinch	• AEI-10 areas of possible historical landfilling • AEI-11 illegal dumping • AEI-13 vehicle crashes and spills	Medium
Little Hartley	• AEI-10 areas of possible historical landfilling • AEI-11 illegal dumping • AEI-12 Lolly Bug Little Hartley former service station • AEI-13 vehicle crashes and spills • AEI-14 previously demolished historical buildings • AEI-15 former Little Hartley airfield • AEI-16 historical use of pesticides and herbicides • AEI-20 CSR building products clay/shale, structural clay mine	Medium

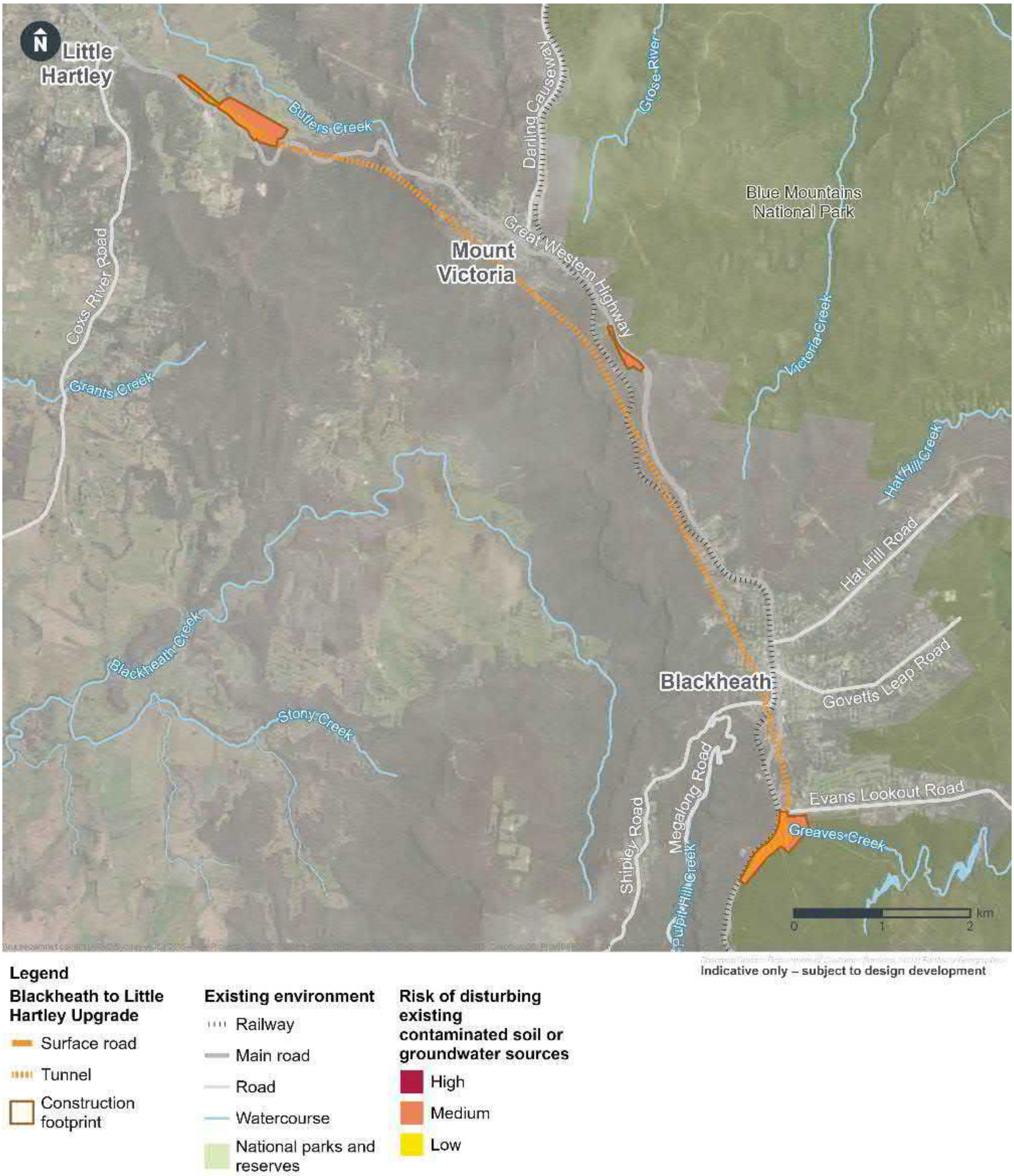


Figure 15-6 Pre-mitigation contamination risks relevant to the project

Tunnelling

Coal seams of varying thicknesses may be encountered during tunnel construction between Mount Victoria and Little Hartley, and therefore coal seam or methane gas may also be present in the surrounding geology. The risks to construction worker safety would be mitigated through measures such as advance investigation and monitoring, and possibly gas drainage (depressurising the coal seams of gas and water).

Groundwater from coal seams is likely to be saline and may contain concentrations of dissolved methane and hydrogen sulfide, as well as some heavy metals that would require treatment prior to discharge. Given the majority of the tunnels are likely to be constructed within bedrock and the majority of the tunnel would be tanked to minimise groundwater ingress, the potential risk for contaminated groundwater to be intercepted would be low. Intercepted groundwater would be directed to the construction water treatment plants where it would be treated and then reused and/or discharged.

15.4 Potential impacts – operation

15.4.1 Soils

Once construction is complete, potential impacts from saline or acid sulfate soils or erosion and sedimentation impacts would be negligible as:

- soils would generally not be disturbed during operation of the project
- the project would be located within land mapped as low to extremely low acid sulfate soil probability
- the overall salinity hazard along the project alignment would be very low
- exposed soil would be rehabilitated with vegetation cover to minimise erosion and sedimentation.

Further information on acid sulfate soils is provided in Chapter 14 (Surface water and flooding).

15.4.2 Contamination

Potential contamination sources during operation of the project would include:

- chemical and oil leaks or spills associated with vehicle accidents
- chemical and oil storage and use at operational ancillary facilities
- potentially contaminated stormwater flowing into tunnel portals, water treatment plant, or sediment ponds
- water discharged for fire suppression in the tunnel
- potential chemical leaks or inadequately treated discharge from water quality treatment plant used to treat stormwater ingress or water discharged for fire suppression in the tunnel.

These impacts could potentially cause localised soil and sediment contamination, and groundwater and surface water pollution if not managed appropriately. The receivers that could be potentially impacted include:

- riparian and aquatic flora and fauna near and within waterbodies and tributaries near the project
- nearby flora and fauna
- onsite maintenance workers carrying out intrusive works.

Potential contamination impacts associated with operation of the project were assigned a pre-mitigation risk rating (refer to Section 2.3.4 of Appendix K (Technical report – Contamination). No areas with high contamination risk were identified. Potential operational contamination impacts from key operational infrastructure and their pre-mitigation risk ratings are presented in Table 15-4. Risk ratings would be reduced through the implementation of appropriate mitigation measures as detailed in Section 15.5.

Table 15-4 Potential contamination issues during operation

Infrastructure	Potential contamination impact	Risk rating
Tunnel operations facility at Blackheath	• contamination impacts from leaks and spills from oils, fuels, solvents and other chemicals stored and used at the facility if not stored and handled in accordance with applicable regulations.	Medium
Water treatment plant at Little Hartley	• minimal soil or groundwater contamination impacts would be expected from the operation of the water treatment plant • sources of contamination could be from small volumes of oils, fuels, solvents and other chemicals used for operation and maintenance if not stored and handled in accordance with regulations and from leaks and spills of untreated wastewater.	Medium
Sediment and water quality basins at Blackheath and Little Hartley	• minimal soil or groundwater contamination impacts would be expected from the operation of the sediment and water quality basins • sources of contamination could be from spills of untreated surface water and inappropriate management of contaminated sediments.	Medium
Ventilation facilities and associated infrastructure – Blackheath and Little Hartley	• under the ventilation outlet option, minimal soil or groundwater contamination impacts would be expected from the operation of the substation and ventilation facilities • under the portal emissions option, negligible soil or groundwater impacts would be expected from the operation of portal emissions infrastructure • sources of contamination could be from small volumes of oils, fuels, solvents and other chemicals used for operation and maintenance if not stored and handled in accordance with regulations.	Low
Tunnels	• during operation, groundwater seepage, stormwater drainage at tunnel portals, tunnel wash-down water, fire suppressant deluge or fire main rupture and spillage of flammable and other hazardous materials would be captured by tunnel drainage and treated, reused or discharged to the receiving water bodies. If the discharged water is not treated to the required standard there could be adverse impacts on water quality of the receiving environments • groundwater quality may be impacted along parts of the tunnel alignment due to overlying contamination sources impacting groundwater. The mainline tunnels have been designed to minimise intersecting highly permeable material that could result in high groundwater inflows into the tunnels and would be tanked to minimise groundwater ingress.	Low

Infrastructure	Potential contamination impact	Risk rating
Other features including utility connections and substations for power supply	• sources of contamination could be leaks and spills of small volumes of oils, fuels, solvents and other chemicals used for operation and maintenance if not stored and handled in accordance with regulations • inappropriate soil management practices during installation of utilities, spills and leaks from substations and not assessing imported materials.	Medium

15.5 Environmental mitigation measures

15.5.1 Performance outcomes

Performance outcomes for the project in relation to soils and contamination are listed in Table 15-5 and identify measurable performance-based standards for environmental management.

Table 15-5 Soils and contamination performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
The environmental values of land, including soils, subsoils and landforms, are protected.	Design and construct the project to minimise the disturbance of soils and changes in landform. Rehabilitate disturbed land that is not required for operational infrastructure to a state comparable with its pre-disturbance condition or as otherwise agreed with the landowner.	Design and construction
Risks arising from the disturbance and excavation of land and disposal of soil are minimised, including disturbance to acid sulfate soils and site contamination.	Characterise and evaluate the risks associated with land and soils affected by the project prior to disturbance, including with respect to potential contamination and acid sulfate soils. Develop and implement management measures specific to the characteristics and risks of land and soils to be disturbed, including the preparation of a Remedial Action Plan for contaminated land where relevant.	Construction

15.5.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential soil and contamination impacts of the project are listed in Table 15-6. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 15-6 Environmental mitigation measures – soils and contamination

ID	Mitigation measure	Timing
SC1	A Detailed Site Investigation (DSI) will be carried out for areas of environmental interest within the construction footprint identified as posing a medium or greater risk, in accordance with the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (as amended 2013) and other relevant guidelines. If the DSI identifies that remediation of contaminated land is required, a Remedial Action Plan will be developed and implemented in accordance with relevant guidelines and codes of practice. If required, remediation will be performed as an integrated component of construction and to a standard commensurate with the proposed end use of the land.	Design
SC2	An unexpected contamination finds procedure will be developed and implemented during construction of the project. The unexpected contamination finds procedure that includes a process for addressing unexpected contamination and will generally include provision for: • cessation of works within the affected area until inspection of the suspected contamination by a qualified contaminated lands specialist (verification by a certified contaminated land practitioner) • collection of soil samples for analysis based on observations • assessment of results against applicable land use or waste classification criteria in accordance with applicable statutory guidelines • management of the contamination in accordance with applicable statutory guidelines.	Construction
SC3	An Acid Sulfate Rock Management Plan (ASRMP) will be prepared as part of the Construction Environmental Management Plan (CEMP), taking into account the management guidelines in the *Acid Sulfate Soil Manual* (ASSMAC, 1998) and the *National Acid Sulfate Soils Guidance: National Sulfate Soils Identification and Laboratory Methods Manual* (Water Quality Australia, 2018). The ASRMP will include the process for identification, management and handling and re-use or disposal of acid sulfate rock.	Construction

16 Aboriginal cultural heritage

This chapter summarises the Aboriginal cultural heritage assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full Aboriginal cultural heritage assessment is provided in Appendix L (Technical report – Aboriginal heritage).

16.1 Assessment approach

The Aboriginal cultural heritage assessment has been informed by an Aboriginal Cultural Heritage Assessment Report carried out in accordance with the Procedure for Aboriginal Cultural Heritage Consultation and Investigation (PACHCI) (Roads and Maritime Services, 2011c), which included:

- a PACHCI Stage 3 for the Great Western Highway Duplication – Katoomba to Lithgow (the Upgrade Program). This report is referred to as PACHCI 2021 and provided in Annexure A of Appendix L (Technical report – Aboriginal heritage))
- a PACHCI Addendum for the project (referred to as PACHCI Addendum and provided in Appendix L (Technical report – Aboriginal heritage)). This addendum was required based on further design refinement between Blackheath and Little Hartley and areas that couldn't be accessed for survey in 2019-2020.

The Aboriginal cultural heritage impact assessment methodology for the project included:

- defining a study area for the Aboriginal cultural heritage assessment (see Figure 16-1). A broader study area was defined for the PACHCI 2021 and refined for the PACHCI Addendum
- desktop-based activities including review of previous reports, relevant registers and databases including:
  - the World Heritage List (WHL), the Australian Heritage Database (AHD), the State Heritage Register (SHR), Blue Mountains Local Environmental Plan (LEP) 2015 and Lithgow LEP 2014 for listed Aboriginal places
  - the Aboriginal Heritage Information Management System (AHIMS) for registered Aboriginal sites surrounding the project
  - review of the landscape context of the project, with specific consideration to its implications for past Aboriginal land use (archaeological potential)
- development of a predictive model to determine landforms of high archaeological potential
- consultation with Registered Aboriginal Parties (RAPs), including to understand the cultural values significant to Aboriginal people
- the PACHCI 2021 including site surveys conducted between November 2019 and March 2020, a total of fifteen days
- the PACHCI Addendum targeted site surveys with RAPs occurred over three days in May 2022 to confirm the extent of known Aboriginal sites and places and identify potential new sites
- assessment of the potential direct and indirect Aboriginal cultural heritage impacts of the project
- identification of mitigation measures to minimise the risk of potential impacts to Aboriginal cultural heritage.

Further details of the Aboriginal cultural heritage assessment methodology are provided in Appendix L (Technical report – Aboriginal heritage).

16.2 Existing environment

16.2.1 Cultural landscape

The project would be located on Dharug, Deerubbin, Gundungurra and Wiradjuri country with surrounding language groups including Darkinung to the north and Kuring-gai, Eora, and Tharawal to the east. The Dharug tribes are likely to have intertwined borders with the Gundungurra and the Wiradjuri tribes who also inhabited parts of the Blue Mountains.

The Dharug people were described to have tribal boundaries expanding from the mouth of the Hawkesbury River inland to Lithgow and the Newnes Plateau, with differing dialects spoken in the coastal and mountain areas (Tindale, 1974). The Blue Mountains area occupied by the Dharug people was known as Muru Marak or mountain pathway (Attenbrow, 2003). Similarities existed amongst the tribal groups in their use of traditional material culture. Wood, stone, shell and bone comprised the raw materials of this world, most of which have little chance of being preserved in an archaeological record. Culturally modified trees, which were used in the production of items such as canoes, containers, shelters and bowls have the potential to be present within the region as do carved trees associated with ceremonial sites. Evidence of campsites, with deposits of stone artefacts, hearths or middens, in contrast, are likely to be found where the landscape has not been subject to ground disturbance.

The upper Blue Mountains are characterised by dense vegetation, steep cliffs, valleys and watercourses, which lie on an undulating plain. Flowering vegetation such as Eucalyptus and Banksias would have been used as valuable resources by Aboriginal groups in the Blue Mountains area.

The area between Blackheath and Mount Victoria is underlain by Narrabeen Group sandstones and is comprised of abrupt cliffs and exposed sandstone. This landform pattern is representative of a dissected plateau, an elevated area that has undergone severe erosion, which creates sharp cliffs. The Great Western Highway is located on a relatively narrow ridgeline and a steep slope at Victoria Pass. It is anticipated that unidentified areas of Aboriginal cultural heritage value may occur on slopes such as these.

The project is adjacent to numerous watercourses situated in valleys including tributaries of the Coxs River to the west, the River Lett to the north, the Grose River to the east, and Govetts Creek to the south. Waterways were used by Aboriginal groups within the upper Blue Mountains for a variety of resources including fishing and making tools from raw stone materials such as basalt. Waterways were central elements of the cultural landscape, and governed Aboriginal people's choice of living places, travel routes, and gathering places for cultural and ceremonial activities (Annexure A of Appendix L (Technical report – Aboriginal heritage)). As such, many places of Aboriginal cultural significance occur along waterways. There is potential for unidentified areas of Aboriginal cultural heritage value to be present within topsoil nearby watercourses in the form of open stone artefact sites, and slopes near valley heads and Victoria Pass, in the form of rock shelters (Annexure A of Appendix L (Technical report – Aboriginal heritage)).

Chapter 17 (Non-Aboriginal heritage) describes the Greater Blue Mountains World Heritage Area including an additional area that has been nominated for inclusion on the National Heritage List (the Greater Blue Mountains Area – (Additional Values))for containing outstanding natural and cultural values including Aboriginal cultural values.

Generally, the landscape in the direct vicinity of the project has been highly modified. The built form has been influenced by the development of the Great Western Highway and associated features including road and street lighting, secondary roads, picnic areas, and a mix of commercial farming and smaller rural residential farm lots as well as the development of local townships including Blackheath and Mount Victoria. Due to extensive vegetation clearance, landscape modification and infrastructure development, most Aboriginal deposits that were present in these areas are likely to have been destroyed.

The project would traverse a number of unresolved Aboriginal land claims. Land claims under the *Aboriginal Land Rights Act 1983 (*NSW) do not necessarily denote Aboriginal cultural or scientific archaeological values. Land Councils are not required to establish cultural association with lands when making land claims under the *Aboriginal Land Rights Act 1983* (NSW). Further information regarding Aboriginal land claims is included in Chapter 20 (Business, land use and property).

16.2.2 Consultation with Registered Aboriginal Parties

In accordance with the requirements of the Aboriginal Cultural Heritage Consultation Requirements for Proponents (DECCW, 2010), consultation was undertaken with RAPs.

As part of the PACHCI 2021, 15 RAPs were involved in site surveys between 2019 and 2020. Aboriginal community consultation was carried out with the Warrabinga-Wiradjuri Native Title Group and Deerubbin and Bathurst Local Aboriginal Land Councils (LALCs). This consultation included identification of key Aboriginal stakeholders, archaeological site survey and engagement with these stakeholders during preparation of the Aboriginal Cultural Heritage Assessment Report.

As part of the project specific PACHCI Addendum, additional site surveys were undertaken in 2022 with the following RAPs:

- Waawaar Awaaa Aboriginal Corporation
- Dharug Ngurra Aboriginal Corporation
- Mingaan Wiradjuri Aboriginal Corporation
- Bathurst LALC.

As identified during these site surveys, sites or places in the landscape found by the RAPs to be associated with intangible cultural heritage are summarised in Table 16-1.

Further details on the Aboriginal community consultation carried out are provided in Annexure A of Appendix L (Technical report – Aboriginal heritage).

Table 16-1 Aboriginal cultural heritage values relevant to the study area

Cultural heritage values	Description
Resource gathering locations and techniques	Indigenous communities note that fish, plants and other foods are still collected throughout the region. The primary resource gathering locations and gathering techniques used are known and passed down through generations.
Campsites	Campsites are culturally significant for Aboriginal people as they provide a link to the ancestral past. Campsites also help identify significant resource zones, landscape pathways taken by their ancestors and communication with other groups.
Culturally modified or scarred trees	Scarred trees are of great importance to knowledge holders as they are of sacred and ceremonial importance. European land use and agricultural practices has resulted in scarred trees often being the only remaining markers for ceremonial sites and burials in the landscape.
Watercourses, waterholes, springs	Permanent water bodies are culturally significant as a central location for the gathering of people, resource collection and camping. Gullies and creeks also provide rich resources for Aboriginal people in the area, as well as provide habitat for platypuses which is a totem within the area.

Cultural heritage values	Description
Transit routes, pathways through the landscape and songlines	The pathways and routes taken by ancestors are culturally valuable to Aboriginal people. These pathways connect ceremonial and spiritual sites, as well as providing a connection route for trading and meeting with neighbouring tribes. The Blue Mountains is interwoven with songlines, with many knowledge holders believing that the Great Western Highway is built over one of the main songlines of the area connected to other pathways such as Mount York and Bells Line of Road. Songlines are an intangible cultural value as Aboriginal people feel connection to these spiritual pathways.
Plants and animals	Flora and fauna are not only seen as resources but hold cultural significance in spiritual and ceremonial values. Key animals preside within the rivers and waterways in the area surrounding the project. Platypus and eels have been specifically identified by community members.
Rock art engravings at Mount Victoria	A large goanna rock art engraving incorporating various art styles located at Mount Victoria (location not disclosed) is highly significant due to the styles incorporated into the art, that can be connected to Central Western art styles. The goanna also has three eyes on its head, which could be concerned with Diamond Lore. This Lore is associated with your identity and who you are.
Burial sites	Burial sites are of great importance and their protection is a high concern to Aboriginal people as the locations of burials are rarely documented. No known burial sites are located within proximity of the project. Knowledge holders have noted that scarred trees can be a marker for burial within the landscape.
Post-contact sites	Post-contact sites are places that have gained significance to Aboriginal people since the arrival of European settlers and are defined as an area where Indigenous people would have had a deep interaction with settlers. Contact sites predominantly depict an altering and destructive process.
Ridgelines	Knowledge holders commented on the importance of ridgelines as routes for travel and connectors to ceremony, resources and the receiving of sacred knowledge.
Cultural knowledge	Knowledge holders expressed that possessing cultural knowledge is both a sacred and a cultural right, and that sharing and passing on this knowledge can be a culturally burdensome task. Conversely, knowledge holders also noted that there is a strong history of losing cultural knowledge. Community members asserted that the loss of cultural knowledge that began with early colonisation and settlement has been exacerbated by the ongoing development in the region.
Ceremony or teaching sites in Blackheath	There are likely to be several sites used for ceremonies or teaching on Hat Hill Road, Blackheath.

Cultural heritage values	Description
Astronomy	Indigenous Australians are the world's oldest astronomers, presenting an unprecedented knowledge of the stars over the span of thousands of years of observation. Astronomy was used by indigenous Australians to develop calendars and navigate the land. Each tribe lived according to the cycle of the stars, which influenced what they hunted and ate, and where they travelled. Aboriginal people would likely have taken advantage of the high elevation of certain ridgelines and mountains within the project area.

16.2.3 Recorded Aboriginal sites

Aboriginal Heritage Information Management System

As part of the PACHCI 2021, an initial search of the AHIMS database was undertaken in 2019. An updated search was undertaken in 2021 which identified 36 registered Aboriginal sites within the search area comprising:

- 20 isolated artefacts
- one modified tree (carved or scarred)
- seven open camp sites
- one isolated artefact and modified tree (carved or scarred)
- six habitation structures (rockshelters), and PAD
- one habitation structure (rockshelter), PAD, and modified tree (scarred tree).

An updated search of the Aboriginal Heritage Information Management System (AHIMS) conducted for the PACHCI Addendum in June 2022 identified 93 registered sites. No AHIMS sites were identified within the study areas at Soldiers Pinch or Blackheath. Seven registered Aboriginal sites were identified in study area at Little Hartley as summarised in Table 16-2.

AHIMS sites are not presented in the public exhibition version of this chapter.

Table 16-2 AHIMS sites within the study area

Site ID	Site type
45-4-1075	Open artefact scatter
45-4-1076	Isolated find
45-4-1077	Open artefact scatter
45-4-1078	Open artefact scatter
45-4-1079	Open artefact scatter
45-4-1080	Open artefact scatter
45-4-1112	Scarred tree and isolated find

16.2.4 Site survey results

Previous archaeological investigations in the Upper Blue Mountains have demonstrated the presence of Aboriginal objects such as rock shelters and camp sites throughout the region, with certain areas such as heads of valleys and major creek lines as showing more archaeological potential.

As part of the PACHCI 2021, archaeological survey of the project area was carried out between November 2019 and March 2020 (Annexure A of Appendix L (Technical report – Aboriginal heritage)). These surveys indicate that rock shelters are anticipated on slopes at Victoria Pass, but there was low potential for them to be located elsewhere within the project study area. Scarred trees were predicted to occur at Victoria Pass, however due to extensive disturbance and the presence of farmed land the potential for them to be present in this location is reduced.

Further site surveys carried out between 2019 and 2022 confirmed that the study area has been subject to substantial and widespread previous disturbance. All sites listed in Table 16-2 were surveyed and found to be invalid for reasons including no artefacts being present, previous site disturbance and no evidence of cultural modification.

Three additional Aboriginal sites, shown on Figure 16-2 and Figure 16-3 were identified within the study area during surveys, including a culturally modified tree, an isolated find and an artefact scatter. These sites, as well as a description of their status and location relevant to the project are listed in Table 16-3.

These unregistered sites are not presented in the public exhibition version of this chapter.

Table 16-3 Additional Aboriginal sites identified during site surveys

Site name	Feature(s)	Location	Site status
Blackheath Portal Scar Tree 1	Culturally modified tree (carved or scarred)	Blackheath	Located within the part of the Blackheath construction footprint that will be used for the Katoomba to Blackheath Upgrade. This site will be subject to the conditions of an Aboriginal Heritage Impact Permit (AHIP) obtained for the Katoomba to Blackheath Upgrade if impacts cannot be mitigated. This site will have been managed in accordance with an AHIP, prior to disturbance of the site by the project.
Hammer Stone 1 GWH	Isolated find	Little Hartley	Located outside the Little Hartley construction footprint.
Hartley Grange 2	Artefact: 9	Little Hartley	Located outside the Little Hartley construction footprint, but within the construction footprint for the Little Hartley to Lithgow Upgrade. This site will be subject to the conditions of an AHIP obtained for the Little Hartley to Lithgow Upgrade if impacts cannot be mitigated.

Figure 16-1 Overview of Aboriginal cultural heritage study area and values near the project

Figure 16-2 Aboriginal cultural heritage values at Blackheath

Figure 16-3 Aboriginal cultural heritage values at Little Hartley

16.3 Potential impacts – construction

Impacts on Aboriginal cultural heritage due to the project can be either direct or indirect. Direct impacts include the removal, modification or destruction of an Aboriginal site, while indirect impacts are associated with construction vibration generated by tunnelling or surface works and the settlement of land due to tunnelling below or in proximity to Aboriginal sites, as well as indirect impacts to the Aboriginal site setting (visual impacts, changes to vistas/landscapes) and changes to ongoing use or environmental association.

16.3.1 Avoidance and minimisation of impacts

The overall guiding principle for cultural heritage management is that where possible Aboriginal sites would be conserved. If conservation is not practical, measures would be taken to mitigate against impacts to Aboriginal sites. No direct impacts to Aboriginal sites would occur as a result of the project (refer to Section 8.1 of Appendix L (Technical report – Aboriginal heritage).

Where unavoidable impacts occur then measures to mitigate and manage impacts are proposed. Mitigation measures primarily concern preserving the heritage values of sites beyond the physical existence of the site. The most common methods involve detailed recording of Aboriginal objects, archaeological salvage excavations, artefact analysis and, where appropriate, reburial of Aboriginal objects in a location determined by the RAPs.

The key design feature adopted to minimise impacts on Aboriginal heritage is selection of a tunnel option between Blackheath and Little Hartley to minimise surface disturbance and the potential to impact Aboriginal heritage sites located between these two locations. Further detail on efforts to avoid and minimise potential environmental impacts is described in Chapter 3 (Project alternatives and options).

The water supply pipeline between the Little Hartley construction footprint and Lithgow would be located wholly within existing and/or new road reserves and the indicative alignment has been designed to avoid impacts to Aboriginal cultural heritage and high risk Aboriginal landscapes such as waterways.

16.3.2 Direct impacts

The valid Aboriginal sites detailed in Section 16.2 are located outside the construction footprint for the project, therefore no direct Aboriginal cultural heritage impacts are anticipated as a result of the project.

The project would directly affect the Greater Blue Mountains Area – (Additional Values) nomination for the National Heritage List, including:

- the majority of the Blackheath construction footprint, and then through permanent operational infrastructure at Blackheath
- the north east corner of the Soldiers Pinch construction footprint.

Although not yet included on the National Heritage List, the Greater Blue Mountains Area – (Additional Values) is nominated for containing outstanding natural and cultural values. This nomination for additional values includes Aboriginal cultural values, and other natural values not covered by the Greater Blue Mountains World Heritage Area listing, such as scenic values and geological formations. In relation to cultural values, further research has come to light since the World Heritage List and National Heritage List entries, providing additional evidence for cultural values, such as rock art and the importance of the Greater Blue Mountains Area to the contemporary Aboriginal community. Further discussion of the scope of the Greater Blue Mountains Area – (Additional Values) is provided in Appendix M (Technical report – non-Aboriginal heritage).

The project construction footprint has been subject to assessment of Aboriginal archaeological potential. Both the Soldiers Pinch and Blackheath construction footprints have been assessed as having low archaeological potential (see Figure 16-2). This, combined with the absence of Aboriginal cultural heritage items and high levels of disturbance in both areas support the conclusion that neither site would present significant Aboriginal cultural heritage values in the context of the Greater Blue Mountains Area – (Additional Values) nomination. Further, site disturbance at the Soldiers Pinch construction site would be temporary, and subject to rehabilitation at the conclusion of works. Overall, the project would not have a significant impact on Aboriginal cultural heritage values associated with the Greater Blue Mountains Area – (Additional Values) nomination.

The Little Hartley construction site has been located and configured to avoid known Aboriginal cultural heritage items and areas of high archaeological potential (see Figure 16-3).

The cumulative Aboriginal cultural heritage impacts of the Upgrade Program including this project are addressed in Chapter 24 (Cumulative impacts).

16.3.3 Indirect impacts

Based on tunnel depth and location, vibration from tunnelling is unlikely to impact Aboriginal sites.

Hartley Grange 2 (see #45-4-1190 in Figure 16-3) is around 30 metres from the construction footprint and within the minimum working distance for some types of vibration intensive plant. However, this site consists of individual stone artefacts which are unlikely to be damaged by vibration and are within or adjacent to a dirt road regularly traversed by light vehicles and farming machinery, therefore potential impacts would be unlikely (refer to Chapter 11 (Noise and vibration).

Based on the settlement analysis provided in Chapter 13 (Groundwater and geology), predicted settlement calculations indicate that that no known Aboriginal heritage items would be affected by settlement.

Transport for NSW recognises the potential for the project to indirectly impact the cultural heritage values identified in Table 16-1. Findings of the PACHCI 2021 included identification of:

- potential impacts to cultural values associated with a goanna rock art engraving at Mount Victoria and that further engagement with knowledge holders is recommended to assess this goanna rock art engraving. The project would not impact this Aboriginal site
- potential impacts to the Great Western Highway which is recognised as a culturally significant songline and walking track including its historic use as a connector to other pathways such as Mount York and Bells Line of Road.

Previous and ongoing consultation with Aboriginal stakeholders is outlined in Chapter 7 (Community and stakeholder engagement). The process to integrate connection to Country, and Aboriginal culture and heritage into the project design is outlined in Chapter 4 (Project description).

A preliminary Aboriginal Narrative Report and Body of Story Report has been prepared for the Upgrade Program to assist with the interpretation and integration of intangible Aboriginal cultural values collected during Aboriginal consultation and exploratory workshops by giving Aboriginal communities a voice in the design of the Upgrade Program. The report includes a series of core narratives and stories and outlines a set of overarching cultural design principles to inform the projects design principles. These highlight opportunities to develop a design that would deepen the understanding of place and the rich history of the Aboriginal cultural, spiritual and physical connection to the area and importantly will facilitate greater Aboriginal visibility.

Examples of how some of the cultural values identified in this chapter would be considered in the project design are discussed in Section 5.6 of Appendix N (Technical report – Urban design, landscape and visual).

16.4 Potential impacts – operation

No direct impacts to Aboriginal cultural heritage are expected during the operation of the project.

Potential indirect impacts largely relate to changes to landscape character and visual amenity. Design development for the project has minimised the extent of surface infrastructure by locating most of the project's infrastructure underground to minimise visual impacts and to be sympathetic to the surrounding landscape context. The process to integrate connection to Country, and Aboriginal culture and heritage into the project design is outlined in Chapter 4 (Project description).

16.5 Environmental mitigation measures

16.5.1 Performance outcomes

Performance outcomes for the project in relation to Aboriginal cultural heritage are listed in Table 16-4 and identify measurable performance-based standards for environmental management.

Table 16-4 Aboriginal cultural heritage performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
The design, construction and operation of the project facilitates, to the greatest extent possible, the long term protection, conservation and management of the heritage significance of Aboriginal objects and places. The design, construction and operation of the project avoids or minimises impacts, to the greatest extent possible, on the heritage significance of Aboriginal objects and places.	Avoid or minimise direct and indirect impacts on known or unexpected Aboriginal values, objects and places.	Construction
	Incorporate Aboriginal heritage interpretation and Aboriginal cultural design principles into the design of the project in consultation with Aboriginal stakeholders.	Design

16.5.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential Aboriginal cultural heritage impacts as a result of the project are detailed in Table 16-5. A full list of mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 16-5 Environmental mitigation measures – Aboriginal cultural heritage

ID	Mitigation measure	Timing
AH1	If unexpected items of potential Aboriginal cultural heritage significance, including potential Aboriginal burials or skeletal material, are discovered during construction of the project, all relevant activities in the vicinity of the find will cease and the unexpected/chance finds requirements specified in the Unexpected Heritage Items Procedure (Transport for NSW, 2022d) will be followed.	Construction

17 Non-Aboriginal heritage

This chapter summarises the non-Aboriginal heritage assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full non-Aboriginal heritage assessment is provided in Appendix M (Technical report – Non-Aboriginal heritage).

17.1 Assessment approach

17.1.1 Study area

The non-Aboriginal heritage assessment study area for the project includes a 200 metre buffer around the areas of surface disturbance required for construction and the surface area above the project tunnels, as shown in Figure 17-1.

17.1.2 Literature and database review

The following archaeological and historical literature and databases were reviewed to identify known non-Aboriginal heritage items located in the vicinity of the project:

- World Heritage List
- Commonwealth Heritage List
- National Heritage List
- NSW State Heritage Register
- Section 170 Heritage and Conservation Registers
- Blue Mountains Local Environmental Plan (LEP) 2015
- Lithgow LEP 2014.

Searches of non-statutory databases were also carried out and included the Register of National Estate and the Register of the National Trust of Australia. Where relevant, conservation management plans and other heritage management documents have been used to provide additional information regarding heritage significance.

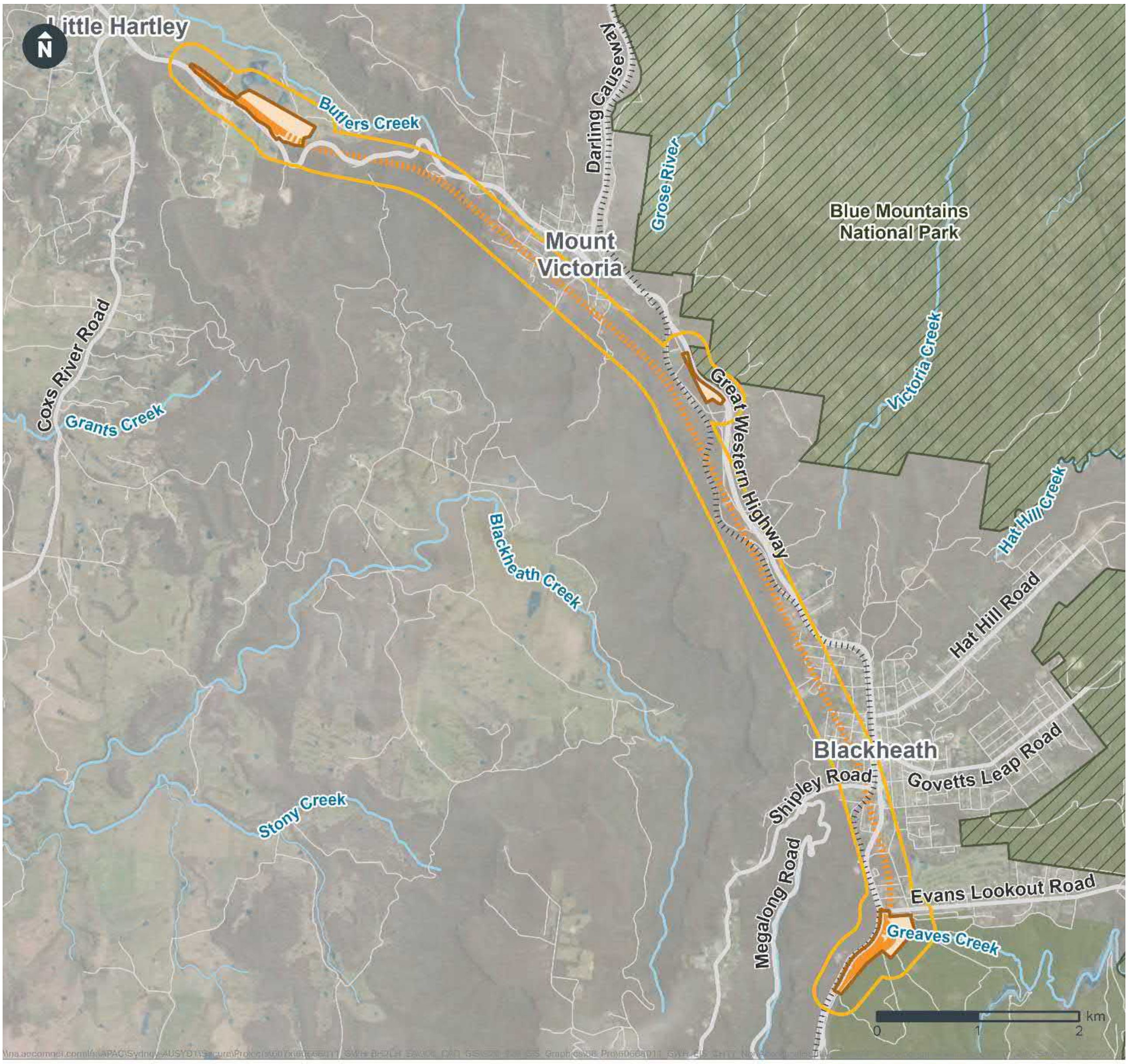
A preliminary assessment of other potential heritage items and previously unknown archaeological items that would be directly or indirectly impacted by the project was also completed using historic plans and photographs, historical newspapers and other primary and secondary historical sources along with the non-Aboriginal heritage assessments for the other Upgrade Program components.

The non-Aboriginal heritage impact assessment was carried out in accordance with the following policies and guidelines.

- Greater Blue Mountains World Heritage Area Strategic Plan (NSW National Parks and Wildlife Service, 2009)
- The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance (Australia ICOMOS, 2013)
- NSW Skeletal Remains: Guidelines for Management of Human Remains (Heritage NSW, 1998)
- Care agreement application form: Criteria for the assessment of excavation directors (Heritage NSW, 2011)
- NSW Heritage Manual (Heritage NSW, various)
- Assessing Heritage Significance (NSW Heritage Office, 2001).

17.1.3 Field survey

Heritage items identified as having the potential to be either directly or indirectly affected by the project were inspected during a field survey on 18 January 2022 to confirm their specific location and condition.



Indicative only – subject to design development

Legend

Blackheath to Little Hartley Upgrade
- Surface road
- Tunnel
- Construction footprint
- Study area

Existing environment
- Railway
- Main road
- Road
- Watercourse and drainage
- National parks and reserves

Listed Heritage
- Greater Blue Mountains World Heritage Area

Figure 17-1 Non-Aboriginal heritage assessment study area

17.1.4 Significance assessment

Heritage items were identified as relevant to the project if they occurred within the study area and either:

- were located within the construction footprint, as shown in Figure 17-1, and may be affected by direct or indirect impacts
- were within 60 metres of the construction footprint or the outer edge of the tunnel alignment at surface level (as shown in Figure 17-1)[1].

In addition, landscape scale indirect impacts were considered for the Greater Blue Mountains World Heritage Area (World Heritage List and National Heritage List) given its significance and anticipated level of stakeholder interest.

Significance assessments for the identified heritage items are provided in Annexure B of Appendix M (Technical report – Non-Aboriginal heritage).

17.1.5 Impact assessment

Potential non-Aboriginal heritage impacts as a result of the project have been categorised as follows:

- direct impacts – resulting in physical alteration or damage, modification or demolition of that heritage item
- indirect impacts – resulting in changes to the heritage item or its surroundings as a result of the project (such as visual/landscape setting impacts, vibration and settlement impacts and changes in use, association or access to a heritage item).

The overall magnitude of impact resulting from the project has been defined as:

- major – impacts that result in a substantial permanent and/or irreversible loss of fabric of a heritage item or to its setting
- moderate – impacts that result in a partial loss of a heritage item's significant fabric or setting
- minor – impacts that are small or affect a small area, or an alteration to a minor feature or element
- negligible – impacts that do not alter or change the heritage item.

Further details of these magnitude levels are provided in Section 2.3 of Appendix M (Technical report – Non-Aboriginal heritage).

17.2 Existing environment

17.2.1 Historical context

Greater Blue Mountains Area

The Greater Blue Mountains Area consists of around one million hectares of mostly forested landscape on a sandstone plateau around 60 to 180 kilometres west of Sydney. It is listed on the World Heritage List and partly encompasses the Blue Mountains National Park.

It is an area of breathtaking views, rugged tablelands, sheer cliffs, deep, inaccessible valleys and swamps which support a rich and diverse ecosystem. The unique plants and animals that live in this natural place tell the story of Australia's antiquity, its diversity of life and its superlative beauty. This area demonstrates the evolution of Australia's unique eucalypt vegetation and its associated communities, plants and animals.

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[1]60 metres has been adopted based on the minimum working distances for vibration intensive plant and equipment, as outlined in Appendix G (Technical report – Noise and vibration)

In addition to its biodiversity values, the Greater Blue Mountains Area also contains ancient, relict species of global significance such as the recently discovered Wollemi pine (*Wollemia nobilis*) which was thought to have been extinct. The few surviving trees of this ancient species are known only from three small populations located in remote, inaccessible gorges within the Greater Blue Mountains Area.

An additional area has been nominated for inclusion on the National Heritage List, referred to as the Greater Blue Mountains Area – Additional Values. This area has been nominated for inclusion on the National Heritage List, and not the World Heritage List. For the purpose of the assessment, it has been assumed that the Greater Blue Mountains Area – Additional Values, if listed, would have identical or similar significance to the current Greater Blue Mountains Area World Heritage List and National Heritage List entries. These areas are shown in Figure 17-2 and Figure 17-5. An assessment of significance for these areas is provided in Annexure B of Appendix M (Technical report – Non-Aboriginal heritage).

Coxs Road

Coxs Road, previously known as Coxs Way, has been a key transport route since the early nineteenth century. The best known successful expedition to the Blue Mountains was undertaken by Gregory Blaxland, William Lawson and William Charles Wentworth in 1813 which was most likely achieved by following paths previously established by Aboriginal people (Jacobs & Arcadis, 2021).

This expedition led to the construction of Coxs Road between 1814 and 1815 which was the first built road through the Blue Mountains. Construction was overseen by William Cox and carried out by convicts from the Nepean River through Emu Ford, over Mount York and Mount Blaxland to Bathurst (Karskens, 1988).

In 1822 William Lawson cut a new road around four kilometres before Mount York that ended in Bathurst which was up to around 16 kilometres shorter than the original Coxs Way. This new route continued to be used until at least 1827. In 1827 another route between Coxs Road and Lawsons Long Alley (a descent off Mount York built in 1824) was built descending from Mount York along a ridge. Work on the road started in 1829 which became known as Lockyers Road (after the man overseeing the work).

Mitchells Road/the Western Road/Great Western Highway

While Coxs Road was a key transport route for settlers, many found the descent at Coxs Pass difficult and dangerous. Further, with the increase of traffic, the road began to deteriorate, therefore making it more dangerous. To overcome this, explorer and surveyor Major Thomas Mitchell set about improving roads including establishing the Western Road as one of the earliest routes from Emu Ford (now Emu Plains) to Bathurst. The current Great Western Highway largely follows Mitchell’s route.

Victoria Pass

Construction for a route that avoided Mount Blaxland and descended Mount York not far from Coxs Pass began construction in 1829. The route required extensive engineering, including considerable cutting and filling and heavy masonry retaining walls, side drains and culverts. This road became known as Lockyers Road.

During construction of Lockyers Road, it was determined that the large descent at Mount York could be avoided by spanning the deep gorge at Mount Victoria which would bypass Mount York altogether. Construction on Lockyers Road was halted and construction on the new pass, now known as Victoria Pass, began in the early 1830s. Numerous upgrades and realignment works were undertaken for Victoria Pass and by 1862, the whole section had been cut to the present alignment of the highway with little of the original Coxs Road in use.

Stockades

Coxs Western Road, Lockyers Road, Mitchells Western Road and Victoria Pass were all built using convict labour, which required accommodation for both the convicts and their military guards. Numerous stockades were built along the alignment of these roads to accommodate the convict labour. Two of these sites intersect with the study area, including the Blackheath stockade which is a registered heritage item and archaeological site on the Blue Mountains LEP, and Mount Victoria stockade which although it is not a registered item, is considered to be of potential State heritage significance (see Table 17-3). In general, few stockade sites have been archaeologically investigated to a great degree.

Blackheath

During settlers first crossing of the Blue Mountains in 1813, many were thought to have camped on land that is now part of the village of Blackheath. In 1823, Coxs Road passed through Blackheath. The precise route of that road appears to deviate each side of the existing Great Western Highway. The first known building in Blackheath appears to have been the Scotch Thistle Inn which was opened in 1831 and was described as being a substantial single-storey stone structure.

The Blackheath Stockade was constructed in 1844. Following the closure of the Blackheath Stockade in 1849, settlement did not begin in the Blackheath area until the coming of the railway, which reached Blackheath in 1868. Land began to be sold in 1879, with subdivisions following from the late nineteenth/early twentieth centuries. By the early 20th century, tourists from Sydney began coming to Blackheath.

Mount Victoria

Mount Victoria was originally marked as One Tree Hill in 1813. Most references to the area in the early 1830s include Mount Vittoria and Vittoria Pass. By the 1840s, the area began to be called Mount Victoria, although both Vittoria and Victoria were used interchangeably in official documentation.

The earliest buildings in Mount Victoria were the Toll House and Welcome Inn. The Toll House was constructed in 1849 to collect tolls from road users, which became an increasingly important source of revenue for the development and maintenance of major road systems. The Toll House still exists however the formerly adjacent buildings (the Welcome Inn and store) are now an archaeological site within the curtilage of Karawatha House.

Little Hartley

Many of the early buildings along the Great Western Highway at Little Hartley were constructed in around 1860 and served as inns to provide refreshments to travellers and their animals, either before or after traversing Victoria Pass.

Historic inns

Construction of Coxs Road and other roads through the Blue Mountains spurred development in the area in the form of inns and accommodation for travellers along the route westbound towards Bathurst. The establishment of townships often followed the development of these inns, including at Blackheath, Mount Victoria and Little Hartley.

Little Hartley was formed around popular travellers' inns such as the Golden Fleece Inn at the foot of Mount York, the Royal Garter Inn (currently known as Billesdene Grange) located adjacent to the Little Hartley Heritage Conservation Area, and Joseph Collits Inn which became Edward Field's Hotel (Transport for NSW, 2021c). However, development at Little Hartley was more sprawling in nature along the Great Western Highway rather than clustered.

17.2.2 Heritage items and conservation areas

The listed heritage items located within the study area are presented in Section 3.2 of Appendix M (Technical report – Non-Aboriginal heritage) and are shown in Figure 17-2 to Figure 17-8. The listed heritage items within 60 metres of the construction footprint and tunnel alignment are presented in Table 17-1. Of these, four items would be directly or indirectly impacted by the project. Assessment of the potential project impacts on these four items, in addition to the areas of potential archaeology identified in Section 17.2.3, is provided in Section 17.3.

Table 17-1 Statutory listings within 60 metres of the construction footprint and/ or tunnel alignment

Heritage item, address	Heritage list and identifier	Relevant project component	Within construction footprint[1]	Impacted by the project
Greater Blue Mountains Area Katoomba, NSW	World Heritage List	Soldiers Pinch construction footprint	×	×
Greater Blue Mountains Area – Additional Values Katoomba	Nominated Place – National Heritage List	Blackheath construction footprint, Soldiers Pinch construction footprint	✓	✓ (direct)
Soldiers Pinch Near Great Western Highway, Blackheath/Mount Victoria	Blue Mountains LEP, MV009	Soldiers Pinch construction footprint	✓	✓ (indirect)
Rosedale Great Western Highway, Little Hartley	Lithgow LEP, I024	Little Hartley construction footprint	×	✓ (indirect)
Nioka 2209 Great Western Highway, Little Hartley	Lithgow LEP, I025	Little Hartley construction footprint	×	✓ (indirect)
Blackheath Stockade and the Western Road – archaeological sites Blackheath	Blue Mountains LEP, BH034	Tunnel alignment	×	×
Lookout Hill Heritage Conservation Area Blackheath	Blue Mountains LEP, BH215	Tunnel alignment	×	×
St Mounts 1A and 3 Abbott Street and 194-196 Great Western Highway, Blackheath	Blue Mountains LEP, BH052	Tunnel alignment	×	×
Blackheath West Heritage Conservation Area Blackheath	Blue Mountains LEP, BH214	Tunnel alignment	×	×
Guinness Lodge/Evanville 1-5 Waragil Street, Blackheath	Blue Mountains LEP, BH059	Tunnel alignment	×	×
Tree Tops and garden 16 Clyde Avenue, Blackheath	Blue Mountains LEP BH065	Tunnel alignment	×	×
Ban Tigh, Brewery site and Garden 26-34 Waragil Street, Blackheath	Blue Mountains LEP BH060	Tunnel alignment	×	×

Heritage item, address	Heritage list and identifier	Relevant project component	Within construction footprint[1]	Impacted by the project
Osborne Cottage (site only) 52-106 Thirroul Avenue, Blackheath	Blue Mountains LEP, BH039	Tunnel alignment	×	×
Montana 37 Ada Road, Blackheath	Blue Mountains LEP, BH071	Tunnel alignment	×	×
Central Mount Victoria Heritage Conservation Area Mount Victoria	Blue Mountains LEP, MV023	Tunnel alignment	×	×
Mitchell's Ridge Monument Reserve Great Western Highway, Mount Victoria	Blue Mountains LEP, MV015	Tunnel alignment	×	×
Victoria Pass Great Western Highway, Mount Victoria	Blue Mountains LEP, MV087	Tunnel alignment	×	×
	Lithgow LEP, A183	Tunnel alignment	×	
Berghofer's Pass Berghofer Drive and 2-4 Great Western Highway, Mount Victoria	Blue Mountains LEP, MY001	Tunnel alignment	×	×

Table note:

1. ✓ indicates the heritage item is within the construction footprint. × indicates the heritage item is outside but within 60 metres of the construction footprint

17.2.3 Archaeological potential

Four areas of archaeological potential were identified within the study area, as summarised in Table 17-2 and shown in Figure 17-3, Figure 17-7 and Figure 17-8. This includes one listed archaeological item and three areas with the potential to yield archaeological information (potential archaeological sites). Of the four areas of archaeological potential identified within the study area, two areas of archaeological potential may be directly or indirectly impacted by the project, being the Mount Victoria Stockade and Plough Inn potential archaeological sites.

