Chapter 5
Construction

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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.

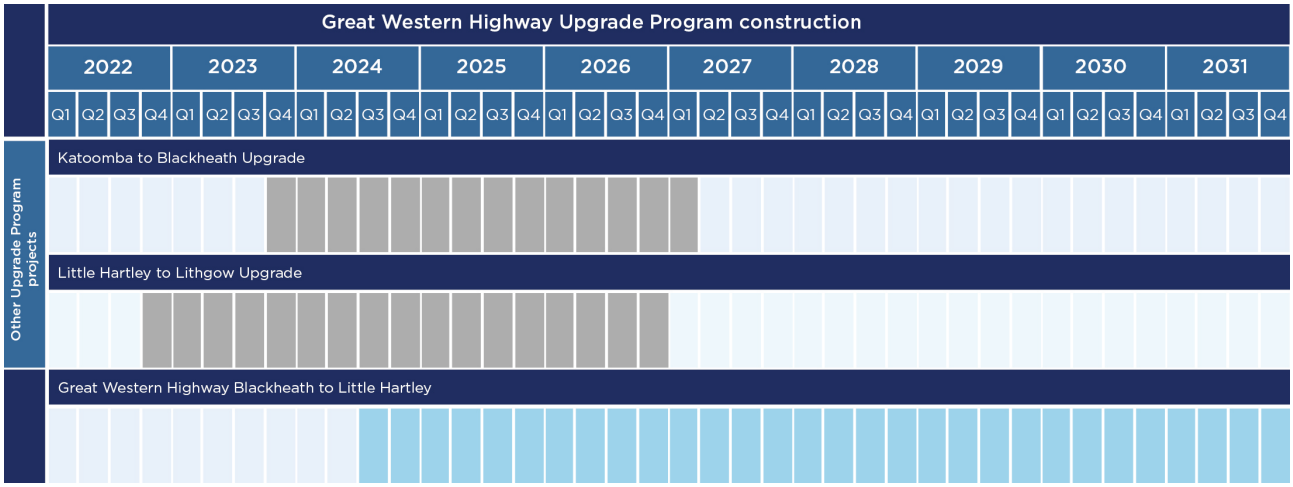
5.2 Construction program

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.

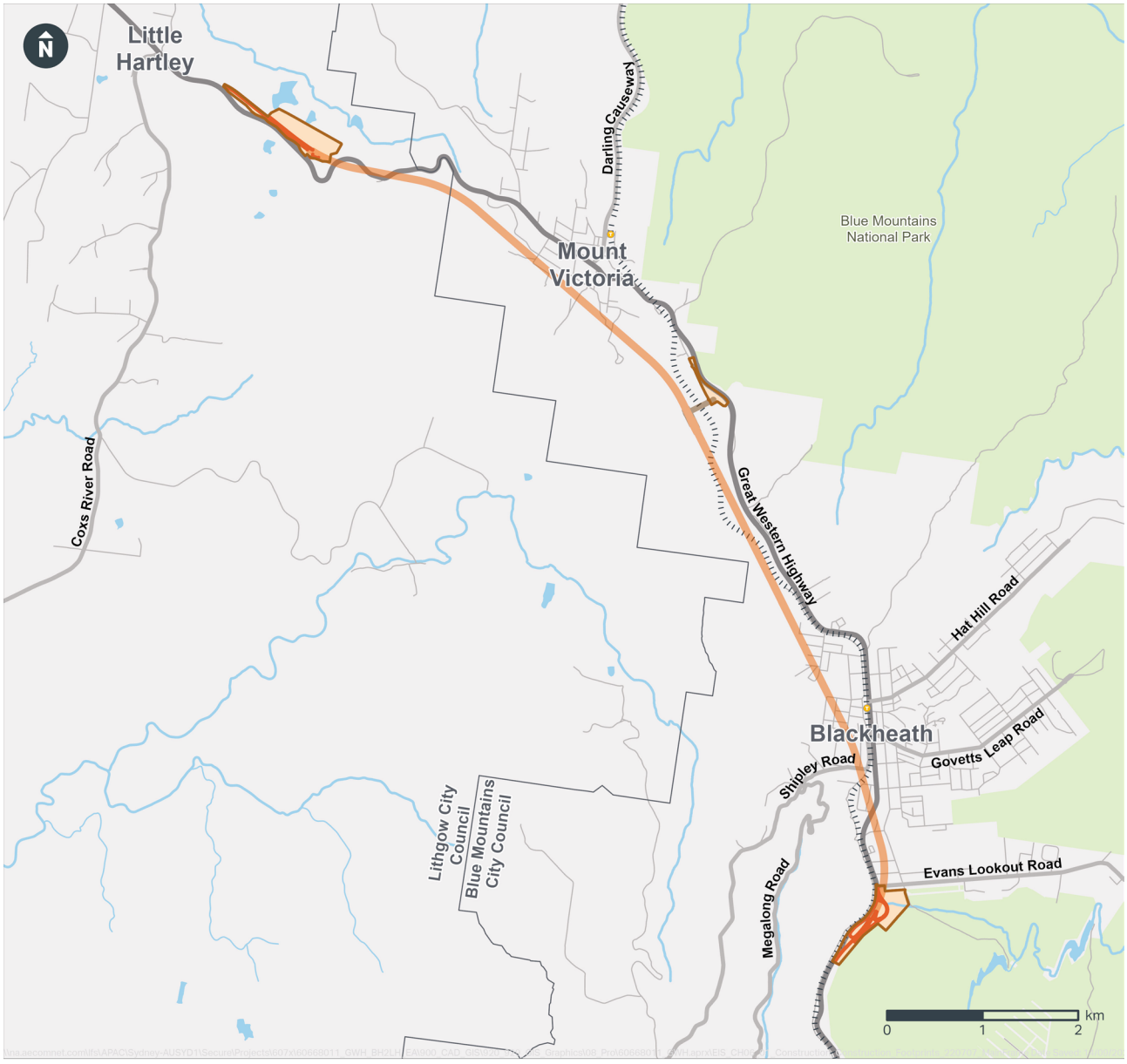


Figure 5-1 Construction footprint

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.

