# Appendix J
# Surface water and flooding

# Great Western Highway Blackheath to Little Hartley

## Appendix J - Technical report - Surface water and flooding

Client:Transport for NSW

ABN: 18 804 239 602

Prepared by

**AECOM Australia Pty Ltd**
Gadigal Country, Level 21, 420 George Street, Sydney NSW 2000, PO Box Q410, QVB Post Office NSW 1230, Australia
T +61 2 8008 1700  www.aecom.com
ABN 20 093 846 925

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# Glossary and abbreviations

| Term | Description |
|---|---|
| AECOM | AECOM Australia Pty Ltd |
| AEP | Annual Exceedance Probability |
| AHD | Australian Height Datum |
| ANZECC | Australian and New Zealand Environment and Conservation Council |
| AWS | Automated weather station |
| BoM | Bureau of Meteorology |
| CEMP | Construction Environmental Management Plan |
| Council | Lithgow City Council |
| DEM | Digital Elevation Model |
| DCP | Development Control Plan |
| EIS | Environmental Impact Statement |
| EP&A Act | Environmental Planning and Assessment Act 1979 |
| EPB | Earth Pressure Balance |
| GBMA | Greater Blue Mountains World Heritage Area |
| GP | Gross Pollutants |
| GWH | Great Western Highway |
| GPT | Gross Pollutant Trap |
| ha | hectares |
| Hazard | In relation to the NSW Floodplain Development Manual (2005) the hazard is flooding which has the potential to cause damage to the community. |
| HRC | Healthy Rivers Commission |
| ISEPP | State Environmental Planning Policy (Infrastructure) 2007 |
| kL | kilolitre |
| km | kilometre |
| LGA | Local Government Area |
| LTAAEL | long-term average annual extraction limit |
| m | metres |
| mm | millimetres |
| $m^2$ | square metres |
| $m^3$ | cubic metres |
| mg/L | milligram per litre |
| ML | megalitres |
| MUSIC | Model for Urban Stormwater Improvement Conceptualisation |
| NorBE | Neutral or beneficial effect on water quality |
| NSW | New South Wales |

| Term | Description |
|---|---|
| NWQMS | National Water Quality Management Strategy |
| POEO Act | Protection of the Environment Operations Act 1997 (NSW) |
| PMF | Probable Maximum Flood |
| REF | Review of Environmental Factors |
| RFOs | NSW River Flow Objectives |
| Risk | Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the NSW Floodplain Development Manual (2005) it is the likelihood of consequences arising from the interaction of floods, communities and the environment. |
| SEARs | Secretary's Environmental Assessment Requirements |
| SEPP | State Environmental Planning Policy |
| SWMP | Soil and Water Management Plan |
| TBM | Tunnel boring machine |
| THPSS | Temperate Highland Peat Swamps on Sandstone |
| TN | Total Nitrogen |
| TP | Total Phosphorus |
| TSS | Total Suspended Solids |
| WAL | Water Access Licence |
| WCMS | Water Cycle Management Study |
| WM Act | Water Management Act 2000 (NSW) |
| WQOs | Water Quality Objectives |
| WSP | Water Sharing Plan |
| WSUD | Water Sensitive Urban Design |

# Executive summary

## Project background

The Great Western Highway is to be upgraded 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: 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).

Transport for NSW (Transport) 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 proposed tunnel portals. The project would be located within the Blue Mountains and Lithgow Local Government Areas (LGA).

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

This Surface Water and Flooding Technical Report has been prepared as part of the Environmental Impact Statement (EIS) for this project. This report assesses the potential impacts of the construction and operational phases of the project on surface water and flooding. The Secretary's Environmental Assessment Requirements (SEARs) for the project and agency comments have also been referenced in the assessment to ensure that all potential impacts have been adequately considered.

The findings of this technical report are summarised below.

## Existing environment

### Baseline Environment

The review of the existing environment considers changes to the existing environment based on a future, baseline scenario i.e. the baseline environment, which assumes that the following projects are operational:

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

These adjacent projects would install drainage, flooding and water quality infrastructure that would be integrated with, and also serve the project. This assessment has been prepared on the basis that:

- all drainage infrastructure downstream of the project will be sized and constructed so that it can accommodate discharges from the project without affecting the drainage performance of the project

- treatment devices would be incorporated to manage the quality of stormwater runoff including flow diversions, treatment systems, flow spreaders and infiltration areas. These devices have been designed to accommodate runoff from the adjacent east and west projects where necessary in addition to runoff from the project.

The assessment of potential flooding impacts has also considered the adjacent east and west projects.

**Surface water**

The project sits within the wider Hawkesbury-Nepean River Catchment. The Blackheath and Soldiers Pinch construction footprints would be located within the Grose River sub-catchment and the Little Hartley construction footprint would be located within the mid Coxs River sub-catchment. The Blackheath construction footprint would also be located within the Blue Mountains Catchment. The Coxs River sub-catchment and the Blue Mountains Catchment are part of the Sydney Drinking Water Catchment. Therefore, the Blackheath and Little Hartley areas of the project will be required to demonstrate that a neutral or beneficial effect (NorBE) on water quality can be achieved.

Overall, the available data and reporting suggests that the water quality of the surrounding water courses and broader catchments close to the project vary from good to poor. The water quality in the mid Coxs River catchment was found to be mostly compliant with ANZECC Water Quality Guideline values with pH, conductivity and total aluminium found to be non-compliant with guidelines. Greaves Creek sub-catchment (which sits within the Sydney Drinking Water Blue Mountains Catchment) was found to be non-compliant with the guidelines for pH, dissolved oxygen, total phosphorus, oxidised nitrogen, ammoniacal nitrogen, total aluminium and chlorophyll a.

**Flooding**

Flood modelling was conducted to determine the existing flood behaviour in the vicinity of the Blackheath and Little Hartley portal areas. A desktop flood assessment was conducted to predict the flood behaviour in the vicinity of the Soldiers Pinch construction footprint.

At Blackheath, the project would be located on a natural ridge line and the majority of water would flow naturally towards the east or west away from the existing Great Western Highway. Within the flood model extent, three major flow paths were identified in the probable maximum flood (PMF) for the existing condition. The estimated flood depth is mainly shallow, below around 0.2 metres, within the Blackheath construction footprint.

The Soldiers Pinch construction footprint would be located to the east of the natural ridge line. An existing natural channel flows in the easterly direction through the proposed construction footprint, conveying flows from the upstream catchment towards Victoria Brook, which is part of the Grose River catchment. There may be some localised ponding at depressions along and around the channel, however, the channel likely transports flows downstream before any major ponding occurs in the existing condition.

Deep water ponding in the existing condition occurs at the Rosedale Creek culvert crossing that traverses the Little Hartley construction footprint. For all the existing condition storm events modelled the ponding that occurs in this location is greater than two metres. Additionally, across the storm events modelled there are five locations within the flood model extent where the existing Great Western Highway is overtopped.

## Potential impacts

### Construction

Construction of the project is expected to take around eight years. Subject to planning approval, construction is planned to commence in 2024 and be completed by late 2031; however, the project would be open to traffic by 2030.

The key potential construction phase surface water and flooding impacts (without mitigation) identified in this assessment include:

- increased surface water runoff (e.g. due to removal of vegetation) and associated impacts to surface water quality due to the increased mobilisation of sediments (soil erosion) and contaminant laden stormwater

- accidental spills and leaks of substances (e.g. fuel and oils) and associated impacts to surface water quality
- concreting activities impacting receiving waterways as a result of accidental runoff of concrete washout water and spills of excess or waste concrete
- earthworks and changes to the construction footprint resulting in concentrated flows, as opposed to sheet flow, that have potential to disrupt existing surface water flow paths, scour the earth and increase sediment loads carried by surface waters
- activities related to discharges potentially resulting in increased erosion and scouring due to increased discharged volumes and impacts to ambient water quality due to inadequate treatment of discharges which may contain sediments and other mobilised pollutants
- disturbance and oxidisation of acid sulfate rock (ASR) around Little Hartley during construction excavation and earthworks leading to acidification of runoff
- flooding leading to inundation and damage to construction sites, machinery, equipment and stockpiles and delays in construction programming
- diversion of existing flow paths leading to 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.

**Operation**

The key potential operational phase surface water and flooding impacts (without mitigation) identified in this assessment include:

- changes to surface water runoff to waterways (Coxs River and Grose River systems) due to the increase in impervious surfaces, which could lead to increases in runoff flow rates and pollutant loads washing off the impervious surfaces
- litter, accidental spills or leaks of substances (e.g. fuels and oils), during routine operation and maintenance activities, have the potential to contaminate surface water runoff into waterways and impact visual amenity
- potential for pollution in runoff and increases in runoff volume to damage the peat swamps at Blackheath, Soldiers Pinch and Little Hartley
- acidification of runoff from oxidation of inadequately treated acid sulfate rock (ASR) around Little Hartley
- diversion of existing flow paths leading to increased velocity and ponding
- increase in velocity, scour potential and flood hazard due to floodwaters
- groundwater drawdown, due to permanently drained mid-tunnel caverns and tunnel portals resulting in potential baseflow reductions at creeks and swamps.

**Cumulative**

The cumulative impact assessment identified that other projects have the potential to impact surface water and flooding during their respective construction phases. The key cumulative impacts are associated with all stages of the Great Western Highway Upgrade Program, particularly the stages which overlap the project, including the Katoomba to Blackheath Upgrade (East Section) and the Little Hartley to Lithgow Upgrade (West Section).

## Management of impacts

A construction environment management plan (CEMP) would be prepared for the project, and would guide the management, monitoring and reporting of surface water issues during construction. Management of flooding and surface water flows during construction would be in accordance with the practices and principles in the Managing Urban Stormwater: Soils and Construction - Volume 1 and

Volume 2A, also known as the 'Blue Book' (Landcom 2004). Management of construction impacts to groundwater dependent ecosystems are described in Appendix H of the EIS (Technical report – Biodiversity) and Appendix I of the EIS (Technical report – Groundwater). Key construction management and mitigation measures related to surface water and flooding include:

- sizing, construction and commissioning of sediment and water quality basins
- installation of sediment management devices, scour protection and energy dissipaters,
- storage and stockpiling zones would be located clear of any frequently flooded and low lying areas and managed in accordance with relevant stockpiling guidelines
- stabilisation of the surface of batters and drains, including temporary works and diversions
- regular monitoring of weather and rainfall conditions to identify potential flood conditions and manage potential flooding impacts
- operation of construction wastewater treatment plants to adequately treat construction wastewater before discharge.

Further investigation will be carried out in relation to the interaction of surface water and groundwater drawdown impacts (potential change in contribution to surface water baseflow) during both construction and operation. In particular, to further investigate the potential for reduced baseflows to the valley floor infill swamps of Greaves Creek near the Blackheath portal. This further investigation and assessment would determine the need and extent of further mitigation.

For the operation phase, the management of flooding and surface water flows have been accommodated in the design of the project drainage systems. Stormwater treatment devices have been integrated into the design to meet the requirement for Neutral or Beneficial Effect (NorBE) on runoff water quality, thus meeting the requirements of Section 8.8 of the Biodiversity and Conservation SEPP and the NSW Water Quality Objectives. An operational water treatment plant would treat wastewater and groundwater inflows to levels consistent with water quality requirements before being discharged. An operational environmental management plan would be developed to manage water-related incidents such as spills, with spill response and management procedures.

## Conclusion

The construction and operation of the project has the potential to impact surface water and flooding without the implementation of adequate mitigation measures. With the implementation of the mitigation measures and treatments outlined in this report the project would have a minimal impact on surface water and flooding.

# 1 Introduction

## 1.1 Project context and 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: 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).

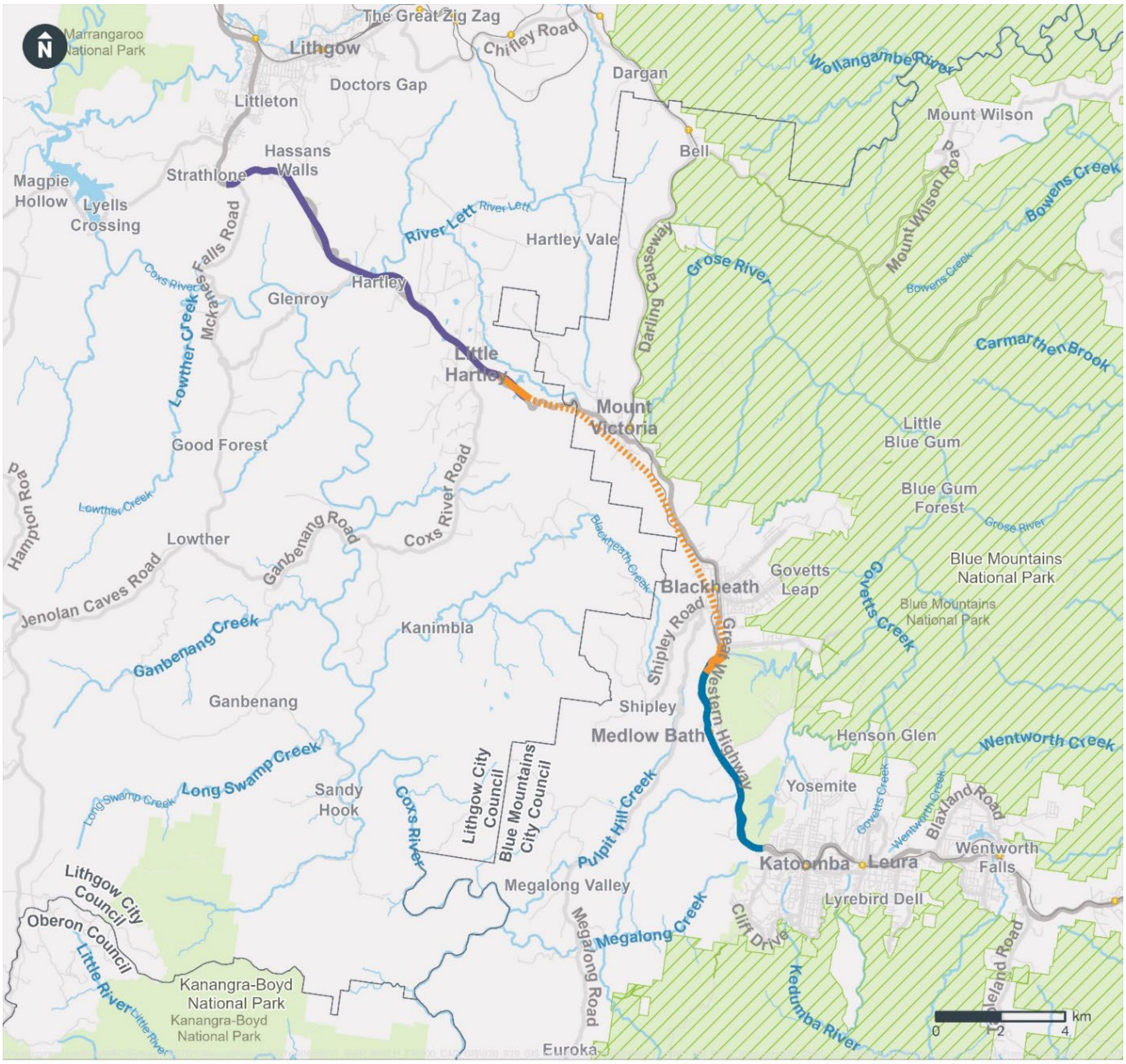
The components of the Upgrade Program are shown in Figure 1-1.

Transport for NSW (Transport) is seeking approval under Division 5.2, Part 5 of the NSW *Environmental Planning and Assessment Act 1979* (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 proposed tunnel portals.

The project would be located around 90 kilometres northwest of the Sydney CBD and located within the Blue Mountains and Lithgow Local Government Areas (LGA).

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




Indicative only – subject to design development

**Legend**

**Centreline**
- Surface road
- Tunnel

**Katoomba to Blackheath Upgrade (including Medlow Bath)**
- Surface road

**Little Hartley to Lithgow Upgrade**
- Surface road

**Existing enviroment**
- Railway
- Main road
- Road
- Watercourse

- Greater Blue Mountains World Heritage Area
- National parks and reserves
- Local government area

**Figure 1-1 The Great Western Highway Upgrade Program**

## 1.2 The project

### 1.2.1 Key components of the project

Key components of the project are summarised in Table 1-1 and shown in Figure 1-2. These components are described in more detail in Chapter 4 (Project description) of the environmental impact statement (EIS). The indicative operational configuration of the surface road network at Blackheath and Little Hartley is shown in Figure 1-3 and Figure 1-4.

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 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:<br>• mainline carriage ways and on- and off-ramps at the Blackheath portal, located adjacent to the existing Great Western Highway and south of Evans Lookout Road<br>• 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 ancillary facilities | Operational infrastructure that would be provided by the project include:<br>• a tunnel operations facility adjacent to the Blackheath portal<br>• in-tunnel ventilation systems including jet fans and ventilation ducts connecting to the ventilation facilities<br>• one of two potential options for tunnel ventilation currently being investigated, being:<br>• ventilation design to support emissions via ventilation outlets<br>• ventilation design to support emissions via portals<br>• water quality infrastructure including sediment and water quality basins, an onsite detention tank at Blackheath and a water treatment plant at Little Hartley<br>• fire and life safety systems, emergency evacuation and ventilation infrastructure and Closed-Circuit Television<br>• lighting and signage including variable message signs and associated infrastructure such as overhead gantries. |
| Utilities | Key utilities required for the project would include:<br>• a new electricity substation at Little Hartley to facilitate construction and operational power supply<br>• a new pipeline between Little Hartley and Lithgow to facilitate construction and operational water supply<br>• other utility connections and modifications, including electricity substations in the tunnel. |
| Other project elements | The project would also include:<br>• integrated urban design initiatives<br>• landscaping planting. |

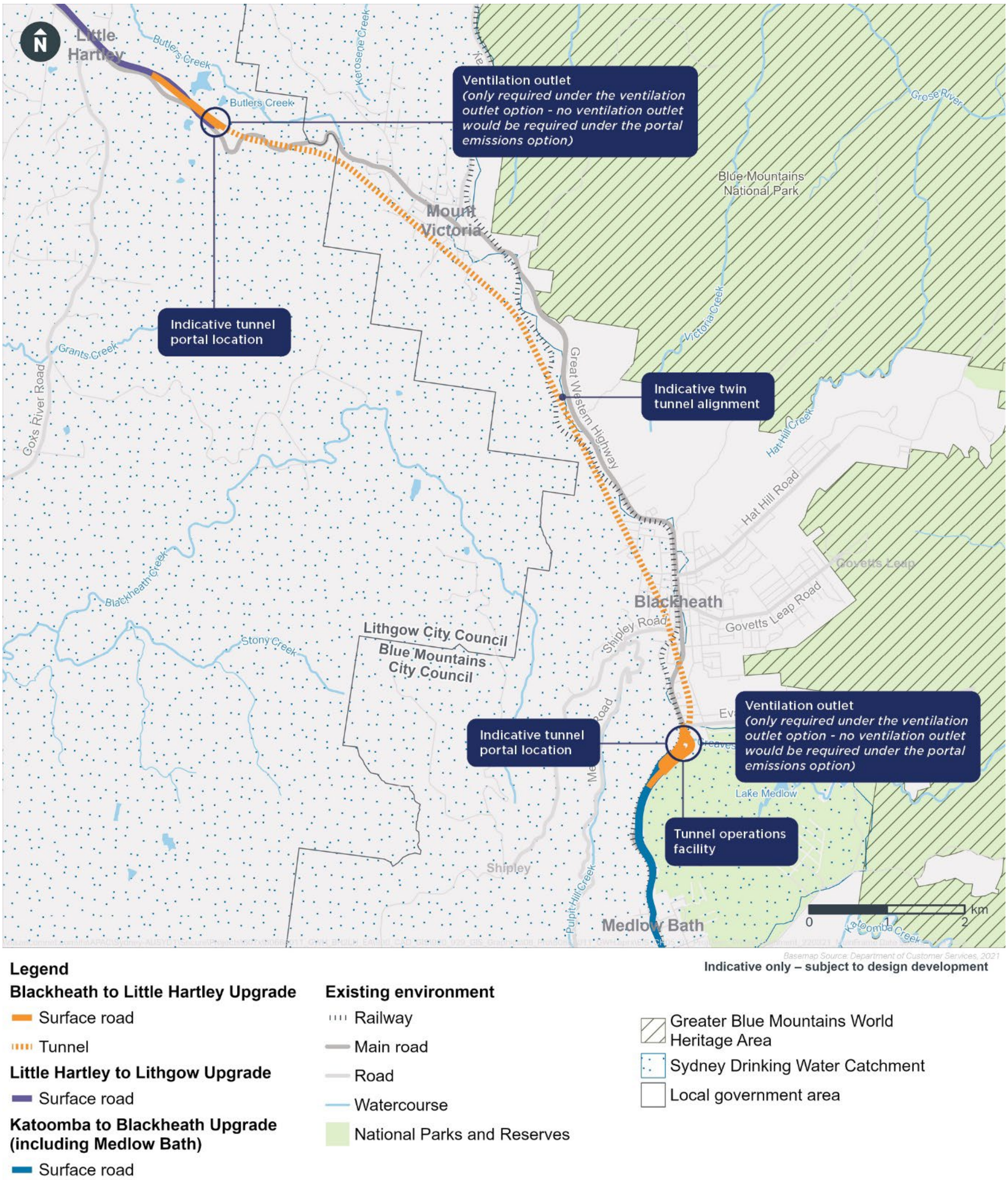
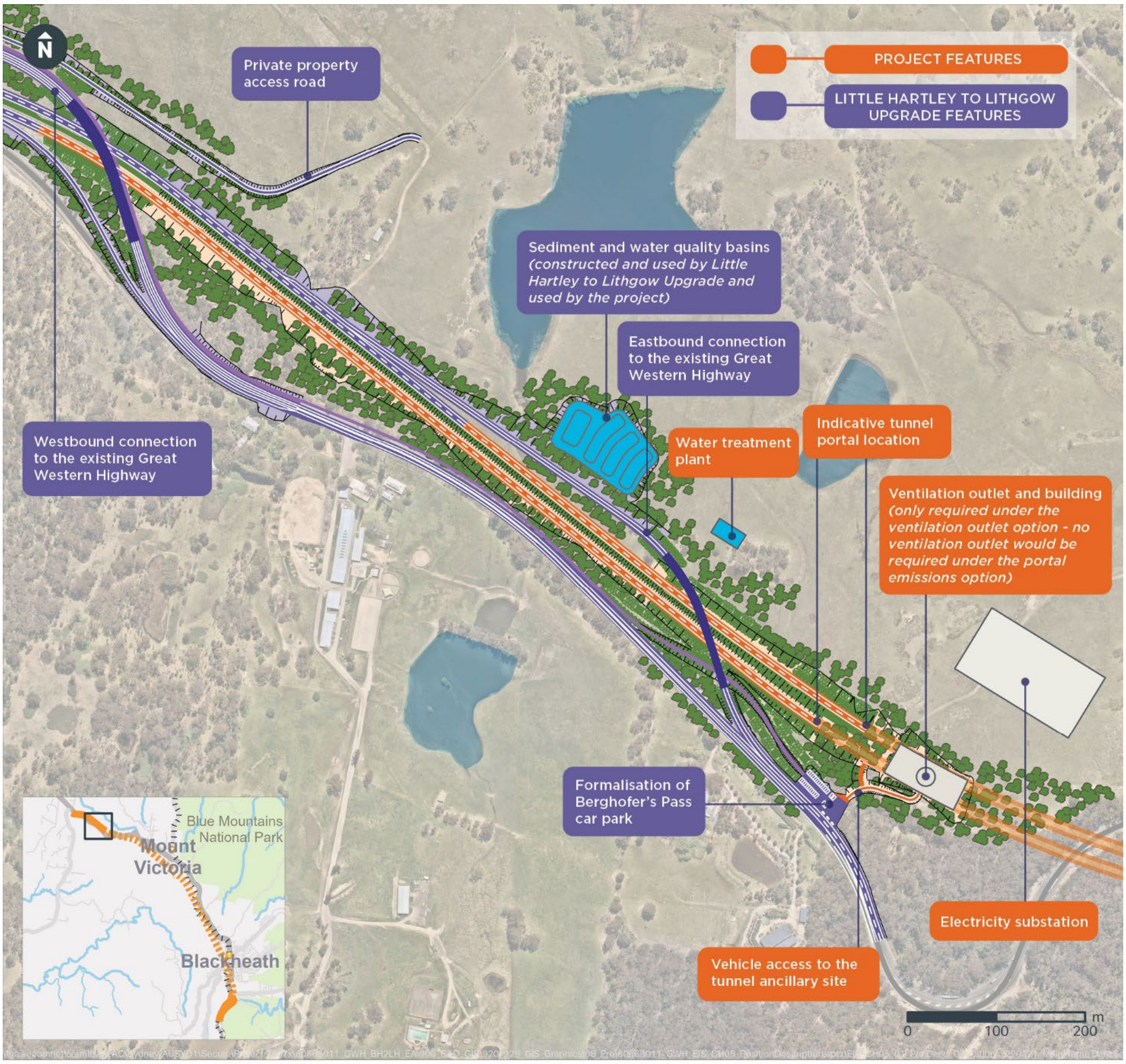



**Figure 1-2 Overview of the project**


**Figure 1-3 Indicative operational configuration at Blackheath**




Indicative only – subject to design development

**Legend**

| Blackheath to Little Hartley Upgrade | Existing environment | Operational infrastructure and landscaping | Little Hartley to Lithgow Upgrade |
|---|---|---|---|
| Tunnel | Railway | Buildings | Surface road |
| Surface road | Upgraded Great Western Highway | Water quality management | Overbridge |
| Road batters | National Parks and Reserves | Landscape planting | Active transport trail |
| | | | Batters |

**Figure 1-4 Indicative operational configuration at Little Hartley**

### 1.2.2 Project construction

Construction of the project would 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.

These activities are described in more detail in Chapter 5 (Construction) of the EIS. Further detail on the project scope as it relates to surface water and flooding is provided in Section 1.2.4 below. The potential impacts of specific activities are considered in more detail in Section 3.

The indicative construction footprint for the project is shown in Figure 1-5 to Figure 1-7, including construction site layout and access arrangements.

Construction of the project is expected to take around eight years. Subject to planning approval, construction is planned to commence in 2024 and be completed by late 2031; however, the project would be opened to traffic by 2030.


**Figure 1-5 Indicative construction footprint at Blackheath**


**Figure 1-6 Indicative construction footprint at Soldiers Pinch**

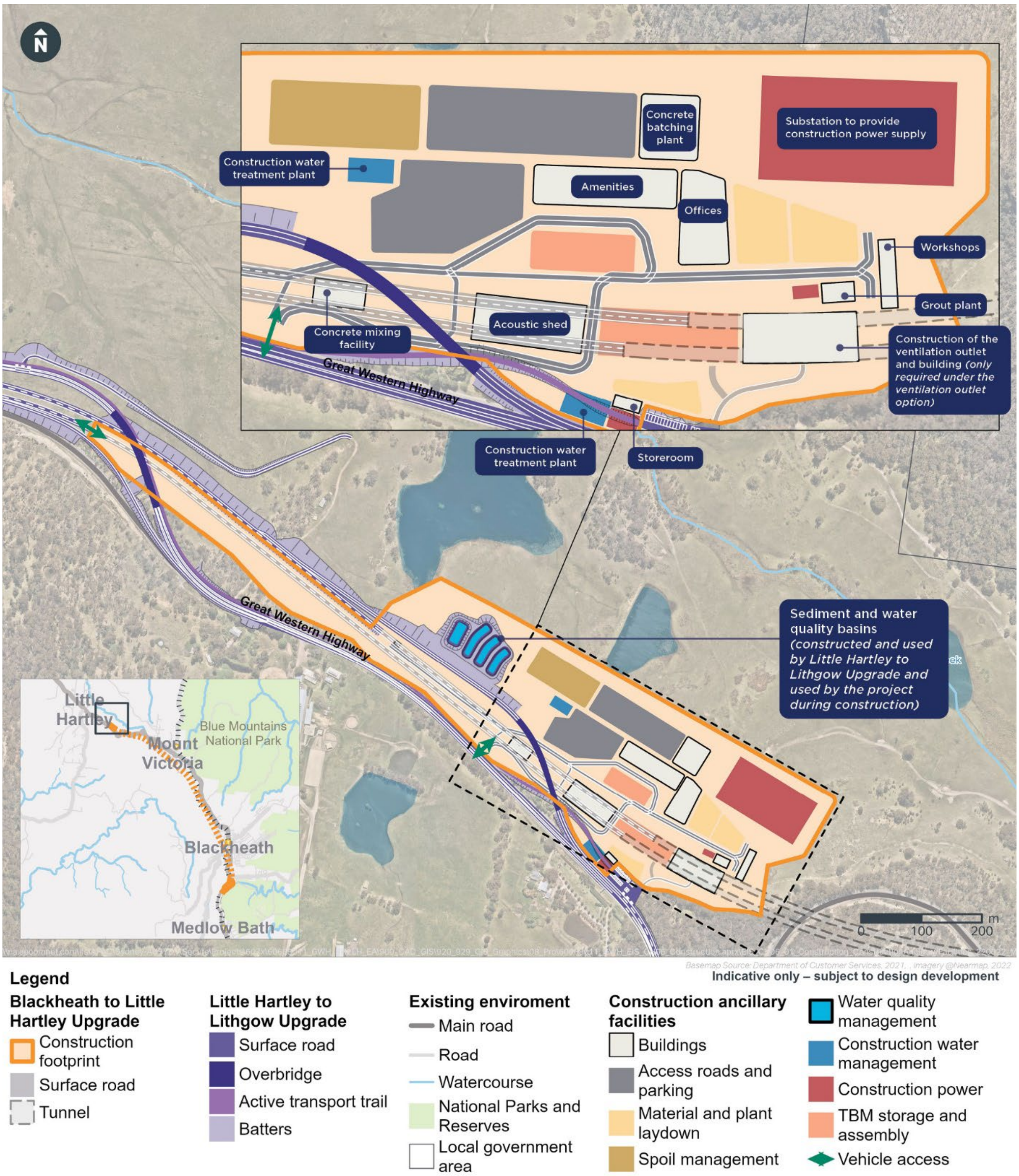



**Figure 1-7 Indicative construction footprint at Little Hartley**

### 1.2.3 Baseline Environment

The Katoomba to Blackheath and Little Hartley to Lithgow Upgrades adjoining the project to the east and west respectively would be under construction when construction of the project commences (refer to Figure 1-8). To minimise environmental impacts, parts of the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade construction footprints would be used to support construction of the project.