Table 17-2 Archaeological potential within the study area

Site and status	Description and location	Location	Impacted by the project
Blackheath Stockade Blue Mountains LEP (BH034) *Known archaeological potential of local significance*	The Blackheath Stockade is an archaeological site that covered a large area of Blackheath adjacent to the existing Great Western Highway. The buildings associated with the stockade were located more or less on the line of the existing railway and Great Western Highway between the later Prince George Street and Govett Street, around one kilometre north of the Blackheath portal as shown in Figure 17-3. The Blackheath Stockade is a listed heritage item under the Blue Mountains LEP 2015 (BH034).		×
Mount Victoria Stockade *Potential archaeological site*	The Mount Victoria Stockade site intersects with the Little Hartley construction footprint and is shown as the potential heritage item in Figure 17-8. Mount Victoria Stockade was constructed in the early 1830s to house convicts constructing Victoria Pass.		✓ (direct)

Site and status	Description and location	Location	Impacted by the project
of State significance	Although disturbed, Mount Victoria Stockade has never been subject to detailed archaeological investigation. The site therefore retains the potential to yield information regarding the layout of the stockade, artefacts evidencing the use of the stockade by both convicts and the military and the site's overall use during the construction of Victoria Pass. The removal of some surface and subsurface material by the landowners has disturbed the site but is not thought to have been extensive enough to obscure the archaeological evidence that the site may still hold.		
Site of the Plough Inn *Potential archaeological site of local significance*	The probable location of the Plough Inn site is likely to be on the northern side of the Great Western Highway at the foot of Victoria Pass. The site intersects with the Little Hartley construction footprint, with the indicative location shown in Figure 17-8. The site of the Plough Inn is a potential archaeological site that was constructed in the 19th century. The potential site has previously been described as a substantial building that had been tended to with obvious care. The precise location of the Plough Inn is unknown. It is considered probable that Plough Inn is located opposite Rosedale, which is partially located within the construction footprint. However, it is also possible that the site may have already been destroyed by road widening of the Great Western Highway. Depending on the former inn's location, any archaeological deposits for the inn may have already been removed. Surface works associated with the Great Western Highway Little Hartley to Lithgow Upgrade would be carried out ahead of the project in the area identified as potentially containing archaeological remains associated with the Plough Inn. In this case, if archaeological remains do in fact exist, they are likely to be encountered during the construction of the Little Hartley to Lithgow Upgrade and would have been appropriately managed prior to ground disturbing works for the project.		✓ (potential direct subject to confirmation of site location)
Mitchell's Line of Road *Potential archaeological site of local significance*	The site is located on the southern side of the Great Western Highway, around one kilometre north-west of the Little Hartley tunnel portals, as shown in Figure 17-8. Two sections of Mitchell's Road were identified as once being part of Mitchell's Line of Road. While much of Mitchells Road has been previously obscured by the existing Great Western Highway road upgrades, it is considered possible that some remnants of Mitchell's Road may be present. The site is located outside but within proximity to the construction footprint.		✗

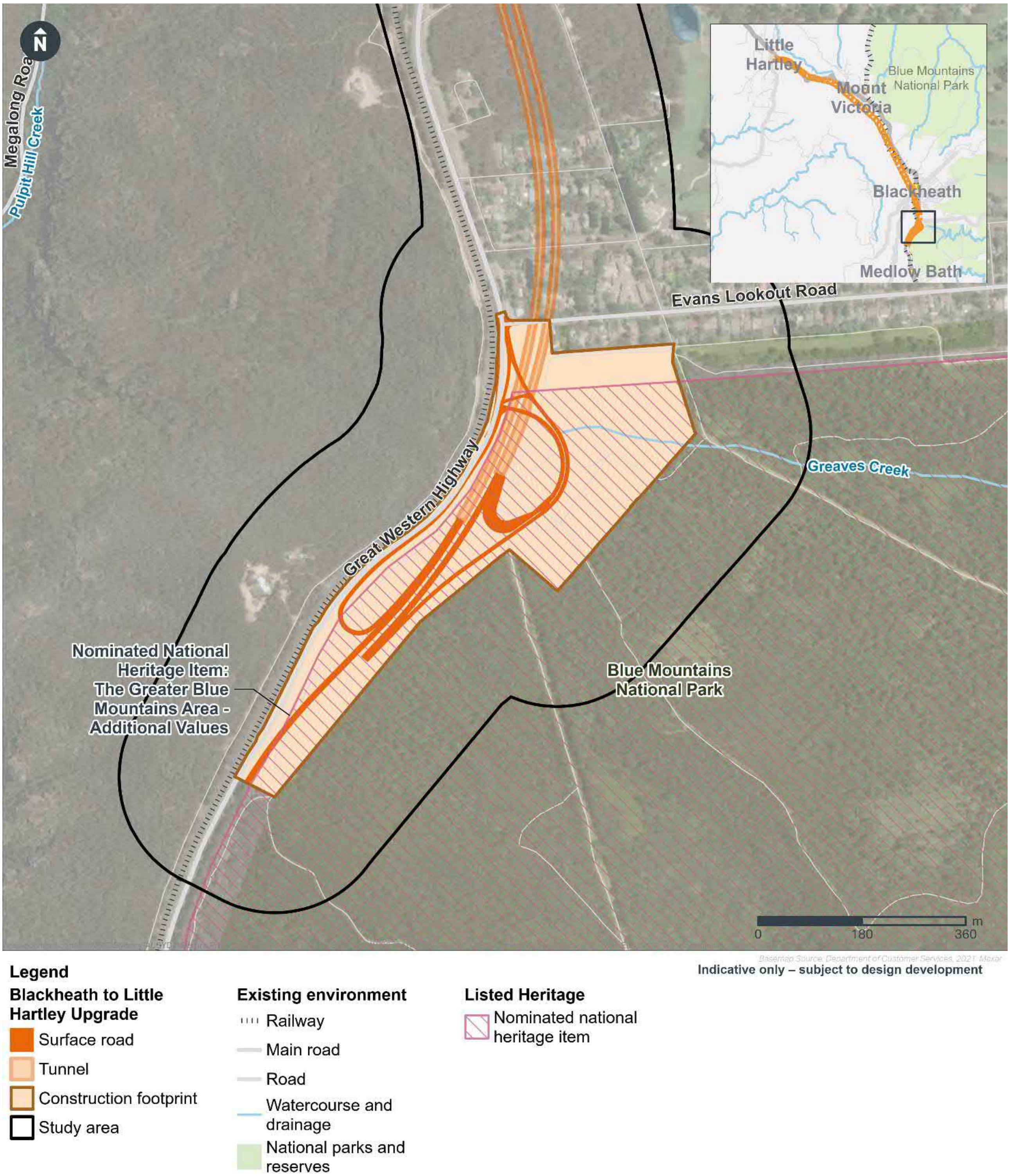


Figure 17-2 Non-Aboriginal heritage items around Blackheath – map 1

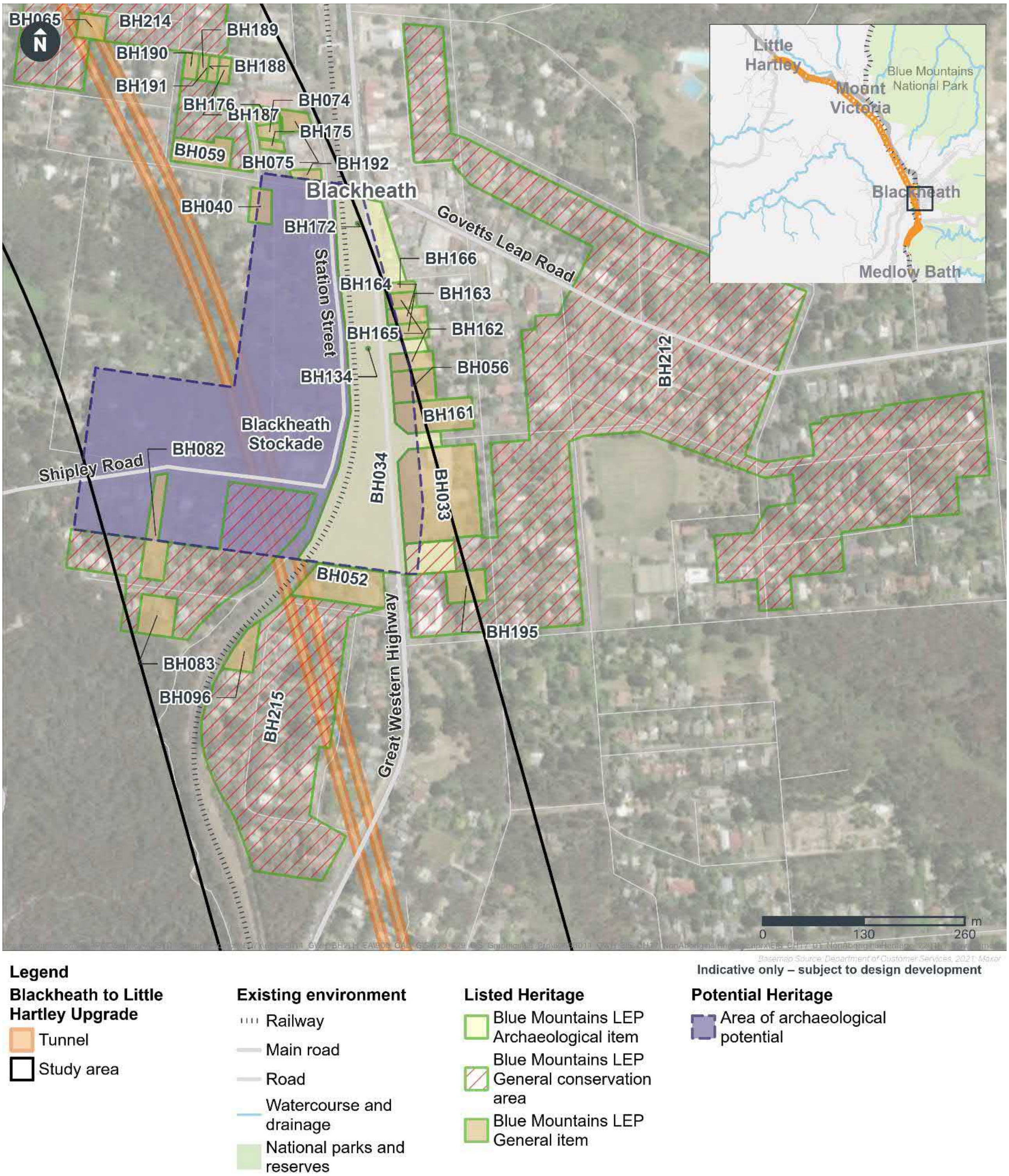


Figure 17-3 Non-Aboriginal heritage items around Blackheath – map 2

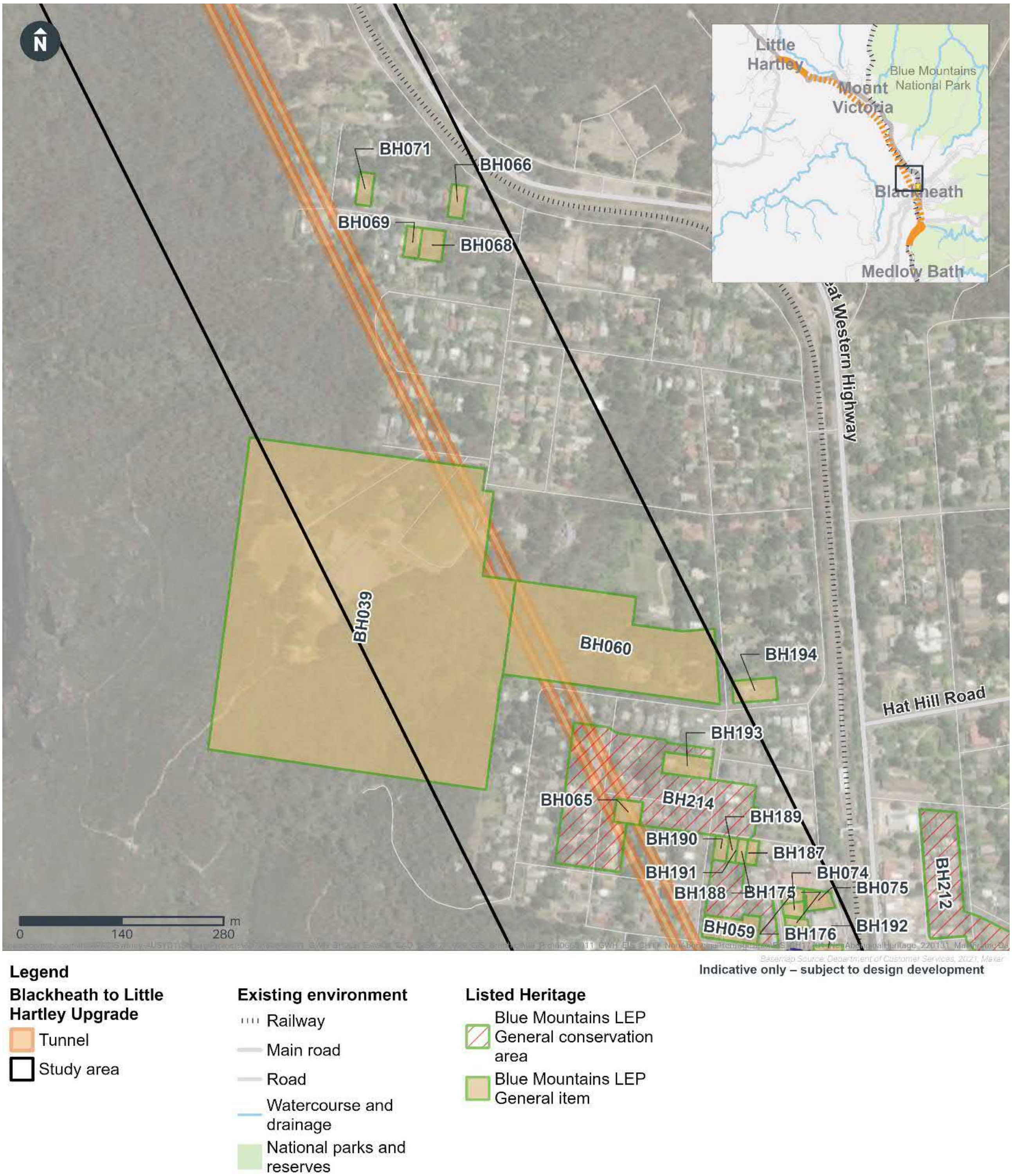
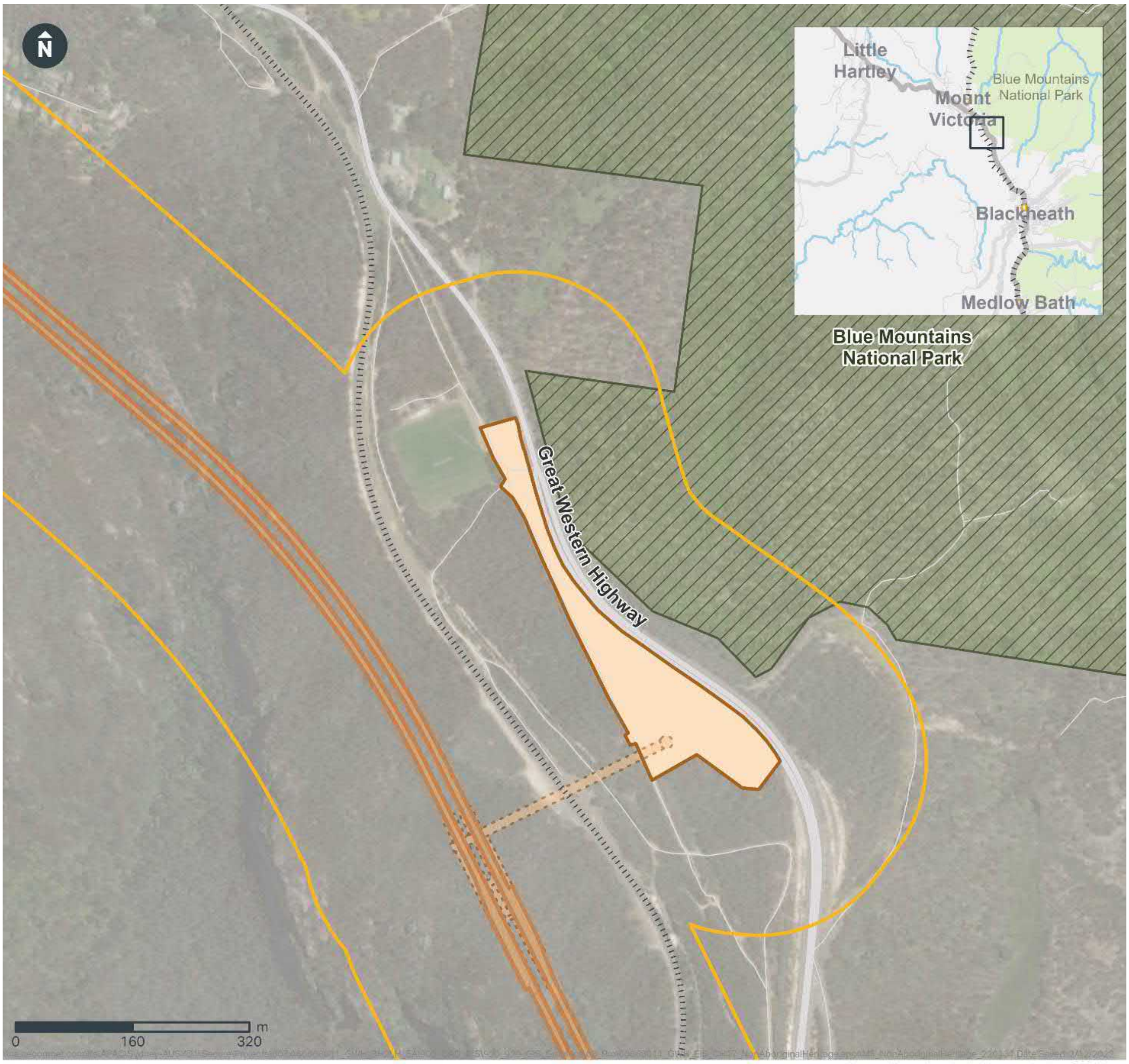


Figure 17-4 Non-Aboriginal heritage items around Blackheath – map 3



Indicative only – subject to design development

Legend

Blackheath to Little Hartley Upgrade
- Tunnel
- Mid-tunnel access shaft and adit
- Construction footprint
- Study area

Existing environment
- Railway
- Main road
- Road
- Watercourse and drainage
- National parks and reserves

Listed Heritage
- Greater Blue Mountains World Heritage Area

Figure 17-5 Non-Aboriginal heritage items around Soldiers Pinch

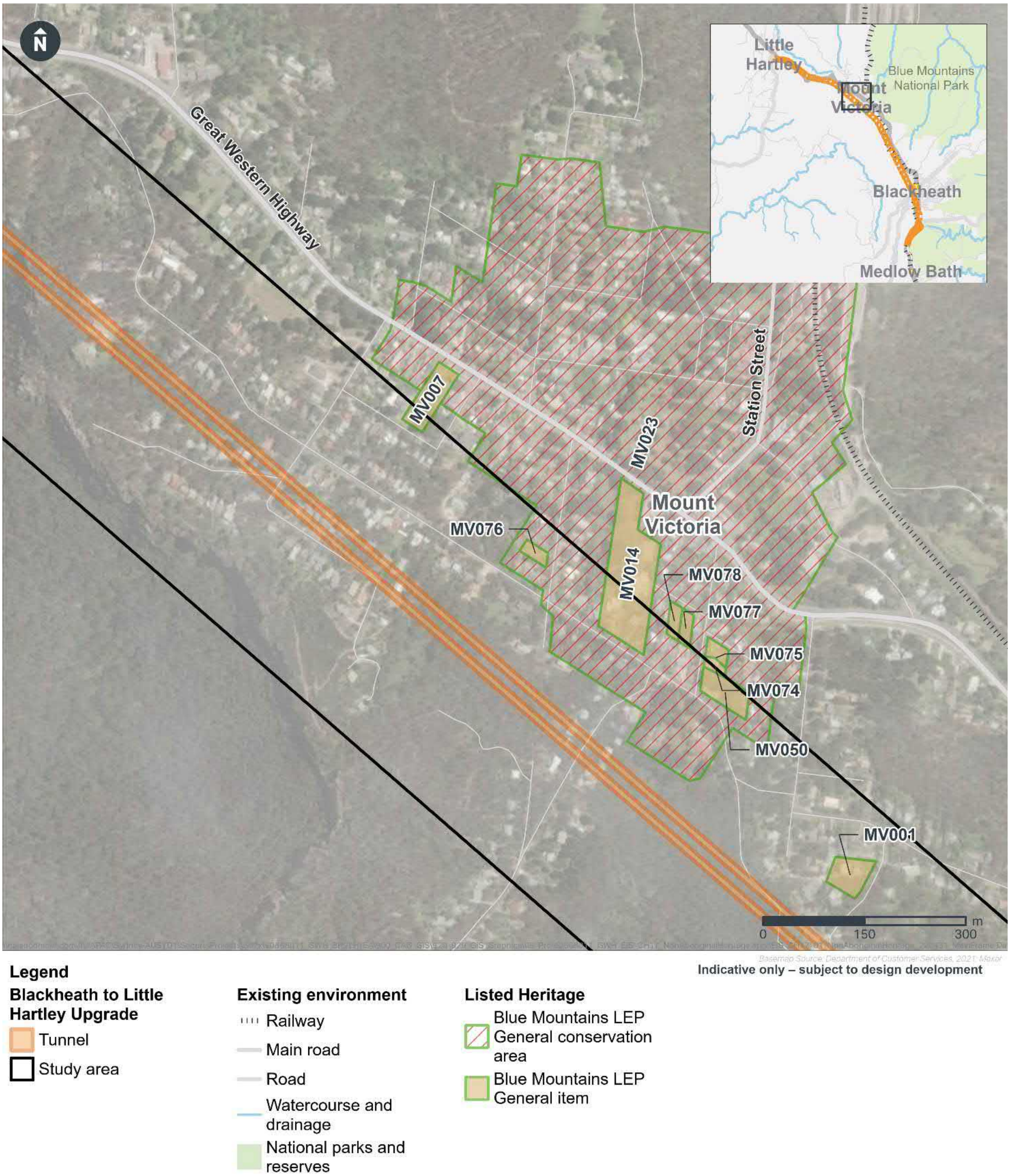


Figure 17-6 Non-Aboriginal heritage items around Mount Victoria – map 1

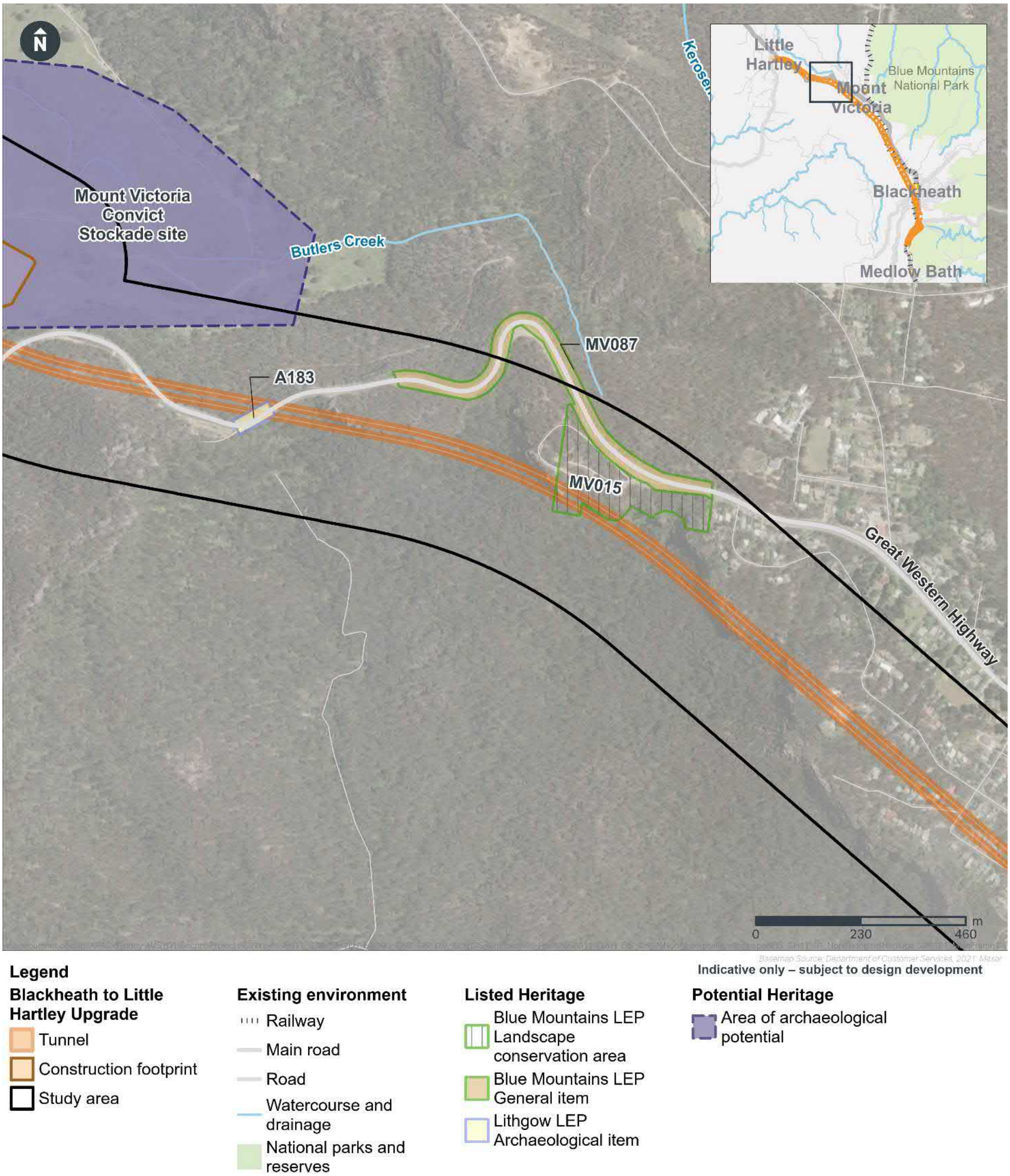


Figure 17-7 Non-Aboriginal heritage items around Mount Victoria – map 2

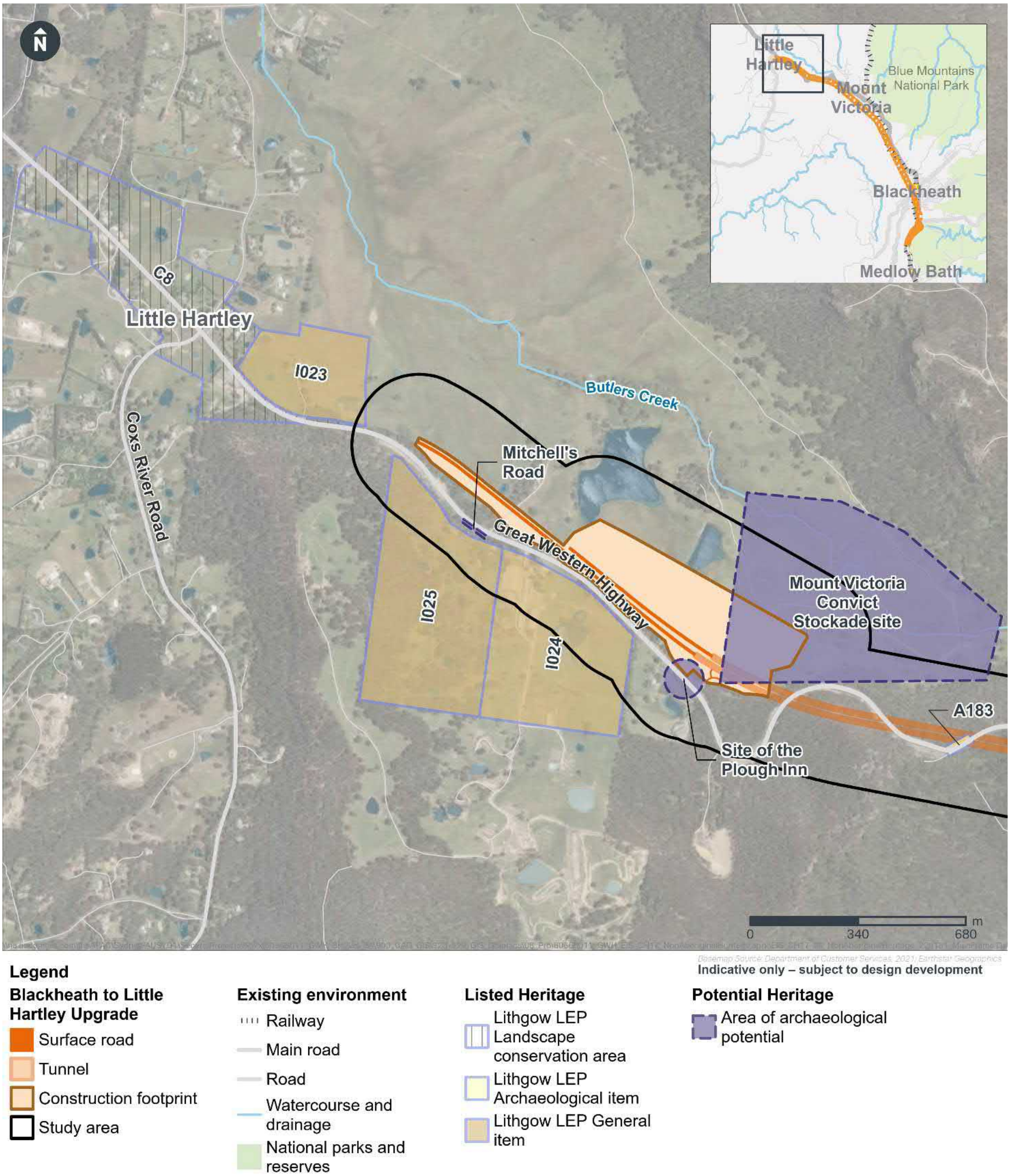


Figure 17-8 Non-Aboriginal heritage items around Little Hartley

17.3 Potential impacts

The project has the potential to impact on non-Aboriginal heritage through:

- direct impacts during construction to heritage items and areas of archaeological potential within the construction footprint
- indirect impacts during construction for heritage items and areas of archaeological potential in proximity to the construction footprint or tunnelling activities
- indirect impacts during operation.

The following sections provide a summary of the design refinements adopted to minimise potential non-Aboriginal heritage impacts, as well as the potential direct and indirect impacts of the project on non-Aboriginal heritage. Further discussion of potential impacts is provided in Appendix M (Technical report – Non-Aboriginal heritage). Mitigation measures to manage the potential impacts are outlined in Section 17.4.

17.3.1 Avoidance and minimisation of impacts

The project has been designed to minimise impacts on non-Aboriginal heritage in the following ways:

- selection of the project over other strategic alternatives such as upgrading the existing railway line or Bells Line of Road (refer to Section 3.3) which would have greater direct impacts on the Greater Blue Mountains World Heritage Area
- a tunnel option between Blackheath and Little Hartley instead of two shorter tunnels substantially minimises surface impacts, including through Blackheath town centre where there are multiple heritage listed items located along the Great Western Highway that may have been impacted by surface road widening
- the tunnel option allows the majority of the operational project infrastructure to be located underground minimising potential indirect visual impacts to the Greater Blue Mountains World Heritage Area
- the tunnel alignment has been designed to avoid traversing underneath the Greater Blue Mountains World Heritage Area
- by excavating from Little Hartley to Blackheath, the size of the Blackheath construction footprint has been minimised, limiting the extent of impacts to the Greater Blue Mountains Area (Additional Values) nomination for the National Heritage List
- the water supply pipeline between the Little Hartley construction footprint and Lithgow would be located wholly within existing and/or new road reserves and the indicative alignment has been designed to avoid impacts to non-Aboriginal heritage
- proposals for landscape design and revegetation that would be peer reviewed through the NSW State Design Review Panel, including the Government Architect.

Further detail on efforts to avoid and minimise potential environmental impacts is described in Chapter 3 (Project alternatives and options).

17.3.2 Direct impacts during construction

Table 17-3 provides an assessment of the listed heritage items and areas of archaeological potential within the study area that may be subject to potential direct impacts during construction.

Further detail relating to the potential direct impacts during construction is provided in Section 4.1 of Appendix M (Technical report – Non-Aboriginal heritage).

The Greater Blue Mountains Area (World Heritage List and National Heritage List) would not be directly affected by construction. All construction work for the project would take place outside the World Heritage curtilage. Further assessment of this item including consideration against the Significant Impact Guidelines 1.1 - Matters of National Environmental Significance (Department of the Environment, Water, Heritage and the Arts, 2013) is included in Chapter 4, Annexure A and Annexure B of Appendix M (Technical report – Non-Aboriginal heritage).

Table 17-3 Potential direct impacts on heritage items during construction

Item, listing ID and significance	Potential direct impact	Magnitude
Greater Blue Mountains Area – Additional Values *Unlisted, nominated for the National Heritage List (NHL)*	The Blackheath construction footprint and north-eastern portion of the Soldiers Pinch construction footprint are located within the curtilage of this item (see Figure 17-2 and Figure 17-5). Although not yet included on the National Heritage List, it is nominated because it is considered to have nationally significant natural and cultural values. Vegetation clearance, construction site establishment and construction of project elements associated with the project would result in a direct impact to the item's curtilage. While the majority of the Blackheath construction footprint would be located within the nominated item, this area has been previously cleared and used for housing and recreational purposes from early in the 20th century. Biodiversity values related to the nominated heritage item include high condition native vegetation, which has been assessed in Chapter 12 (Biodiversity). Given the areas near the project are known and predicted to support native vegetation, the biodiversity impact assessment concluded that these direct impacts to threatened species would be minor. Further discussion of impacts to this nominated heritage item is provided in Section 4.1 of Appendix M (Technical report – Non-Aboriginal heritage).	Minor
	At Soldiers Pinch, the north-eastern portion of the construction footprint would be within the item, which would directly impact the perimeter of the nominated site through native vegetation clearance and presence of construction site components. The previous alignment of the Great Western Highway in 2002 (further north) and the route of the existing Great Western Highway has spatially disconnected this vegetation from the rest of the nominated item. Biodiversity values related to the nominated heritage item include high condition native vegetation, which has been assessed in Chapter 12 (Biodiversity). For the same reason as above, the biodiversity impact assessment concluded that these direct impacts to threatened species would be minor. The Soldiers Pinch construction footprint has previously been used as a stockpiling area since 2002. Given the relatively small area impacted, the previous vegetation disturbance, and the current use of the area as a construction site, the impact of the project on the nominated item would be minor.	Minor

Item, listing ID and significance	Potential direct impact	Magnitude
Soldiers Pinch Blue Mountains LEP (MV009) *Local significance*	The Soldiers Pinch construction footprint is located within the curtilage of this item (see Figure 17-5), which was a historical road and rail route that passed through the area in 1814. Previous and ongoing development has likely resulted in the disturbance of the item, with little diagnostic or significant physical evidence remaining of the previous roads. The condition of the south-eastern section of the Soldiers Pinch construction footprint is highly disturbed and currently used as a construction site. Given its current condition and use, it is considered unlikely that the 1814 alignment has survived previous impacts. Therefore, the potential direct impact is likely to be negligible. However, given the historical significance of Coxs Road, as detailed in Section 17.2.1, a detailed survey should be carried out prior to commencement of ground-disturbing works, as per the mitigation measures detailed in Section 17.4.	Negligible
Mount Victoria Stockade *Potential archaeological site of State significance*	Part of the Little Hartley construction footprint encroaches into the indicative curtilage of this site (see Figure 17-8). Although the site is not a listed archaeological item and is not recorded on either the State Heritage Register or the Lithgow LEP, its heritage significance has consistently been assessed as being of State heritage significance in previous archaeological assessments since its identification in the 1990s. As noted in Section 17.2.1 little archaeological work has been undertaken on stockade sites, making it difficult to determine the potential significance of impacts to the item. Reliance is therefore placed on previous observations made by other researchers regarding archaeological potential and the physical extent of the site. As the site is potentially of State heritage significance, it is recommended that refinement of the design of the surface works and operational infrastructure be carried out to avoid impacting this site, or that a full archaeological assessment of the portion of the site is to be completed prior to any ground disturbing works that would take place in this location, as per the mitigation measures detailed in Section 17.4.	Moderate
Site of the Plough Inn *Potential archaeological site of local significance*	Given the modification of the landscape and previous development over the past century, the precise location of the Plough Inn is not certain including whether any archaeological remains have survived. As detailed in Section 17.2.3, if archaeological remains do in fact exist, they are likely to be encountered during the construction of the Little Hartley to Lithgow Upgrade and would have been appropriately managed prior to ground disturbing works for the project. Notwithstanding, given the uncertainty around the precise location of the Plough Inn site, construction work in this area would be managed through unexpected heritage items protocols, as per the mitigation measures detailed in Section 17.4. The potential impact to any archaeological remains, if they exist, would therefore be major.	Major

17.3.3 Indirect impacts

Indirect visual impacts during construction

Potential visual impacts to heritage items and conservation areas during construction would be temporary. At both the Blackheath and Little Hartley construction footprints, construction activities associated with adjacent Great Western Highway Upgrade Program components would have already introduced construction works and associated visual and landscape changes.

At Blackheath, the relevant heritage item that may be affected by visual impacts during construction is the unlisted but nominated Greater Blue Mountains Area (Additional Values) site. While the visual impacts associated with the Blackheath construction footprint would be a major change, the visual heritage value of this item is mainly limited to associated deep gorges/ canyons and associated forest cover. There are no gorges/ canyons within the Blackheath construction footprint or within the visual catchment around it. Therefore, although the Blackheath construction footprint would be visible from parts of the nominated site, it would not have an indirect visual impact on the nominated values of the heritage item.

At Soldiers Pinch, the relevant heritage items that may be affected by visual impacts during construction of the project include the Soldiers Pinch heritage item (Blue Mountains LEP, MV001) and part of the unlisted but nominated Greater Blue Mountains Area (Additional Values) site. As noted above, due to the absence of gorges and canyons and the previously disturbed nature of the construction footprint, the project would not pose any indirect visual impacts on the heritage significance of the Greater Blue Mountains Area (Additional Values) site during construction. The Soldiers Pinch heritage item comprises historical road alignments and associated infrastructure and does not rely on its setting for its significance.

At Little Hartley, heritage items in proximity to the project and potentially within minimum working distances for cosmetic damage from vibration would include Nioka (Lithgow LEP, I025) and Rosedale (Lithgow LEP, I024). Heritage buildings associated with the Nioka listing would be located around 70 to 80 metres away from the construction footprint. Vegetation would also screen the property from the Little Hartley construction footprint. Heritage buildings associated with the Rosedale listing would be slightly closer (60 to 70 metres away) and given its elevation and uninterrupted views would be highly sensitive to visual change. The landscape and visual assessment provided in Chapter 18 (Landscape and visual) has assessed this magnitude of visual impact to be moderate. Opportunities would be investigated to provide early visual screening of Rosedale from the Little Hartley construction footprint and construction activities. Measures to minimise potential visual impacts to heritage items during construction are detailed in Section 17.4 and Chapter 18 (Landscape and visual).

Indirect ground settlement impacts during construction

A ground settlement impact assessment was carried out for the project. Several heritage items were included in the identified zone of influence; however all impacts were considered negligible (damage category 0) or slight (damage category 2) (based on Mair et al (1996) and Rankin (1988) damage categorisation). Further detail on the ground settlement assessment, including measures to minimise potential ground settlement impacts, is provided in Chapter 13 (Groundwater and geology).

Indirect visual impacts during operation

Table 17-4 provides an assessment of the listed heritage items within the study area that may be subject to potential indirect visual impacts as a result of the project. Mitigation measures to manage potential operational visual impacts to heritage items are outlined in Section 17.4.

The project may result in potential indirect visual impacts to heritage items from the addition of the tunnel portals, the Blackheath operational ancillary facility, ventilation outlets (if this design option is used), urban design initiatives, and/or utilities connections/substations and landscaping. Given the bulk and scale of the operational ancillary facilities proposed at Little Hartley, no additional indirect impacts to the items below are anticipated by the ventilation design option. Further discussion of ventilation design options and landscape and visual impacts is provided in Section 18.4.2 of Chapter 18 (Landscape and visual).

Table 17-4 Potential indirect visual impacts on heritage items

Item, listing ID and significance	Potential indirect visual impact during construction	Magnitude
Greater Blue Mountains Area (Additional Values) *Unlisted, nominated for the National Heritage List (NHL)*	At a variety of viewpoints at Blackheath, the magnitude of change and sensitivity of the visual receiver would be high (except if a portal emissions design option is chosen, whereby impacts would be lower), as noted in Chapter 18 (Landscape and visual). However, it is unlikely that this visual impact would translate to a material effect on heritage values given the nominated values of this item do not include a visual setting, with the exception of deep gorges/canyons and associated forest cover, none of which are present within the visual catchment of the Blackheath operational facilities.	Negligible
Rosedale Lithgow LEP 2014 (I024) *Local significance*	Rosedale is a locally listed heritage item fronting the Great Western Highway in Little Hartley. The item is set within the Butlers Creek Valley landscape character zone (LCZ3), which was assessed as potentially incurring a high to moderate adverse impact (see Chapter 18 (Landscape and visual)). The heritage item would likely be visually impacted by elevated project elements including mainline carriageways, operational ancillary facilities and tunnel portals proposed at Little Hartley, which would be prominent visual features in the existing open, pastoral landscape. The potential to use vegetation screenings to reduce the visual impact of the project at Rosedale, including opportunities to retain existing mature trees, would serve to screen the operational infrastructure from the views of the heritage item. Measures to minimise the visual impacts on heritage items, including use of vegetation screening, are provided in Section 17.4.	Moderate
Nioka Lithgow LEP 2014 (I025) *Local significance*	Nioka is a locally listed heritage item set back from the Great Western Highway at Little Hartley. The item is set within the Butlers Creek Valley landscape character zone (LCZ3), which was assessed potentially incurring a high to moderate adverse impact (see Chapter 18 (Landscape and visual)). The heritage item is screened from the Great Western Highway by mature vegetation along its north-east and south-west elevations. Therefore, the introduction of operational infrastructure at Little Hartley is unlikely to visually impact the heritage item. Measures to minimise the visual impacts on heritage items, including use of vegetation screening, are provided in Section 17.4.	Negligible

17.4 Environmental mitigation measures

17.4.1 Performance outcomes

Performance outcomes for the project in relation to non-Aboriginal heritage are listed in Table 17-5 and identify measurable performance-based standards for environmental management.

Table 17-5 Non-Aboriginal heritage performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
The design, construction and operation of the project facilitates, to the greatest extent possible, the of long term protection, conservation and management of the heritage significance items of environmental heritage value. The design, construction and operation of the project avoids or minimises impacts, to the greatest extent possible, on the heritage significance of environmental heritage value.	Avoid direct and avoid or minimise any indirect impacts to the World Heritage listed Greater Blue Mountains Area.	Construction
	Avoid or minimise direct and indirect impacts to existing heritage items listed on statutory heritage lists and registers. Where a direct or indirect impact cannot be avoided, develop mitigation and management measures reflecting the long term protection, conservation and management of the affected heritage item.	Design and Construction
	Where disturbance of known and suspected areas of potential archaeological significance cannot be avoided, carry out investigations of the areas of potential archaeological significance in accordance with applicable guidelines, prior to disturbance and minimise the extent of disturbance.	Design and Construction

17.4.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential non-Aboriginal heritage impacts as a result of the project are detailed in Table 17-6. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 17-6 Environmental mitigation measures – non-Aboriginal heritage

ID	Mitigation measure	Timing
NAH1	The Construction Environmental Management Plan (CEMP) for the project will include measures applicable to the Soldiers Pinch construction site to minimise the risk of accidents and incidents impacting on the nearby Greater Blue Mountains World Heritage Area. The CEMP will also include provision for construction workers at the Soldiers Pinch construction site to be made aware of the location and significance of the World Heritage Area as part of site inductions and environmental awareness training.	Construction
NAH2	Opportunities to minimise the extent of native vegetation clearing within the footprint of the Greater Blue Mountains Area (Additional Values) National Heritage List nomination will be considered during further design development (refer to environmental mitigation measure B4). In areas where clearing native vegetation cannot be avoided, locally endemic native species will be used in landscaping to reflect the ecological heritage values in the nomination (refer to environmental mitigation measure LV2).	Design

ID	Mitigation measure	Timing
NAH3	If unexpected items of potential non-Aboriginal heritage significance are discovered during construction of the project, all relevant activities in the vicinity will cease in the vicinity of the find and the Unexpected Heritage Items Procedure (Transport for NSW, 2022d) will be followed.	Construction
NAH4	A detailed archaeological survey will be carried out by a suitably qualified archaeologist within those parts of the Mount Victoria Stockade site and the potential Plough Inn site that would be directly affected by construction of the project, and which have not been previously disturbed/ surveyed by the Little Hartley to Lithgow Upgrade project. The detailed archaeological survey will be carried out prior to ground disturbance by the project, and will assess site features, potential for archaeological deposits, significance and proposed management measures.	Design
NAH5	The potential for construction activities to impact remaining sections of Cox's Road (1814) within the Soldiers Pinch construction site that have not been previously disturbed will be investigated as part of further design development. If construction activities at Soldiers Pinch are likely to affect remaining sections of Coxs Road, a detailed archaeological survey will be carried out to map those remaining sections prior to the commencement of ground disturbing works.	Design
NAH6	Construction planning for the project will aim to avoid the use of vibration intensive plant and equipment within the minimum separation distances from the Rosedale homestead, for that plant and equipment (refer to measure NV8). Where minimum separation distances cannot be achieved: • a condition/ dilapidation survey of the Rosedale homestead will be completed prior to and at the completion of the relevant construction works • vibration monitoring will be carried out at the Rosedale homestead during the relevant construction works.	Design
NAH7	The project will be designed and constructed so that tunnelling does not exceed the structural damage criteria (peak particle velocity) for structures that are particularly sensitive to vibration and have intrinsic value, as detailed in German standard *DIN 4150-3: 1992-02 Vibration in Buildings – Part 3: Effects on Structures*, at any heritage building/ structure (refer to environmental mitigation measure GW5).	Design and construction
NAH8	Opportunities to retain existing mature vegetation within and along the Great Western Highway corridor at Little Hartley will be considered in coordination with the Little Hartley to Lithgow Upgrade project. If existing mature vegetation cannot be retained, alternative vegetation screening measures will be identified and implemented, such as landscaping associated with the project and/ or the Little Hartley to Lithgow Upgrade project, or plantings on the Rosedale property in consultation and with the agreement of the property owner and will be in keeping with the existing cultural values of heritage items surrounding the project.	Design

18 Landscape character and visual

This chapter summarises the landscape character and visual assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full landscape character and visual assessment is provided in Appendix N (Technical report – Urban design, landscape and visual). Urban design components of the project are discussed in Chapter 4 (Project description).

18.1 Assessment approach

The landscape character and visual impact assessment for the project was undertaken in accordance with the Environmental Impacts Assessment Practice Note – Guideline for Landscape Character and Visual Impact Assessment EIA-N04 (Transport for NSW, 2020c) and included:

- a desktop assessment including:
  - consideration of relevant legislation and policy requirements
  - review of the landscape, topography, land use and heritage context of the area around the project
  - identification of a study area
  - determination of landscape character zones, sensitive receiver locations and potential viewpoints within the study area
- a site visit to survey the area around the project to assess landscape character and confirm significant landforms and representative viewpoints
- assessment of the potential landscape character and visual impacts of the project during construction and operation
- identification of mitigation measures to mitigate the potential impacts identified.

18.1.1 Study area, landscape character zones and viewpoints

The study area for the assessment includes the potential visual catchment, or areas where visibility of the project is anticipated during construction and operation, including nearby lookouts from hiking trails. The study area is shown in Figure 18-1.

Landscape character zones were determined based on characteristics such as vegetation, geology, landform, land use and development density. Considering these differing natural and social elements across the landscape, four landscape character zones were identified as shown in Figure 18-1.

Considering a range of factors including receiver types (motorists, residents, visitors), view type (at-grade, elevated, or panoramic), distance from the project and any important or protected views identified in planning documents, 17 representative viewpoints were identified. The representative viewpoints have been selected to represent locations where the operational infrastructure would be most visually prominent at Blackheath and Little Hartley and are shown in Figure 18-2 and Figure 18-3 respectively.

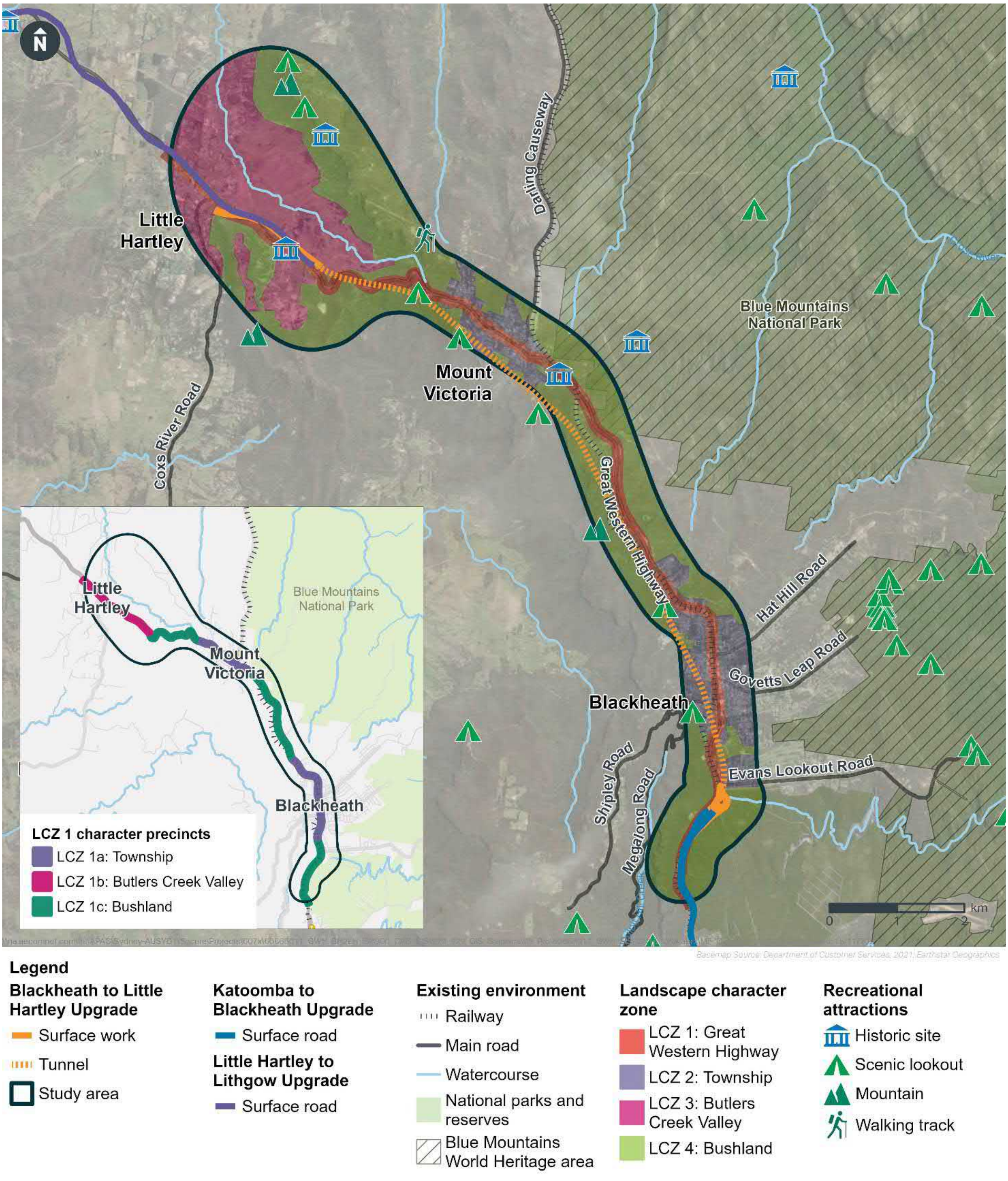


Figure 18-1 Study area and landscape character zones

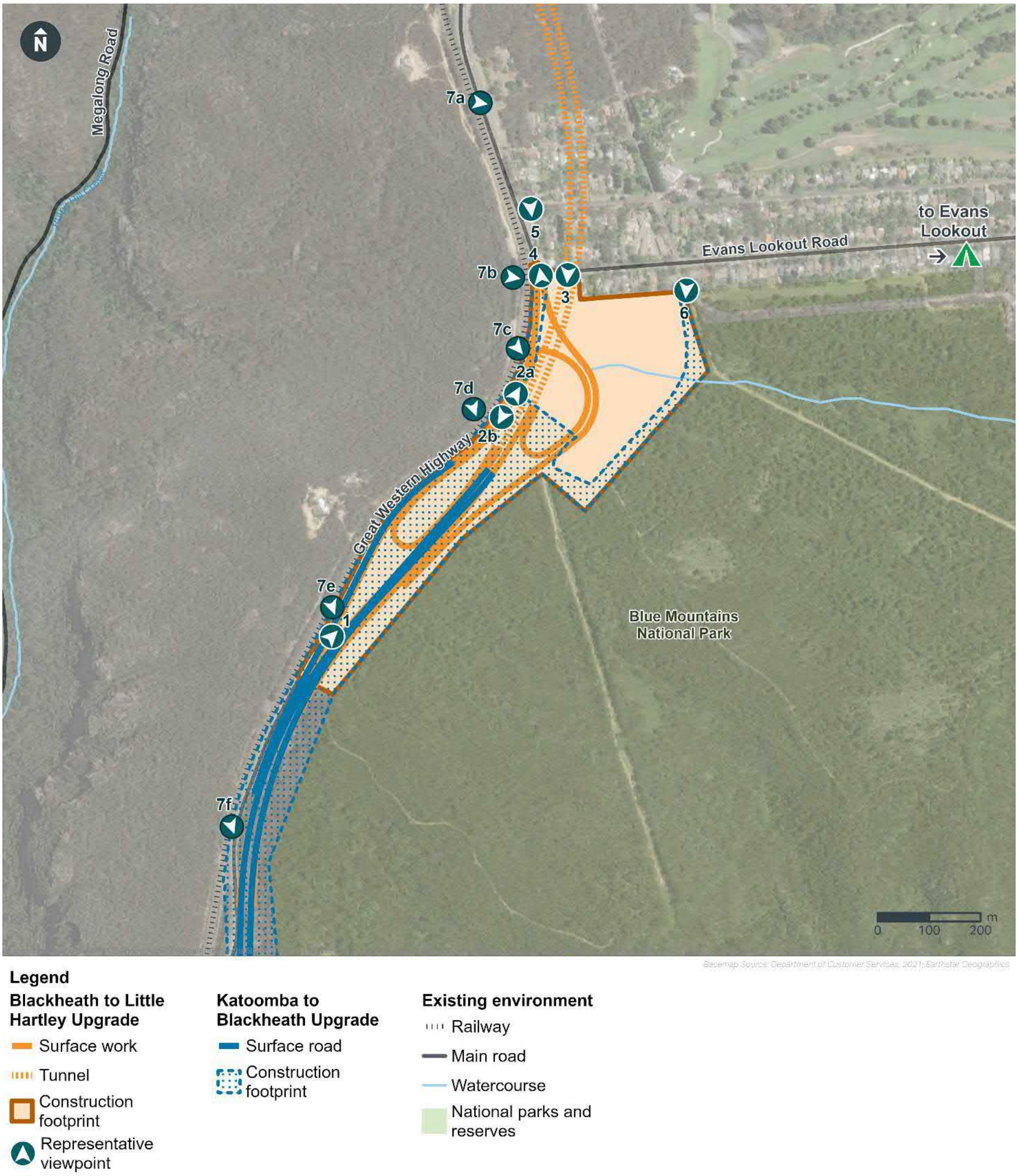


Figure 18-2 Representative viewpoints at Blackheath

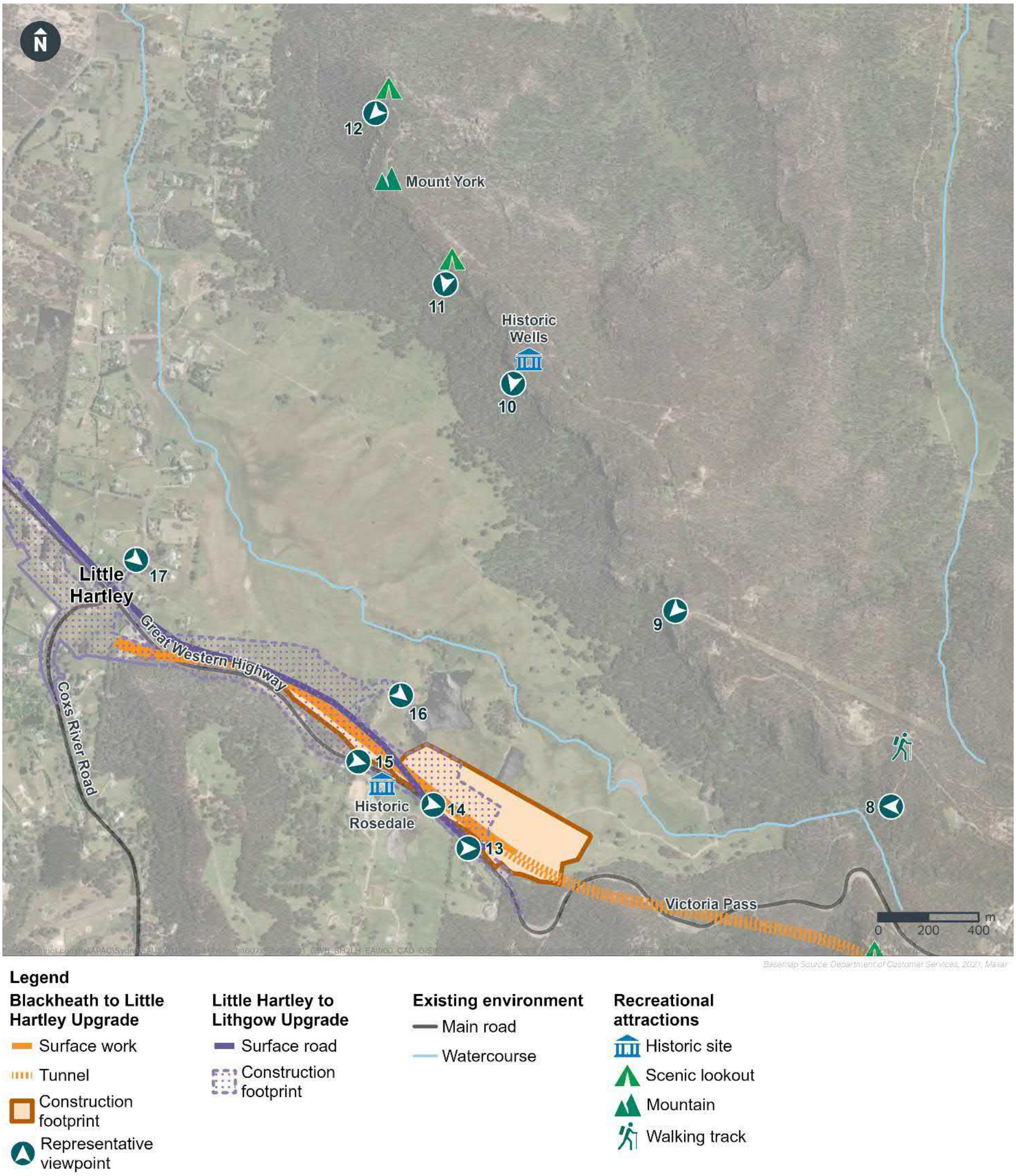


Figure 18-3 Representative viewpoints at Little Hartley

18.1.2 Assessment criteria

The landscape character and visual impact ratings have been determined using the sensitivity and magnitude matrix based on the Environmental Impacts Assessment Practice Note – Guideline for Landscape Character and Visual Impact Assessment EIA-N04 (Transport for NSW, 2020c) as shown in Figure 18-4.

Sensitivity is a qualitative measurement considering the capacity of the landscape character zone or visual receiver to absorb change from the project. Magnitude is a qualitative measurement of the scale, form and character of the project when compared to the existing environment. For the visual impact assessment, this includes consideration of how far the project is from the viewer.

The matrix below is used to determine the overall impact level, which represents a combination of sensitivity and magnitude ratings. The effect of the overall impact was then qualitatively assessed as ‘adverse’, ‘neutral’ or ‘beneficial’ when measured against the existing environment.

SENSITIVITY	MAGNITUDE OF EFFECT			
	High	**Moderate**	**Low**	**Negligible**
High	High	High-Moderate	Moderate	Negligible
Moderate	High-Moderate	Moderate	Moderate-Low	Negligible
Low	Moderate	Moderate-Low	Low	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible

Figure 18-4 Landscape character and visual impact grading matrix

18.1.3 Ventilation design options

The preferred ventilation design for the project has not been determined, and therefore two options have been assessed in the environmental impact assessment including emissions via ventilation outlets and emissions via portals.

Portal emissions would not require additional built structures. The ventilation outlet option would include a 10 metre tall structure (above the finished surface level) near the Blackheath and Little Hartley portals assumed to be a cylindrical form around 10 metres in diameter. Further detail regarding portal emissions and ventilation outlet emissions options is provided in Chapter 3 (Project alternatives and options), Chapter 4 (Project description) and Chapter 9 (Air quality).

Both options have been considered in Section 18.4 with qualitative ratings related to visual impacts summarised in Table 18-7 and Table 18-8.

18.2 Existing environment

The existing environment around the study area is characterised by dense vegetation from the Blue Mountains National Park, as well as built forms attributed to the towns of Blackheath and Mount Victoria. The project crosses areas with varied local context, differing built form elements, unique natural characteristics and various land uses.

The Greater Blue Mountains World Heritage Area is listed on the World Heritage List and is located outside but near the construction footprints at Blackheath and Soldiers Pinch (see Figure 18-1). The significance of the area is closely tied to ecological, biological and conservation importance. An additional area of the Greater Blue Mountains Area is nominated for listing on the National Heritage List (referred to as the Greater Blue Mountains Area – Additional Values) and extends across parts of the construction footprints at Blackheath and Soldiers Pinch. Further information about these items is provided in Chapter 17 (Non-Aboriginal heritage).

With regard to the study area, the Greater Blue Mountains World Heritage Area is closest to the project at the Soldiers Pinch construction site. Part of the study area encroaches on the Greater Blue Mountains World Heritage Area, however no viewpoints are contained in this area. From the Greater Blue Mountains World Heritage Area, views to the project are not available, therefore viewpoints have not been selected from this area. Further, the project is not located within or near any views which impact the Greater Blue Mountains World Heritage Area or National Park.

The presence of the Greater Blue Mountains World Heritage Area is a consideration of the value of the landscape in the area surrounding the project and has been included in the general sensitivity of the landscape character zones assessed.

18.2.1 Baseline environment

This assessment considers a baseline environment for the operational visual impact assessment, which for the purpose of this assessment, the other components of the Great Western Highway Upgrade Program (Upgrade Program) have been completed at the commencement of project construction including the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade.

At Blackheath the baseline environment would be comprised of the existing environment, in addition to elements from the Katoomba to Blackheath Upgrade which include:

- a connection from Katoomba to Blackheath, using the existing Great Western Highway alignment, to provide a local road connection to the Blackheath township
- a dual lane carriageway, in addition to the existing Great Western Highway, extending east of Blackheath to Katoomba
- an active transport trail which would run along the existing Great Western Highway until Blackheath, where it would run along the eastern side of the Blackheath construction site
- sediment and water quality basins
- vegetation clearance and landscape and revegetation
- road infrastructure including a utilities corridor, fencing, safety barriers, lighting and signage.

At Little Hartley the baseline environment would be comprised of the existing environment, in addition to elements from the Little Hartley to Lithgow Upgrade which include:

- a dual lane carriageway extending west of Little Hartley
- two bridge structures adjacent to the Little Hartley portal over the carriageway connecting to the existing Great Western Highway alignment
- an active transport trail which would run along the local service road alignment adjacent to the Little Hartley portal to Berghofer's Pass
- formalisation of Berghofer's Pass car park
- sediment and water quality basins
- vegetation clearance and landscape and revegetation
- upgraded private property access, and other road infrastructure such as fencing, safety barriers, lighting and signage.

18.2.2 Landscape character

A description and sensitivity rating for each landscape character zone based on the baseline environment described in Section 18.2.1 is provided in Table 18-1. Landscape character zone 1 has been further categorised into character precincts based on surrounding landscapes: landscape character zone 1a (Township), landscape character zone 1b (Butlers Creek Valley), and landscape character zone 1c (Bushland).

Table 18-1 Landscape character zones and sensitivity

Landscape character zone	Description	Sensitivity
Landscape character zone 1a: Great Western Highway (Township)	The landscape of the Great Western Highway where it passes through the Blackheath and Mount Victoria townships is characterised by road infrastructure supporting connections to commercial and residential areas and includes signalised intersections and street trees.	Low
Landscape character zone 1b: Great Western Highway (Butlers Creek Valley)	The Great Western Highway at the bottom of Victoria Pass is characterised by the curving road adjacent to pockets of native and exotic vegetation associated with the pastoral landscape. The majority of this area would be subject to landscape character impacts from the Little Hartley to Lithgow Upgrade.	Moderate
Landscape character zone 1c: Great Western Highway (Bushland)	The Great Western Highway where it passes through scenic areas of bushland associated with the Blue Mountains National Park. Parts of this area would be subject to landscape character impacts from the Katoomba to Blackheath Upgrade.	High
Landscape character zone 2: Township	The more densely populated townships within the study area, located off the Great Western Highway including Blackheath and Mount Victoria, typically comprised of a central commercial area surrounded by residential development with heritage items, such as older commercial buildings, individual houses or heritage conservation areas.	Low
Landscape character zone 3: Harley Valley	The valley near Little Hartley, comprising open pastoral landscapes surrounded by densely vegetated bushland slopes, sensitive to new built forms given these are limited within the area.	High
Landscape character zone 4: Bushland	The dense, rugged bushland that surrounds the majority of the Great Western Highway unique to the Blue Mountains and Greater Blue Mountains World Heritage Area, comprising eucalypt woodland and forests, with lookouts common along steep ridge lines looking toward the valley.	High

18.2.3 Viewpoint locations

A total of 17 viewpoints were identified to present representative visual changes in the landscape and to assess the potential visual impacts of the project on visual receivers. Viewpoints identified at Blackheath are shown in Figure 18-2, while viewpoints identified at Little Hartley are shown in Figure 18-3. All viewpoints are described in Section 7 of Appendix N (Technical report – Urban design, landscape and visual).

Table 18-2 provides a description of the eight viewpoints assessed as having high and high to moderate impacts as a result of construction and/or operation of the project.