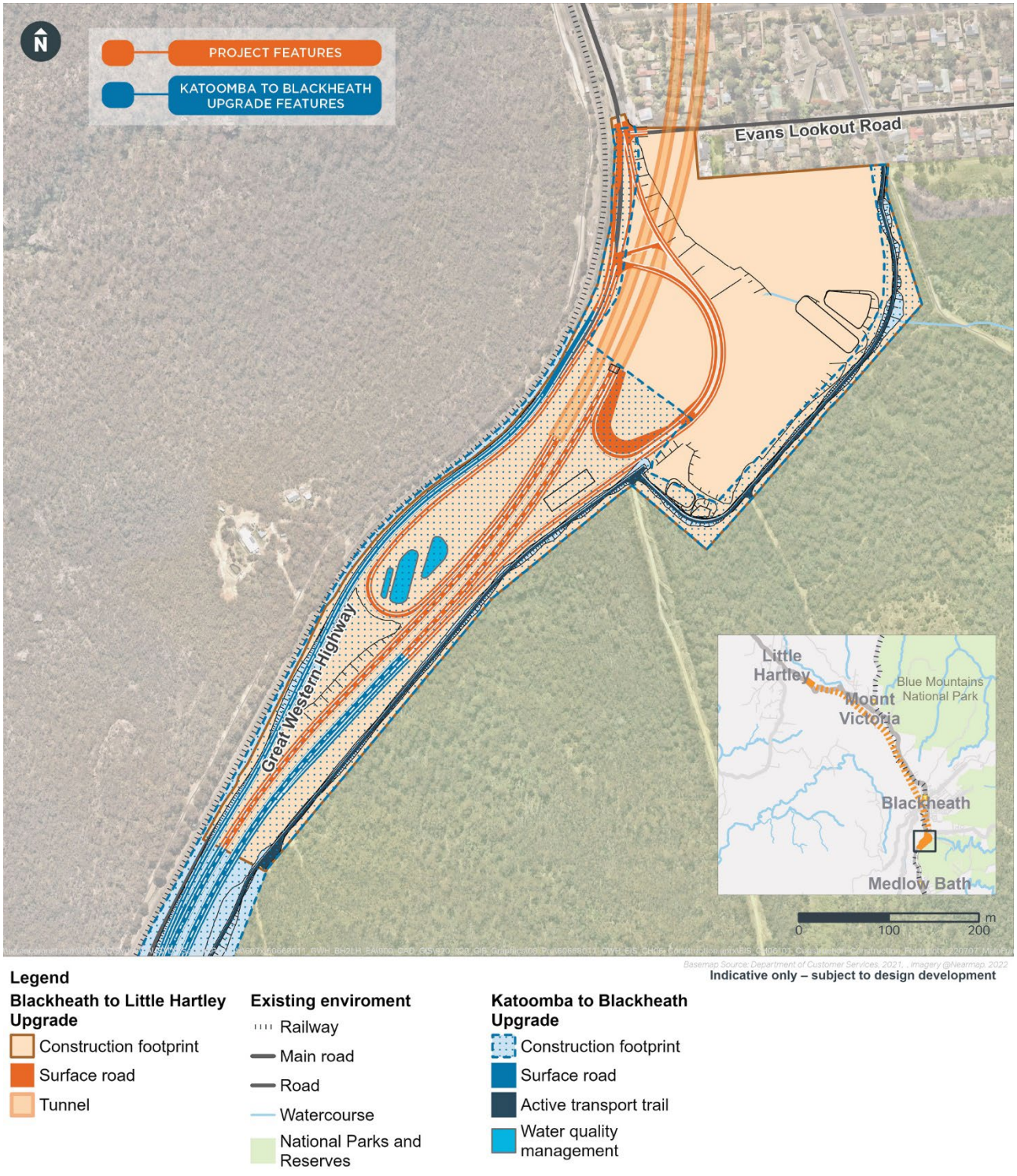


Figure 5-2 Indicative construction footprint at Blackheath

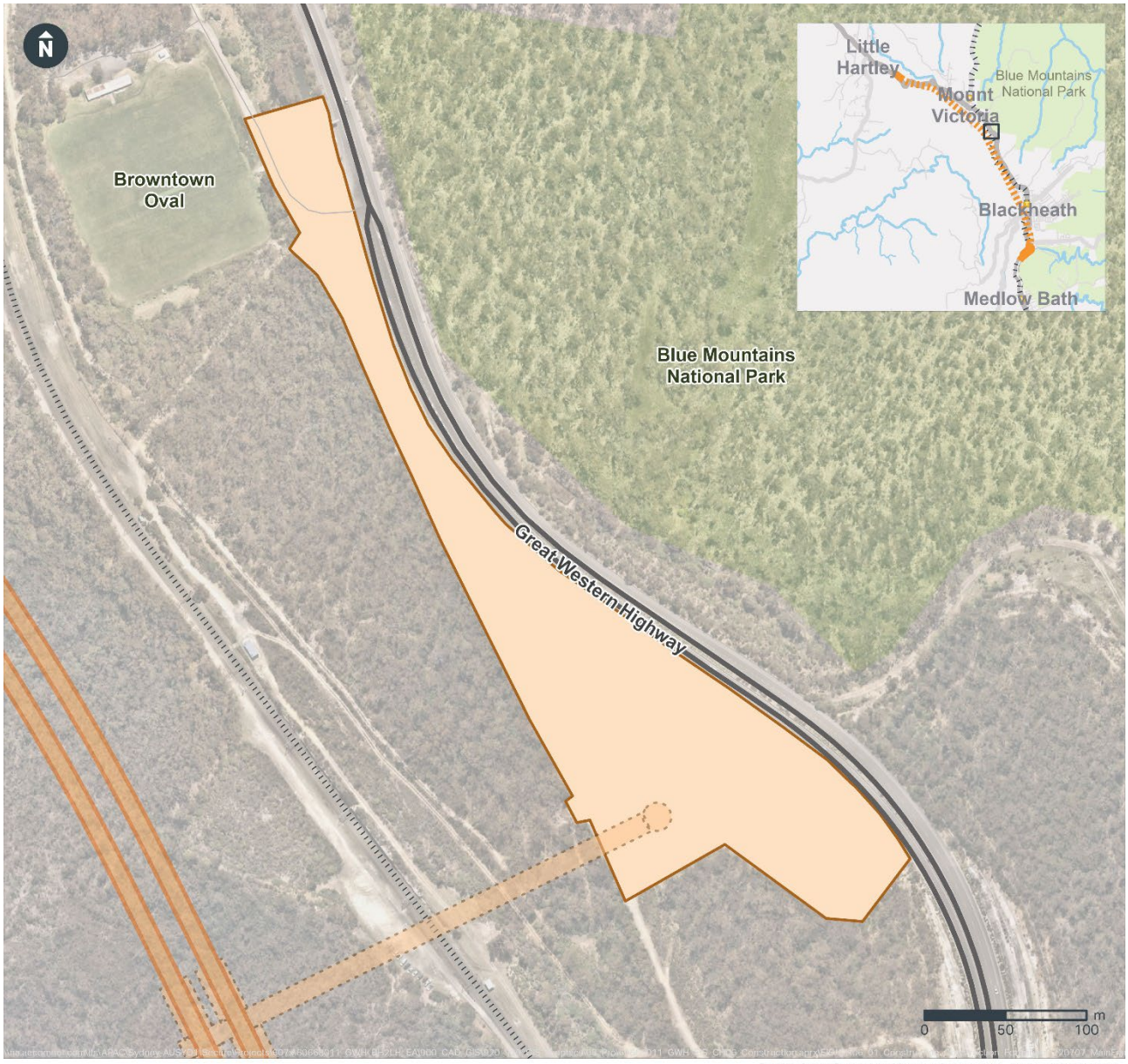


Figure 5-3 Indicative construction footprint at Soldiers Pinch

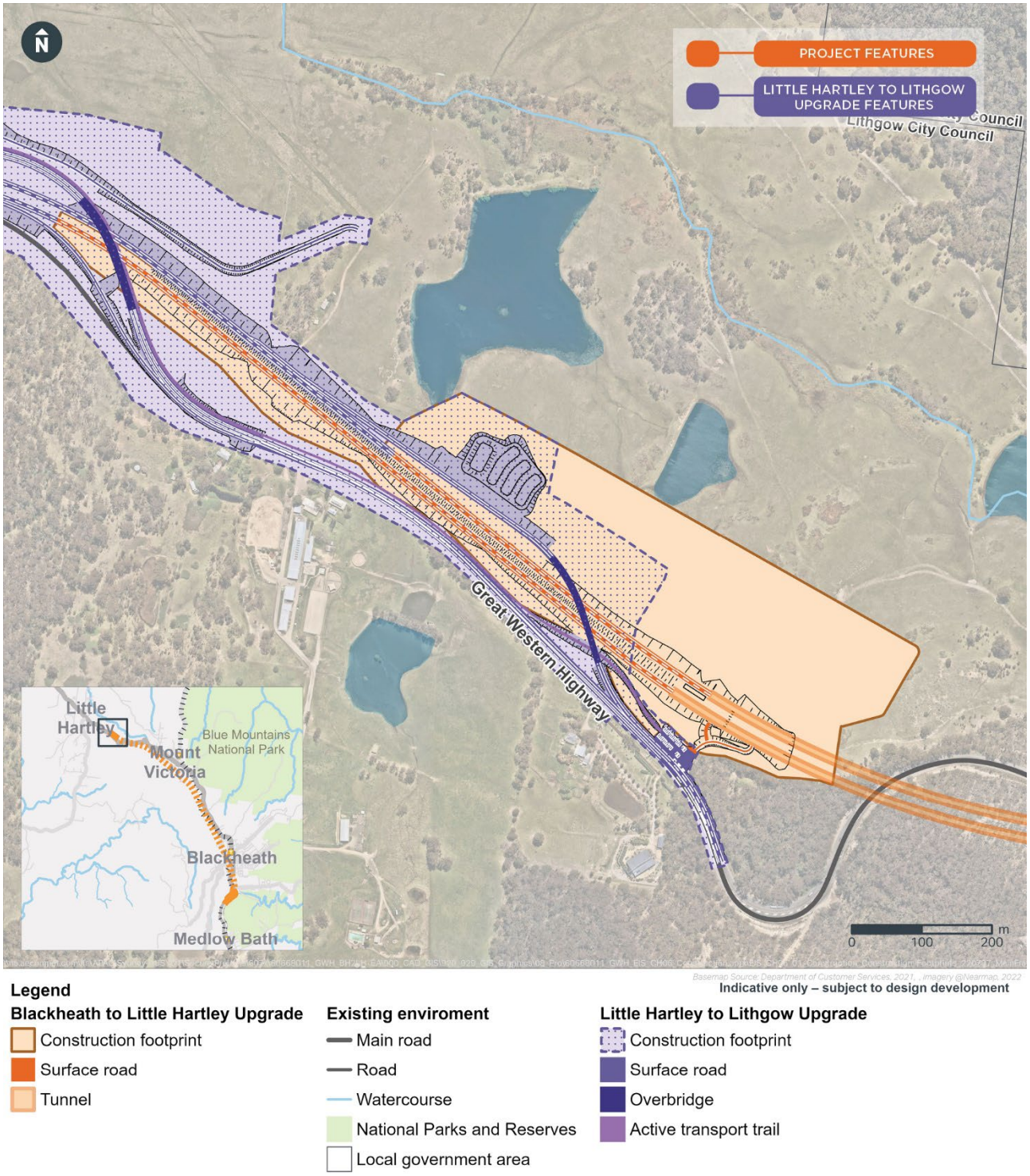


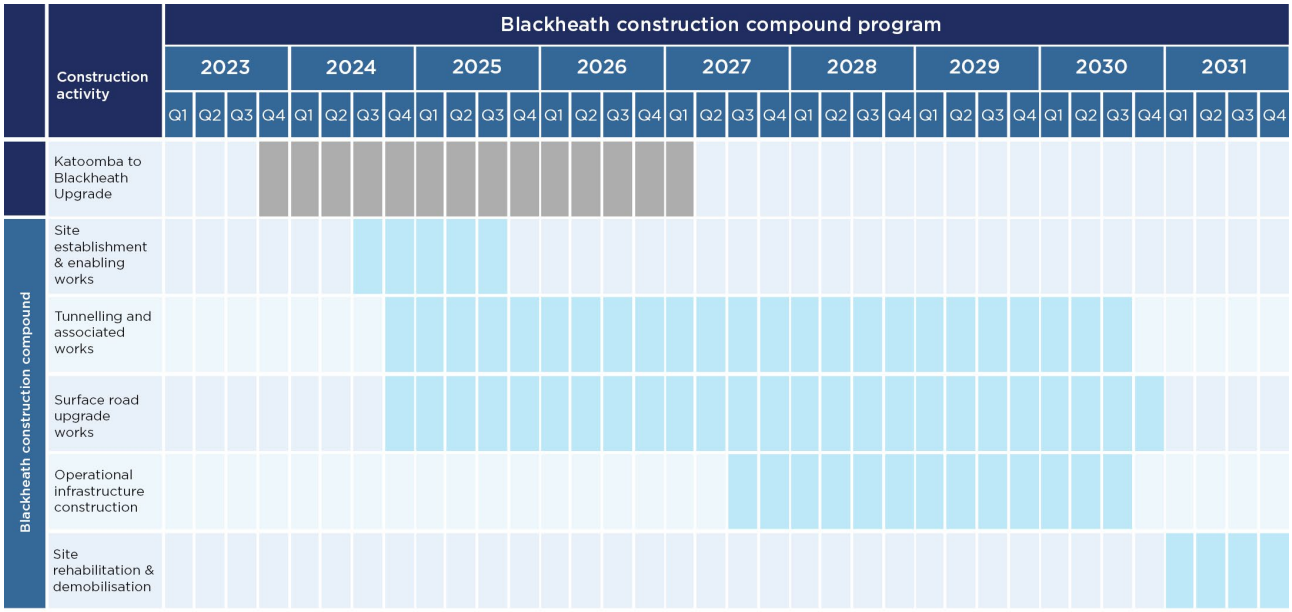
Figure 5-4 Indicative construction footprint at Little Hartley