As a result, the following activities will be undertaken at the construction sites as part of the Katoomba to Blackheath and Little Hartley to Lithgow Upgrades:

- vegetation would be cleared
- topsoil would be levelled and compacted
- site access tracks would be established
- as required for the respective projects, water quality controls such as water quality and sediment basins would be installed.

The environmental impacts associated with these works have been assessed as part of the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade.

The construction footprint for these projects are shown in Figure 1-9 and Figure 1-10 and form the baseline environment considered at Blackheath and Little Hartley for this EIS.

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

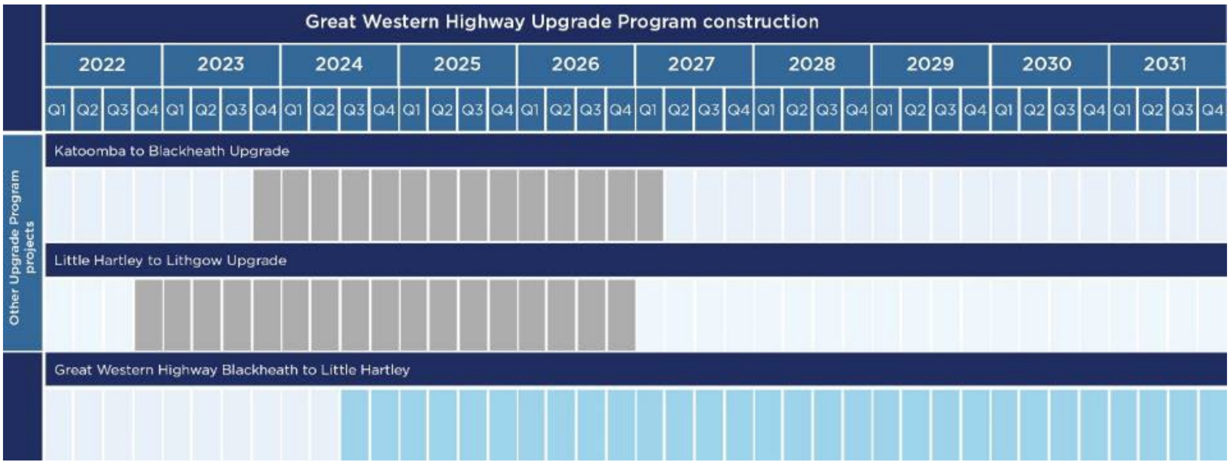



**Figure 1-8 Great Western Highway Upgrade Program construction**

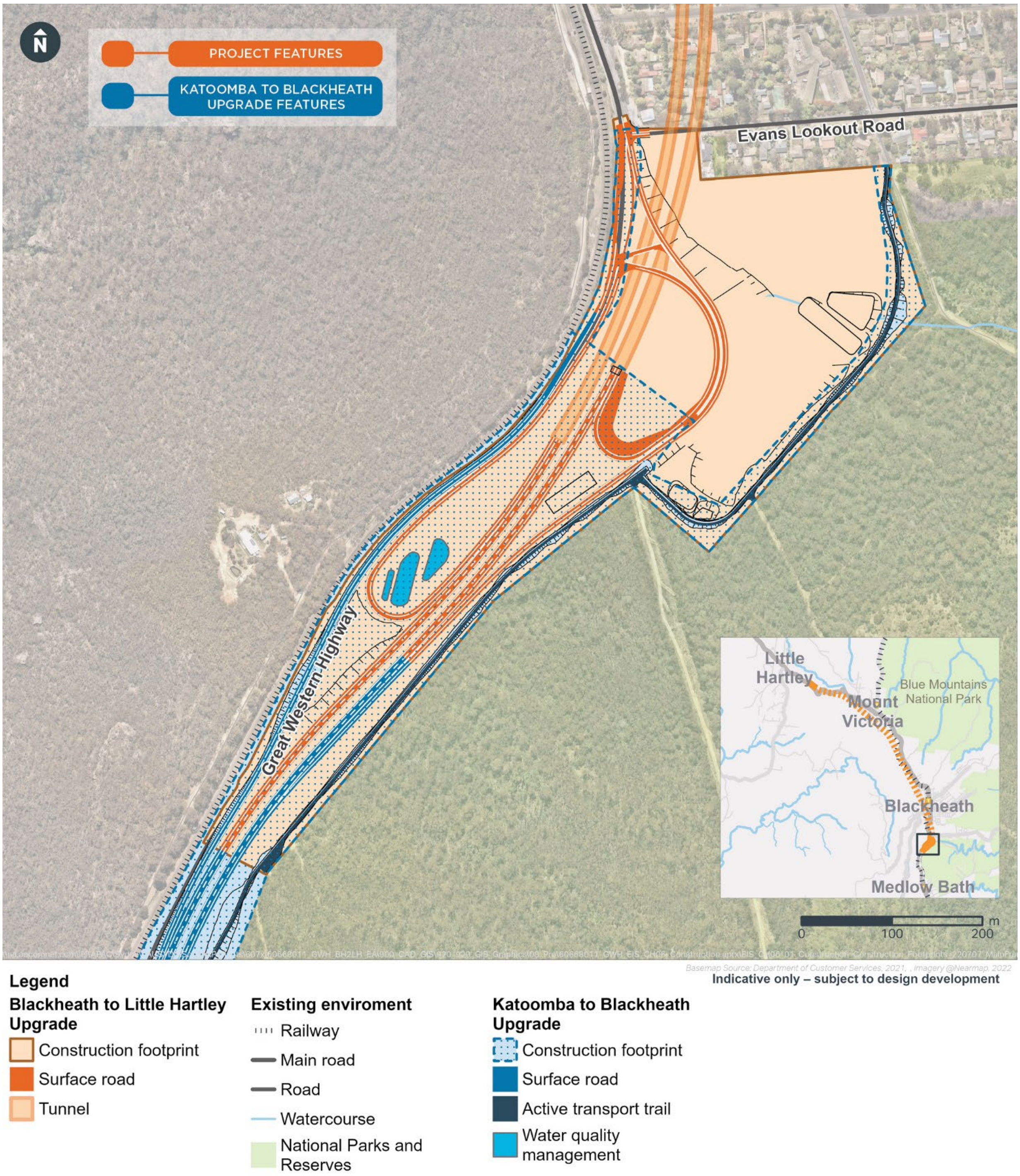
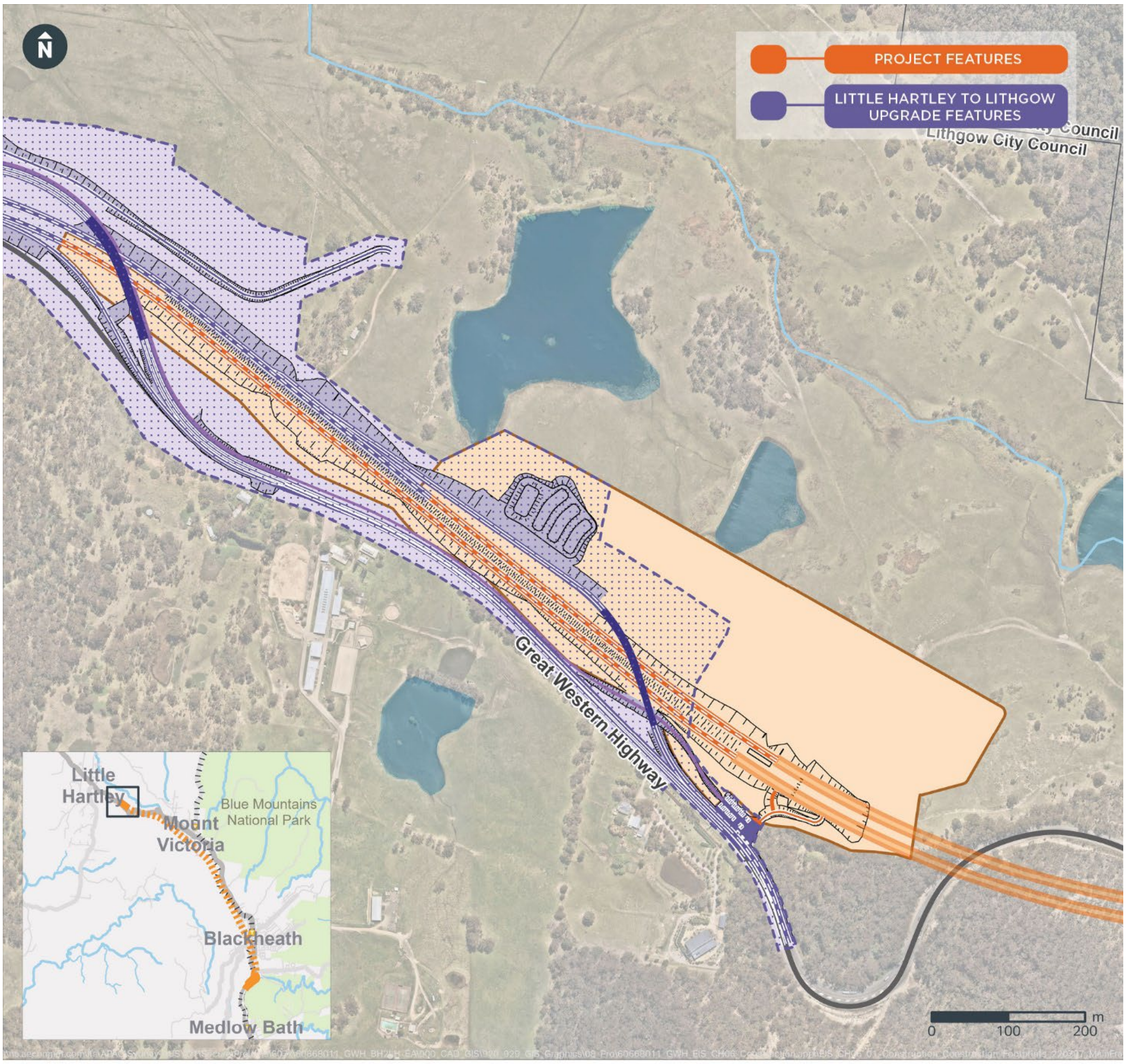



**Figure 1-9 Baseline environment at Blackheath**




Basemap Source: Department of Customer Services, 2021, , imagery @Nearmap, 2022

**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 1-10 Baseline environment at Little Hartley**

### 1.2.4 Other project specific aspects

Key elements of the project relevant to surface water, flooding, water quality and water use include:

- construction of new pits, pipes, culverts, headwalls, scour protection, detention basins, stormwater treatment devices such as bioretention systems, flow spreaders and proprietary treatment devices for the surface roads and drainage network
- adjustment of existing pits to suit new road alignments on existing surface roads
- upgrade or capacity improvements of other existing cross drainage structures which cross underneath the existing Great Western Highway, including the extension of the Rosedale Creek culvert crossing under the existing Great Western Highway. 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
- 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 engineering specifications. Where pipes and culverts are required to be installed under existing roadways they may be constructed via under-boring or pipejacking methodologies to minimise potential traffic impacts. This would occur where the work cannot be feasibly carried out in stages across existing carriageways
- construction, commissioning and operation of a water treatment plant located at Little Hartley. The water treatment plant would primarily provide treatment for groundwater collected within the tunnel prior to its discharge to the environment and for process water collected by the tunnel surface drainage system from washdown or deluge operations or exercises
- the project would be connected to the mains water supply network to provide water for essential services such as fire deluge and washdown. Raw water and mains water would be used in cases where treated groundwater and rainwater harvesting are of insufficient quality or quantity to fully meet project needs.

Refer to 4 (Project description) and Chapter 5 (Construction) of the EIS for additional detail.

## 1.3 Purpose of this report

This surface water and flooding technical report is one of the technical documents that forms part of the EIS. The purpose of this technical report is to provide a surface water and flooding assessment that addresses the requirements outlined in Section 1.3.1. This technical report provides an assessment of the potential surface water, flooding and water use impacts relating to the construction and operation of the project.

### 1.3.1 Assessment requirements

The Secretary’s environmental assessment requirements (SEARs) relating to the potential construction and operational surface water and flooding impacts of the project and where these requirements are addressed in this technical report are outlined in Table 1-2.

**Table 1-2 Secretary's environmental assessment requirements – Surface water**

| SEARs | |
|---|---|
| **Requirement** | **Section where addressed in report** |
| **6. Flooding** | |
| **Desired performance outcome:** The project minimises adverse impacts on existing flooding characteristics. Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure. | |
| 1. Changes to flood behaviour during construction and operation for a full range of flood events up to the probable maximum flood (taking into account storm intensity due to climate change) must be assessed (and modelled where required) including:<br>a. any detrimental increases in the potential flood affectation of other properties, developments, assets and infrastructure;<br>b. consistency (or inconsistency) with applicable local government council floodplain risk management plans and any rural floodplain management plans;<br>c. compatibility with the flood hazard of the land;<br>d. compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land;<br>e. downstream velocity and scour potential;<br>f. how the tunnel entries would be protected from flooding during construction;<br>g. existing and proposed emergency management, evacuation and access and contingency measures and impacts the development may have upon existing community emergency management arrangements for flooding. These matters must be discussed with the State Emergency Services and Council(s);<br>h. any impacts the development may have on the social and economic costs to the community as consequence of flooding; and<br>i. measures required to mitigate, manage and/or offset potential flood risks attributable to the project. | 1.b – Section 2.2.3 describes the flood impact assessment methodology and criteria in line with applicable local government council floodplain risk management plans.<br>1.a and 1.c – Section 3.9 describes existing flood behaviour.<br>1.a, 1.c, 1.d, 1.e, 1.f – Section 4.2 provides an assessment of potential flooding impacts during construction, including hydraulic functions, storage areas, flood hazard, velocity, scour potential and how tunnel entries would be protected.<br>1.a, 1.c, 1.d, 1.e – Section 5.2 provides an assessment of potential flooding impacts during operation, including hydraulic functions, storage areas, flood hazard, velocity, scour potential and how tunnel entries would be protected.<br>1.a and 1.h – Section 4.2 and 5.2 address any detrimental increases in the potential flood affectation of other properties, developments, assets and infrastructure in the construction and operation phase<br>1.g and 1.h – Section 4.2.4 and Section 5.2.3 discusses impacts of the project on the social and economic costs to the community and impacts of the project on existing community emergency management arrangements for flooding.<br>1.e – Sections 4.3 and 5.3 also discuss the potential impacts of scour and erosion.<br>1.i – Section 7.2 outlines measures required to mitigate and manage potential flood risks to the project. |
| 2. The assessment must take into consideration any flood studies undertaken by the relevant local government councils, where available. | Relevant flood assessments for surrounding projects are listed in Section 2.2.1. No local government flood studies are available for this project. |

| SEARs | |
|---|---|
| **Requirement** | **Section where addressed in report** |
| 3. The assessment must include maps of all features relevant to flooding as described in the Floodplain Development Manual including flood prone land and the flood planning area. | Provided in Annexure A |
| 4. Flood management objectives and outcomes must be clearly identified and substantiated to address the characteristics of the environment and relevant legislative, management and guidance requirements.<br>*Note: The 0.55 and 0.2% AEP year flood events are to be used as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.* | Discussed in Section 2.2.3. |
| **17. Water – Hydrology** | |
| **Desired performance outcome:**<br>Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised.<br>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).<br>Sustainable use of water resources.<br>Consideration of tunnel boring methods to minimise groundwater drawdown impacts and dewatering's. | |
| 1. Describe (and map) the existing hydrological regime for any surface and groundwater resources (including reliance by users and for ecological purposes or by groundwater dependent ecosystems) likely to be impacted by the project, including stream orders, as well as the location of all proposed intake and discharge locations. | Section 3 describes existing conditions.<br>Proposed discharge locations are described in Section 5.3.2.<br>Section 7 provides measures to manage impacts on surface water and groundwater hydrology. |
| 2. Provide a detailed construction and operational water balance for ground and surface water including the volume, frequency and quality of discharges at proposed intake and discharge locations, and confirmation that any water supply needs can be sourced from an appropriately authorised and reliable supply, including the source of the supply. | Addressed in Section 4.5 and Section 5.5. |

| SEARs | |
|---|---|
| **Requirement** | **Section where addressed in report** |
| 3. Surface and groundwater hydrological impacts of the construction and operation of the project and any ancillary facilities (both built elements and discharges) in accordance with the current guidelines, including:<br>a. natural processes within rivers and wetlands that affect the health of fluvial and riparian systems;<br>b. impacts to downstream water-dependent fauna and flora;<br>c. impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, waterfalls, hanging swamps, other ecosystems and species, groundwater users, and the potential for settlement;<br>d. changes to environmental water availability and flows, both regulated/licensed and unregulated/rules-based sources;<br>e. direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and destabilisation of escarpment features;<br>f. measures for minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems; and<br>g. water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation. | 3.a, 3.b, 3.c, 3.d – Section 3 provides an overview of surface and groundwater behaviour.<br>3.a, 3.b, 3.c, 3.d, 3.e, 3.f, 3.g – Section 4.3, 4.4 and 4.5 provides an assessment of potential impacts during construction.<br>3.a, 3.b, 3.c, 3.d, 3.e, 3.f, 3.g – Section 5.3, 5.4 and 5.5 provides an assessment of potential impacts during operation.<br>3.f – Section 7 provides measures to manage these impacts. |

| SEARs | |
|---|---|
| **Requirement** | **Section where addressed in report** |
| **18. Water – Quality** | |
| **Desired performance outcome:** 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). | |
| 1. Water quality impacts, including:<br>a. stating the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associated trigger values or criteria for the identified environmental values in accordance with the Australia & New Zealand Guidelines for Fresh & Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government;<br>b. identifying and estimating the quality and quantity of pollutants that may be discharged and the degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants that pose a risk of non-trivial harm to human health and the environment;<br>c. identifying the rainfall event that the water quality protection measures will be designed to cope with;<br>d. the significance of any identified impacts including consideration of the relevant ambient water quality outcomes;<br>e. demonstrating how construction and operation of the project will, to the extent that the project can influence, ensure that:<br>- where the NSW WQOs for receiving waters are currently being met, they will continue to be protected; and<br>- where the NSW WQOs are not currently being met, activities will work toward their achievement over time;<br>f. justifying, if required, why the WQOs cannot be maintained or achieved over time;<br>g. demonstrating that all practical measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented;<br>h. identifying sensitive receiving environments and develop a strategy to avoid or minimise impacts on these environments; and<br>i. identifying proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality. The results of the baseline monitoring must be included in the EIS. | 1.a – WQOs are provided in Section 2.2.4.<br>1.a, 1.b, 1.e, 1.f, 1.h – Existing surface water quality is described in Section 3.6.<br>1.b, 1.c, 1.d, 1.e, 1.f, 1.g, 1.h – Potential impacts on water quality during construction, including the requirements for sizing treatment devices to specific events are assessed in Section 4.3.<br>1.b, 1.c, 1.d, 1.e, 1.f, 1.g, 1.h – Potential impacts on water quality during operation are assessed in Section 5.3.<br>1.c, 1.e, 1.g, 1.h – Section 7 discusses measures to manage these identified impacts.<br>1.f – The project will maintain/achieve NSW WQO's through compliance with NorBE for water quality.<br>1.g – Section 5.3.1 details the stormwater treatment opportunities considered for the project to avoid or minimise water pollution and protect human health and the environment.<br>1.i – Proposed monitoring locations, monitoring frequency and indicators of surface water quality are assessed in Section 7. Available baseline water quality data is presented in Section 3.6.2. |

### 1.3.2 Consultation

Consultation with State Emergency Services and Lithgow City Council was undertaken to review the flood and surface water behaviour as a result of the project during the construction and operation phases. Consultation concluded that with appropriate stormwater management measures, no impacts would be expected to existing and proposed emergency management, evacuation and access, contingency measures and existing community emergency management arrangements for flooding.

Consultation with Blue Mountains City Council was not undertaken as no flood impacts are anticipated within the Blue Mountains LGA.

# 2 Assessment methodology

## 2.1 Relevant legislation, policies and guidelines

This section presents relevant legislation, guidelines and policies governing management and assessment of surface water, flooding and water quality, as summarised in Table 2-1. Key legislation, policies and guidelines are further detailed in the following sub-sections.

**Table 2-1 Relevant legislation, policies and guidelines**

| Relevant legislation, policies and guidelines |
|---|
| **Legislation and policies** |
| • *Water Act 1912* (NSW) and *Water Management Act 2000* (NSW)<br>  - NSW Water Sharing Plans<br>• *Water NSW Act 2014* (NSW)<br>• *Protection of the Environment Operations Act 1997* (NSW)<br>• *Fisheries Management Act 1994 (NSW)*<br>• *Soil Conservation Act 1938 (NSW)*<br>• *Environmental Planning and Assessment Act 1979* (NSW)<br>  - State Environmental Planning Policy (Biodiversity and Conservation) 2021<br>• *Environment Protection and Biodiversity Conservation Act 1999* (Cth) |
| Guidelines |
| • National Water Quality Management Strategy<br>  - Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000)<br>  - Australian Drinking Water Guidelines (NHMRC/NRMMC, 2011)<br>• NSW Water Quality and River Flow Objectives (DEC, 2006)<br>• Neutral or Beneficial Effect (NorBE) on Water Quality Assessment Guideline (Water NSW, 2021)<br>• Developments in the Sydney Drinking Water Catchment - Water Quality Information Requirements (Water NSW, 2020)<br>• Managing Urban Stormwater-Volume 2D Main Road Construction, NSW Department of Environment, Climate Change and Water (DECCW, 2008)<br>• Managing Urban Stormwater- Soils and Construction, Volume 1, 4th Edition (Landcom, 2004)<br>• Australian Runoff Quality - A Guide to Water Sensitive Urban Design (Engineers Australia, 2006)<br>• National Environment Protection (Assessment of Site Contamination) Measure (NEPC, 2003)<br>• Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DECC, 2008)<br>• Using MUSIC in Sydney's Drinking Water Catchment (Sydney Catchment Authority, 2012)<br>• Roads and Traffic Authority, 1999, Code of practice for Water Management - Road Development and Management (RTA, 1999)<br>• Roads and Traffic Authority, 2003b, Road Design Guideline: Section 8 Erosion and Sediment (RTA, 2003b)<br>• Stockpile Site Management Procedures (RTA, 2001)<br>• Guideline for Construction Water Quality Monitoring (RTA, 2003c)<br>• Erosion and Sediment Management Procedure (RTA, 2009a)<br>• Guideline for Construction Water Quality Monitoring (RTA, 2003d)<br>• Road Runoff and Drainage: Environmental Impacts and Management Options (Austroads, 2001)<br>• Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure (Austroads, 2003)<br>• Code of Practice for Water Management – Road Development and Management (RTA, 1997)<br>• Procedures for Selecting Treatment Strategies to Control Road Runoff (RTA, 2003a)<br>• NSW Government's Floodplain Development Manual, 2005 (DIPNR, 2005) |

### 2.1.1 *Water Act 1912* and *Water Management Act 2000*

Surface water in NSW is managed by DPE (Water) under the *Water Act 1912* (NSW) (Water Act) and the *Water Management Act 2000* (NSW) (WM Act). The WM Act is gradually replacing the planning and management frameworks in the Water Act although some provisions of the Water Act remain in operation. The WM Act regulates water use for rivers and aquifers where water sharing plans (WSP) have commenced, while the Water Act continues to operate in the remaining areas of the State. If an activity results in a net loss of either groundwater or surface water from a source covered by a WSP, then an approval and/or licence is required. The WM Act requires:

- a water access licence (WAL) to take water
- a water supply works approval to construct a work
- a water use approval to use the water.

Transport is seeking State significant infrastructure and critical State significant infrastructure declaration for the project. 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. Sections 5.16 and 5.17 of the EP&A Act require that Transport, as the proponent for the project, prepare an EIS for the project.

If the project is declared to be State significant infrastructure or critical State significant infrastructure, the approvals listed above are not required. Notwithstanding, an equivalent level of environmental impact assessment as would be required to obtain relevant WM Act approvals is presented in the EIS, including this surface water and flooding assessment and in Appendix I (Technical working paper – Groundwater).

An aquifer interference approval under Section 91(3) of the WM Act is not required for the project as a proclamation has not been made under section 88A of the WM Act.

**NSW Water Sharing Plans**

WSPs are the main tool in the WM Act to allocate and provide water for the environmental health of rivers and groundwater systems, while also providing licence holders access to water. WSPs define the rules for how water is allocated and have been developed under the WM Act for all water sources in NSW. The aims of the WSPs are to:

- clarify the rights of the environment, basic landholders, town water suppliers and other licensed users
- define the long-term average annual extraction limit (LTAAEL) for water sources
- set rules to manage the impacts of extractions
- facilitate the trading of water between users.

The *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011* (the Unregulated River WSP) (NSW Government, 2011) covers 88 management zones grouped into six water sources, including the 'Upper Nepean and Upstream Warragamba' and the 'Hawkesbury and Lower Nepean Rivers' water sources and extraction management units. The project would be located along the ridge line that separates these two, including surface works within both water source and extraction management units. The project would not involve extraction of surface water from a water source regulated under the Unregulated River WSP during construction or operation.

The potential to take groundwater regulated under the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* (the Groundwater WSP), is assessed and discussed in Appendix I of the EIS (Technical report – Groundwater).

A replacement of the Water Sharing Plan for the *Greater Metropolitan Region Unregulated River Water Sources* is expected to commence in mid-2023. The replacement plan will retain the intent of these rules in the current 2011 water sharing plan and include amendment clauses to allow for boundary changes, access and trade rule changes to be introduced in the future, during the life of the replacement plan.

### *2.1.2 Water NSW Act 2014*

The *Water NSW Act 2014* (WNSW Act) and associated *Water NSW Regulation 2020* (WNSW Regulation) establish Water NSW and a framework for the declaration, management and control of Sydney's drinking water catchments.

As outlined in Section 3.4, the majority of the project would be located within or beneath the Coxs River catchment, which forms part of the Sydney Drinking Water Catchment eventually draining to Warragamba Dam. This would include most of the project tunnels, the Soldiers Pinch surface works (construction phase only), and surface works at Little Hartley (construction and operation phases).

Surface works at Blackheath (construction and operation phases) would be located within the Blackheath Special Area, listed under Schedule 1 of the WNSW Regulation. The Blackheath 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.

Water quality in the drinking water catchments is protected from adverse impacts that may arise from development in the catchments through the application of *State Environmental Planning Policy (Biodiversity and Conservation) 2021* (Biodiversity and Conservation SEPP) under the *Environmental Planning and Assessment Act 1979 (NSW)*.

### 2.1.3 State Environmental Planning Policy (Biodiversity and Conservation) 2021

*State Environmental Planning Policy (Biodiversity and Conservation) 2021* (Biodiversity and Conservation SEPP) does not apply to the project because it has been declared to be State significant infrastructure. Notwithstanding, the Biodiversity and Conservation SEPP is discussed here because it provides context to the NorBE completed for the project.

The project would be carried out within the Greater Sydney drinking water catchment. For other developments and activities proposed within the drinking water catchment (being developments and activities not declared to be State significant infrastructure), the Biodiversity and Conservation SEPP requires that Water NSW's current recommended practices and standards be applied. These recommended practices and standards have been considered and applied to the project where relevant.

This SEPP also requires that activities be subject to an assessment of NorBE on water quality. Although the project is not bound to comply with this requirement, a NorBE assessment has nonetheless been completed as a matter of good practice (Section 4.3.2).

Chapter 8 of the Biodiversity and Conservation SEPP includes provisions formerly comprising *State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011*. These provisions aim to:

- provide for healthy water catchments that will deliver high quality water and permit development that is compatible with that goal
- ensure that consent authorities only allow proposed developments that have a neutral or beneficial effect (NorBE) on water quality
- support water quality objectives in the Sydney Drinking Water Catchment.