Table 18-2 Viewpoints assessed as having high and high to moderate impacts

Viewpoint	Description
2a	Located on the Great Western Highway at Tennyson Road in Blackheath representing the view of motorists looking north-east (travelling westbound) adjacent to the scenic nature of the Blue Mountains National Park (see Figure 18-5).
2b	Located on the Great Western Highway at Tennyson Road in Blackheath representing the view of motorists looking south-west (travelling eastbound) adjacent to the scenic nature of the Blue Mountains National Park.
3	Located on Evans Lookout Road in Blackheath, which provides access to Blue Mountains National Park and the Greater Blue Mountains World Heritage Area and associated hiking trails, representing the view of motorists and residents looking south (travelling eastbound) toward the Great Western Highway.
6	Located on Valley View Road in Blackheath, representing the view of residents looking south from the rear of residential properties.
7	Includes 6 views (7a-7f) located along the train line at Blackheath representing the view of commuters looking south (travelling eastbound) with an elevated view to the Great Western Highway, adjacent to the scenic nature of the Blue Mountains National Park (see Figure 18-9).
9	Located at an informal lookout point at an existing transmission easement (for exact location see Figure 18-3), representing an elevated view from visitors and two residential houses looking south-west over the Hartley Valley (see Figure 18-11).
10	Located near the Historic Wells lookout, representing an elevated view from visitors looking south over the Hartley Valley.
15	Located at the Hartley Valley Holiday Farm within a landscape conservation area, representing a view from motorists and visitors looking east (see Figure 18-13).

18.3 Potential impacts – construction

Construction activities, including night lighting at Blackheath, Soldiers Pinch and Little Hartley construction sites that involve or support tunnelling activities, are likely to result in potential landscape character and visual impacts. Receivers who would likely be impacted include but are not limited to:

- residents that adjoin and/or have views of the project and/or construction sites
- road users
- visitors to nearby recreational attractions.

The most visible construction activities would likely include:

- clearing of vegetation and earthworks
- construction of structures to support the permanent tunnel operational facilities described in Chapter 5 (Construction)
- operation of heavy and/or light vehicles for construction site access and spoil haulage movements

- presence of visually prominent plant and equipment, including cranes, roadheaders, tunnel boring machines (TBMs) and construction hoarding
- TBM assembly and launch areas, concrete batching plant and acoustic shed at the Little Hartley construction site
- lighting for night-time works.

An indicative list of construction equipment and activities required for the project is provided in Chapter 5 (Construction). In general, potential construction impacts would be localised to the area within and immediately surrounding the construction footprint. However, as the proposed construction period would be up to around eight years, measures to mitigate potential landscape character and visual impacts at the construction sites are detailed in Section 18.5.

18.3.1 Landscape character

Landscape character impacts during construction would be anticipated at all landscape character zones identified in Section 18.2.2 with the exception of landscape character zone 2 as no surface works are proposed at this location and therefore construction landscape character impacts are anticipated to be negligible.

A summary of the landscape character impacts during construction for each landscape character zone is provided in Table 18-3.

Table 18-3 Summary of landscape character impacts during construction

Landscape character zone	Sensitivity	Potential impact discussion	Impact rating
Landscape character zone 1a: Great Western Highway (Township) 1a	Low	The other components of the Upgrade Program would result in the increased presence of construction activities surrounding the project, reducing the magnitude of change of the project. Construction of the project would overlap with construction activities at Blackheath and Little Hartley, both spatially and temporally as a result of the Upgrade Program. This overlap of construction activities would result in an overall impact rating of high to moderate (adverse).	High to moderate (adverse)
Landscape character zone 1b: Great Western Highway (Butlers Creek Valley) 1b	Moderate		High to moderate (adverse)
Landscape character zone 1c: Great Western Highway (Bushland) 1c	High		High to moderate (adverse)
Landscape character zone 2: Township 2	Low	None.	Negligible (neutral)
Landscape character zone 3: Harley Valley 3	High	The Little Hartley construction site would substantially impact the quiet, rural valley centred around Butlers Creek, adding to the clutter of construction associated with the Little Hartley to Lithgow Upgrade, including large equipment, activities and ancillary facilities within the landscape.	High (adverse)

Landscape character zone	Sensitivity	Potential impact discussion	Impact rating
Landscape character zone 4: Bushland4	High	At Blackheath, the vegetation clearing from the Katoomba to Blackheath Upgrade would result in the spatial widening of the Great Western Highway. This would comprise a distinct shift in the local character of the area within the Great Western Highway corridor and within the local area of bushland to the east, within the Blue Mountains National Park.	High (adverse)

18.3.2 Visual impacts

Assessment of the potential construction impacts for all viewpoints is included in Section 7 of Appendix N (Technical report – Urban design, landscape and visual). Potential moderate and high to moderate impacts to viewpoints are summarised in this section.

Blackheath

Table 18-4 provides a summary of the potential moderate and high to moderate impacts to viewpoints at Blackheath during construction. Road users on the Great Western Highway, including tourists or those accessing recreational attractions, would see detailed views of the Blackheath construction site as well as a widened road corridor due to vegetation clearance.

A small number of residents at the rear of their properties on Evans Lookout Road between Valley View Road and the Great Western Highway would be able to see the Blackheath construction site fencing and hoarding. Residents on Evans Lookout Road would see a higher volume of traffic, given construction vehicles would access the Blackheath construction site at the intersection of the Great Western Highway and Evans Lookout Road. Residents on Valley View Road may experience a smaller increase in light vehicle construction traffic vehicles as this road would be used for light vehicle access to the Blackheath construction site.

Visual receivers including residents and tourists or recreational road users, who may expect to experience scenic outlooks throughout their journey, are considered highly sensitive and would be visually impacted during construction.

Measures to mitigate these potential visual impacts are detailed in Section 18.5.

Table 18-4 Summary of high and high to moderate visual impacts during construction at Blackheath

Viewpoint	Potential impact discussion	Sensitivity	Magnitude of change	Overall impact rating
2a: Great Western Highway at Tennyson Road looking north	The project would result in a large area to the north and east of the viewpoint being cleared of vegetation, followed by earthworks that would extend down the hillside to the east. If selected as the preferred ventilation design, construction of the ventilation outlet would be seen to the north east with the visual clutter of the construction site further down the hillside.	High	High	High (adverse)
3: Evans Lookout Road	The area to the south of the viewpoint would be cleared of vegetation and open up a view of fencing, hoarding and construction activities associated with the upgrade of the intersection of Evans Lookout Road and the Great Western Highway and the construction of the eastbound on-ramp and connection with the upgraded Great Western Highway in the fore to middle ground of the view.	Moderate	High	High to moderate (adverse)
4. Great Western Highway at Evans Lookout Road	The project would result in the presence of general construction activity, including roadworks, earthworks and construction equipment within this viewpoint. Construction vehicles would be seen turning between the Great Western Highway and Evans Lookout Road however this access would have been used during construction of the Katoomba to Blackheath Upgrade and therefore would not result in changes to the baseline view. The visual clutter of construction would be seen over a substantial portion of the viewpoint and would comprise an adverse change within the view.	Moderate	High	High to moderate (adverse)
6: Valley View Road	Vegetation would be cleared to open up the view of the valley to the south. The presence of hoarding and fencing around the construction site would limit views into the site, however if no fencing is provided, construction activity would be clearly viewed in the fore and middle ground, including earthworks, construction equipment and machinery and stockpiling.	Moderate	High	High to moderate (adverse)

Viewpoint	Potential impact discussion	Sensitivity	Magnitude of change	Overall impact rating
7: the train from Blackheath	Vegetation would be cleared to the north of the Katoomba to Blackheath Upgrade which would open up views into the valley to the east. The elevated viewpoint would result in views over any boundary fencing, allowing views into the construction footprint. General construction activity would be clearly visible in the fore and middle ground of the viewpoint, including earthworks, construction equipment and machinery, stockpiling and amenities buildings.	High	High	High (adverse)

Soldiers Pinch

Road users on the Great Western Highway would have limited views to the Soldiers Pinch construction site given its lower elevation in the landscape. Further, the project would only be visible to the road users for a short duration as they travel along the Great Western Highway. Lighting required for night-time construction works would be visually prominent to road users passing by. The main changes that would be noticeable for road users include vegetation clearing, construction equipment such as mid-tunnel access shaft and cranes and construction plant and material laydown.

This site is considered to have moderate sensitivity and a low magnitude of change. The overall impact rating for the visual impacts at Soldiers Pinch would be moderate to low (adverse).

Little Hartley

Table 18-5 provides a summary of the potential moderate and high to moderate impacts to viewpoints at Little Hartley during construction.

Road users on the Great Western Highway, including tourists or those accessing the area for recreational purposes, would see construction works associated with Little Hartley construction site. A small number of residents would be able to view the construction site and associated work from their properties on the Great Western Highway in Little Hartley. Construction activities and/or machinery that would be visible to these visual receivers include lighting required for night-time works, TBM operations, an acoustic shed and other large construction infrastructure.

Measures to mitigate these potential visual impacts are detailed in Section 18.5.

Table 18-5 Summary of moderate and high to moderate visual impacts during construction at Little Hartley

Viewpoint	Potential impact discussion	Sensitivity	Magnitude of change	Overall impact rating
8: Berghofer's Pass	The project would visually comprise an extension of the construction footprint for the Little Hartley to Lithgow Upgrade which would result in earthworks and general construction activity being visible beyond the project construction footprint. However, from this distance it is unlikely that much detail of this activity would be discernible	Moderate	Moderate	Moderate (adverse)
9: Transmission easement lookout	Activities and machinery within the construction footprint, such as earthworks, TBM transport, assembly and launch, the acoustic shed and concrete mixing facilities would be visually prominent. Night lighting would be visible within the construction footprint for the hauling of spoil within Little Hartley valley.	High	Moderate	High to moderate (adverse)
10: Historic Wells lookout	The project would comprise an extension of the construction footprint of the Little Hartley to Lithgow Upgrade. Only the larger elements within the construction site would be discernible against the visual clutter within the construction footprint, including the larger buildings and stockpile areas, earthworks and sheds. Night lighting would be visible within the construction footprint for the hauling of spoil within the valley.	Moderate	High	High to moderate (adverse)
11: Bardens lookout	Construction activities would be seen as an area of visual clutter extending to the south from the Little Hartley to Lithgow Upgrade construction footprint. It is unlikely much detail would be seen from this viewpoint due to the oblique viewing angle.	Moderate	Moderate	Moderate (adverse)
13: Great Western Highway	The project would be seen in the middle to the background of this viewpoint, beyond the Little Hartley to Lithgow Upgrade. The view would include the acoustic shed, TBM assembly area and other general construction activity. Trucks hauling spoilage would access the construction footprint during the day and night, with night lighting required to facilitate the movements and other construction activity.	Low	High	Moderate (adverse)

Viewpoint	Potential impact discussion	Sensitivity	Magnitude of change	Overall impact rating
14. Great Western Highway	Larger elements of the project construction would be visible from this viewpoint, including the concrete mixing facility, the top of the acoustics shed and earthworks equipment associated with construction of the dual carriageway. Night lighting would be visible within the construction footprint, along with construction traffic accessing the construction site during the day and night.	Low	High	Moderate (adverse)
15: Hartley Valley Holiday Farm	Earthworks and roadworks would be visible from this viewpoint. Vegetation would have already been removed, opening up views across the valley. Construction activities would be seen in the middle to background of the viewpoint. Night lighting associated with the removal of spoil would be visible within the valley, along with an increase in construction traffic on the existing Great Western Highway.	High	Moderate	High to moderate (adverse)
16: 2200 Great Western Highway	Construction activities associated with the Upgrade Program, including sediment and water quality basins and the eastbound carriageway of the Great Western Highway. The project would be visible beyond these construction activities, including stockpiling, a construction water treatment plant, and the visual clutter within the construction footprint seen from a reasonable distance away. Night lighting associated with the removal of spoil would be visible against the backdrop of Victoria Pass and Mount Sugarloaf.	Moderate	Moderate	Moderate (adverse)

18.4 Potential impacts – operation

Landscape character and visual impacts during operation of the project would likely impact the following receivers:

- residents that adjoin and/or have views of the project and/or operational infrastructure
- road users
- visitors to nearby recreational attractions.

The water supply pipeline between the Little Hartley construction footprint and Lithgow would be located underground or integrated within existing infrastructure (such as bridges) and would therefore have negligible visual impacts during operation.

Both ventilation design options described in Section 18.1.3 have been considered in the operational impact assessment. While the overall impact rating for each ventilation design option is similar, the qualitative rating differs (i.e. whether the impact is considered 'adverse' 'neutral' or 'beneficial' in nature).

As Soldiers Pinch would only be used to support construction of the project, this area has not been considered in the operational assessment.

18.4.1 Landscape character

A summary discussion of potential operational impacts to each landscape character zone is provided below with the impact ratings findings summarised in Table 18-6. The overall impact ratings do not consider the implementation of mitigation measures to reduce impacts. Landscaping and other measures, such as murals and surface decoration of ventilation outlets (if selected as the ventilation design), would be considered to reduce potential landscape character impacts. These measures, detailed in Section 18.5, may reduce the overall impact ratings detailed below.

Table 18-6 Summary of landscape character impacts during operation

Landscape character zones	Sensitivity	Magnitude of change	Overall impact rating	Qualitative rating	
				Ventilation outlets	Portal emissions
Landscape character zone 1a	Low	Low	Low	Beneficial	Beneficial
Landscape character zone 1b	Moderate	High	High to moderate	Adverse	Neutral
Landscape character zone 1c	High	Moderate	High to moderate	Adverse	Neutral
Landscape character zone 2	Low	Negligible	Negligible	Neutral	Neutral
Landscape character zone 3	High	Moderate	High to moderate	Adverse	Adverse
Landscape character zone 4	High	Moderate	High to moderate	Adverse	Adverse

Landscape character zone 1a: Great Western Highway: Township

The project would not result in direct changes to townships along the Great Western Highway within the study area. The project would, however, substantially reduce traffic and heavy vehicles on the existing Great Western Highway, resulting in improved accessibility and amenity of the townships along the Great Western Highway, particularly Blackheath.

Landscape character zone 1b: Great Western Highway: Butlers Creek Valley

The project would introduce a number of road infrastructure changes including the Little Hartley portal, surface road connections and operational infrastructure such as a water treatment plant and substation at this location. If selected as the preferred ventilation design, the ventilation outlet would introduce a 10 metre tall structure above the finished surface level near the Little Hartley portal. The project would tie in with infrastructure delivered by the Little Hartley to Lithgow Upgrade which would have changed the landscape character zone before the project. The project would introduce operational infrastructure comprising an uncharacteristic built form in this area.

Both ventilation design options would have an overall impact rating of high to moderate. The portal emissions option would have a qualitative rating of neutral, while the ventilation outlet option would have a qualitative rating of adverse given the visual impact of the structure within the landscape. Measures to mitigate these impacts are detailed in Section 18.5.

Landscape character zone 1c: Great Western Highway: Bushland

The project would result in localised widening on the Great Western Highway and an upgraded interchange at Blackheath. If selected as the preferred ventilation design, the ventilation outlet would introduce a 10 metre tall structure above the finished surface level near the Blackheath portal. While the project would involve the widening of landscape character zone 1c into the neighbouring landscape character zone 4 (Bushland), the project has been designed to be well integrated into the landscape, including by locating the ventilation building underground. Landscape planting would help integrate the project with the surrounding landscape. The upgraded surface interchange would be similar to others nearby (i.e. at Leura). Additionally, elements of the Katoomba to Blackheath Upgrade would comprise a change to the landscape character zone that precedes the project.

Both ventilation design options would have an overall impact rating of high to moderate. The portal emissions option would have a qualitative rating of neutral, while the ventilation outlet option would have a qualitative rating of adverse given the new structure would be uncharacteristic within the existing Great Western Highway corridor. Measures to mitigate these impacts, such as landscaping between new carriageways and on- and off-ramps, are detailed in Section 18.5.

Landscape character zone 2: Township

No operational infrastructure would occur within view of landscape character zone 2 and therefore the overall impact rating is negligible. The closest project elements would include landscape planting and surface road upgrades near Evans Lookout Road south of Blackheath, however these are located within landscape character zone 1a.

Landscape character zone 3: Butlers Creek Valley

Operational project elements including the Little Hartley portal and new surface road upgrades would be contained within this landscape character zone. The widening of the Great Western Highway and the addition of large built structures such as the Little Hartley portal would elevate the prominence of the transport corridor which would reduce the open landscape contained within the ridgelines of the Great Western Highway within landscape character zone 3. If selected as the preferred ventilation design, the ventilation outlet would introduce a 10 metre tall structure above the finished surface level near the Little Hartley portal which would add to the large visual elements within this landscape character zone.

While the landscape character zone would already be substantially altered by the Little Hartley to Lithgow Upgrade, the built form proposed as part of the project would still comprise uncharacteristically large elements to the landscape character zone. Irrespective of the ventilation design, the overall impacting rating would be high to moderate (adverse). Measures to mitigate these potential impacts, such as landscaping and visually embedding project elements within low points in the landscape, are detailed in Section 18.5.

Landscape character zone 4: Bushland

Key visual operational project elements at Blackheath would include the tunnel portal, upgraded surface roads, the tunnel operations facility, water quality basins, signage and landscape planting. These new structures would elevate the prominence of the transport corridor. While uncharacteristic of the landscape character zone, the perceived scale of the tunnel operations facility would be perceived as being reduced by the surrounding bushland enclosing the facility and landscape planting proposed.

While the landscape character zone would already be substantially altered by the Katoomba to Blackheath Upgrade, the project would require additional vegetation removal. Irrespective of the ventilation design, the overall impact rating would be high to moderate (adverse). Measures to mitigate these potential impacts are detailed in Section 18.5.

18.4.2 Visual impacts

The project would be in tunnel for the majority of its length, which generally limits the potential for visual impacts to the areas around the tunnel portals where surface works and operational infrastructure are proposed.

Assessment of the potential operational impacts for all viewpoints is included in Section 7 of Appendix N (Technical report – Urban design, landscape and visual). This includes potential impacts to viewpoints 5, 12, 13, 14 and 17 that were considered to range between low (adverse), low to negligible (neutral) and negligible (neutral).

Those viewpoints subject to potential moderate and high impacts are discussed in the sections below. The overall impact ratings described in Table 18-7 and Table 18-8 do not consider the implementation of mitigation measures to reduce impacts. Landscaping and other measures, such as considering murals and surface decoration of ventilation outlets (if selected as the ventilation design), would be considered to reduce potential visual impacts. These measures, detailed in Section 18.5, may reduce the overall impact ratings detailed below.

Blackheath

Assessment of the potential operational visual impacts at all Blackheath viewpoints is included in Appendix N (Technical report – Urban design, landscape and visual). Moderate and high potential impacts to viewpoints located at Blackheath are summarised in Table 18-7.

Three viewpoints would have an overall visual impact rating of high (viewpoints 2a, 2b and 7). Existing views, as well as visual representations of the project from these viewpoints are shown in Figure 18-5 to Figure 18-10.

The existing environment presented in these viewpoints is different to the baseline environment defined in Section 18.2.1. The baseline environment at Blackheath would show reduced vegetation having been cleared for the Katoomba to Blackheath Upgrade. Some additional vegetation clearance would be required for the project which would comprise a substantial change at Blackheath from the existing environment which is located amongst dense bushland on a sloping site.

Views east across the valley that were previously screened by vegetation would become exposed to motorists, cyclists and train commuters. The increased width of the Great Western Highway corridor, the Blackheath portal, the tunnel operations facility and the ventilation outlet (if selected as the ventilation design) would result in substantial long-term changes. The scale of these elements would be uncharacteristic of the surrounding environment. Given the presence of other large operational infrastructure, the portal emissions option (if selected as the ventilation design), would only partly reduce the impact at viewpoint 7.

Overall, the visual impact of the project at Blackheath is considered to be moderate (adverse). This is based on consideration of the unique sensitivities of the Blue Mountains and the high value of the landscape and views linked to tourism, the natural environment and heritage values.

Table 18-7 Summary of moderate and high visual impacts during operation at Blackheath

Viewpoint	Potential impact discussion	Ventilation option	Sensitivity	Magnitude of change	Overall impact rating
1: Great Western Highway	Additional road corridor and transport infrastructure would include: • a two-lane Great Western Highway westbound carriageway which connects to the tunnel at the Blackheath portal • landscape plantings around the upgraded surface roads.	Ventilation outlet or portal emissions	Moderate	Moderate	Moderate (neutral)
2a: Great Western Highway at Tennyson Road looking north	Additional road corridor and transport infrastructure with cleared vegetation exposing the: • Great Western Highway westbound carriage • tunnel on-ramp • Blackheath portal • ventilation outlet (if selected as the ventilation design)[1]. See Figure 18-6.	Ventilation outlet or portal emissions	High	High	High (adverse)
2b: Great Western Highway at Tennyson Road looking south	Additional road corridor and transport infrastructure with cleared vegetation exposing the: • sloping landscape to the east • tunnel off-ramp (seen from an elevated viewpoint). See Figure 18-8.	Ventilation outlet or portal emissions	High	High	High (adverse)

[1] The ventilation outlet is unlikely to affect the magnitude of change at this location. The qualitative rating would remain as adverse given the level of change to the view due to the visual changes during operation of the project

Viewpoint	Potential impact discussion	Ventilation option	Sensitivity	Magnitude of change	Overall impact rating
3: Evans Lookout Road	Noticeably cleared areas and minor additional infrastructure including: • vegetation clearance and landscape planting to screen the road infrastructure • new batters along the Great Western Highway • new road surface and fencing • ventilation outlet (if selected as the ventilation design), which would comprise a large, uncharacteristic piece of infrastructure in this view.	Ventilation outlet or portal emissions	Moderate	Moderate	Moderate (adverse)
4: Great Western Highway at Evans Lookout Road	No new dominant elements with small scale changes including: • upgrade of the existing intersection • Great Western Highway retained with new fencing, safety barriers and signage.	Ventilation outlet or portal emissions	Moderate	Low	Moderate to low (neutral)
6: Valley View Road	No new dominant elements with small scale changes including: • landscape planting • ventilation outlet (if selected as the ventilation design), which may be seen over the tops of trees until proposed landscape planting matures.	Ventilation outlet or portal emissions	Moderate	Low	Moderate to low (neutral)

Viewpoint	Potential impact discussion	Ventilation option	Sensitivity	Magnitude of change	Overall impact rating
7: the train from Blackheath	Moderate to expansive additional road corridor and transport infrastructure including: • on- and off-ramps and local road connections • upgrade to the Great Western Highway and Evans Lookout Road intersection • fencing, landscaping, signage and other road infrastructure • the tunnel operational facility • ventilation outlet (if selected as the ventilation design), which would be seen in the horizon over longer periods of time by commuters and would be an uncharacteristic built form against the surrounding bushland. See Figure 18-10.	Ventilation outlet	High	High	High (adverse)
		Portal emissions	High	Moderate	High to moderate (neutral)


Figure 18-5 Viewpoint 2a – existing view westbound showing the Great Western Highway at Tennyson Road

Figure 18-6 Viewpoint 2a – proposed view westbound showing the upgraded Great Western Highway on the left and the ventilation outlet (if selected as the ventilation design) on the right

Figure 18-7 Viewpoint 2b – existing view eastbound showing the Great Western Highway

Figure 18-8 Viewpoint 2b – proposed view looking eastbound showing the upgraded Great Western Highway on the right and the Blackheath off-ramp on the left

Figure 18-9 Viewpoint 7(b) and 7(c) – existing views east from the train line showing the Great Western Highway

Figure 18-10 Viewpoint 7(b) and 7(c) – proposed views east from the train line showing the vegetation to be cleared for the project in pink

Little Hartley

Assessment of the potential operational visual impacts at all Little Hartley viewpoints is included in Appendix N (Technical report – Urban design, landscape and visual). Moderate and high potential impacts to viewpoints located at Little Hartley are summarised in Table 18-8.

Two viewpoints would have an overall impact rating of high to moderate (viewpoints 9 and 15). Existing views, as well as visual representations of the project from these viewpoints are shown in Figure 18-11 to Figure 18-14.

From the elevated viewpoints, the substantial distance from the project coupled with undulating terrain typically limits the overall impact of the project. Viewpoints located along the Great Western Highway typically look out to the Little Hartley to Lithgow Upgrade works which screen the impact of the project. At viewpoint 15, the project is seen from a partially elevated position, where the widened Great Western Highway corridor would be noticeable.

The ventilation outlet (if selected as the ventilation design), water treatment plant and the substation would comprise the most prominent elements of the project. While these elements would be uncharacteristic of the surrounding environment, they would be partially screened by landscape planting proposed as part of the project.

Overall, the visual impact of the project at Little Hartley is considered to be moderate (adverse). This is based on consideration of the picturesque character of the Little Hartley valley, the high volume of tourist traffic and activity and recreational hiking trails nearby.

Table 18-8 Summary of moderate and high visual impacts during operation at Little Hartley

Viewpoint	Operational visual impact	Ventilation option	Sensitivity	Magnitude of change	Overall visual rating
8: Berghofer's Pass	Additional infrastructure, seen in conjunction with more prominent Little Hartley to Lithgow Upgrade elements, viewed from afar including: • water treatment plant and substation • limited view of the new surface road extending westbound from Little Hartley • landscaping • ventilation outlet (if selected as the ventilation design).	Ventilation outlet or portal emissions	Moderate	Moderate	Moderate (adverse)
9: Transmission easement lookout	A similar view as from viewpoint 8 described above, but closer. See Figure 18-12.	Ventilation outlet or portal emissions	High	Moderate	High to moderate (adverse)
10: Historic Wells lookout	A similar view as from viewpoint 8 described above, but further away than viewpoint 8 and 9.	Ventilation outlet or portal emissions	Moderate	Moderate	Moderate (adverse)
11: Bardens lookout	Small scale changes seen from an oblique angle from afar and partially screened by vegetation.	Ventilation outlet or portal emissions	Moderate	Low	Moderate to low (neutral)

Viewpoint	Operational visual impact	Ventilation option	Sensitivity	Magnitude of change	Overall visual rating
15: Hartley Valley Holiday Farm	Increased infrastructure within the valley setting, seen in conjunction with more prominent Little Hartley to Lithgow Upgrade elements at grade, with introduced project elements including: • carriageway which is elevated from the surrounding property • safety barriers, signage and passing traffic • landscaping. See Figure 18-14.	Ventilation outlet or portal emissions	High	Moderate	High to moderate (adverse)
16: 2200 Great Western Highway	Small scale changes seen from afar and partially screened by the Little Hartley to Lithgow Upgrade, the ventilation outlet (if selected as the ventilation design) and the Little Hartley portal tucked away in the hillside due to the low elevation at this viewpoint.	Ventilation outlet or portal emissions	Moderate	Low	Moderate to low (adverse)

Figure 18-11 Viewpoint 9 – existing view south over the Little Hartley valley

Figure 18-12 Viewpoint 9 – proposed view south over the Little Hartley valley

Figure 18-13 Viewpoint 15 – existing view eastbound towards Victoria Pass

Figure 18-14 Viewpoint 15 – proposed view eastbound towards Victoria Pass showing the bridge structure (delivered by the Little Hartley to Lithgow Upgrade), water treatment plant and substation

18.5 Environmental mitigation measures

18.5.1 Performance outcomes

Performance outcomes for the project in relation to urban design, landscape and visual impacts are listed in Table 18-9 and identify measurable performance-based standards for environmental management.

Table 18-9 Urban design, landscape and visual performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
The project is well designed and enhances the environment where is it located, including improved accessibility and connectivity for communities and public spaces. The project helps to support the health and wellbeing of Country by valuing, respecting and being guided by Aboriginal people.	Design the project to respond to the surrounding landscape character and integrate the design of built and natural environments in an understandable, complementary, and sustainable way, establishing a robust Connection to Country. Incorporate Aboriginal heritage interpretation and Aboriginal cultural design principles into the design of the project in consultation with Aboriginal stakeholders.	Design
The project contributes to greener places through the enhancement and provision of green infrastructure.	Design and construct the project to include green infrastructure as part of surface operational infrastructure, where feasible.	Design and construction

18.5.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential landscape character and visual impacts as a result of the project are detailed in Table 18-10. A full list of mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 18-10 Environmental mitigation measures – landscape character and visual impacts

ID	Mitigation measure	Timing
LV1	A Place Design and Landscape Plan (PDLP) will be prepared to minimise landscape character and visual impacts, and detail and guide the implementation of landscape features to be installed as part of the project. This would include requirements for: • landscape and re-vegetation • the provision of vegetative screening to soften the appearance of structural elements of the project and provide screening of sensitive views to the project • requirements of the Aboriginal and non-Aboriginal cultural and heritage interpretation • site levels and grades for the project that integrate with the surrounding terrain to assist with the visual assimilation of the project into the surrounding landscape where practicable. The gradients of engineered slopes will seek to maximise the establishment of vegetation and allow for appropriate maintenance.	Construction

ID	Mitigation measure	Timing
	The PDLP will be prepared in accordance with applicable guidelines, be consistent with the project identity in the EIS and relevant urban design objectives and principles for the project including consideration of implementation of Crime Prevention Through Environmental Design (CPTED) principles, and in consultation with the relevant councils.	
LV2	As part of further design development, opportunities to visually integrate the project into the landscape, will be considered and will reflect the landscape and revegetation requirements identified in environmental mitigation measures for biodiversity and non-Aboriginal heritage. This will consider measures including: • retention and protection of existing trees where reasonable and feasible, particularly along the unaltered edges of the existing Great Western Highway • avoidance of formal rows of trees or blocks of shrub and grass plantings as these would be uncharacteristic within both the Blackheath and Little Hartley landscape settings • reinstatement of cleared native vegetation to achieve a net increase in tree numbers and canopy in proximity to the project that will not be covered by a biodiversity offset strategy • strategic placement and planting of vegetation in line with the surrounding landscape character zone(s) • sourcing locally endemic native species • carrying out appropriate soil analysis and identification of soil preparation requirements for landscaping treatments to inform the PDLP and vegetation management in accordance with the *Batter Surface Stabilisation Guideline* (RMS, 2015).	Design
LV3	The Construction Environmental Management Plan (CEMP) will include specific measures to minimise the visual intrusion of construction areas and construction compounds.	Construction
LV4	Lighting employed during construction and operation will be minimised, taking into account: • minimum lighting requirements and design standards to maintain safety during construction and safety for operational traffic • guidance on the management of obtrusive lighting effects in *AS4282-1997: Control of the Obtrusive Effects of Outdoor Lighting* • guidance on good lighting principles provided in Part 4 of *Dark Sky Planning Guideline* (DPE, 2016a) • the biodiversity lighting requirements for the project (refer to environmental mitigation measure B8).	Design, construction and operation

19 Social impacts

This chapter summarises the social impact assessment (SIA) carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full SIA is provided in Appendix O (Technical report – Social).

19.1 Assessment approach

19.1.1 Overview

The SIA considers both local community impacts and impacts likely to occur on a broader or more regional scale. It has been prepared in accordance with the Social Impact Assessment Guideline for State Significant projects (Department of Planning, Industry and Environment (DPIE), 2021e) (the SIA guideline), which provides a consistent framework and approach to the assessment of social impacts associated with State significant infrastructure projects in NSW. In accordance with the SIA guideline, the following methodology was adopted for the assessment:

- development of a social baseline for the social locality, based on analysis of Australian Bureau of Statistics (ABS) 2021 and 2016 Census data[1] (ABS 2021; ABS, 2016), and identification of community stakeholders, social indicators and community assets
- community consultation including residential interviews and business surveys carried out in April 2022 to understand key community values, aspirations and concerns held by the community
- assessment of the potential social impacts of construction and operation of the project considering the social impact categories identified in the SIA guideline, including assessment of the residual impacts following the application of proposed mitigation measures
- identification of appropriate mitigation measures to manage potential impacts.

19.1.2 Social locality

The social locality for the SIA reflects the project's likely area of influence. The social locality includes the following ABS State Suburbs (SSCs) as shown in Figure 19-1:

- Blackheath SSC
- Mount Victoria SSC
- Little Hartley SSC
- Kanimbla SSC.

Of these SSCs, Blackheath SSC and Mount Victoria SSC are located in the Blue Mountains Local Government Area (LGA); and Little Hartley SSC and Kanimbla SSC are located in the Lithgow LGA.

In addition to the social locality, social infrastructure within a two kilometre radius of the project has also been considered.

[1]Some 2021 Census data required for the SIA was not available during preparation of the report (including data relating to employment status, industry of employment, method of travel to work and socio-economic indexes for areas). In these instances, 2016 data was used to develop the social baseline. The SIA has also used more recent consultation results, including SIA-project specific consultation undertaken in April 2022 to inform the social baseline.

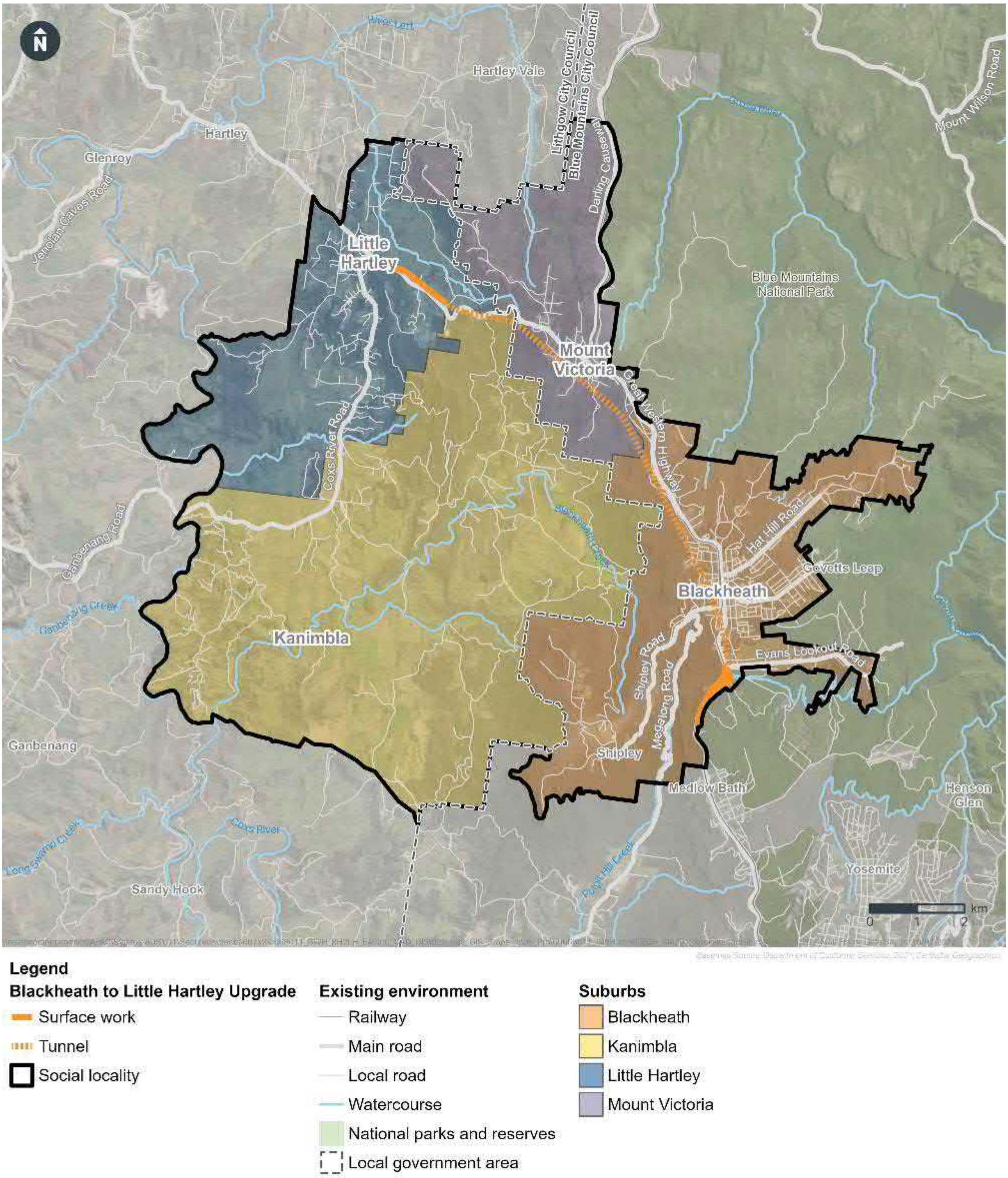


Figure 19-1 Social impact assessment social locality

19.1.3 Assessment of significance

Potential social impacts from the project would be varied in nature and would include both positive and negative impacts; tangible or intangible impacts; and physically observable or psychological impacts.

The significance of potential social impacts has been determined using the likelihood and magnitude matrix in Figure 19-2. The SIA has been prepared with reference to the categories outlined in the SIA guideline, and potential impacts have been grouped by these categories accordingly in Section 19.3 and 19.4.

LIKELIHOOD	MAGNITUDE LEVEL				
	Minimal	Minor	Moderate	Major	Transformational
Almost certain	Low	Medium	High	Very High	Very High
Likely	Low	Medium	High	High	Very High
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Very unlikely	Low	Low	Low	Medium	Medium

Figure 19-2 Social impact significance matrix (DPIE, 2021a)

19.2 Social baseline

The social baseline describes the social context without the project (i.e. prior to the commencement of construction or operation). It documents the existing social environment, conditions and trends relevant to the social locality and social impacts of the project.

19.2.1 Demographic profile

The demographic profile of the social locality, in comparison to the whole of NSW, is presented in Figure 19-3.

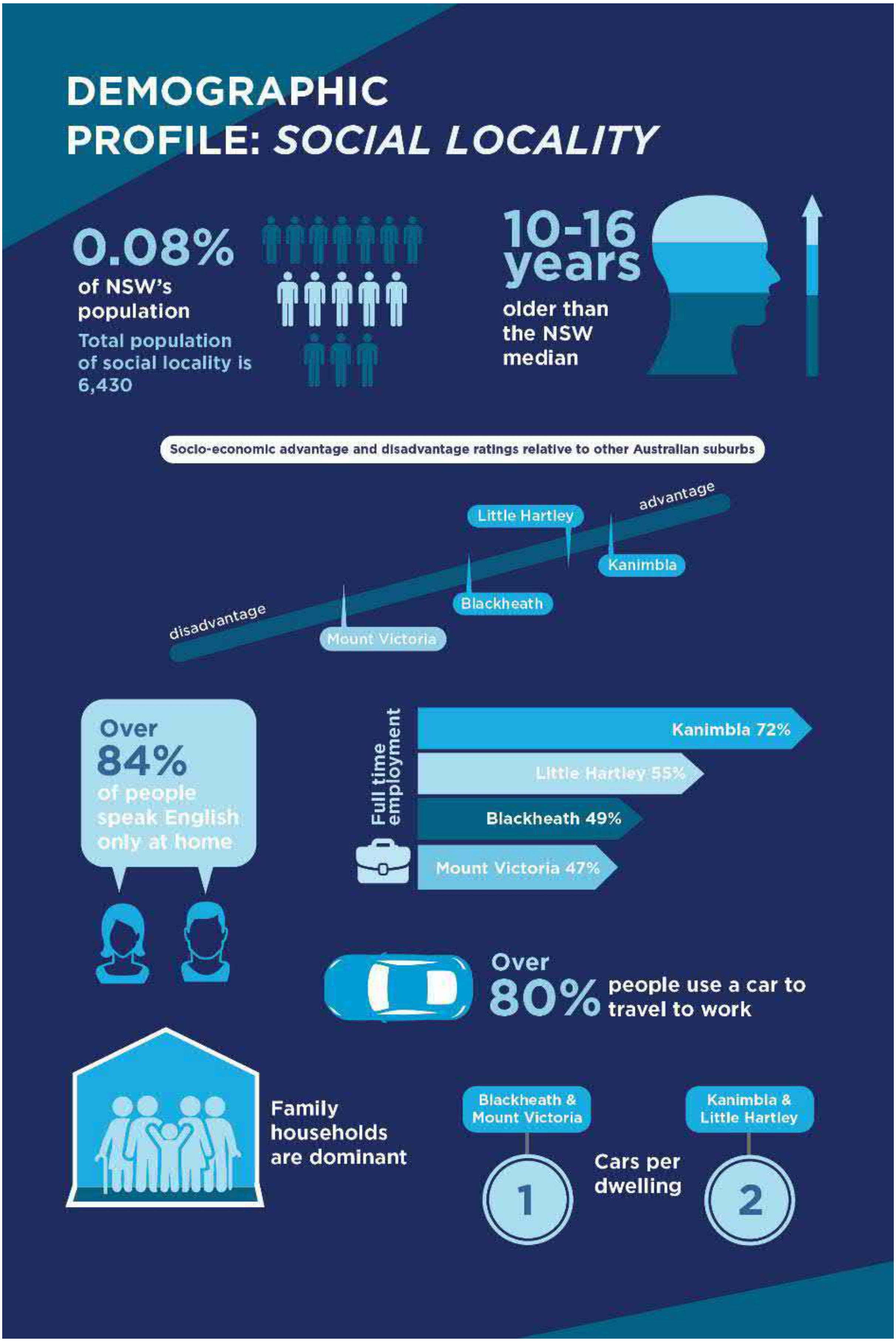


Figure 19-3 Demographic profile of the social locality

19.2.2 Social infrastructure

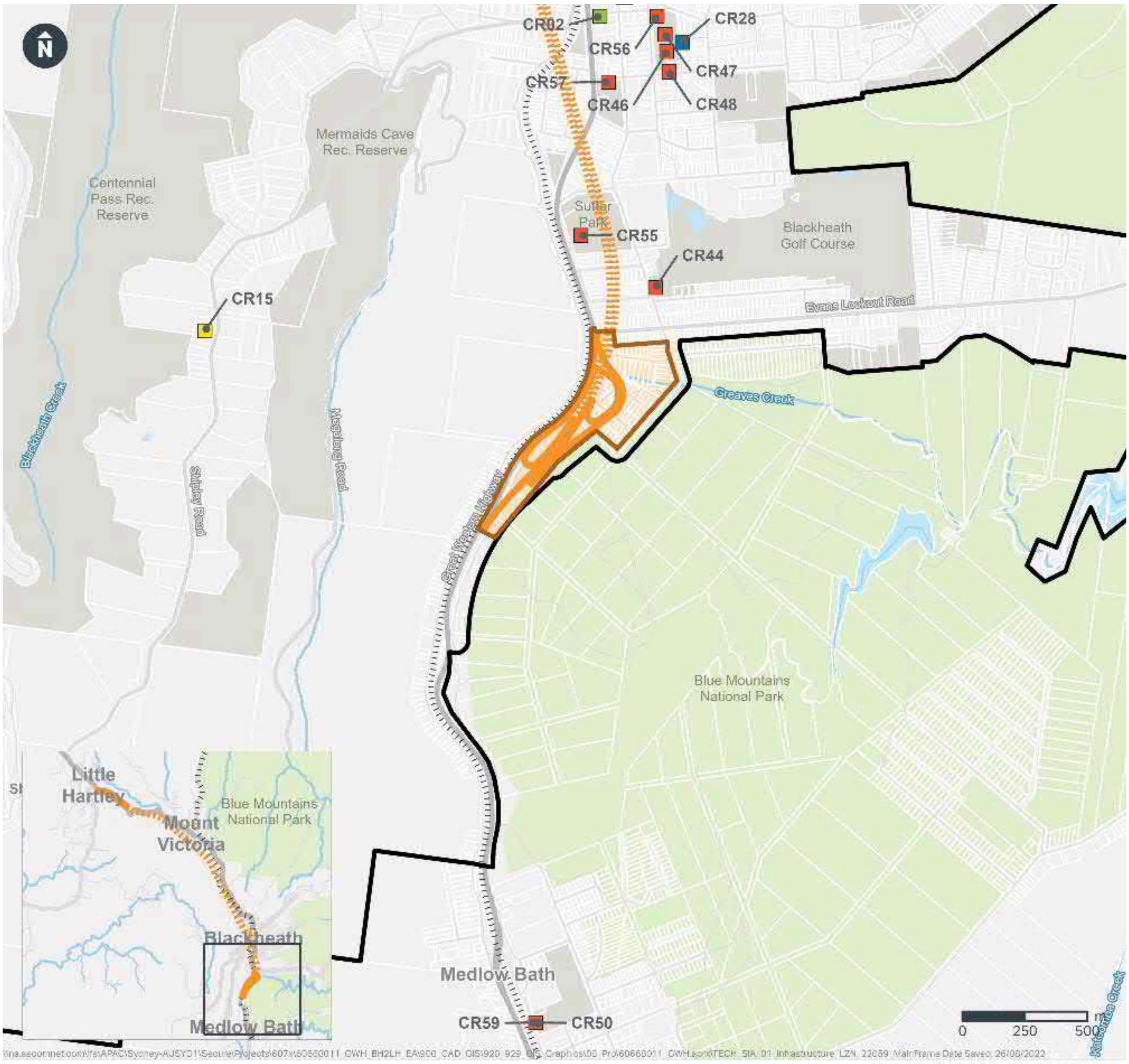
Social infrastructure relevant to the project is shown in Figure 19-4 to Figure 19-7 and includes:

- **educational facilities** – within proximity to the project these generally include primary schools, combined schools (with both primary and secondary students), and childcare centres
- **health, medical and emergency services** – a range of healthcare services are located within the social locality, generally within the Blackheath town centre
- **aged care facilities** – there are limited aged care facilities within the social locality. Several aged care facilities are located further away in regional centres such as Katoomba and Lithgow
- **places of worship** – these generally include churches
- **community service facilities** – within proximity to the project these generally include community centres, public libraries, museums and galleries, community gardens and cemeteries. The majority of community service facilities are located in the Blackheath town centre
- **sporting and recreational facilities** – within proximity to the project these generally include passive and active recreational spaces such as parks and sporting facilities. In addition to these facilities, the Blue Mountains National Park is a regional attractor which provides recreational opportunities, such as walking and mountain biking trails.

Social infrastructure is generally clustered around the Blackheath town centre, which includes a range of community and recreational facilities, as well as local medical services. Some social infrastructure is also located around the Mount Victoria town centre, including childcare centres, a school (mixed primary and secondary school) and some local parks. There is limited social infrastructure present within Little Hartley and no social infrastructure identified in Kanimbla.

One social infrastructure facility (Browntown Oval) would be located directly adjacent to the northwest of the Soldiers Pinch construction site. Browntown Oval comprises a sports ground available for use by the general public and community groups.

There are around 512 short-term accommodation properties within the social locality. Occupancy rates for short-term accommodation vary throughout the year with the highest occupancy rate generally between April to June, and busiest periods typically being weekends and school holidays. There is a relatively low proportion of long-term accommodation in the social locality, when compared to NSW, generally likely due to the high volume of short-term rental accommodation and holiday homes in the area. Further discussion of accommodation in the social locality is provided in Section 3.6 of Appendix O (Technical report – Social).



Legend

Blackheath to Little Hartley Upgrade
- Surface work
- Tunnel
- Construction footprint
- Social locality

Existing environment
- Railway
- Main road
- Road
- Watercourse and drainage
- National Parks and Reserves
- Local parks

Community receivers
- Community services facilities
- Educational facilities
- Health, medical and emergency service facilities
- Places of worship
- Sporting and recreational facilities

Figure 19-4 Social infrastructure at Blackheath – map 1

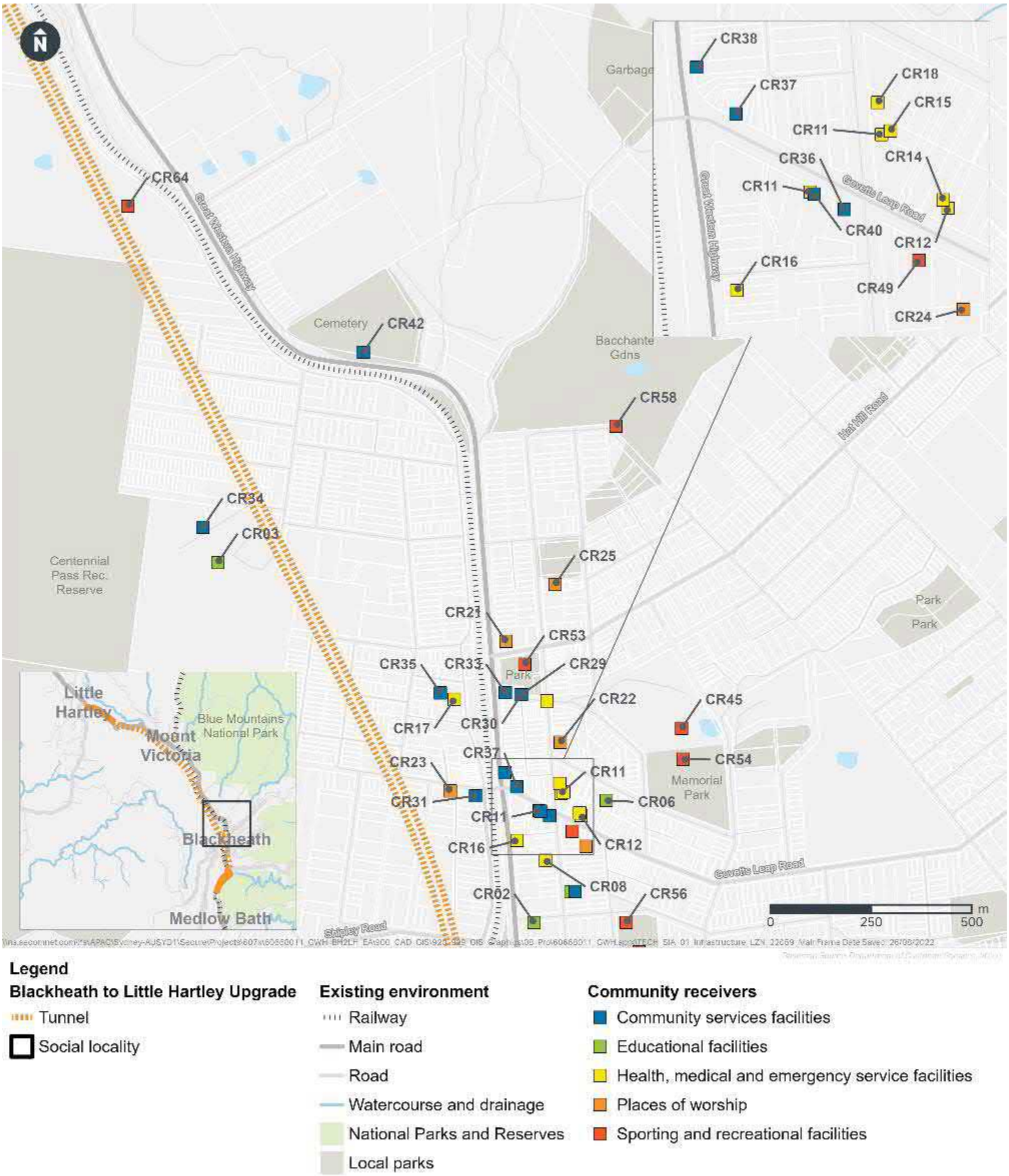
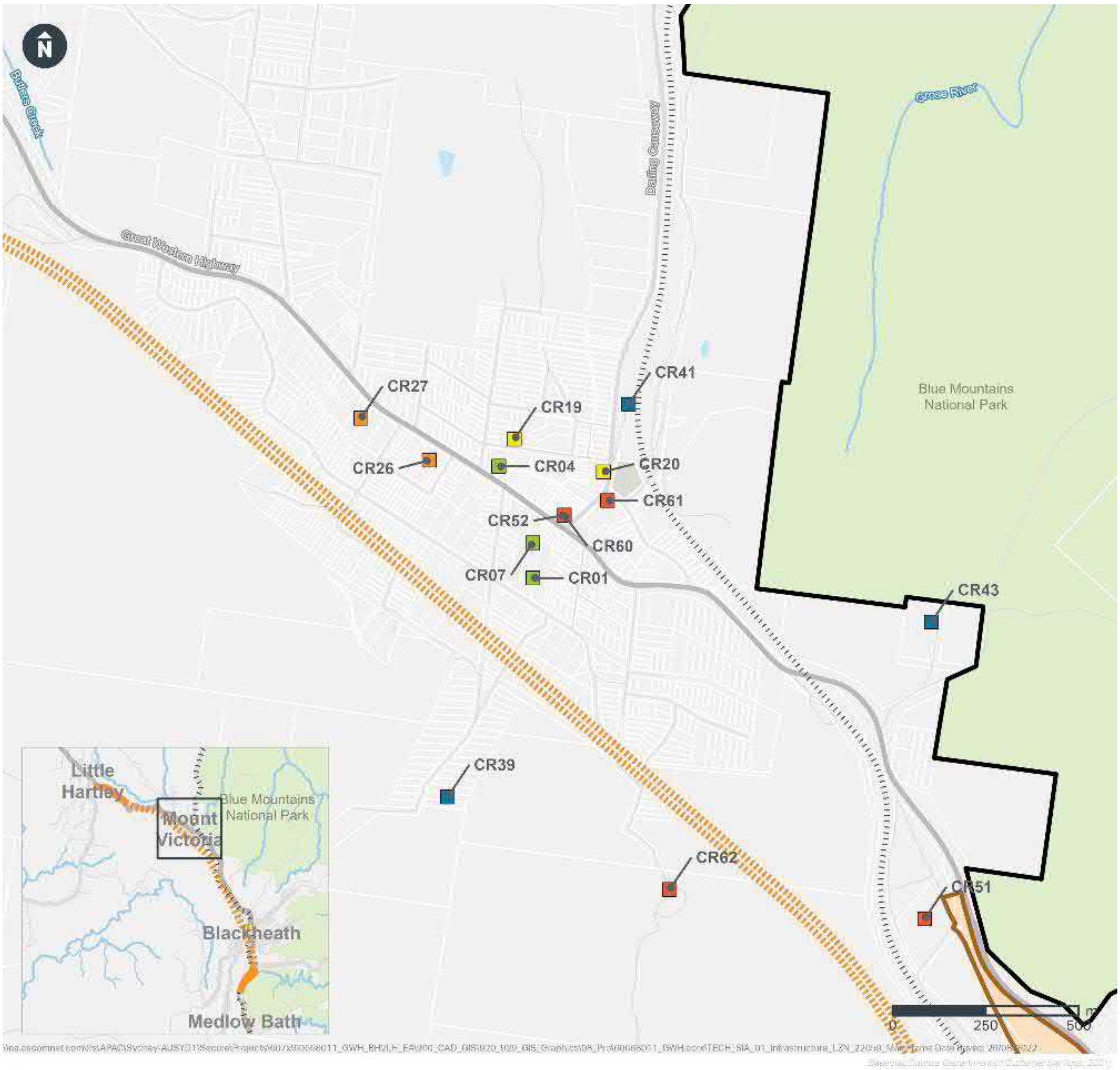


Figure 19-5 Social infrastructure at Blackheath – map 2



Legend

Blackheath to Little Hartley Upgrade
- Tunnel
- Social locality
- Construction footprint

Existing environment
- Railway
- Main road
- Road
- Watercourse and drainage
- National Parks and Reserves
- Local parks

Community receivers
- Community services facilities
- Educational facilities
- Health, medical and emergency service facilities
- Places of worship
- Sporting and recreational facilities

Figure 19-6 Social infrastructure at Mount Victoria

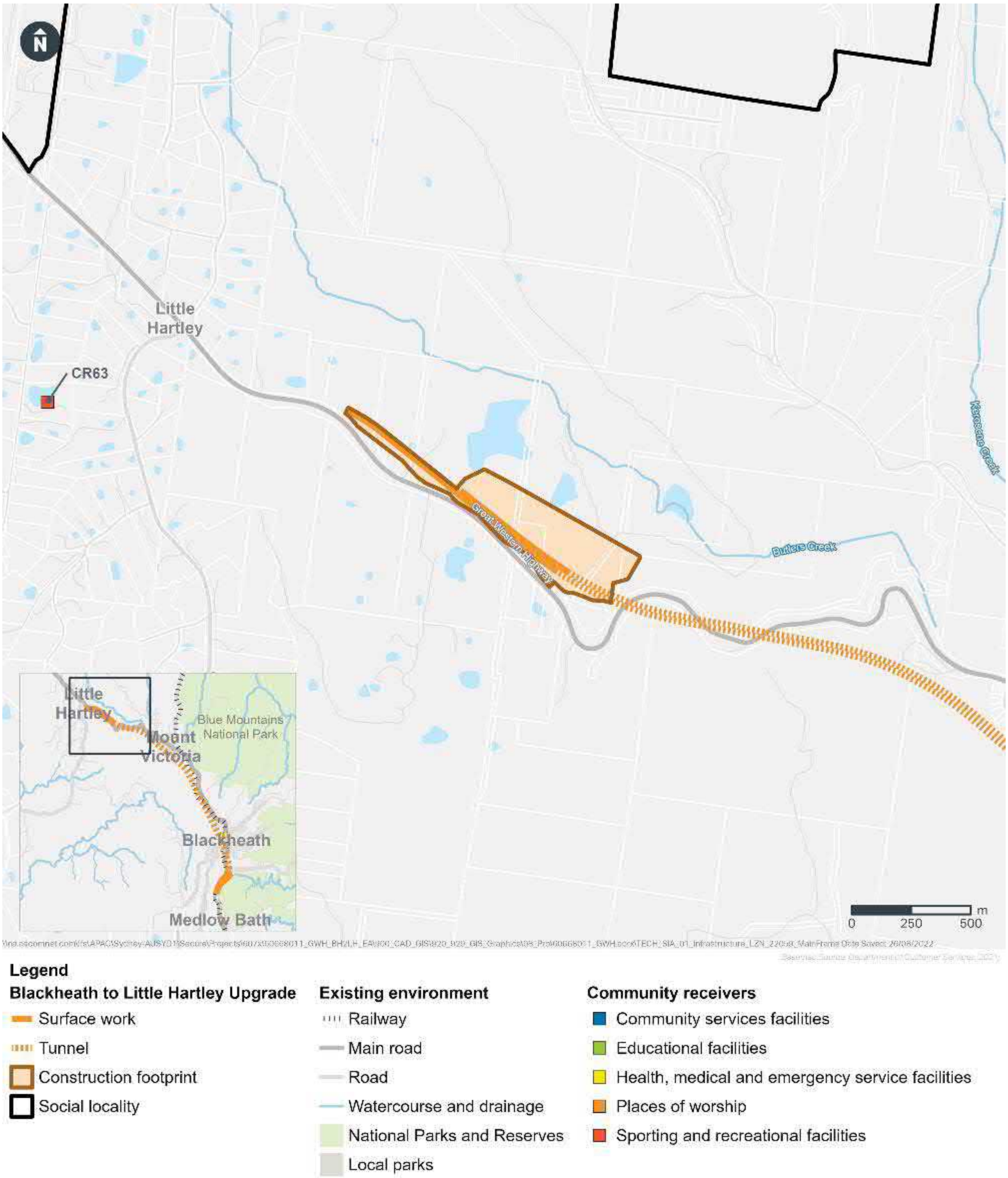


Figure 19-7 Social infrastructure at Little Hartley

19.2.3 Community values, aspirations and concerns

As per the SIA guideline, a range of engagement techniques including residential interviews and business surveys have been employed to canvass the views of a wide range of affected people within the community. A summary of community values, aspirations and concerns identified from this community consultation is provided in Table 19-1. Community values, aspirations and concerns as well as other outcomes of community consultation are further described in Section 4 of Appendix O (Technical report – Social).