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 activity	Soldiers Pinch construction compound program																													
		2024				2025				2026				2027				2028				2029				2030				2031			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Soldiers Pinch construction compound	Site establishment & enabling works																														
	Tunnelling and associated works																														
	Site rehabilitation & demobilisation																														

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.

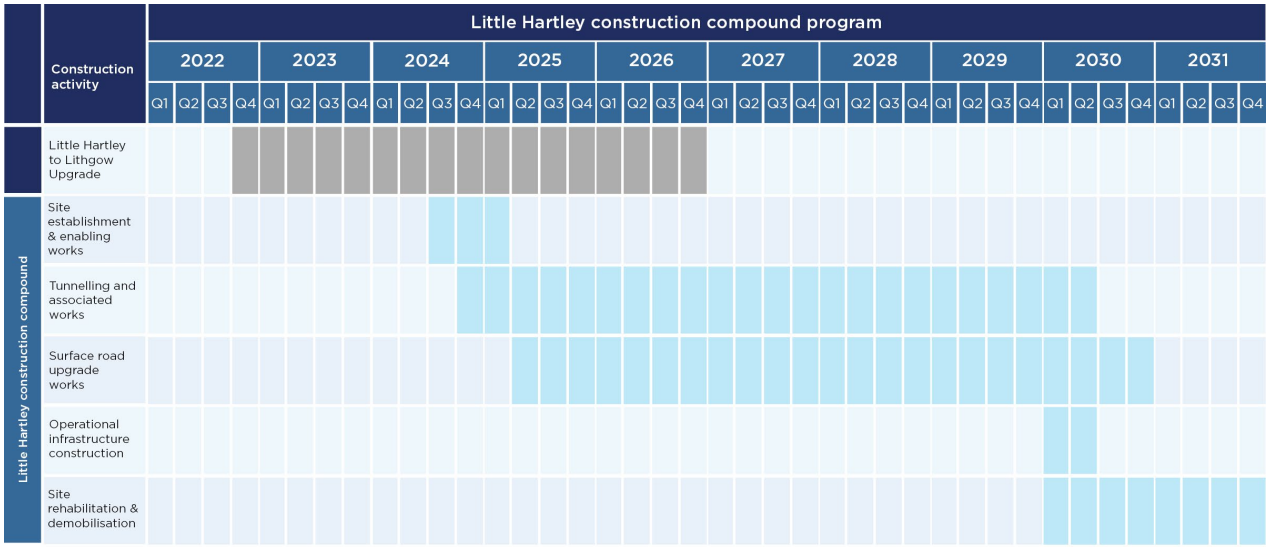
Figure 5-6 Indicative Soldiers Pinch construction site layout

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.