In relation to the project, Chapter 8 of the Biodiversity and Conservation SEPP specifies that developments and activities carried out in Sydney's drinking water catchments should incorporate Water NSW's recommended practices and standards (Part 8.2). If not, satisfactory demonstration should be provided than an outcome not less than that achieved by Water NSW's standards and practices should be provided.

Section 8.8 of the Biodiversity and Conservation SEPP also requires that before an activity such as the project is carried out, consideration is given to whether it would have a neutral or beneficial effect (NorBE) on water quality. A NorBE assessment has been carried out for the project (refer to Section 5.3.2), consistent with the NorBE assessment guidelines (refer to Section 2.1.7).

### 2.1.4 National Water Quality Management Strategy 2018

The purpose of the National Water Quality Management Strategy (NWQMS) is to protect the nation's water resources by maintaining and improving water quality, while supporting dependent aquatic and terrestrial ecosystems, agricultural and urban communities, and industry (Water Quality Australia 2017). The strategy provides three channels for delivery, being policy, process (framework) and guidelines, to ensure effective and well-informed development and implementation of water quality management plans and measures. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality discussed in Section 2.1.5 form part of this strategy.

### 2.1.5 Australian and New Zealand Water Quality Guidelines for Fresh and Marine Water Quality

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council (ANZECC)) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000)) provide an agreed framework for assessing water quality in terms of whether the water is suitable for a range of environmental values and water quality objectives (including human uses). The framework guides users through the necessary steps for planning and managing water quality and sediment quality. The guidelines provide detailed approaches, identifying indicators and values for selected indicators to protect management goals. The ANZECC (2000) guidelines have recently been revised as the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018). This assessment has been carried out in accordance with the SEARs, which makes specific reference to ANZECC (2000), see sections 4.3 and 5.3.

### 2.1.6 NSW Water Quality and River Flow Objectives, and the Healthy Rivers Commission Inquiry

For each catchment in NSW, the State government has endorsed the community’s environmental values for water, known as the NSW Water Quality Objectives (WQOs). The NSW WQOs (NSW Department of Environment, Climate Change and Water (DECCW) 2006) are consistent with the agreed national framework of the ANZECC Water Quality Guidelines and are ’primarily aimed at maintaining and improving water quality, for the purposes of supporting aquatic ecosystems, recreation and where applicable water supply and the production of aquatic foods suitable for consumption and aquaculture activities’ (DECCW 2006). The NSW River Flow Objectives (RFOs) (DECCW 2006) are the agreed strategic goals for surface water flow management. They identify the key elements of the flow regime that protect river health and water quality for ecosystems and human uses.

The Hawkesbury-Nepean catchment was subject to an independent inquiry by the Healthy Rivers Commission (HRC) during the period that WQOs for catchments across NSW were approved by the NSW Government (September 1999). Hence, environmental objectives were not provided for the Hawkesbury-Nepean catchment.

The HRC inquiry outlined WQOs and recommended water quality guideline values for the Hawkesbury-Nepean system, based on the identified ‘environmental values’ and uses for waterways. These WQOs were agreed to by the NSW Government through a statement of Joint Intent in 2001, with the WQOs relevant to the project summarised in Table 2-4 (refer to Section 2.2.4).

### 2.1.7 Neutral or Beneficial Effect (NorBE) on Water Quality Assessment Guideline (2021)

The Neutral or Beneficial Effect on Water Quality Assessment Guideline 2021 (WaterNSW) (the NorBE guideline) provides guidance on the requirement under the Biodiversity and Conservation SEPP (refer to Section 2.1.3) for a NorBE assessment for developments and activities proposed to be carried out in the Sydney Drinking Water Catchment.

The NorBE guideline has been applied to the assessment of whether the project would have a neutral or beneficial on water quality in the drinking water catchment (refer to Section 4.3 and Section 5.3.2).

### 2.1.8 Developments in the Sydney Drinking Water Catchment - Water Quality Information Requirements (2020)

*Developments in the Sydney Drinking Water Catchment - Water Quality Information Requirements* (WaterNSW, 2020) outlines the information required to demonstrate that a project can achieve a neutral or beneficial effect (NorBE) on water quality. The guideline stipulates that a water cycle management study (WCMS) or equivalent information should be provided to support an assessment of NorBE on water quality.

Information requirements specified in the guideline depend on the scale and nature of the particular development. In the case of the project, it is a ‘Module 5’ development type, which is described in the guideline as:

*Highly complex or non-standard developments that are the highest risk to water quality - typically major industrial and commercial developments, agriculture developments such as intensive livestock farms and intensive plant growing, extractive industries, and tourism and recreational developments.*

Sections 4 and 5 of this report provides detail on the NorBE assessment carried out for the project. Further information, including detailed soil and water management plans would be developed as part of ongoing design development and detailed construction planning in consultation with relevant agencies, including WaterNSW.

#### 2.1.9 Using MUSIC in Sydney Drinking Water Catchment

*Using MUSIC in the Sydney Drinking Water Catchment* (WaterNSW, 2019) provides guidance on the preparation of MUSIC stormwater quality models to demonstrate NorBE on water quality. The manual includes instructions relating to setup of pre- and post- development layouts, considering the existing site characteristics, the climatic region, drainage configuration and the configuration of post-development layouts and proposed treatment measures in the context of NorBE. Guidance provided in the manual has been applied to the MUSIC modelling carried out for the project (refer to Section 5.3).

#### 2.1.10 Australian Rainfall and Runoff 2019

*Australian Rainfall and Runoff 2019* (ARR) (Commonwealth of Australia, 2019) provides guidance for estimating design flood characteristics in Australia. The latest issue was finalised in 2019 and was the result of several years of updates to the previous version of ARR (Engineers Australia, 1987). Guidance provided by the ARR has been applied to the assessment of flooding impacts associated with the project (refer to Section 5.2).

#### 2.1.11 Managing Urban Stormwater: Soils and Construction - Volume 1 and Volume 2A (the Blue Book)

Principles for the management of stormwater during construction are documented in Managing Urban Stormwater: Soils and Construction - Volume 1 and Volume 2A, also known as the ‘Blue Book’. These management principles have been applied in the development of construction phase mitigation and management measures (refer to Section 7.2).

#### 2.1.12 Protection of the Environment Operations Act 1997

The *NSW Protection of the Environment Operations Act 1997* (POEO Act) is administered by the NSW Environment Protection Authority (EPA) for the purposes of regulating air and water pollution, noise control and waste management. The POEO Act contains pollution controls and requirements for granting environment protection licences (EPLs) for scheduled activities under Schedule 1 of the POEO Act. Construction of the proposal, including ‘Road construction related earthworks, any extraction of materials necessary for construction, and any on site processing (including crushing, grinding or separating) of any extracted materials or other materials used in construction’ constitutes a scheduled activity under Schedule 1 of the Act.

Transport for NSW would be required to obtain and hold an EPL for the duration of the construction period. This licence would require Transport to comply with section 120 of the POEO Act and to maintain and implement erosion and sediment control measures during construction in accordance with Managing Urban Stormwater–Soils and Construction Volume 1 (Landcom, 2004) and Volume 2 (DECCW, 2008), collectively referred to as ‘the Blue Book’.

### 2.2 Methodology

The methodology is based on the requirements of the SEARs and other guidelines, including NorBE, as well as the likely surface water and flooding risk posed by the project. A number of qualitative and quantitative assessments have been completed to identify, assess and mitigate potential impacts to surface water, flooding and water quality resulting from the project which are outlined in the following sections.

### 2.2.1 Data and information sources

The following data and information sources (see Table 2-2) were acquired, reviewed and adopted for the purpose of this assessment.

**Table 2-2 Relevant data and information sources summary**

| Relevance | Document / dataset | Data source | Description | Date |
|---|---|---|---|---|
| **Spatial data** | Elevation data and contours | NSW Government Spatial Services | Digital Elevation Model (DEM) at a resolution of 1 m obtained from ELVIS (Elevation Information System) | 2019 |
| | Environmental Planning Instrument (EPI) Drinking Water Catchments | EPI and Department of Planning, Industry and Environment | Sydney Drinking Water Catchment boundaries | 2021 |
| | Temperate Highland Peat Swamps on Sandstone community (THPSS) | Sharing and Enabling Environmental Data portal | THPSS vegetation was mapped using a 25 m Digital Elevation Modal (DEM) coupled with orthorectified aerial photography, the THPSS of the Sydney Basin were mapped in ArcGIS | 2016 |
| | Road Design Drawings | AECOM Aurecon Joint Venture | Concept Design | 2022 |
| **Surface water quality data** | Blue Mountains Waterways Health Report 2017 | Blue Mountains City Council's Healthy Waterways team | Trends in waterway health for sites monitored in the region | 2017 |
| | Annual Water Quality Monitoring Report 2020-21 | WaterNSW | Catchment water quality benchmarks | 2021 |
| | 2019 Audit of the Sydney Drinking Water Catchment | EcoLogical | Biodiversity and habitats, river conditions | 2019 |
| **Nearby projects and documentation** | Great Western Highway Upgrade Program: Little Hartley to Lithgow (West Section) | Jacobs Arcadis Joint Venture | Review of Environmental Factors | 2021 |
| | Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) | Jacobs Arcadis Joint Venture | Submissions Report | 2022 |
| | Great Western Highway Upgrade - Medlow Bath | Mott MacDonald | Review of Environmental Factors | 2021 |
| | Great Western Highway Upgrade Program: Katoomba to Blackheath (East Section) | Aurecon | Review of Environmental Factors | 2022 |
| | Great Western Highway Upgrade, | NSW Government | Concept Design - Water Quality Report | 2013 |

| Relevance | Document / dataset | Data source | Description | Date |
|---|---|---|---|---|
| | Mount Victoria to Lithgow Alliance | Roads and Traffic Authority | | |

### 2.2.2 General

The assessment of potential impacts on surface water, flooding, and water quality arising from the project included:

- collation and analysis of legislative requirements, guidelines and regulations
- a desktop review and analysis of existing information to characterise the existing and baseline environment, identify surface water receptors, sensitive receiving environments, existing flood behaviours and drainage infrastructure
- consideration of the location of the project in the context of surrounding catchment areas and potential sensitivity and influence on downstream waterways
- identification of key topographical features such as likely overland flow paths and low/sag points around the project
- surface water hydrology and flooding assessment (described in Section 2.2.3)
- surface water quality assessment (described in Section 2.2.4 below)
- assessment of other issues related to surface water (described in Section 2.2.5 below)
- assessment of cumulative impacts through identification and review of other projects in the area
- development of mitigation and management measures to address the impacts identified for both construction and operation of the project.

### 2.2.3 Surface water hydrology and flooding assessment

The assessment of surface water hydrology and flooding incorporated the following:

- flood information and studies completed by the relevant local government councils, where available, have been reviewed to assess existing flood behaviour
- an assessment of all features relevant to flooding as described in the NSW Floodplain Development Manual (DIPNR, 2005) including flood prone land and the flood planning area. No applicable local government floodplain risk management plans or rural floodplain management plans have been identified for the project
- a desktop review of legislative requirements, guidelines and regulations to identify the flood management and modelling objectives
- a qualitative discussion of potential impacts during construction, for all construction footprints, has been completed based on a review of existing watercourses, flood information and topography to manage and avoid construction impacts on any existing flow paths
- two-dimensional flood modelling has been completed at Blackheath to investigate the existing flooding behaviour for the Probable Maximum Flood (PMF). Due to the low flood risk identified from this modelling, no further modelling of additional flood events (including storm intensity due to climate change) were required at this location
- two-dimensional flood modelling for a full range of flood events (including PMF and storm intensity due to climate change) has been completed for the major transverse drainage crossing along Rosedale Creek at Little Hartley under existing and operational conditions
- mitigation measures have been identified to avoid or minimise potential flood impacts.

### Flooding criteria and objectives

The flood assessment criteria and objectives adopted for this assessment are stated in Table 2-3. These objectives have been determined and selected based on a number of project requirements and are consistent with other recent comparable projects.

**Table 2-3 Flooding design and assessment criteria**

| Item | Sub-group | Criteria | Source |
|---|---|---|---|
| Flood Immunity | Surface Road | The road must achieve flood immunity in the 1% AEP event, with the PMF event also checked. | QA Specification PS271 |
| | Tunnel | Design flood levels and design protection measures where a tunnel could be exposed to flooding must be determined. | QA Specification PS233 |
| Flood afflux for areas outside the project boundary | Residential, commercial and industrial areas | Less than 10 mm for residential, commercial and industrial areas, and buildings affected by existing finished floor level inundation for events up to and including the 1% AEP | Recent conditions of approval for similar projects. |
| | Agricultural land | Less than 50 mm for agricultural land for events up to and including the 1% AEP event. | Recent conditions of approval for similar projects. |
| | Pasture, forest and recreational areas | Generally, less than 250 mm increase with localised increases of up to 400 mm acceptable over small areas (nominally less than five hectares) in all events up to and including the 1% AEP event. | Recent conditions of approval for similar projects. |
| Scour | | No adverse increase in peak flood velocity for events up to and including the 1% AEP | Recent conditions of approval for similar projects. |
| Emergency management | | No adverse impact upon community flood emergency management plans – unless alternative risk mitigation is proposed. | Recent conditions of approval for similar projects. |
| Flood Damage | | No property damage in the 1% AEP event and no structural damage in the 0.05% AEP event. | QA Specification PS271 |
| Blockage | Pit inlets | Blockage allowance of 50% at sag pits and 20% at on-grade pits. | QA Specification PS271 |
| | Culverts | Must consider the site-specific risk of blockage on a case-by-case basis and determine appropriate blockage factors using the latest ARR guidelines.<br>As a minimum requirement; 50% blockage factor for all culverts has been considered.<br>Design of transverse culverts should match existing stream grades and maintain a minimum velocity of 0.7 m/s to prevent siltation. | QA Specification PS271,<br>Council DCPs, and ARR 2019<br>Guide to Road Design – Part 5B |
| Climate Change | | Design to the 1% AEP event and undertake a separate sensitivity test (or 'stress-test') to assess the impacts of climate change on the design. This includes impacts resulting from | Technical Guide – Climate Change and ARR 2019 Guidelines |

| Item | Sub-group | Criteria | Source |
|---|---|---|---|
| | | an increase in rainfall intensity and sea level rise.<br>Sea level rise is not likely to impact this project.<br>In accordance with ARR 2019 Guidelines, the larger and rarer 0.2% AEP event (from Flooding SEARs) has been adopted to represent the rainfall and runoff that could result from climate change for a 1% AEP event, as a conservative method. | |

**Flood modelling extents**

The model extent for the preliminary hydraulic assessment at Blackheath was defined by the upstream ridgeline which runs adjacent to the existing Great Western Highway alignment. A buffer zone to capture the downstream environment was defined so that backwatering effects at the downstream environment were not likely to influence the model results.

The Rosedale Creek (Little Hartley) model extent encompasses all potentially flood affected land due to the project, covering an area of 4.6 square kilometres. The boundaries of the model extent include Mount York Road to the north and the upper catchment boundary of Rosedale Creek to the south. The interchange between Great Western Highway and Coxs River Road comprised the western model boundary. A point along the Great Western Highway, three kilometres east from this interchange, comprised the eastern extent of the model boundary.

These model extents are indicated on Figure 3-14 and Figure 3-18.

### 2.2.4 Surface water quality

To demonstrate that the project is designed, constructed and operated to protect 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 waters), the assessment of surface water quality incorporates the following:

- review of available water quality data and existing conditions to obtain background information on catchment history and land use, define the existing environment and to describe the catchment. The downstream receiving environment has been the subject of several studies which were used to characterise the surface water quality conditions, including:
  - Sydney Drinking Water Catchment Audit 2019 (Eco Logical Australia 2020)
  - Annual Water Quality Monitoring Report 2020-21 (WaterNSW 2021)
  - Blue Mountains Waterways Health Report 2017 (Blue Mountains City Council 2017).
- defining the area that influences the surface water environments
- assessing potential construction and operational impacts relating to surface water quality during both construction and operation of the project, with reference to:
  - Ambient NSW Water Quality Objectives and Environmental Values (see Table 2-4)
  - Australia & New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018)
  - NorBE assessment tool published by WaterNSW
  - Local water quality objectives and criteria.
- review of surface water impacts and constraints for the project construction facilities

- modelling completed using MUSIC software to estimate the quantity of key stormwater pollutants (total suspended solids, total nitrogen, total phosphorus and gross pollutants) generated and to assess potential impacts to water quality to address the requirements of the NorBE Assessment Guidelines
- identification of appropriate mitigation and management measures to mitigate potential impacts on the environment during construction, following the principles of the Managing Urban Stormwater: Soils and Construction, Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008)
- qualitative assessment of impacts to adjacent water users including erosion and sediment control, water supply and licensing considerations
- identification of appropriate mitigation and management measures to mitigate potential impacts on water quality during operation, including a description of the proposed treatment designs and outcomes
- developing recommendations for a water quality monitoring program during pre-construction, construction and operation of the project.

Key water quality indicators applied to the assessment of the water quality impacts of the project are summarised in Table 2-4, and reflect the water quality objectives (WQOs) for the Hawkesbury-Nepean River system.

The Government-endorsed WQOs for the Hawkesbury–Nepean are contained in the final report of the Healthy Rivers Commission (HRC) on the Hawkesbury–Nepean River system (HRC 1998). The Government confirmed these objectives in its response to the Hawkesbury–Nepean Statements of Joint Intent that encompassed Government decisions on the HRC's Hawkesbury- Nepean Inquiry (NSW Government 2001). In response to the Statements of Joint Intent, the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 was developed. This policy requires that any development within the catchment has either a neutral or beneficial effect on the quality of water across the catchment.

**Table 2-4 Key water quality indicators for the Hawkesbury-Nepean River system and related numerical criteria for environmental values using ANZG (2018) Water Quality Guidelines**

| Environmental value | Indicator | Guideline value |
|---|---|---|
| **Aquatic ecosystems** - maintaining or improving the ecological condition of waterbodies and riparian zones over long term | Total phosphorus | 0.020 mg/L |
| | Total nitrogen | 0.25 mg/L |
| | Turbidity | 2-25 NTU |
| | Salinity (as conductivity) | 30-350 µS/cm |
| | Dissolved oxygen | 90-110% saturation |
| | pH | 6.5-8.0 |
| | Toxicants | As per ANZG (2018) toxicant default guideline values (95% level of protection for slightly to moderately disturbed ecosystems and 99% level of protection for toxicants that bioaccumulate) unless discharge criteria are agreed with relevant authorities |
| **Visual amenity** - aesthetic qualities of waters | Visual clarity and colour | Natural visual clarity should not be reduced by more than 20%. Natural hue of water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%. |
| | Surface films and debris | Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and litter n/a (no quantitative value specified) |

| Environmental value | Indicator | Guideline value |
|---|---|---|
| | Nuisance organisms | Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts n/a (no quantitative value specified) |
| **Primary contact recreation** - maintaining or improving water quality for activities such as swimming where there is a high probability of water being swallowed | Faecal coliforms, enterococci, algae and blue-green algae | As per the NHMRC (2008) Guidelines for managing risks in recreational water. |
| | Protozoans | Pathogenic free-living protozoans should be absent from bodies of fresh water. |
| | Chemical contaminants | Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation. Toxic substances should not exceed values in table 9.3 of the NHMRC (2008) guidelines. |
| | Visual clarity and colour | As per the visual amenity guidelines. |
| | Temperature | 15°-35°C for prolonged exposure. |
| **Secondary contact recreation** - maintaining or improving water quality of activities such as boating and wading, where there is a low probability of water being swallowed | Faecal coliforms, enterococci, algae and blue-green algae | As per the NHMRC (2008) Guidelines for managing risks in recreational water. Secondary contact recreation – maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed. |
| | Nuisance organisms | As per the visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable. |
| | Chemical contaminants | Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable of recreation. Toxic substances should not exceed values in Table 9.3 of NHMRC (2008) guidelines. |
| | Visual clarity and colour | As per the visual amenity guidelines. |
| | Surface films | As per the visual amenity guidelines. |
| **Irrigation water supply** - protecting the quality of waters applied to crops and pastures | Algae and blue-green algae | Should not be visible. No more than low algal levels are desired to protect irrigation equipment. |
| | Salinity | To assess the salinity and sodicity of water for irrigation use, a number of interactive factors must be considered including irrigation water quality, soil properties, plant salt tolerance, climate, landscapes and water and soil management. For more information, refer to Chapter 4.2.4 of ANZECC/ARMCANZ 2000 Guidelines. |
| | Thermotolerant coliforms (faecal coliforms) | Trigger values for thermotolerant coliforms in irrigation water used for food and non-food crops are provided in Table 4.2.2 of the ANZECC/ARMCANZ 2000 Guidelines. |

| Environmental value | Indicator | Guideline value |
|---|---|---|
| | Heavy metals and metalloids | Long term trigger values (LTV) and short-term trigger values (STV) for heavy metals and metalloids in irrigation water are presented in Table 4.2.10 of the ANZECC/ARMCANZ (2000) guidelines. |
| **Livestock water supply** - protecting water quality to maximise production of healthy livestock | Algae and blue-green algae | An increasing risk to livestock health is likely when cell counts of microcystins exceed 11 500 cells/mL and/or concentrations of microcystins exceed 0.0023mg/L expressed as microcystin-LR toxicity equivalents. |
| | Salinity | Recommended concentrations of total dissolved solids in drinking water for livestock are given in Table 4.3.1 of the ANZECC/ARMCANZ (2000) Guidelines. |
| | Thermotolerant coliforms (faecal coliforms) | Drinking water for livestock should contain less than 100 thermotolerant coliforms per 100 mL (median value). |
| | Chemical contaminants | Refer to Table 4.3.2 of the ANZECC/ARMCANZ (2000) Guidelines for heavy metals and metalloids in livestock drinking water.<br>Refer to Australian Drinking Water Guidelines (NHMRC and NRMMC, 2018) for information regarding pesticides and other organic contaminants, using criteria for raw drinking water. |
| Aquatic foods (cooked) - refers to protecting water quality so that it is suitable for production of aquatic foods for human consumption and aquaculture activities | Algae and blue-green algae | No guideline is directly applicable, but toxins present in blue green algae may accumulated in other aquatic organisms. |
| | Faecal coliforms | Guideline in water for shellfish: The median faecal coliform concentration should not exceed 14 MPN/100mL; with no more than 10% of the samples exceeding 43 MPN/100mL.<br>Standard in edible tissue: Fish destined for human consumption should not exceed a limit of 2.3 MPN E Coli/g of flesh with a standard plate count of 100,000 organisms/g. |
| | Toxicants (as applied to aquaculture activities) | Metals:<br>Copper – less than 0.005mg/L<br>Mercury – less than 0.001mg/L<br>Zinc – less than 0.005mg/L.<br>Organochlorines:<br>Chlordane – less than 0.004mg/L (saltwater production)<br>PCBs – less than 0.002mg/L. |
| | Physico-chemical indicators | Suspended solids: less than 0.04mg/L<br>Temperature: less than 2°C change over one hour. |
| Raw water supply agreement to the Warragamba WFP | Turbidity | 10 NTU |
| | True Colour at 400nm | 70 CU |
| | Iron | 3.5 mg/L |
| | Manganese | 1.40 mg/L |
| | Aluminium | 2.60 mg/L |
| | Hardness | 25.0 – 70.0 mg/L as $CaCO_3$ |

| Environmental value | Indicator | Guideline value |
|---|---|---|
| | Alkalinity | 15.0 – 60.0 mg/L as $CaCO_3$ |
| | Algae | 2000 ASU/ml |
| | Toxicants | As per the ADWG guidelines (NHMRC, 2011) for metals not specified in the raw water supply agreement |

### 2.2.5 Water balance, wastewater and other surface water issues

To demonstrate that long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised other investigations and assessments carried out for the project include:

- developing a water balance to understand water demand and discharge requirements during construction and operation of the project
- assessing the generation of wastewater, its treatment, reuse and disposal for the construction and operation phases of the project and identification of mitigation measures where required
- identifying mitigation and management measures to be applied during construction and operational phase to mitigate potential impacts associated with water use and wastewater.

# 3 Existing environment

This section provides a summary of the existing environment along and around the project corridor, as relevant to the assessment of potential surface water and flooding impacts. It includes details of climate and weather, topography, drainage and surface water resources, geology, and surface water users (human and ecological).

The study area for this assessment in relation to national parks (i.e. Blue Mountains National Park), reserves, watercourses and catchments is shown in Figure 3-1. The construction footprint would be close to the Greater Blue Mountains World Heritage Area (GBMA) at Blackheath and Soldiers Pinch. This has been assessed against the World Heritage significance criteria and National Heritage significance criteria in Appendix M (Technical report – Non-Aboriginal heritage) of the EIS.

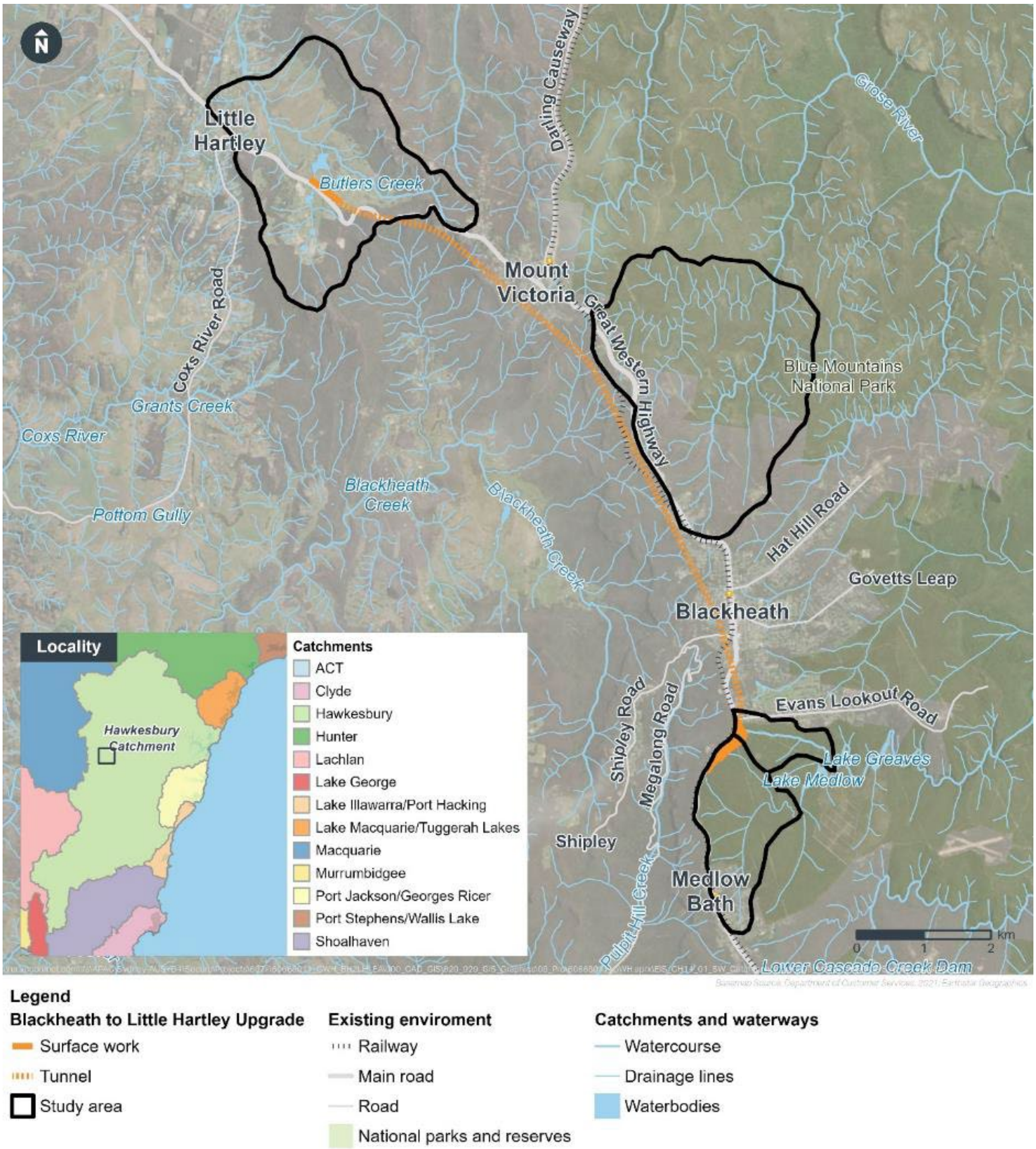



**Figure 3-1 Assessment study area**

## 3.1 Climate and rainfall

The Australian Bureau of Meteorology (BoM) operates several automated weather stations (AWS) near the project that have been used to inform this surface water and flooding assessment, including:

- Mount Victoria (Selsdon Street) (063056) – rainfall data available from January 1872 to December 1990
- Mount Boyce AWS (063292) – temperature and rainfall data available from June 1994 to present
- Blackheath (Wombat Street) (063295) – rainfall data available from July 1996 to present
- Little Hartley AWS (Roscommon) (063270) – rainfall data available from July 1994 to December 2021

- Katoomba AWS (Farnells Road) (063039) – temperature and rainfall data available from November 1885 to December 2021

The locations of these weather stations relative to the project and the surface water and flooding assessment study area are shown on Figure 3-3.