Table 19-1 Community values, aspirations, and concerns

Values	Aspirations	Concerns
• Proximity to the natural environment (i.e. the Blue Mountains National Park) and associated recreational opportunities such as bushwalking • Community facilities and services (i.e. community groups, museums, galleries, art facilities and schools) • Social elements of the community (i.e. closeness to the community, friendly neighbours and presence of young families) • The existing local character (i.e. the 'small town feel' and quiet nature of the area).	• Improvements in local facilities and social infrastructure in Blackheath and Mount Victoria • Preservation of township character in Little Hartley.	• Traffic congestion and travel time • Road safety • Healthcare access • The local economy.

19.3 Potential impacts – construction

A summary of the potential social impacts of construction of the project before and after mitigation is provided in Table 19-2. While the residual risk rating of a small number of the predicted construction impacts remains medium, impacts are predominantly temporary and would be minimised through the implementation of the mitigation measures identified in Table 19-5.

The demographic profile of people in close proximity to the construction footprint was not discernible as any one particular group (based on social, cultural, economic, gender or other factors). Based on the residual impact significance assessment in Table 19-2, the potential for impacts to local rental affordability during the construction of the project may affect distributive equity.

The increased demand for accommodation by the construction workforce may affect people on lower incomes who rent in the region. This demographic group may include marginalised groups such as single parents, women and people who speak English as a second language. Further discussion on potential impacts to distributive equity during construction is provided in Section 5.9 of Appendix O (Technical report – Social).

Table 19-2 Potential social impacts during construction

Initial impact significance	Mitigation measure	Residual impact significance
Way of life		
Changes to how people move around Temporary modifications to the existing road and public transport network, and the presence of construction traffic where construction haul routes are proposed, may disrupt the ability of residents, visitors and road users to move around their local area. Given that impacts would be generally limited to the Great Western Highway corridor, with only minor traffic disruptions on local streets, the magnitude of impact would be minor. These impacts would be likely to occur. As such, the overall significance of the impact would be medium (negative).	• implementation of the Construction Environmental Management Plan (CEMP) and Construction Transport and Access Management Plan (CTAMP) as well as other transport management measures identified in Chapter 8 (Transport and traffic) • clear, frequent and inclusive communication though the implementation of the Stakeholder Engagement Strategy • establishment of a monitoring process through the Social Impact Management Plan (SIMP), to facilitate feedback on construction impacts and enable measures to be reviewed and amended if required, to respond to specific impacts.	Low (negative)
Acquisition of property If compensation does not allow property owners and tenants to access similar housing in the local area, acquisition may result in residents needing to relocate to other more affordable areas or incurring increased levels of debt to remain in the area. People who are required to relocate because of property acquisition may also experience a degree of physical and emotional stress, particularly for the elderly, disabled, long-term residents or those with poor health. Private property acquisition for the project would affect two landowners (refer to Chapter 20 (Business, land use and property)). As per the SIA guideline, potentially vulnerable and marginalised groups have been identified and considered as part of this assessment. These proposed property acquisitions are generally not in areas which are considered socially disadvantaged relative to other Australian suburbs.	• acquisition required for the project would be carried out in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* (NSW) • where required discussions would be held with affected property owners concerning the purchase, lease, or licence of land • landowners and tenants of landowners affected by acquisition would be supported by access to counselling services throughout the process and a community relations support toll-free telephone line would be established to help respond to community concerns.	Nil

Initial impact significance	Mitigation measure	Residual impact significance
Overall, given the minimal acquisition required, the magnitude of impact would be minor. These social impacts would be unlikely to occur. The overall significance of the impact would be low (negative).		
Access to and use of social infrastructure Access to social infrastructure at Blackheath and Mount Victoria may be indirectly affected by temporary increases in travel times due to the presence of construction vehicles in the general area, including in particular access to Browntown Oval, as this intersection of the Great Western Highway would be used by construction vehicles accessing the Soldiers Pinch construction site. Overall, as social infrastructure in the locality would generally still be available for use, the overall magnitude of impact to users of social infrastructure within the social locality as a whole would be minor. These social impacts would be likely to occur. The overall significance of impacts to the access and use of social infrastructure would be medium (negative).	• consultation would be carried out with managers of Browntown Oval about construction timing and potential impacts, with the aim of minimising potential disruptions to Browntown Oval • implementation of the CEMP and CTAMP as well as other transport management measures identified in Chapter 8 (Transport and traffic) • clear, frequent and inclusive communication though the Stakeholder Engagement Strategy • establishment of a monitoring process through the SIMP to facilitate feedback and review and amend mitigation measures if required to respond to specific impacts.	Low (negative)
Community		
Demographics and community composition Potential impacts to the makeup and identity of the community may arise from the introduction of construction workers to the social locality. Potential community concerns may include community concerns associated with the inward movement of a typically young, male workforce into established towns, including concerns about worker attitudes and perceptions of safety impacting existing values and sense of community. Overall, given the size of the local population and construction workforce, the project may result in temporary impacts to the local demographic profile, including an increase in daytime population, which may raise concerns	• the construction workforce would be sourced from the local area where possible, to manage the need for people to relocate to the area for the duration of construction, and to contribute to local employment opportunities. This would be a focus of the Skills, Employment and Industry Development Strategy being implemented for the Upgrade Program, including this project	Low (negative)

Initial impact significance	Mitigation measure	Residual impact significance
among community members. The magnitude of this impact would be moderate. The likelihood of the project resulting in broader demographic changes during construction would be possible. As such the overall significance of the impact would be medium (negative).	• construction workers would be briefed on respectful and appropriate behaviours in the community • clear, frequent and inclusive communication though the Stakeholder Engagement Strategy • establishment of a monitoring process through the SIMP, to facilitate feedback on construction impacts and enable measures to be reviewed and amended if required, to respond to specific impacts.	
Social cohesion and sense of place Temporary changes in access may exacerbate the existing barrier associated with the existing Great Western Highway. The presence of construction traffic may impact the ability of pedestrians and cyclists to cross-roads, or increase travel times for vehicle users, somewhat limiting their opportunity to socialise within the community, however construction vehicle volumes would be relatively small and spread across 24 hours per day. People may also experience some limited amenity impacts from construction at town centres, or places of social infrastructure. The magnitude of this impact would be moderate. Overall, the likelihood of these impacts occurring would be possible. As such the overall social significance in relation to community cohesion and sense of place would be medium (negative).	• implementation of the CEMP, CTAMP, Construction Noise and Vibration Management Plan (CNVMP) and mitigation measures identified to address noise, traffic, air quality and landscape and visual impacts • clear, frequent and inclusive communication though the Stakeholder Engagement Strategy • establishment of a monitoring process through the SIMP, to facilitate feedback on construction impacts and enable measures to be reviewed and amended if required, to respond to specific impacts.	Low (negative)
Accessibility		
Access and connectivity Changes to access and transport networks can affect the ability of residents and members of the local community to get to work, study or visit friends and family. Minor increases in travel times would occur due to changes to the road network during construction. Though some on-site parking would be provided for workers within the construction sites, some workers may use	• implementation of the CEMP and CTAMP, as well as other transport management measures identified in Chapter 8 (Transport and traffic) • clear, frequent and inclusive communication though the Stakeholder Engagement Strategy	Low (negative)

Initial impact significance	Mitigation measure	Residual impact significance
street-parking which may impact the availability of street parking for residents and visitors. Active transport trails to be provided as part of the Great Western Highway East – Katoomba to Blackheath and Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section), would be maintained during construction of the project. Some temporary modifications to existing pedestrian or cyclist facilities may be required, such as the Little Hartley construction site where construction vehicles would need to cross over the shared path. Access to a recreational trail located near the intersection of Browntown Oval and the Great Western Highway would be temporarily impacted by the Soldiers Pinch construction site during construction. If required, the trail would be temporarily diverted around the Soldiers Pinch construction site to maintain public safety, potentially increasing both the walking or cycling travel time and travel distance by around 150 metres. The temporary change would not result in an impact to the availability of recreational trails for use in the social locality. The overall magnitude of the impact on access and connectivity during construction would be minor. The likelihood of these impacts occurring would be likely. As such the overall social significance in relation to access and connectivity would be a medium (negative) impact.	• establishment of a monitoring process through the SIMP, to facilitate feedback on construction impacts and enable measures to be reviewed and amended if required, to respond to specific impacts.	
Utilities and digital access Temporary disruptions to utilities, whether planned or unplanned, have the potential to adversely impact the ability of residents and local businesses to access and use infrastructure. This could include temporary loss of operation of business-critical machinery or equipment, impacts upon residential household routines, or interruptions to classes at education facilities. Utility disruptions, in particular to telecommunications infrastructure, could also impact residents' ability to work or study from home. During construction, public utilities and services may be temporarily disrupted while they are relocated, or for safety reasons. Where required, services would be protected, relocated	• utility checks and consultation with the relevant utility providers would be carried out during design development and construction to confirm the presence of utilities and utility protection measures • clear, frequent and inclusive communication though the Stakeholder Engagement Strategy.	Low (negative)

Initial impact significance	Mitigation measure	Residual impact significance
or removed before construction to avoid disruption or damage to this powerline, or other existing services located in the vicinity of the project. Overall, the magnitude of this impact is considered to be moderate. The likelihood of these impacts occurring would be unlikely. As such the overall social significance in relation to utilities and digital access would be medium (negative).		
Access to accommodation The project is expected to support an indicative peak construction workforce of up to 1,100 full time equivalent jobs over the duration of construction. Some of this workforce is likely to require short and long term accommodation within the social locality and region more broadly. Around 50 per cent of the peak workforce may require requiring longer-term relocation near the project. Use of the longer term private rental market in the social locality to accommodate workers would likely limit supply for existing residents who rent, and potentially increase prices for rental properties. Low-income households may be particularly sensitive to these changes, may experience rental stress and/or may be at risk of displacement from the area. Overall, the magnitude of the impact of the project on accommodation would be moderate. The likelihood would be possible, resulting in an overall medium (negative) impact.	• the construction workforce would be sourced from the local area where possible, to manage the need for people to relocate to the area for the duration of construction, and to contribute to local employment opportunities. This would be a focus of the skills and employment strategy implemented for the project (see Table 19-5) • development of a workforce accommodation strategy to confirm accommodation requirements and options, which would aim to minimise potential adverse impacts to the rental market and short-term accommodation availability.	Low (negative)

Initial impact significance	Mitigation measure	Residual impact significance
Health and wellbeing		
Health and wellbeing impacts Impacts to the health and wellbeing of residents and visitors within the vicinity of the construction footprint may arise during construction including direct impacts such as such as increased stress, due to ongoing construction impacts. Unmitigated dust impacts from construction activities present a low risk to community health. Worst case scenario noise modelling has identified potential sleep disturbance impacts to some receivers during construction with the potential to cause annoyances and stress. Potential changes in safety may also arise for pedestrians, cyclists, and vehicle users due to changes in the transport network and the presence of construction vehicles. The magnitude of impacts on health and wellbeing during construction would be moderate. Groups with pre-existing health conditions (both physical and mental health), or the elderly and young children are likely to experience a heightened sensitivity to health and wellbeing impacts. As such, the magnitude of impact on health and wellbeing during construction for these groups is considered to be moderate. The likelihood of these changes affecting health and wellbeing would be possible.	• implementation of the CEMP, CTAMP, CNVMP as well as mitigation measures to address noise, traffic, air quality and landscape and visual impacts • clear, frequent and inclusive communication though the Stakeholder Engagement Strategy • establishment of a monitoring process through the SIMP, to facilitate feedback on construction impacts and enable measures to be reviewed and amended if required, to respond to specific impacts.	Medium (negative) for vulnerable groups, low (negative) for other residents and visitors
Surroundings		
Local amenity Construction of the project has the potential to temporarily affect amenity as a result of changes to traffic, noise and vibration, air quality, landscape character and visual amenity. Residents and visitors to the area near the Blackheath construction site may experience a temporary reduction in surrounding amenity and enjoyment of the area due to a high (unmitigated) risk of impacts related to dust soiling. Noise modelling has identified potential sleep disturbance impacts to some receivers during construction. Vegetation clearing and the establishment of construction sites may temporarily affect some	• implementation of the CEMP, CTAMP, CNVMP and mitigation measures to address noise, traffic, air quality and landscape and visual impacts • clear, frequent and inclusive communication though the Stakeholder Engagement Strategy • establishment of a monitoring process through the SIMP, to facilitate feedback on construction impacts and enable measures to be reviewed	Medium (negative)

Initial impact significance	Mitigation measure	Residual impact significance
people's enjoyment of the visual character of the area, particularly at Blackheath. Overall, there would be several changes to amenity in the social locality during the construction of the project, which would collectively have a moderate magnitude in areas where people live and interact. The likelihood of this impact would be likely. The overall significance of the social impact would therefore be high (negative).	and amended if required, to respond to specific impacts.	
Natural features Potential impacts to the natural features associated with the Blue Mountains National Park which are integral to the environmental values of the residents and the broader community would generally be confined to the construction footprint and its immediate surroundings. There would be direct and indirect impacts to biodiversity during construction which could impact the environmental values of the area including loss of vegetation and flora and fauna habitat. Public access and use of recreational areas of the Blue Mountains National Park would generally be maintained, allowing people to continue to use natural features of the area which they value. The overall magnitude of impact would be minor, given that the area to be directly affected is relatively compact and restricted to the construction footprint. The likelihood of impacts to natural features which people value would be likely. The overall social significance of impacts to natural features of the social locality would be medium (negative).	• implementation of the CEMP, CTAMP, CNVMP, Construction Flora and Fauna Management Plan (CFFMP) and mitigation measures to address noise, traffic, air quality, landscape and visual and biodiversity impacts • clear, frequent and inclusive communication though the Stakeholder Engagement Strategy • establishment of a monitoring process through the SIMP, to facilitate feedback on construction impacts and enable measures to be reviewed and amended if required, to respond to specific impacts.	Low (negative)
Crime, safety and security The presence of construction footprint may result in changes to perceptions of safety in the area, including changes to local sight lines, restrictions in pedestrian traffic reducing passive surveillance, the provision of new surfaces for graffiti, or the attraction of thieves to the construction footprint. The construction sites would be secured and are generally located away from urban centres and are unlikely to be targets for crime or substantially change the presence of passive	• potential safety concerns would be manageable through the application of the principles of Crime Prevention Through Environmental Design at construction sites • regular communication with the community and stakeholders throughout construction would also allow residents to	Nil

Initial impact significance	Mitigation measure	Residual impact significance
surveillance in these areas. Some community members may however experience some concern about a potential reduction in safety and security. Based on the nature of the potential safety impacts, and location of the construction sites away from urban centres, the magnitude of impact would be minimal. The likelihood of construction sites substantially changing the security of the surrounding area would be unlikely. As such the overall significance of impact would be a low (negative) impact.	understand construction plans and therefore be better prepared for the temporary changes to the area.	
Culture		
Community values Construction of the project has the potential to impact the following key resident and community values identified during consultation: • proximity to the natural environment and associated recreational opportunities – impacts to the environmental values of the area associated with vegetation removal, loss of habitat and indirect impacts on the viability of habitat (e.g. due to dust, noise and light spill) • community facilities and services – access to these facilities from areas outside the town may be indirectly affected by temporary increases in travel times due to the presence of construction vehicles along the Great Western Highway • social elements of the community – changes in access, where required, may somewhat exacerbate the existing barrier to social cohesion associated with the motorway • existing local character – the visibility of construction footprint and equipment, and exceedances of noise management levels at nearby receivers would contribute to a reduction in the character of the area. Overall, construction of the project may temporarily affect elements which the community value, however the majority of these would remain available for use by the community. The magnitude of changes to community values would be moderate. These would be possible, resulting in a medium (negative) impact.	• implementation of the CEMP, CTAMP, CNVMP, CFFMP and mitigation measures to address noise, traffic, air quality, landscape and visual and biodiversity impacts • clear, frequent and inclusive communication though the Stakeholder Engagement Strategy • establishment of a monitoring process through the SIMP, to facilitate feedback on construction impacts and enable measures to be reviewed and amended if required, to respond to specific impacts.	Medium (negative)

Initial impact significance	Mitigation measure	Residual impact significance
Landscape elements valued by Aboriginal communities Construction of the project may impact on Country and intangible Aboriginal cultural values. Landscape and visual impacts on surrounding bushland could impact on valued elements of the landscape. Furthermore, two partial construction leases; one at Soldiers Pinch and one at Little Hartley required for construction would be subject to unresolved Aboriginal Land Claims (refer to Chapter 20 (Business, land use and property)). This may indicate that the use of these areas during construction may temporarily limit access to an area which is of importance to Aboriginal communities and stakeholders. Impacts to wellbeing and livelihoods of Aboriginal communities, or cultural or spiritual loss, could arise from these and other potential impacts to Country. Ongoing design development would continue to include engagement with Aboriginal knowledge holders to minimise this impact. Overall, the potential magnitude of this impact is considered moderate. The likelihood of negative impacts to landscape elements valued by Aboriginal communities has been considered unlikely. As such the overall significance of impact would be a medium (negative) impact.	• ongoing implementation of a Connected with Country design process as described in Chapter 4 (Project description), which includes ongoing engagement with Aboriginal stakeholders.	Low (negative)

Initial impact significance	Mitigation measure	Residual impact significance
Non-Aboriginal culture and heritage The construction of the project has the potential to affect the non-Aboriginal cultural value of the area. Potential moderate direct impacts are predicted to the curtilage of the locally significant Soldiers Pinch heritage item, which was a historical road and rail route that passed through the area in 1814, however these would be temporary in nature. Potential impacts to the Mount Victoria Stockade (state significance) and Plough Inn (local significance) are considered moderate and major respectively. The project would not impact the Blue Mountains National Park or Greater Blue Mountains World Heritage Area. Potential impacts to the Greater Blue Mountains Area (Additional Values), which has been nominated for inclusion on the National Heritage List, would be negligible considering the small section being affected relative to the overall size of the nominated item. Given that potential impacts to historic heritage items from the project are generally considered negligible to minor, or would be temporary in nature, the magnitude of potential social impacts associated with impacts to non-Aboriginal heritage are considered minor. The likelihood of these impacts occurring would be likely. As such the overall significance of impact would be a medium (negative) impact.	• implementation of the CEMP, Construction Heritage Management Plan (CHMP) and mitigation measures to manage heritage impacts • a detailed archaeological survey will be carried out within those parts of the Mount Victoria Stockade site and the potential Plough Inn site that would be directly affected by construction of the project, and which have not been previously disturbed/ surveyed by the Little Hartley to Lithgow Upgrade project • development of a heritage interpretation strategy for the project which identifies key stories and interpretive opportunities related to non-Aboriginal heritage. The strategy would address historic and contemporary heritage and community values and would identify innovative and engaging opportunities for interpretation.	Low (negative)
Livelihoods		
Business impacts Businesses across the social locality may be affected during construction by temporary changes in passing trade, access and travel time (for employees, customers, and deliveries), changes to parking availability and impacts to local amenity. Potential impacts to the operation and viability of businesses can in turn affect people's livelihoods (for example, their ability to sustain themselves through employment or business opportunities). Businesses may experience temporary amenity impacts associated with increases in noise and vibration, potential utility disruptions and changes to traffic conditions during construction. The overall magnitude of adverse amenity	• a skills and employment strategy has been developed to enhance potential business and economic benefits including identification of how the project would promote opportunities for upskilling and training of the local workforce • access to local businesses would be maintained during construction • ongoing consultation with local businesses to allow for time to prepare for changed traffic conditions.	Medium (negative) and Low (positive)

Initial impact significance	Mitigation measure	Residual impact significance
impacts to businesses would be minor. The likelihood of these impacts being experienced within the social locality would be possible, resulting in a medium (negative) social impact. Key benefits would include temporary uplift in revenues of retail businesses in the social locality (such as food and beverage businesses), which would experience an increase in passing trade due to the presence of construction workers in the area. Due to the presence of construction activities, local and regional construction contractors and businesses who service or supply goods to the construction industry are also expected to experience an increase in business activity. The overall magnitude of economic benefits during construction in the social locality would be moderate. The likelihood of these impacts being experienced within the social locality would be possible, resulting in a medium (positive) social impact.		
Tourism impacts Businesses which rely on tourism are likely to be affected by changes in amenity and passing trade. While there may be some benefits to local accommodation providers due to a potential upturn in trade, changes in amenity and availability of accommodation during construction could have a temporary negative impact on the attractiveness of the area to tourists, and flow on effects on employment in tourism. This could impact livelihoods by impacting people's capacity to earn an income throughout employment in tourism. The overall magnitude of tourism-related impacts to livelihoods during construction in the social locality would be minor, and the likelihood would be possible, resulting in a medium (negative) social impact.	• implementation of the CEMP, CTAMP, CNVMP and mitigation measures to address noise, traffic, air quality and landscape and visual impacts • construction workers would be sourced from the local area, where possible, to manage demand on accommodation. This would be a focus of the skills and employment strategy for the project (see Table 19-5)	Low (negative)
Economic impacts Construction activity can benefit the economy by injecting money into the local, regional and state economies. This can result in employment and business opportunities for people. The capital expenditure required for the project would create increased opportunities for both businesses and workers associated with	• to enhance potential business and economic benefits, a Skills, Employment and Industry Development Strategy is being implemented for the Upgrade Program, including this project, to	Medium (positive)

Initial impact significance	Mitigation measure	Residual impact significance
construction, while also resulting in substantial flow-on impacts to other parts of the local economy, including for local businesses and the local workforce within the social locality. Construction businesses, industries and skilled workers in the social locality would also experience these benefits. Increased employment opportunities as a result of temporary revenue increases would provide livelihood benefits through supporting local business and employment in these businesses. The overall magnitude of economic benefits during construction in the social locality would be moderate, given that the benefits would likely be dispersed across the broader region. The likelihood of these impacts being experienced within the social locality would be possible, resulting in a medium (positive) social impact.	promote opportunities for upskilling and training of the local workforce. Its key focus areas are jobs, skills, diversity and business initiatives that achieve local economic and social outcomes	
Decision making systems		
Despite the consultation carried out to date (refer to Chapter 7 (Community and stakeholder engagement)), there is the potential for some community members to express dissatisfaction with their ability to influence the decision making, construction methodology or design of the project. The preparation and exhibition of the environmental impact statement is a statutory process which enables people to make a submission expressing their support, objection or comments on the project and its potential impacts. Given that the views and experience of decision-making systems can vary substantially from person to person, a magnitude and likelihood rating has not been applied.	Transport for NSW (Transport) would continue to listen to and engage with the community during the project, including the construction period and seek to address any such issues as far as reasonably practical. This would include the provision of community complaint and information lines which would be made accessible to different groups within the community	Nil

19.4 Potential impacts – operation

A summary of the potential social impacts of operation of the project before and after mitigation is provided in Table 19-3.

The demographic profile of people impacted during operation was not discernible as any one particular group (based on social, cultural, economic, gender or other factors). Based on the residual impact significance assessment in Table 19-2, it is unlikely that there would be particular associated distributive equity impact on the basis of social group. During operation concerns may be raised by those likely to be affected by direct amenity impacts, including those living or working nearby to the portals of the tunnel who may be exposed to greater noise, air quality, and visual impacts.

While the project would operate for long enough to result in intergenerational impacts, the potential for these is expected to be limited on the basis that the project would continue to provide a similar benefit for people in subsequent generations as it does at the commencement of operation.

While some social cost would be borne by the current generation (such as adverse amenity impacts during the construction period), the SIMP will guide monitoring and adaptive management of social impacts resulting from the project for the first three years of operation. Further discussion on potential impacts to distributive equity during operation is provided in Section 6.9 of Appendix O (Technical report – Social).

Table 19-3 Potential social impacts during operation

Initial impact significance	Mitigation measure	Residual impact significance
Way of life		
Changes to how people move around By diverting a substantial proportion of through traffic (including freight) into the project tunnels, the project would allow the existing Great Western Highway to mainly cater for local traffic which would substantially improve movement for residents and the broader community in and around Blackheath and Mount Victoria. This would also improve road safety for motorists and active transport users by separating through and local traffic and reducing potential traffic conflicts. The project would also improve travel times to employment centres outside the social locality, such as Greater Sydney and Lithgow, for residents who use the tunnels. This would generally include residents near Blackheath travelling west, and residents near Little Hartley travelling east. The project would also improve the resilience of the Great Western Highway corridor between Blackheath and Little Hartley to bushfire risk and other natural disasters as the new tunnel would provide an additional route of travel across this section of the Blue Mountains. Given the potential extent of improvements, the magnitude of impact would be major. These impacts would be likely to occur. As such, the	• adoption of urban design objectives and criteria and implementation of the State Design Review Panel process set out in Chapter 4 (Project description) would provide a high quality design outcome • as set out in Chapter 8 (Transport and traffic), Transport would continue to work with local councils to investigate an active transport link between Blackheath and Little Hartley separately to the project. Other potential opportunities for active transport and placemaking initiatives would be subject to ongoing investigation and consultation with relevant local councils • community and stakeholder engagement	High (positive)

Initial impact significance	Mitigation measure	Residual impact significance
overall significance of the positive impact would be high. **Access to and use of social infrastructure** The project has the potential to positively affect the ability of residents to access social infrastructure within the social locality, particularly via the existing Great Western Highway which would mainly cater for local traffic. The substantial reduction to traffic volumes along the existing Great Western Highway through Blackheath and Mount Victoria would noticeably improve the accessibility and amenity of these townships. Reduced through traffic would generally result in improved travel times for local traffic accessing social infrastructure within the social locality. The majority of social infrastructure is located within the Blackheath and Mount Victoria centres, and at a considerable distance from the tunnel portals. As such there is expected to be limited potential for direct adverse amenity impacts to these receivers during operation. The overall magnitude of the improvement in access to social infrastructure would be moderate. These social impacts would be likely to occur. The overall significance of impacts to the access and use of social infrastructure would be high (positive).	during ongoing design development.	
Culture		
Demographics and community composition No change to the demographic profile of the social locality is anticipated, as the project would only require a small operational workforce. The project is also unlikely to enable other changes that may induce any substantial demographic changes, however the improvements in accessibility resulting from the project may make the social locality a more desirable area to live. The overall magnitude of this impact would be minor. The likelihood of the project resulting in broader demographic changes during operation would be very unlikely. As such the overall significance of the impact would be low.	N/A	Nil

Initial impact significance	Mitigation measure	Residual impact significance
Social cohesion and sense of place A reduction in traffic on the existing Great Western Highway would improve the ability of residents and visitors to safely and efficiently interact in the local area, particularly in Blackheath and Mount Victoria (e.g. by improving travel times (for motorists) and minimising potential interaction between active transport users and heavy vehicles while crossing the road). This would contribute to an improvement in the overall social cohesion of the social locality and could enhance the sense of place through potential activation of these locations. Reduced traffic volumes and a substantial reduction in heavy vehicles on the existing Great Western Highway would also offer improved amenity, further enhancing sense of place. The magnitude of this impact is considered to be moderate. The likelihood of these impacts occurring would be likely. As such the overall significance of the positive impact would be high (positive).	• adoption of urban design objectives and criteria and implementation of the State Design Review Panel process set out in Chapter 4 (Project description) would provide a high quality design outcome • as set out in Chapter 8 (Transport and traffic), Transport would continue to work with local councils to investigate an active transport link between Blackheath and Little Hartley separately to the project. Other potential opportunities for active transport and placemaking initiatives would be subject to ongoing investigation and consultation with relevant councils • community and stakeholder engagement during ongoing design development.	High (positive)
Accessibility		
Access and connectivity The project would divert a substantial proportion of through traffic from the existing Great Western Highway into the twin tunnels, allowing the existing surface section of the highway to mainly cater for local and tourist traffic. Reductions in traffic volumes on the existing Great Western Highway would improve the amenity and safety for active transport users. Additionally, by providing an alternative route to the existing Great Western Highway alignment between Blackheath and Little Hartley, the project could improve network resilience by improving access for emergency vehicles in the event of an incident. Overall, the project would provide substantial access and connectivity benefits both locally and regionally. These benefits would improve access to jobs, businesses, education, services, and social	• adoption of urban design objectives and criteria and implementation of the State Design Review Panel process set out in Chapter 4 (Project description) would provide a high quality design outcome • as set out in Chapter 8 (Transport and traffic), Transport would continue to work with local councils to investigate an active transport link between Blackheath and Little Hartley separately to the	High (positive)

Initial impact significance	Mitigation measure	Residual impact significance
facilities for the community, including vulnerable persons. These benefits would also address the community concerns associated with existing traffic congestion and road safety identified in the residential interviews. Given the benefits associated with access and connectivity and the importance of these benefits to the community, the magnitude of impact would be major. The likelihood would be likely, resulting in a high (positive) significance.	project. Other potential opportunities for active transport and placemaking initiatives would be subject to ongoing investigation and consultation with relevant councils • community and stakeholder engagement during ongoing design development.	
Access to accommodation Once operational, the project would generally not impact the availability of accommodation within the social locality, due to the small operational workforce requirements. Accommodation facilities may benefit from an increase in business, due to an increase in visitors/tourism as a result of improvements in amenity associated with decreased traffic on the existing Great Western Highway. The overall magnitude of impacts to access to accommodation would be minimal. The likelihood of the project to impact the availability of accommodation in the social locality would to be very unlikely. As such the overall significance of the impact would be low.	N/A	Nil

Initial impact significance	Mitigation measure	Residual impact significance
Health and wellbeing		
Health and wellbeing impacts Operation of the project would result in a decrease in the level of exposure to nitrogen dioxide in the population within the study area that may have some long term health benefits. Operation would also result in lower levels of exposure to particulate matter concentrations, which has the potential for some long term health benefits to the community. Some receivers are expected to experience noise in excess of the adopted noise criteria, though the majority would experience a change of noise levels less than two dB(A), which is unlikely to be discernible or impact on health. Maximum localised / individual risk to health associated with particulate matter has been identified as lower under the ventilation outlet design option, however both ventilation options would result in low, acceptable impacts. The ventilation outlet option is predicted to result in more exceedances of noise management levels compared to the portal emissions option, however the differences are relatively minor (i.e. up to nine additional receivers affected) and during emergency conditions. Overall, operation of the project may result in both positive and negative impacts on health and wellbeing of residents. The overall likelihood of these impacts occurring would be likely. The magnitude of positive impacts is considered to be minor, with the magnitude of adverse impacts to health and wellbeing also being minimal. On this basis, the overall social significance of health and wellbeing would be medium (positive) and low (negative).	• mitigation measures would be implemented to manage operational noise impacts and thereby minimise the potential for health-related impacts to some receivers. Mitigation measures to manage noise and vibration during operation of the project are discussed in Chapter 11 (Noise and vibration) • an air quality monitoring program will be developed in consultation with relevant stakeholders and implemented to confirm the in-tunnel air quality and ambient air quality performance of the project during the first two years of operation.	Medium (positive) and low (negative)
Surroundings		
Local amenity The project would generally improve amenity experienced by residents and visitors around Blackheath and Mount Victoria by reducing the volume of traffic on the existing Great Western Highway. Road traffic noise and vehicle emissions within the town centres of Blackheath and Mount Victoria are expected to decrease due to the reduction in vehicles using the surface road. Potential reductions in amenity may occur due to	• adoption of urban design objectives and criteria and implementation of the State Design Review Panel process set out in Chapter 4 (Project description) would provide a high quality design outcome • as set out in Chapter 8 (Transport and traffic), Transport would	High (positive) and low (negative)

Initial impact significance	Mitigation measure	Residual impact significance
noise impacts from fixed facilities for receivers at Blackheath. The ventilation outlet design option would result in exceedances at more receivers than the portal emissions design option, though exceedances are relatively minor for both options. Adverse visual impacts are likely to be confined to discrete areas at the end of the tunnel where surface works and operational infrastructure are proposed, including at Blackheath and Little Hartley. The portal emissions option would only moderately reduce the impact rating at these points, given the presence of other large operational infrastructure. The combined impact of improvements in amenity would be of moderate magnitude and would be likely to occur. This would result in a high (positive) social impact significance in bypassed areas. The combined impact of potential adverse impacts to residents and visitors closest to portal infrastructure would be minor, given that there are relatively fewer receivers in these locations compared to the townships. This impact would be likely to occur, resulting in medium (negative) impacts in areas closest to portal infrastructure.	continue to work with local councils to investigate an active transport link between Blackheath and Little Hartley separately to the project. Other potential opportunities for active transport and placemaking initiatives would be subject to ongoing investigation and consultation with relevant councils • community and stakeholder engagement throughout detailed design development • additional measures if a ventilation outlet option is adopted, such as the murals painted on the building at Evans Lookout Road, Blackheath, which pay homage to the natural environment within the Blue Mountains • operational noise and air quality monitoring to confirm that relevant targets are achieved • community and stakeholder engagement during ongoing design development.	
Natural features The project would minimise impacts to the Blue Mountains National Park and biodiversity relative to other project options considered (for example, a surface road upgrade), as it would primarily be located underground. There is the potential for indirect impacts to adjacent vegetation and habitat (e.g., due to a change in land use patterns) and potential impacts on aquatic ecology due to changes in hydrology and water quality. Surface infrastructure would partly detract from the landscape amenity of the bushland along the Great Western Highway. If selected, the ventilation outlet option would	• adoption of urban design objectives and criteria and implementation of the State Design Review Panel process set out in Chapter 4 (Project description) would provide a high quality design outcome • development of a landscape concept design plan for the project to ensure that new native plantings are	Low (negative)

Initial impact significance	Mitigation measure	Residual impact significance
comprise a 10 metre structure which could result in additional minor landscape impacts relative to the portal emissions option. Access and connectivity benefits from reduced traffic on the existing Great Western Highway between Blackheath and Little Hartley could enhance people's ability to access recreational facilities associated with the National Park. Overall, operation of the project would result in indirect impacts to natural features that could impact the environmental values of the area. The social implications of these impacts would be minor in magnitude, and likely to occur, resulting in an overall medium (negative) social impact.	consistent with the existing landscape character and screen views to the proposed operational infrastructure.	
Crime, safety and security Given that the project largely comprises underground infrastructure, there are limited surface elements which have the potential to be affected by or generate crime and security-related risks. A reduction in traffic on the existing Great Western Highway would also be expected to improve road safety for pedestrians and active transport users, by reducing their interaction with vehicles. The tunnel portals would be located away from prominent public areas. Other operational ancillary facilities (including the tunnel operations facility at Blackheath and ventilation outlets, if required) would be co-located with the portals. Taking into account the low level of concern expressed by the community in relation to this issue, the magnitude of impact would be minimal. Given the nature of the project, with limited security-related risks, adverse impacts to crime, or a deterioration in security in the community is considered unlikely to occur. The overall significance of the impact would be low (negative).	• operational ancillary facilities would be secured, include adequate lighting and would be designed with consideration of Crime Prevention Through Environmental Design principles.	Nil
Culture		
Community values Operation of the project has the potential to impact the following key community values identified during consultation: • proximity to the natural environment and associated recreational opportunities – the presence of surface infrastructure may	• adoption of urban design objectives and criteria and implementation of the State Design Review Panel process set out in Chapter 4 (Project description) would	Medium (positive)

Initial impact significance	Mitigation measure	Residual impact significance
somewhat detract from the appearance of bushland within the social locality • community facilities and services – substantial reduction to traffic volumes along the existing Great Western Highway through Blackheath and Mount Victoria would noticeably improve the accessibility and amenity of these townships, where the majority of community facilities and services are located • social elements of the community – the substantial reduction in traffic on the surface road would improve people's ability to safely and efficiently interact in the local area, particularly in town centres in Blackheath and Mount Victoria, e.g., by improving travel times (for vehicle users). This would contribute to an improvement in the overall social cohesion of the social locality • the existing local character – the level of amenity within areas bypassed by the project, particularly in Blackheath and Mount Victoria town centres, is anticipated to improve, thereby enhancing the existing local character of these areas. However, in areas closest to portal infrastructure in Blackheath and Little Hartley, residents and visitors to the area may experience adverse changes in their surroundings associated with noise, visual and air quality impacts. Overall, as the project is expected to enhance elements of the community which are were identified to be highly valued, the overall magnitude of impacts upon community values would be minor, and would be likely to occur, resulting in a medium (positive) impact.	provide a high quality design outcome • community and stakeholder engagement during ongoing design development.	

Initial impact significance	Mitigation measure	Residual impact significance
Aboriginal culture and heritage Operation of the project is unlikely to impact identified elements of Aboriginal culture and value. In response to the key principles for action in the Connecting with Country Draft Framework (Government Architect NSW, 2020b), the project would be a visual interpretation of the cultural identity of the Country. The operation of the project would also be unlikely to change people's access to and use of identified cultural sites. However, if not appropriately managed through the design process, ongoing impacts associated with the operation of the project, for example landscape and visual impacts associated with surface infrastructure, could impact upon elements of the area which are valued by Aboriginal communities. Based on the above, the likelihood of negative impacts to Aboriginal cultural heritage and values would have moderate consequences and would be very unlikely. As such the overall significance of impact would be a low (negative) impact.	• adoption of urban design objectives and criteria and implementation of the State Design Review Panel process set out in Chapter 4 (Project description) would provide a high quality design outcome • in line with the Designing with Country framework (Government Architect NSW, 2020a), engagement with Aboriginal knowledge holders with a view to incorporating Aboriginal culture and heritage into the design development of the project • community and stakeholder engagement throughout ongoing design development.	Nil
Non-Aboriginal culture and heritage Operation of the project is unlikely to impact identified elements of non-Aboriginal culture and value including the community's existing level of access to and appreciation of non-Aboriginal heritage items. The likelihood of negative impacts to non-Aboriginal heritage and values is considered to have moderate consequences and would be very unlikely. As such the overall significance of impact would be a low (negative) impact.	• adoption of urban design objectives and criteria and implementation of the State Design Review Panel process set out in Chapter 4 (Project description) would provide a high quality design outcome • heritage interpretation strategy to address historic and contemporary heritage and community values and identify innovative and engaging opportunities for interpretation • community and stakeholder engagement throughout ongoing design development.	Nil

Initial impact significance	Mitigation measure	Residual impact significance
Livelihoods		
Business impacts During the operation of the project, visitors travelling in vehicles may choose to travel via the project, thereby reducing their opportunity to visit businesses in bypassed areas. While some businesses which rely on passing trade may be adversely affected in the short-term, in the medium to longer term there are expected to be improved conditions for businesses due to improvements in local amenity. Businesses which service local residents and tourism would generally remain viable, thereby retaining employment opportunities for people within these businesses. The magnitude of this impact would be minor. The likelihood of this occurring would be possible given that similar impacts have occurred as a result of other bypass projects (refer to Appendix P (Technical report – Economics and business)). As such the overall social significance would be medium (negative), however would improve over time as improvements in local amenity would potentially attract further visitors.	• implementation of a strategy for directional signage to ensure effective and appropriate signposting for key locations along the project, to continue to attract visitors. Transport would also consult with relevant councils regarding opportunities to encourage visitors to areas which are bypassed by the project.	Low (negative)
Tourism related impacts By improving access to the Blue Mountains National Park and other cultural and recreational opportunities (e.g. Mount Victoria Museum), walking trails and sporting facilities, the project is expected to increase tourism expenditure within the Blue Mountains and Lithgow LGAs, including within the social locality. Accommodation and other businesses which cater to tourism may benefit from an increase in demand, as bypassed areas become more attractive to visit due to decreases in traffic, in particular heavy vehicles, on the existing Great Western Highway, and the subsequent improvements in amenity that would arise. Potential growth of tourism related businesses may create more job opportunities in the long term. The magnitude of this impact would be minor. The likelihood of this occurring would be possible given that similar impacts have occurred as a result of other bypass projects (refer to Appendix P (Technical report – Economics and business)). As such the overall social significance would be medium (positive).		Medium (positive)

Initial impact significance	Mitigation measure	Residual impact significance
Economic impacts The operation of the project is expected to have broader economic benefits to the region in which the social locality is situated (comprising the Blue Mountains and Lithgow LGAs). During the first ten years of operation, the project is predicted to provide a direct impact of between around $8 and around $10 million per annum in net output for Blue Mountains City Council and Lithgow City Council LGAs (refer to Appendix P (Technical report – Economics and business)). The broader economic benefits of the project would likely result in flow on effects for livelihoods within the social locality. In particular, an increase in tourism spend in the area would provide greater opportunity for people to earn an income through employment in the tourism industry. The overall magnitude of economic benefits during operation in the social locality would be considered minor, given that the benefits would likely be dispersed across the broader region. The likelihood of these impacts being experienced within the social locality would be possible, resulting in a medium (positive) social impact.		Medium (positive)
Decision-making systems		
Community engagement has been undertaken throughout the development of the project, including at key strategic design stages (refer to Chapter 7 (Community and stakeholder engagement)). Further, the preparation and exhibition of the environmental impact statement is a statutory process which enables people to make a submission expressing their support, objection or comments on the project and its potential impacts. Once operational, the project would have limited impact upon people's ability to interact in decisions that affect them. Given that the views and experience of decision-making systems can vary substantially from person to person, a magnitude and likelihood rating has not been applied.	Transport will continue to listen and engage with the community throughout the detailed design and seek to address any such issues as far as reasonably practical.	Nil

19.5 Environmental mitigation measures

19.5.1 Performance outcomes

Performance outcomes for the project in relation to social impacts are listed in Table 19-4 and identify measurable performance-based standards for environmental management.

Table 19-4 Social performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
The project is designed to provide socially sustainable outcomes. The project will maximise the social and economic welfare of the community. The project will deliver better development outcomes by minimising negative social impacts and enhancing positive social impacts on affected communities	Design and implement the project to provide a net positive social and economic outcome, including: • avoiding or minimising the environmental impacts of the project during construction and operation (refer to project objectives in other areas) • avoiding or minimising direct and indirect impacts on social infrastructure • avoiding or minimising disruptions to local businesses during construction • maximising project employment within the region during construction and operation, subject to project needs and qualifications of regional resources • develop and implement clear, timely and inclusive stakeholder engagement and information measures.	Design, construction and operation

19.5.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential social impacts as a result of the project are detailed in Table 19-5. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 19-5 Environmental mitigation measures – social impacts

ID	Mitigation measure	Timing
SI1	A Social Impact Management Plan (SIMP) will be prepared and implemented during construction and for the first three years of operation of the project. The SIMP will be prepared in consultation with the relevant local councils and will guide monitoring and adaptive management of social impacts resulting from the project. The SIMP will include details of: • desired social outcomes for the project • adaptive management and mitigation strategies to address potential impacts • a process of monitoring predicted social impacts against actual impacts • indicators used to monitor desired social outcomes • a process for reporting on social impacts • identification of appropriate stakeholder responsibilities. The SIMP will be developed taking into account the requirements of the Skills, Employment and Industry Development Strategy for the Great Western Highway Upgrade Program, and the environmental mitigation measures developed for potential business, land use and property impacts.	Construction and operation

ID	Mitigation measure	Timing
SI2	Managers of social infrastructure located adjacent to the construction footprint (including Browntown Oval) will be notified of the timing and duration of construction works and engaged in relation to the management of potential impacts on the social infrastructure, with the aim of minimising potential disruptions to the use of the social infrastructure from construction activities.	Construction
SI3	Construction workers for the project will be employed from the local area, where possible, to manage the need for people to relocate to the area for the duration of construction, and to contribute to local employment opportunities.	Construction
SI4	A construction workforce accommodation strategy will be prepared to confirm workforce accommodation requirements and options, in order to minimise potential adverse impacts to the rental market and short-term accommodation availability. This strategy will include consultation with local councils to better understand the market and how worker demand may be managed.	Design and construction
SI5	Opportunities to encourage visitors to areas that are bypassed by the project will be identified in consultation with the relevant local councils and other relevant government agencies. This will include development and implementation of a directional signage strategy during construction and operation of the project, and in accordance with applicable traffic signage standards and guidelines. The strategy will be developed with the aim of signposting key locations along the project corridor, and identifying the range of services, businesses and social infrastructure within the bypassed areas.	Design, construction and operation
SI16	Stakeholder engagement activities carried out during construction will be accessible to a range of groups in the community. This will include, at a minimum, a range of engagement methods (including options for physical copies of engagement materials) and opportunities for translated materials, upon request.	Construction

20 Business, land use and property

This chapter summarises the business, land use and property assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full business and economic impact assessment is provided in Appendix P (Technical report – Economics and business).

20.1 Assessment approach

The approach to the assessment of the potential economic and business impacts of the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project) included:

- definition of the study area
- identification and consultation with local community members and businesses who could be affected by the project
- quantitative assessment of local business and economic impacts to determine the expected net change in economic activity associated with the construction and operation of the project on both the regional and state economies
- qualitative assessment of other potential economic impacts of the project identified through literature review and community and stakeholder consultation
- identifying mitigation measures for local businesses.

The approach to the assessment of the potential property and land use impacts of the project included:

- reviewing the existing environment with regard to existing properties and land uses around the project
- reviewing key strategic land use planning polices and documents relevant to the project to identify future land uses and planning and development controls
- assessing the potential impacts on properties including those that would need to be acquired to construct and operate the project
- assessing the potential impacts on land uses during construction and operation of the project
- identifying mitigation measures to avoid, minimise and manage impacts on property and land use.

20.2 Existing environment

20.2.1 Local businesses

For the purposes of the business impact assessment, the study area comprised the suburbs of Blackheath, Kanimbla, Mount Victoria and Little Hartley. These suburbs represent the areas where the more immediate impacts of the project have the potential to occur and are shown in Figure 20-1.

Businesses in the study area are generally clustered along the existing Great Western Highway at local town centres including Blackheath, Mount Victoria and Little Hartley (shown in Figure 20-1). A description of the local businesses for each suburb in the study area is provided in Table 20-1.

Table 20-1 Description of local businesses within the study area

Business centre	General description
Blackheath	Blackheath has an antique centre in the Victory Theatre, several gift stores, a supermarket, general store and several cafes and restaurants. There are two fuel stations in Blackheath, both situated on the existing Great Western Highway. Blackheath has around 50 accommodation options listed on booking.com, including hotels, cottages, cabins and motor inns.
Mount Victoria	Mount Victoria has a retro-style cinema, public gardens and is in close proximity to several walking trails and lookouts. The business composition in Mount Victoria includes a newsagency, a post office, and several retail stores and food and beverage venues. There is also one fuel station on the corner of the current route of the Great Western Highway and Mount York Road. Mount Victoria has around 10 accommodation options listed on booking.com, including several old grand homes which have been converted to guest houses.
Little Hartley	The Little Hartley village has a lolly shop, a café, a pizza shop and a pub (though this is currently closed). Little Hartley also has an art gallery, hosts garden shows throughout the year and is located a short distance from a range of activities including horse riding, fishing and bushwalking. Little Hartley has three accommodation options listed on booking.com and a caravan park on Browns Gap Road.
Kanimbla	Kanimbla itself does not feature any businesses outside of the three accommodation options listed on booking.com, however, it is in close proximity to the larger centres of Blackheath, Mount Victoria and Katoomba. There are also a number of walking trails, lookout points and campgrounds around Kanimbla which attract visitors.

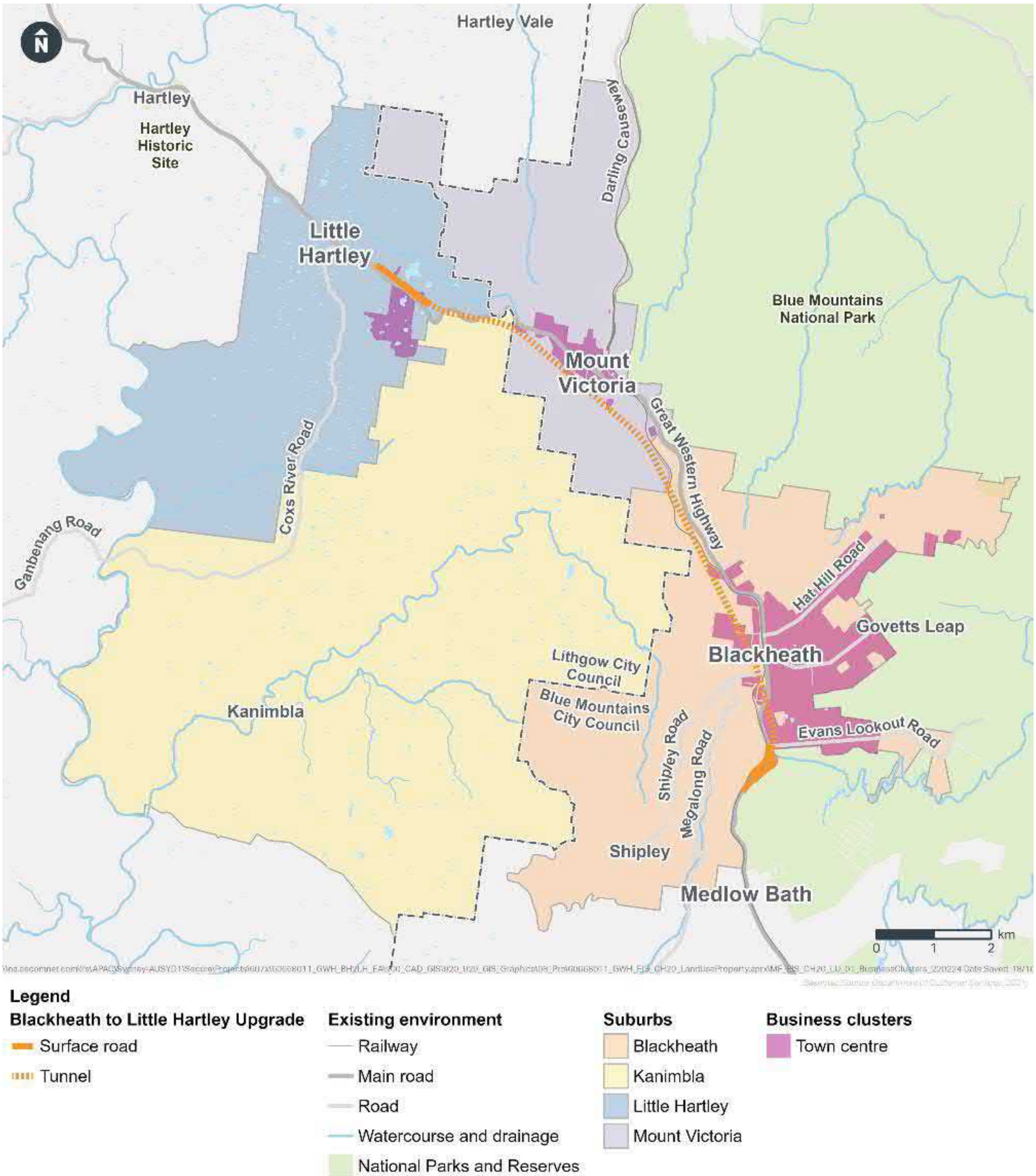


Figure 20-1 Town centres within the study area

20.2.2 Economic context

For the purposes of the economic impact assessment, the regional area covering the Blue Mountains and Lithgow local government areas (LGAs) has been considered to represent the expected area of influence related to the project. A summary of the existing economic environment of the regional area is provided in Figure 20-2.

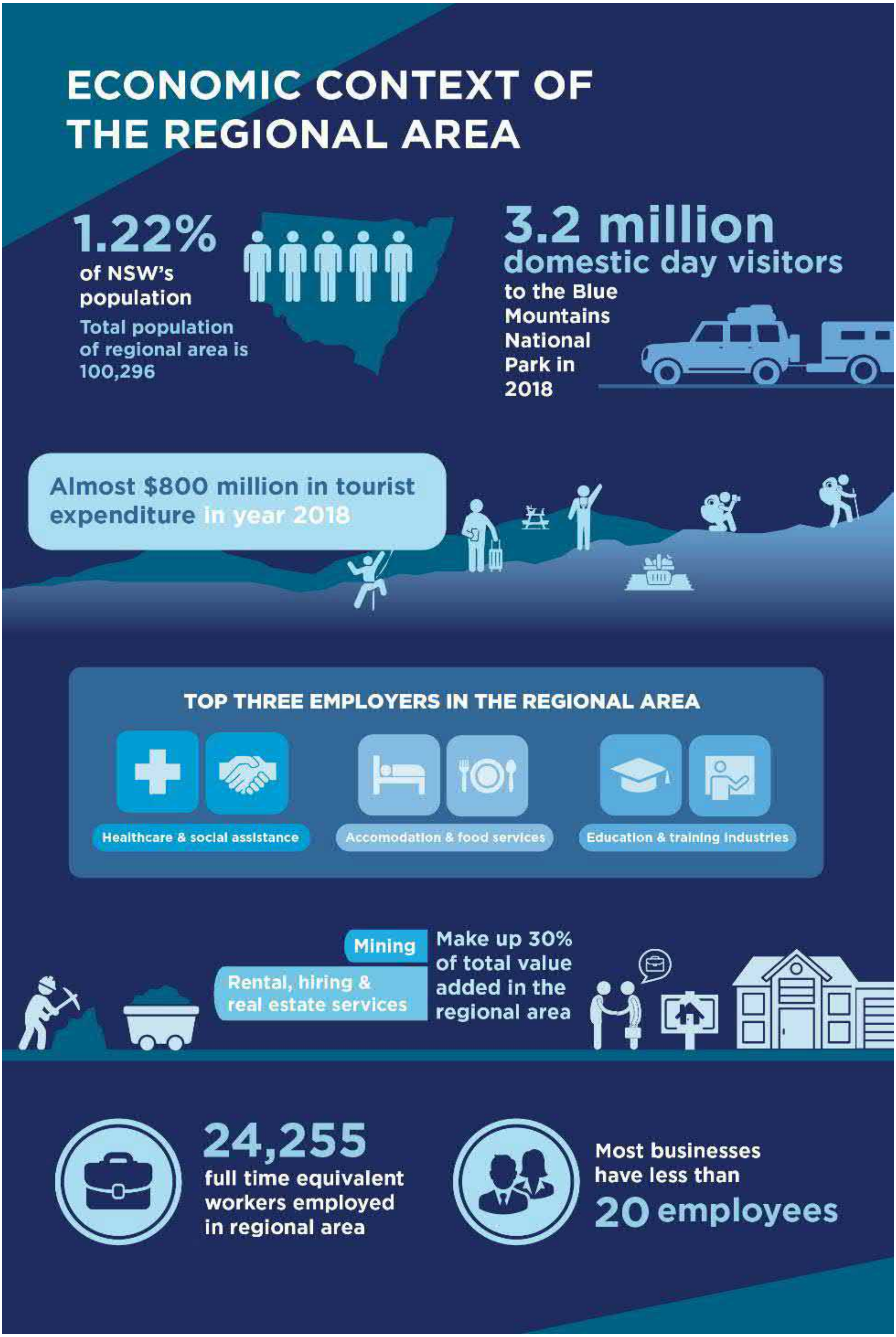


Figure 20-2 Economic context of the regional area

20.2.3 Land use and property context

The project would be located on land within the Blue Mountains and Lithgow LGAs. Land use zoning around the project is set by the following environmental planning instruments:

- Blue Mountains Local Environmental Plan 2015 (Blue Mountains LEP 2015)
- Lithgow Local Environmental Plan 2014 (Lithgow LEP 2014).

For the purposes of the land use and property assessment, the project has been divided into three sections based on existing land use as follows and described below:

- Blackheath
- Blackheath to Mount Victoria
- Mount Victoria to Little Hartley.

The project is located within the Sydney Drinking Water Catchment and partially located within the Blue Mountains Special Area at Blackheath, which lie within the larger Hawkesbury-Nepean River catchment as shown in Chapter 14 (Surface water and flooding). Land within these catchments plays and important role in capturing drinking water for Greater Sydney.

The NSW Exploration and Mining Titles database (Department of Regional NSW, 2019) has been reviewed. No exploration or mining licences are located within the project's construction footprint.

One mining licence (ML 259) applies to a small area of land about 220 metres south of the Little Hartley construction footprint. This mining license covers an area of around 11 hectares in which mining activities for clay and shale minerals are currently carried out. The licence was renewed on 18 August 2018 and is due to expire on 18 August 2039.

Land subject to the mining area would not be impacted by construction or operation of the project.

Blackheath

Land use zones at Blackheath are defined under the Blue Mountains LEP 2015 as shown in Figure 20-3. The majority of land within this area is characterised by Zone E1-E4 denoting various conservation zones.

The Blackheath landscape is dominated by the Great Western Highway alignment, a two lane road running through the middle of the town. Blackheath Station is located in the town centre, west of the Great Western Highway. The rail line servicing Blackheath Station runs in a north-south direction at this location, following a similar alignment to the Great Western Highway.

The current land uses generally comprise commercial properties located in the Blackheath town centre (see Table 20-1). Beyond the town centre is predominately low density residential with small pockets of medium density residential land uses. The majority of residential properties consist of one and two story detached dwellings. A small area of industrial land use is located adjacent to Blackheath Station, consisting of a mechanical and various other businesses.

Several areas of public recreation are located just outside of the town centre including Campbell Rhododendron Gardens, Blackheath Memorial Park, Blackheath Oval, Whitley Park, Sutton Park and Blackheath Gardens. The Blue Mountains National Park is located east of the Great Western Highway and Blackheath Station is a dominant feature of the Blackheath landscape.

Around Blackheath, the project would affect land previously reserved under the *National Parks and Wildlife Act 1974* (NPW Act) as part of the Blue Mountains National Park, zoned as C1 national parks and nature reserves. This area of National Park was revoked by Act of Parliament in August 2022 and land in this area is now zoned as SP2 infrastructure (see Figure 20-3). Details of the National Park revocation are provided in Table 20-3 and a discussion of impacts resulting from this revocation process is provided in Section 20.3.

Changes in land use associated with the Great Western Highway East – Katoomba to Blackheath Upgrade (Katoomba to Blackheath Upgrade) at Blackheath form the baseline environment considered at Blackheath. For further information on the baseline environment, refer to Chapter 5 (Construction).