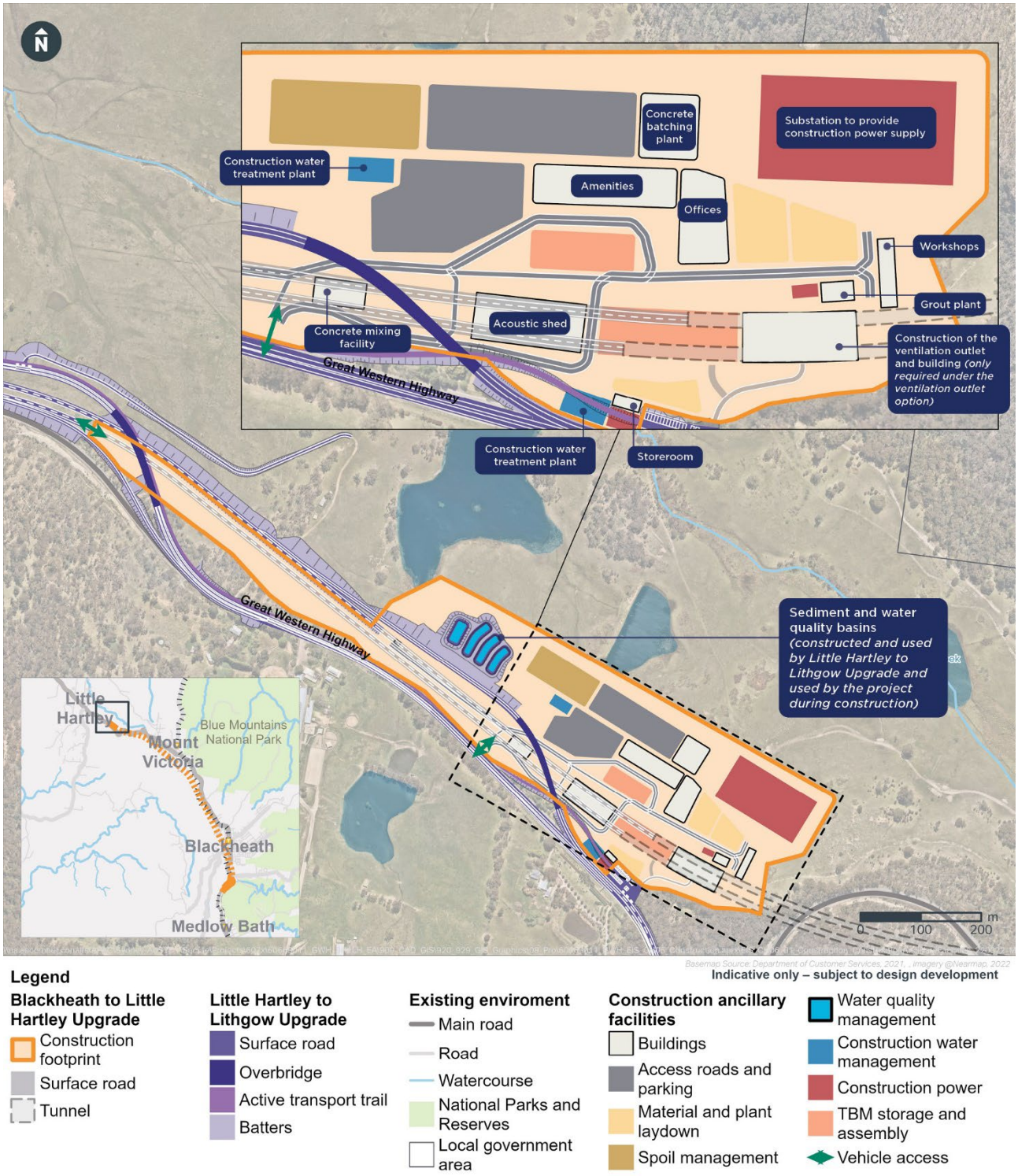


Figure 5-7 Indicative Little Hartley construction site layout

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.

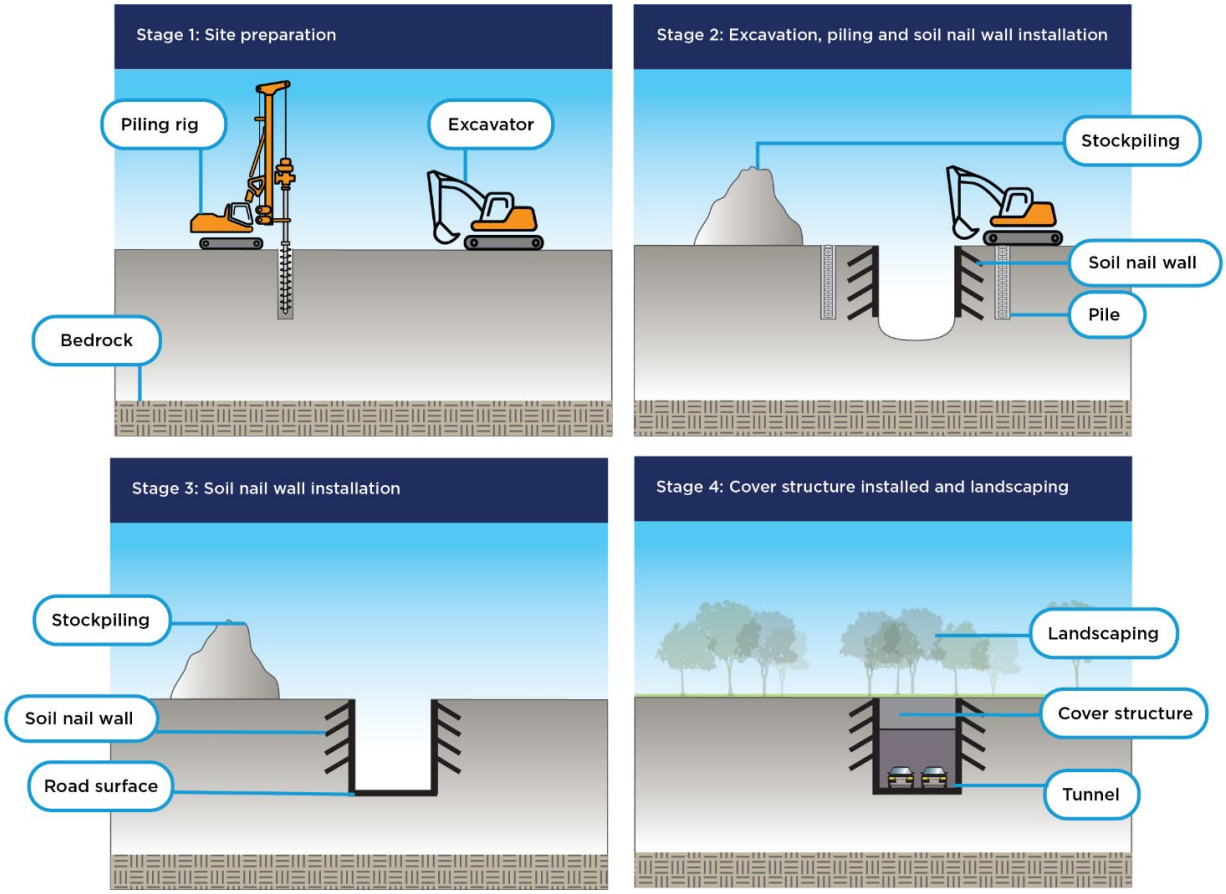


Figure 5-8 Indicative cut-and-cover construction methodology

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).