### 3.1.1 Temperature

Mean monthly maximum temperatures recorded at Mount Boyce and Katoomba (refer to Figure 3-2) show that the region is typical of a cool temperate mountain climate. Snow and/or sleet is common during the winter months.


**Figure 3-2 Comparison of mean monthly maximum temperature**

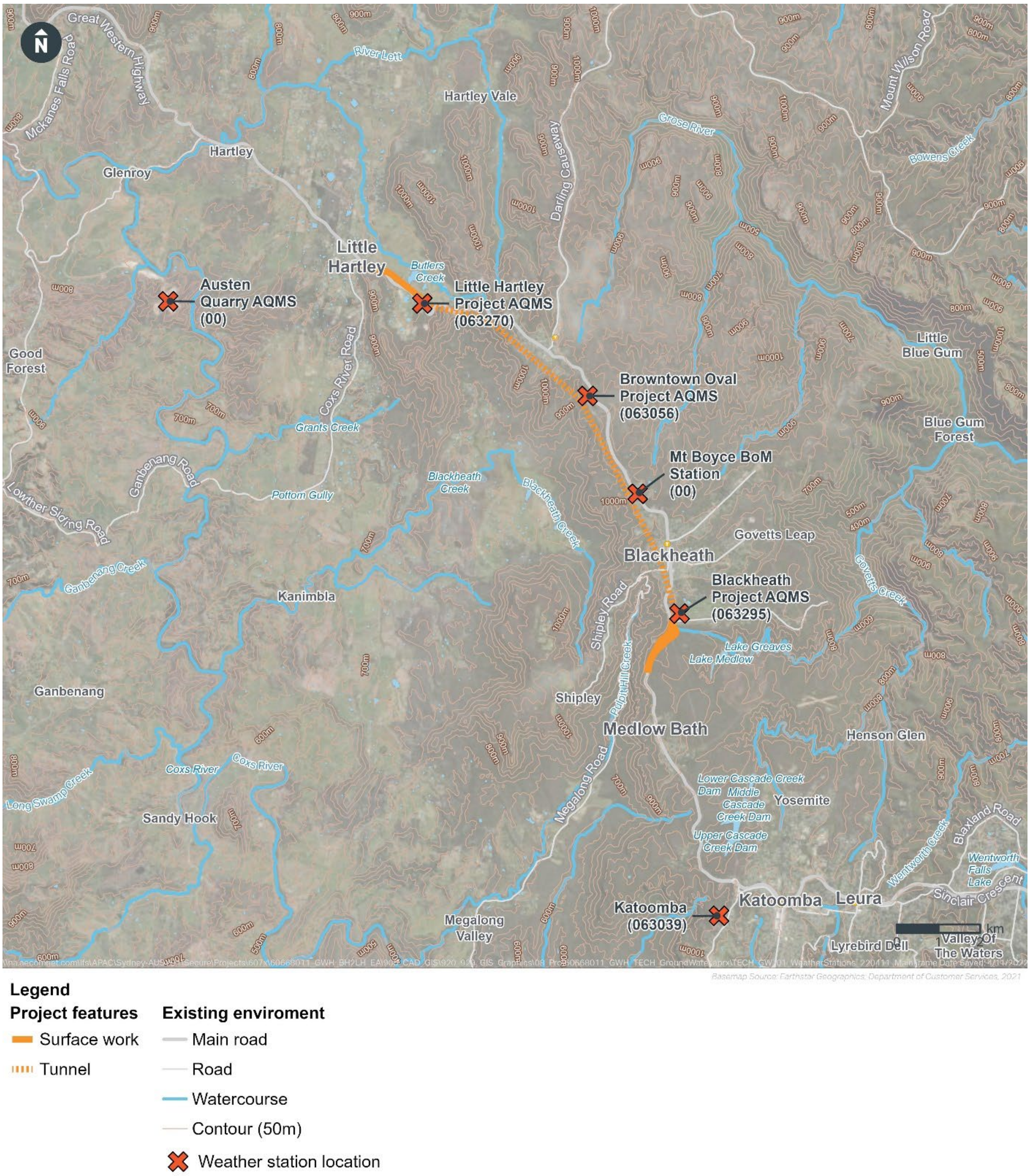



**Figure 3-3 BoM weather station locations**

### 3.1.2 Rainfall

Available mean monthly rainfall data for the five BoM weather stations used in the surface water quality assessment are summarised in Table 3-1. This data indicates an average annual rainfall of between 712 mm and 1480 mm for the region. Figure 3-4 compares the mean monthly rainfall recorded at the five weather stations.

**Table 3-1 Mean monthly rainfall (mm) for selected BoM weather stations**

| Station | Mean monthly rainfall (mm) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | January | February | March | April | May | June | July | August | September | October | November | December | Annual |
| **Mount Boyce** | 118 | 139 | 134 | 63 | 54 | 75 | 45 | 57 | 54 | 69 | 105 | 86 | 1006 |
| **Blackheath** | 126 | 171 | 144 | 73 | 53 | 84 | 46 | 54 | 49 | 74 | 117 | 100 | 1130 |
| **Mount Victoria** | 117 | 121 | 110 | 90 | 79 | 91 | 72 | 67 | 62 | 78 | 82 | 92 | 1063 |
| **Little Hartley** | 77 | 76 | 66 | 41 | 36 | 49 | 38 | 48 | 45 | 42 | 75 | 61 | 712 |
| **Katoomba** | 162 | 179 | 172 | 120 | 99 | 118 | 82 | 79 | 71 | 92 | 110 | 122 | 1408 |

*Notes:*
*BoM Blackheath AWS (Wombat Street), No.063925 – data between 1996 to December 2021*
*BoM Mount Victoria AWS (Selsdon Street), No. 063056 – data between 1872 to December 1990*
*BoM Mount Boyce AWS, No.063292 – data between 1994 to December 2021*
*BoM Little Hartley AWS (Roscommon), No.063270 – data between 1994 to December 2021*
*BoM Katoomba AWS (Farnells Road), No.063039 – data between 1886 to December 2021*

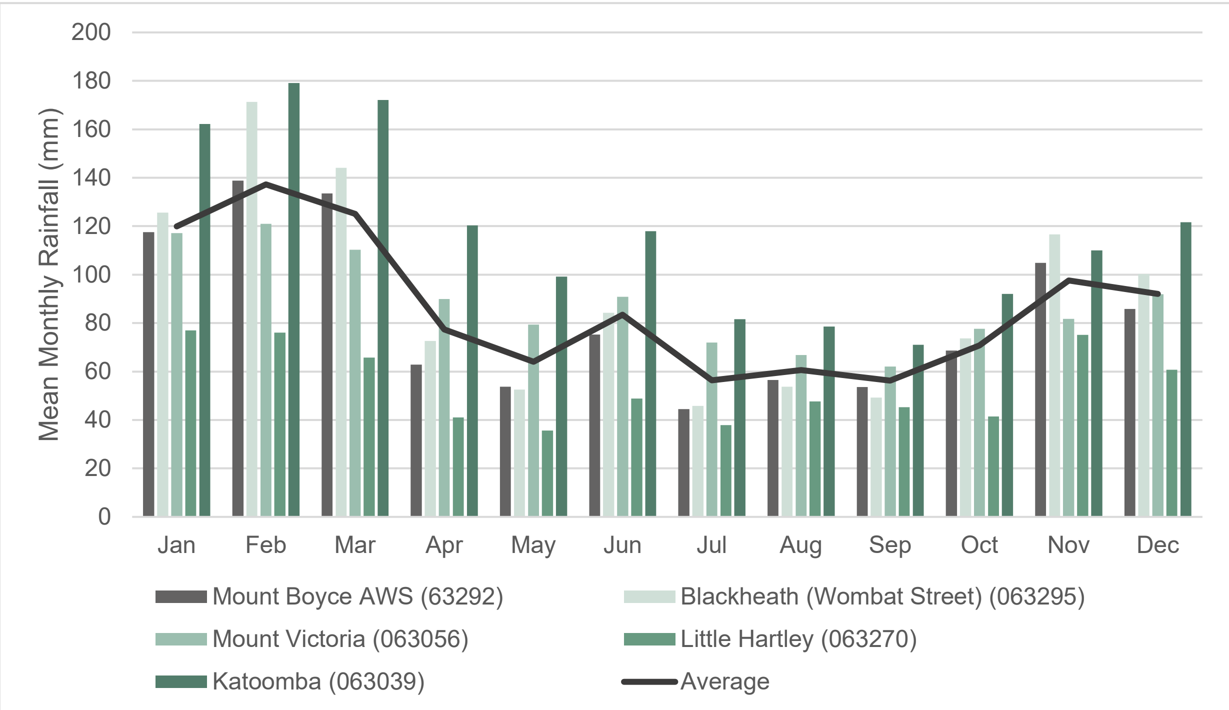



**Figure 3-4 Comparison of mean monthly rainfall**

### 3.1.3 Evaporation

Evaporation has not been measured at the weather stations used in this surface water impact assessment. However, pan evaporation mapping published by the BoM (refer to Figure 3-5) indicates that the total average annual evaporation in the region in which the project would be located is between 1,400 mm and 1,600 mm.

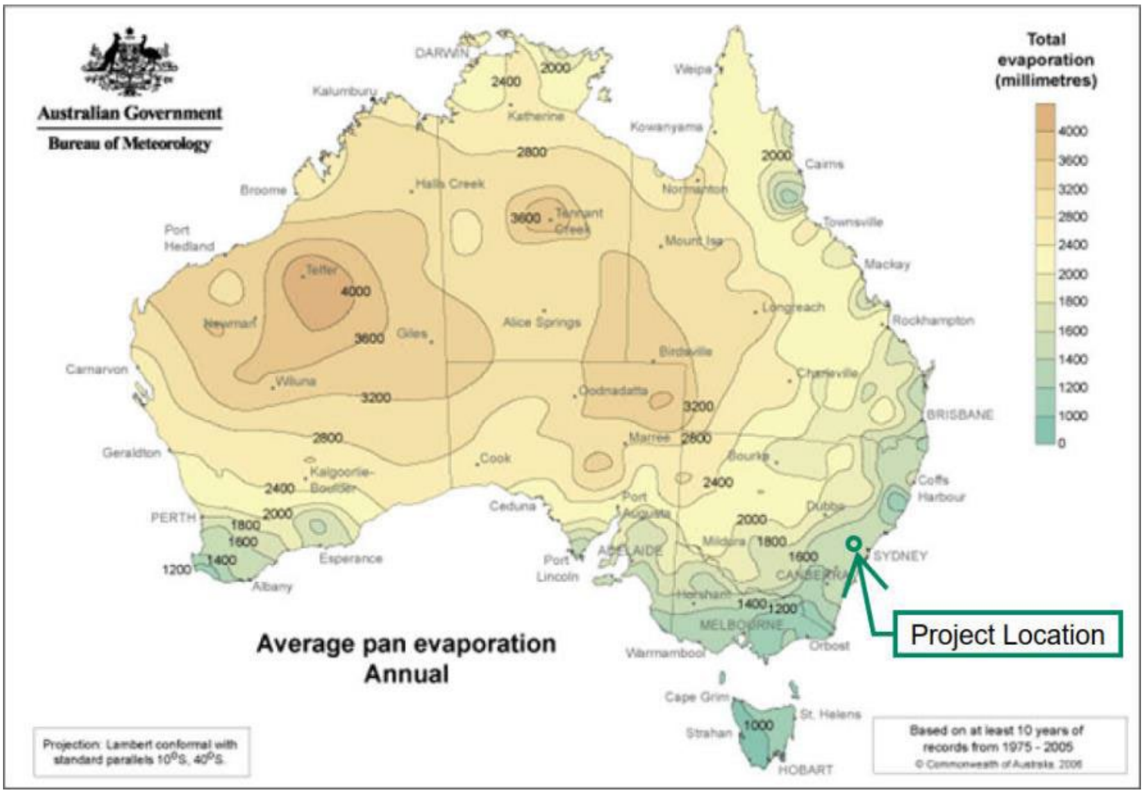



Figure 3-5 Average annual evaporation (BoM 2006)

## 3.2 Topographical setting and drainage

The tunnel would be generally aligned with and beneath the existing Great Western Highway, which is located along a ridge line. The lands to the east are generally similar or higher elevation and lands to the west follow a moderately steep slope down towards the Megalong Valley. There are numerous mountain peaks on both sides of the project corridor, including Mount Victoria which is around 1,000 to 1,100 metres Australian Height Datum (AHD). The topography of the project is shown in Figure 3-6.

Numerous creeks and gullies traverse or extend from the Great Western Highway and connect as tributaries of rivers on both sides of the project corridor. Those on the western side of the existing Great Western Highway feed into the Coxs River and those on the eastern side of the Great Western Highway feed into the Grose River.

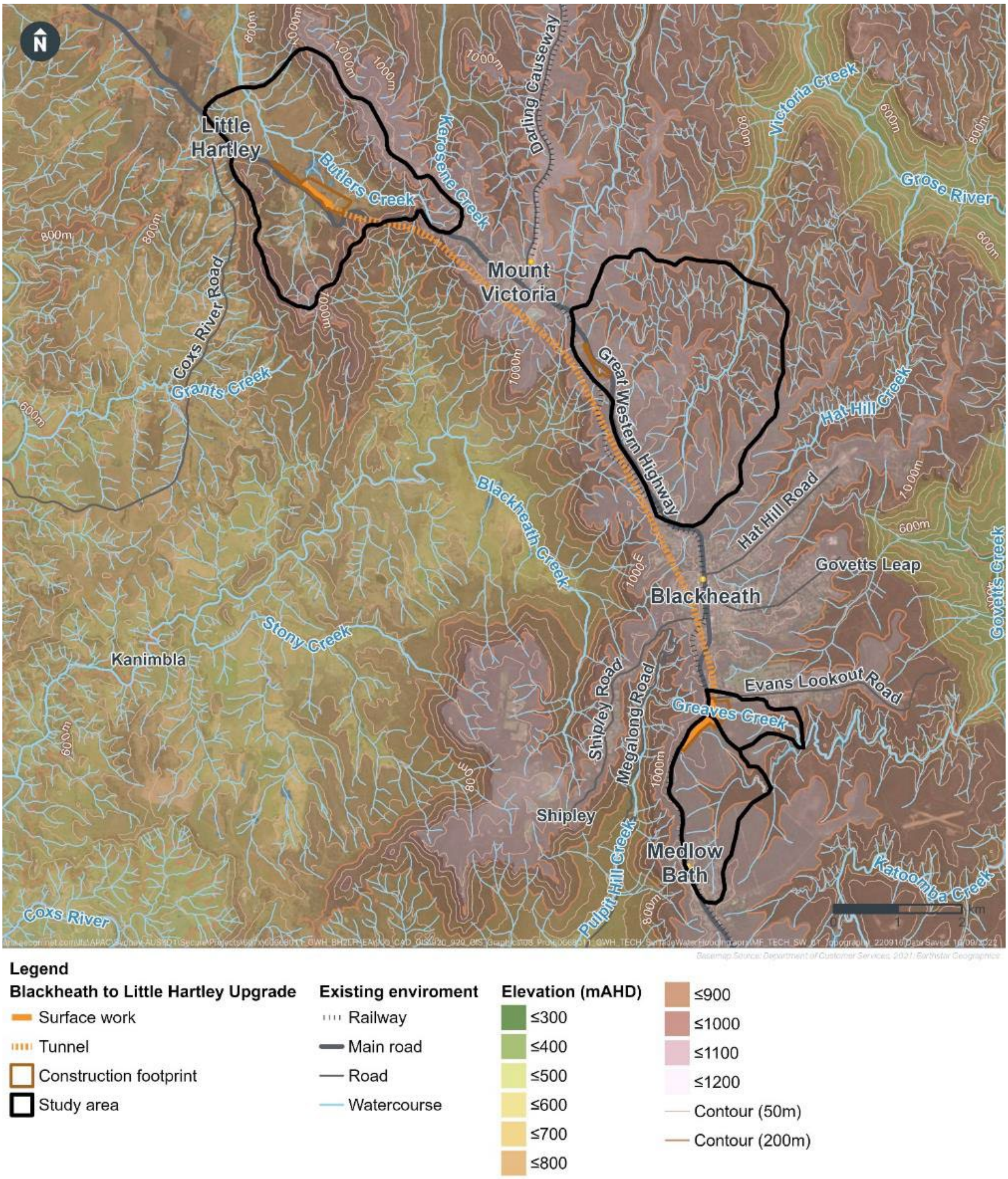



**Figure 3-6 Topographic map**

## 3.3 Geology and soil landscapes

### 3.3.1 Geology

The eastern portion of the project around Blackheath is characterised by Sandstone comprising interbedded Widden Brook conglomerate, sandstone, siltstone and claystone. The central portion around Mount Victoria and Soldiers Pinch is characterised by shale, sandstone, conglomerate and chert with coal and torbanite seams. The western portion around Little Hartley is characterised by shale, conglomerate and sandstone including lenticular development of the Megalong conglomerate.

The bedrock beneath the project and through which the project tunnels would pass comprises of units of the Narrabeen Group (Triassic), Illawarra Coal Measures and Shoalhaven Group (Permian), and the Kanimblan cycle of the Lachlan Orogen (Carboniferous) (King, 1994).

More detailed information on the geology of the area is provided in Appendix I (Technical Report - Groundwater) of the EIS.

### 3.3.2 Soil landscapes

Soil landscape types along the project corridor and surrounding areas are shown Figure 3-7.

The soil landscape at the Blackheath construction footprint is Medlow Bath. The soil landscapes at Soldiers Pinch construction footprint are Wollangambe and Medlow Bath. The soil landscapes at the Little Hartley construction footprint are Hassans Walls, Cullen Bullen and predominantly Lithgow. The characteristics of these soil landscapes are summarised in Table 3-2.

**Table 3-2 Soil landscapes within the Project construction footprint**

| Soil landscape name | Characteristics | Erosion potential (Landcom, 2004) | Qualities and limitations |
|---|---|---|---|
| Medlow Bath (mb) | Occurs on narrow crests and moderately inclined sideslopes on Narrabeen Group sandstones.<br>Soils comprise of sand, loamy sand and clayey sand. | Localised shallow soils and rock outcrop contribute to areas of high erosion hazard. | Stony, acid soils of very low fertility, very high potential aluminium toxicity, localised rock outcrop, localised shallow soils. |
| Wollangambe (wo) | Occurs on rounded crests and moderately to steeply inclined sideslopes on Narrabeen Group sandstones.<br>Soils comprise loamy sand, clayey sand and clay. | Shallow soils with localised rock outcrop; high erosion hazard; localised steep slopes with mass movement and rock fall hazards; general hazard to foundations. | High to severe water erosion hazard, steep slopes, shallow soils, localised rock fall hazard, localised rock outcrop. |
| Hassans Walls (hw) | Occurs on cliffs derived from Narrabeen Group sandstones and steep colluvial talus sideslopes developed over the Illawarra Coal Measures and the Shoalhaven Group.<br>Soils comprise loamy sand, sand and clay. | Very steep slopes, mass movement and rock falls; shallow soils and rock outcrop; high erosion hazard; general hazard for foundations. | Severe rock fall hazard, mine subsidence, steep slopes, extreme water erosion hazard, mass movement hazard, severe foundation hazard, rock outcrop and localised shallow soils, high run-on, non-cohesive soils (localised). |
| Cullen Bullen (cb) | Occurs on rolling low hills and rises on Illawarra Coal measures and the Berry Formation.<br>Soils comprise sandy clay loam and pedal clay. | High erosion hazard; high run-on to low areas; localised rock outcrop and rock fall; localised hazards for foundations. | Hardsetting topsoils, high water erosion hazard, localised mine subsidence district, high run-on, rock outcrop, localised rock fall hazard and localised high foundation hazard. |
| Lithgow (li) | Occurs on flat to undulating rises and broad valley floors on Illawarra Coal Measures and the Berry Formation. | High run-on to low areas; subject to localised rock fall and mine subsidence. | Hardsetting topsoils, high run-on, localised mine subsidence district, localised rock fall hazard, localised high potential aluminium toxicity. |

| Soil landscape name | Characteristics | Erosion potential (Landcom, 2004) | Qualities and limitations |
|---|---|---|---|
| | Soils comprise sandy loam, clay loam and fine sandy clay loam. | | |

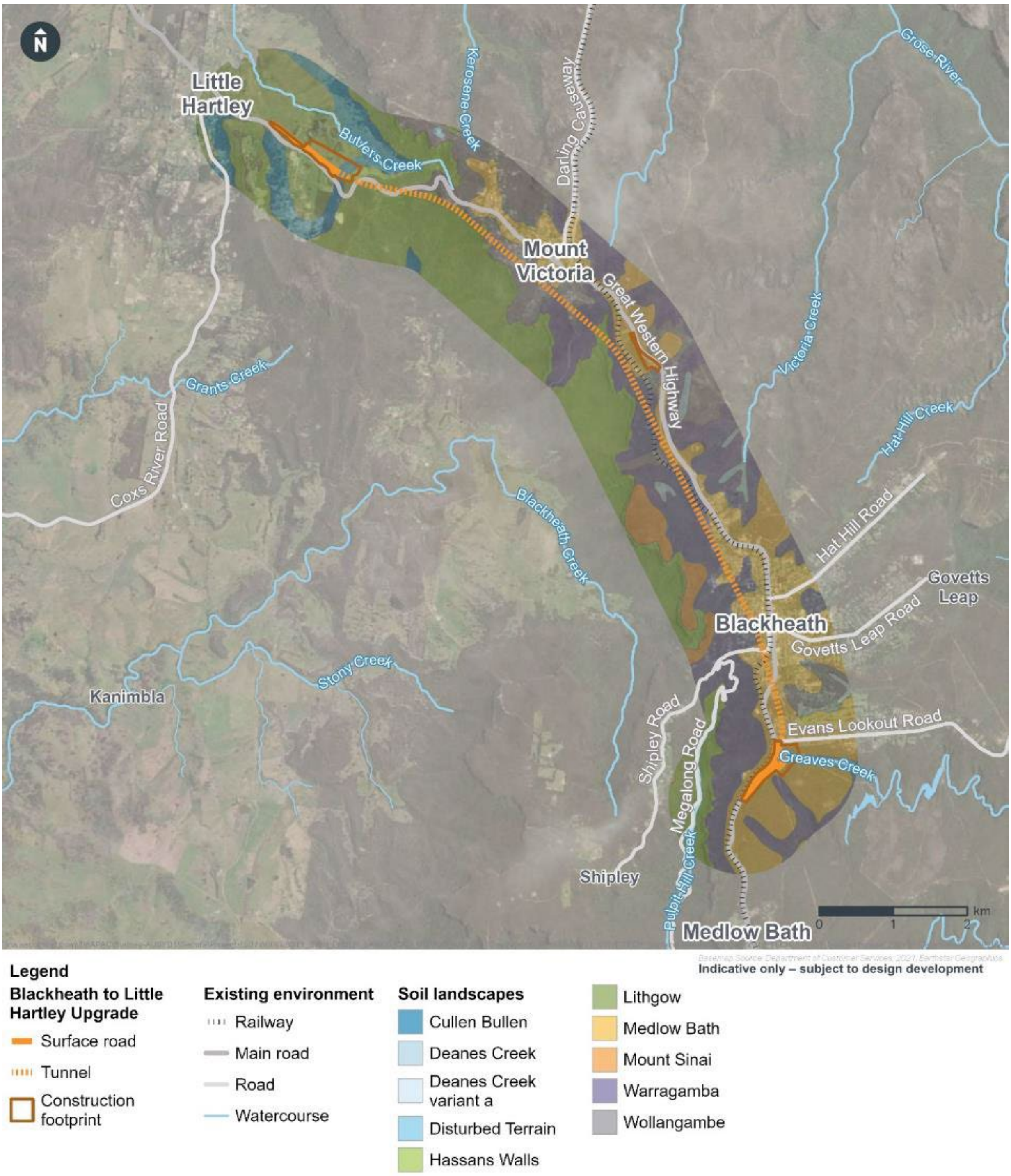



**Figure 3-7 Soil landscapes map**

### 3.3.3 Salinity

There was no dry land salinity data identified within the project corridor or surrounding areas.

### 3.3.4 Groundwater quality

Groundwater quality in the study area varies based on geological unit as outlined in Table 3-3.

**Table 3-3 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 typically comprises low salinity and low dissolved metal concentrations (likely recently recharged) and is slightly acidic. Groundwater within the Illawarra Coal Measures is slightly less acidic but has a relatively high level of total dissolved solids. Samples taken for Shoalhaven Group groundwater 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 are discussed in Chapter 15 (Soils and contamination) of the EIS.

### 3.3.5 Acid sulfate soils

The risk of encountering acid sulfate soils is low (see Figure 3-8). The area around the project is predominantly classified as C – extremely low probability of acid sulfate soil occurrence (one to five per cent chance of occurrence with occurrences in small, localised areas). The western portion of the project around Little Hartley is classified B – low probability of acid sulfate soil occurrence (six to 70 per cent chance or occurrence). For further details, refer to Appendix I (Technical report – Groundwater).

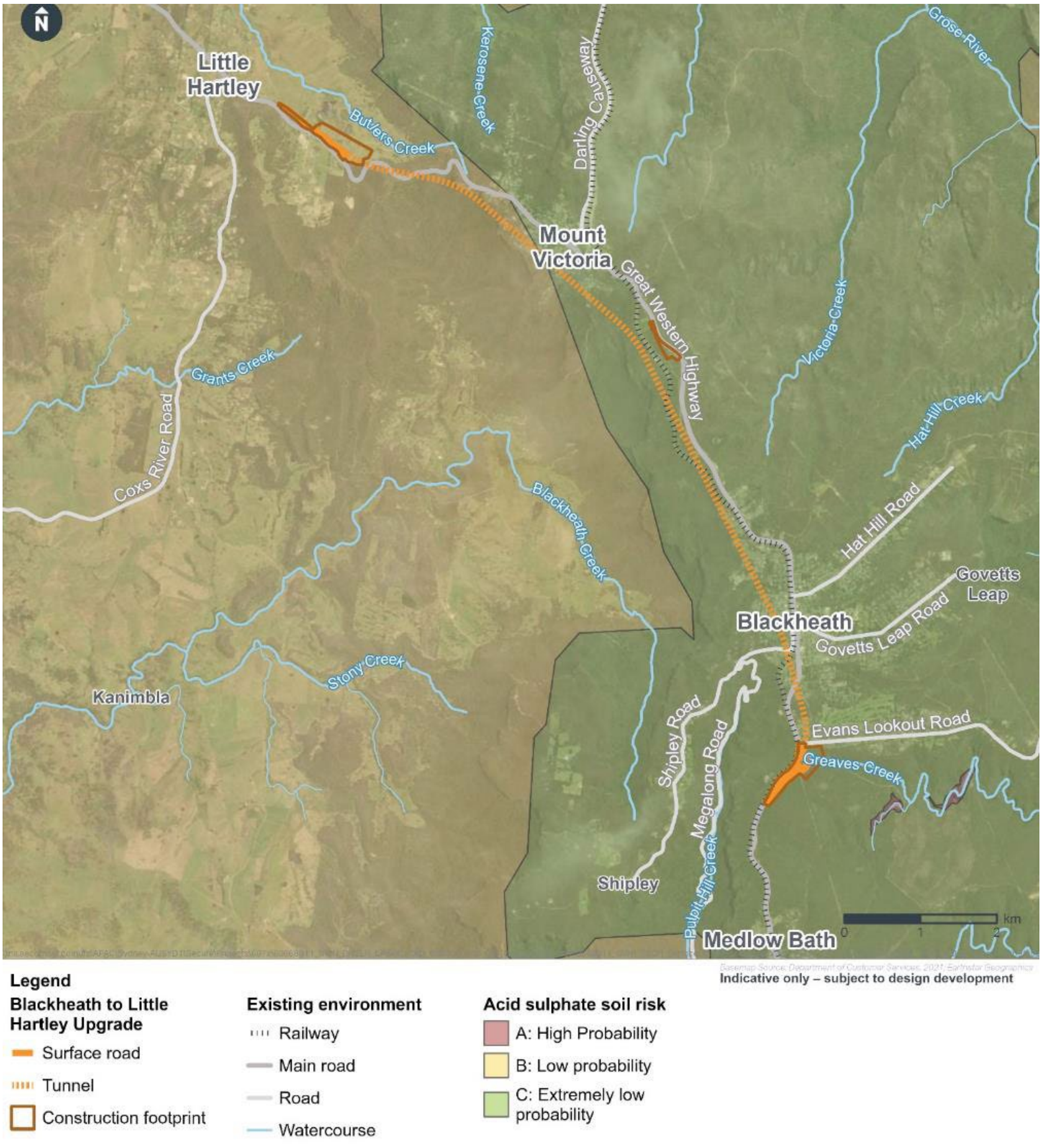



**Figure 3-8 Acid sulfate soil risk near the project footprint (ASRIS database)**

### 3.3.6 Acid sulfate rock

Acid sulfate rock (ASR) contains sulfide or sulfate minerals (commonly pyrite) that have the potential to oxidise during excavation and produce sulfuric acid that can impact environmental conditions.