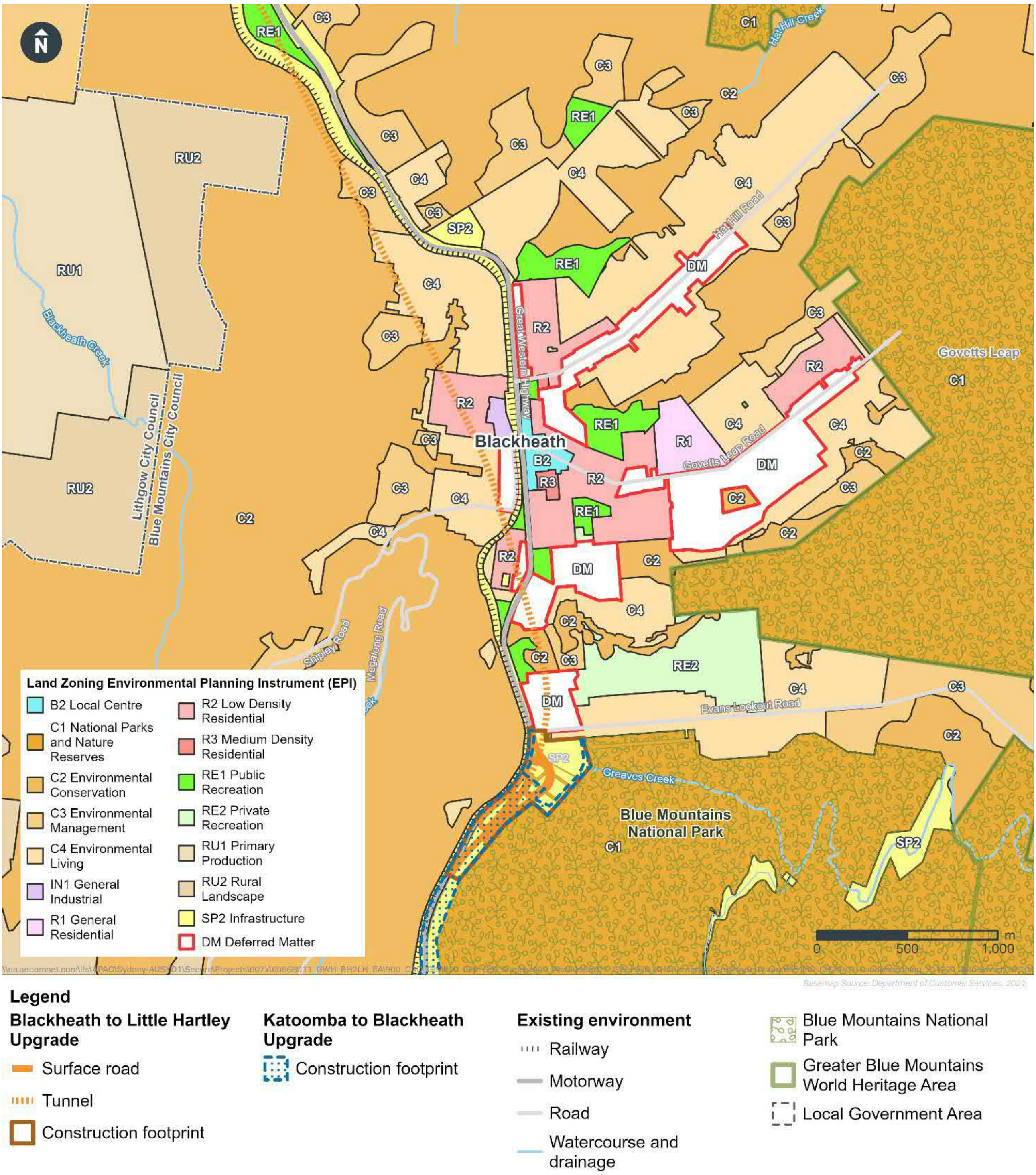


Figure 20-3 Land use zoning at Blackheath

Blackheath to Mount Victoria

Land use zones between Blackheath and Mount Victoria are defined under the Blue Mountains LEP 2015 as shown in Figure 20-4.

The vast majority of this area is made up of the Blue Mountains National Park and other nature reserves and recreational areas. This area also includes the Great Western Highway, a two lane road running from the southeast to the northwest through the middle of Mount Victoria, and Mount Victoria Station located around 300 metres north of the existing Great Western Highway alignment.

The land use in this area is consistent with the semi-rural character of Mount Victoria. Upon the approach to Mount Victoria town centre, the Great Western Highway alignment is bordered to the east by the Blue Mountains National Park and other surrounding bushland. Within the Mount Victoria town centre, low density residential and commercial land uses adjoin the Great Western Highway. The majority of residential properties consist of one and two story detached dwellings. Commercial land uses are described in Table 20-1.

Public recreation areas are located at Browntown Oval and Mount Victoria Memorial Park. Mount Victoria Public School is located 150 metres west of the Great Western Highway and places of worship are also located along the road.

The Blue Mountains National Park is a dominant feature at this location, bordering the Great Western Highway to the east along with environmental conservation areas surrounding the Great Western Highway and Mount Victoria town centre.

Mount Victoria to Little Hartley

Land use zones around Mount Victoria are defined by the Blue Mountains LEP 2015 and land use zones around Little Hartley are defined by the Lithgow LEP 2014 as shown in Figure 20-5.

The land use in this area is generally consistent with the rural character of Little Hartley, with the majority of the section characterised by environmental conservation zones.

The Great Western Highway is a dominant feature of the landscape, with some residential and commercial properties either side of the alignment at Little Hartley. Residential properties within this section are detached, single story dwellings and are primarily located on larger pieces of land resulting in the properties being well set back from the road. Commercial properties are described in Table 20-1.

A large area designated as primary production is present to the north of the Great Western Highway, with large lot residential land use present in the western portion of this section. Public recreation between Mount Victoria and Little Hartley includes Mitchell Ridge Lookout.

Changes in land use associated with the Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade) form the baseline environment considered at Little Hartley. The Little Hartley to Lithgow Upgrade would occupy land zoned as SP2 infrastructure in the future. For further information on the baseline environment, refer to Chapter 5 (Construction).

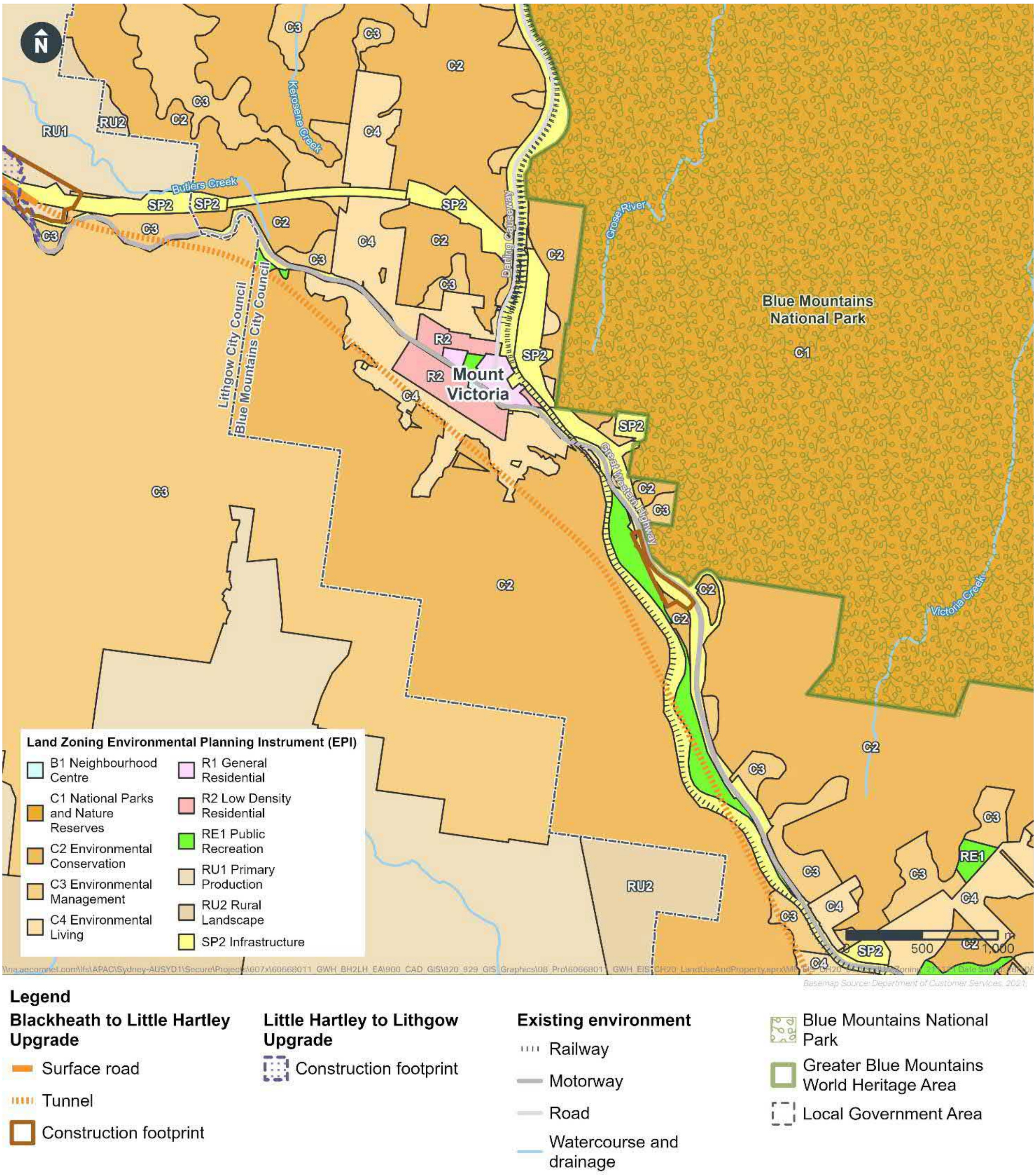


Figure 20-4 Land use zoning between Blackheath and Mount Victoria

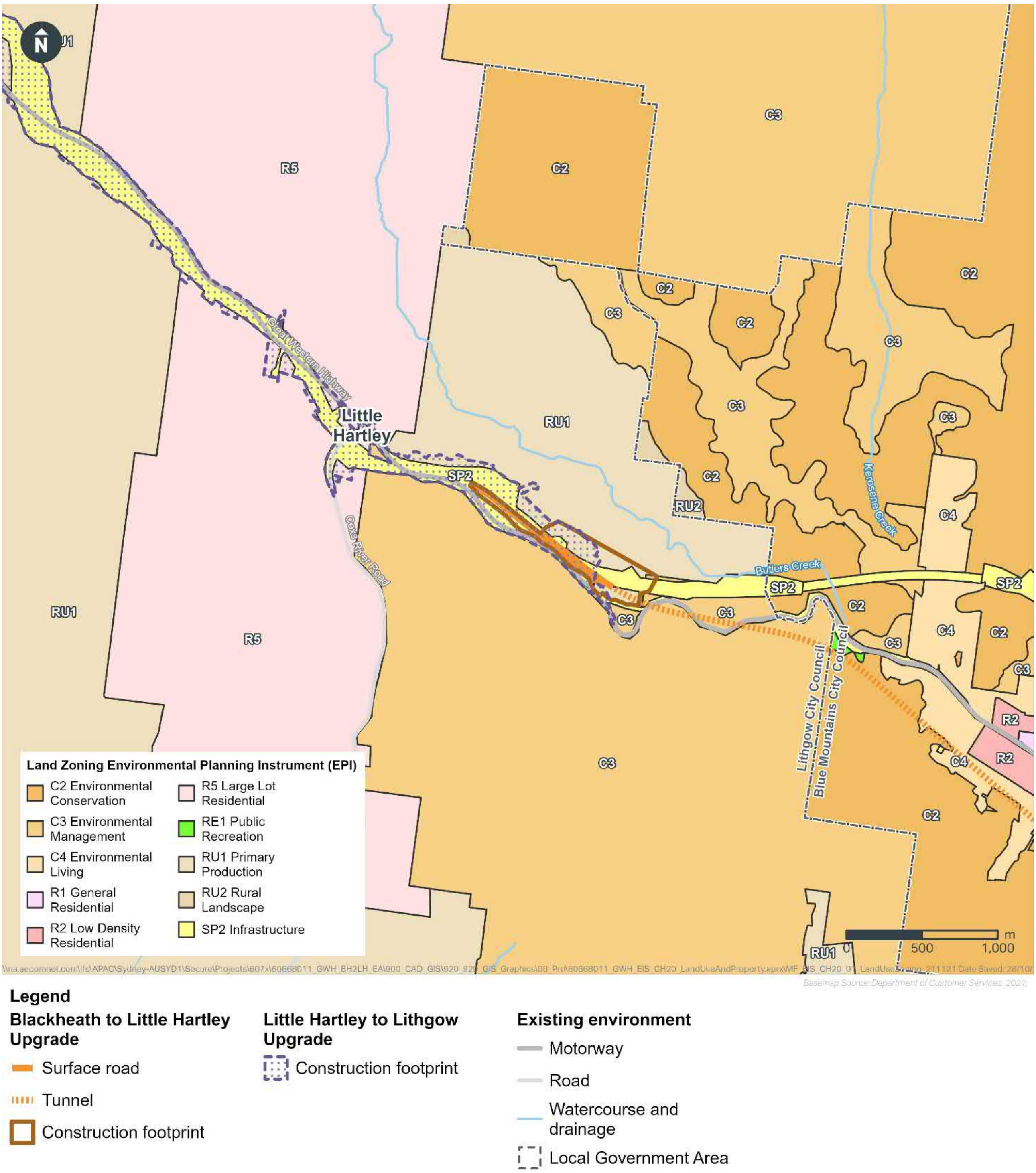


Figure 20-5 Land use zoning between Mount Victoria and Little Hartley

20.3 National Park revocation

As discussed above, at Blackheath part of the project and part of the Katoomba to Blackheath Upgrade traverses land previously reserved under the NPW Act as part of the Blue Mountains National Park. This part of the National Park was revoked by Act of Parliament in August 2022, and transfer of this land to Transport for NSW (Transport) is in progress.

This section discusses the potential to impact on the biological, cultural and other values protected by the NPW Act in relation to the revocation process, including but not limited to:

- biodiversity values associated with the Greater Blue Mountains World Heritage Area listing
- cultural heritage values associated with Aboriginal occupation and past recreation and land use
- other values including recreation, public use, and park management assets.

As discussed in Chapter 12 (Biodiversity), the land subject to revocation is currently affected by a high degree of edge effects due to its close proximity to the existing Great Western Highway. Areas of retained native vegetation adjacent the land subject to revocation are known and predicted to support the same native vegetation and threatened ecological communities as those directly impacted by the project. Potential impacts to the NSW reserve system as a result the revocation of National Park land are therefore considered minimal.

Based on the assessments provided in Chapter 12 (Biodiversity), Chapter 16 (Aboriginal cultural heritage) and Chapter 17 (Non-Aboriginal heritage), potential impacts to biodiversity values and cultural heritage values are not anticipated from the project. The revoked land is not publicly accessible due to its location within the Water NSW Blackheath Special Catchment Area so there would be no associated loss of recreation land or public use.

Environmental input at an early stage of design development for the project has led to a design which minimises potential impacts including to the Blue Mountains National Park. Alternative options to avoid National Park would have resulted in substantial property acquisition and longer construction timeframes, inconsistent with the project objectives described in Chapter 3 (Project alternatives and options).

Compensatory lands will be acquired by Transport and transferred to National Parks and Wildlife Services (NPWS) ownership in consultation with NPWS to offset the land revoked due to the project.

20.4 Potential impacts – construction

20.4.1 Local businesses

The potential impact on local businesses as a result of additional construction traffic generated by the project is expected to be relatively minor. Average vehicle travel time in 2026 is estimated to be around three per cent higher due to project construction, compared to a without project scenario. Therefore, freight and commercial vehicle transport costs are not expected to be greatly affected (refer to Section 8.3.1 of Chapter 8 (Transport and traffic)).

The construction sites would be located over one kilometre away from town centres in Blackheath and Mount Victoria. The indicative construction strategy has been developed to minimise the number of heavy vehicles that need to travel through the Blackheath and Mount Victoria townships by focusing spoil haulage and TBM support activities from Little Hartley. Based on the location of construction sites relative to town centres, it is expected that on-street parking supply in town centres would not be substantially affected during construction (refer to Section 4.1.2 of Appendix P (Technical report – Economics and business)). Construction vehicle movements are therefore unlikely to affect access to businesses either by vehicle or active transport.

The potential for business impacts during construction, such as an increase in travel time or increased noise, would be more than offset by the anticipated increase in economic activity related to investment by construction workers in the local area. Transport has developed a Skills, Employment and Industry Development Strategy for the Upgrade Program which will be applied to the project. This strategy will identify measures to provide early notification and information to local business to allow time to prepare for and respond to changes in traffic (see Section 20.6.2).

No businesses would be acquired as part of the project. Potential benefits that would be provided to businesses in the local area as a result of project construction could include:

- accommodation – temporary uplift in local commercial accommodation occupancy during the construction phase
- retail – temporary uplift in revenues of retail business as a result of spending from construction workers during the construction phase of the project (i.e., workforce spending)
- construction – temporary uplift to revenues for local construction related businesses located within the regional area.

20.4.2 Regional economy

During construction, there is expected to be an increase in economic activity within the regional area. The capital expenditure required for the project would create increased opportunities for both businesses and workers associated with construction, while also resulting in flow-on impacts to other parts of the local economy, including for local businesses and the local workforce. The Skills, Employment and Industry Development Strategy for the Upgrade Program includes project specific opportunities for upskilling and training of the local workforce (see Section 20.6.2).

Predicted economic impacts during construction as a result of the project's expected capital expenditure including gross output (market value of goods and services produced) and value added (market value of goods and services produced after deducting the cost of goods and services used) are shown in Figure 20-6.

Figure 20-6 Economic impacts during construction (2024 to 2031)

20.4.3 Land use

The project has the potential to impact land use where construction work is required. These impacts would be temporary in nature, except for sites that are subsequently used for operational infrastructure (see Section 20.5.3).

By-products of certain land uses such as agriculture and infrastructure developments have the potential to impact the quality of Greater Sydney's drinking water. Potential impacts to water quality are discussed in Chapter 14 (Surface water and flooding).

Table 20-2 outlines the potential land use impacts at each construction site required for the project.

Table 20-2 Potential land use impacts during construction

Construction site	Potential impacts on land use during construction
Blackheath	The Blackheath construction site would be located on land zoned SP2 infrastructure following the revocation of the National Park in August 2022. The use of this construction site would not impact on the existing land use as it would be zoned for infrastructure related uses, as outlined in Section 20.2.3.
Soldiers Pinch	The Soldiers Pinch construction site would temporarily occupy land zoned for infrastructure, public recreation, and environmental conservation. The location and layout of the construction site has been designed to specifically avoid impacts to Browntown oval (refer to Chapter 3 (Project alternatives and options)). Other areas of land zoned as public recreation within the Soldiers Pinch construction site would be required to accommodate access arrangements to the site. The construction site would temporarily require the use of around 0.65 ha of Crown land zoned for public recreation and environmental conservation over the duration of construction works at the Soldiers Pinch construction site.
Little Hartley	The Little Hartley construction site would occupy land zoned for infrastructure, primary production and environmental management. This construction site would temporarily impact around 0.6 hectares of Crown land zoned for primary production and infrastructure as well as other areas of primary production and environmental management for the duration of construction works at the Little Hartley construction site.

20.4.4 Property

Property acquisition and leasing

The project has been designed and developed to minimise property acquisitions and has prioritised the use of Transport land. Notwithstanding this, some temporary use and permanent acquisition would be required. All property acquisitions required for the project would be carried out in accordance with the NSW *Land Acquisition (Just Terms Compensation) Act 1991*, and in accordance with the land acquisition reforms announced by the NSW Government in 2016.

There would be no residential property acquisition at Blackheath or Soldiers Pinch. There would be one residential property and land from a second private property acquired at Little Hartley as part of the Little Hartley to Lithgow Upgrade that would also be required for the project.

The water supply pipeline between the Little Hartley construction footprint and Lithgow would be located wholly within the existing and/or new road reserves and the indicative alignment has been designed to avoid impacts on property and land use.

Temporary use of properties would be managed through leasing arrangements or property acquisition should lease arrangements not be practical. Where required discussions would be held with affected property owners concerning the purchase, lease, or licence of land. Landowners and tenants of landowners affected by acquisition would be supported by access to counselling services throughout the process and a community relations support toll-free telephone line would be established to respond to any community concerns. Affected landowners will be consulted to determine appropriate measures to maintain property access and the potential need to relocate or alter infrastructure on the property (see Section 20.6.2).

At Blackheath, part of the project and part of the Katoomba to Blackheath Upgrade traverses land previously reserved under the NPW Act as part of the Blue Mountains National Park. This part of the National Park was revoked in August 2022 by Act of Parliament and transfer of this land to Transport is in progress (see Section 20.3 and refer to Appendix B (Statutory compliance)). As a result, the project would not directly impact the Blue Mountains National Park.

Several properties required for the project are subject to unresolved Aboriginal Land Claims. The majority of these relate to substratum acquisition, with one unresolved claim over a partial surface construction lease at Soldiers Pinch (the area shaded green as part of Lot7300/DP1129198 in Figure 20-8) and one unresolved claim over a partial surface construction lease at Little Hartley (Lot7313/DP1162788 shown in Figure 20-9). These land claims under the *Aboriginal Land Rights Act 1983* (NSW) do not necessarily denote Aboriginal cultural or scientific archaeological values. Land Councils are not required to establish cultural association with lands when making land claims under the *Aboriginal Land Rights Act 1983*. The use of this surface land would be for the duration of construction and would not impact the extent of Crown land available for Aboriginal land claims.

The indicative property acquisition and construction leases that would be required to construct and operate the project are summarised in Table 20-3 to Table 20-5 and shown in Figure 20-7 to Figure 20-9. The potential impacts of property acquisition to people are further discussed in Chapter 19 (Social impacts).

Blackheath

Property acquisition at Blackheath relates to the National Park revocation required for both the project and the Katoomba to Blackheath Upgrade (see Section 20.3). The revoked area is around 26 hectares in total. Around 17 hectares of this area lies within the Blackheath construction footprint.

Historically, the land subject to National Parks revocation had been subdivided by Blue Mountains City Council prior to its transfer to the NPWS, which is why there are multiple Lot/DPs presented in Figure 20-7. In addition to the revocation of part of the National Park land, acquisition of one surface property owned by Blue Mountains City Council would be required at Blackheath. This property was inadvertently omitted from the historic land transfer between Blue Mountains City Council and the NPWS and remained in the ownership of Council. This meant that the property was not owned by the NPWS and therefore was not included in the recent revocation process.

Details of the property acquisition required at Blackheath are summarised in Table 20-3.

Table 20-3 Property acquisition at Blackheath

Ownership	Lot/DP	Acquisition type	Construction lease or permanent
NPWS	National Park revocation	Total[1]	Permanent
Blue Mountains City Council	338/8484	Total	Permanent

Table notes:

1. Refers to the nominated revocation area which involves partial acquisition of Lot 3, 261, 262, 263 and 12 towards the southern extent of the Blackheath construction footprint, and total acquisition of the parcels historically owned by council.

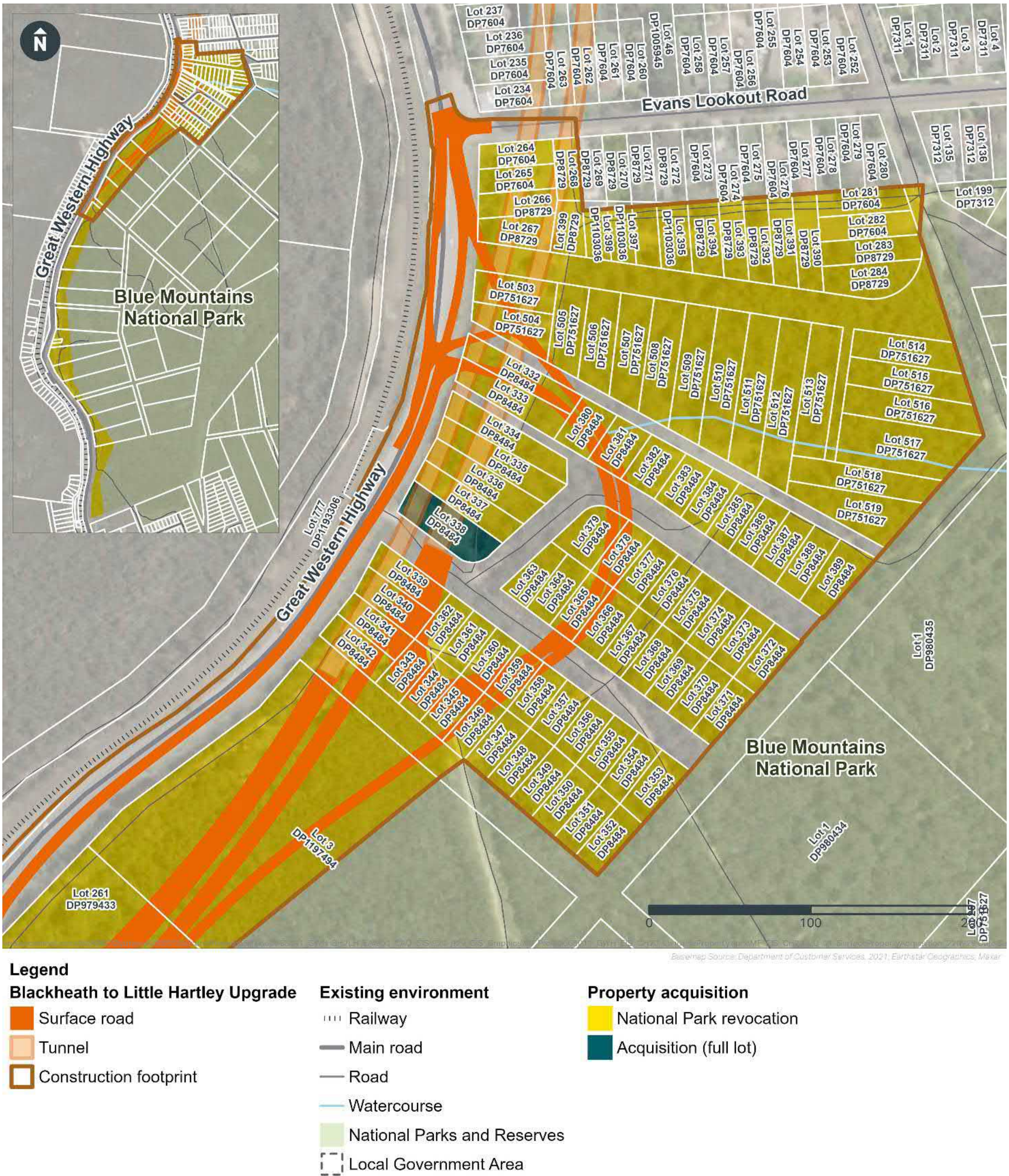


Figure 20-7 Property acquisition requirements at Blackheath

Soldiers Pinch

The majority of the Soldiers Pinch construction site is part of the Great Western Highway road reserve and would not need to be acquired. One partial construction lease at Soldiers Pinch would be required to accommodate the construction of a mid-point access shaft, around 0.65 hectares in area (see Figure 20-8).

Details of the construction lease required at Soldiers Pinch are summarised in Table 20-4.

Table 20-4 Property acquisition at Soldiers Pinch

Ownership	Lot/DP	Acquisition type	Construction lease or permanent
State of NSW (Crown Land)	7300/1129198[1]	Partial	Construction lease

Table notes:

1. Lot/DP subject to an Aboriginal Land Claim and Aboriginal Land Use Agreement

Figure 20-8 Construction lease requirements at Soldiers Pinch

Little Hartley

As discussed in Section 20.2.3, property acquisition at Little Hartley is required for the project and the Little Hartley to Lithgow Upgrade. At Little Hartley, the vast majority of property requirements for both projects are common (overlap) and acquisition requirements have been considered at an Upgrade Program level.

Property requirements at Little Hartley for the Little Hartley to Lithgow Upgrade would affect private property (across multiple Lot/DPs) owned by two landowners. Property requirements for the project would include a construction lease of part of a property owned by Blue Mountains City Council (around 0.6 hectares). Other property affected by the project would already be acquired or subject to construction lease as part of the Little Hartley to Lithgow Upgrade (see Figure 20-9).

Crown Roads are located within the Little Hartley construction footprint adjacent to Lot1/DP587763 (see Figure 20-9). Currently, the project is not required to acquire these crown roads, therefore they are not shaded in Figure 20-9 or included in Table 20-5. Under section 151 of the *Roads Act 1993*, Transport for NSW may, with the consent of the Minister for Roads, Maritime and Freight transfer a specified Crown Road to Council by order published in the Gazette.

The total area of acquisition required at Little Hartley, including properties acquired as part of the Little Hartley to Lithgow Upgrade, is around 34 hectares. Around 20 hectares of this area lies within the Little Hartley construction footprint for the project.

Details of the property acquisition required at Little Hartley are summarised in Table 20-5.

Table 20-5 Property acquisition at Little Hartley

Ownership	Lot/DP	Acquisition type	Acquired by	Construction lease or permanent
Private	1/840442	Partial	Little Hartley to Lithgow Upgrade	Permanent
	1/840442	Partial	Little Hartley to Lithgow Upgrade	Construction lease
Private	1/587763	Partial	Little Hartley to Lithgow Upgrade	Construction lease
Private	1/587763	Partial	Little Hartley to Lithgow Upgrade	Permanent
	4/1130411	Partial	Little Hartley to Lithgow Upgrade	Permanent
	3/1130411	Partial	Little Hartley to Lithgow Upgrade	Permanent
	2/1130411	Partial	Little Hartley to Lithgow Upgrade	Permanent
Private	360/587763	Total	Little Hartley to Lithgow Upgrade	Permanent
State of NSW (Crown Land)	7313/1162788[1]	Partial	The project	Construction lease

Table notes:

1. Lot/DP subject to an Aboriginal Land Claim

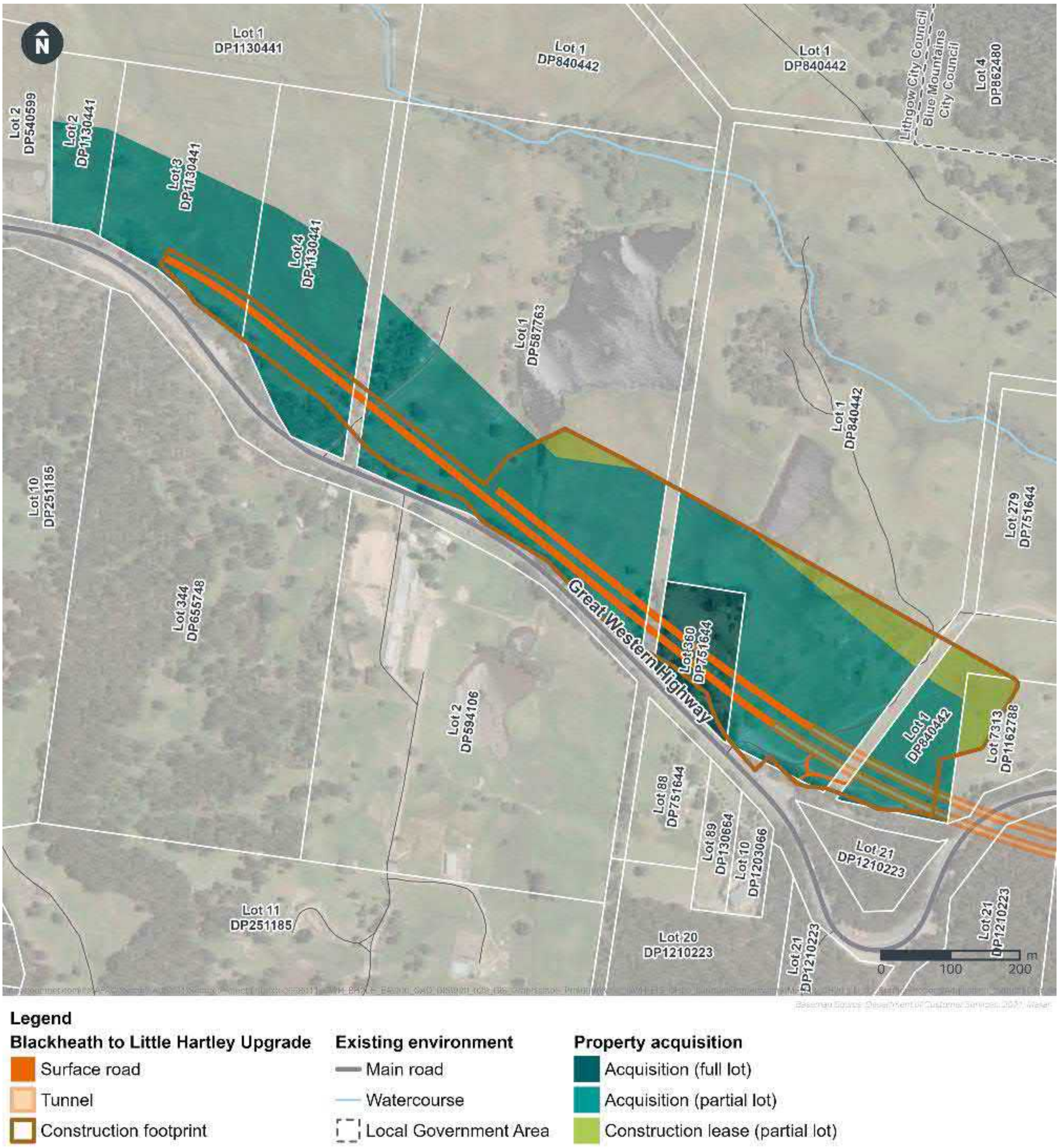


Figure 20-9 Property acquisition and construction lease requirements at Little Hartley

Acquisition of substratum

The construction and operation of the project would require the acquisition of land below the surface of the ground to accommodate the tunnels (substratum acquisition) as shown in Figure 20-10.

This substratum acquisition would consist of a stratum acquisition envelope around the tunnels, including any associated ground support area that may be required. In some circumstances, the introduction of the tunnels has the potential to limit development above the tunnels, for example an underground carpark. However, this is generally only the case where the tunnel depth is shallow, near tunnel portals. Given the existing land use of the area and limited potential for future development particularly around the tunnel portals, this impact would be unlikely to occur. Around

295 properties, the majority of which are located in Blackheath, would be subject to substratum acquisition for the project.

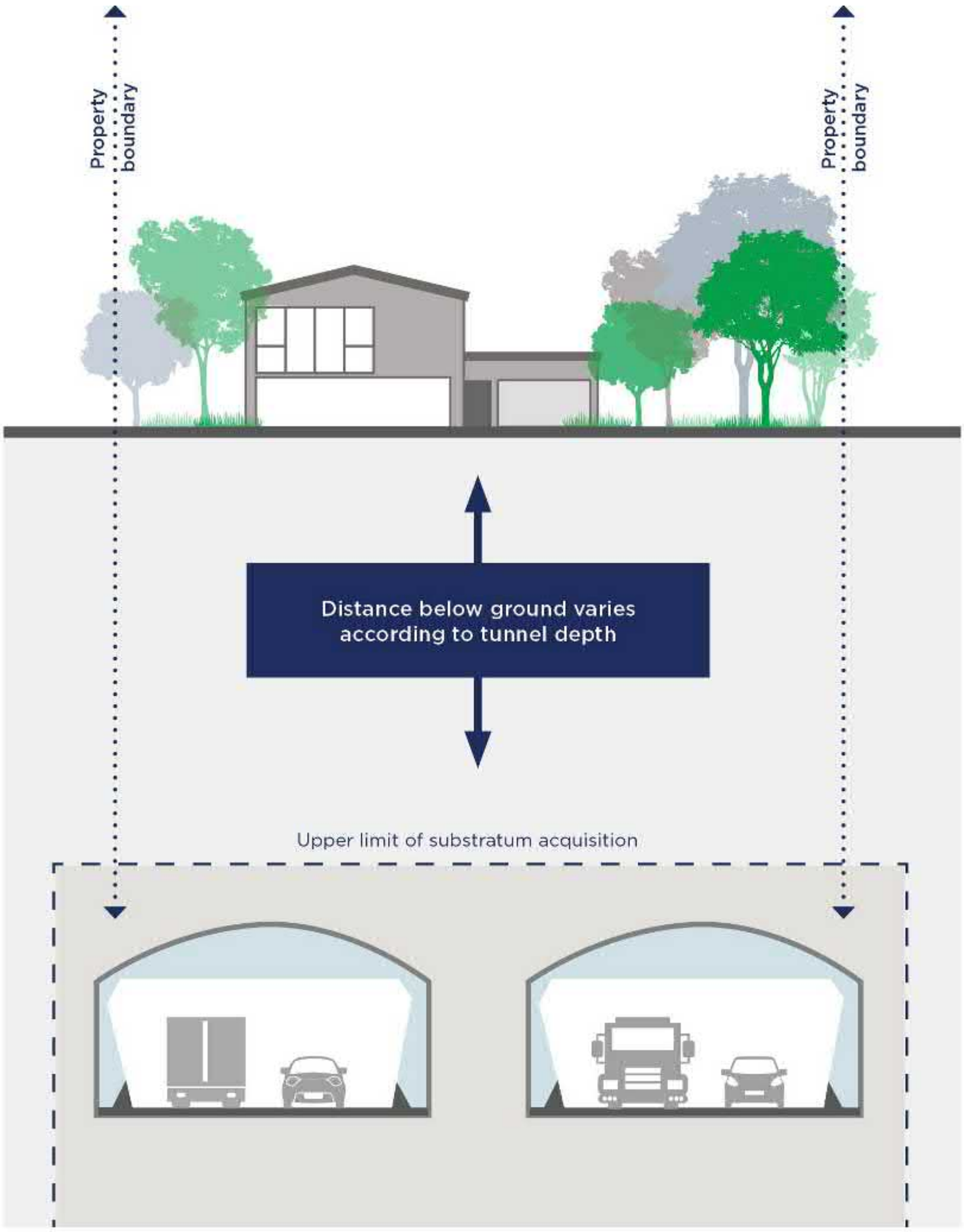


Figure 20-10 Example of substratum acquisition

Ground movement impacts

Ground movement (or settlement) due to excavation or disturbance below ground may present a risk to the stability of nearby buildings and other structures during construction of the project.

An assessment of potential ground movement impacts associated with the project is provided in Chapter 13 (Groundwater and geology). The assessment identified negligible risk of settlement impacts to buildings. Potential impacts to property and structures as a result of ground movement impacts is therefore considered highly unlikely during both construction and operation of the project. Further discussion regarding ground movement and potential settlement impacts is included in Chapter 13 (Groundwater and geology). Assessment of potential ground movement impacts on heritage items is included in Chapter 17 (Non-Aboriginal heritage).

Protected and sensitive lands

Potential impacts to protected and environmentally sensitive lands from the project are outlined in Table 20-6.

Table 20-6 Potential impacts of the project on environmentally sensitive land and processes

Environmentally sensitive land and/or process	Where addressed in the EIS
Protected areas (including land and water) managed and/or reserved under the NPW Act	The project would not directly impact on protected areas managed and/or reserved under the NPW Act. Potential indirect impacts include: • edge effects (refer to Chapter 12 (Biodiversity)) • impacts to groundwater and groundwater dependent ecosystems (refer to Chapter 13 (Groundwater and geology) and Chapter 12 (Biodiversity)) • impacts to water quality and streamflow (refer to Chapter 14 (Surface water and flooding)). The National Park revocation process is discussed in Section 20.3.
Key Fish Habitat as mapped and defined in accordance with the *Fisheries Management Act* 1994 (FM Act)	The project has the potential to indirectly impact water quality and flows at watercourses mapped as Key Fish Habitat under the FM Act. Potential impacts to water quality are discussed in Chapter 14 (Surface water and flooding), and potential impacts to aquatic ecology are discussed in Chapter 12 (Biodiversity).
Waterfront land as defined in the *Water Management Act* 2000	The project is not anticipated to impact on any waterfront land. Potential impacts on surface water are discussed in Chapter 14 (Surface water and flooding).
Land or waters identified as Critical Habitat under the FM Act or *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) or areas of outstanding biodiversity value under the *Biodiversity Conservation Act* 2016 (BC Act)	Some areas impacted by the project may qualify as Critical Habitat under the FM Act or EPBC Act. Impacts to Critical Habitat are detailed in Appendix H (Technical report – Biodiversity), and potential impacts to threatened fauna are summarised in Chapter 12 (Biodiversity). There are no areas of outstanding biodiversity value or areas of Critical Habitat under the FM Act or EPBC Act within the biodiversity assessment area. The Greater Blue Mountains World Heritage Area has not been declared an area of outstanding biodiversity value. Though the values of the Greater Blue Mountains World Heritage Area relate to high quality vegetation and threatened species, along with Aboriginal cultural heritage values, the project is not anticipated to impact these values (refer to Chapter 12 (Biodiversity) and Chapter 16 (Aboriginal cultural heritage)).
Biodiversity stewardship sites, private conservation lands and other lands identified as offsets	The project does not impact lands identified as offsets. Potential biodiversity impacts are discussed in Chapter 12 (Biodiversity).

Environmentally sensitive land and/or process	Where addressed in the EIS
Schedule 1 Special Areas under the Water NSW Regulation 2020	The project is partially located within the Blue Mountains Special Area at Blackheath. Potential impacts are discussed in Chapter 14 (Surface water and flooding). Access to the Sydney Drinking Water Catchment at Blackheath via B6 Lake Medlow Trail (fire trail accessed via Valley View Road) would be maintained during construction.

20.4.5 Impacts adjacent to National Park

Developments that may impact on land managed by NPWS must assess the impact of the development against the Developments adjacent to National Parks and Wildlife Service lands: Guidelines for consent and planning authorities (the NPWS guidelines) (NPWS, 2020).

Table 20-7 provides a summary of how the projects related to issues to be considered when assessing proposals adjacent to NPWS parks. These potential impacts are relevant to the Blackheath construction site which is located near the Blue Mountains National Park.

Table 20-7 NPWS guidelines for development

Issue for consideration	Project compliance
Erosion and sediment control	Potential impacts from the project on erosion and sedimentation would be negligible (refer to Chapter 14 (Surface water and flooding)).
Stormwater runoff	The project complies with Neutral or Beneficial Effect on Water Quality (NorBE) requirements for discharge into the Sydney Drinking Water Catchment, and potential flooding impacts would be minor and temporary in nature (refer to Chapter 14 (Surface water and flooding)).
Wastewater	The project complies with NorBE requirements for discharge into the Sydney Drinking Water Catchment. Wastewater is discussed in Chapter 21 (Resource use and waste management).
Pests, weeds and edge effects	There is the potential for edge effects including weed spread as a result of project construction. Potential impacts along with mitigation measures are discussed in Chapter 12 (Biodiversity).
Fire and the location of asset protection zones	Fire risk has been assessed for the project and is discussed in Chapter 22 (Hazards and risk). Operational ancillary facilities would be located and designed taking into account Planning for Bush Fire Protection (NSW Rural Fire Service, 2019) and AS3959-2018 guidelines which prescribe minimum setback distances for infrastructure near bushfire prone land.
Boundary encroachments and access through NPWS land	No public access to construction sites would be permitted and access to construction sites would not traverse NPWS land. Construction access and footprints are defined in Chapter 5 (Construction).
Visual, odour, noise, vibration, air quality and amenity impacts	Potential visual, odour, noise, vibration and air quality are further discussed in Chapter 18 (Landscape and visual), Chapter 11 (Noise and vibration) and Chapter 9 (Air quality).

Issue for consideration	Project compliance
Threats to ecological connectivity and groundwater-dependent ecosystems	The project is unlikely to fragment movement corridors for fauna. The project has the potential to indirectly impact groundwater dependent ecosystems. Potential impacts are further discussed in Chapter 12 (Biodiversity) and Chapter 13 (Groundwater and geology).
Cultural heritage	No direct Aboriginal cultural heritage impacts are anticipated as a result of the project. The project may result in potential indirect visual impacts to heritage items from the addition of operational infrastructure at the tunnel portals. These are discussed in Chapter 16 (Aboriginal cultural heritage) and Chapter 17 (Non-Aboriginal heritage).
Access to parks	Access to the Blue Mountains National Park at Blackheath via B6 Lake Medlow Trail (fire trail accessed via Valley View Road) would be maintained during construction.

20.5 Potential impacts – operation

20.5.1 Local businesses

Tourism and accommodation businesses

By improving access to the Blue Mountains National Park and other cultural and recreational opportunities (e.g. Mount Victoria Museum), walking trails and sporting facilities, the project is expected to increase tourism expenditure within the region. It is estimated the project could help to increase tourism expenditure in the region by an average of around $8 million per year due to improved accessibility and increased attractiveness of tourism destinations within the regional area (refer to Section 4.2.1 of Appendix P (Technical report – Economics and business).

Accommodation businesses may benefit from an increase in demand due to improvements in amenity associated with decreased traffic on the highway (refer to Section 8.4.1 of Chapter 8 (Transport and traffic)). However, accommodation requirements for employees required to support operation of the project are not expected to have a material impact on accommodation businesses within the regional study area.

Retail businesses

During operation, a substantial proportion of vehicles would travel via the project (refer to Section 8.4.1 of Chapter 8 (Transport and traffic)), thereby reducing their opportunity to visit business in bypassed areas.

In Blackheath and Mount Victoria, businesses such as petrol stations, take-away food businesses and other retail stores would be most likely to experience a reduction in business activity due to reliance on passing trade. Little Hartley may be more susceptible to potential impacts due to its smaller population and higher relative reliance on passing trade (refer to Section 4.2.2.2 of Appendix P (Technical report - Economics and business)).

Downturns in passing trade are expected to be short-term, and the long-term impacts on passing trade are generally positive (Parolin 2011; Parolin, 2012) (refer to Section 4.2.2 of Appendix P (Technical report – Economics and business)). Transport will identify opportunities such as the development and implementation of a directional signage strategy for the project, which would encourage visitors to areas that are bypassed including businesses (see Section 20.6.2).

Improved productivity

Operation of the project would help address traffic congestion and travel time concerns held by the community by reducing traffic and congestion on the existing highway, taking trucks off the surface roads, and reducing the risk of accidents (refer to Section 8.4.1 of Chapter 8 (Transport and traffic)). This would also help to improve travel times for both local traffic, and freight traffic using the project, which would provide productivity improvements for business and freight related road users. It is also likely that the project could result in improved access to more productive jobs for local residents, while also improving access to the region for other workers.

20.5.2 Regional economy

Once operational, the project is expected to provide an ongoing economic impact on the regional economy through three key drivers outlined in Figure 20-11.

Figure 20-11 Key economic impact drivers during operation of the project

It is estimated that during the first ten years of operations, the project would increase total gross output in the regional area by an average of around $15 million per year, with total value added in the region increasing by around $8 million per year. This impact would be largely driven by the productivity uplift associated with business and freight related benefits and increased tourism spend within the regional area. This uplift is expected to be partly offset by a modest decline in passing trade activity, due to a reduction in local through traffic (refer to Appendix P (Technical report – Economics and business)).

The project would also contribute to a total reduction in the current route for high productivity vehicles over 20 metres in length by up to 100 kilometres between Sydney and Central West NSW, improving links between the national high productivity heavy vehicle network and Sydney.

In the first ten years of operation, it is estimated that the project would result in the economic impacts identified in Figure 20-12.

Figure 20-12 Economic impacts during operation (2030 to 2040)

20.5.3 Land use

Land use changes as a result of the project would occur largely in response to the physical introduction of permanent project infrastructure at Blackheath and Little Hartley. The location of operational infrastructure has been developed in consideration of existing land uses to minimise permanent impacts and is discussed further in Table 20-8.

Land used for construction of the project and which is not required to operate the project would be rehabilitated and returned to an equivalent state as soon as practicable following the completion of construction.

Table 20-8 Potential land use impacts during operation

Location	Potential impacts on land use during operation
Blackheath	Land occupied by the Blackheath construction site would continue to support operational infrastructure for the project including the tunnel operations facility, ventilation outlet (if required under the ventilation outlet option), operational maintenance parking, new surface roads and sediment and water quality infrastructure. Operational infrastructure has been designed to be located as close to the tunnel as possible to minimise impacts to land use. The establishment of this infrastructure at this location would be consistent with land use zone objectives as it is zoned for infrastructure related uses.
	There are currently no building height restrictions applicable to land around the Blackheath portal area.
Soldiers Pinch	At the completion of construction, the residual land at Soldiers Pinch construction site would be rehabilitated and returned to an equivalent state. The land would be retained as road reserve and no impacts to land use during operation of the project are therefore anticipated at this location.
Little Hartley	At the completion of construction, part of the Little Hartley construction site (the area subject to construction lease) would be rehabilitated to its original state or as otherwise agreed with the landowner. The remainder of the site would be used to support operational requirements for the project including a water treatment plant, incident response management centre, ventilation outlet (if required under the ventilation outlet option), new surface roads, sediment and water quality basins and an electricity substation. Operational infrastructure has been designed to be located as close to the tunnel as possible to minimise impacts to land use. The infrastructure at Little Hartley would be located on land previously occupied by the Little Hartley construction site zoned as primary production, environmental management and infrastructure (see Section 20.4.3) The establishment of the water treatment plant and substation as permanent infrastructure would permanently change parts of the existing land use from primary production and environmental management to permanent project infrastructure. The remaining areas of land occupied by this infrastructure is zoned for infrastructure related purposes and is consistent with these land use zone objectives.
	There are currently no building height restrictions applicable to land around the Little Hartley portal area.

20.5.4 Property

Property access would be maintained along the project alignment during operation.

Where necessary at Little Hartley, alternative access arrangements would be provided by the Little Hartley to Lithgow Upgrade to maintain access in consultation with the affected landowners.

20.6 Environmental mitigation measures

20.6.1 Performance outcomes

Performance outcomes for the project in relation to business, land use and property are listed in Table 20-9 and identify measurable performance-based standards for environmental management.

Table 20-9 Business, land use and property performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
The project minimises adverse impacts to property and business and achieves appropriate integration with adjoining land uses, including maintenance of appropriate access to properties and community facilities, and minimisation of displacement of existing land use activities, dwellings and infrastructure. The project maximises positive impact opportunities	Design and implement the project to provide a net positive property, businesses and land use outcome, including: • avoiding or minimising the environmental impacts of the project during construction and operation (refer to project objectives in other areas) • minimising the construction and operational footprints of the project • avoiding or minimising disruptions to local businesses during construction • rehabilitating disturbed land that is not required for operational infrastructure to a state comparable with its pre-disturbance condition.	Design, construction and operation

20.6.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential business, land use and property impacts as a result of the project are detailed in Table 20-10. A full list of mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 20-10 Environmental mitigation measures – business, land use and property

ID	Mitigation measure	Timing
BU1	The Skills, Employment and Industry Development Strategy for the Great Western Highway Upgrade Program will be applied to the project, with project-specific measures developed and implemented during construction of the project, including: • opportunities to promote and deliver upskilling and training for the local workforce • a strategy for jobs, diversity and business initiatives to achieve local economic and social outcomes in areas affected by the project • a strategy, developed in consultation with the relevant local councils, to provide early notification and information to local business to allow time to prepare for and respond to changes in traffic during construction of the project Project-specific skills, employment and industry development measures will be identified and implemented taking into account the requirements of and to be complementary with the Social Impact Management Plan (SIMP) for the project (refer to environmental mitigation measure SI1).	Construction

ID	Mitigation measure	Timing
BU2	Access to local businesses will be maintained during construction of the project. If existing access arrangements cannot be maintained, an acceptable alternative access will be provided in consultation with the affected business owner.	Construction
LU1	Land temporarily occupied during construction but not acquired for permanent operational infrastructure will be rehabilitated to a condition comparable to its pre-construction state or as otherwise agreed, in consultation with the relevant landowner.	Construction
LU2	Landowners whose properties will be affected by temporary occupation during construction or partial acquisition will be consulted to determine appropriate measures to maintain property access and the potential need to relocate or alter infrastructure on the property.	Construction

21 Resource use and waste management

21.1 Assessment approach

The assessment of resource use and waste management for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project) comprised:

- review of the regulatory framework for waste management (including spoil reuse, recycling and disposal options)
- review of the likely resources required for the construction and operation of the project, including materials, water and power
- review of the likely waste streams, volumes and classifications
- estimating the quantities of bulk earthworks and spoil that would be generated during construction
- identification of opportunities for the avoidance, minimisation and reuse of waste, including targets for the beneficial reuse of solid wastes, water and other waste consistent with the project's sustainability framework (refer to Chapter 23 (Sustainability, climate change and greenhouse gas))
- identification of the environmental impacts associated with resource use and the generation, handling, storage and disposal of waste materials
- identification of management strategies for waste during construction and operation, including:
  - managing construction waste through the resource management hierarchy established under the *Waste Avoidance and Recovery Act 2001* (see Figure 21-1)
  - developing procedures for the assessment, handling, stockpiling and disposal of potentially contaminated materials and construction water, in accordance with the Waste Classification Guidelines (NSW Environment Protection Authority, 2014)
  - identifying resource replacement opportunities for achieving circular economy outcomes under the NSW Waste and Sustainable Materials Strategy 2041 (NSW Department of Planning, Industry and Environment, 2021b).

Figure 21-1 Resource management hierarchy considered for the project

21.2 Potential impacts – construction

Potential impacts during construction of the project relate to:

- construction resource use, including construction materials, water and power
- generation and management of wastes (non-spoil)
- generation and management of spoil.

21.2.1 Construction resource use

Construction materials

Indicative quantities of anticipated construction materials are provided in Table 21-1. Other items such as timber, electrical materials and landscaping materials would also be required. The portal emissions option would require less construction materials (such as for the ventilation building and outlet) compared to the ventilation outlet option (if identified as the preferred option).

Table 21-1 Indicative quantities of resources required for construction

Material	Indicative quantity required
Asphalt	26,800 m^3
Sprayed bitumen	226,100 L
Ready mixed concrete	478,900 m^3
Precast concrete	572,700 m^3
Aggregates – gravel/sand	20,600 m^3
Steel	42,600 t
Aluminium	22 t

Material	Indicative quantity required
Glass	1,300 m^2
PVC piping	63.5 t
Concrete piping	600 t
Plastic sheeting	35,000 m^2
Composites – compressed fibre cement	127,500 m^2
Coatings and finishes	38,900 m^2
Water treatment chemicals	1,259,000 L

Construction material requirements for the project are typical for a tunnel project of this scale. While the resource requirements of the project do have the potential to temporarily impact resource availability within the Blue Mountains region over the construction period, the period between the approval of the project and the start of major construction would be sufficient to allow the market to prepare for the needs of the project in conjunction with the resource needs of other infrastructure projects being constructed in NSW, including nearby projects listed in Chapter 24 (Cumulative impacts).

The design of the project has included careful consideration of the construction methodology and selection of materials and resources to ensure fitness for purpose and to minimise resource consumption. Consistent with the resource management hierarchy of the *Waste Avoidance and Resource Recovery Act 2001*, resource consumption would be further minimised during construction through reuse, where possible. For example, temporary work structures such as road plates and tunnel formwork would be reused.

Options for resource recycling would continue to be investigated during ongoing design development and would include consideration of alternatives for high impact resources such as concrete, aggregates and steel. Potential initiatives would include:

- minimising the embodied energy impacts of steel by maximising the use of recycled steel and steel produced using energy reducing processes
- identifying and implementing best practice low impact alternative materials in the construction supply chain including recycled materials and engineered timber
- undertaking lifecycle assessments and minimising the embodied energy impacts of materials, by selecting low carbon alternatives and considering durability and local sourcing
- prioritising products made from recycled content.

The following targets have been developed to support carbon and energy management during construction of the project:

- achieve at least a 10 per cent reduction from baseline greenhouse gas emissions during construction when compared to business as usual
- offset at least 25 per cent of the carbon emissions associated with consumption of fuel and electricity during construction through the purchase of approved offsets or renewable energy
- 10 per cent reduction of construction stage scope 1 emissions (greenhouse gas emissions generated by sources owned or controlled by the project) using Climate Active Standard eligible offsets
- reusing or recycling 100 per cent of uncontaminated spoil generated for beneficial purposes in accordance with the resource management hierarchy.

Water

Water would be required during construction activities including:

- tunnelling activities, cooling of tunnel boring machines (TBMs) and dust suppression
- surface works such as during compaction of pavement materials and for dust suppression
- concrete batching
- site offices and worker amenities.

Estimated indicative water use for the construction of the project is outlined in Table 21-2.

Table 21-2 Estimated indicative water use for the construction of the project

Activity	Indicative quantity (kilolitres per month)	Water source
Tunnelling	51,700	Potable and recycled
Earthworks	11,900	Potable and recycled
Site facilities	750	Potable
Dust suppression	5,000	Potable and recycled
Concreting	400	Potable and recycled (where properties meet relevant specifications)
Total	**69,750**	

Measures to avoid and minimise water consumption, particularly of potable water, have been included in the design and construction planning for the project. Examples of these measures include:

- use of dust extraction and ventilation systems to control dust in tunnels during construction to minimise the use of water as a dust suppressant
- capture, treatment and use of construction water and rainwater at construction sites to minimise the use of potable water during construction
- use of site-sourced water for dust suppression in civil works and landscaping.

Potential water sources for construction of the project would include:

- stormwater/ rainwater harvesting (non-potable water)
- water from nearby farm dams (non-potable water)
- treated construction water, including groundwater if encountered and collected during tunnel excavation (non-potable water)
- water from Lithgow City Council via a pipeline (potable water), delivered as part of the project (refer to Chapter 4 (Project description)).

Further investigation is being carried out for the use of groundwater to support construction activities at Little Hartley.

Where feasible and reasonable, and where water quality and volume requirements are met, non-potable water sources would be prioritised.

The following targets have been developed to support water resource efficiency during construction of the project:

- reduce water use by at least 10 per cent compared to business as usual

- source at least 33 per cent of the water used in construction from non-potable sources
- implement rainwater harvesting and reuse systems at construction sites.

The average total water demand during construction is estimated to be 69,750 kilolitres per month. Given this volume, and despite maximising the reuse of non-potable water (e.g. treated groundwater or harvested rainwater), it is likely that the majority of water would be sourced from Lithgow City Council (potable water) via a pipeline. Should construction of the project begin prior to construction of the pipeline being completed, water may be trucked in from Lithgow until the pipeline is operational.

A summary of the indicative construction water balance for the project is presented in Chapter 14 (Surface water and flooding).

Power

Electricity supply would be required at all construction sites, including a high voltage supply at the Little Hartley construction site for TBM tunnelling support. Table 21-3 summarises the indicative electricity demand at construction sites for TBMs, roadheaders and other construction equipment.

Power supply would be established prior to construction commencing. The power supply for the Little Hartley construction site would be provided by a new substation and switching station which would connect to the existing power supply network near the Little Hartley portal. Power supply to Blackheath and Soldiers Pinch construction sites would be accommodated by local Endeavour Energy powerlines. If required, generators would be used for a short period of time until power supply is established.

Measures to avoid and minimise electricity consumption have been included in the design and construction planning for the project. Examples of these measures include:

- use of a single source for both construction and operational power supply at Little Hartley
- use of TBM guidance systems for tunnel excavation which would allow TBMs to continuously track the position and direction of tunnelling to minimise excessive electricity consumption
- use of energy efficient site buildings at construction sites that meet the Responsible Construction Leadership Group Sustainable Site Facilities requirements (Responsible Construction Leadership Group, 2018), including LED lighting, effective air-conditioning control and sub-metering of electricity
- use of energy efficient equipment at construction sites, including use of solar powered lights and signage where feasible and reasonable
- efficient design of electricity transmission systems to supply power as efficiently as possible.

Opportunities to include sustainable electricity supply would continue to be investigated during ongoing design development. Further information on the incorporation of sustainable construction methods is provided in Chapter 23 (Sustainability, climate change and greenhouse gas).

Table 21-3 Indicative construction power supply requirements

Construction site and works requiring power	Indicative construction power requirements (Mega Volt Ampere (MVA))
Blackheath: • site establishment • road header support • construction support infrastructure	3.2
Soldiers Pinch: • site establishment • road header support • construction support infrastructure	3.2

Construction site and works requiring power	Indicative construction power requirements (Mega Volt Ampere (MVA))
Little Hartley: • site establishment • TBM support • construction support infrastructure	22

21.2.2 Construction waste generation and management (non-spoil)

General waste

Table 21-4 summarises indicative solid and liquid waste streams that would be generated during construction, including examples of these waste streams, indicative waste stream quantities and anticipated waste classifications. The types of non-spoil construction waste generated by the project are likely to have limited disposal and/or recycling opportunities.