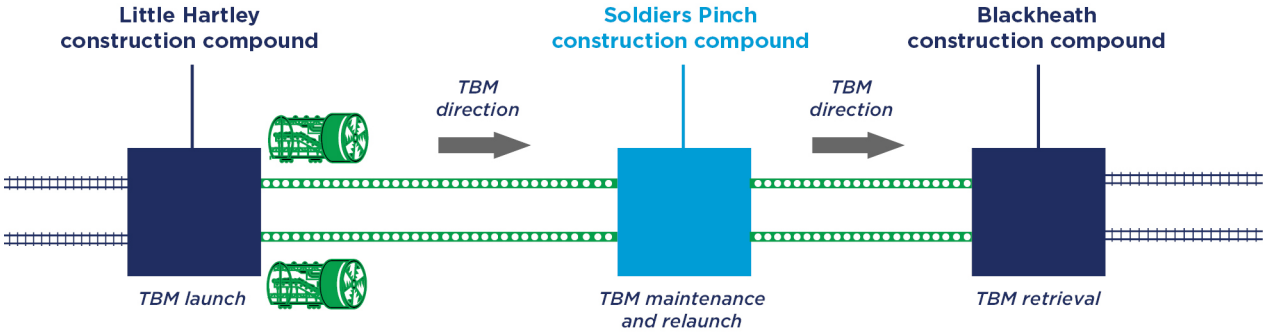


Figure 5-10 Indicative TBM tunnelling strategy

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.

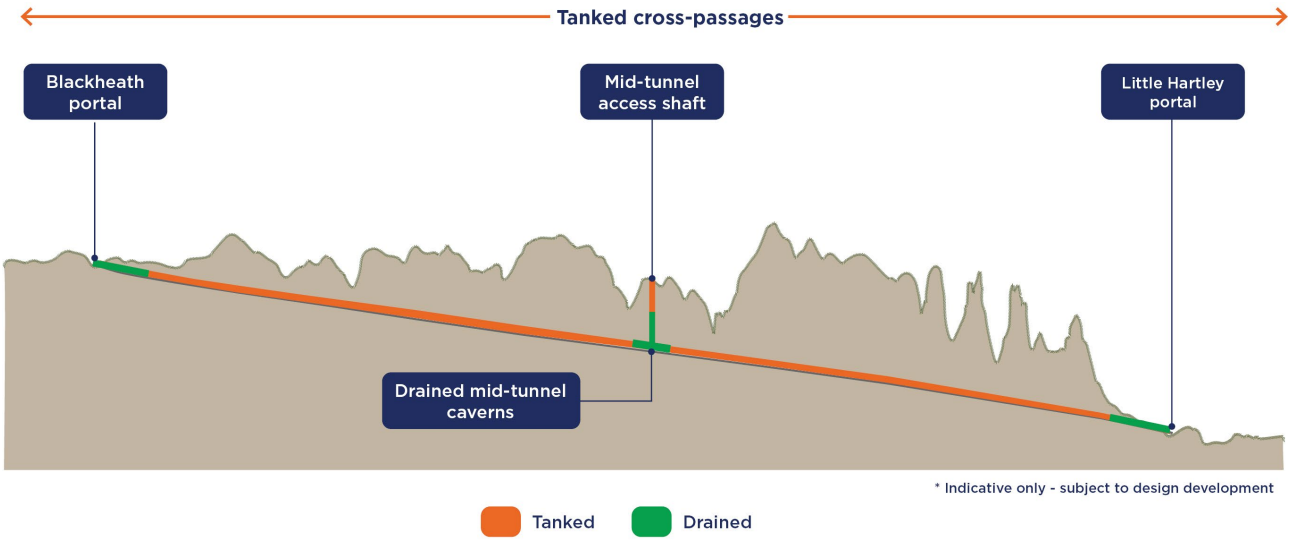


Figure 5-12 Tanked and drained sections of the tunnel and mid-tunnel access shaft