ASR is not expected to be detected at the Blackheath construction footprint of the project or at the Soldiers Pinch construction footprint. ASR is anticipated to be found at the Little Hartley (western) end of the project at depths greater than four metres in unweathered rock that contains sedimentary pyrite due to the geological units identified in the area. Any available pyrite in weathered rock would likely be already oxidised and hence would no longer have the potential to produce sulfuric acid. The geotechnical investigations found that several samples from bores around the Little Hartley portal exceed the criteria for potential acid sulfate rock. Therefore, cut and fill at the Little Hartley end of the project is also likely to contain ASR.

For further detail on acid sulfate rock, refer to Appendix I (Technical report – Groundwater) of the EIS.

## 3.4 Catchment features

### 3.4.1 Land use

An overview of all land uses surrounding the project is provided in Chapter 20 (Business, land use and property) of the EIS.

The project is located within the Hawkesbury-Nepean River catchment. Stricter requirements and controls apply to parts of the project within the Sydney Drinking Water Catchment and within the Blackheath portion of the Blue Mountains Special Area. These catchments are described in the following sections.

Land within these catchments plays and important role in capturing drinking water for Greater Sydney. 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.

### 3.4.2 Hawkesbury-Nepean Catchment

The project would be located within the wider Hawkesbury-Nepean River catchment. The Hawkesbury River and its tributaries are over 470 kilometres long and the Hawkesbury-Nepean River Catchment has an area of around 22,000 square kilometres. Runoff from all areas of the project would ultimately drain to the Hawkesbury River via one of two different drainage pathways and sub-catchments (refer to Figure 3-9 and Figure 3-10):

- Grose River – the surface works at the Blackheath and Soldiers Pinch 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. Grose River flows over 60km in an easterly direction and eventually connects to the Hawkesbury River at its origin, located approximately 30 kilometres east of the project
- Coxs River – the surface works at the Little Hartley areas would be located within the Coxs River sub-catchment, and the majority of the project tunnels would be located beneath it. This catchment starts to drain in a westerly direction before it turns south, loops around to the east and drains back north towards the Hawkesbury River. Runoff from the western portion of the project would drain to Butlers Creek, then River Lett and Coxs River and eventually feed into Lake Burragorang. Discharge from Lake Burragorang is controlled at the Warragamba Dam and flows into the upstream end of the Nepean River. The Nepean River then merges with Grose River to become the Hawkesbury River.

Parts of the project lie within Sydney's Drinking Water Catchments, which are described in the following section.


**Figure 3-9 Catchments and watercourses (NSW Office of Water, 2014)**

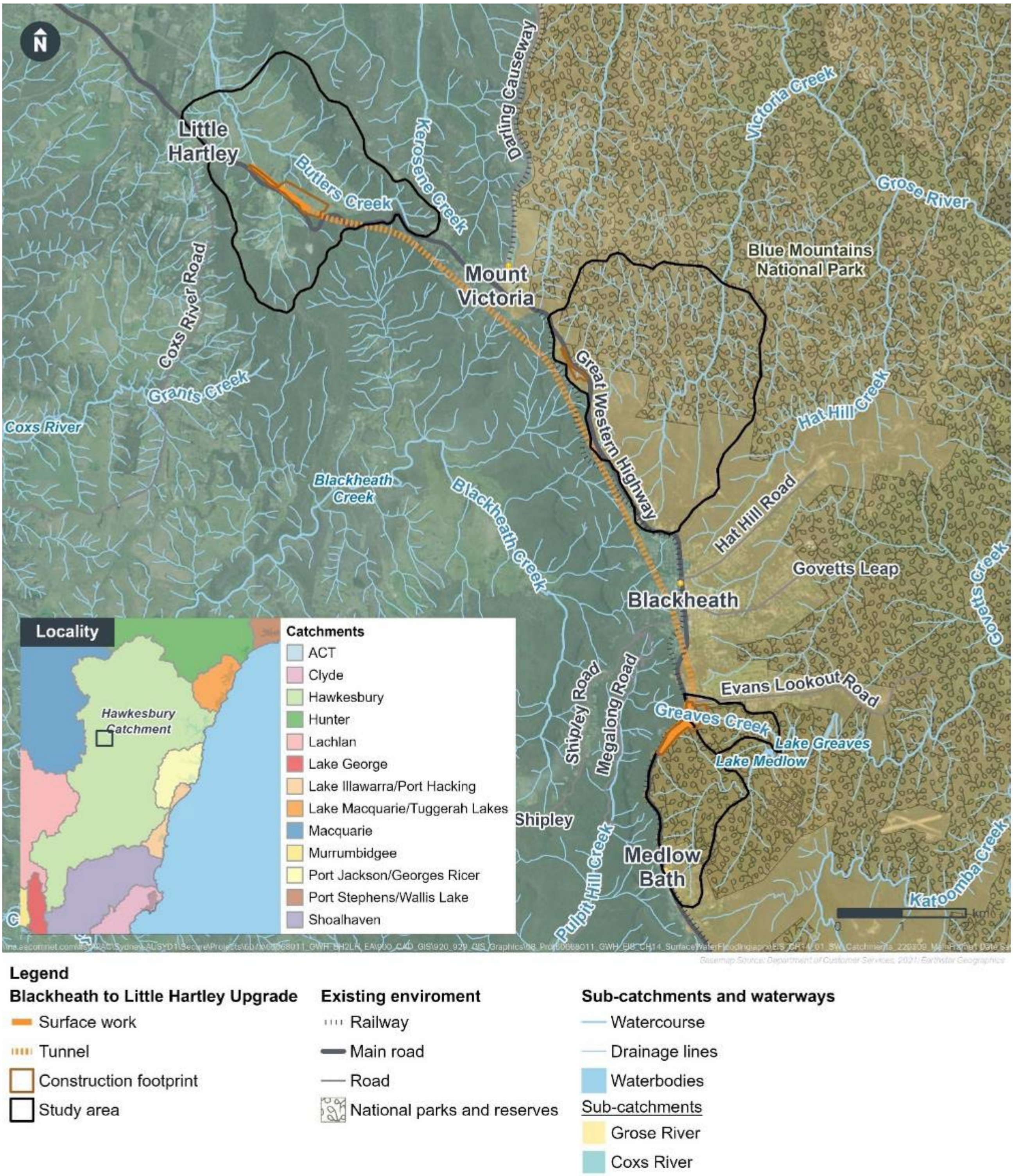



**Figure 3-10 Catchments near the project**

### 3.4.3 Sydney Drinking Water Catchments and water sharing plan

The Blackheath construction footprint would be located within the Blackheath portion of the Blue Mountains Special Area (Schedule 1 Special Area) (refer to Section 2.1.2), which lies in the Grose River catchment and is used to supply water to Blue Mountains townships through a series of smaller local reservoirs such as Lake Greaves and Lake Medlow. Public access to this area is restricted to protect water quality and create a buffer of land around essential water storage. No public access to the Blackheath Special Area would be permitted as the construction site would be appropriately secured (refer to Figure 3-11).

The Soldiers Pinch construction footprint would be located within the Grose River Catchment which drains to the Hawkesbury River and would not be located within any drinking water catchments (refer to Figure 3-12).

The Little Hartley construction footprint would be located at the top of the Sydney Drinking Water Catchment (Coxs River), which drains to Lake Burragorang and Warragamba Dam to the south (refer to Figure 3-13).

The project is also within the following 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.

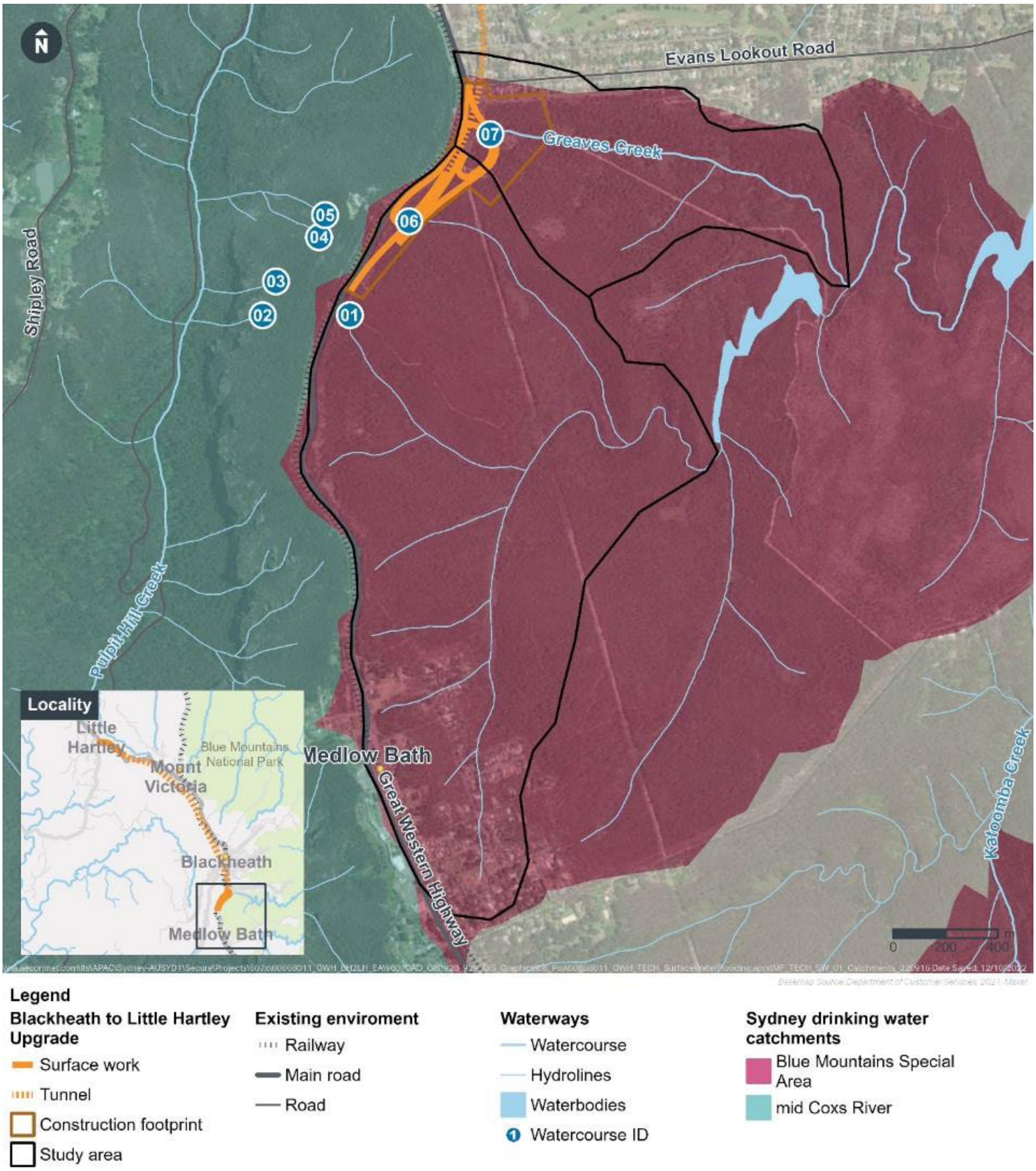



**Figure 3-11 Protected drinking water catchments and key watercourses near the Blackheath construction footprint**

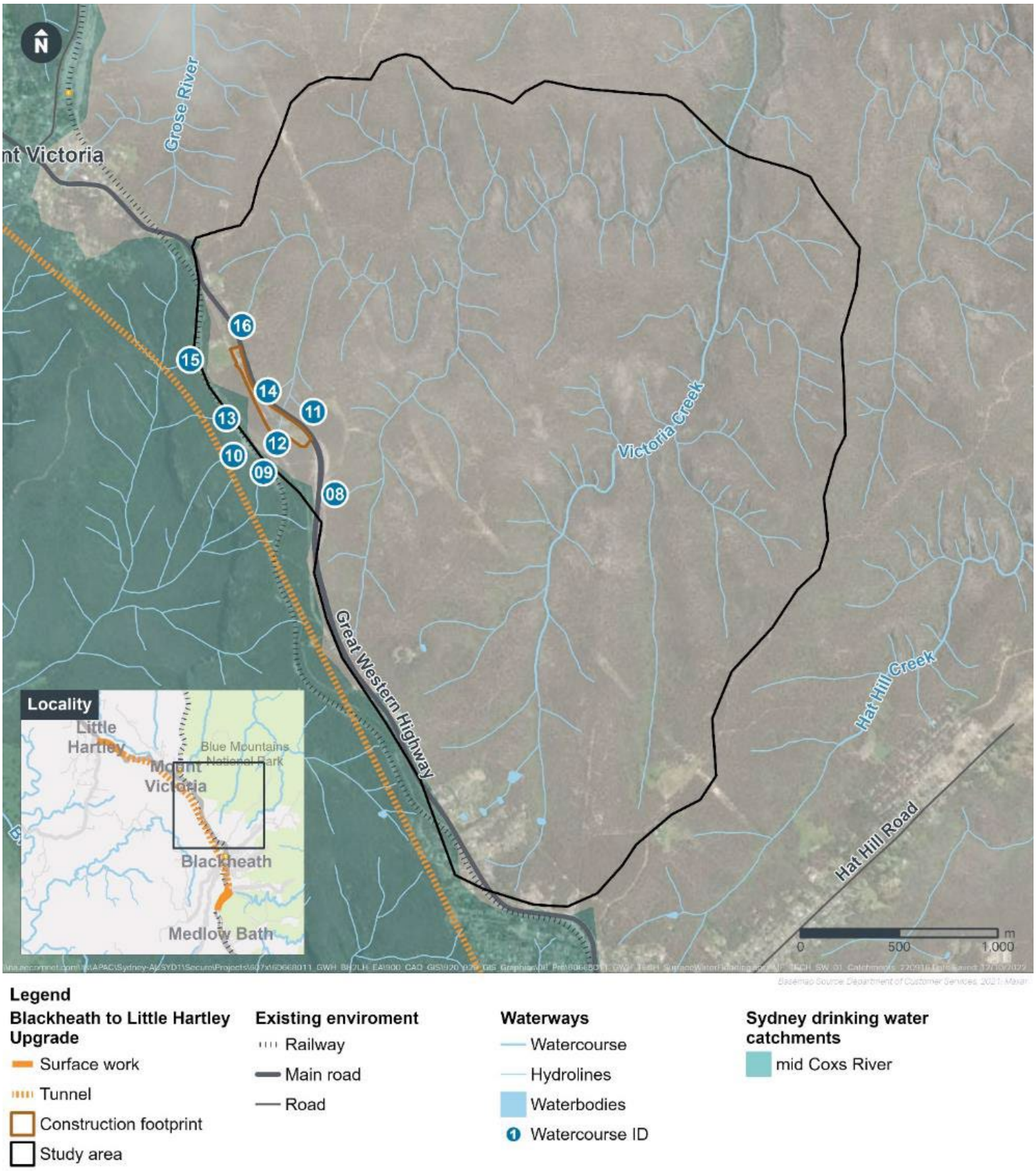



**Figure 3-12 Protected drinking water catchments and key watercourses near the Soldiers Pinch construction footprint**

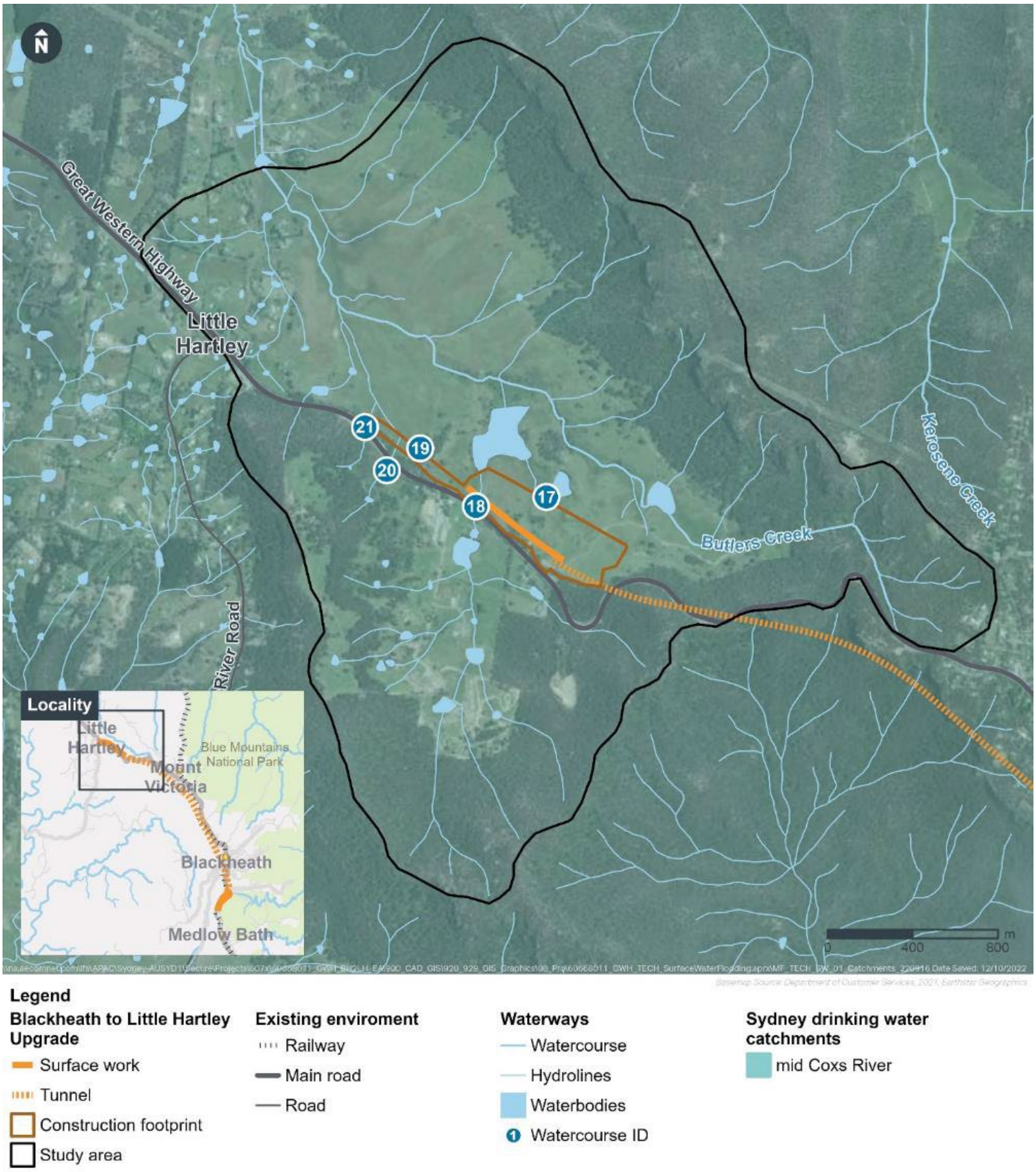



Figure 3-13 Protected drinking water catchments and key watercourses near the Blackheath construction footprint

## 3.5 Watercourses and water bodies

As outlined in Section 3.4, the project would straddle the Coxs River and Grose River catchments. Surface works at Little Hartley and at Soldiers Pinch, and the majority of the project tunnels, would be located within the Coxs River catchment. Surface works at Blackheath would be located within the Grose River catchment.

Watercourses in proximity to project surface works are summarised in Table 3-4 and shown on Figure 3-11 to Figure 3-13.The corresponding watercourse IDs are identified for Blackheath, Soldiers Pinch and Little Hartley respectively. Rosedale Creek (at Little Hartley) is the only third order watercourse within or near the project surface footprint, and one of two watercourses characterised as key fish habitat (KFH). It drains to Butlers Creek, Coxs River and ultimately the Warragamba Dam within The Sydney Drinking Water Catchment. Warragamba Dam is a major water storage for the Greater Sydney Metropolitan Region, supplying drinking water to more than 5 million people.

**Table 3-4 Watercourses within or near the project disturbance footprint**

| ID | Watercourse | Tributary of | Stream type | Within project footprint | Stream order[2] | KFH[1] at nearby watercourse[3] |
|---|---|---|---|---|---|---|
| **Blackheath** | | | | | | |
| 01 | Relton Creek | Adams Creek (Grose River) | Intermittent | No | 1 | No (KFH 0.9 km downstream) |
| 02 | Unnamed waterway | Pulpit Hill Creek (Coxs River) | Ephemeral | No | 1 | No (KFH 0.3 km downstream) |
| 03 | Unnamed waterway | Pulpit Hill Creek (Coxs River) | Ephemeral | No | 1 | No (KFH 0.3 km downstream) |
| 04 | Unnamed waterway | Pulpit Hill Creek (Coxs River) | Ephemeral | No | 1 | No (KFH 0.5 km downstream) |
| 05 | Unnamed waterway | Pulpit Hill Creek (Coxs River) | Ephemeral | No | 1 | No (KFH 0.5 km downstream) |
| 06 | Unnamed waterway | Adams Creek (Grose River) | Intermittent | Yes | 1 | No (KFH 1.2 km downstream) |
| 07 | Greaves Creek | Govetts Creek (Grose River) | Intermittent | Yes | 1 | No (KFH 1.4 km downstream) |
| **Soldiers Pinch** | | | | | | |
| 08 | Unnamed waterway | Boyce Gully (Grose River) | Ephemeral | No | 1 | No (KFH 1.4 km downstream) |
| 09 | Unnamed waterway | Fairy Bower Creek (Coxs River) | Ephemeral | No | 1 | No (KFH 1 km downstream) |
| 10 | Unnamed waterway | Fairy Bower Creek (Coxs River) | Ephemeral | No | 1 | No (KFH 0.9 km downstream) |
| 11 | Unnamed waterway | Victoria Brook (Grose River) | Ephemeral | No | 1 | No (KFH 0.8 km downstream) |
| 12 | Unnamed waterway | Victoria Brook (Grose River) | Ephemeral | Yes | 1 | No (KFH 0.9 km downstream) |
| 13 | Unnamed waterway | Fairy Bower Creek (Coxs River) | Ephemeral | No | 1 | No (KFH 1.2 km downstream) |
| 14 | Unnamed waterway | Victoria Brook (Grose River) | Ephemeral | No | 1 | No (KFH 0.7 km downstream) |
| 15 | Unnamed waterway | Fairy Bower Creek (Coxs River) | Ephemeral | No | 1 | No (KFH 1.3 km downstream) |
| 16 | Unnamed waterway | Victoria Brook (Grose River) | Ephemeral | No | 1 | No (KFH 0.8 km downstream) |

| ID | Watercourse | Tributary of | Stream type | Within project footprint | Stream order[2] | KFH[1] at nearby watercourse[3] |
|---|---|---|---|---|---|---|
| **Little Hartley** | | | | | | |
| 17 | Unnamed waterway | Butlers Creek (Coxs River) | Ephemeral | No | 1 | Yes |
| 18 | Rosedale Creek | Butlers Creek (Coxs River) | Intermittent | Yes | 3 | Yes |
| 19 | Unnamed waterway | Butlers Creek (Coxs River) | Ephemeral | Yes | 1 | No (KFH 0.8 km downstream) |
| 20 | Unnamed waterway | Butlers Creek (Coxs River) | Ephemeral | Yes | 1 | No (KFH 1.1 km downstream) |
| 21 | Unnamed waterway | Butlers Creek (Coxs River) | Ephemeral | Yes | 1 | No (KFH 0.9 km downstream) |

Notes:

1 – Key Fish Habitats (KFH) includes all marine and estuarine habitat up to highest astronomical tide level and most permanent and semi-permanent freshwater habitats including rivers, creeks, lakes, lagoons, billabongs, weir pools and impoundments up to the top of the bank.

2 – (Strahler, 1952)

3 – (DPI, 2013)

## 3.6 Surface water quality

### 3.6.1 Desktop assessment of water quality

An initial review of the WaterNSW Real Time Data and WaterInsights online platforms returned no water quality data within or close to the study area.

The following reports and studies were used to review the water quality in vicinity of the project and its broader location within Sydney Drinking Water and the Hawkesbury-Nepean River Catchments:

- Sydney Drinking Water Catchment Audit 2019 (Eco Logical Australia 2020)
- Annual Water Quality Monitoring Report 2020-21 (WaterNSW 2021)
- Blue Mountains Waterways Health Report 2017 (Blue Mountains City Council 2017).

These documents have been summarised in Table 2-3. Overall, the available data and reporting suggests that the water quality of the surrounding water courses and broader catchments close to the project vary from good to poor.

**Table 3-5 Water quality study summary**

| Report or Study Name | Description | Overall assessment of water quality in relation to study area |
|---|---|---|
| Sydney Drinking Water Catchment Audit 2019<br>Eco Logical Australia<br>July 2016 to June 2019<br>Sydney Drinking Water Catchment | This audit sought to determine if the water quality in streams and storages complied with relevant guidelines during the audit period. Benchmark guidelines were based on the Australian and New Zealand Guidelines for Freshwater and Marine Water Quality (ANZG 2018). | Upper Coxs River – Relatively good water quality with most water quality data being within guideline concentrations<br>Mid Coxs River – Water quality found to be mostly compliant and similar to historic records (previous audits), with pH, conductivity and total aluminium found to be non-compliant with guidelines<br>Lower Coxs River – downstream of urban areas, water quality found to be relatively poor, with conductivity, dissolved oxygen, ammonium nitrogen, oxidised nitrogen found to be non-compliant with guidelines |

| Report or Study Name | Description | Overall assessment of water quality in relation to study area |
|---|---|---|
| Annual Water Quality Monitoring Report<br>WaterNSW<br>2020 – 2021<br>Sydney Drinking Water Catchment | This report describes the results of the water quality monitoring undertaken by WaterNSW during 2020-21 under the Water Monitoring Manual (WMP) for the Sydney Catchment area.<br>Benchmark values from the ANZECC guidelines were used. | Observations were made about the water quality condition of the Greaves Creek sub-catchment, based on recording at Lake Greaves (approximately 1.8 km from the Blackheath end of the project). For the following water quality indicators, the percentage of routine samples outside benchmarks is given below:<br>• pH – 100%<br>• dissolved oxygen (%Sat) – 17%<br>• phosphorus total (mg/L) – 17%<br>• oxidised nitrogen (mg/L) – 33%<br>• ammoniacal nitrogen (mg/L) – 17%<br>• aluminium total (mg/L) – 100%<br>• chlorophyll a (ug/L) – 25%.<br>Due to wet weather events over recent years, recent sampling shows increases in metals (such as aluminium) and organics. Increases in phosphorus that occurred may result in sustained algal growth. |
| Waterways Health Report 2017<br>Blue Mountains City Council<br>2016-2017<br>Location: Blue Mountains City Council Local Government Area (LGA) | This report presents the 2017 Waterway Health Ratings and water quality data for sites tested within council's aquatic monitoring program during autumn 2016. Waterways within Coxs River and Grose River catchments were monitored. | The rating system was adapted from other stream/river health monitoring programs in Australia, with a series of local trigger values developed based on ANZECC Guidelines and Blue Mountains reference site data. Therefore a rating of good health, suggests that data collected was mostly in compliance with guidelines and reference data.<br>In 2016, 52% of the urban waterways monitored were rated as being in good or excellent health, 39% in fair health and 9% in poor health. The following health ratings were given to the waterways close to the study area:<br>• Pulpit Hill Creek (Coxs River Catchment) – Excellent/Good Health<br>• Grose River Tributary – Good health<br>• Adams Creek – Good health<br>• Govetts Leap Brook – Good health |

### 3.6.2 In-situ water quality sampling

To understand the existing water quality conditions 22 in-situ sites nearby to the project were sampled for physicochemical water quality parameters. The results are summarised in Table 3-6. Further detail and locations of in-situ water quality sampling locations are provided in Appendix H (Technical Report – Biodiversity) of the EIS.

**Table 3-6 Summary of in-situ water quality sampling results**

| Sample | ANZECC Water Quality Guidelines[1] Range | Percentage of sites within ANZECC Water Quality Guidelines[1] 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. |
| 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. |
| 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. |

Notes:

1 – (ANZECC, 2018)

## 3.7 Baseline environment incorporating adjacent projects

The review of the existing environment also considers changes to the existing environment based on a future, baseline scenario i.e. the baseline environment, which assumes that the following projects have been assessed, approved and are operational:

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

These projects would develop drainage, flooding and water quality infrastructure that the project would connect to and would be fully integrated in a design sense.

The future, baseline scenario represents an environment where:

- all drainage infrastructure downstream of the project has been sized and constructed so that it can accommodate discharges from the project without affecting the drainage performance of the project.

The sizing of pipes, and attenuation basins in the adjacent east and west projects described above have been designed to accommodate the predicted flows from the project in addition to the flows from the adjacent projects. The Little Hartley to Lithgow Upgrade will construct a section of the Rosedale Creek culvert crossing to accommodate proposed works, as well as upgrading and realigning the culvert on the existing Great Western Highway at Rosedale Creek

- assessment of potential flooding impacts has considered the adjacent projects to the east and west in addition to this project, so that the design provides appropriate flood protection or immunity for the Upgrade Program
- treatment devices are incorporated to manage the quality of stormwater runoff including 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 largely 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 infrastructure delivered by the adjacent projects that comprise the baseline environment are illustrated in Figure 1-3 and Figure 1-4.

The existing environment for the project areas is described below.

## 3.8 Existing surface water drainage infrastructure

### 3.8.1 Blackheath

There is very limited underground drainage infrastructure across the Blackheath areas of the project. The existing Great Western Highway generally has a one-way crossfall, directing surface runoff towards the low side of the highway.