Measures to minimise the generation of waste and to maximise resource recovery have been included in the design and construction planning for the project. Examples of these measures include:

- preference for precast concrete structural elements to improve efficiency and minimise waste
- on-site sorting of materials like timber, steel and concrete to maximise resource reuse on-site or nearby to the construction site where possible.

The identified solid waste construction streams can be adequately managed with the implementation of standard waste management practices (addressing waste generation, storage, disposal and reuse) and the mitigation measures outlined in Table 21-11.

Measures would be implemented to manage unexpected waste volumes and types of waste materials generated from construction. Construction sites would have suitable space to accommodate short-term management of unexpected waste volumes. These areas would be hardstand or lined areas that are appropriately stabilised and bunded. The environmental mitigation measures outlined in Section 21.4.2 would be consistently implemented in the event of unexpected waste volumes and materials generated during construction, along with adherence to all waste principles and relevant legislation and regulations.

Table 21-4 Indicative solid and liquid waste streams generated during construction

Waste stream	Examples of waste	Indicative quantity	Likely waste classification	Likely management method
Demolition wastes	Concrete, bricks, tiles, timber, metals, plasterboard, carpets, electrical and plumbing fittings, furnishings	210 t	General solid waste (non-putrescible)	Sent to licensed facility for recycling and/or disposal.
Aggregates – crushed rock/concrete	Concrete	80,420 t	General solid waste (non-putrescible)	Incorporated into fill through a crushing plant or sent to licensed facility for recycling and/or disposal.

Waste stream	Examples of waste	Indicative quantity	Likely waste classification	Likely management method
Hazardous wastes	Asbestos, heavy metals	2 t	Hazardous waste and/or special waste	Sent to licensed facility with ability to accept material for disposal.
Vegetation wastes	Trees, shrubs, ground cover	13,370 m^3	General solid waste (putrescible)	Mulched and re-used on site.
General construction wastes	Timber formwork, scrap metal, steel, concrete, plasterboards, packaging materials	2,030 t	General solid waste (non-putrescible)	Sent to licensed facility for recycling.
Waste from operation and maintenance of construction vehicles and equipment	Oils	90,400 L	Hazardous waste and/or special waste	Sent to licensed facility for recycling, treatment and/or disposal.
	Tyres	640 (no.)		
	Batteries	160 (no.)		
	Hydraulic hoses	810 (no.)		
General wastes from site offices	Putrescibles (food waste), paper, cardboard, plastics, glass, printer cartridges	220 t	General solid waste (putrescible and non-putrescible)	Sent to licensed facility for recycling and/or disposal.

Water

Water volumes generated during construction would vary depending on the types of construction activities being carried out and the stage of construction. The majority of water generated during construction would be through tunnelling followed by earthworks. A description of how construction water would be managed is provided in Chapter 5 (Construction).

The tunnels would be constructed by TBMs and would be progressively lined with segment lining. The maximum predicted tunnel groundwater inflow level would peak at around 750 to 1,850 cubic metres per day (8.7 to 21.4 litres per second) associated with construction of the cross passages. Non-peak groundwater inflows are predicted to be much lower at other periods during construction. Total inflows would be expected to decrease around 2029 once construction of these elements is complete. Further information on groundwater infiltration and groundwater effects is provided in Chapter 13 (Groundwater and geology).

Smaller volumes of water would be generated by other construction activities, such as dust suppression, concreting and equipment washdown. Indicative construction water treatment plant discharge volumes at the construction sites are summarised in Table 21-5. These volumes conservatively assume that all water would be treated and discharged, and do not take into account the opportunities for water reuse identified above. Further information on water treatment and discharge water quality, as well as the complete water balance for the project, is provided in Chapter 14 (Surface water and flooding).

Stormwater would drain to water quality basins where it would be treated for reuse or discharge from site as appropriate. Groundwater from tunnel inflows would be pumped to the construction water treatment plants where it would be treated and reused where possible or discharged from site as appropriate.

Site amenity water (sewage) would be discharged to a local sewer system where possible or trucked off-site to an appropriate disposal facility.

Table 21-5 Indicative average construction water treatment plant discharge volumes

Construction sites	Estimated discharge (kilolitres per day)	Site amenity water for treatment and discharge or disposal (kilolitres per day)	Potential water available for treatment and reuse (kilolitres per day)
Blackheath	57	12	45
Soldiers Pinch	42	20	22
Little Hartley	915	155	760

Opportunities for water reuse would be investigated and pursued where feasible and reasonable, and subject to meeting water quality requirements for reuse. Options for water reuse may include on-site reuse for construction purposes, such as dust suppression.

The anticipated generation of water from tunnel construction would be greater than the potential for reuse. Therefore, treatment of surplus construction water and off-site discharge would be required. Chapter 6 (Statutory context) outlines the requirement for an environment protection licence for road construction under Chapter 3 of the *Protection of the Environment Operations Act 1997*.

The water collected from tunnelling activities would be tested and treated at construction water treatment plants prior to reuse or discharge. Site-specific trigger values would be used during construction planning when setting the water treatment plant discharge criteria to ensure water meets the requirements for discharge to the Sydney drinking water catchment, including the need to have a neutral or beneficial effect (NorBE) on water quality. Further information on potential water quality impacts is provided in Chapter 14 (Surface water and flooding).

Waste storage and disposal

Appropriate waste storage facilities, such as bins, would be provided for general waste storage during construction. Waste would be classified in accordance with the Waste Classification Guidelines Part 1: Classifying waste and segregated appropriately. Waste collection would be carried out by an authorised contractor for off-site recycling or disposal at a licensed waste facility.

The Lithgow Solid Waste Facility has been identified as a potential waste disposal site which accepts general putrescible and non-putrescible solid waste, asbestos and tyres. The Oberon Waste Facility has been identified as a potential disposal site for other wastes including hazardous materials and liquid wastes such as oils or wastewater not suitable for treatment or discharge. Suitable waste disposal sites that recycle and dispose of construction waste would be further investigated and confirmed during design development by the construction contractor(s) and documented in the Construction Environmental Management Plan. As far as possible, waste disposal locations located to the west of the project would be considered to minimise the transport of waste through Blackheath and Mount Victoria.

Waste would be transported off-site for disposal, which would generally occur during standard construction hours. There is potential for environmental impacts as a result of the transport of waste including dust, mud-tracking and accidental spills. Mitigation measures would be outlined in the Construction Environmental Management Plan (CEMP) including adequate covering of truck loads and washing of heavy vehicle tires to minimise tracking mud onto the road network.

21.2.3 Spoil management

Spoil generation and management

The largest waste stream associated with the project would be spoil generated from the excavation of the tunnels in excess of what can be reused for the project. Smaller quantities of spoil would be generated by excavation required for surface components of the project. Around 7.8 million tonnes of spoil would be generated during construction of the project. Indicative cut and fill volumes for the project are provided in Table 21-6.

Table 21-6 Indicative cut and fill volumes for the project

Location	Cut volume (m^3)	Fill volume (m^3)
Blackheath area earthworks	456,290	231,750
Little Hartley area earthworks	330,630	918,760
Tunnel including mid-tunnel access excavation, cross passages, and substations	3,906,497	Nil
Total	**4,693,417**	**1,150,510**
Balance	**3,542,907 surplus (m^3)** **7,794,396 surplus (t)**	

It is expected that excavated material would consist of a combination of:

- tunnel spoil
- surface excavated material
- roadbuilding materials from within existing road corridors, such as concrete and asphalt
- excavated natural material containing coal, acid sulfate rock or other contaminants.

The project design has considered the principles of the resource management hierarchy as defined in the *Waste Avoidance and Resource Recovery Act 2001*. This has included refining the tunnel alignment to achieve a shorter and straighter tunnel which would reduce the amount of spoil generation. Where possible and fit for purpose, spoil would be beneficially reused as part of the project before alternative off-site reuse options are pursued. The approach to management of spoil for the project is shown in Figure 21-2.

Some tunnelling spoil would be reused as backfill within the tunnel to provide a flat surface for road pavement. Where possible, tunnelling spoil would also be stockpiled for future reuse as fill material for the surface road upgrade works to be constructed for the project. Opportunities to use excess spoil that cannot be reused within the project, for adjacent or nearby Transport for NSW (Transport) projects including other components of the Upgrade Program would be considered.

Excess spoil that cannot be reused within the project or for the other adjacent or nearby Transport projects would be removed primarily from Little Hartley for appropriate off-site reuse. Spoil that cannot be reused on-site would be highly dependent on the final classification of spoil and the timing and availability of alternative off-site reuse locations that can accommodate both the class and volume of spoil expected.

All identified re-use locations would be located to the west of the project, reducing spoil haulage through Blackheath and Mount Victoria (including associated potential safety and amenity impacts). Any surplus spoil that is not suitable for reuse would be sent to an appropriately licensed waste management facility. Spoil would be classified prior to leaving the site in accordance with the Waste Classification Guidelines: Part 1 Classifying Waste, and all spoil intended for off-site reuse would be managed in accordance with the resource recovery orders and exemptions under the Protection of the Environment Operations (Waste) Regulation 2014.

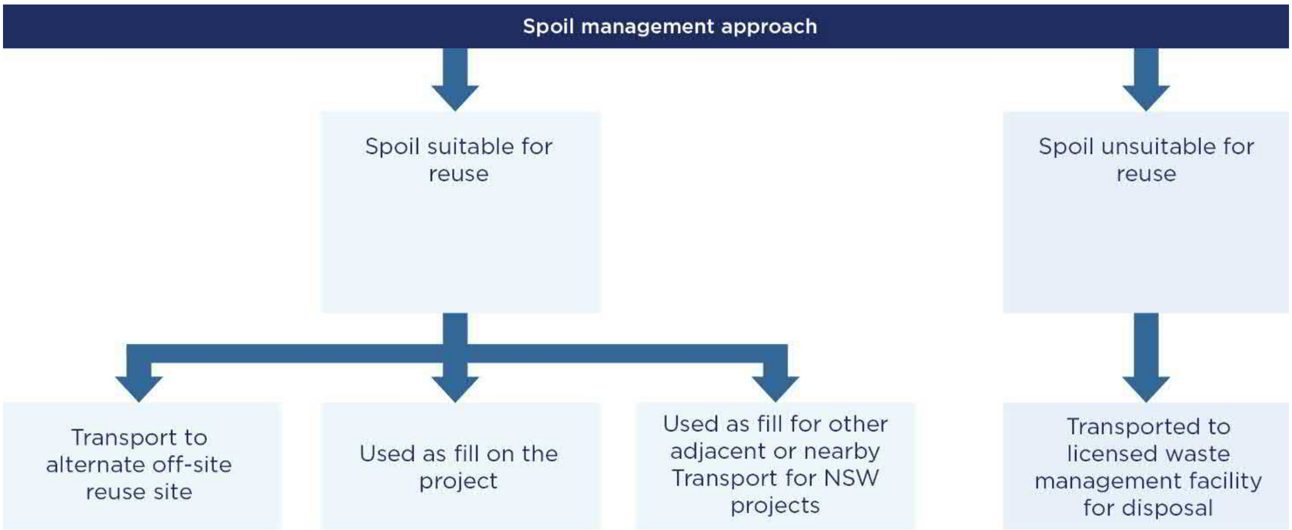


Figure 21-2 Spoil management approach

Table 21-7 lists off-site spoil reuse options that are being investigated for the project. It would be the responsibility of the sites listed in Table 21-7 to obtain the relevant approvals to receive spoil from the project.

Table 21-7 Off-site spoil reuse options currently being considered

Site	Location	Approximate distance west from Little Hartley
Little Hartley to Lithgow Upgrade	Little Hartley	Adjacent
Lidsdale/Kerosene Fly Ash Repository (associated with former Wallerawang power station)	Wallerawang, NSW	30 km
Hytec Austen Quarry	Hartley, NSW	15 km
Hanson Quarry	Clarence, NSW	25 km
Metromix	Marrangaroo, NSW	20 km
Invincible Colliery	Cullen Bullen, NSW	40 km
Cullen Valley Colliery	Cullen Bullen, NSW	40 km

Stockpile management

Stockpiles would be located at all construction sites at Blackheath, Soldiers Pinch and Little Hartley. The estimated stockpiling capacities of these construction sites are provided in Table 21-8. These volumes are indicative and may be subject to change following detailed construction planning by the construction contractor(s) when appointed.

Table 21-8 Indicative estimated stockpile capacities

Stockpile location	Indicative stockpile capacity (m^3)
Blackheath construction site	5,000
Soldiers Pinch construction site	2,500
Little Hartley construction site	20,000

Stockpiles would be located away from nearby sensitive receivers. TBM generated spoil would be managed within an acoustic shed at Little Hartley to minimise the potential impacts from runoff and sedimentation associated with stockpiling, and potential noise impacts from the loading of spoil trucks. Stockpiles would be managed appropriately to avoid potential impacts associated with runoff and sedimentation.

Potential impacts related to stockpiles from runoff and sedimentation are further discussed Section 14.3.1 of Chapter 14 (Surface water and flooding). Potential impacts resulting from the generation and dispersion of dust are assessed in Section 9.5.1 Chapter 9 (Air quality). Potential contamination impacts are discussed in Section 15.3.2 of Chapter 15 (Soils and contamination). The project does not involve excavation or disturbance of landfill areas, or other major contaminated sites and therefore it is not anticipated that leachate would be encountered. Stockpiles would be managed appropriately to avoid potential impacts associated with runoff and sedimentation.

Contaminated spoil

There is potential to discover contaminated material during surface excavation work for the project. There is also the potential for TBM generated spoil from tunnelling work to contain coal, acid sulfate rock and other contaminants.

A contamination assessment has been carried out to determine the potential for encountering contaminated material during construction (refer to Chapter 15 (Soils and contamination)).

The contamination assessment identified a number of areas of environmental interest with contaminants of potential concern near the project. These locations, and types of contaminated material, are detailed in Chapter 15 (Soils and contamination).

Management of contaminated spoil would be carried out in accordance with the mitigation measures outlined in Chapter 15 (Soils and contamination). Any contaminated material disturbed during construction would be separated from uncontaminated material to prevent cross contamination. This spoil would be loaded into sealed and covered trucks for disposal at a suitably licensed waste facility. An Acid Sulfate Rock Management Plan will be prepared as part of the Construction Environmental Management Plan to manage potential acid sulfate rock in spoil.

21.3 Potential impacts – operation

Potential impacts during operation of the project relate to:

- operational resource use, including operational materials, water and electricity
- generation and management of waste.

21.3.1 Operational resource use

Operational materials

Materials used for the operation of the project would be limited to those required for ongoing maintenance activities, and for the operation of the tunnel operations facility and support activities, including the substation and water treatment plant at Little Hartley.

During operation, the project would achieve a minimum 15 per cent reduction in carbon emissions associated with operations, when compared to business as usual.

Water

During operation of the project, water would be required for:

- testing and operation of the tunnel deluge system, which forms part of the fire and life safety system
- tunnel cleaning systems
- tunnel operations facility amenities
- landscape irrigation.

Measures to avoid and minimise water use, particularly potable water, have been included in the project design. An example of these measures includes the reuse of groundwater entering the project tunnels where possible to satisfy the project's requirements and to reduce the demand for potable water.

Water for operation of the project would be sourced according to the following hierarchy, where feasible and reasonable and where water quality and volume requirements are met:

- treated groundwater (non-potable water)
- stormwater/ rainwater harvesting (non-potable water)
- mains supply (potable water).

Indicative volumes of water for each operational activity are provided in Table 21-9.

Table 21-9 Indicative operational water requirements

Operational activity	Total water demand (kilolitres/year)
Deluge testing	7,300
Washdown and cleaning	530
Amenities	5,110
Landscaping	8,980[1]
Total	**21,920 (first year)** **12,940 (subsequent years)**

Table notes:

1. Only required for planting/establishment in the first year of operation

Power

As described in Chapter 3 (Project alternatives and options), two options for tunnel ventilation are being considered for the project: emissions discharged via ventilation outlets or via the tunnel portals. The anticipated operational power supply requirement for the project under a ventilation outlet option would be about 128,000 kWh/day. Under a portal emissions option, the anticipated operational power supply requirement would be about 55,000 kWh/day.

Permanent power supply would be required for the tunnels (including associated mechanical and electrical equipment), traffic control facilities (including the tunnel operations facility and electronic signage), tunnel lighting and surface road lighting. As described in Chapter 4 (Project description), the project would include a series of underground substations at 1.5 kilometre intervals within the tunnel, and an aboveground substation at Little Hartley. Permanent power supply would be provided via connection to the substation and switching station at Little Hartley, established prior to construction commencing (see Section 21.2.1).

Measures to minimise energy consumption and maximise energy efficiency have been included in the project design in line with Transport's initiative to improve operational energy efficiency across the sector, and Transport's commitment to net zero transport operations by 2035 (Transport, 2020a). Examples of these measures include:

- adopting energy efficient lighting technology and smart lighting control systems to reduce operational energy requirements
- adopting an efficient and effective longitudinal tunnel ventilation system design
- locating ventilation outlets close to tunnel exit portals (under the ventilation outlet option only), taking advantage of the movement of vehicles within tunnels to reduce fan usage and energy needed to move exhaust to outlet locations
- exploring opportunities to install solar panels at the tunnel portals and on operational ancillary buildings to supplement non-renewable power sources as part of Transport's initiative to transition to a secure, cost-effective, low emission energy supply (Transport, 2020a).

Opportunities to further minimise energy consumption and maximise energy efficiency would be considered during further design development, in alignment with Transport's commitment to net zero emissions by 2050 (Transport, 2021g).

21.3.2 Operational waste generation

General waste

The type and volume of waste generated from operation of the project would depend on the nature of the activity but would predominantly consist of minor volumes of general waste (such as paper, plastics and food waste). Maintenance and repair activities would also generate a small amount of waste.

The volume and type of waste would be typical of an operational tunnel and could be accommodated by existing waste management facilities. With the implementation of standard waste management practices, the overall impact of operational waste streams would be minimal.

Water

The tunnels would include drainage infrastructure to capture groundwater and stormwater, spills, maintenance water, fire deluge and other potential water sources. The tunnel drainage streams would receive water containing a variety of pollutants (such as fuel, oil grease, and fire suppressants) requiring different treatment before discharge. Wastewater would also be generated from the operational ancillary facilities at Blackheath.

Wastewater (including collected groundwater) would be pumped to a water treatment plant located near the Little Hartley portal. Following treatment, treated water would be reused or discharged to the environment subject to licensing/ agreement with Water NSW and the Environment Protection Authority. Scour protection and energy dissipation would be provided at discharge points to prevent scouring of existing channels. Water not suitable for treatment or discharge to the receiving environment may be taken to a suitable disposal facility. This may include storage and trucking to a suitable disposal site, or pumping the water to a local sewer network. Further information is provided in Chapter 14 (Surface water and flooding) including potential impacts associated with operational stormwater runoff and water discharge.

Operational water would be treated so it meets the requirements for discharge to the Sydney drinking water catchment, including the need to have a neutral or beneficial effect (NorBE) on water quality. Further information on potential water quality impacts is provided in Chapter 14 (Surface water and flooding).

21.4 Environmental mitigation measures

21.4.1 Performance outcomes

Performance outcomes for the project in relation to resource use and waste management are listed in Table 21-10 and identify measurable performance-based standards for environmental management.

Table 21-10 Resource use and waste management performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
All wastes generated during the construction and operation of the project are effectively stored, handled, treated, reused, recycled and/or disposed of lawfully and in a manner that protects environmental values.	Manage waste in accordance with the resource management hierarchy including minimisation and reuse of waste to protect environmental values.	Construction and operation

21.4.2 Mitigation measures

Mitigation measures to avoid, minimise or manage resource use and waste generation as a result of the project are detailed in Table 21-11. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 21-11 Environmental mitigation measures – resource use and waste management

ID	Mitigation measure	Timing
RW1	Construction materials will be sourced with a preference for Australian materials and prefabricated products with low embodied energy, where reasonable and feasible. Resource replacement opportunities will be identified for achieving circular economy outcomes under the NSW Waste and Sustainable Materials Strategy 2041 (DPIE, 2021b).	Design and construction
RW2	The Construction Environmental Management Plan (CEMP) will include specific measures to manage waste, including: • documenting expected waste types and volumes • procedures for managing waste materials including separation, recycling, treatment, and disposal in accordance with relevant guidelines • waste reporting requirements including the implementation of a waste register • the process for identifying waste re-use sites including approval requirements.	Construction
RW3	A Spoil Management Plan (SMP) will be prepared as part of the Construction Environmental Management Plan (CEMP). The SMP will detail spoil management measures including spoil storage and handling, spoil haulage routes, opportunities for spoil reuse and a framework for identifying spoil reuse sites.	Construction

ID	Mitigation measure	Timing
RW4	The project will be designed and implemented with the aim of achieving the following during construction: • at least a 10 per cent reduction in water use during construction • source at least 33 per cent of the project's construction water requirements from non-potable sources • implement rainwater harvesting and reuse systems at construction sites.	Design and construction
RW5	Opportunities to reduce water consumption and to reuse and recycle water within the project will be considered during further design development and implemented during operation, where reasonable and feasible.	Design
RW6	Waste will be managed in accordance with applicable legislation, policies and guidelines, including the *Waste Avoidance and Resource Recovery Act 2001* and the NSW Waste and Sustainable Materials Strategy 2041 (DPIE, 2021b).	Construction and operation

22 Hazards and risk

22.1 Assessment approach

A desktop assessment has been carried out to identify potential environmental and community hazards and risks that could arise as part of the upgrade of the Great Western Highway between Blackheath to Little Hartley (the project), as well as mitigation measures to address identified hazards and reduce risks. The assessment considered the following legislation, guidelines and resources:

- bushfire prone land mapping and developed by the NSW Rural Fire Service
- Planning for Bush Fire Protection (NSW Rural Fire Service, 2019) and AS3959-2018 Construction of Buildings in Bushfire Prone Areas (Australian Standards, 2018)
- *Work Health and Safety Act 2011* (NSW)
- Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW, 2005)
- *Dangerous Goods (Road and Rail Transport) Act 2008* (NSW)
- Dangerous Goods (Road and Rail Transport) Regulation (NSW Government, 2014)
- Australian Standard 4825 (Tunnel fire safety)
- Hazardous and Offensive Development Application Guidelines: Applying SEPP 33 (SEPP 33 guidelines) (NSW Government, 2011)
- Australian Dangerous Goods Code (National Transport Commission, 2020).

22.2 Potential impacts – construction

Potential hazards during construction may be associated with:

- bushfires
- storage, use and transportation of dangerous goods and hazardous substances
- damage or disruption of utilities and services
- potential release of coal seam gas from tunnelling activities
- worker health and safety including tunnel hazards, rock falls and the operation of mobile plant and other machinery.

In addition, there is potential for the following technical hazards during construction as discussed in the respective chapters:

- public safety impacts associated with construction traffic management and access (refer to Chapter 5 (Construction) and Chapter 8 (Transport and traffic))
- motorist, pedestrian and cyclist impacts during construction (refer to Chapter 8 (Transport and traffic))
- dust generation during construction (refer to Chapter 9 (Air quality))
- human health impacts associated with noise and air pollution during construction (refer to Chapter 10 (Human health))
- potential impacts associated with excavations, groundwater, geotechnical uncertainty, ground movement and settlement during construction (refer to Chapter 13 (Groundwater and geology))
- potential hazards associated with flooding, including tunnel flooding, during construction activities (refer to Chapter 14 (Surface water and flooding))

- encountering acid sulfate rock, asbestos and contaminated soils during construction activities (refer to Chapter 15 (Soils and contamination))
- climate change impacts (refer to Chapter 23 (Sustainability, climate change and greenhouse gas)).

22.2.1 Bushfires

The project would be located in an area prone to bushfires. The project would be surrounded by highly vegetated landscapes including the Blue Mountains National Park. These vegetated areas are located between Medlow Bath, Blackheath and Mount Victoria and are managed by the National Parks and Wildlife Service. Between Mount Victoria and Little Hartley, the vegetation is also characterised by dense woodland and is managed by the National Parks and Wildlife Service, Blue Mountains City Council and Lithgow City Council. Vegetation around Little Hartley comprises mostly grassland vegetation including pasture grasses.

The bushfire prone land mapping developed by the NSW Rural Fire Service identifies the vegetation between Blackheath and Mount Victoria, excluding the Blackheath and Mount Victoria town centres, as Category 1 vegetation[1] (see Figure 22-1). Other surrounding vegetation is characterised as Category 3 vegetation. The existing Great Western Highway is mostly categorised as a bushfire buffer zone (NSW Rural Fire Service, 2015) and would form a key emergency evacuation route in the Blue Mountains area.

Bushfires during the 2019-2020 summer burnt about 79 per cent, or 855,310 hectares of the Greater Blue Mountains World Heritage Area (Smith, 2021). On 21 December 2019, the Great Western Highway was closed between Katoomba and Hartley due to the risk of bushfire. As such, the risk of bushfire impacting the project is present and ongoing.

Construction of the project could increase the risk of bushfires resulting from:

- conducting hot work activities such as welding, plant operation and operation of an electricity substation adjacent to vegetated areas
- the presence of combustible materials including mulch stockpiling, fuel and chemical storage.

There is a possibility that bushfires will occur during the course of construction, given the longer lasting bushfire seasons due to the effects of climate change. During construction, efforts would be made to minimise the interaction of hot work activities and potential ignition sources and intact vegetation in the area surrounding the project.

Construction work involving hot work activities would be avoided where possible particularly during periods subject to higher bushfire risk including during total fire bans. Where unavoidable, such activities would be carried out within buildings, purpose-built workshops, or the tunnel during fit-out to provide increased protection of equipment from bushfires.

Appropriate fire suppression and mitigation measures would be required at all construction sites. Mitigation measures to reduce the risk of construction work starting a bushfire and to manage the impact of bushfire events are provided in Table 22-1.

While long-term road closures are not anticipated during construction, there may be short-term disruption to the local road network due to the movement and delivery of construction equipment and machinery. In the event of a flash bushfire emergency, access along the existing Great Western Highway and local roads would be maintained during construction.

During a bushfire emergency, project surface construction work would likely cease if required, minimising potential delays for surface road traffic due to construction work. The majority of construction work would continue in tunnels underground if possible, minimising impacts to

[1] Category 1 vegetation is the highest risk for bushfire in NSW. This vegetation category has the highest combustibility and likelihood of forming fully developed fires including heavy ember production. Category 3 vegetation is medium bush fire risk vegetation. It is higher in bushfire risk than category 2 (and the excluded areas) but lower than Category 1 (NSW Rural Fire Service, 2019).

operation of the surface road network. Appropriate mitigation measures to minimise and manage impacts in the case of emergencies and incidents are outlined in Table 22-1. Further discussion of road emergency measures is provided in Chapter 8 (Transport and traffic).

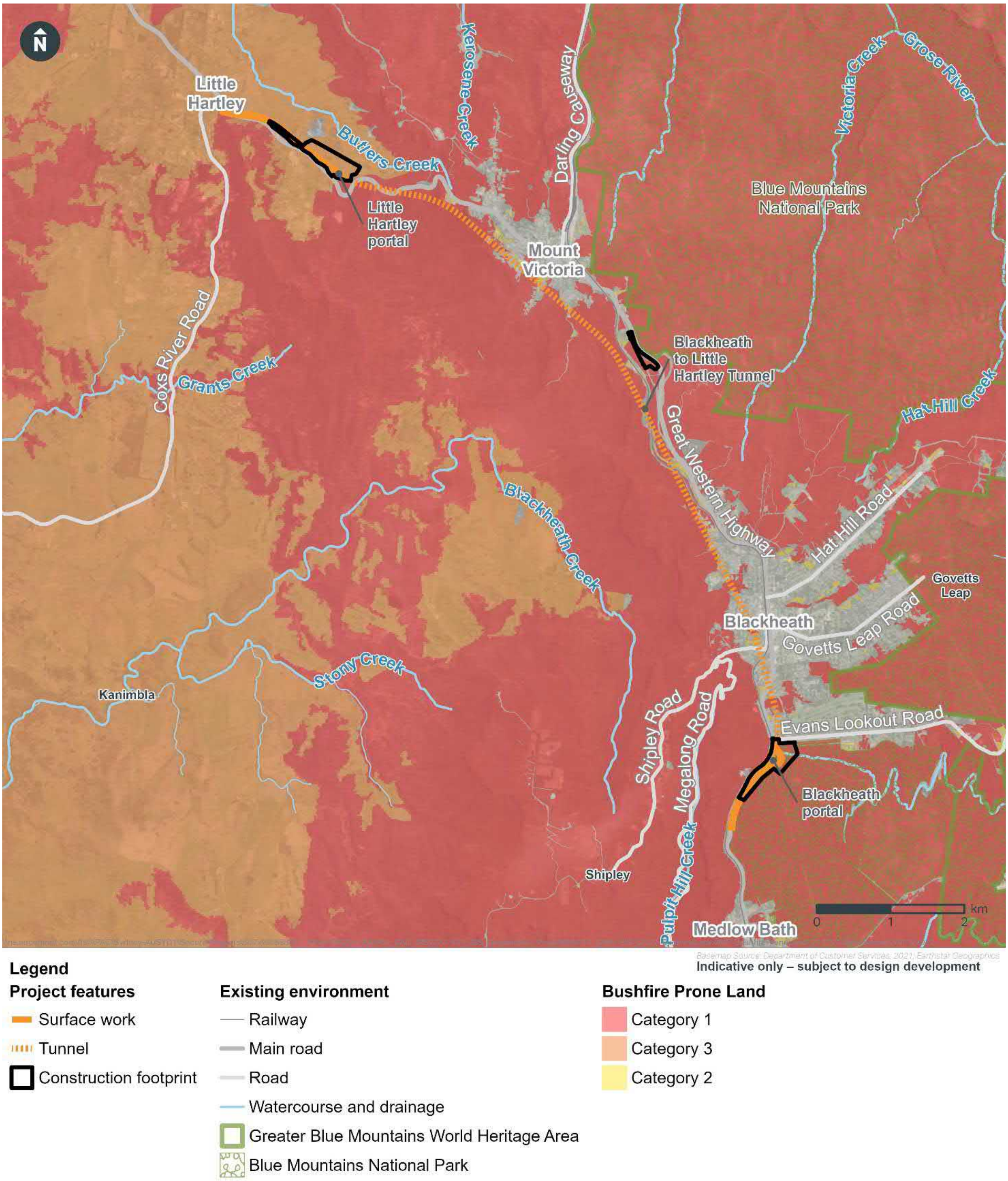


Figure 22-1 Bushfire prone land

22.2.2 Storage, use and transport of dangerous goods and hazardous substances

Dangerous goods and hazardous substances would be temporarily used, stored and transported during construction of the project. This would include petrol, diesel, lubricating and hydraulic oils and greases, industrial grade oxygen, acetylene, cement, premix concrete, concrete curing compounds, concrete retardant, shotcrete accelerator, epoxy glue, coagulants, acids, bases, disinfectant, antiscalant, membrane preservative, de-bonding agents, contaminated waste and paints.

Potential impacts from dangerous goods and hazardous substances during construction may include:

- spills and leaks from construction vehicles and machinery during refuelling, tunnelling and travelling within and between construction sites
- spills or the emission of other hazardous substances from mechanical or other failures of construction machinery
- spills from construction water treatment plants or emission of other hazardous substances due to human error.

The method of storage would vary depending on the materials but would include drums of various sizes, small and intermediate bulk containers, cylinders in racks, bags/pallets and bunded areas where appropriate.

Typically, low volumes of potentially hazardous materials, such as diesel, petrol, lubricants and paints, would be stored on-site, with the exception of the Little Hartley construction site where larger volumes of materials would be required to support tunnel construction. The volume required to be stored on-site would largely depend on the anticipated rates of consumption, with deliveries of dangerous goods coordinated to match consumption rates.

Planning of indicative construction site layouts would ensure hazardous materials are stored appropriately and at an appropriate distance from sensitive receivers, in accordance with the thresholds established under Applying SEPP 33 (NSW Government, 2011). Should the separation distances be unable to be maintained a risk management strategy would be developed on a case-by-case basis.

Environmental hazards and risks associated with the on-site storage, use and transport of chemicals, fuels and materials would be managed through standard mitigation measures to be developed as part of the Construction Environmental Management Plan (CEMP). These measures would include the storage and management of all hazardous substances in accordance with applicable guidelines and standards, so that they do not cause a significant off-site risk.

22.2.3 Damage or disruption of utilities and services

The project would likely require adjustments to existing utility services such as electricity, water, gas and communications. Potential impacts associated with damage, rupture, or failure to shut down or isolate underground utilities during construction include:

- loss of service to local communities if the utility is severed
- electrocution to the construction worker who intercepts the utility
- possible release of untreated sewerage and / or gas from a sewer main, and potential impacts to water mains and drains
- possible release of natural gas from a gas main and possible start of a fire.

Hazards from interference with underground utilities and services would include potential impacts from intercepting existing utilities, as well as utilities required to enable the construction of the project.

The project runs parallel to an overhead 132 kV electricity cable (Line 940/941) located about one kilometre from the Great Western Highway. To avoid disruption or damage to this powerline, or other existing services located in the vicinity of the project, these services would be protected, relocated or removed before construction via the methods outlined in Chapter 5 (Construction).

A preliminary dial-before-you-dig search has identified existing utilities near the Blackheath portal and Little Hartley portal which include telecommunications and electricity conduits, gas, sewer and water mains. Prior to construction, a new dial-before-you-dig search would be conducted followed by pothole surveys, to confirm existing and new underground utilities.

Consultation with utility providers has been carried out and would continue during design development and construction to mitigate the risk of unplanned and unexpected disturbance of utilities. In rare circumstances, the relocation of utilities may result in short term outages of some utilities to surrounding areas.

Mitigation measures to minimise the risk of disruption to project utilities and services are provided in Table 22-1.

22.2.4 Intercepting coal seam gas

The project would involve tunnelling through geology near Little Hartley, which is mapped as Illawarra coal measures, which typically contain coal seams of varying thicknesses. The indicative depth of the Illawarra coal measures geological stratum is shown in Figure 13-1 in Chapter 13 (Groundwater and geology). Coal seam gas is a natural gas found in coal deposits, typically 300-600 metres underground (Department of Climate Change, Energy, the Environment and Water, 2021). Large quantities of gas are stored on the internal surfaces of coal, and contained under pressure.

Given coal seam gas is composed primarily of methane, a potent greenhouse gas, appropriate drainage and venting would be established during construction of the tunnels to limit anthropogenic climate change, potential contamination of groundwater, aquifers and soils, or spontaneous combustion due to the interaction with methane and oxygen or heat from construction equipment.

Tunnelling through the Illawarra coal measures may present a hazard if coal seam or methane gas in the coal measures or surrounding soils are intercepted. The presence of methane and carbon monoxide gases have the potential to create an explosive atmosphere during excavation. To manage this potential impact, detailed site investigations would be carried out to characterise, quantify and map the extent of potential for coal seam gas. If required based on these investigations, gas drainage and venting would be implemented prior to construction in areas where potential coal seam gas is likely to be intercepted.

Impacts associated with interception of coal seam gas are further discussed further in Chapter 5 (Construction) and Chapter 13 (Groundwater and geology).

22.2.5 Public safety

The potential hazards to public safety during construction include:

- fires or explosions
- rock falls at cuttings
- operation of mobile plant and other machinery.

These hazards are discussed below. Other hazards to public safety during construction are discussed in the respective chapters:

- ground movement (refer to Chapter 13 (Groundwater and geology))
- exposure to airborne pollutants (refer to Chapter 9 (Air quality) and Chapter 10 (Human health))
- acid sulfate rock and sources of contamination (refer to Chapter 15 (Soils and contamination))
- flooding (refer to Chapter 14 (Surface water and flooding))
- traffic and pedestrian safety (refer to Chapter 8 (Transport and traffic)).

Fires or explosions

The project would include work near naturally combustible materials within soil. Encountering flammable materials including coal seam gases located underground is discussed in Section 22.2.4. In addition, construction machinery used during construction would contain flammable and combustible materials such as diesel and petrol, and potential ignition sources would include hot work procedures and electrical equipment. The use and storage of combustible materials on-site and at construction sites would generally be located at surface level.

Works, especially those near naturally combustible materials, would increase the risk of fires or explosions. Measures developed during detailed construction planning to manage worker safety in the event of a fire or explosion would also adequately manage potential public safety risks during construction.

Rock falls at cuttings and earthquakes

During excavation of tunnels, rock falls can occur if portal breakthrough areas are not secured properly before excavation. Rock falls have the potential to injure construction workers and community members and may cause damage to construction machinery and private property or vehicles.

In the event of an earthquake during construction, there is potential for ground displacement and shaking which also has the potential to injure construction workers.

Mitigation measures would be applied to reduce the risk of rock falls and earthquakes, including the use of appropriate personal protective equipment, frequent tunnel inspections, scaling, progressive installation of properly secured ground support, safety fencing and overhead protection.

Operation of mobile plant and other machinery

Other construction activities that could result in potential impacts to the safety of workers and the local community if not properly managed include:

- the operation of mobile plant and construction equipment on-site
- construction failures or incidents resulting in fire, flooding, inundation, or excavation collapse.

The potential safety hazards associated with the operation of mobile plant include the plant overturning, objects falling on the plant or plant operator, the operator falling from the plant, or collisions between the plant and other persons or machinery.

The following construction activities can result in construction failures:

- unsafe storage of gas, chemicals or fuels resulting in leaks and possible fire ignition or electrocution
- smoking on-site as a source of fire ignition
- interception of power, gas, sewer or water services causing fires, flooding, or inundation and possible electrocution
- storing excavated materials too close to the trench, stress loading the soil or heavy machinery vibration causing excavation collapse.

Safety hazards during construction would be managed through the implementation of standard workplace health and safety requirements. A Work Health and Safety Management Plan and safe work method statements would be developed in accordance with regulatory requirements.

A range of additional mitigation measures are proposed to manage safety during construction. These are outlined in Chapter 8 (Transport and traffic) to Chapter 24 (Cumulative impacts). A consolidated list of mitigation measures is provided in Appendix R (Compilation of environmental mitigation measures).

22.3 Potential impacts – operation

This section discusses the potential hazards during operation of the project:

- bushfires and other natural disasters
- storage, use and transportation of dangerous goods and hazardous substances
- public safety hazards including the operation of mobile plant and other machinery.

In addition, the following hazards during operation have been identified and are discussed in the respective chapters:

- motorist, pedestrian and cyclist hazards during operation (refer to Chapter 8 (Transport and traffic))
- potential hazards associated with operational in-tunnel and ambient air quality (refer to Chapter 9 (Air quality))
- human health impacts associated with noise and air pollution during operation (refer to Chapter 10 (Human health))
- flooding, including in tunnel flooding, during operation of the project (refer to Chapter 14 (Surface water and flooding))
- geotechnical uncertainty and ground movement during operation (refer to Chapter 13 (Groundwater and geology) and Chapter 20 (Business, land use and property) for ground movement impacts to properties)
- operational hazards associated with climate change impacts, including changes in temperature, rainfall and storm intensity (refer to Chapter 23 (Sustainability, climate change and greenhouse gas)).

22.3.1 Bushfires

Once operational, the project would improve the resilience of the Great Western Highway corridor between Blackheath and Little Hartley to bushfire risk and other natural disasters as the new tunnel would provide an additional route of travel across this section of the Blue Mountains. In the case that other roads across the Blue Mountains such as Bells Line of Road are closed due to bushfire risk, increased capacity would be available along the Great Western Highway with the project.

During more localised bushfire events that may impact the Great Western Highway between Blackheath and Little Hartley, there is potential for the tunnel to be affected by smoke, which could impact the visibility of motorists in the tunnel and the in-tunnel air quality.

The ventilation system described in Chapter 4 (Project description) is designed to operate in emergencies as well as normal conditions for both the ventilation outlet option and the portal emissions option. The system relies on drawing in ambient air into the tunnel. In the event the ambient air outside the tunnel is polluted with bushfire smoke, acceptable air quality may not be able to be maintained in the tunnel. If in-tunnel air quality deteriorates to below acceptable standards due to bushfire smoke, the tunnel would be closed to motorists to minimise impacts to human health. If in-tunnel air quality meets the acceptable standards, the tunnel would remain open and could provide a safe evacuation route.

Most of the project’s operational ancillary facilities would be designed in consideration of bushfire risk, such as road surface materials, retaining walls, road barriers. Operational ancillary facilities would be located and designed taking into account Planning for Bush Fire Protection (NSW Rural Fire Service, 2019) and AS3959-2018 guidelines which prescribe minimum setback distances for infrastructure near bushfire prone land.

Mitigation measures proposed to limit bushfire hazards and risks during operation are provided in Table 22-1. This includes the development of a Bushfire Management Plan to be implemented during operation which would detail the conditions under which the tunnel would be closed and outline access arrangements in the event of a bushfire.

22.3.2 Storage, use and transport of dangerous goods and hazardous substances

Dangerous goods and hazardous substances stored, used and transported for the project during operation would be limited and may include coagulants, polymers, acid and bases. Additional small quantities of other hazardous materials may occasionally be required on-site for the water treatment plant at Little Hartley and to support maintenance activities.

The regulations and safe practices described for the construction phase of the project would also apply to the operational stage (refer to Section 22.2.2).

A decision on whether dangerous goods would be permitted to be transported through the tunnel would be made during ongoing design development in consultation with the relevant stakeholders.

22.3.3 Public safety

There are various potential public safety hazards during the project's operation. The section below discusses the hazards related to the operation of mobile plant and other machinery.

Other hazards to public safety during operation are discussed in the respective chapters:

- in-tunnel and ambient air quality impacts for motorists (refer to Chapter 9 (Air quality), Chapter 10 (Human health))
- traffic incidents in the tunnels or adjoining roads (refer to Chapter 8 (Transport and traffic))
- ground movement (refer to Chapter 13 (Groundwater and geology))
- impacts associated with an operational power supply connection to the project substation at Little Hartley.

Operation of mobile plant and other machinery

Project maintenance activities would include ventilation system testing and maintenance, fire system testing and maintenance, cleaning, road repaving, and repair works as required. These activities could result in potential impacts to the local community if not properly managed. Such hazards could arise from:

- the operation and movement of operational maintenance plant and vehicles on-site
- maintenance incidents resulting in fire, flooding, inundation, or damage to project infrastructure.

Safety hazards during operational activities would be managed through Transport's existing environmental management system, and specifically through a Bushfire Management Plan and an Incident Response Management Plan, as detailed further in Table 22-1.

Earthquakes

The structural design for the tunnel has considered the potential impacts of earthquakes on both the bored tunnel segment and the permanent tunnel lining. This would manage potential ground movement impacts to the tunnel during an earthquake.

22.4 Environmental mitigation measures

Mitigation measures to avoid, minimise or manage project hazards and reduce their risk are detailed in Table 22-1. A full list of performance outcomes and environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 22-1 Environmental mitigation measures – hazards and risk

ID	Mitigation measure	Timing
HR1	A Bushfire Management Plan (BMP) will be prepared and implemented during construction and operation of the project, in consultation with the NSW Rural Fire Service and Fire and Rescue NSW. The BMP will be prepared in accordance with Planning for Bush Fire Protection 2019 (NSW Rural Fire Service, 2019) and AS 3959-2018 – Construction of Buildings in Bushfire-prone Area, and will include: • regular review of bushfire prone land mapping developed by the NSW Rural Fire Service near the project • monitoring of weather and local bushfire ratings • ensuring appropriate access arrangements are available in the event of a bushfire • operational requirements for community notifications in the event of a bushfire • ensuring plant and equipment are fitted with appropriate spark arrestors, where practicable • ensuring appropriate evacuation procedures for workers and the public in case of a bushfire • ensuring site workers are informed of the site rules including designated smoking areas and putting rubbish in designated bins • obtaining hot work permits and implementing total fire bans as required • implementing adequate storage and handling requirements for potentially flammable substances in accordance with relevant guidelines.	Design and construction
HR2	Dangerous goods required during construction and operation of the project will be stored and handled in accordance with the relevant guidelines including: • applicable Australian Standards • for liquids, a minimum bund volume requirement of 110% of the volume of the largest single stored volume, within the bund.	Construction and operation
HR3	Closed circuit television cameras will be installed to monitor traffic flows to enable early detection of incidents and queues in the tunnel.	Operation

23 Sustainability, climate change and greenhouse gas

This chapter summarises the sustainability, climate change and greenhouse gas (GHG) assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full sustainability, climate change and GHG assessment is provided in Appendix Q (Technical report – Climate change and sustainability).

23.1 Sustainability

23.1.1 Sustainability guidelines

The sustainability of the project is guided by the Blackheath to Little Hartley Sustainability Strategy (AECOM & Aurecon Joint Venture, 2022) and relevant Australian and NSW government strategy documents and policies including:

- Future Transport Strategy: Our vision for transport in NSW (Transport for NSW, 2022g)
- Transport Sustainability Plan (Transport for NSW, 2021e)
- NSW Net Zero Plan Stage 1: 2020-2030 (Department of Planning, Industry and Environment, 2020b)
- NSW Climate Change Adaptation Strategy (NSW Government, 2022)
- NSW Sustainable Design Guidelines Version 4.0 (Transport for NSW, 2017)
- NSW Government Resource Efficiency Policy (Office of Environment and Heritage, 2019)
- NSW Climate Change Policy Framework (Office of Environment and Heritage, 2016)
- NSW Waste and Sustainable Materials Strategy 2041 (Department of Planning, Industry and Environment, 2021b)
- A Metropolis of Three Cities – the Greater Sydney Region Plan (Greater Sydney Commission, 2018)
- Beyond the Pavement (Transport for NSW, 2020g).

23.1.2 Infrastructure Sustainability Rating Tool

The Infrastructure Sustainability Council (ISC) Rating Tool provides a comprehensive rating system for evaluating sustainability across the design, construction and operation of infrastructure projects. Sustainability would be assessed in accordance with the ISC Rating Tool (version 1.2) with a target 'Design' and 'As-Built' rating of 'Excellent' being sought for the project.

In August 2021, ISC released version 2.1 of the ISC Rating Tool. This update provides a number of improved and additional categories and credits to further enhance the sustainability performance of major infrastructure projects. The scheduled retirement of version 1.2 of the ISC Rating Tool is at the end of 2023. Transport is updating its internal procedures to enable a gradual and successful transition of future projects to version 2.1. Although ISC version 1.2 is being applied to this project, Transport is managing this transition by continuing to investigate and implement ISC version 2.1 credits where possible to enhance sustainable project outcomes.

23.1.3 Ecologically sustainable development

Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends is referred to as ecologically sustainable development (ESD). These principles are:

- the precautionary principle: lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
- intergenerational equity: the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- conservation of biological diversity and ecological integrity: conservation of biodiversity and ecosystem health should be primary considerations in development
- improved valuation of environmental assets and services: environmental factors should be included in the valuation of assets and services.

The principles of ESD have been considered throughout the development of the project. Chapter 25 (Justification and conclusion) outlines how the project addresses these principles.

23.1.4 Sustainability targets and initiatives

Sustainability initiatives for the project were identified in sustainability workshops with planning and design teams during the design development process and are outlined in Table 23-1. These initiatives would be implemented during further design development and in accordance with the sustainability guidelines outlined in Section 23.1.1. Sustainability initiatives would be reviewed and updated during the design development and construction stages of the project.

Table 23-1 Potential sustainability initiatives to be implemented for the project

Sustainability objective	Potential sustainability initiatives
Energy use	Initiatives for achieving efficiencies in energy use through design of tunnel ventilation, construction programming, construction utilities provision, transport options, offsets and renewable energy generation.
Water use	Initiatives for achieving efficiencies in water use through design of stormwater drainage and utilities, and for reducing potable water use by exploring opportunities to use non-potable water sources instead.
Materials	Initiatives for achieving efficiencies in material lifecycle impacts through the selection of sustainable materials, sourcing near the project to minimise transport, and innovating with recycled materials.
Waste	Including waste minimisation to realise a range of efficiencies (e.g. reduction in transport requirements), the development of a deconstruction plan for mid-tunnel access shaft infrastructure so that it can be dismantled for reuse post-construction, as well as the management and reuse of spoil during construction.
Urban design	Including provision of connectivity with local bushwalking trails and developing an active transport link along the corridor. Transport is investigating potential opportunities for placemaking and active transport initiatives to improve at-surface active transport infrastructure between Blackheath and Little Hartley in consultation with local councils. This would be subject to separate assessment and approval and may be delivered by others.
Environment	Including initiatives to minimise the construction footprint, where possible, and protect ecologically sensitive areas including hollow-bearing trees.
Ecology	Consideration for landscaping to support native species, minimise groundwater drawdown and minimise habitat impacts.
Climate change	Including initiatives to improve the resilience of the project to future extreme climate events.

Sustainability objective	Potential sustainability initiatives
Heritage	Including initiatives for the preservation and enhancement of heritage values.
Health	Consideration of active transport in the project design, and air and noise quality improvement initiatives.
Land use	Initiatives that conserve topsoil and subsoil and minimise impacts to previously undisturbed land.
Stakeholder engagement	Consideration of engagement methods that are tailored for each stakeholder group, particularly vulnerable stakeholders.
Innovation	Initiatives that encourage or rely on solar power such as electric vehicle charging stations and battery storage, optimised tunnel design to utilise space efficiently, and consider alternative materials including recycled materials in the structural design.

The sustainability initiatives for the project would be implemented through:

- targeting an 'Excellent' ISC Rating (see Section 23.1.2)
- climate change risk assessment and adaptation measures developed for the project (see Section 23.2)
- the environmental mitigation measures developed for the design, construction and operational phases of the project (see Appendix R (Compilation of environmental mitigation measures))
- an Infrastructure Sustainability Management Plan which would be developed in future design development.

23.2 Climate change

The peak body for climate change research, the Intergovernmental Panel on Climate Change (IPCC) has confirmed that Australia is experiencing impacts from climate change. Observed trends include changes in the frequency of mean and extreme air temperatures, changes in mean and extreme rainfall, changes in the frequency and intensity of storm events, increases in extreme fire weather events, ocean warming, ocean acidification and sea level rise (IPCC, 2021). The risk of climate change impacts on the project needs to be considered as part of the design process, as it needs to be resilient to these potential impacts.

Infrastructure assets, including road tunnels, are vulnerable to climate change because of their long design lives, during which the potential impacts of climate change would become more significant. Therefore, infrastructure design and planning needs to incorporate mitigation measures, based on the identified climate change risks to an asset.

23.2.1 Assessment approach

A climate change risk assessment was carried out which considered risks and mitigation measures that apply to the project. The climate change risk assessment has been conducted in line with the Transport for NSW Climate Risk Assessment Guidelines (Transport for NSW, 2021g). Risks identified would be reviewed and updated during further design development, during construction, and during operation of the project.

The study area for this assessment has been defined based on data published by the Commonwealth Scientific and Industrial Research Organisation Climate Science Centre. This dataset divides Australia into clusters and sub-clusters based on regional climate trends and natural resources produced in each region. The East Coast South Sub-Cluster was identified as the sub-cluster encompassing the project. This sub-cluster extends from the east coast of NSW to the Central West region of NSW, and from greater Sydney to the Queensland border.

Figure 23-1 provides an overview of the climate change risk assessment approach applied to the project.

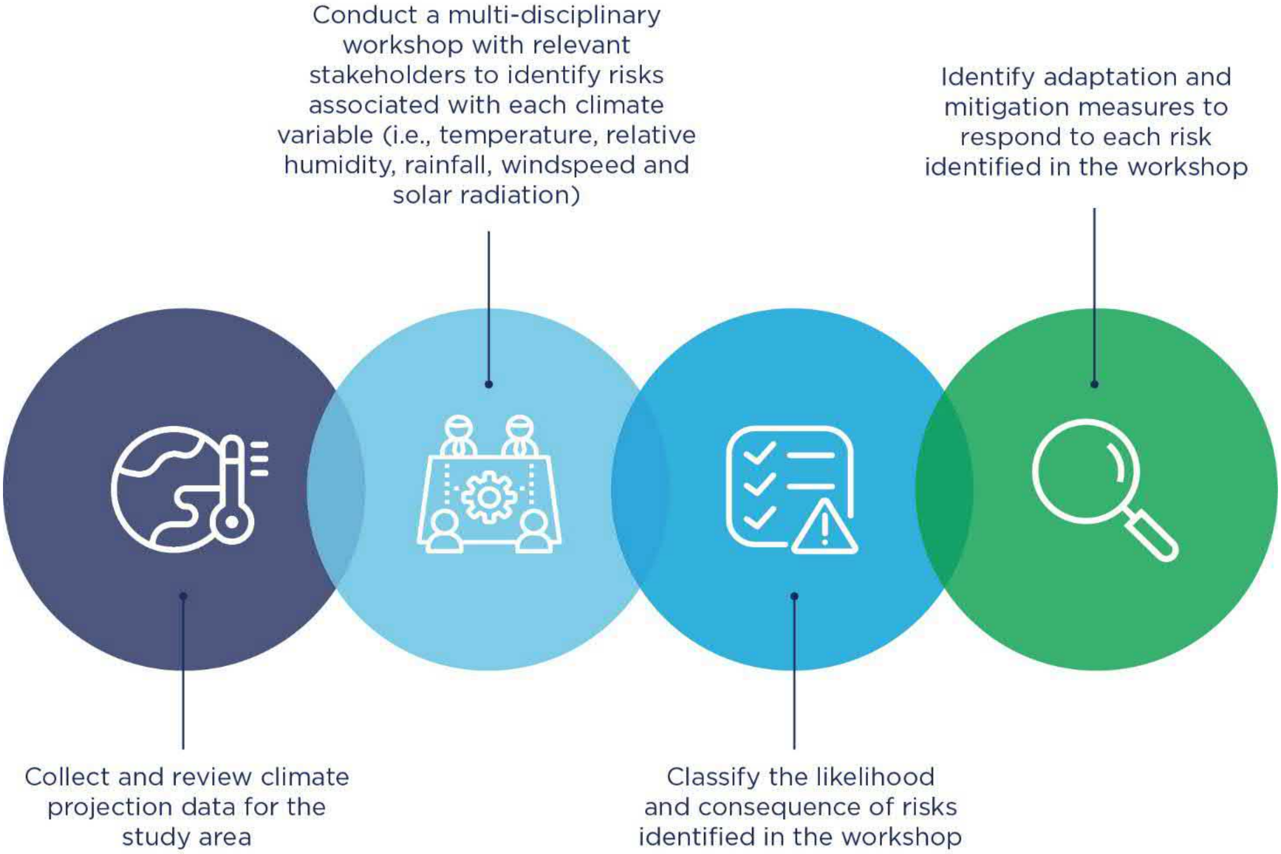


Figure 23-1 Climate change risk assessment approach

23.2.2 Climate change projections

Given the expected design life of the project, its anticipated construction timeframe and available climate data, the following time periods were selected for assessment:

- 2030 – to assess the short-term impacts of climate change
- 2090 – to assess the longer-term impacts of climate change during operation and maintenance of the project.

Historical climate data obtained from the Katoomba Weather Station (Station number: 063039) from 1991-2020 was used to provide context to the potential severity of climate change projections for 2030 and 2090.

Projections extending beyond 2090 can vary and this variation increases exponentially with time. Additionally, there are few publicly available sources for projection data relating to all climate hazards. Therefore 2090 is referred to in this report as a reliable long-term prediction of the likely climate change impacts of each scenario.

Projections are presented for the worst-case emissions scenario, referred to as representative concentration pathway (RCP) 8.5. A summary of climate change projections near the project for the RCP8.5 scenario is provided in Table 23-2.

Table 23-2 Climate change projections in the study area for RCP8.5

Climate variable	1991-2020 climate	2030 climate	2090 climate
Rainfall (mm)			
Mean (yearly)	1,309.2	1,298	1,267
Wettest day	226	235	261
Increase in severe rainfall intensity (%)	-	3.9	15.3
Temperature (°C)			
Hottest day	39.8	41.2	43.9
Coldest night	-3.6	-2.8	-0.2
Extreme heat days (number of days per year)			
Days ≥ 30°C	11.9	15.5	37.3
Days ≥ 35°C	1.1	1.5	7.2
Days ≥ 40°C	0.0	0.0	0.4
Cold days (number of days per year)			
Days ≤ 2°C	35.8	31.2	5.0
Days ≤ 0°C	10.9	7.3	0.4

23.2.3 Climate change risk assessment

A total of 54 pre-mitigation climate change risks for the project were identified in the climate change risk assessment, as detailed in Section 2.3 of Appendix Q (Technical report – Climate change and sustainability). Prior to the assignment of mitigation measures, two risks were rated as medium or high during project construction.

Three climate change risks were rated as high during operation of the project for the 2030 climate scenario, and 19 climate change risks were rated as high during project operation for the 2090 climate scenario.

Mitigation and adaptation measures were then applied to these risks, which were re-assessed for both the 2030 and 2090 climate scenario. Table 23-3 details the medium and high risks identified for construction of the project, and the high risks identified during operation of the project for 2030 (near future) and 2090 (far future) scenarios, both with and without the application of mitigation and adaptation measures.

Post-mitigation, no risks were rated as high or extreme with several rated as low. Out of the 19 risks shown in Table 23-3, post-mitigation there would be:

- two medium risks during construction of the project for the 2030 climate scenario
- eight medium risks during operation of the project for the 2030 climate scenario
- 17 medium risks during operation of the project for the 2090 climate scenario.

Examples of mitigation and adaptation measures applied include:

- incorporating First Nations burning practices into operational maintenance plans to minimise the risk of extreme bushfires
- selecting drought- and heat-tolerant vegetation, especially native species, for project landscaping to reduce temperature and drought impacts
- limiting work hours during extreme weather conditions to minimise health and safety risks to construction workers.

A full list of potential mitigation and adaptation actions is provided in Annexure C of Appendix Q (Technical report – Climate change and sustainability).