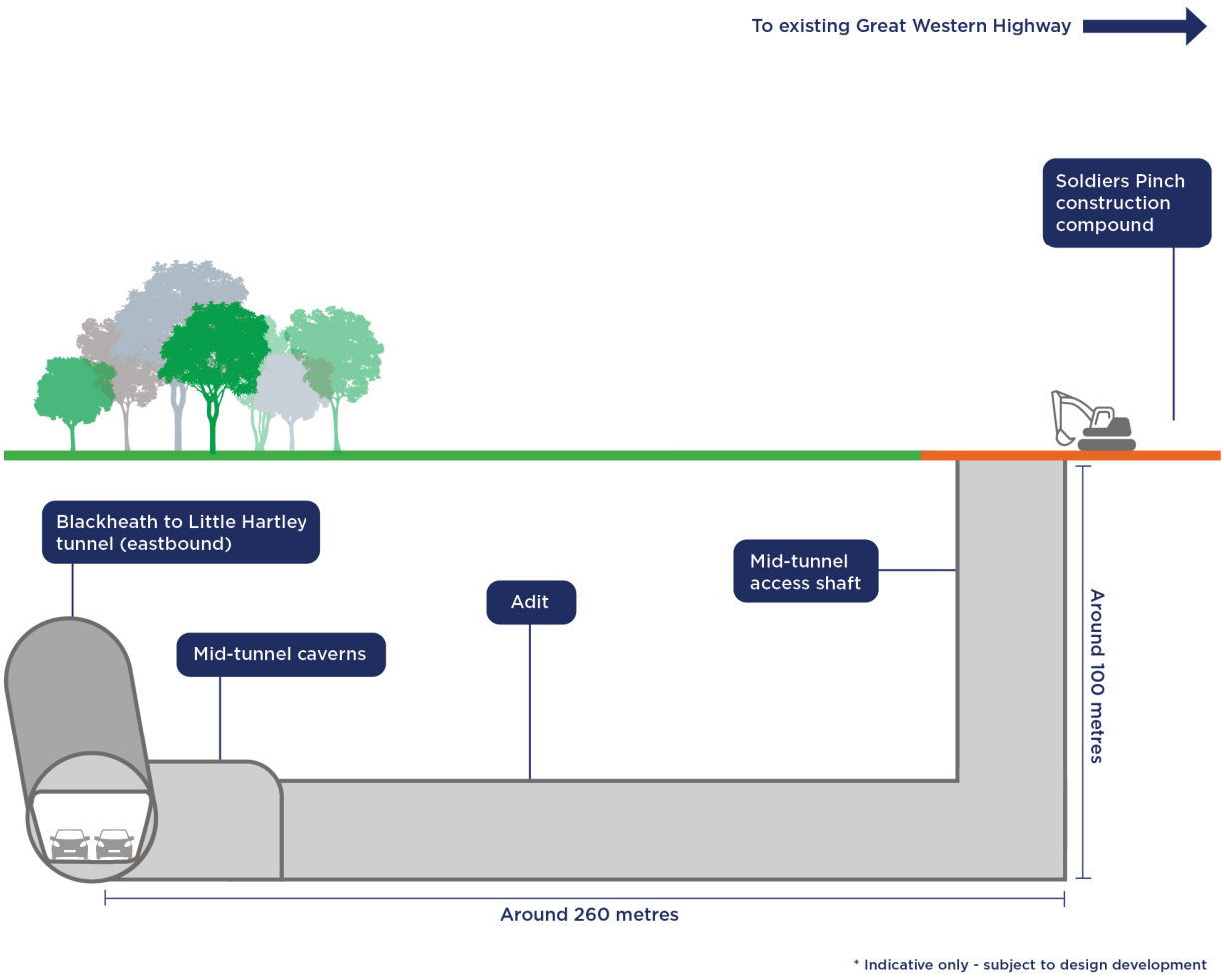


Figure 5-13 Cross section of the mid-tunnel access shaft

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.

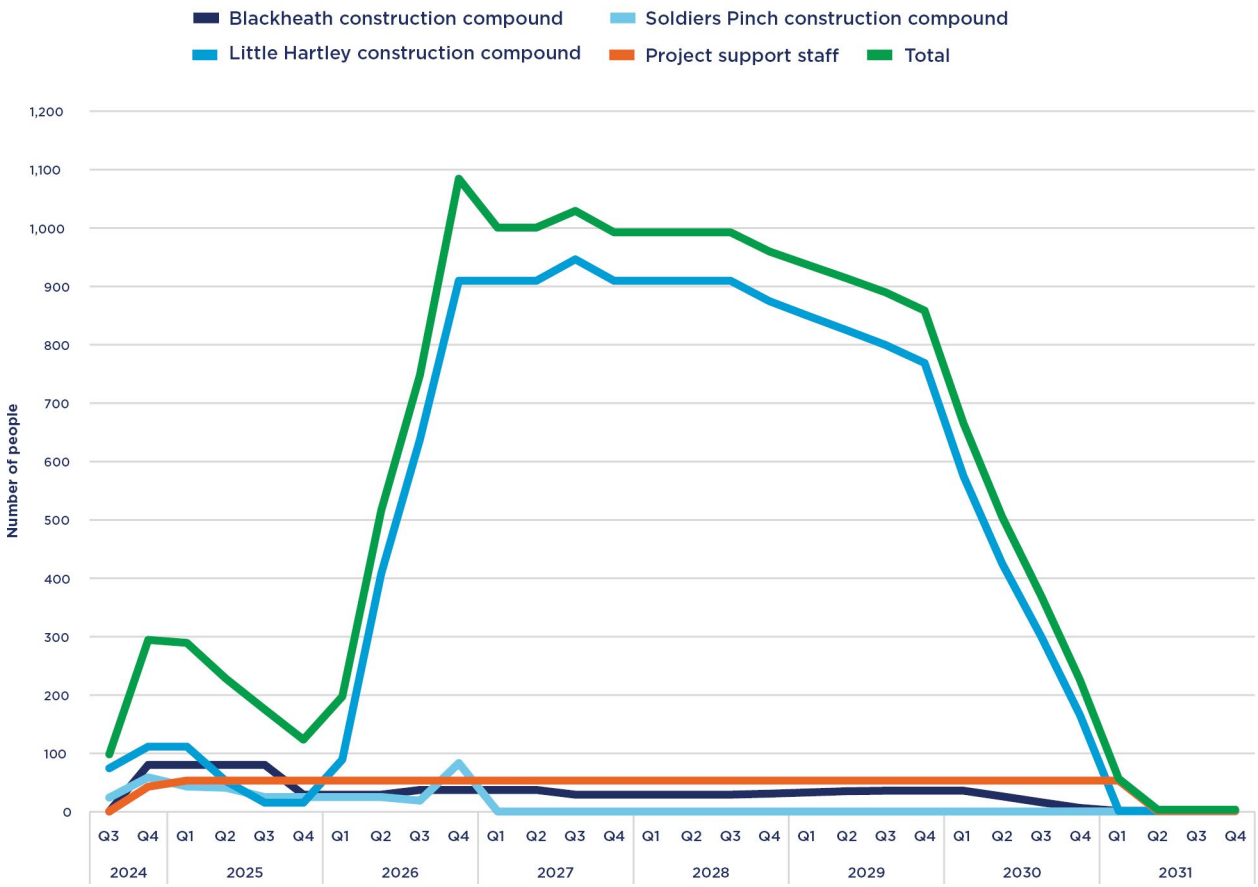


Figure 5-15 Indicative construction workforce distribution

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.