There is an existing roadside swale that runs alongside the westbound lanes, nestled in between the existing Great Western Highway and adjacent rail corridor. Runoff from both the highway and roughly half of the rail corridor is directed into this roadside swale. There are also a few existing culverts beneath the rail embankment that discharge into the swale. These culverts convey and discharge flows from the relatively small catchment on the upstream (western) side of the rail corridor.

Flow within the roadside swale is conveyed towards the nearest inlet pit, generally located within sag points along the swale. Review of the available topographic survey indicated that these inlet pits transfer swale flows into an existing transverse culvert under the Great Western Highway, that then discharges to the heavily vegetated land located on the downstream (eastern) side of the highway.

The other side of the existing Great Western Highway (i.e., along the eastbound lanes) is not kerbed and does not have an existing roadside swale. Where the highway pavement drains towards the eastbound lanes, surface runoff would sheet directly off the highway, down the road embankment batters and across the heavily vegetated land located on the downstream side of the highway.

The drainage infrastructure of the baseline environment, which assumes that the Katoomba to Blackheath Upgrade is operational, has been sized and constructed so that it can accommodate discharges from the surface road without negatively affecting the drainage performance of existing environment. This design includes drainage pipes diverting stormwater runoff from roads to five bioretention basins along the Medlow Bath to Blackheath section. The sizing of pipes, and attenuation basins have been designed to accommodate the flows expected from the completion of the Katoomba to Blackheath Upgrade.

### 3.8.2 Soldiers Pinch

The existing surface water drainage infrastructure was assessed based on review of aerial imagery and one metre contours as topographic survey was not available. The construction footprint comprises of predominantly densely vegetated land, degraded asphalt and unsealed road and a revegetated decommissioned construction stockpile area.

There is no existing formal drainage at Solders Pinch. All 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.

### 3.8.3 Little Hartley

The existing Great Western Highway at Little Hartley has sections of both kerbed and un-kerbed surface roads. The highway is generally kerbed where it is in cut and un-kerbed where it is in fill. Existing drainage for both kerbed and un-kerbed sections of the highway is as follows:

- kerbed: piped drainage is typically adopted along kerbed sections of the existing Great Western Highway. These pit and pipe networks run along both sides of the highway and capture surface road runoff, in addition to runoff from some of the adjacent verge area / vegetated land.

  There are a number of inlet pits spaced at regular intervals along these drains. These pits transfer surface flows into the existing underground drainage network, which then discharges to an existing channel, watercourse and/or transverse culvert. Any bypass flows, not captured by these inlet pits, are directed towards the nearest outlet or transverse culvert via the drains.
- un-kerbed: surface road runoff sheets directly off the highway at un-kerbed sections of the existing Great Western Highway. Runoff sheeting off the highway and towards the downstream (eastern) side sheets down the highway embankment batters and then across the adjacent land, leading towards the nearest watercourse. Runoff sheeting off the highway and towards the upstream (western) side is directed into a roadside swale that conveys flow towards the nearest inlet pit or transverse culvert.

The drainage infrastructure of the baseline environment, which assumes that the Little Hartley to Lithgow upgrade is operational, has been sized and constructed so that it can accommodate discharges from the surface road without negatively affecting the drainage performance of the existing environment. This design includes the provision of cross and longitudinal drainage infrastructure, including upgrades to existing pipes and culverts, as well as new drainage infrastructure (pits and pipes) for new sections of road, swales and scour protection. Drainage outlets would discharge to open channels, water quality basins or existing waterways depending on quality for the runoff. The sizing of pipes, and attenuation basins have been designed to accommodate the flows expected from the completion of the Little Hartley to Lithgow Upgrade.

## 3.9 Existing flood behaviour

The following sections provide a brief description of previous flood studies, existing flood behaviour for mainstream flooding and major overland flow for the footprint of the three construction locations.

### 3.9.1 Previous studies

Desktop research sought previous flood studies, floodplain management studies and flow gauge records in vicinity of the project to better understand existing flood behaviours and assist with the development and calibration of flood models prepared for this Project.

Review of flow gauge data showed no available records along downstream watercourses.

Previous flood modelling encompassing the project is limited to two flood studies that were prepared at different stages during the development of the Upgrade Program. Details of the two available flood studies are summarised in Table 3-7. No applicable local government floodplain risk management plans or rural floodplain management plans have been identified for the project.

**Table 3-7 Previous flood studies**

| Reference | Description | Modelling approach |
|---|---|---|
| Mount Victoria to Lithgow Alliance (2013) | At the time of this study, the Upgrade Program involved improvements to the existing road alignment. It did not include the introduction of underground tunnels.<br>The study assessed the Upgrade Program from Mount Victoria to Lithgow with flood assessments completed at all major transverse drainage crossings.<br>The study was completed prior to the release | Peak flow rates were estimated using XP RAFTS and hydraulic assessments of each major transverse crossing were undertaken using the one dimensional (1D) version of HEC RAS. |

| Reference | Description | Modelling approach |
|---|---|---|
| | of the latest Australian Rainfall and Runoff guidelines (Ball et al., 2019). The flood assessments were therefore completed in accordance with the previous version of Australian Rainfall and Runoff (Institute of Engineers, Australia, 1987). | |
| Jacobs Arcadis Joint Venture (2021) | This study considers the Little Hartley to Lithgow Upgrade only.<br>Flood modelling was completed at the two major transverse crossings: one at River Lett and Boxes Creek, and another at Rosedale Creek.<br>The Rosedale Creek crossing is also included in this project.<br>The modelling was completed in accordance with the latest Australian Rainfall and Runoff guidelines (Ball et al., 2019). | Two-dimensional (2D) rainfall on grid modelling within TUFLOW.<br>Two separate models were developed – one for each of the two major transverse crossings. |

Modelling techniques and assumptions included in these flood studies helped guide the hydrological and hydraulic modelling undertaken as part of this Project, in order to maintain consistency across the broader Great Western Highway Upgrade.

### 3.9.2 Blackheath

At Blackheath, the project would be located on a natural ridge line and is therefore not likely to be impacted by overland flow. The majority of water would flow naturally towards the east or west away from the existing highway. The existing PMF depth and velocity for the Blackheath project area is shown in Figure 3-14 and Figure 3-15.

The baseline PMF depth results identify three major overland flow paths within the construction footprint at location one to three in Figure 3-14 where flood depth is greater (up to around 0.75 metres) and in other locations the flood depth is mainly shallow below 0.2 metres. At location four in Figure 3-14 there is an existing area of localised ponding where a depth above 1.2 metres is experienced adjacent to the railway that would not impact the project, as the railway is not overtopped.

The existing PMF velocity results (Figure 3-15) identify areas of higher velocity associated with existing flow paths 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.

The Katoomba to Blackheath Upgrade adjoining to the east of the project would be under construction when construction of the project commences. The baseline environment flooding behaviour associated with these works has been assessed as part of the upgrade. There is expected to be some flood risk during construction 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. During operation of the Katoomba to Blackheath Upgrade flooding impacts are generally considered to be minor. Downstream flooding impacts are also minimised through improvement of hydraulic capacity of the design drainage infrastructure relative to the existing conditions, and flow control structures at all discharge locations.

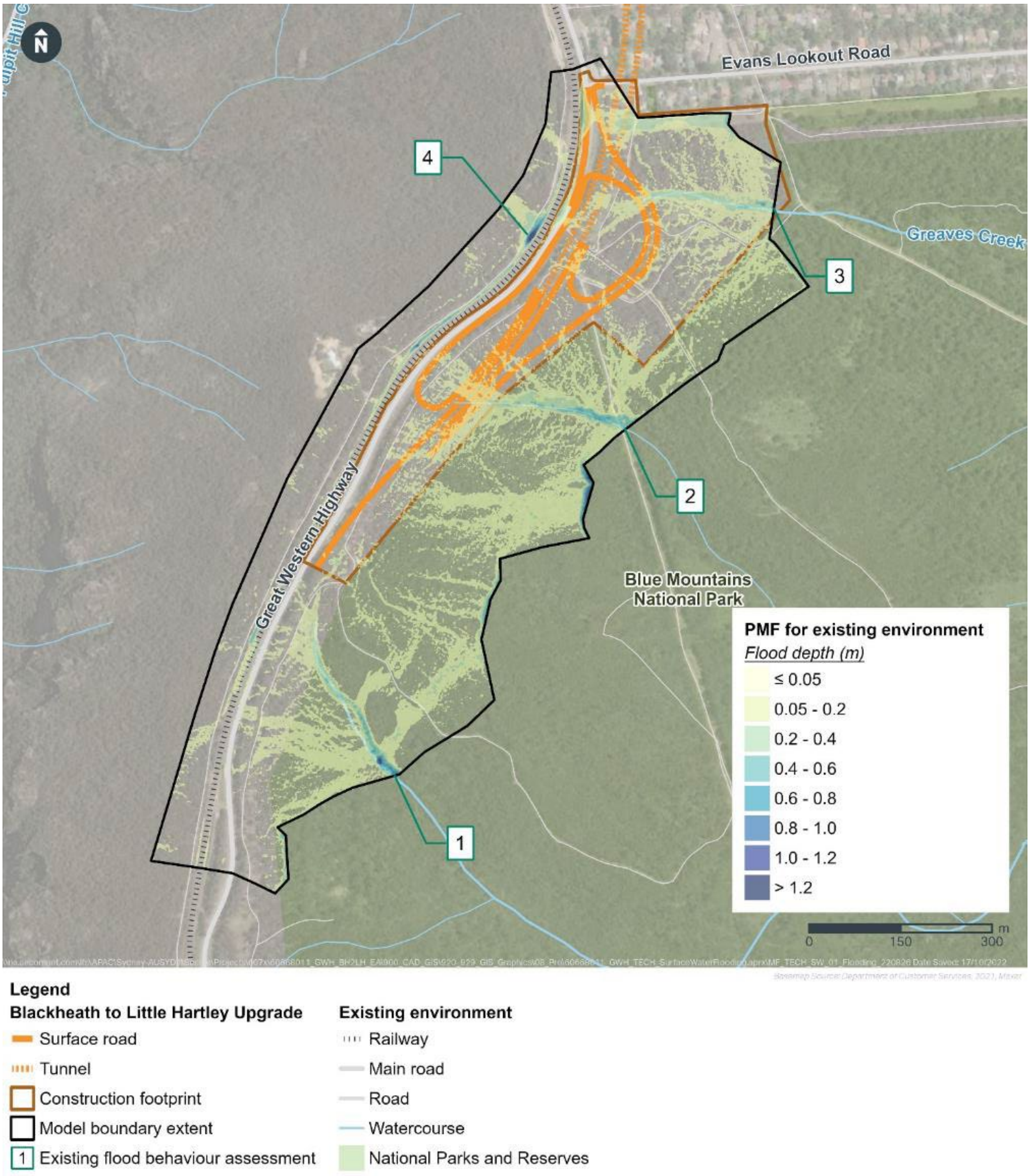



**Figure 3-14 Existing modelled flood depth for the PMF at Blackheath**

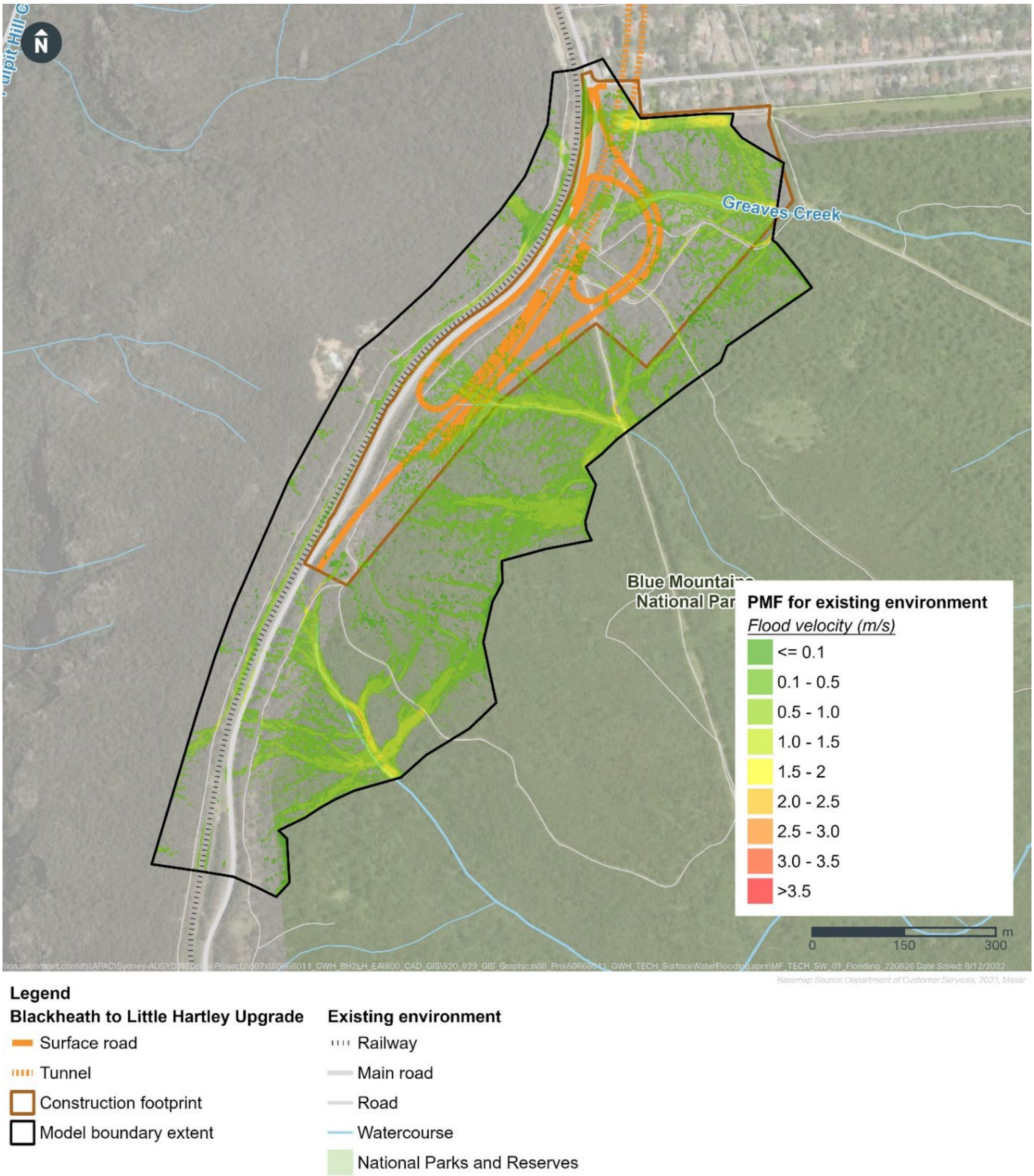



**Figure 3-15 Existing modelled flood velocity for the PMF at Blackheath**

### 3.9.3 Soldiers Pinch

The Soldiers Pinch construction footprint would be located at the highest point of the study area close to the natural ridge line. Hence, the upstream catchment area contributing to surface water flows within the Soldiers Pinch construction footprint is around 10 hectares in comparison to the total construction footprint area which is around four hectares. An existing natural drainage channel runs from west to east through the construction footprint. There may be some localised ponding at depressions along and around the natural drainage channel, however, the channel likely conveys flows downstream towards Grose River before any major ponding occurs. Figure 3-16 shows the upstream catchments and localised flow paths at the proposed Soldiers Pinch construction footprint.

The existing Great Western Highway is raised approximately eight metres above the ground level of the surrounding environment based on Light Detection and Ranging (LiDAR) data and is unlikely to be overtopped by floodwaters. Water passes under the highway and flows towards Grose River and/ or infiltrates into the surrounding environment.

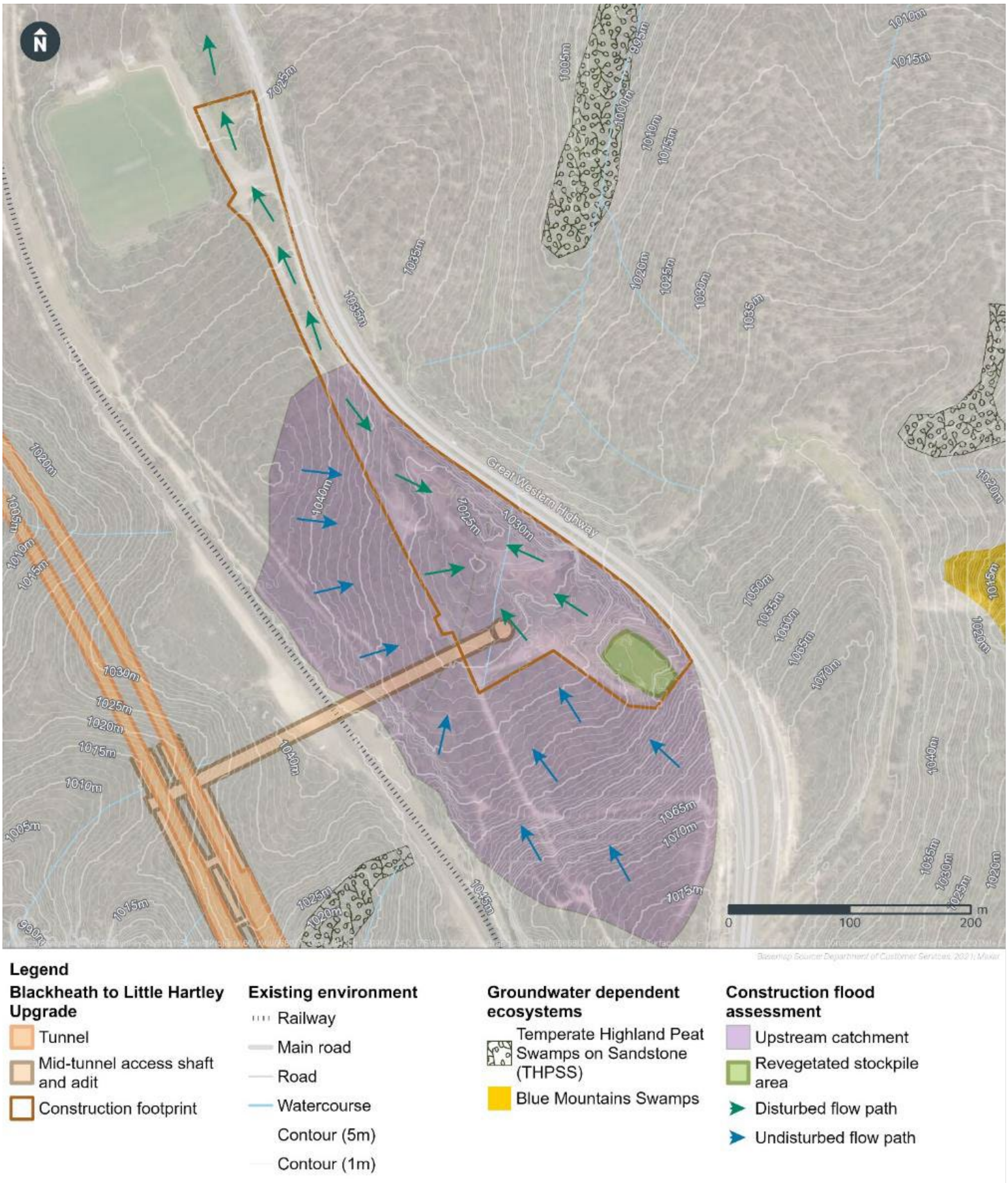



**Figure 3-16 Existing surface water behaviour overview at Soldiers Pinch**

### 3.9.4 Little Hartley

Under baseline conditions for all the design rainfall events modelled (including five per cent, two per cent, one per cent and 0.2 per cent Average Exceedance Probability (AEP) and PMF), deep water ponding above two metres is observed at the upstream location of the culvert crossing at Rosedale

Creek. Across the storm events modelled, there are also five locations identified within the flood model extent where the existing Great Western Highway is overtopped. The existing one per cent AEP flood depth and flood hazard maps are shown in Figure 3-18 and Figure 3-19 respectively.

The existing one per cent AEP peak flood velocities for Little Hartley identify areas of higher velocity associated with existing flow paths including 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.

Flood hazard is assessed through consideration of flood depth and velocity. In relation to the NSW Floodplain Development Manual (DIPNR 2005), hazard is flood behaviour which has the potential to cause damage to the community. Based on the general flood hazard categories outlined by the Australian Emergency Management Institute in 2014, vulnerability curves are shown in Figure 3-17. At the upstream and downstream ends of the culvert crossing at Rosedale Creek, the existing flood hazard for the existing one per cent AEP storm event is H5 (unsafe for people or vehicles with all buildings vulnerable to structural damage). See Figure 3-19 for the existing flood hazard at Little Hartley.

The Little Hartley to Lithgow Upgrade REF (Transport for NSW, 2021b) also showed there would be a localised flood level increase of 110 millimetres on the flood-affected pasture at Rosedale Creek for the one per cent AEP resulting from construction of the Little Hartley to Lithgow Upgrade. No specific flood mitigation measures were proposed for the Little Hartley to Lithgow Upgrade as the modelled flooding impacts are within the industry-accepted range for the surrounding land types.

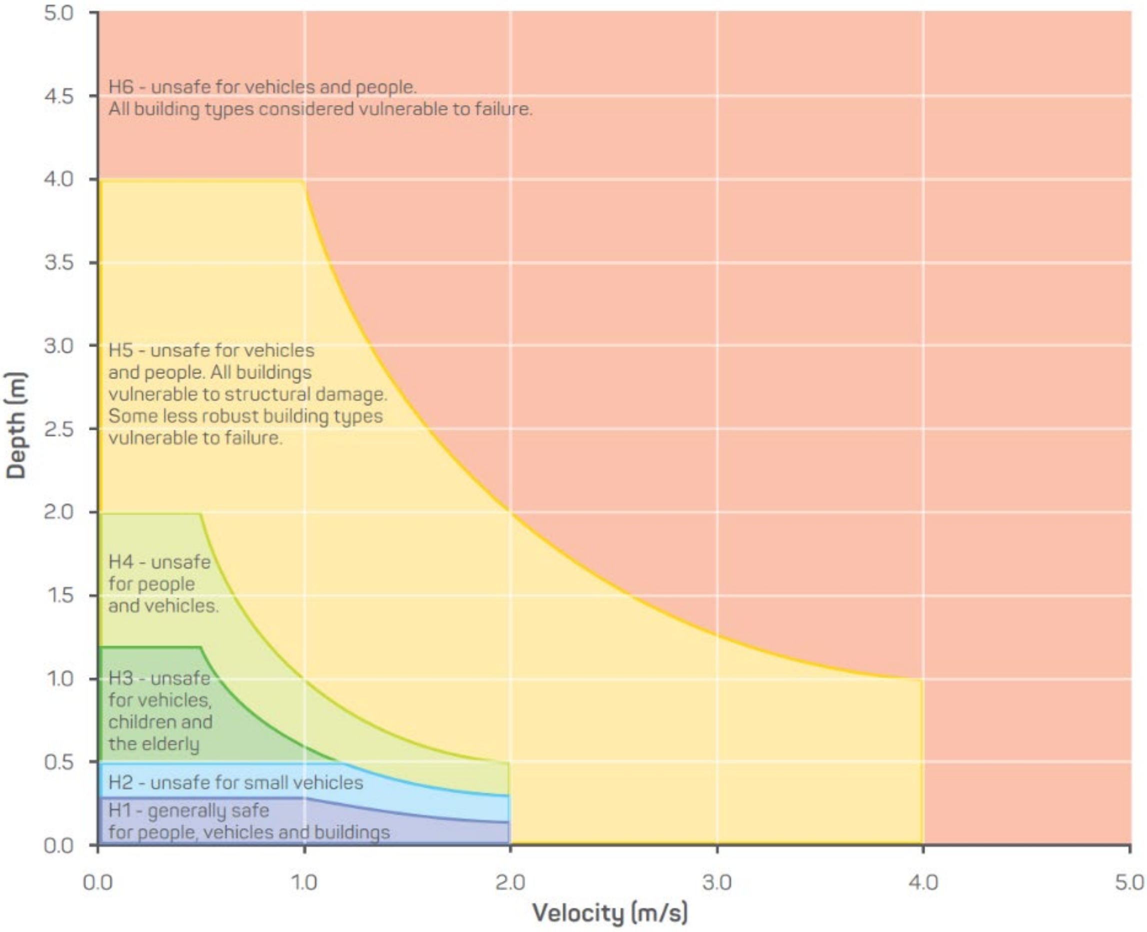



**Figure 3-17 General flood hazard vulnerability curves (Commonwealth of Australia 2017)**

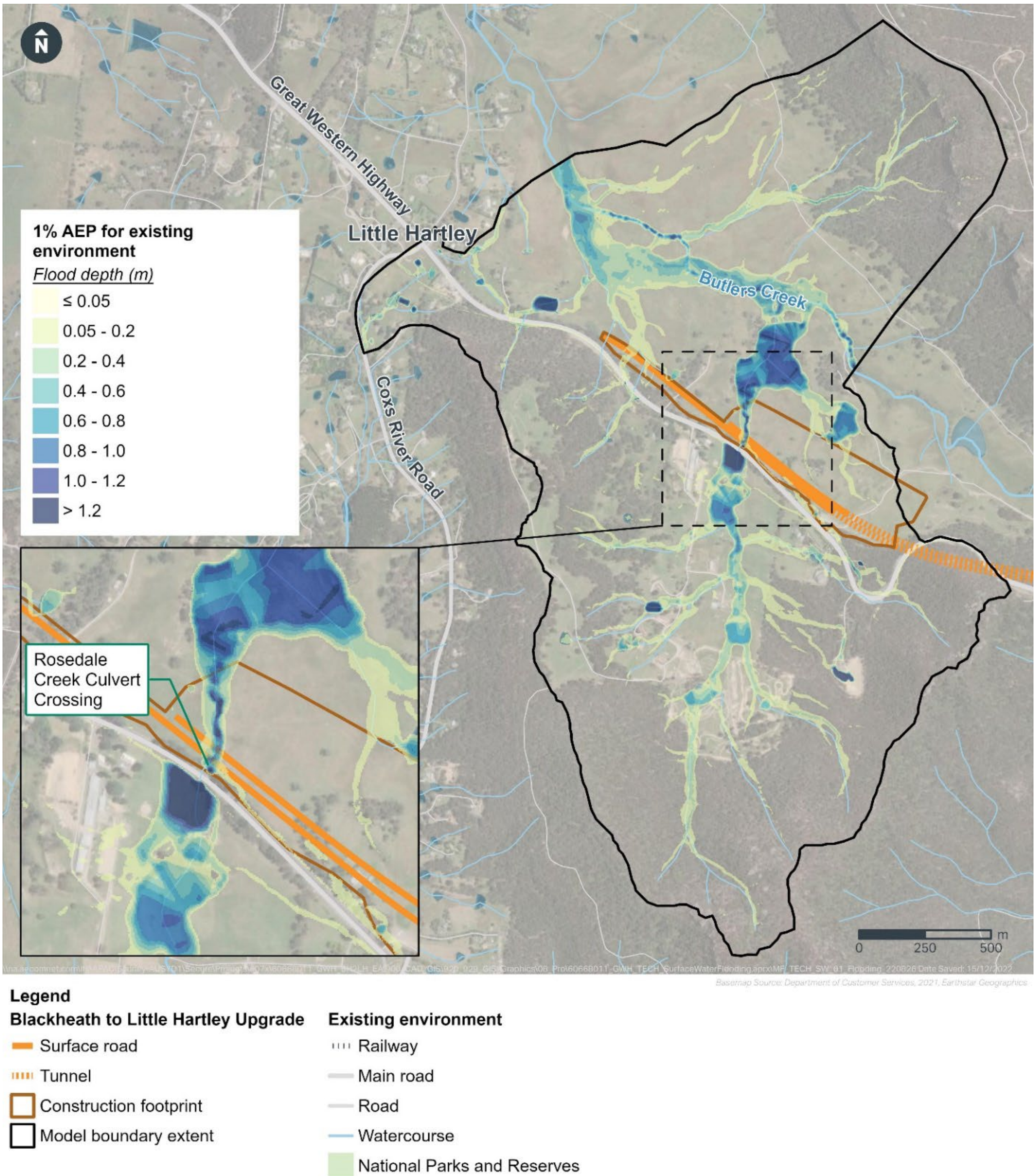



**Figure 3-18 Baseline modelled flood depth at Rosedale Creek for the 1% AEP (with Little Hartley to Lithgow project)**

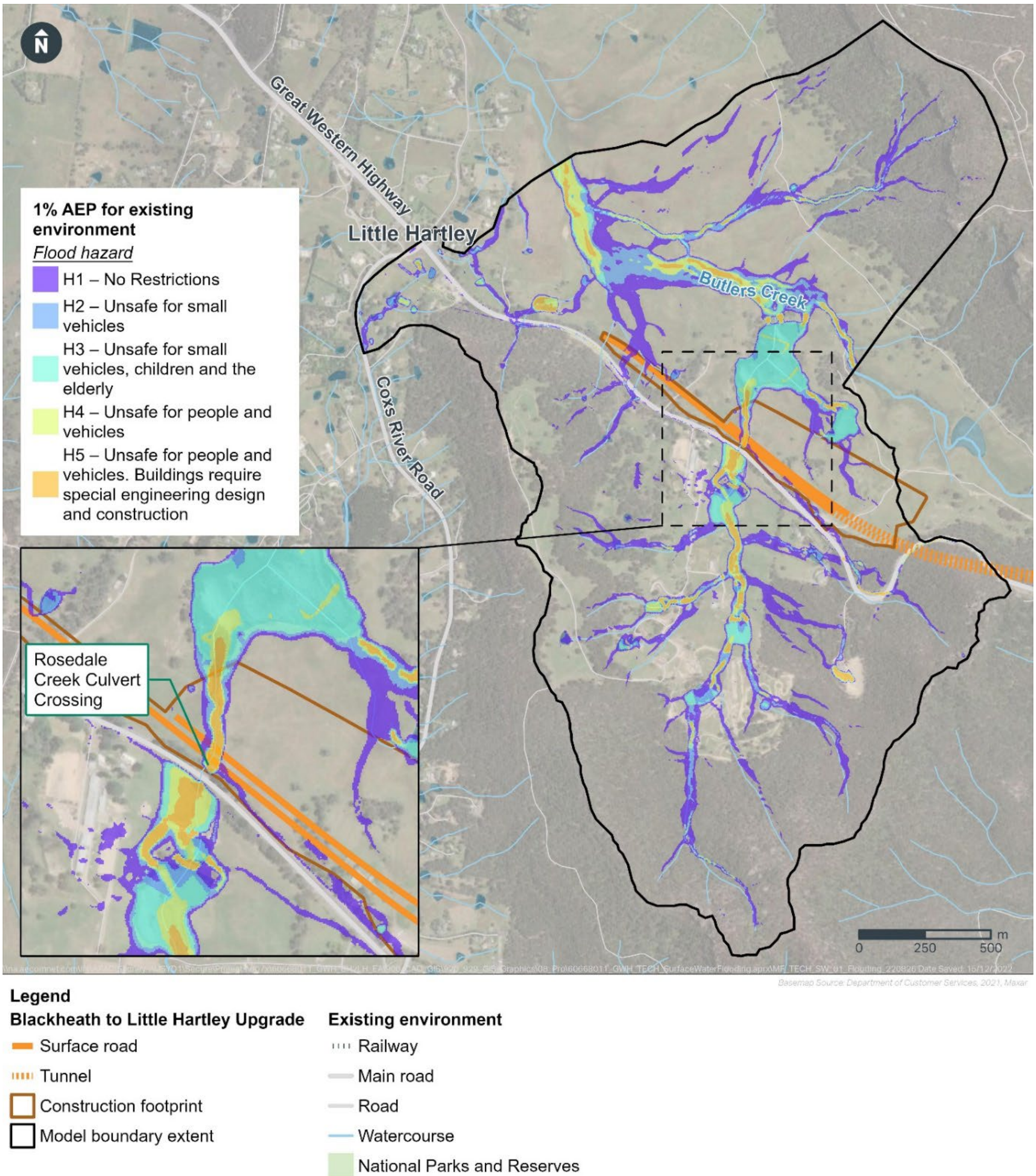



**Figure 3-19 Baseline modelled flood hazard at Rosedale Creek for the 1% AEP (with Little Hartley to Lithgow project)**

### 3.9.5 Emergency management

Existing emergency evacuation routes are assumed to be eastbound and westbound via the Great Western Highway, as the main transport infrastructure through the area.