Table 23-3 Medium to high climate change risks during construction and operation of the project

Risk #[1]	Climate risk	Timing	Pre-mitigation		Post-mitigation	
			2030 rating	2090 rating	2030 rating	2090 rating
11	Temperature – increased extreme heat days leads to an increased risk of heat stress for construction and maintenance workers	Construction	High	Extreme	Medium	Medium
33	Storm intensity – increased storm intensity leading to safety risk to construction and maintenance workers	Construction	Medium	High	Medium	Medium
3	Temperature – increased exposure to higher temperatures affects the resilience of soil and vegetation and results in a loss of biodiversity and impacts to project landscaping	Operation	Medium	High	Low	Medium
5	Temperature – high temperatures lead to a preference for private vehicles compared to other transport modes which will increase traffic through the tunnel increasing wear of road surface leading to increased maintenance (e.g., resurfacing)	Operation	Medium	High	Medium	Medium
8	Temperature – extreme heat days lead to potential failure of mechanical and electrical systems	Operation	Medium	High	Medium	Medium
13	Drought – increased frequency and severity of drought conditions leads to increased dust build up in mechanical ventilation systems requiring additional maintenance	Operation	High	High	Low	Medium
18	Drought – increased frequency and severity of extreme rainfall events leads to water quality impacts to downstream receivers (groundwater dependent ecosystems, drinking water catchments etc.) leading to biodiversity and reputational impacts	Operation	Medium	High	Low	Medium

Risk #[1]	Climate risk	Timing	Pre-mitigation		Post-mitigation	
			2030 rating	2090 rating	2030 rating	2090 rating
20	Flooding – increased frequency and severity of extreme rainfall events leads to overloading of upstream detention basins and flooding impacts to the project site	Operation	Medium	High	Low	Medium
21	Flooding – increased frequency and severity of extreme rainfall events leads to corrosion of steel structures and decreased durability of other structural materials requiring additional maintenance or replacement	Operation	Medium	High	Low	Medium
23	Flooding – increased frequency and severity of extreme rainfall events leads to increased risk of landslides to new and existing embankments and damage to structures	Operation	Medium	High	Low	Medium
28	Flooding – increased storm intensity leading to damage of structures	Operation	Medium	High	Low	Medium
39	Storm intensity – increased storm intensity leading to increased hail speed and size causing impact on vehicles and commuters at tunnel exits and entries	Operation	Medium	High	Medium	Medium
42	Bushfire – increased frequency and intensity of bushfires leading to entry and exit of the tunnel becoming blocked and travellers becoming trapped inside the tunnel	Operation	Medium	High	Medium	Medium
43	Bushfire – increased frequency and intensity of bushfires leading to a loss of biodiversity and impacts to project landscaping	Operation	High	High	Medium	Medium

Risk #[1]	Climate risk	Timing	Pre-mitigation		Post-mitigation	
			2030 rating	2090 rating	2030 rating	2090 rating
44	Bushfire – increased frequency and intensity of bushfires leading to damage to infrastructure (e.g., noise walls, pavement) resulting in increased maintenance and decrease in operational safety	Operation	Medium	High	Medium	Medium
48	Bushfire – increased frequency and intensity of bushfires leading to damage to power infrastructure impacting tunnel operations	Operation	High	High	Low	Medium
51	Bushfire – increased solar radiation leading to increased strike risk for fauna seeking shade	Operation	Medium	High	Medium	Medium
52	Solar radiation – increased solar radiation leading to increased harmful UV effects to operations personnel	Operation	Medium	High	Medium	Medium
54	Solar radiation – increased frequency and severity of drought conditions leads to increased water scarcity impacting fire prevention systems and increased damage to infrastructure within the tunnel and a health risk for workers and motorists	Operation	Medium	High	Low	Medium

Table notes:

1. Risk numbers correspond to the comprehensive list of climate change risks shown in Section 2.3 of Appendix Q (Technical report – Climate change and sustainability)

23.3 Greenhouse gas

GHGs are gases in the atmosphere that absorb and re-radiate heat from the sun, thereby trapping heat in the lower atmosphere and influencing global temperatures. Emissions of GHGs into the atmosphere are caused by both natural processes (e.g. bushfires) and human activities (e.g. burning of fossil fuels).

Since the industrial revolution there has been an increase in the amount of GHGs emitted from human activities, which has increased the global concentration of GHGs in the atmosphere. This has led to an increase in the Earth's average surface temperature (IPCC, 2021). Adapting to these changes is necessary to minimise the impacts of climate change on the natural and built environments and the NSW communities and economy (NSW Government, 2022).

23.3.1 Assessment approach

The Carbon Estimate Reporting Tool (CERT) developed by Transport for NSW to measure and report GHG emissions has been used to estimate GHG emissions associated with the project. As the GHG assessment has been carried out during an early phase of the design process, high-level and conservative estimates have been applied where exact material types, construction methodologies, and/ or resource requirements are unknown.

GHG emissions from the project have been categorised into direct and indirect emission sources as defined by the Greenhouse Gas Protocol (World Resources Institute and World Business Council for Sustainable Development, n.d.). Emissions sources identified for the GHG assessment for both construction and operation of the project are outlined in Figure 23-2.

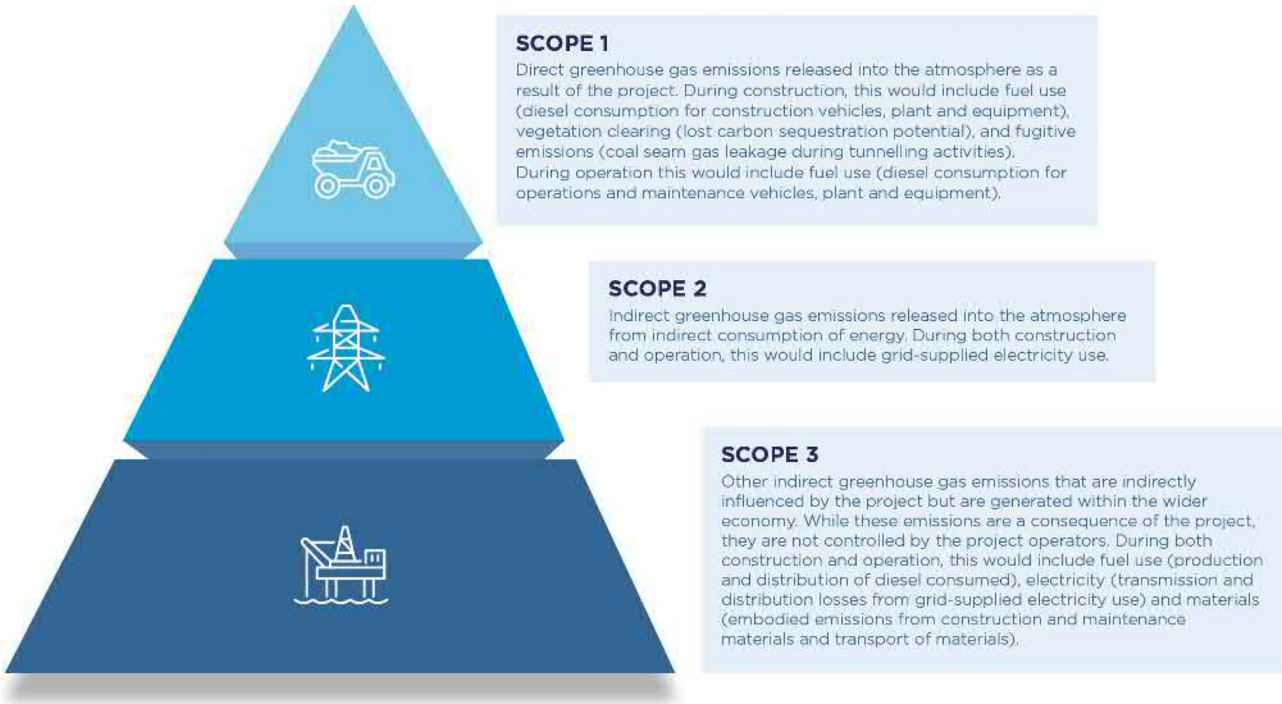


Figure 23-2 Scope 1, 2, and 3 GHG emissions as defined by the Greenhouse Gas Protocol

The GHG assessment provides preliminary estimates based on current indicative design and construction information.

The approach for the GHG assessment for the project included:

- defining the assessment boundary and identifying potential sources of GHG emissions associated with the project
- determining the quantity of each emission source

- quantifying the potential GHG emissions associated with each source
- calculating the potential GHG emissions associated with the project in tonnes of carbon dioxide equivalent (tCO_2-e)
- developing GHG minimisation measures to be considered during design development.

23.3.2 Estimated GHG emissions during construction

Resource use estimates

Key emissions sources and indicative emissions volumes during project construction are presented in Table 23-4 and shown in Figure 23-3. Indicative emission volumes are based on the current project design and subject to change during design development and detailed construction planning.

These results show that the majority of GHG emissions produced during construction are associated with electricity use (scope 2), and embodied emissions from the manufacture of construction materials (scope 3). This is largely due to the electricity and construction materials required for the tunnel boring machines. The difference between construction GHG emissions for both ventilation scenarios (i.e., ventilation outlet and portal emissions) would be negligible.

In addition to the quantitative GHG assessment summarised in Table 23-4, the following activities associated with construction of the new water supply pipeline between Little Hartley and Lithgow would increase plant and equipment energy requirements and materials use and lead to an increase in GHG emissions:

- trench excavation and pipeline installation including backfill and rehabilitation
- concrete foundation and/or encasements works and thrust blocks
- connection to Lithgow water supply.

Table 23-4 Indicative construction GHG emissions by scope and emissions source

Emission source	Emissions (tCO^2-e)[1]			
	Scope 1	Scope 2	Scope 3	Total
Diesel combustion (site vehicles, precast segment delivery and spoil haulage)	72,210	0	3,700	75,910
Diesel combustion (plant and equipment)	50,680	0	2,600	53,260
Vegetation removal	4,740	0	0	4,740
Electricity consumption	0	525,200	47,130	572,330
Embodied emissions from construction materials (including delivery to construction sites)	0	0	689,610	689,610
Fugitive emissions (methane gas from coal seams) during tunnelling	11,290	0	0	11,290
Total	**138,900**	**525,200**	**743,040**	**1,407,140**

Table notes:

1. Indicative emission volumes have been rounded to the nearest 10 t CO2e

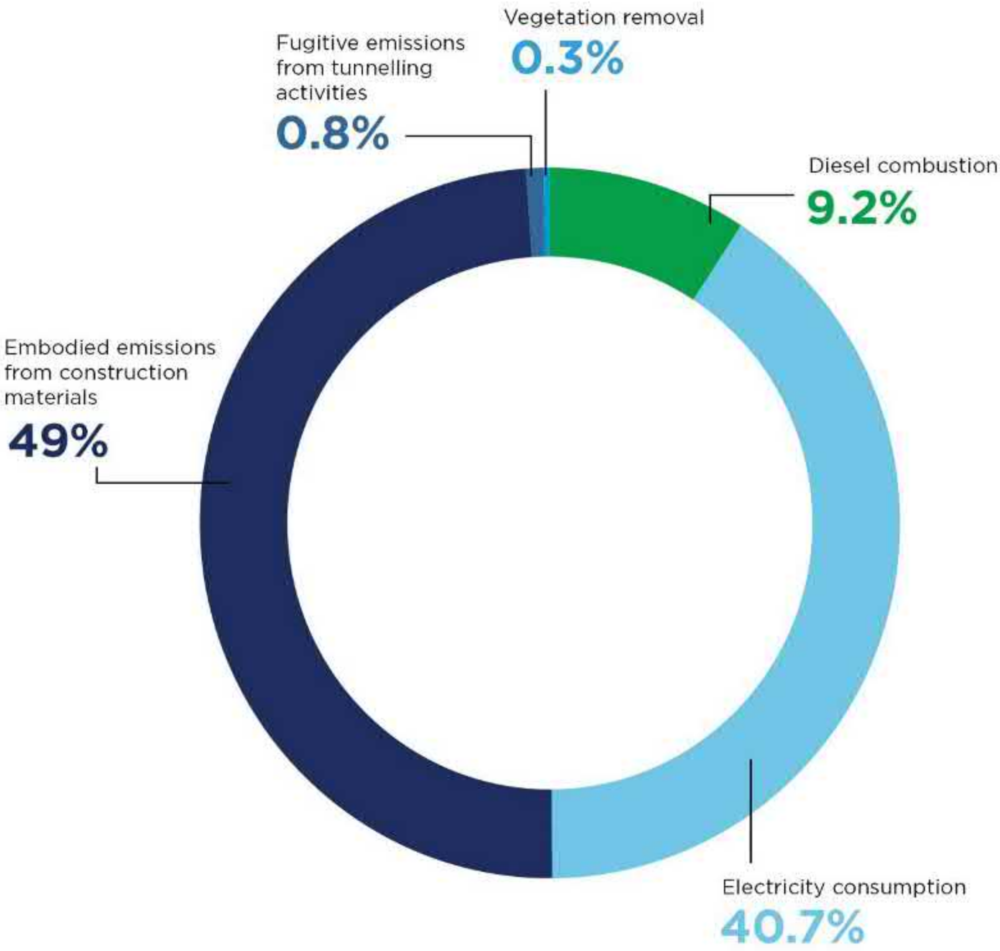


Figure 23-3 Construction GHG emissions by source

Potential coal seam gases

As discussed in Chapter 5 (Construction) and Chapter 13 (Groundwater and geology), the project would require tunnelling through coal seams between the Little Hartley portal and the mid-tunnel access shaft. Coal seams contain methane gas which is a GHG and could be emitted during tunnelling activities. The GHG assessment has incorporated this risk by including estimates of fugitive emissions produced during tunnelling activities. The management of potential coal seam gas is discussed in Chapter 15 (Soils and contamination).

23.3.3 Estimated GHG emissions during operation

Key emissions sources and indicative emission volumes during project operation for both ventilation options are shown in Table 23-5. Indicative emission volumes are based on the current project design and subject to change during design development.

Under both ventilation options, the greatest source of GHG emissions during operation would likely be from electricity consumption from ventilation and lighting systems for the design life of the project. Under both ventilation options, the amount of scope 1 GHG emissions would be the same.

Under the portal emissions option, the project would generate around 2,087,800 tonnes less of scope 2 GHG emissions and around 187,370 tonnes less of scope 3 GHG emissions compared to the ventilation outlet option. The portal emissions option would have a total saving of around 2,275,170 tonnes of GHG emissions which is a saving of around 65 per cent. This is expected to occur (at least in the short-term) due to an easing of congestion, increased travel speed, and reduced travel time as a result of the project, resulting in lower emissions per vehicle per kilometre.

Operation of the water supply pipeline would result in negligible impacts to the project's GHG emissions. Operation of the pipeline may impact emissions in areas outside the assessment boundary, such as pumping energy requirements by relevant water supply operators.

Table 23-5 Operational GHG emissions by scope and emissions source over the design life of the project (100 years)

Emission source	Ventilation option	Emissions (tCO2-e)[1]			
		Scope 1	Scope 2	Scope 3	Total
Operation emissions (electricity consumption and fuel combustion from operations vehicles)	Ventilation outlet	8,370	3,484,780	313,170	3,806,320
	Portal emissions	8,370	1,396,980	125,800	1,531,150
Maintenance emissions (maintenance plant, equipment and materials)	Ventilation outlet / portal emissions	5,040	0	37,560	42,600
Road users (net change in vehicle tailpipe emissions)	Ventilation outlet / portal emissions	0	0	-298,930	-298,930
Total	**Ventilation outlet**	**13,410**	**3,484,780**	**51,800**	**3,549,990**
	Portal emissions	**13,410**	**1,396,980**	**-135,570**	**1,274,820**

Table notes:

1. Indicative emission volumes have been rounded to the nearest 10 t CO2e

23.4 Environmental mitigation measures

23.4.1 Performance outcomes

Performance outcomes for the project in relation to sustainability, climate change and GHG are listed in Table 23-6 and identify measurable performance-based standards for environmental management.

Table 23-6 Sustainability and climate change performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
The project is designed, constructed and operated to be resilient to the future impacts of climate change.	Design and implement the project taking into account current climate change projections and potential future climate change impacts.	Design, construction and operation

SEARs desired performance outcome	Project performance outcome	Timing
The project reduces the NSW Government's operating costs and ensures the effective and efficient use of resources. Conservation of natural resources is maximised.	Design and implement the project to minimise capital and operational costs, consistent with NSW Treasury requirements. Design and implement the project to achieve a minimum Infrastructure Sustainability 'Design' and 'As-Built' rating of 'Excellent' under version 1.2 of the ISC rating tool.	Design, construction and operation

23.4.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential sustainability, climate change and GHG impacts as a result of the project are detailed in Table 23-7. A full list of mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 23-7 Environmental mitigation measures – sustainability, climate change and GHG

ID	Mitigation measure	Timing
CC1	A climate change risk assessment will be carried as part of further design development. Adaptation actions will be identified and implemented to address extreme and high climate change risks, and will be considered for medium climate change risks where reasonable and feasible.	Design
SU1	An Infrastructure Sustainability Management Plan will be prepared and implemented as part of further design development to guide the implementation of sustainability initiatives. The Plan will detail how the project will achieve an Infrastructure Sustainability rating of 'Excellent'.	Design
SU2	As part of further design development, construction and operation of the project, the initiatives identified in the Great Western Highway Upgrade Program's Sustainability Strategy will be considered.	Design and operation
GG1	Opportunities to minimise greenhouse gas emissions from the project, including as a result of interactions with coal seams, will be identified as part of further design development, and will be implemented during construction and operation where reasonable and feasible. Consideration of opportunities to minimise greenhouse gas emissions will include: • reducing the electricity requirements of the project and/ or sourcing electricity from a renewable energy source • selecting construction materials with reduced embodied greenhouse gas emissions, through reduced materials use, lower emissions construction materials, and/ or local sourcing of materials • selecting plant and equipment with lower fuel/ electricity consumption and/ or greater energy efficiency.	Design, construction and operation

ID	Mitigation measure	Timing
GG2	The project will be designed and implemented with the aim of achieving the following: • at least a 10 per cent reduction in carbon emissions during construction • offset at least 25 per cent of the carbon emissions associated with consumption of fuel and electricity through the purchase of approved offsets and/ or renewable energy during construction • at least a 10 per cent reduction in scope 1 greenhouse gas emissions using Climate Active Standard eligible offsets during construction • at least a 15 per cent reduction in carbon emissions during operation. • A baseline against which the target reductions above will be evaluated will be established during detailed design, with reference to typical construction materials and methodologies, and operational processes and procedures, applied to other road tunnels in NSW.	Design, construction and operation

24 Cumulative impacts

This chapter summarises the cumulative impact assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project).

24.1 Cumulative impacts defined

Cumulative impacts have the potential to occur when benefits or impacts from a project overlap or interact with those of other projects, potentially resulting in a larger overall impact (positive or negative) on the environment or local communities. Cumulative impacts may occur when projects are constructed or operated concurrently or consecutively.

The extent to which another development or activity could interact with the construction and/or operation of the project would depend on its scale, location and/or timing of construction. Generally, cumulative impacts would be expected to occur where other long-duration or large magnitude construction activities are undertaken close to, and over a similar timescale to, construction activities for the project; or where consecutive construction occurs in the same area. Additionally, operation of the project could cause cumulative benefits when the project interacts with or possibly enhances the construction or operation of other projects.

24.2 Assessment approach

The cumulative impact assessment methodology for this project has been developed in accordance with the State Significant Infrastructure Guidelines (Department of Planning, Industry and Environment, 2022) and Cumulative Impact Assessment Guidelines for State Significant Projects (Department of Planning, Industry and Environment, 2021d). The methodology is illustrated in Figure 24-1 and described in more detail in the following sections.

Figure 24-1 Overview of cumulative impact assessment methodology

24.2.1 Identification of potential projects

Projects identified for consideration in the cumulative impact assessment included those that met the following screening criteria:

- spatially relevant (i.e., the development or activity overlaps with, is adjacent to or within 10 kilometres of the project)
- timing (i.e., the expected timing of its construction and/or operation overlaps or occurs consecutively to construction and/or operation of the project)
- scale (i.e., large-scale major development or infrastructure projects that have the potential to result in cumulative impacts with the project, as listed on the NSW Government Major Project website, the Transport for NSW project website and relevant council websites)
- status (i.e., projects in development with sufficient publicly available information to inform this environmental impact statement and with an adequate level of detail to assess the potential cumulative impacts).

24.2.2 Projects included in the cumulative impact assessment

Projects identified for consideration in the cumulative impact assessment are listed in Table 24-1. Projects identified for inclusion in the cumulative impact assessment have met the criteria listed above and are shown in Figure 24-2. Given the regional setting of the project within the Blue Mountains and Lithgow local government areas (LGAs), there are fewer major projects within the locality.

Figure 24-3 shows the construction and operational timeframes for each project considered in the cumulative impact assessment and how these overlap with the project. Subject to planning approval, construction is planned to commence in 2024 and continue until 2031. The project is expected to open to traffic by 2030.

Table 24-1 Projects considered for the cumulative impact assessment

Project and description	Spatial relevance	Timing	Scale	Status	Project included?
Great Western Highway Upgrade – Katoomba to Blackheath (Katoomba to Blackheath Upgrade) The Katoomba to Blackheath Upgrade involves widening of around 5.3 kilometres of the existing Great Western Highway between Rowan Lane, Katoomba and Tennyson Road, Blackheath from one to two lanes in each direction to be a four-lane divided carriageway.	Located immediately east of the project along the Great Western Highway	Katoomba to Blackheath Upgrade - construction expected to commence in 2023 and be completed in 2027.	Large-scale highway project	**Approved (2022)** Review of environmental factors (REF) and Submission Report publicly available	Yes
Great Western Highway Upgrade – Medlow Bath (Medlow Bath Upgrade) The Medlow Bath Upgrade involves upgrade of a 1.2 kilometre section of the existing Great Western Highway at Medlow Bath to a four-lane divided carriageway.	Located three kilometres east of the project along the Great Western Highway.	Medlow Bath Upgrade - construction has commenced and is expected to be completed by early 2024.	Large-scale highway project	**Approved (2022)** REF and Submission Reports publicly available	Yes

Project and description	Spatial relevance	Timing	Scale	Status	Project included?
Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade) Upgrade of the Great Western Highway between Little Hartley and Lithgow. The project includes upgrade of about 14 kilometres of highway to a four lane divided highway.	Located immediately west of the project on the existing Great Western Highway alignment	Construction has commenced and is expected to be completed by 2026.	Large-scale highway project	**Approved (2022)** REF and concept design display for proposed modifications to the Little Hartley to Lithgow Upgrade publicly available.	Yes
Blackheath Village Centre Upgrade Blue Mountains City Council is planning improvements to the public domain of Blackheath over the coming 10 to 15 years including improvements to roads and active transport infrastructure, housing and community infrastructure.	Located within and surrounding Blackheath Town Centre, which is located around two kilometres north of the Blackheath portal	Work commenced in 2021	Localised urban amenity work	Limited publicly available information to inform a cumulative impact assessment	No This work comprises a number of small projects at Blackheath with relatively short construction timeframes that do not meet the scale criteria defined in Section 24.2.1. Transport for NSW would continue engagement with Blue Mountains City Council regarding the status of this work and potential interface with the project.

Project and description	Spatial relevance	Timing	Scale	Status	Project included?
Austen Quarry Stage 2 Extension Extension of the extraction area and overburden emplacement within the existing Austen Quarry of around 15.8 and 9.9 hectares respectively.	Located off Jenolan Caves Road over six kilometres west of the project	Unknown	Large-scale mining operations project	**Approved (2014)** Limited publicly available information to inform a cumulative impact assessment	No Located over six kilometres west of the project and does not meet the threshold to be considered in this assessment. Transport for NSW would continue engagement with Lithgow City Council regarding the status of the project and potential interface with the project.

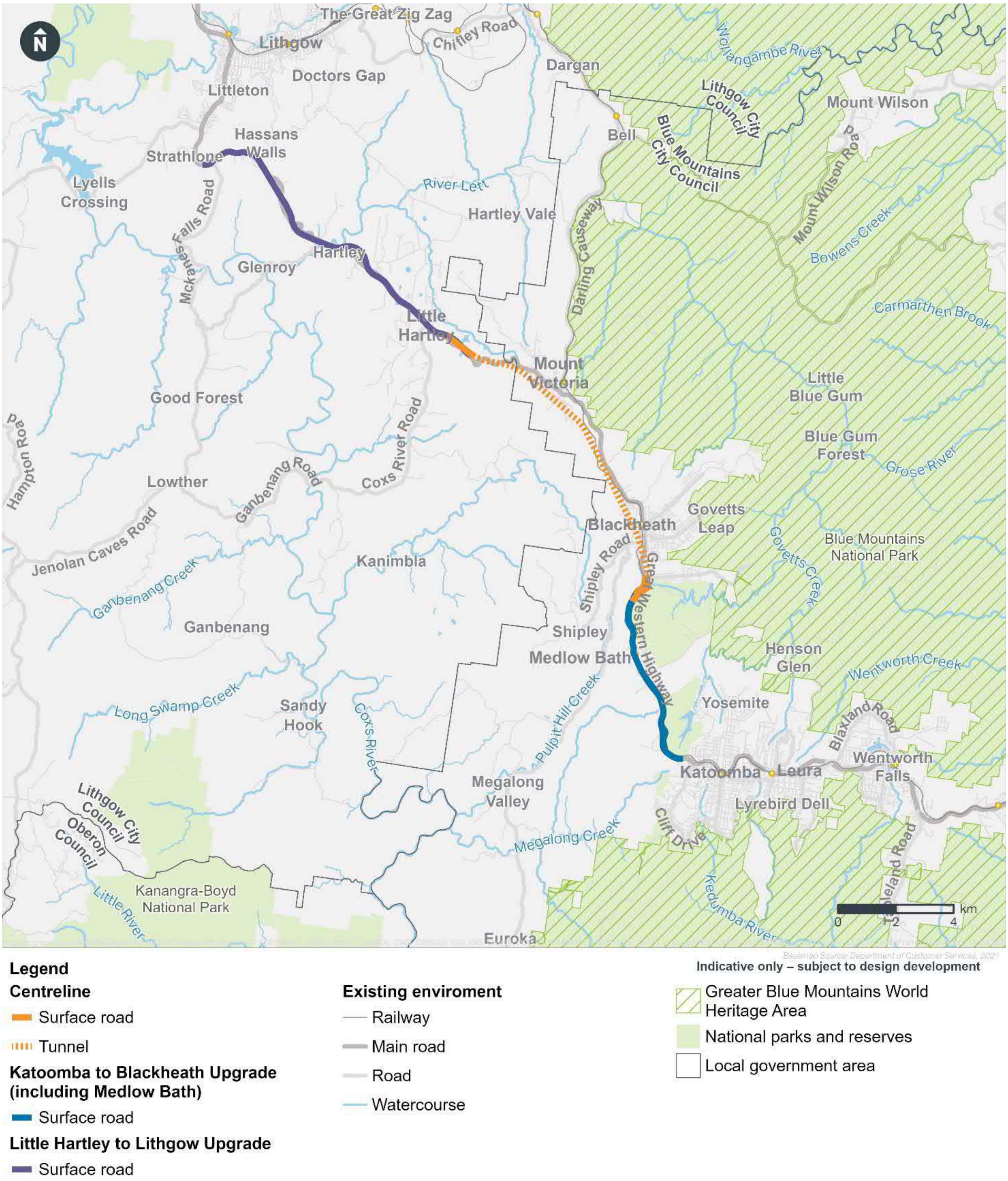


Figure 24-2 Projects included in the cumulative impact assessment

Figure 24-3 Indicative construction duration for relevant projects

24.2.3 Type of assessment

Table 24-2 identifies relevant environmental aspects that may be subject to potential cumulative impacts during construction and operation from the included projects in Table 24-1. A description of these potential impacts is provided in Section 24.4 and Section 24.5.

Table 24-2 Nature of potential cumulative impacts

Key construction issues	Key operational issues
• transport and traffic • air quality • human health • noise and vibration • biodiversity • groundwater and geology • surface water and flooding • Aboriginal cultural heritage • Non-Aboriginal heritage • landscape and visual • social • business, land use and property • sustainability, climate change and greenhouse gas (GHG)	• transport and traffic • air quality • human health • noise and vibration • groundwater and geology • surface water and flooding • landscape and visual • social • business, land use and property • sustainability, climate change and GHG

Depending on the environmental aspect, the cumulative impact assessment may be quantitative, qualitative, or a combination of both. In most cases, a qualitative assessment has been undertaken for potential cumulative construction and operation impacts across key issues, as described in Section 24.4 and Section 24.5 respectively.

24.3 Baseline environment

The baseline environment for the cumulative impact assessment undertaken for the project comprises the road network and surrounding environment without any Upgrade Program infrastructure. The cumulative assessment assumes that construction of the Upgrade Program infrastructure has commenced at the time of project construction.

As shown in Figure 24-3, the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade adjoining the project to the east and west respectively would be under construction when construction of the project commences. To minimise environmental impacts, parts of the construction sites used for the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade would be used to support construction of the project.

The following activities would be carried out as part of the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade:

- vegetation would be cleared
- topsoil would be levelled and compacted
- site access tracks would be established
- water quality controls such as water quality and sediment basins would be installed.

These areas are shown in Figure 24-4 and Figure 24-5.

Limited overlap is anticipated with the Medlow Bath Upgrade as construction of the Medlow Bath Upgrade is anticipated to be completed by early 2024 before the peak construction year for the project (2026). Construction of the project would overlap with the construction activities associated with the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade which are due to be completed in 2027 and 2026 respectively, however peak construction years are not expected to overlap.

Further information related to the timing for the project, the Katoomba to Blackheath Upgrade (at Blackheath) and Little Hartley to Lithgow Upgrade (at Little Hartley) is shown in Table 24-3 and Table 24-4. The activities shown would not occur for the entire duration shown, however flexibility has been provided so that activities can be staged appropriately to minimise impacts and the interface with the adjacent projects.

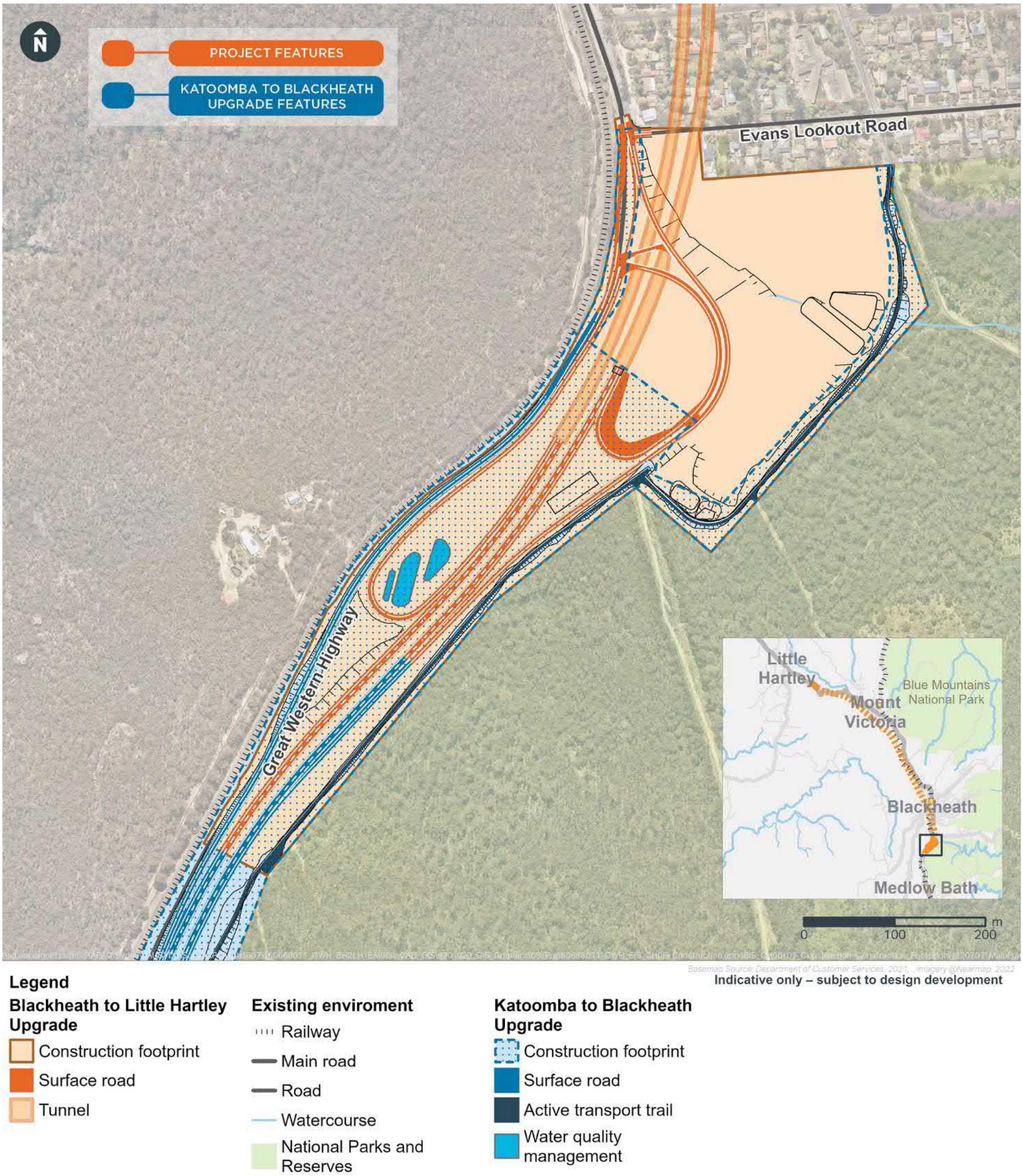
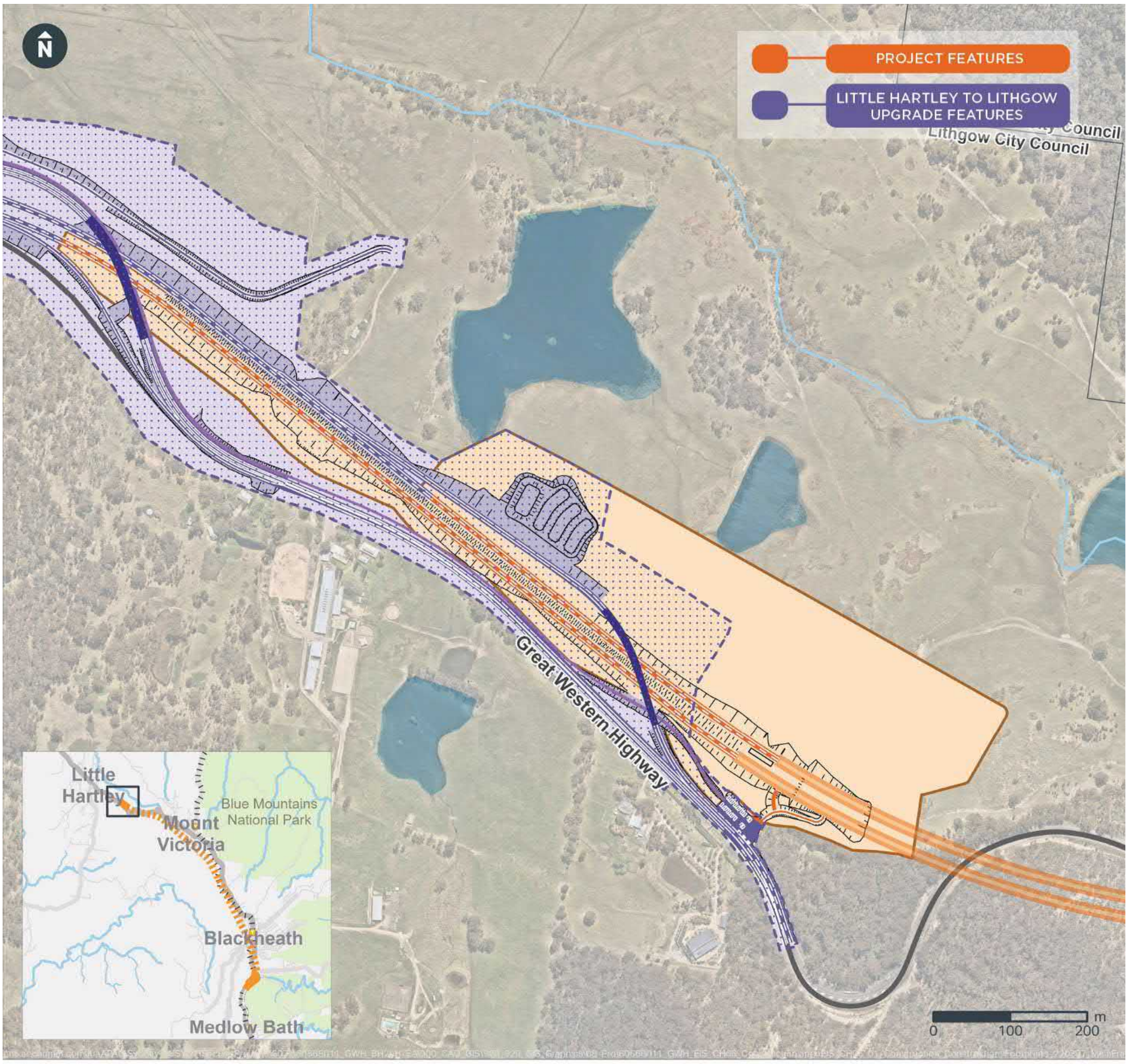


Figure 24-4 Indicative construction footprints and construction footprint overlap between the Katoomba to Blackheath Upgrade and the project at Blackheath



Indicative only – subject to design development

Legend

Blackheath to Little Hartley Upgrade	Existing enviroment	Little Hartley to Lithgow Upgrade
Construction footprint	Main road	Construction footprint
Surface road	Road	Surface road
Tunnel	Watercourse	Overbridge
	National Parks and Reserves	Active transport trail
	Local government area	

Figure 24-5 Indicative construction footprints and construction footprint overlap between the Little Hartley to Lithgow Upgrade and the project at Little Hartley

Table 24-3 Indicative construction program – Blackheath

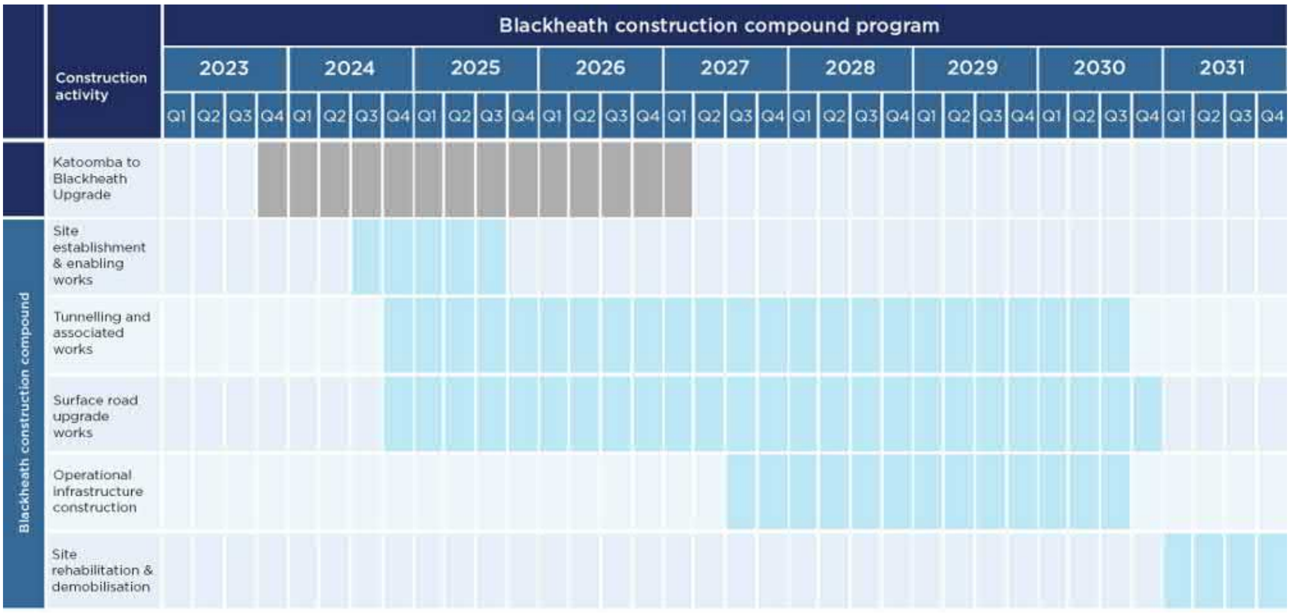
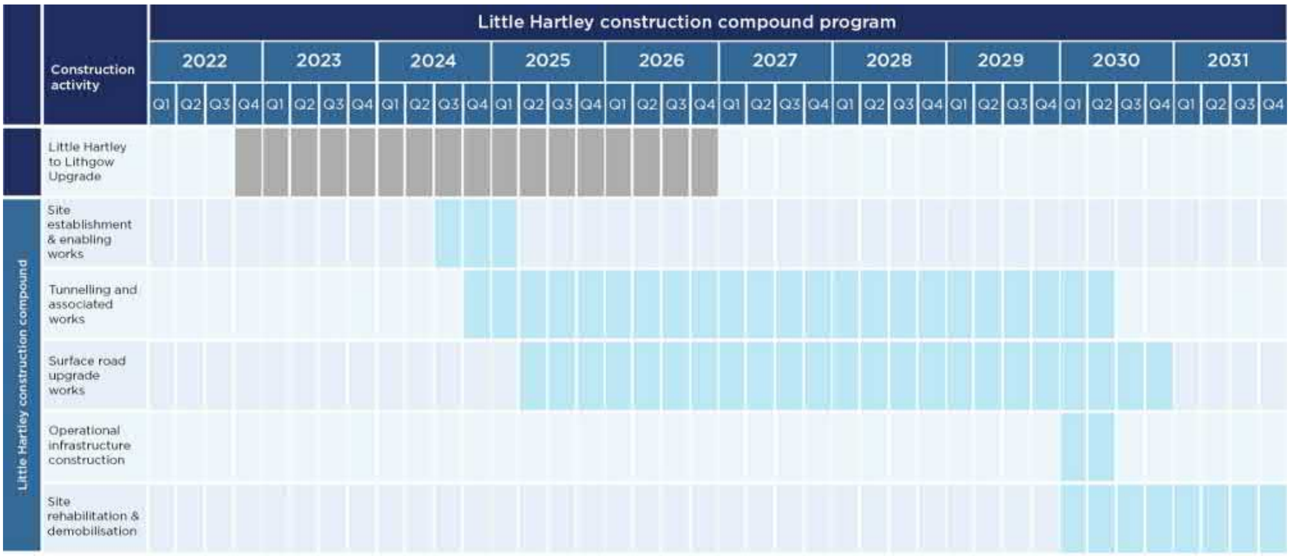


Table 24-4 Indicative construction program – Little Hartley



24.4 Potential impacts – construction

Potential cumulative impacts during construction are related to:

- transport and traffic
- air quality
- human health
- noise and vibration
- biodiversity
- groundwater and geology
- surface water and flooding
- Aboriginal cultural heritage
- non-Aboriginal heritage

- landscape and visual
- social
- business, land use and property
- sustainability, climate change and GHG.

These impacts are summarised in Sections 24.4.1 to Section 24.4.13. Further details on the potential cumulative impacts during construction are presented in the respective technical reports.

24.4.1 Transport and traffic

Table 24-5 presents the estimated peak cumulative heavy vehicle volumes generated by the Upgrade Program along the Great Western Highway during construction. It is estimated that the Upgrade Program would result in around an additional:

- 2,600 heavy vehicles per day along the Great Western Highway, which is 45 per cent more than the project alone
- 3,315 light vehicles per day along the Great Western Highway, which is 40 per cent more than the project alone.

It is anticipated that vehicles associated with the Katoomba to Blackheath Upgrade and Medlow Bath Upgrade would mostly travel between the project and the east via the Great Western Highway and similarly, the vehicles associated with the Little Hartley to Lithgow Upgrade would mostly travel between the project and the west via the Great Western Highway.

The project's heavy vehicles would most likely travel to and from the west and the project's light vehicles would likely travel to and from the east. As a result of the likely directional split of traffic, the total vehicle movements shown in Table 24-5 would not be experienced at any one location along the Great Western Highway.

Table 24-5 Indicative peak cumulative traffic volumes along the Great Western Highway[1]

Upgrade Program	Daily light vehicle movements	Daily heavy vehicle movements	Total vehicle movements
Blackheath to Little Hartley (the project)	2,355	1,805	4,160
Medlow Bath Upgrade	360	200	560
Katoomba to Blackheath Upgrade	200	140	340
Little Hartley to Lithgow Upgrade	400	450	850
Total	**3,315**	**2,595**	**5,910**

Table notes:

1. Vehicle movement refers to each movement that a vehicle makes e.g. one vehicle would usually make two movements (in and out) per day.

Cumulative construction traffic impacts associated with the Upgrade Program may include localised increased congestion, poor intersection performance and reduced travel speeds around Blackheath and Little Hartley resulting from the combined construction traffic generation and more extensive speed limit reductions associated with these projects. In addition, multiple traffic switches, lane reductions and speed limit reductions would be active across the Upgrade Program. The cumulative impacts of these traffic management measures would likely result in lower travel speeds and longer travel times (in the order of 10 minutes) along the Great Western Highway between Katoomba and Lithgow, particularly at night or off-peak periods when these are most likely to occur.

Work across the Upgrade Program would be staged appropriately to minimise these impacts. In particular, the Katoomba to Blackheath and Little Hartley to Lithgow Upgrade would have completed work in the vicinity of the project prior to peak activities associated with the project commencing. Construction worker shift changeover for the project which would account for a large proportion of total light vehicle movements would be scheduled to occur outside peak hour travel times. In addition, upgraded sections of the Great Western Highway would be opened to traffic sequentially, providing additional mid-block capacity and grade separated or upgraded intersections along the corridor as works are completed.

24.4.2 Air quality

The highest potential for cumulative air quality impacts is where construction of the project would overlap with construction of the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade. This would potentially result in receivers at Blackheath and Little Hartley experiencing greater air quality impacts for a longer duration given the concurrent and consecutive nature of the Upgrade Program components. Potential cumulative air quality construction impacts would largely be attributed to:

- dust from demolition, earthworks, stockpiling and mobilisation of dust from vehicles and/or machinery leaving construction sites
- emissions from construction vehicles and mobile and stationary equipment.

The Medlow Bath Upgrade is located around three kilometres east of the project and construction is expected to be completed by early-2024 which would have limited overlap with the project. Therefore, cumulative air quality impacts with the Medlow Bath Upgrade are not anticipated during construction.

Parts of the construction sites used for the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade would be used to support construction of the project. As outlined in Section 24.3, construction activities for the Upgrade Program would be staged appropriately to minimise the interface with the adjacent projects and avoid concurrent construction activities in the same localities. With the implementation of appropriate dust mitigation during construction, potential cumulative air quality impacts would be minor.

24.4.3 Human health

The human health assessment has focused on health-related impacts associated with air quality, noise and vibration and social impacts of the Upgrade Program. Where there is the potential for cumulative construction impacts on air quality (particularly from dust) and noise (see Section 24.4.2 and 24.4.4 respectively), there is also potential for related cumulative human health impacts. Extended exposure to construction related impacts from a prolonged construction duration may increase levels of stress and anxiety in some individuals located close to where projects overlap at Blackheath and Little Hartley.

With the implementation of air quality and noise mitigation measures (refer to Appendix R (Compilation of environmental mitigation measures)), the potential for cumulative human health impacts is considered low (for air quality) to moderate (for noise). These mitigation measures would adequately address construction related impacts such that the levels are not of concern to community health.

24.4.4 Noise and vibration

Sensitive receivers located in areas where the project overlaps spatially with the Katoomba to Blackheath Upgrade (at Blackheath) and the Little Hartley to Lithgow Upgrade (at Little Hartley) may be affected by cumulative construction noise. Cumulative construction noise could potentially increase noise levels at one particular receiver by up to 3 dBA above the highest noise level predicted for a particular project (assuming that at any one location equal noise levels from two stages of work are experienced). An overview of the noise sensitive receivers most likely to be impacted by cumulative construction noise is shown in Figure 24-4 and at Badgerys Creek in Figure 24-5. (see Figure 24-6). Cumulative impacts are likely to be restricted to standard hours only as utility works for the adjacent projects would be undertaken before commencement of the project and not be undertaken concurrently.

Parts of the construction sites used for the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade would be used to support the construction of the project. While works would be staged to minimise concurrent activities occurring within the same localities, identification of sensitive receivers subject to increased noise levels from projects under concurrent construction would be determined during design development and detailed construction planning when further construction programming information is available. At Blackheath and Little Hartley construction sites, it is likely that noise mitigation measures confirmed during design development and implemented for the project (e.g. such as acoustic sheds) would also reduce the impact of cumulative noise from adjoining projects.

Provided the minimum working distances provided in Section 4.7 of Appendix G (Technical report – Noise and vibration) are implemented, it is highly unlikely that cumulative vibration would impact receivers near the boundaries between neighbouring projects.

Although there would be minimum concurrent impacts from cumulative construction noise, there is potential for receivers to experience construction noise fatigue due to the consecutive nature and increased duration of the cumulative construction period. Receivers at Little Hartley are expected to be particularly impacted as they would be impacted by noise generated from the Little Hartley to Lithgow surface works, as well as tunnelling support activities at the Little Hartley construction site for the project. Construction fatigue would predominantly be managed through stakeholder notification and engagement. Where practicable, respite would be provided and the total duration of works would be minimised as far as practicable.

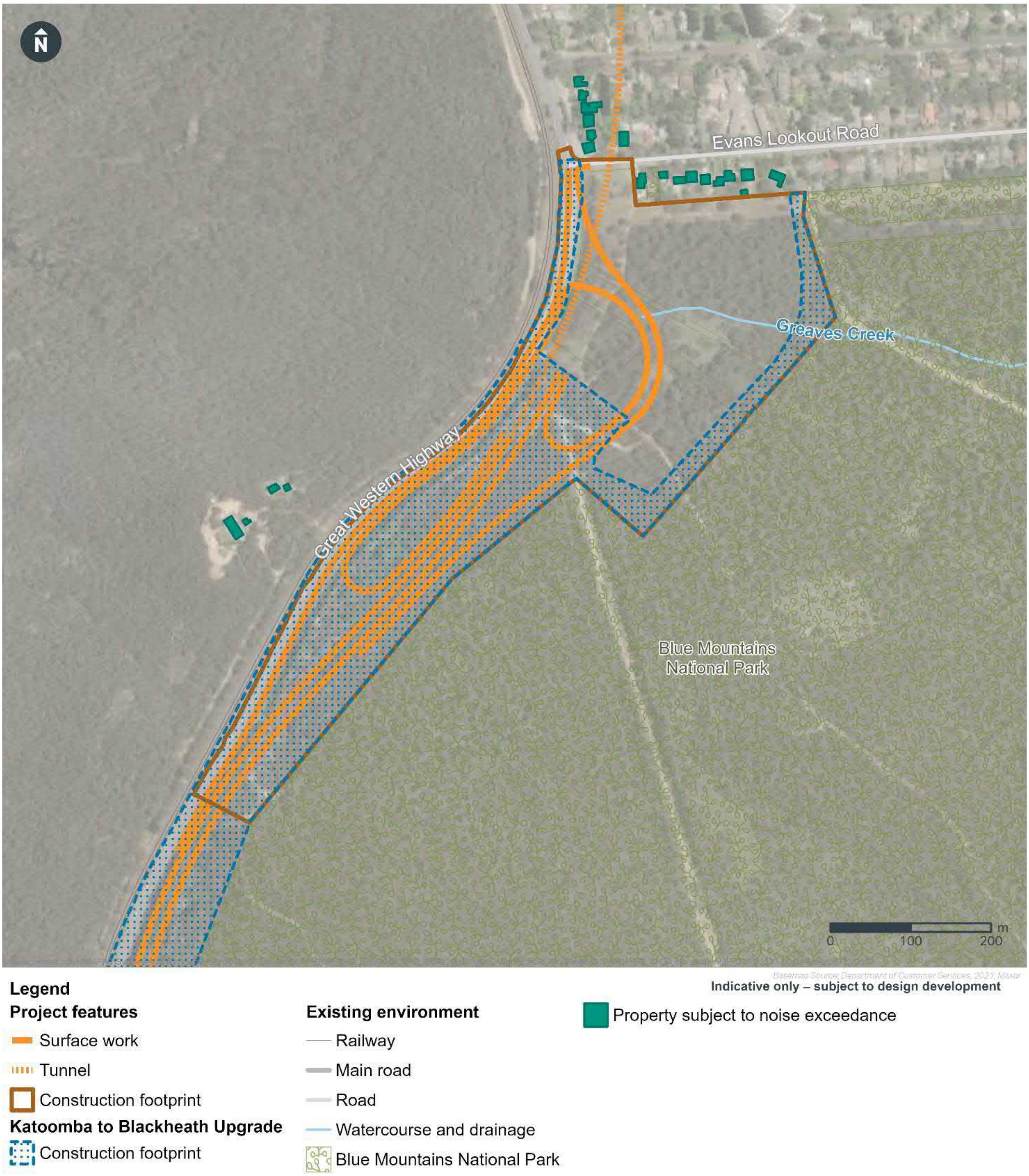


Figure 24-6 Receivers potentially impacted by cumulative noise at Blackheath

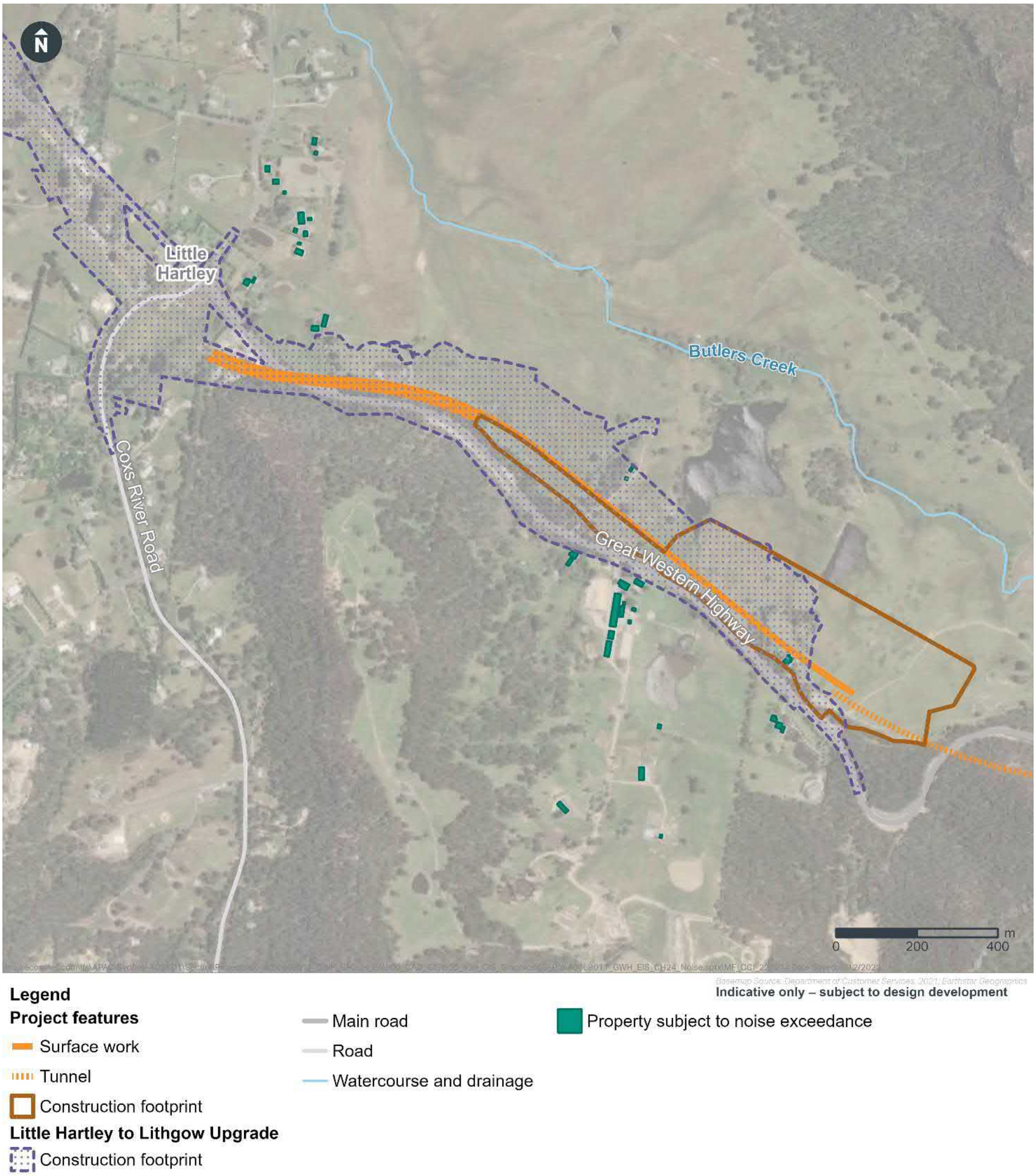


Figure 24-7 Receivers potentially impacted by cumulative noise at Little Hartley

24.4.5 Biodiversity

Parts of the construction sites for the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade would be used to support construction of the project, minimising the amount of vegetation to be removed for the Upgrade Program.

Potential cumulative biodiversity impacts from the Upgrade Program would include:

- increased removal of native vegetation
- increased removal of hollow-bearing trees.

These impacts are presented in Table 24-6 and Table 24-7 respectively. The project would comprise around 7.6 per cent of cumulative native vegetation impacts and around 5.6 percent of hollow-bearing tree cumulative impacts from the Upgrade Program.

As shown in Table 24-6, the project would specifically contribute to the cumulative impact to PCT 1248 (Sydney Peppermint – Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion). This PCT is not associated with any threatened ecological communities listed under the *Biodiversity Conservation Act 2016* (NSW) or the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth).

Given the context of the retained vegetation within the Blue Mountains National Park (more than 200,000 hectares), the removal of a relatively small amount of vegetation across the Upgrade Program is unlikely to substantially impact or reduce the availability of habitat critical to the survival of threatened flora or fauna. In the context of native vegetation retained and impacts to the Greater Blue Mountains World Heritage Area avoided, cumulative impacts to native vegetation are considered minor.

The Upgrade Program is largely located within an existing road corridor and native vegetation adjacent the Great Western Highway is already subject to a high degree of edge effects. As parts of the Great Western Highway corridor would be widened as result of the Upgrade Program, a slight cumulative increase in edge effects is expected. The implementation of standard mitigation measures consistently across the Upgrade Program would mean that cumulative impacts on biodiversity would not be substantial.

Table 24-6 Cumulative impacts to native vegetation

Plant Community Type (PCT) and condition	Area impacted (ha)				
	The project	Katoomba to Blackheath Upgrade	Medlow Bath Upgrade	Little Hartley to Lithgow Upgrade	Total cumulative impact
PCT 708 Moderate	0.50	-	-	-	**0.50**
PCT 708 High	1.30	-	-	-	**1.30**
PCT 731 Good	-	-	-	12.44	**12.44**
PCT 731 Variant – good	-	-	-	3.08	**3.08**
PCT 731 Moderate	-	-	-	14.61	**14.61**
PCT 732 Moderate	-	-	-	6.42	**6.42**
PCT 766 Low	0.43	-	-	-	**0.43**
PCT 963 Good	-	-	-	1.20	**1.20**
PCT 967 Low	-	0.70	-	-	**0.70**
PCT 967 Moderate	-	0.06	-	-	**0.06**
PCT 1103 Disturbed	-	-	-	1.71	**1.71**
PCT 1103 Low-Moderate	-	-	-	4.79	**4.79**
PCT 1103 Moderate	-	-	-	6.2	**6.2**
PCT 1103 Good	-	-	-	10.72	**10.72**
PCT 1155 Moderate	-	-	-	9.72	**9.72**
PCT 1248 Poor	-	-	0.02	-	**0.02**
PCT 1248 Low	0.33	19.06	-	-	**19.39**
PCT 1248 Moderate	0.86	27.74	0.34	-	**28.94**
PCT 1248 High	6.10	-	-	-	**6.10**
PCT 1615 Low	0.01	-	-	-	**0.01**
PCT 1615 Moderate	0.18	-	-	-	**0.18**
Total native vegetation	**9.71**	**47.56**	**0.36**	**70.89**	**128.52**

Table 24-7 Cumulative impacts to hollow-bearing trees

Biodiversity value impacted	Total count				
	The project	Katoomba to Blackheath Upgrade	Medlow Bath Upgrade	Little Hartley to Lithgow Upgrade	Total cumulative impact
Hollow-bearing trees	20	207	0	142	**369**

24.4.6 Groundwater and geology

The project may result in potential impacts to groundwater flow rates and drawdown near the portals and mid-tunnel access shaft, adit and cavern due to tunnelling and the construction of these items. Localised excavations (cuts) for the Upgrade Program have the potential to result in cumulative impacts to groundwater level and flow. This is likely to occur where excavation would be deeper than the water table. The closest cut for the Little Hartley to Lithgow Upgrade is around four metres west of the Little Hartley portal. The maximum depth of the cut is about 5.5 metres, above the water table depth of six metres below ground level and therefore is unlikely to impact groundwater levels at this location. Proposed cuts for the Katoomba to Blackheath Upgrade are less than five metres in depth in the vicinity of the project and are not anticipated to intercept groundwater. Potential impacts to sensitive receivers and groundwater users due to the long-term cumulative groundwater drawdown during construction of the Upgrade Program is therefore considered to be low.