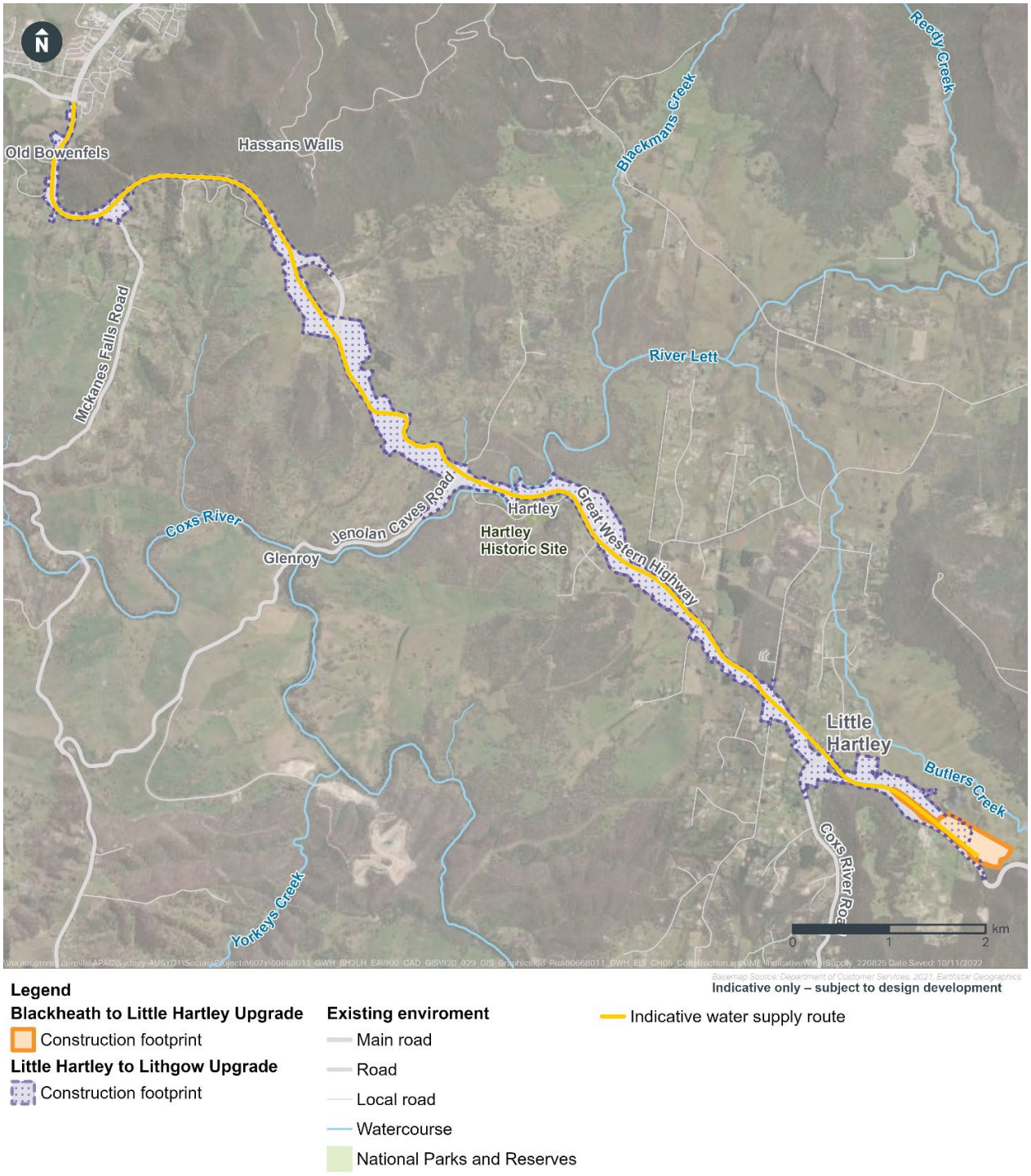


Figure 5-16 Indicative water supply pipeline route

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.

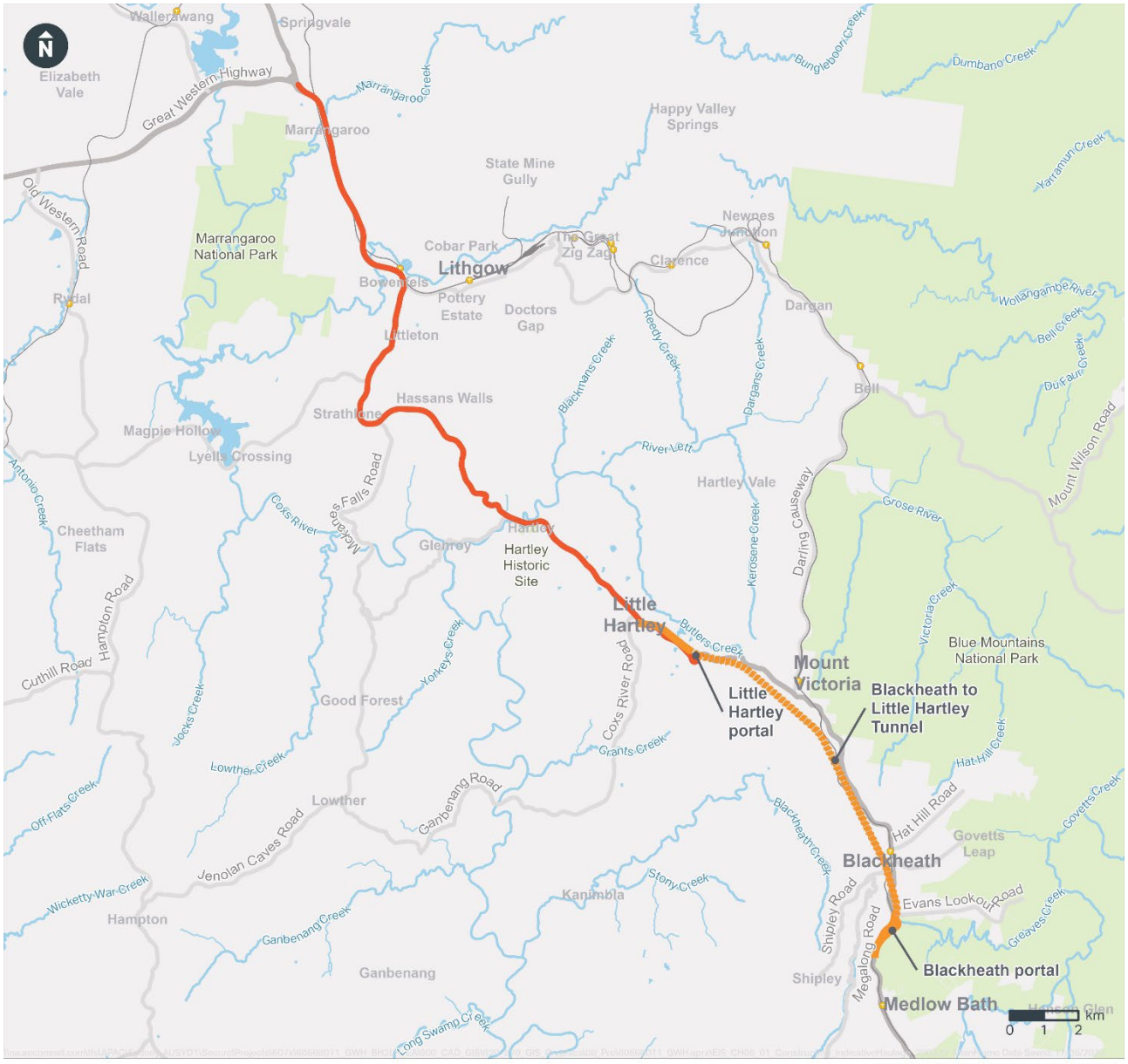


Figure 5-17 Indicative spoil haulage route