No formal emergency management, evacuation and access and contingency measures have been identified at Blackheath, Soldiers Pinch or Little Hartley.

## 3.10 Biodiversity

### 3.10.1 Plant community types

The Blackheath construction footprint and its surrounding area consists of predominantly remnant bushland and the Little Hartley construction footprint and its surrounding area consists of predominantly cleared agricultural land and farm dams.

Native vegetation of varying levels of disturbance are currently present at the Blackheath, Soldiers Pinch and Little Hartley construction sites. The following plant community types (PCT) can be found within these construction footprints:

- PCT 708 Blue Mountains Mallee Ash - Dwarf Casuarina heath of the upper Blue Mountains, Sydney Basin Bioregion
- PCT 766 Carex sedgeland of the slopes and tablelands
- PCT 1078 Prickly Tea-tree - sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion
- PCT 1248 Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion
- 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
- PCT 1740 Tall Spike Rush freshwater wetland.

Clearance of native vegetation would be required within the three construction footprints. Some of the vegetation within the Blackheath and Little Hartley construction footprints would be cleared during the construction phase of the adjacent projects. This includes direct impacts to habitat for three threatened species credit species. These species are the Large-eared Pied Bat *Chalinolobus dwyeri*, Purple Copper Butterfly *Paralucia spinifera* and Greater Glider *Petauroides volans*.

### 3.10.2 Sensitive receiving environments

Aquatic ecosystems within stream environments may be sensitive to changes in surface runoff. Temperate Highland Peat Swamps on Sandstone community (THPSS) are an aquatic ecosystem listed as an endangered ecological community under the EPBC 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 NSW *Biodiversity Conservation Act 2016* (BC Act) make up THPSS. These are:

- Blue Mountains Swamps in the Sydney Basin Bioregion (Vulnerable, BC 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).

The community of Blue Mountains Swamps in the Sydney Basin Bioregion have also been identified in close proximity to the project based on the Native vegetation mapping in the Blue Mountains 1999 - 2002. Blue Mountains Swamps in the Sydney Basin Bioregion have a NSW Conservation Status of Vulnerable Ecological Community and a Commonwealth Status of Endangered.

Figure 3-20 shows sensitive receiving environments, including THPSS and Blue Mountains Swamps, in proximity to the project. THPSS are also classified as groundwater dependent ecosystems (GDEs) which are communities of plants and animals whose extent and life processes are dependent on groundwater, such as through wetlands or springs. Despite this classification as groundwater dependent, swamps such at the valley infill swamps are also influenced by surface runoff. The relationship of THPSS with groundwater and surface water runoff is illustrated in Figure 3-21 and Figure 3-22.

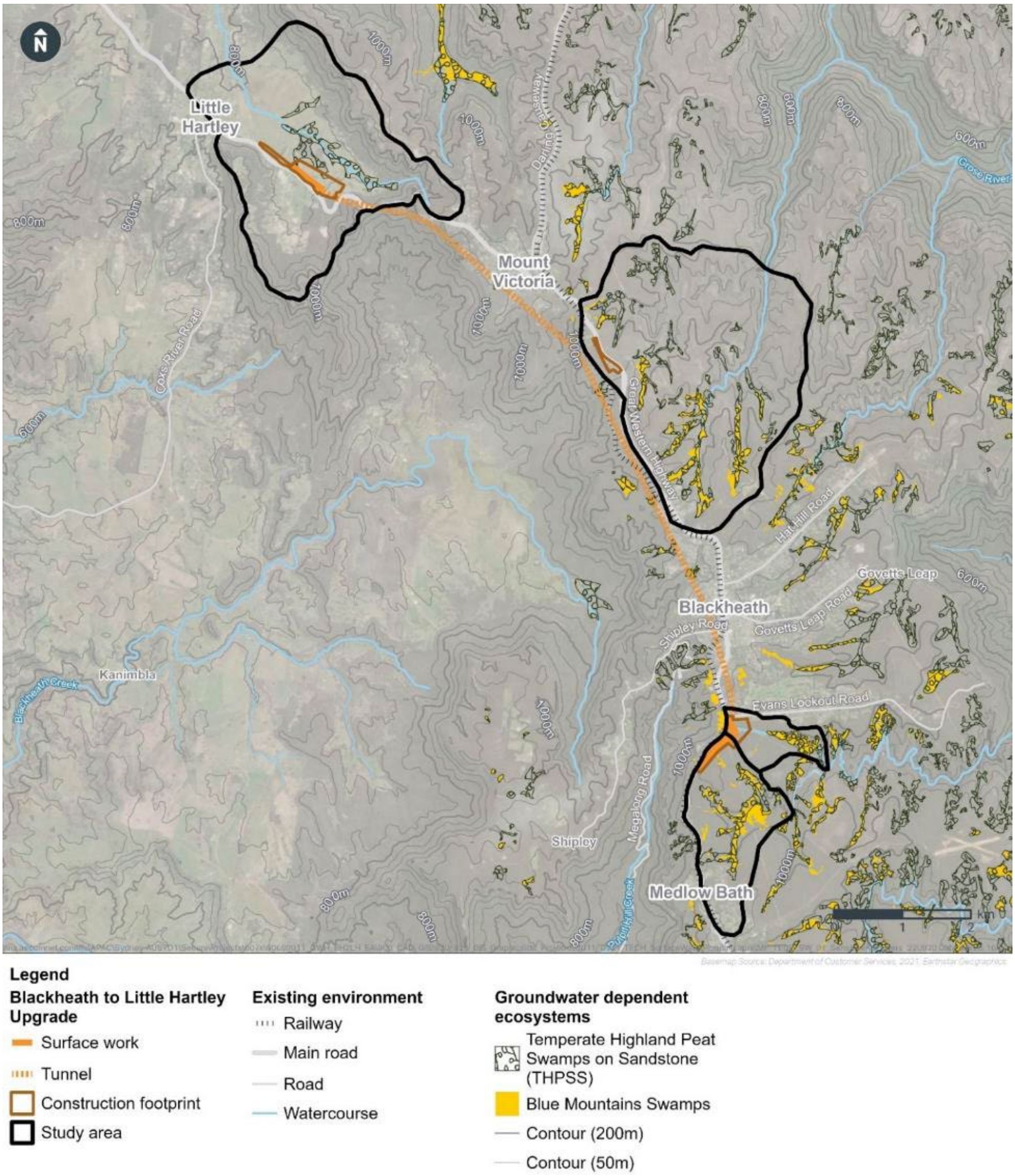



**Figure 3-20 Sensitive receiving environments and groundwater dependent ecosystems**

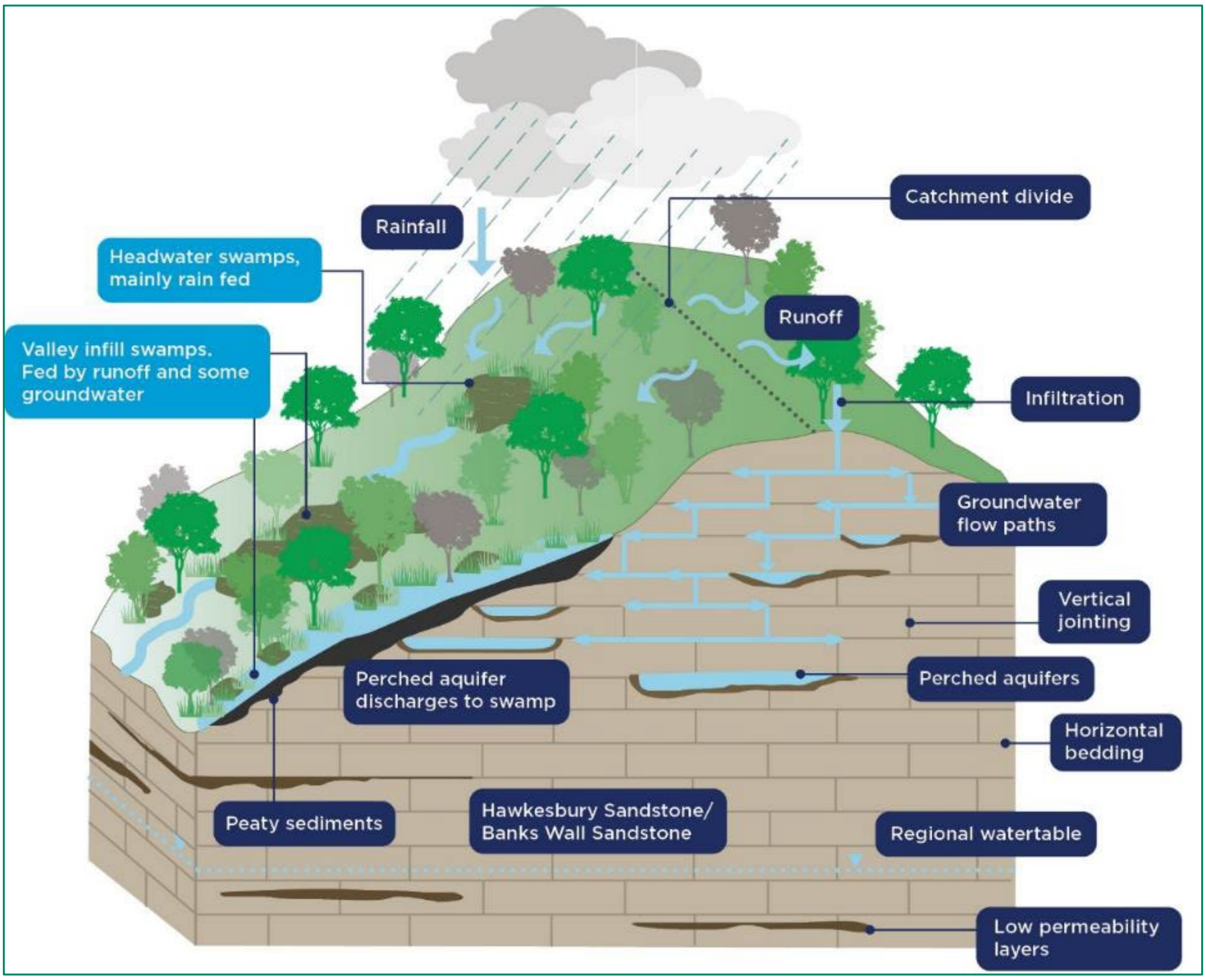



**Figure 3-21 THPSS groundwater relationship (headwater swamps and valley infill swamps)**

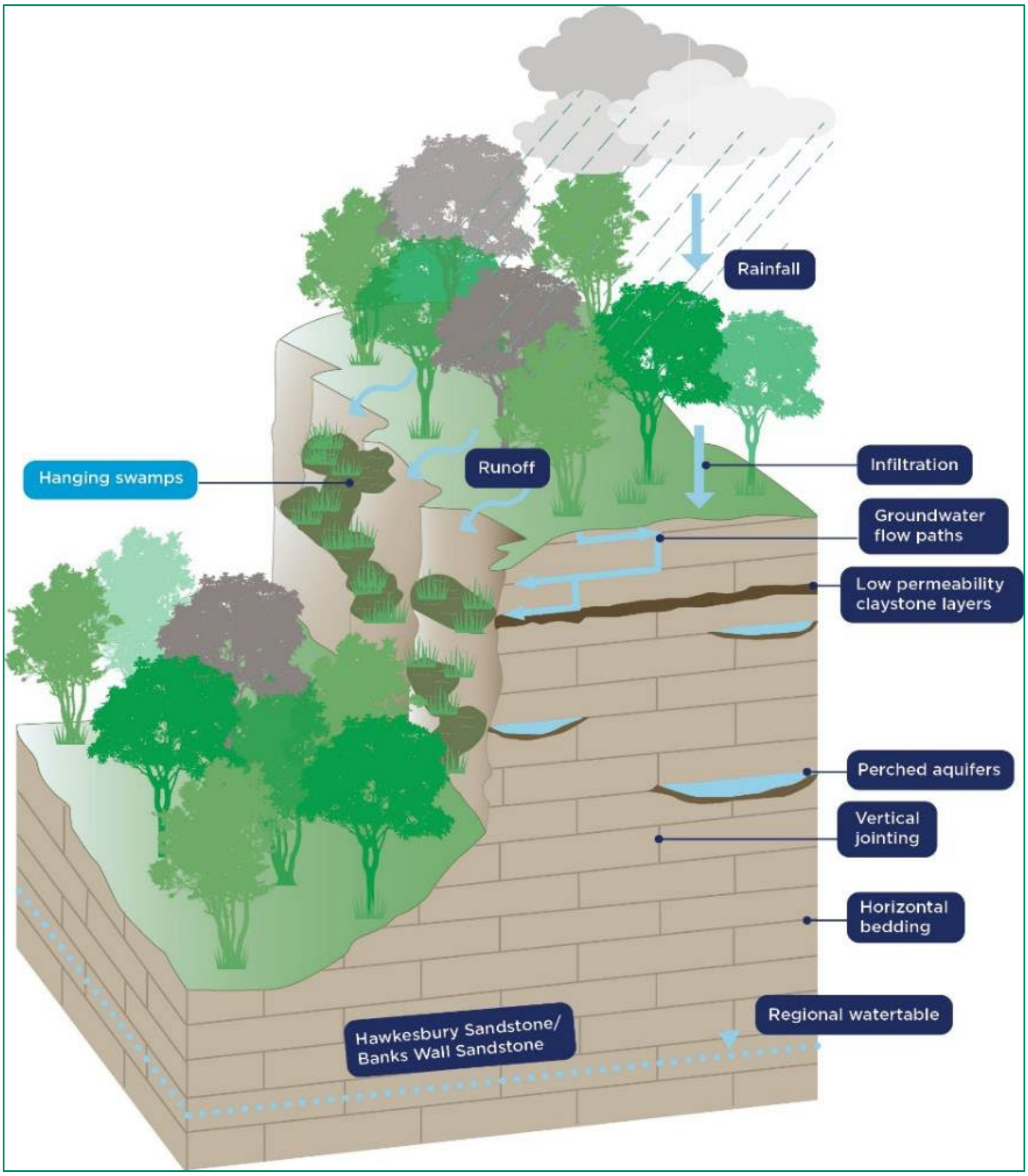



**Figure 3-22 THPSS groundwater relationship (hanging swamps)**

Review of threatened fish distribution via NSW Fisheries Spatial Data Portal (DPI, 2022) shows that no watercourses within two kilometres of the construction footprints are considered likely habitat for threatened fish. However, these watercourses are tributaries to either the Grose River or the Coxs River catchments, both of which are considered habitat for Macquarie Perch (*Macquaria australasica*) which is listed as endangered under the FM Act 1994 and EPBC Act 1999.

## 3.11 Registered groundwater users

A search of the WaterNSW Real Time Data online database (WaterNSW, 2022) and the Bureau of Meteorology (BoM) Australian Groundwater Explorer (BoM, 2022) was carried out in March 2022 indicated that there are 112 registered groundwater bores located within the groundwater study area. Details of the registered groundwater bores are provided in Appendix I (Technical Report - Groundwater) of the EIS.

The registered groundwater bores include:

- 36 bores used for domestic/general use purposes
- six bores used for irrigation purposes
- 48 bores used for stock and domestic purposes
- one bore used for industrial/domestic purposes
- 19 bores used for monitoring purposes
- two bores used for unknown purposes.

# 4 Assessment of construction impacts

## 4.1 Overview

### 4.1.1 Consideration of baseline environment

The assessment of construction impacts to the environment considers changes to the existing environment based on a future, interim baseline scenario, which assumes that construction of the following projects is complete where they interface with the project:

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

As described in Section 3.7, the water quality controls and drainage infrastructure such as sediment basins which are part of the Blackheath and Little Hartley construction footprints would be sized, prepared and used as part of the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade.

These basins and drainage infrastructure would be appropriately sized to manage and mitigate the pollutants and flow volumes from the construction and operation of the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade, as well as the construction and operation of this project, meeting the required criteria for all projects.

This assessment of potential construction impacts is based upon construction activities for the project outlined in Chapter 4 (Project description) of the EIS and is focussed on those impacts that could result from the Blackheath to Little Hartley Upgrade project only.

### 4.1.2 Tunnel ventilation system options

No additional construction impacts to drainage networks, overland flow paths, flood risk or water quality risk are expected to result from the installation of the tunnel ventilation system, as these systems are contained within the proposed construction areas, and the ventilation building for both options is located underground and with the outlet being integrated with the surrounding landform.

The construction footprint would remain consistent regardless of which tunnel ventilation option is progressed, therefore no additional construction impacts related to surface water are expected to result dependent on which system option is selected.

## 4.2 Flooding

The assessment of potential flooding impacts during construction of the project is based on a review of the likely construction works and their potential impact to the existing surface water behaviour. Overall, potential flooding impacts identified during construction of the project that could occur without the implementation of appropriate management measures, 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 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.

The following sections provide a summary of the assessed flood risk during the construction phase of the project. These sections demonstrate consistency with previous flood studies (Section 3.9.1) and compliance with the NSW Floodplain Development Manual (DIPNR, 2005). No additional applicable local government floodplain risk management plans or rural floodplain management plans have been identified for the project.

### 4.2.1 Blackheath

As discussed in Section 3.9.2, the Blackheath construction footprint would be located on a natural ridge line and not likely to be impacted by overland flow. Flood modelling has identified three 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 PMF depths under existing conditions are shown in Figure 3-14 and the following maximum depths within the construction footprint were predicted by the model:

- 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 the construction phase would be considered as part of further design development and detailed construction planning, for example construction site layouts (especially stockpiles) would be designed to manage and direct all flows so they are effectively diverted or unimpeded. Diversion and blocking of surface water flow paths due to construction activities could also create some instances of localised flooding. With the implementation of standard management measures (in accordance with the Blue Book (Landcom, 2004)), the potential impacts to surrounding properties and local flooding, 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 also potential for overland flow to impact both tunnel entries during construction. Construction sequencing should be considered in the construction environment management plan (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.

### 4.2.2 Soldiers Pinch

As discussed in Section 3.9.3, the Soldiers Pinch construction footprint would be located close to a natural ridge line. The construction footprint has an upstream catchment of around 10 hectares and an existing natural channel that runs from west to east through the construction footprint. Localised ponding could occur at elevations below around 1035 metres AHD due to depressions along and around the channel. Hence, stockpiles located at elevations below 1035 metres AHD have the potential to obstruct floodwater and alter flow paths. The layout of the construction site, including the placement of construction plant and equipment, site offices and material stockpiles relative to overland flow paths would be considered as part of further design development and detailed construction planning.

The flood results for the five percent 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 using the Rational Method estimate that the flow rate through the existing channel during a five per cent AEP event would be around 0.3 $m^3/s$. 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 the 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 any changes in surface water behaviour as a result of construction works. The sediment basin would be appropriately designed in accordance with the 'Blue Book' (Landcom, 2004) for the safe conveyance of floodwaters so that it would not be damaged, cause any local flooding nor result in sediment being discharged into receiving drainage lines and waterways.

### 4.2.3 Little Hartley

An assessment of potential flood impacts during construction phase of the project at Little Hartley has considered the full range of flood events (refer to Annexure A). 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 areas of stockpiling and chemical storage. The existing five per cent AEP flood depth and flood hazard maps are shown in Figure 4-1 and Figure 4-2, with observations in relation to flow conveyance, storage areas and flood hazard summarised in Table 4-1. The Little Hartley construction footprint would be largely located outside of the five per cent AEP flood extents.

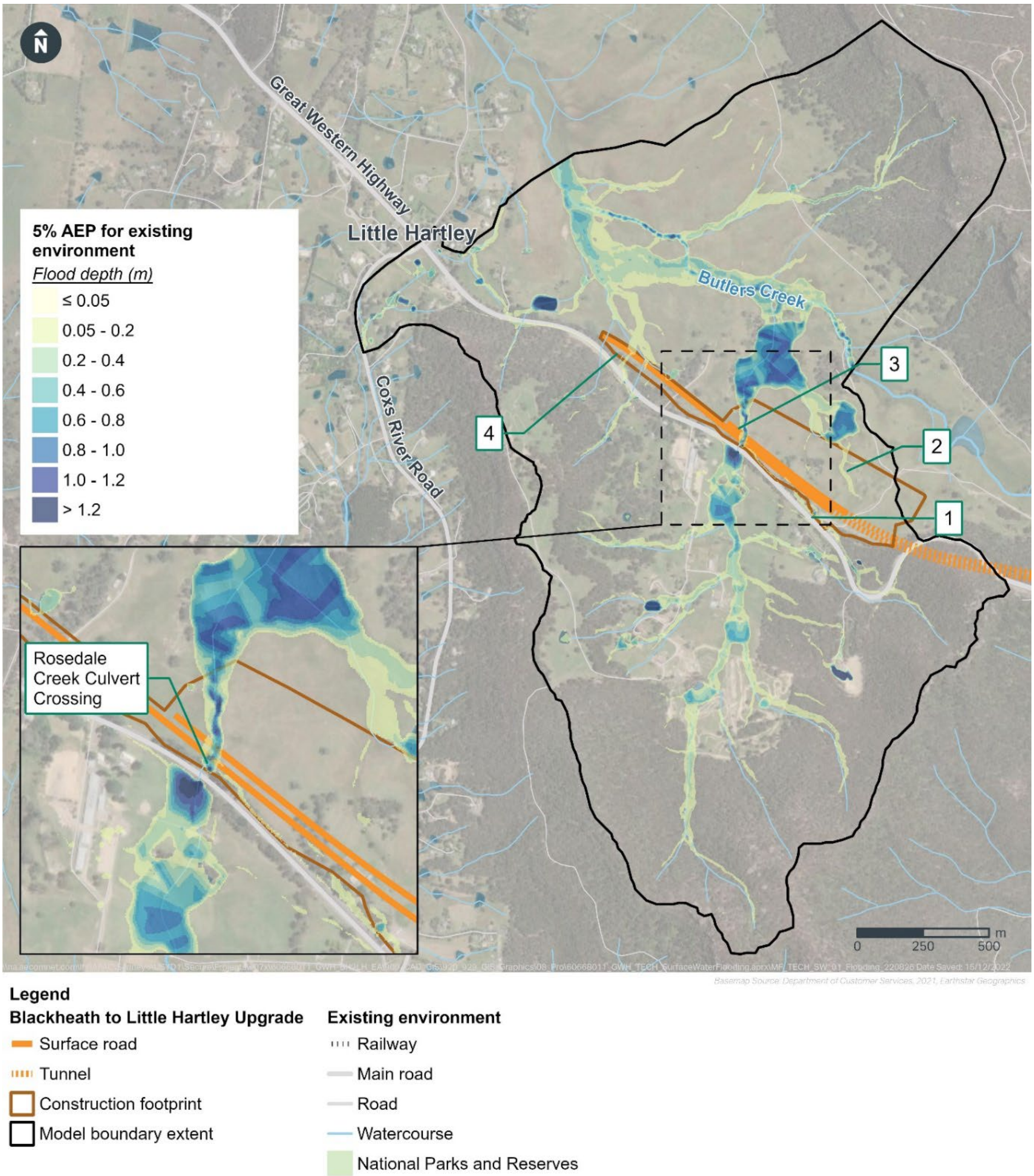



**Figure 4-1 Baseline modelled flood depth at Rosedale Creek (Little Hartley construction site) for the 5% AEP (with the Little Hartley to Lithgow project)**