24.4.7 Surface water and flooding

The project construction activities have the potential to temporarily impact the water quality of surrounding waterways, however these would be appropriately managed and would be minor.

The project and the Little Hartley to Lithgow Upgrade are both located in the Sydney Drinking Water Catchment and would implement guidelines and principles from the Blue Book to demonstrate a neutral effect on water quality (NorBE), therefore there would be no cumulative impacts expected to surface water quality at Blackheath and Little Hartley. The following potential cumulative surface water impacts were considered:

- overland flow from the Katoomba to Blackheath Upgrade construction footprint could wash construction materials, fuels and chemicals into the natural drainage line at Blackheath if not adequately managed leading to detrimental impacts to surface water quality in the receiving waterways prior to commencement of the project. Construction basins are proposed along the Katoomba to Blackheath Upgrade to capture runoff and manage these impacts in accordance with the Blue Book (Landcom, 2004)
- Little Hartley to Lithgow Upgrade construction works may lead to water quality impacts such as increased turbidity in receiving waterways including Rosedale Creek, from erosion and scour and increased nutrients which can lead to algal blooms. To mitigate these impacts at Rosedale Creek, proposed erosion and sediment control measures and the sizing of temporary sediment basins used during construction would meet the requirements of the Blue Book (Landcom, 2004) for both projects. With the implementation mitigation measures, the Little Hartley to Lithgow Upgrade would have a minimal impact on existing water quality and therefore there would be no cumulative impacts on surface water quality at Rosedale Creek.

There is potential for inundation under a five per cent annual exceedance probability event at Little Hartley during construction of the project, however no cumulative impacts on flood behaviour are expected during construction.

24.4.8 Aboriginal cultural heritage

No direct Aboriginal cultural heritage impacts are anticipated as a result of the project.

When considering the potential cumulative impacts of the Upgrade Program, Aboriginal sites do not exist in isolation and rather are associated with particular landforms and natural features. For example, a single site assessment identifying an artefact scatter in association with a rock shelter may find this site type common and typical. However, this site type and association may be rare within the region and therefore its context would have significance at a regional level and result in cumulative impacts if it were to be impacted. Likewise, the relative rarity of a site type needs to be considered when assessing the cumulative impacts of a project for a region's archaeology.

Construction of the Upgrade Program would result in potential direct impacts to 22 Aboriginal sites. These sites are of increased significance due to their rarity in an increasingly developed environment. The Aboriginal cultural heritage values across the Upgrade Program would be reduced if complete loss of these sites was to occur. Potential negligible or indirect impacts to a site are not considered to be a risk for cumulative impacts to the region's Aboriginal cultural heritage.

A preliminary Aboriginal Narrative Report and Body of Story Report has been prepared for the Upgrade Program to assist with the interpretation and integration of intangible Aboriginal cultural values collected during Aboriginal consultation and exploratory workshops by giving Aboriginal communities a voice in the design of the Upgrade Program. Examples of how some of the cultural values identified in the Aboriginal cultural heritage assessment for the project would be considered in the project design are discussed in Section 5.6 of Appendix N (Technical report – Urban design, landscape and visual). Consultation with Aboriginal stakeholders is further discussed in Chapter 16 (Aboriginal cultural heritage).

24.4.9 Non-Aboriginal heritage

Construction of the project has the potential to result in cumulative impacts to three heritage items and conservation areas identified in the non-Aboriginal heritage assessment.

Depending on the precise location of this archaeological site, the site of the Plough Inn could be subject to major direct impact from either the Little Hartley to Lithgow Upgrade or the project, whichever is constructed first. Currently, the Little Hartley to Lithgow Upgrade is expected to be constructed and affect the archaeological site prior to commencement of construction of the project. Overall, the site of the Plough Inn has been assessed as being potentially subject to a major direct cumulative impact. Cumulative vibration and visual impacts from construction of the Little Hartley to Lithgow Upgrade and the project also has the potential to result in moderate indirect impacts to the Rosedale local heritage item.

Construction of the project and the Katoomba to Blackheath Upgrade would result in direct cumulative impacts to the Greater Blue Mountains Area – Additional Values (a nominated National Heritage List item) of which native vegetation is an important feature. Given that the areas of retained native vegetation near the project are known and predicted to support the same native vegetation, these direct impacts are considered minor.

24.4.10 Landscape and visual

Construction of the Upgrade Program would result in potential visual and landscape character impacts at Blackheath and Little Hartley associated with increased construction footprints and the length of time construction activity would occur at these locations. In comparison to the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade, the construction footprint for the project is relatively small and predominantly in areas already impacted by the adjacent projects as most of the project alignment is in the tunnel.

Landscape character

At Blackheath, the Great Western Highway corridor would be widened between Medlow Bath and the Blackheath tunnel portals, with the removal of stands of bushland vegetation to the east of

Great Western Highway to accommodate the widening. This would substantially open up views east across the valley. This impact would occur to support construction of the Katoomba to Blackheath Upgrade and the project construction footprint at Blackheath. Similarly, the cumulative construction footprint at Little Hartley for the project and the Little Hartley to Lithgow Upgrade would be an uncharacteristic addition to the existing quiet, rural valley setting.

Visual impact

Visual receptors within the Little Hartley valley (predominantly residents), at lookouts along the Mount York escarpment (typically hikers and tourists), and receivers travelling along the Great Western Highway are sensitive due to the relationship of these receptors to the views seen from their properties or while engaging in recreational activities and the potential change to these views.

The Upgrade Program would result in the increased presence of construction-related infrastructure and an extended construction footprint and duration which would increase the magnitude of change experienced at most viewpoints during construction.

24.4.11 Social

Cumulative social impacts during construction would be predominantly experienced at Blackheath and Little Hartley, where the project interfaces with the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade. Communities around these particular areas would be subject to sequential construction impacts from the Upgrade Program over an extended period of time (up to around eight to nine years). Cumulative social impacts during construction include:

- increased stress and impacts to people’s way of life and their ability to move around the social locality, from cumulative increased congestion, poor intersection performance and reduced travel speeds at Blackheath and Little Hartley
- additional impacts to people’s sense of place and wellbeing from cumulative construction noise, vibration and dust changing the amenity of nearby properties and social infrastructure
- potential decline in the way people experience their surroundings from cumulative landscape character impacts
- additional impacts to the natural landscape, which is valued by the community, due to cumulative removal of native vegetation
- potential construction fatigue due to the cumulative extended construction period and associated traffic, noise, air quality and amenity impacts
- improvements to people’s capacity to earn an income and associated benefits to livelihood as some retail and construction businesses would experience higher levels of spending across the Upgrade Program.

The overall unmitigated social significance of potential cumulative construction impacts would be a medium (negative) impact (refer to Chapter 19 (Social impacts) for rating definitions). Opportunities to minimise and manage cumulative impacts across the Great Western Highway Upgrade Program will be identified in consultation with other projects in the Upgrade Program, and implemented where reasonable and feasible.

24.4.12 Business, land use and property

The cumulative capital expenditure and number of workers associated with construction of the Upgrade Program would result in additional economic benefits, including increased output and jobs created for the Lithgow and Blue Mountains LGAs compared to the project in isolation. An increased proportion of construction related jobs located in these regions would also be expected during construction of the Upgrade Program, which is expected to span for around nine years.

The economic benefits of the Upgrade Program are likely to include higher levels of spending at local accommodation and retail businesses over the duration of construction compared to the project in isolation. While the increase in the number of workers in the area may put pressure on accommodation supply and result in shortages in accommodation in the short-term, this impact is expected to be partially mitigated by the sourcing of local workers who already live in the area.

The Upgrade Program has avoided the requirement for property acquisition that would result in the loss of businesses.

24.4.13 Sustainability, climate change and greenhouse gas

Construction of the project would result in around 0.09 mega tonnes of carbon dioxide equivalent (Mt CO_2e) per year of construction.

Construction of the Little Hartley to Lithgow Upgrade in combination with the project would result in 0.127 mega tonnes of Mt CO_2e per year of construction. This is equivalent to 0.096 per cent of total NSW annual emissions in 2020.

While the Katoomba to Blackheath Upgrade and Medlow Bath Upgrade greenhouse gas emissions haven't been quantified, these would be of a similar order of magnitude as the Little Hartley to Lithgow Upgrade.

24.5 Potential impacts – operation

Potential cumulative impacts during operation are related to:

- transport and traffic
- air quality
- human health
- noise and vibration
- groundwater and geology
- surface water and flooding
- landscape and visual
- social
- business, land use and property
- sustainability, climate change and GHG.

These impacts are summarised in Sections 24.5.1 to Section 24.5.10. Further details on the potential cumulative impacts during operation are presented in the respective technical reports.

24.5.1 Transport and traffic

The Upgrade Program would provide a new connection for higher productivity freight vehicles longer than 20 metres for 34 kilometres between Katoomba and Lithgow.

Following the completion of the Upgrade Program, average travel times along the Great Western Highway between Katoomba and Lithgow would reduce by up to 13 minutes in 2030 and 15 minutes in 2040. The total trip would take less than 30 minutes.

Following the completion of the Upgrade Program, average vehicle speeds on the Great Western Highway between Katoomba and Lithgow would increase from an average of:

- 57 kilometres per hour to 77 kilometres per hour in 2030
- 54 kilometres per hour to 76 kilometres per hour in 2040.

The travel times demonstrate that the Upgrade Program would result in a 10 to 15 minute (20 to 35 per cent) travel time saving for heavy vehicles travelling between Katoomba and Lithgow during the weekday AM and PM peak hours.

The vehicle speeds demonstrate that the Upgrade Program would result in improved heavy vehicle speeds including 15 to 20 kilometres per hour (30 to 40 per cent) in the eastbound direction and 12 to 16 kilometres per hour (25 to 30 per cent) in the westbound direction.

These improved travel speeds and travel time savings would provide substantial benefits for regional freight transport.

24.5.2 Air quality

The operational air quality impact assessment carried out for the project (Appendix E (Technical report – Air quality)) included all components of the Upgrade Program and has therefore considered the potential cumulative impacts of the Upgrade Program.

Operational air quality impacts were assessed for both tunnel ventilation design options currently being investigated for the project (emissions via ventilation outlets or portals). In both ventilation outlet and portal emissions scenarios, predicted total ground level concentrations were below the NSW Environment Protection Authority's criteria for all pollutants and all modelled scenarios at the worst affected receptors. This assessment is further summarised in Section 9.6 of Chapter 9 (Air quality).

24.5.3 Human health

During operation, the Upgrade Program would result in community health benefits associated with reduced levels of traffic congestion, improved connectivity between Sydney and Central West NSW, reduced travel times, and improved air quality and traffic noise (for receivers between Blackheath and Little Hartley).

24.5.4 Noise and vibration

The operational traffic noise assessment carried out for the project (Appendix G (Technical report – Noise and vibration)) included all components of the Upgrade Program and has therefore considered the potential cumulative impacts of the Upgrade Program.

Operation of the Upgrade Program is expected to result in reduced noise levels at around 2,000 residential receivers where the tunnel provides a bypass to the existing surface road between Blackheath and Little Hartley. By providing an improved gradient and alignment, the project would also reduce maximum noise levels and events associated with truck engine braking, exhausts and horns. Some receivers located adjacent to where new and upgraded sections of surface road are proposed may experience elevated levels of operational road traffic noise. Where predicted cumulative traffic noise levels exceed criteria, mitigation options for noise affected receivers will be considered. This assessment is further summarised in Section 11.4 of Chapter 11 (Noise and vibration).

24.5.5 Groundwater and geology

As discussed in Section 24.4.6, proposed cuts for the Katoomba to Blackheath Upgrade are less than five metres in depth within the vicinity of the project, and are not anticipated to intercept groundwater. Groundwater drawdown from the tunnels during operation is expected to be limited. The maximum simulated spatial extent of water table drawdown during operation of the project at the Little Hartley portals is expected to be less than 500 metres from the portals. Given the closest cut that intercepts groundwater from the Little Hartley to Lithgow Upgrade is around 1.2 kilometres west of the Little Hartley portals, the estimated groundwater drawdown contours are not anticipated to overlap and therefore no cumulative impact to groundwater level or flow is expected. Potential impacts to sensitive receivers and groundwater users due to the long-term cumulative groundwater drawdown during operation of the Upgrade Program is considered to be low.

24.5.6 Surface water and flooding

The Katoomba to Blackheath and Little Hartley to Lithgow Upgrade would drain to the Sydney Drinking Water Catchment and surface runoff treatment for both of these projects would meet the requirements for a NorBE. As such cumulative water quality impacts during operation of the project to the receiving waterways including tributaries of Grose River and Coxs River catchments is neutral and would not contribute to cumulative impacts with other projects.

At Little Hartley, existing conditions include a potential localised flood level increase at the upstream end of the Rosedale Creek culvert beneath the existing Great Western Highway. During operation of both projects at Little Hartley, flood modelling indicates that a flood level increase would no longer be expected due to the proposed culvert upgrade as part of this project. Therefore, there is expected to be a cumulative benefit on flood behaviour during operation at Little Hartley.

24.5.7 Landscape and visual

The Upgrade Program would result in substantial changes both to landscape character and views. The scale of the widened road corridor and the larger pieces of infrastructure that would be added to the landscape, particularly the operational ancillary facilities, divided carriageways, bridges, tunnel portals, and lighting, would be uncharacteristic with the existing landscape setting.

Landscape character

During operation, the narrow, winding Great Western Highway embedded within the landscape would increase in prominence, with the widened road corridor and large scale of the operational infrastructure enforcing more of a presence on the surrounding landscape. Tree planting, particularly within and around the surface works at Blackheath and Little Hartley would assist in reducing the cumulative visual impacts within the landscape over time.

The overall combined impact of the Upgrade Program on landscape character is considered to be high (adverse). A Place Design and Landscape Plan (PDLP) will be prepared to minimise landscape character and visual impacts, and detail and guide the implementation of landscape features to be installed as part of the project. The PDLP will be prepared in accordance with applicable guidelines, be consistent with the project identity in the EIS and relevant urban design objectives and principles for the project including consideration of implementation of Crime Prevention Through Environmental Design principles, and in consultation with the relevant councils.

Visual impact

Visual receptors within the Little Hartley valley (predominantly residents), at lookouts along the Mount York escarpment (typically hikers and tourists), and receivers travelling along the Great Western Highway are sensitive due to the relationship of these receptors to the views seen from their properties or while engaging in recreational activities and the potential change to these views.

The cumulative impact of the Upgrade Program would be the substantial widening of the Great Western Highway corridor with the addition of uncharacteristically large operational infrastructure. At Little Hartley for example, cumulatively, the view would be characterised by bridges, tunnel portals and batters, a water treatment plant, substation and ventilation outlet (if this ventilation option is selected) increasing the magnitude of change experienced at most viewpoints. Tree planting, particularly within and around the surface works at Blackheath and Little Hartley would reduce the impact of these structures over time, particularly when seen from the Mount York escarpment and from residences within the Little Hartley valley. Urban design principles and objectives that would guide design development to ensure the project design integrates with the existing setting are outlined in Appendix N (Technical report – Urban design, landscape and visual).

The overall combined impact of the Upgrade Program on views is considered to be high (adverse).

24.5.8 Social

Cumulative social impacts during operation primarily consist of social benefits as a result of substantial travel time improvements and decreases in congestion on the existing Great Western Highway as a result of the Upgrade Program.

These social benefits include:

- improved accessibility within the social locality and the broader region, and improved access to local businesses, facilities, jobs and social infrastructure
- substantial improvements in amenity and road user safety in bypassed town centres, contributing to an improved sense of place, as well as potentially attracting additional tourists and visitors
- enhanced wellbeing and decreased stress from the reduction in travel times and congestion experienced by road users
- the accessibility and safety benefits delivered by the project would be enhanced by additional active transport and safety initiatives, including active transport trails to the east and west of the project (provided as part of the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade), and the formalisation of the informal Berghofer's Pass car park to improve the safety and amenity of the car park for visitors (as part of the Little Hartley to Lithgow Upgrade).

There is some potential for adverse changes to how local residents and visitors experience their surroundings and sense of place, particularly in relation to visual amenity, associated with the collective presence of surface infrastructure in Blackheath and Little Hartley. A Place Design and Landscape Plan would be implemented to provide consistency in design, and landscaping provided for screening, to manage this impact (refer to Chapter 18 (Landscape and visual)).

The overall unmitigated social significance of cumulative operation impacts would be a high (positive) impact (refer to Chapter 19 (Social impacts) for rating definitions).

24.5.9 Business, land use and property

During operation, the cumulative impacts of the project and the Katoomba to Blackheath Upgrade (including the Medlow Bath Upgrade) and Little Hartley to Lithgow Upgrade would include large travel time reductions, increased vehicle speeds, increased capacity for freight traffic volumes and improved road safety for drivers travelling through the Blue Mountains. For communities in the Blue Mountains it is anticipated that this would result in increased productivity for local workers, as well as further improving the accessibility and attractiveness of local tourist attractions, with the impacts resulting from the Upgrade Program likely to be greater than changes by the project in isolation.

The cumulative impact from the Upgrade Program is also likely to result in greater changes to passing trade activity across the Lithgow and Blue Mountains LGAs. Depending on the nature of the business – specifically the type of industry, location and reliance on passing trade – the actual impact of these impacts would vary, however retail trade businesses are likely to be most severely impacted.

24.5.10 Sustainability, climate change and greenhouse gas

Cumulative climate change impacts associated with operation of the Upgrade Program would occur as a result of interdependencies with the surrounding environment, with the potential to increase climate change risks for the receiving environment. These interdependencies include:

- increased overland flow and changes to drainage lines resulting in increased risk of localised flooding and/or increase flows to receiving environments
- increase in impervious surfaces, however given that the majority of the project would be below the surface in tunnels, this increase is not anticipated to result in substantial cumulative impacts
- interactions with existing drainage systems. The project drainage infrastructure has been designed to account for the capacity of existing drainage systems, such that it would meet or improve current drainage flows
- project infrastructure providing additional options for access and evacuation during extreme events including for emergency management and response.

The mitigation measures identified in Chapter 23 (Sustainability, climate change and greenhouse gas) would improve project's resilience to climate change and reduce potential interdependencies and cumulative climate change risks. The implementation of adaptation measures to address climate change risks provides opportunities to improve the resilience of infrastructure within the region.

The Little Hartley to Lithgow Upgrade is predicted to result in around 0.001 Mt CO_2e per year during operation. Combined with the Blackheath to Little Hartley Upgrade and the project, this would result in a combined 0.036 Mt CO_2e under the ventilation outlet option, and 0.015 Mt CO_2e under the portal emissions option. These are equivalent to 0.027 and 0.011 per cent of total NSW annual emissions in 2020 for the ventilation outlet and portal emissions options respectively.

24.6 Environmental mitigation measures

Mitigation measures to avoid, minimise or manage potential cumulative impacts as a result of the project are outlined in Table 24-8. A full list of performance outcomes and environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 24-8 Environmental mitigation measures – cumulative impacts

ID	Mitigation measure	Timing
CI1	Opportunities to minimise and manage cumulative impacts across the Great Western Highway Upgrade Program will be identified in consultation with the other projects in the Upgrade Program, and implemented where reasonable and feasible. Key focus areas for the minimisation and management of potential cumulative impacts will include: • construction planning and staging, including coordination of construction activities and provision of respite periods to manage construction fatigue • coordination of stakeholder notification and engagement requirements and activities across the Upgrade Program to manage consultation fatigue • construction phase amenity, particularly in relation to traffic, dust, noise and vibration • avoidance and minimisation of impacts on biodiversity, Aboriginal heritage and non-Aboriginal heritage • coordination of waste and resource management, including spoil/ cut-and-fill balances, surface water management and water supply requirements, recycling and sustainability initiatives.	Design

25 Justification and conclusion

25.1 Project justification

25.1.1 Biophysical, economic and social considerations

This environmental impact statement (EIS) has considered the potential environmental impacts associated with the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project), including biophysical, economic and social considerations.

Design response

The project design has been developed to avoid and/or minimise impacts to the community and the environment. Community and stakeholder consultation carried out to date has informed selection of the preferred option as well as design refinements in response to key issues raised by the community (including the Blackheath portal location in consultation with the Blackheath Co-Design Committee). Key design refinements adopted to help avoid and/or minimise environmental impacts include:

- selecting a long tunnel option to minimise surface impacts between Blackheath and Little Hartley, resulting in a substantial reduction in surface construction footprint (around 300,000 square metres) which may have directly or indirectly affected the Blue Mountains National Park, the Greater Blue Mountains World Heritage Area and Browntown Oval had the short tunnel option been selected
- continued use of construction footprints required for the Great Western Highway East – Katoomba to Blackheath Upgrade (Katoomba to Blackheath Upgrade) and Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade) for the project. These areas will have already been cleared of vegetation and used to support construction for those projects, which helps to minimise additional surface impacts including vegetation clearance for this project
- adopting a construction methodology with tunnel excavation via two tunnel boring machines (TBMs) (rather than roadheaders) which would limit groundwater drawdown and related groundwater impacts through the progressive and almost immediate installation of concrete tunnel segments with waterproof lining
- advancing the TBMs from the Little Hartley construction site towards the east, which would:
  - minimise spoil haulage and segment deliveries through the townships of Blackheath and Mount Victoria and associated traffic, safety and amenity impacts, including minimising use of Victoria Pass by heavy vehicles
  - minimise the construction footprint at Blackheath, reducing native vegetation clearance as the site would not need to accommodate a TBM launch area
- optimising the construction strategy to consolidate construction site requirements, including avoiding the need for construction sites at:
  - Browntown Oval which would allow for ongoing community use of this social infrastructure
  - the old Blackheath tip site which would limit potential exposure of contamination at this site and avoid potential biodiversity, amenity and traffic related impacts associated with access requirements to this site
- optimising the surface connectivity at Blackheath which has reduced the operational footprint, minimising visual impacts for road users, tourists and residents near the Blackheath portal, and simplifying the Blackheath interchange and associated improved driver-safety outcomes

- ongoing consideration of two potential tunnel ventilation options. The use of portal emissions instead of ventilation outlets (if identified as the preferred option) would require less construction materials, minimise visual impacts and improve sustainability outcomes given the lower resource use and operational energy consumption of this option.

Further information regarding design refinements aimed at minimising biophysical, economic and social impacts is provided in Table 3-13 of Chapter 3 (Project alternatives and options). Strategic alternatives and project options were also informed by the outcomes of community and stakeholder engagement. The project would continue to be refined as part of ongoing design development and where relevant, in response to feedback from the community and other stakeholders. A summary of the key issues raised during community consultation and where these issues are addressed in the EIS is provided in Appendix C (Community engagement).

Project benefits

While the project would have some unavoidable impacts (see Section 25.3), the project would deliver substantial benefits and opportunities including:

- improved economic development, productivity, and recovery – during the first ten years of operation, the project would contribute up to around $10 million per year in net output for the regional area (refer to Chapter 20 (Business, land use and property)) and would create a faster, safer, and more efficient freight connection between Blackheath and Little Hartley. During construction, the project would create up to 1,100 jobs and is expected to contribute around $130 million per year to the regional economy
- improved resilience and future-proofing – the project would provide an alternative route to the current Great Western Highway between Blackheath and Little Hartley and would improve access for emergency vehicles in the event of an incident. It would also assist in minimising broader traffic delays and disruptions that may be caused by an incident. The project has been designed to improve the level of service for predicted traffic volumes in future years with scope to accommodate future growth
- improved network performance – the project would reduce light vehicle travel times between Blackheath and Little Hartley by around nine minutes, and heavy vehicle travel times by around nine minutes during the weekday AM peak hour period. The project would also provide a connection for high productivity vehicles longer than 20 metres (with an upper limit of 36 metres) between Blackheath and Little Hartley, contributing to a total reduction in the current route for these vehicles by up to 100 kilometres between Sydney and Central West NSW. The project would substantially reduce traffic on the existing Great Western Highway between Blackheath and Little Hartley improving travel time, speeds and safety on this part of the route
- safety improvements – the project would provide a safer alternative to the current steep grades, limited overtaking opportunities and at-grade intersections along sections of the Great Western Highway between Blackheath and Little Hartley. The project would provide a bypass route for heavy vehicles, avoiding local townships and two school zones and allowing separation of through and freight traffic from local and tourist traffic
- movement, place, and amenity improvements – the project would result in improved amenity for residents of Blackheath and Mount Victoria due to a substantial reduction in traffic and associated reductions in traffic noise and vehicle emissions for around 2,000 residents along the existing Great Western Highway. The project would also incorporate urban design principles as described in Chapter 4 (Project description) and create potential opportunities for placemaking initiatives by reducing through traffic, including freight vehicles, at key locations along the Great Western Highway, particularly at Blackheath and Mount Victoria. These placemaking opportunities are consistent with the Movement and Place Framework (NSW Government, 2020a) adopted by Transport for the Upgrade Program.

In addition, the project (as part of the Great Western Highway Upgrade Program – Katoomba to Lithgow (the Upgrade Program)) would also present socio-economic opportunities, including:

- improving connections between the national high productivity vehicle network and Sydney
- strengthening supply chains due to better access to regions
- improving access to employment opportunities and services.

A summary of how the project meets the project objectives using a traffic light rating system to demonstrate strong alignment (green), some or neutral alignment (yellow) or limited or no alignment (red) is provided in Table 25-1. Further information is provided in Chapter 3 (Project alternatives and options).

Table 25-1 Performance of the project against the project objectives

Objective	How the project option performed against the objective	Rating
Economic development	• would provide additional transport capacity across the Blue Mountains and enhances the connection of the regions • would improve freight accessibility by providing access for B-doubles and Performance Based Standards level 2 vehicles up to 36 metres long • would help to address the predicted 30 per cent rise in truck volumes on the Great Western Highway by 2036 (Transport for NSW, 2021d).	Green
Resilience	• would enable improved resilience through additional lanes which would enable increased road capacity and safety opportunities, allowing essential services better access to the area during vehicle incidents or extreme weather events • would provide an alternative route for transport and essential services between Blackheath and Little Hartley, in the event of road closure along the Great Western Highway.	Green
Transport network performance	• would provide additional transport capacity by reducing current traffic queues for both private and commercial vehicles on the Great Western Highway which can be up to eight kilometres in length and incur delays of up to 80 minutes in peak periods (Transport for NSW, 2021d). This option would reduce congestion due to freight movement and weekend and peak holiday traffic to a greater extent than the Blackheath and Mount Victoria tunnel bypasses option • would not provide the same level of local connectivity as the Blackheath and Mount Victoria tunnel bypasses option • would allow opportunities for overtaking, currently not available in certain areas where there is a single lane arrangement in each direction, such as through Victoria Pass • would positively impact the local surface road network performance between Blackheath and Little Hartley, given through traffic would likely utilise the tunnel infrastructure.	Green

Objective	How the project option performed against the objective	Rating
Safety	• would improve safety of the corridor for road transport users by providing additional traffic lanes, reducing congestion • would separate through (freight) traffic travelling at higher speeds, more likely to use the tunnel, and local traffic likely to use the existing Great Western Highway • would improve the safety of the road corridor at Victoria Pass by bypassing steep grades and tight curves on the current highway alignment • would have improved in-tunnel gradient which would allow for a more consistent travel speed and lower speed differentials between the surface road and in-tunnel road networks as compared with the Blackheath and Mount Victoria tunnel bypasses option.	●
Environment	• would require the least surface property acquisition of all options except the do minimum option, given the majority of the duplicated road network would be located underground • would require less native vegetation removal than the Blackheath and Mount Victoria tunnel bypasses, given vegetation removal would be required at two portal locations and a reduced number of associated construction sites • would reduce amenity impacts for local residents and businesses, such as noise, vibration, visual impacts, given the predominantly underground nature of the option • would minimise impacts to groundwater dependent ecosystems as compared to the Blackheath and Mount Victoria tunnel bypasses option due to deeper excavation/tunnelling leading to less interaction with the perched aquifers the ecosystems rely on • would result in greater fuel efficiency for tunnel users and less greenhouse gas emissions given the lower in-tunnel gradient • would be generally consistent with stakeholder feedback received indicating preference for tunnel options, further described in Chapter 7 (Community and stakeholder engagement).	●
Value for money	• would result in a slight reduction in vehicle travel times as compared to the Blackheath and Mount Victoria tunnel bypasses option due to reduced tunnel grades • would be slightly more expensive than the Blackheath and Mount Victoria tunnel bypasses option, however this would be value for money given this option would perform better on the above project objectives than all other options including a shorter construction duration, and less construction staging and associated accessibility impacts.	●

25.1.2 Ecologically sustainable development

The project is consistent with the four principles of ecologically sustainable development outlined in the Environmental Planning and Assessment Regulation 2021 (NSW) (EP&A Regulation) as follows:

The precautionary principle

This EIS was prepared adopting an appropriate level of conservativism and includes an assessment of the realistic worst case scenario impacts for a variety of environmental aspects including groundwater and geology, transport and traffic, noise and vibration, air quality, human health and biodiversity technical assessments. A precautionary approach to tunnel emissions alternatives has been adopted in the EIS, with both the ventilation outlet and portal emissions design options assessed for potential air quality and human health impacts. A summary of the key differences in potential impacts for both ventilation options is provided in Table 3-12.

The project has been developed through an environment-led design process whereby preliminary environmental investigations and assessment informed the project alternatives and options analysis to identify opportunities to minimise potential impacts to the sensitive environment of the Blue Mountains (see Section 25.1.1). The precautionary principle would be applied to construction of the project through the implementation of unexpected finds protocols to address unexpected biodiversity, contamination or hazardous materials or heritage finds. The findings of the EIS indicate that there would be no threat of serious or irreversible damage to the environment.

Intergenerational equity

Once operational, the project would be designed to meet needs of both current and future generations and would contribute to an increase in resilience and capacity of the Greater Sydney and Central West transport network. The project would provide long term benefits by improving economic development, productivity, freight accessibility, resilience, and the overall liveability and safety of those in the Blue Mountains, Central West and Orana regions.

Construction of the project has the potential for some degree of environmental and social disturbance largely related to amenity impacts and changes to traffic movements and access. However, the potential for environmental and social disturbance as a result of construction has to be balanced against the long-term benefits of the project overall.

Conservation of biological diversity and ecological integrity

The project has been developed to minimise impacts to areas of high ecological value, including to the Blue Mountains National Park and to groundwater dependent ecosystems by minimising groundwater drawdown through the project tunnelling methodology. Potential indirect and direct impacts may arise during construction, including potential impacts associated with groundwater drawdown and surface water discharges. A Biodiversity Development Assessment Report has been completed to identify potential impacts on biodiversity and a range of mitigation measures for implementation (refer to Appendix H (Technical report – Biodiversity)).

An assessment of the project’s potential impact on threatened species, ecological communities and migratory species (as discussed in Chapter 12 (Biodiversity), as well as the Greater Blue Mountains World Heritage Area (as discussed in Chapter 17 (Non-Aboriginal heritage) found that the project’s level of impact on Matters of National Environmental Significance (MNES) is not significant. Transport has lodged a referral with the Department of Climate Change, Energy, the Environment and Water (DCCEEW) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). DCCEEW is currently considering the referral and has not yet advised on whether the project constitutes a controlled action under the EPBC Act.

Improved valuation, pricing and incentive mechanisms

The value placed on the environment was inherent in the development of the design. In addition, the costs associated with the planning and design of measures to avoid and minimise adverse environmental impacts and the costs to implement these have been considered in the overall project costs.

25.2 Objects of the Environmental Planning and Assessment Act 1979

Consideration of the project against the objects of the *Environmental Planning and Assessment Act 1979* (EP&A Act) is provided in Table 25-2.

Table 25-2 Objects of the *Environmental Planning and Assessment Act 1979*

EP&A Act objects	Project attributes
To promote the social and economic welfare of the community and a better environment by the proper management, development and conservation of the State's natural and other resources	The project has been designed to minimise impacts on the environment where possible including the need for land acquisition. The project has also minimised impacts on existing development and local communities by locating the majority of the project underground and minimising surface disturbance. The project has been designed to conserve the State's natural and other resources, such as the Blue Mountains National Park and Greater Blue Mountains World Heritage Area. During construction and operation of the project, opportunities would be taken to reduce material use and maximise the use of materials with low embodied environmental impact, where practical.
To facilitate ecologically sustainable development by integrating relevant economic, environmental and social considerations in decision-making about environmental planning and assessment	The project is consistent with the principles of ecologically sustainable development as outlined in Section 25.1.2.
To promote the orderly and economic use and development of land	The project has been designed to: • provide improved efficiency of the road network, including for freight and commercial users, resulting in economic benefits for NSW • provide a safer alternative to the existing steep grades along sections of the Great Western Highway between Blackheath and Little Hartley, particularly at Victoria Pass • minimise impacts to the surrounding natural and built environments where possible, for example by adopting a tunnel design that minimises surface impacts, and integrating design features such as tunnel portals and ventilation facilities, into the existing road corridors as far as practical • integrate with, and thereby minimise disruption to, existing development and other projects, such as other components of the Upgrade Program.
To promote the delivery and maintenance of affordable housing	Not applicable to this project.

EP&A Act objects	Project attributes
To protect the environment, including the conservation of threatened and other species of native animals and plants, ecological communities and their habitats	Direct impacts to terrestrial biodiversity would be minimised by adopting a long tunnel design and minimising surface impacts, including minimising surface construction site requirements, adopting a TBM construction method that limits groundwater ingress and related groundwater drawdown impacts, including to groundwater dependent ecosystems (refer to Chapter 3 (Project alternatives and options)). The project's impacts on terrestrial and aquatic ecology have been assessed in detail and measures to avoid, mitigate, and offset potential impacts on native animals, plants and ecological communities have been developed (refer to Chapter 12 (Biodiversity)).
To promote the sustainable management of built and cultural heritage (including Aboriginal cultural heritage)	Design development has included a focus on avoiding or minimising potential Aboriginal and non-Aboriginal heritage impacts. This has included selection of a long tunnel option and where possible selecting construction sites that minimise potential direct impacts to heritage items and potential archaeological sites (refer to Chapter 3 (Project alternatives and options)). The project has avoided direct impacts to Greater Blue Mountains World Heritage Area and has minimised indirect impacts including potential visual impacts, noise and vibration and air quality impacts. The project would respond to the Designing with Country (Government Architect NSW, 2020a) and Connecting with Country (Government Architect NSW, 2020b) frameworks (refer to Chapter 4 (Project description). Consultation has been carried out with Aboriginal knowledge holders whose lands traverse the project to appropriately respect and integrate Aboriginal culture and heritage into the design including themes such as nature and people.

EP&A Act objects	Project attributes
To promote good design and amenity of the built environment	The project would provide improved access and connectivity through improved travel times and improved travel time reliability for local and regional motorists. The project would also improve the amenity of the local area by separating local and tourist traffic from through traffic for the townships of Blackheath and Mount Victoria. The forecast substantial reduction of surface traffic from the Great Western Highway is expected to result in an overall improvement in noise levels and general amenity within the communities of Blackheath and Mount Victoria, when compared with the existing situation. There would be ongoing investigations in consultation with relevant stakeholders and councils regarding opportunities for placemaking initiatives that may be realised due to a reduction in surface traffic volumes as a result of the project in accordance with the Movement and Place Framework (NSW Government, 2020a), particularly at Blackheath and Mount Victoria. Two options for tunnel ventilation are currently being investigated (ventilation outlets and portal emissions), with the design of the project able to accommodate both options. The urban design objectives developed for the project drive the ongoing design development outcomes in accordance with key urban design guidelines and policies including Better Placed (Government Architect NSW, 2017), Beyond the Pavement (Transport for NSW, 2020b) and Tunnel Urban Design Guidelines (Roads and Maritime Services, 2017).
To promote the proper construction and maintenance of buildings, including the protection of the health and safety of their occupants	The construction of the project, including associated buildings for operational ancillary infrastructure, would be completed in line with the applicable Australian and international safety standards and guidelines.
To promote the sharing of the responsibility for environmental planning between the different levels of government in the State	The responsibility for environmental planning and approval in relation to the project rests primarily with the NSW Government. No formal approval role is required by local government however, consultation has been carried out with the relevant local councils and government agencies throughout the development of the project and the preparation of this EIS and consultation would continue as part of the project development process. As outlined in Section 25.1.2, the project would not have a significant impact on MNES. Transport has lodged a referral with DCCEEW under the EPBC Act. DCCEEW is currently considering the referral and has not yet advised on whether the project constitutes a controlled action under the EPBC Act.

EP&A Act objects	Project attributes
To provide increased opportunity for community participation in environmental planning and assessment	Consultation has been carried out through all stages of project development, with targeted community consultation undertaken in 2019 when the preferred strategic corridor for the Upgrade Program was placed on public display. The Blackheath Co-design Committee was established in early 2020 to enable close collaboration with local stakeholders and community representatives. The Blackheath Co-design Committee's feedback was a key input into the decision-making process for a preferred route option and design through Blackheath. Further community consultation was undertaken in early 2022 for the preferred option. This included targeted surveys carried out at businesses and residences at Blackheath, Mount Victoria and Little Hartley to support the social impact assessment and business assessment for the EIS. Community feedback has been considered at each stage of the project development process to inform the selection of the preferred corridor and subsequent design options and refinements (refer to Chapter 7 (Community and stakeholder engagement)). Community consultation would continue through public exhibition of this EIS and during further design development and construction, subject to approval.

25.3 Conclusion

This EIS addresses the key issues identified in the Secretary's environmental assessment requirements issued under Division 5.2 of the EP&A Act and the relevant provisions of Part 8 of the EP&A Regulation.

As a component of the Upgrade Program, the project would support regional and economic development by providing a more efficient link between Central West NSW and the Sydney motorway network, as well as delivering improved safety conditions and travel times for freight, tourist and general traffic. In particular, the project would result in amenity improvements to residents of Blackheath and Mount Victoria, safety and network improvements. The project would promote network resilience and future proofing by providing an alternative route to the current Great Western Highway alignment between Blackheath and Little Hartley and improving access for emergency vehicles in the event of an incident. The project has also been designed to improve the level of service for predicted traffic volumes in future years with scope to accommodate future growth, and would promote economic development, productivity and recovery.

As discussed in Chapter 3 (Project alternatives and options), the merits of the project were considered in the context of a range of other alternatives and options, including a do nothing option, based on the extent to which they could meet the project objectives and how well they performed with reference to other transport, environmental, engineering, social and economic factors. The do nothing alternative would not address the limited overtaking opportunities, steep grades and lengthy travel times on the Great Western Highway, resulting in the road safety issues, considerable delays and congestion, freight inefficiencies and vulnerability to closure that the existing Great Western Highway experiences. Other alternatives considered would not satisfy the needs and objectives as effectively as the project.

Key environmental issues have been examined throughout the design development process. Consultation has been carried out with the community and relevant stakeholders during the assessment process with key potential environmental impacts identified at an early stage, and where possible, avoided or minimised through appropriate design refinement and mitigation. This has resulted in an iterative design development process to manage potential impacts.

As for any major infrastructure project of this scale, there are likely to be residual impacts. Designing the project to be mainly underground has substantially reduced potential impacts and largely confined impacts to the construction stage. The project would be subject to ongoing investigations and design development in consultation with relevant stakeholders and the community and seek to further minimise potential impacts.

Key impacts during construction of the project would include:

- temporary road network performance impacts during construction including relatively minor and manageable increases in traffic volumes and weekday peak hour travel times
- temporary air quality and noise and vibration impacts where sensitive receivers are located within proximity to construction activities at Blackheath and Little Hartley
- removal of native vegetation, hollow-bearing trees and habitat for threatened fauna species
- potential reduction in baseflow to Greaves Creek as a result of groundwater drawdown potentially impacting plant community types associated with groundwater dependent ecosystems
- potential impacts to one unlisted but nominated heritage site (Greater Blue Mountains Area – Additional Values), two potential archaeological sites during construction (Mount Victoria Stockade and Plough Inn) and one heritage item during operation (Rosedale)
- temporary visual impacts from construction elements and activities.

Potential impacts during operation of the project would include:

- a negligible increase in air pollutant concentrations around the tunnel portals for both ventilation design options
- a reduction in road traffic noise at around 2,000 receivers along the existing Great Western Highway between Little Hartley and Blackheath and increased road traffic and facilities noise at some receivers
- potential reduction in baseflow to Greaves Creek as a result of groundwater drawdown potentially impacting plant community types associated with groundwater dependent ecosystems
- visual impacts and change in landscape character with the introduction of tunnel portals, ventilation outlets (if identified as the preferred option) and other operational infrastructure.

With the effective implementation of identified environmental mitigation measures, the potential residual environmental impacts of the project are considered manageable, and the project would be in the public interest.

26 References and terminology

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26.2 Glossary of terms and abbreviations

26.2.1 Terms

Term	Definition
active transport	Collective term for walking and cycling
acute or short-term exposure	Contact with a substance that occurs only once or for a short period of time, typically an hour or less, but may be up to 14 days
adverse health effect	A change in body function or cell structure that might lead to disease or health problems
Air Quality Criteria	Refers to the ambient air quality criteria set by the NSW EPA used to assess predicted ground level pollutant concentrations under the Approved Methods for Modelling and Assessment of Air Pollutants in NSW
AM peak hour	Trips travelling on the road network defined in Appendix D (Technical report – Transport and traffic)
ambient noise	The all-encompassing noise at a point composed of sound from all sources near and far

Term	Definition
amenity	Refers to the quality of a place, its appearance, feel and sound, and the way the community experiences the place. Amenity contributes to a community's identity and its sense of place. Aesthetic qualities are an important part of amenity, but the broader concept of amenity is determined also by the physical design of a place and the human activity that takes place within it. A place that has 'amenity' is regarded as pleasant and attractive, as well as convenient and comfortable
Approved Methods (air quality)	Approved Methods for Modelling and Assessment of Air Pollutants in NSW 2017
background concentration (air quality)	Describes all contributing sources of a pollutant concentration other than road traffic. It includes, for example, contributions from natural sources, industry and domestic activity
background noise	The underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed. The L90 sound pressure level is used to quantify background noise
biodiversity offsets	The gain in biodiversity values achieved from the implementation of management actions on areas of land, to compensate for losses to biodiversity values from the impacts of development
Blackheath Co-Design Committee	A project working group comprising representatives from Transport for NSW, key stakeholders, the community, Blue Mountains City Council and emergency services
capacity	The nominal maximum number of vehicles which has a reasonable expectation of passing over a given section of a lane or roadway in one direction during a given time period under prevailing roadway conditions
carcinogen	A substance that causes cancer
chronic or long-term exposure	Contact with a substance that occurs repeatedly over a long time, with the USEPA indicating defining this as exposures that occur for more than approximately 10% of a lifetime, Exposures that occur for less than 10% of a lifespan are considered sub-chronic
climate change	A change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer
construction fatigue	An impact that may be experienced by receivers that are in the vicinity of concurrent or consecutive project construction activities where the activities overlap or have little or no break between the activities of one project, or multiple adjacent projects
construction footprint	The total extent of surface disturbance areas required for the construction of the project, including construction and operational ancillary facilities and land temporarily required for construction
corridor	A substantial segment of the transport network, in which parallel, possibly competing, transport routes (and modes, where appropriate) operate between two locations

Term	Definition
cumulative (human health)	Total exposure, used in the health impact assessment to refer to exposures that include the background plus project, or to multiple different sources from the project
cut-and-cover	A method of tunnel construction whereby the structure is built in an open excavation and subsequently covered
day (noise)	Construction noise: • the period from 7am to 6pm Monday to Saturday and 8am to 6pm Sundays and Public Holidays Road traffic noise: • the period from 7am to 10pm every day of the week
direct impact (biodiversity)	Direct impacts on biodiversity values include those related to clearing native vegetation and threatened species habitat, and impacts on biodiversity values prescribed by the Biodiversity Conservation Regulation 2017 (NSW)
drained	Describing structures that groundwater can enter to lower the groundwater level adjacent the structure
drawdown	Reduction in the level of the water table caused by changes in the local environment
earthworks	Operations involved in loosening, excavating, placing, shaping and compacting soil or rock
ecosystem credits	A measurement of the value of threatened ecological communities, threatened species habitat for species that can be reliably predicted to occur with a plant community type (PCT), and PCTs generally. Ecosystem credits measure the loss in biodiversity values at a development, activity, clearing or biodiversity certification site and the gain in biodiversity values at a biodiversity stewardship site
emission factor	A quantity which expresses the mass of a pollutant emitted per unit or activity
erosion	A natural process where wind or water detaches a soil particle and provides energy to move the particle
evening (noise)	Construction noise: • the period from 6pm to 10pm Monday to Sunday and Public Holidays Road traffic noise: • not applicable
exposure (human health)	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure)
flood prone land	Land susceptible to flooding by the probable maximum flood (also referred to as flood liable land)
floodplain	Area of land which is inundated by floods up to and including the probable maximum flood event (i.e., flood prone land)

Term	Definition
Great Western Highway	Major east to west arterial road between Sydney and Bathurst
greenhouse gas	Gaseous constituents of the atmosphere that absorb and emit infra-red radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This radiation generates heat which warms the atmosphere, and therefore greenhouse gases are a key contributor to the changing climate
groundwater dependent ecosystem	Communities of plants, animals and other organisms whose extent and life process are dependent on groundwater, such as wetlands and vegetation on coastal sand dunes
habitat	An area or areas occupied, or periodically or occasionally occupied, by a species, population or ecological community, including any biotic or abiotic component
heavy vehicles	A heavy vehicle is classified as a Class 3 vehicle (a two-axle truck) or larger, in accordance with the Austroads Vehicle Classification System
impact	Influence or effect exerted by a project or other activity on the natural, built and community environment
indirect impact	Impacts that occur when the project affects native vegetation and threatened species habitat beyond the subject land or within retained areas (e.g., transporting weeds or pathogens, dumping rubbish). This includes impacts from activities related to the construction or operational phase of the project and prescribed impacts
inhalation (human health)	The act of breathing. A hazardous substance can enter the body this way
Katoomba to Blackheath Upgrade	Great Western Highway East – Katoomba to Blackheath Upgrade. Part of the Great Western Highway Upgrade Program
lane	A portion of the carriageway allotted for the use of a single line of vehicles
Little Hartley to Lithgow Upgrade	Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section). Part of the Great Western Highway Upgrade Program
Medlow Bath Upgrade	Great Western Highway – Medlow Bath. Part of the Great Western Highway Upgrade Program
Matter of National Environmental Significance	A matter of national environmental significance (MNES) is any of the nine defined components protected by a provision of Part 3 of the EPBC Act
microns	Unit of length equal to one millionth of a metre
mid-block	The section of road between two intersections
mitigation	Actions or measures to avoid or reduce the impacts of a project

Term	Definition
morbidity	A diseased condition or state or the incidence or prevalence of disease in a population
mortality	Death, which may occur as a result of a range of reasons or diseases
night (noise)	Construction noise: • the period from 10pm to 7am Monday to Saturday and 10pm to 8am Sundays and Public Holidays Road traffic noise: • the period from 10pm to 7am every day of the week
peak flood level	The maximum water level occurring during a flood event
peak flood velocity	The maximum velocity of the water in flooding at any given location
placemaking	Describes an approach to the planning, design and management of public spaces
PM peak hour	Trips travelling on the road network defined in Appendix D (Technical report – Transport and traffic)
population	A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age)
population (biodiversity)	A group of organisms, all of the same species, occupying a particular area
portal emissions option	One of two tunnel ventilation options being considered for the project. This option would involve tunnel emissions being dispersed via the tunnel portals
prescribed impacts	The prescribed impacts identified in Clause 6.1 of the Biodiversity Conservation (BC) Regulation. Prescribed impacts can be direct or indirect impacts
the project	Upgrade of the Great Western Highway between Blackheath and Little Hartley
project impact criteria	Air quality impact criteria developed specifically for the project and endorsed by Advisory Committee on Tunnel Air Quality (ACTAQ). The criteria are listed in Appendix E (Technical report – Air quality)
proponent	For the purpose of the project, the proponent is Transport for NSW
residual impacts	Impacts of the project that remain after mitigation measures are implemented
residual land	Land that would be wholly or partially occupied during construction of the project, but would not be required for permanent operational infrastructure or other operational activities
risk	The probability that something would cause injury or harm
runoff	the amount of rainfall that ends up as streamflow, also known as rainfall excess

Term	Definition
Scope 1 emissions	Direct emissions: greenhouse gas emissions generated by sources owned or controlled by the project, for example emissions generated by the use of diesel fuel in project-owned construction plant, equipment or vehicles
Scope 2 emissions	Indirect emissions: greenhouse gas emissions from the consumption of purchased electricity in project-owned or controlled equipment or operations. These greenhouse gas emissions are generated outside the project's boundaries, for example the use of electricity purchased from the grid
Scope 3 emissions	Indirect upstream/downstream emissions: greenhouse gas emissions generated in the wider economy due to third party supply chains and road users as a consequence of activity within the boundary of the project, for example greenhouse gas emissions associated with the mining, production and transport of materials used in construction (referred to as the embodied energy of a material)
sensitive receiver	Includes residences, educational institutions (including preschools, schools, universities, TAFE colleges), health care facilities (including nursing homes, hospitals), religious facilities (including churches), child care centres, passive recreation areas (including outdoor grounds used for teaching), active recreation areas (including parks and sports grounds), commercial premises (including film and television studios, research facilities, entertainment spaces, temporary accommodation such as caravan parks and camping grounds, restaurants, office premises, retail spaces and industrial premises)
settlement or ground movement	Refers to how ground can move due to the construction of new infrastructure
serious and irreversible impact	Impacts likely to contribute significantly to the risk of a threatened species or ecological community becoming extinct in accordance with the principles set out in Clause 6.7(2) of the BC regulation
social infrastructure	Infrastructure assets that deliver social services and other community uses, including schools, hospitals, childcare centres, libraries, and sport and recreation facilities. The term can also be used to broadly encompass the networks of facilities, places, spaces, programs, projects, and services that sustain a communities' quality of life and wellbeing
sound power level	The total sound emitted by a source
species credits	The class of biodiversity credits created or required for the impact on threatened species that cannot be reliably predicted to use an area of land based on habitat surrogates. Species that require species credits are listed in the Threatened Biodiversity Data Collection
standard construction hours	7am to 6pm Monday to Friday, 8am to 1pm Saturdays, and no work on Sundays or public holidays
stockpile	Temporary stored materials such as soil, sand, gravel, spoil/waste

Term	Definition
study area	Based on the project design to be assessed in the EIS, each technical discipline has defined a study area based on the project footprint and a suitable buffer area
substratum acquisition	The acquisition of land below the surface of the ground
traffic noise	The total noise resulting from road traffic. The Leq sound pressure level is used to quantify traffic noise
Transport	Transport for NSW
the Upgrade Program	The Upgrade Program consists of: • Great Western Highway Upgrade – Medlow Bath (Medlow Bath Upgrade): upgrade and duplication of the existing surface road corridor with intersection improvements and a new pedestrian bridge • Great Western Highway East – Katoomba to Blackheath (Katoomba to Blackheath Upgrade): upgrade, duplication and widening of the existing surface road corridor, with connections to the existing Great Western Highway east of Blackheath • Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade): upgrade, duplication and widening of the existing surface road corridor, with connections to the existing Great Western Highway at Little Hartley • Great Western Highway Blackheath to Little Hartley: construction and operation of a twin tunnel bypass of Blackheath and Mount Victoria and surface road works for tie-ins to the east and west of the tunnel (the project)
undrained	Describing structures that do not let in groundwater either by cut-off or waterproofing, thereby limiting groundwater drawdown in the aquifer surrounding the structure
ventilation outlet option	One of two tunnel ventilation options being considered for the project. This option would include a ventilation building and ventilation outlet near the tunnel portals at Blackheath and at Little Hartley
waste hierarchy	Approach of prioritising waste avoidance and resource recovery (including reuse, reprocessing, recycling and energy recover) before consideration of waste disposal

26.2.2 Abbreviations

Abbreviation	Definition
ABS	Australian Bureau of Statistics
ACHAR	Aboriginal Cultural Heritage Assessment Report
ACTAQ	Advisory Committee on Tunnel Air Quality
AEI	Areas of environmental interest
AEP	Annual exceedance probability

Abbreviation	Definition
AHD	Aboriginal Heritage Database
AHIP	Aboriginal Heritage Impact Permit
AHIMS	Aboriginal Heritage Information Management System
AHMP	Aboriginal Heritage Management Plan
AIP	Aquifer Interference Policy
ASR	Acid sulfate rock
ASRMP	Acid sulfate rock management plan
ASSMP	Acid sulfate soils management plan
AQIA	Air quality impact assessment
AQMS	Air quality monitoring station
BAM	Biodiversity Assessment Method
BC Act	*Biodiversity Conservation Act 2016* (NSW)
BC Regulation	Biodiversity Conservation Regulation 2017 (NSW)
BCC	Blackheath Co-Design Committee
BDAR	Biodiversity Development Assessment Report
BoM	Bureau of Meteorology
BTEXN	Benzene, toluene, ethylbenzene, xylenes and naphthalene
CBD	Central Business District
CCTV	Closed Circuit Television
CEMP	Construction Environmental Management Plan - A site specific plan developed for the construction phase to ensure that all contractors and sub-contractors comply with the environmental conditions of approval and that the environmental risks are properly managed
CNVMP	Construction Noise and Vibration Management Plan
CTAMP	Construction Transport and Access Management Plan
CWMP	Construction Waste Management Plan
CO	Carbon monoxide
CO_2	Carbon dioxide
CoPC	Contaminants of potential concern

Abbreviation	Definition
dB	Decibel. A logarithmic scale is used to describe the level of sound, referenced to a standard level. It is widely accepted that a 3dB change in traffic noise levels (of the same character) is barely, if at all detectable; whereas a change of 5 dB is clearly noticeable. A 10 dB increase is typically considered to sound twice as loud (noting a change of -10 dB would typically sound half as loud)
dB(A)	A-weighted decibels. The A weighting is a frequency filter applied to measured noise levels to represent how the human ear hears sounds. Adjustments are applied between 10Hz and 20 kHz. When an overall sound level is A-weighted it is expressed in units of dB(A) or dBA
DECCW	Department of Environment, Climate Change and Water
DPE	NSW Department of Planning and Environment
DPE Water	NSW Department of Planning and Environment Water
DPI	Department of Primary Industries
DPM	Diesel particulate matter
EIS	Environmental impact statement
EPA	NSW Environmental Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW). Provides the legislative framework for land use planning and development assessment in NSW
EP&A Regulation	Environmental Planning and Assessment Regulation 2000 (NSW)
EPBC Act	*Environment Protection and Biodiversity Act 1999* (Commonwealth)
EPL	Environment Protection Licence
FM Act	*Fisheries Management Act 1994* (NSW)
GDE	Groundwater dependent ecosystem
GRAMM	Graz Mesoscale Model
GRAL	Graz Lagrangian Model
ha	Hectares
IAQM	Institute of Air Quality Management
ICNG	Interim Construction Noise Guideline
INSW	Infrastructure New South Wales
IRSD	Index of Relative Socio-economic Disadvantage. The IRSD is a general socio-economic index that summarises a range of information about the socioeconomic condition of people and households within an area and provides an indicator of the relative disadvantage or lack of disadvantage within a population

Abbreviation	Definition
ITS	Intelligent Transport Systems
KTP	Key Threatening Process
LALC	Local Aboriginal Land Council
LCZ	Landscape character zone
Leq	Equivalent continuous sound level. The constant sound level which, when occurring over the same period of time, would result in the receiver experiencing the same amount of sound energy
LGA	Local Government Area
Lmax	The maximum sound pressure level measured over the measurement period
Lmin	The minimum sound pressure level measured over the measurement period
LoS	Level of service. A qualitative measure describing operational conditions within a traffic stream and their perception by motorists and/or passengers
m	Metres
m AHD	Metres Australian Height Datum
mg/m^3	Milligrams per cubic metre
microns	Unit of length equal to one millionth of a metre
MNES	Matter of National Environmental Significance
m/s	Metres per second
m^3/s	Cubic metres per second
NCA	Noise catchment area
NEPC	National Environment Protection Council
NHL	National Heritage List
NO	Nitrogen oxide
NorBE	Neutral or beneficial effect on water quality
NO_2	Nitrogen dioxide
NML	Noise management level
NSW	New South Wales
O_3	Ozone
OCPs	Organochlorine pesticides
OEMP	Operational environmental management plan

Abbreviation	Definition
OPPs	Organophosphorus pesticides
PACHCI	Procedure for Aboriginal Cultural Heritage Consultation and Investigation
PAHs	Polycyclic aromatic hydrocarbons
PA system	Public address system
PBS	Performance based standards
PCBs	Polychlorinated biphenyls
PCT	Plant community type
PFAS	Per- and poly-fluoroalkyl substances
PM	Particulate matter
PMF	Probable maximum flood
$PM_{2.5}$	Particulate matter equal to or less than 2.5 microns in diameter
PM_{10}	Particulate matter equal to or less than 10 microns in diameter
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
ppm	Parts per million
PVC	Polyvinyl chloride
RAP	Registered Aboriginal Party
RBL	Rating background level. The overall background level for each day, evening and night period for the entire length of noise monitoring
SAII	Serious and irreversible impact
SEARs	Secretary's environmental assessment requirements
SEPP	State environmental planning policy
SHR	State Heritage Register
SIDRA	Modelling software used to assess intersection performance
SSI	State significant infrastructure
SVOCs	Semi-volatile organic compounds
TBM	Tunnel boring machine
tCO2-e	Tonnes of carbon dioxide equivalent
TEC	Threatened ecological community
THPSS	Temperate Highland Peat Swamps on Sandstone

Abbreviation	Definition
TPH	Total petroleum hydrocarbons
TRH	Total recoverable hydrocarbons
USEPA	Unites States Environmental Protection Agency
VENM	Virgin excavated natural material
VHT	vehicle hours travelled
VIC EPA	Victoria Environment Protection Authority
VKT	Vehicle kilometres travelled
VMS	Variable message sign
VOCs	Volatile organic compounds
WHL	World Heritage List
WHO	World Health Organisation
UK	United Kingdom
$\mu g/m^3$	Micrograms per cubic metre