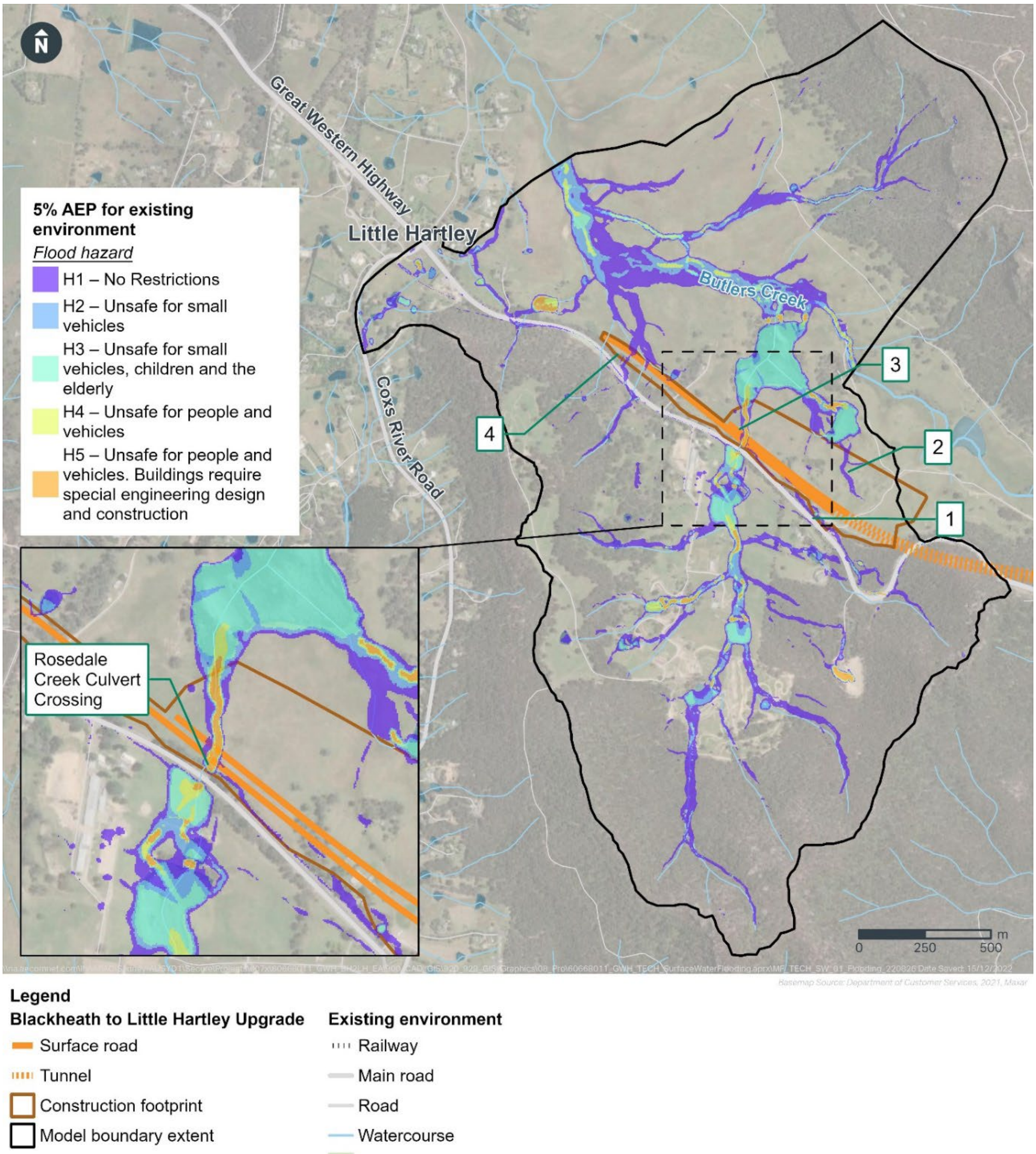
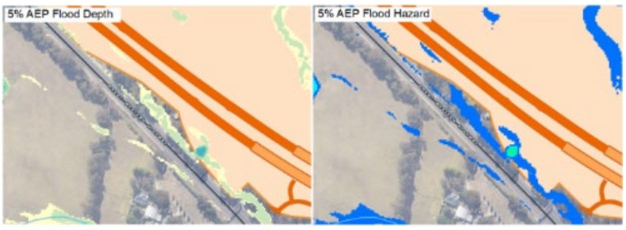
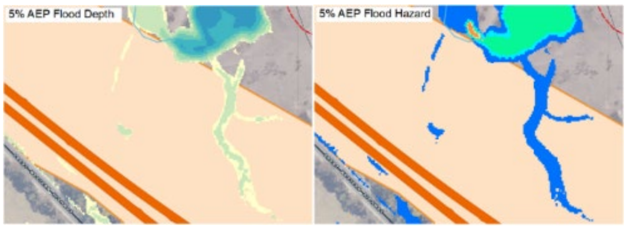
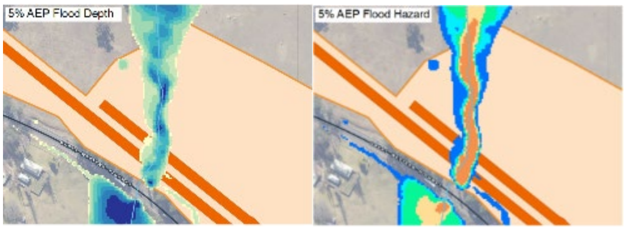
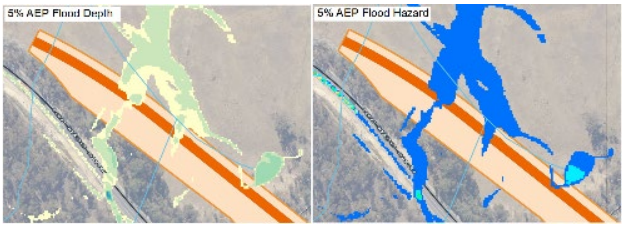



**Figure 4-2 Baseline modelled flood hazard at Rosedale Creek (Little Hartley construction site) for the 5% AEP (with the Little Hartley to Lithgow project)**

**Table 4-1 Construction flood impact assessment for the Little Hartley construction site**

| ID* | Flooding behaviour** | Construction assessment |
|---|---|---|
| 1 | **Eastern extent at tunnel portals**   | For the 5% AEP storm event the flood depth reaches up to 0.8 m and a small area is classified as H3 as indicated by the light blue and green colour, indicating floodwaters are 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 existing 5% AEP storm event. |
| 2 | **Immediately west of tunnel portals**   | Based on the 5% AEP flood hazard there are no restrictions at this location, as indicated by the dark blue colour. There are some flow paths and flood extents during the 5% AEP. 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 existing 5% AEP storm event. |
| 3 | **Rosedale Creek**   | For the existing 5% AEP storm event the flood depth is modelled to exceed 1.2 m and the flood hazard rating is H5 (unsafe for people and vehicles, as indicated by the orange colour within the flooded area). The concentrated existing flow at this location (Rosedale Creek) contributes to the high hazard risk and poses 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 existing modelled 5% AEP flood hazard there are no restrictions. There are some flow paths and flood extents during the 5% AEP. 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 existing 5% AEP storm event. |

* Locations indicated on Figure 4-1 and Figure 4-2

** Legend for flooding behaviour mapping:

Surface road
Tunnel
Construction footprint
Flood model extent
Main road
Local road
Track
Named Watercourse
Hydroline

**5% AEP Flood Depth**
< = 0.07
0.07 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
1.0 - 1.2
> 1.2

**5% AEP Flood Hazard**
H1 - No restrictions
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for people and vehicles
H5 - Unsafe for people or vehicles. Buildings require special engineering design and construction.

As indicated in Table 4-1, 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 existing five per cent AEP flood extents as they may obstruct floodwater and alter flooding patterns. Inundation of stockpile areas by floodwater can also lead to damage and material and sediment being washed into the receiving drainage lines and waterways. Material and sediments entering receiving waterways may lead to increased turbidity, reduced dissolved oxygen levels and increased toxicant concentrations which impact aquatic ecosystems.

Flood management measures and site planning would be conducted in accordance with the Blue Book (Landcom, 2004) as part of the construction environment management plan (CEMP). These measures 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.

Construction sequencing would be considered in developing the CEMP to manage and direct flow paths away from both tunnel portals. Based on the five per cent AEP flood modelling there is no overland flow expected to occur near the tunnel portals at Little Hartley.

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.

#### 4.2.4 Emergency management, social and economic costs to the community

Existing emergency evacuation routes are assumed to be eastbound and westbound via Great Western Highway, and these would be retained throughout the construction phase. Recommendations from the Blue Book (Landcom, 2004) would be implemented to minimise flooding impacts during the construction of the project so that the impacts to existing community emergency management arrangements for flooding (including existing emergency management, evacuation and access and contingency measures) would be minimal.

Consultation with State Emergency Services and Lithgow City Council was undertaken to review the flood behaviour 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 LGA.

Changes to flood behaviour due to the construction of the project are not expected to impact any properties or infrastructure, particularly as there are no impacts beyond the project boundary. Therefore, with the implementation of these recommendations there are unlikely to be any associated social and economic costs to the community. Mitigation measures are detailed in Table 7-2 such as construction planning and staging to minimise flooding impacts.

### 4.3 Surface water runoff

Aquatic ecosystems are sensitive to changes in surface runoff quality, quantity and velocity. 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 (i.e. increased velocity causing greater potential for scour)
- cause 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.

Table 4-2 provides a summary of the potential soil and water related impacts during construction of the project. The receiving waterways for the potential impacts stated below are both the Coxs River and Grose River systems. Each of the potential impacts outlined in Table 4-2 is considered with respect to the environmental values and WQOs listed in Table 2-4.

**Table 4-2 Potential impacts to surface water quality during construction**

| ID | Activity/ source | Pollutants or factors of concern | Potential surface water quality impact (without mitigation) |
|---|---|---|---|
| C1 | Clearing of vegetation and the resultant exposed soils could result in mobilisation and release of sediment laden runoff from construction areas or stockpiles of soil.<br>The direct disturbance of waterway bed and/or banks as a result of earthworks and construction of instream structures could result in soil and bank erosion and mobilisation of sediments into receiving waterways, particularly around the existing transverse drainage at Rosedale Creek.<br>The 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.<br>Vehicle movement across construction site areas 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. | Sediment, nutrients, contaminants, gross pollutants and impacts to vegetation | • sediments could smother receiving waterways impacting aquatic ecosystems.<br>• increased turbidity, lower dissolved oxygen levels, and increases in toxicant concentrations could impact aquatic ecosystems.<br>• nutrients associated with sediments could lead to algal blooms and aquatic weed growth, which could impact aquatic ecosystems, recreation, irrigation, livestock, and aquatic foods.<br>• reduced visual amenity could result from turbid water and visible gross pollutants, impacting recreation and visual amenity.<br>• potential for pollution and impacts described above to impact peat swamps identified at Blackheath and Little Hartley, as well as the WaterNSW Special Area at Blackheath (public access to this area is restricted to protect water quality and create a buffer of land around essential water storages). |
| C2 | Leakage or spills of petroleum hydrocarbons, lubricants, effluent, oils and greases from machinery or equipment, during refuelling or accidental spill could potentially result in pollutants being conveyed to downstream waterways | Hydrocarbons, oil and grease, hydraulic fluids, other hazardous chemicals | • oil sheen on water surface could impact amenity or recreation<br>• increases in toxicant concentration could lead to fish kills and other aquatic ecosystem impacts, livestock, and aquatic foods, including impacts to peat swamps identified at Blackheath and Little Hartley, as well as the WaterNSW Special Area at Blackheath |

| ID | Activity/ source | Pollutants or factors of concern | Potential surface water quality impact (without mitigation) |
|---|---|---|---|
| C3 | Concreting activities could impact receiving waterways as follows:<br>• accidental runoff of concrete washout water into waterways<br>• chemicals used in treatment and curing of concrete and mobilisation of concrete dust through wind and runoff could impact waterways<br>• spills of excess or waste concrete could be discharged into stormwater systems. | High pH, chromium, contaminants, waste, sediment, gross pollutants | • increases in alkalinity and toxicant concentration which could lead to impacts to aquatic ecosystems such as fish kills and undesirable impacts to livestock<br>• increased turbidity could impact aquatic ecosystems, amenity and recreation<br>• changes in alkalinity and toxicity also have the potential to impact peat swamps identified at Blackheath and Little Hartley<br>• pollution of surface water within the WaterNSW Special Area at Blackheath. |
| C4 | Earthworks and changes to the site resulting in concentrated flows, as opposed to sheet flow, that have potential to disrupt existing surface water flow paths, scour the earth and increase sediment loads carried by surface waters | Sediment, nutrients, contaminants | • increased turbidity, lower dissolved oxygen levels and increased nutrients which could lead to algal blooms and aquatic weed growth which could impact aquatic ecosystems<br>• increases in toxicant concentration<br>• reduced visual amenity (turbidity)<br>• away from waterways: localised ponding could occur creating drainage/flooding issues within nearby properties and surrounding downstream environment<br>• potential for pollution and impacts described above to impact peat swamps identified at Blackheath and Little Hartley, as well as the WaterNSW Special Area at Blackheath. |

| ID | Activity/ source | Pollutants or factors of concern | Potential surface water quality impact (without mitigation) |
|---|---|---|---|
| C5 | Activities related to discharges from the project include:<br>• dewatering open excavations following periods of rainfall, which may contain sediments and other pollutants mobilised by the rainfall<br>• increase in 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<br>• impacts to ambient water quality as a result of poorly treated discharges from the construction water treatment plants. | Sediment, nutrients, contaminants | • increases in alkalinity and toxicant concentration which could lead to fish kills and other undesirable impacts to aquatic ecosystems, livestock, and aquatic foods<br>• increased turbidity, lower dissolved oxygen levels and nutrients which could lead to algal blooms and aquatic weed growth, which could impact aquatic ecosystems, amenity, recreation, irrigation, livestock, and aquatic foods<br>• potential for pollution and impacts described above to impact peat swamps identified at Blackheath and Little Hartley, as well as the WaterNSW Special Area at Blackheath. |
| C6 | Oxidation of acid sulfate rock (ASR) at Little Hartley during construction excavation, earthworks and tunnelling | Increased acidity of surface water and runoff, damage to vegetation and ecosystem | • produce sulfuric acid resulting in more aggressive conditions and increased acidity of surface water impacting quality<br>• reduction in pH of downstream receivers can stress aquatic fauna and flora<br>• reduction in pH can increase solubility of metal pollutants which can negatively impact aquatic organisms. |
| C7 | Stockpiling of material containing acid sulfate rock (ASR) at Little Hartley leading to acidification of runoff | Increased acidity of surface water, damage to vegetation and ecosystem | • rainfall and runoff from stockpiles containing ASR leading to acidic runoff, which has the same impacts as described in C6 above |
| C8 | Construction components of the tunnel and other underground structures have the potential to impact surrounding groundwater quality and subsequently surface water quality | Particulate matter leading to an increase in suspended solids | • increased turbidity, lower dissolved oxygen levels, and increases in toxicant concentrations could impact aquatic ecosystems |

If not adequately managed, construction activities associated with the project could lead to erosion of exposed soil and stockpiled materials and an increase in sediment loads entering nearby watercourses and impacting sensitive receiving environments downstream. The project could also result in the accumulation of potentially contaminated sediments in sedimentation and water quality basins. Water quality impacts include increased turbidity and elevated concentrations of nutrients and other pollutants.

### 4.3.1 Application of the Blue Book

Erosion and sedimentation risks posed by the project arise from the fragile and dispersive nature of the site soils, which are easily eroded by rainfall and overland flows. Salinity and turbidity are likely to be the greatest risks to water quality during the construction phase. Particular focus would be given to spoil and stockpile management given the large volumes of spoil to be managed by this project.

Potential impacts to water quality resulting from erosion and sedimentation would be managed through the thorough application of the principles of the Blue Book (Landcom, 2004), accompanied by monitoring and management to improve erosion and sedimentation control practices or implement other adaptive management measures as required. The Blue Book also provides guidance on the sizing if construction sediment basins which is dependent on a number of project specific parameters, including:

- catchment shape, size and slope
- drainage patterns
- surface condition, soil type (including soil hydrologic group) and vegetative cover
- rainfall intensity and runoff coefficient.

The sizing of these basins would also account for the concurrent construction and common discharge locations of the Upgrade Program.

### 4.3.2 NorBE Compliance

Erosion and sedimentation controls outlined in Section 7.1 and procedures for the management of sedimentation and water quality basins would be outlined in the Soil and Water Management Plan, contained in the Construction Environment Management Plan (CEMP). Surface water control and management measures throughout the project would be selected, designed and implemented in accordance with Managing Urban Stormwater – Soils and Construction, Volume 1 (Landcom, 2004) and Volume 2D (DECCW, 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.

With the implementation of these controls, potential construction related erosion and sedimentation impacts to surface water would be appropriately managed and would be negligible.

## 4.4 Baseflow changes

Aquatic ecosystems may be sensitive to changes 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. This is discussed in detail in Appendix I (Technical report – Groundwater) of the EIS.

Numerical groundwater modelling undertaken for the project has estimated the potential reduction in baseflow to watercourses during construction. These results are provided in Table 4-3 of Appendix I (Technical report – Groundwater) and indicate that dewatering due to construction activities is predicted to create a small reduction in baseflow (in the order of one per cent) at Greaves Creek which is located immediately east of the Blackheath portal where the highest levels of groundwater drawdown are predicted. Minimal reductions in baseflow are expected at other locations along the tunnel.

Reductions in baseflow during construction are expected to be of short duration (less than six months) therefore unlikely to impact the survival of plant communities as this would be within the plant tolerance limits for seasonal variability. However, 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 7).

## 4.5 Water use and wastewater

### 4.5.1 Water use and supply

For the construction of the project, water supply would be required during many construction activities including:

- tunnelling activities
  - cooling of tunnel boring machines (TBMs)
  - dust suppression
  - spoil conditioning
  - wash-down
  - firefighting
  - mixing of grout and bentonite
  - drilling
- surface works such as during compaction of pavement materials and for dust suppression
- concrete batching
- site offices, facilities and worker amenities.

Estimated indicative average water use for the construction of the project is outlined in Table 4-3.

**Table 4-3 Estimated indicative average water use for construction activities of the project for the period of highest water demand (anticipated to be 2026/2027)**

| Activity | Portion of total water use | Indicative average quantity (kL per month) | Water source |
|---|---|---|---|
| Tunnelling | 74% | 51,700 | Potable and recycled |
| Earthworks | 17% | 11,900 | Potable and recycled |
| Site facilities | 1% | 750 | Potable |
| Dust suppression | 7% | 5,000 | Potable and recycled |
| Concreting | 1% | 400 | Potable and recycled (where properties meet relevant specifications) |
| **Total** | | **69,750** | |

Water use would vary over the construction program. Indicative annual construction water demand over the construction phase is summarised in Table 4-4.

**Table 4-4 Indicative water use (kL) for each year of the construction of the project**

| | Indicative annual water use (kL) | | | | | | |
|---|---|---|---|---|---|---|---|
| Construction year | 2024 / 2025 | 2025 / 2026 | 2026 / 2027 | 2027 / 2028 | 2028 / 2029 | 2029 / 2030 | 2030 / 2031 |
| Blackheath | 6000 | 8700 | 58100 | 7100 | 5000 | 6600 | 4400 |
| Midpoint | 11600 | 26700 | 6700 | 0 | 0 | 0 | 1000 |
| Little Hartley | 13300 | 283000 | 772600 | 515900 | 397400 | 148700 | 0 |

| | Indicative annual water use (kL) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Construction year** | **2024 / 2025** | **2025 / 2026** | **2026 / 2027** | **2027 / 2028** | **2028 / 2029** | **2029 / 2030** | **2030 / 2031** |
| **Total** | **30900** | **318400** | **837400** | **523000** | **402400** | **155300** | **5400** |

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/re-use of construction water and rainwater at construction sites (through the erosion and sediment controls, construction water treatment plant and sediment basins,) to minimise the use of potable water during construction
- use of site-sourced water for dust suppression in civil works and landscaping.

Water for construction of the project would be sourced according to the following hierarchy, where feasible and reasonable, and where water quality and volume requirements are met:

- stormwater harvesting (non-potable water uses)
- on-site construction water treatment and reuse, including tunnel seepage (groundwater) (non-potable water uses)
- raw water and potable water.

The majority of water would be sourced from raw and potable water, with the remaining coming from treated groundwater from tunnelling activities or harvested rainwater (non-potable water). A new pipeline would supply raw and potable water from the Lithgow town water supply to the Little Hartley construction footprint to support construction activities including the TBM. The pipeline is described in more detail in Chapter 4 (Project description) of the EIS.

A summary of the indicative construction water balance is presented in Figure 4-3.

### 4.5.2 Wastewater

Wastewater volumes generated during construction would vary depending on the types of construction activities being carried out and the stage of construction. The majority of wastewater 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) of the EIS.

As the tunnels would be constructed by TBMs with the progressive installation of a concrete segment lining, the groundwater infiltration rate across the project is expected to be minor.

Groundwater and other construction wastewater would need to be captured, treated and reused, or discharged. A summary of expected groundwater inflows during construction is provided in Table 4-6, maximum tunnel groundwater inflows are predicted to peak at around 300 to 380 kilolitres per day (around 3.4 to 4.4 litres per second) in 2025-2026 coinciding with construction of the Blackheath portal, mid-tunnel access shaft, adit and caverns excavation. Tunnel groundwater inflow would be pumped to construction water treatment plants at Blackheath, Soldiers Pinch and Little Hartley, where it would be treated to a quality consistent with water quality requirements for either reuse or discharge. Based on the results summarised in Table 4-6, groundwater inflows could therefore supply around 10 to 50 percent of construction water demands.

Model results presented in Table 4-6 are based on average climate conditions. The 50$^{th}$ percentile represents the median estimate from models that test many parameters and the 95$^{th}$ percentile includes modelling parameters that allow greater groundwater inflows.

Smaller volumes of wastewater would be generated by other construction activities, such as concreting and equipment washdown. The use of chemicals in the treatment and curing of concrete, as well as concrete dust, could result in chemical changes to the water such as increased alkalinity of wastewater, which would require treatment before discharge. A summary of the indicative construction water balance is presented in Figure 4-3.

Treated wastewater would be recirculated to the TBM cutting face or used for surface dust suppression. Additional, Site amenity water (sewerage) would be discharged to a local sewer system where possible or trucked off-site to an appropriate disposal location.

Opportunities for water reuse would be investigated and implemented where feasible and reasonable, and subject to meeting water reuse quality requirements. This may include on-site reuse for construction purposes, such as dust suppression.

Where surplus treated groundwater and construction water needs to be discharged it may be discharged to the local stormwater system or to a local watercourse at nominated discharge locations. 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.

Treatment and discharge of wastewater would be regulated by an Environmental 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 Section 8.2.2 of the State Environmental Planning Policy (Biodiversity and Conservation) 2021 which requires that developments have a neutral or beneficial effect (NorBE) on water quality.

Further information on groundwater infiltration and groundwater effects is provided in Chapter 13 (Groundwater and geology) of the EIS.

### 4.5.3 Water licensing

Groundwater modelling undertaken for the project indicates that groundwater would enter the tunnel during construction. Groundwater that enters the tunnel would be captured by the tunnel drainage system, and treated at the water treatment plant at Little Hartley. Potential to reuse treated groundwater within the project would be investigated as part of design development. Surplus treated groundwater would be discharged to Rosedale Creek.

The project is located on land subject to existing water sharing plans (*Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011* and *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources, 2011*).

An aquifer interference approval under Section 91(3) of the WM Act is not required for the project as a proclamation has not been made under section 88A of the WM Act.

Groundwater modelling estimates of the losses to surface water flows during construction are summarised in Table 4-5. These will be reviewed following further investigation during design development and in consultation with DPE Water.

**Table 4-5 Indicative water abstraction from surface water flows**

| Water Source / Management Zone | Estimated Take^ (ML/yr) | Comment |
|---|---|---|
| | Construction | |
| **Surface Water:** Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011 | | |
| Upper Nepean & Upstream Warragamba Water Source – Dharabuladh Management Zone (west of the project) | 41 to 139* | Maximum surface water take calculated from sub-catchment reductions in baseflow. |
| Hawkesbury and Lower Nepean Rivers Water Source: Grose River Management Zone (west of the project) | 10 to 29* | |
| * This will depend on pre-treatment options at cross-passages and further data acquisition.<br>^ Ranges are the annualised $50^{th}$%ile and $95^{th}$%ile maximum take. | | |

(Watershed HydroGeo, 2022, Great Western Highway – Blackheath to Little Hartley Groundwater Modelling Report)

Groundwater modelling indicates that groundwater inflows would increase once construction of the tunnel cross-passages commences in late 2026 and that inflows would further increase in 2028 once tunnelling reaches the mid-point caverns. This modelled outcome is based on current understanding of the expected geological conditions and the TBM currently proposed for tunnelling. The actual TBM method adopted may be further subject to review as additional information becomes available.

Groundwater inflows rapidly decrease during 2029 as construction of underground infrastructure is completed, specifically, once the cross-passages and twin tunnels are tanked.

Groundwater inflows further decrease in 2030 after the mid-tunnel access shaft and adit are backfilled (simulated as occurring in 2030).

As shown in Table 4-6, the twin tunnels between the mid-tunnel caverns and Blackheath, and the tunnel cross-passages, are predicted to contribute to the highest volumes of groundwater inflow during the construction phase. The cross-passages would be tanked upon construction completion and twin tunnels would be progressively tanked as tunnelling progresses and therefore groundwater inflows associated with these structures would be temporary and would recover after construction at these locations.

**Table 4-6 Summary of modelled groundwater inflows during construction phase (mid-2024 to Q3 2030)**

| Project feature | Final construction | Indicative construction groundwater inflows (kL/day) | |
|---|---|---|---|
| | | Average[1] | Maximum[2] |
| | | $50^{th}$ percentile | $95^{th}$ percentile |
| Tunnel – Little Hartley to mid-tunnel caverns | Tanked | 0.0 | 0.0 |
| Tunnel – mid-tunnel caverns to Blackheath | Tanked | 26.6 | 82.4 |
| Cross-passages | Tanked | 76.5 | 222.1 |
| Mid-tunnel access shaft | Tanked and drained - Infilled at end of construction phase | 1.2 | 8.9 |
| Mid-tunnel adit | Drained - Infilled at end of construction phase | 1.1 | 12.5 |
| Mid-tunnel caverns | Drained | 2.5 | 11.9 |
| Little Hartley portals | Drained | 5.6 | 16.2 |
| Blackheath portals | Drained | 21.0 | 45.4 |
| **Estimated peak inflow during construction[3]** | | **107.8** | **317. 2** |

Table notes:

1. Average estimates are based on the $50^{th}$ percentile of many model runs of average conditions
2. Maximum estimates are based on the $95^{th}$ percentile of many model runs of average conditions
3. The estimated peak inflow during construction is not the sum of the maximum inflows from each project feature, as these would occur at different phases of construction, it is the combined peak inflow that would occur during construction

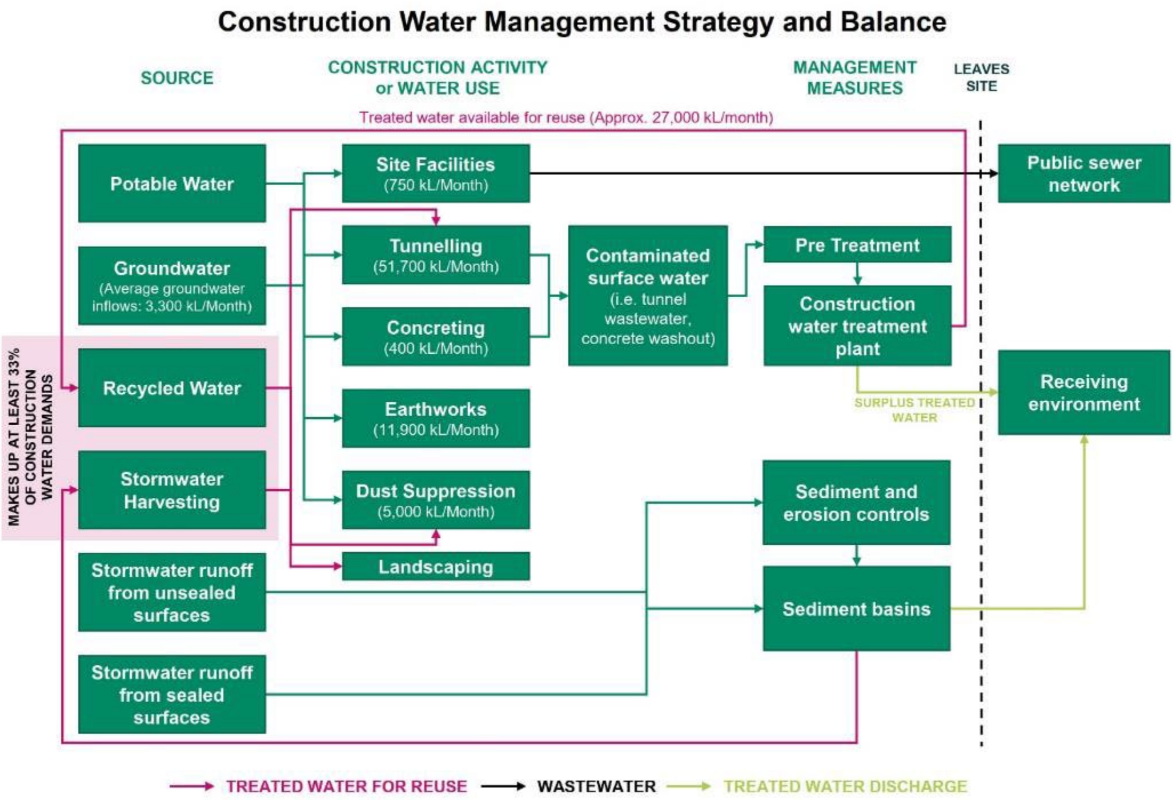



**Figure 4-3 Indicative construction water management strategy and balance**

# 5 Assessment of operational impacts

## 5.1 Overview

### 5.1.1 Consideration of baseline environment

The assessment of operational impacts to the environment considers changes to the existing environment based on a future, baseline scenario. This differs from the existing environment as it assumes that the following projects are operational:

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

The assessment of the potential impacts is focussed on those impacts that could result from the operation of the Blackheath to Little Hartley Upgrade project only.

As described further in 5.3.1, devices for the treatment of stormwater runoff from the project have been incorporated into the design and construction staging of the projects listed above. This integrated design approach is necessary based on staging and phasing of the Upgrade Program and limitations in space within the project footprint to accommodate effective and functional water quality control infrastructure.

The future, baseline scenario adopted for this project assumes that the above projects would be operational, and that the proposed devices for stormwater treatment would be in place. The proposed stormwater treatment devices are required to meet the water quality objectives of the project, as well as the treatment required for the adjacent projects. Therefore, integrated water quality treatment measures for the Upgrade Program are included in the following NorBE assessment, ensuring that the requirements are met at all stages of the upgrades and a beneficial effect on water quality is achieved.

### 5.1.2 Tunnel ventilation system options

No additional operational impacts to drainage networks, overland flow paths, flood risk or water quality risk are expected to result from the operation of the tunnel ventilation system, as these systems are contained within the proposed operational areas, and the ventilation building for both options is located underground and with the outlet being integrated with the surrounding landform.

The operational area of the project would remain consistent regardless of which tunnel ventilation option is progressed, therefore no additional operational impacts related to surface water and flooding are expected to result dependent on which system option is selected.

## 5.2 Flooding

The assessment of potential risks and impacts of flooding during the operational phase of the project has been based on a review of the proposed surface works and their potential impact to the existing surface water behaviour.

It should be noted that the road design can be categorised as either surface road or tunnelled road, where tunnelled portions of the road would not have an impact on flooding as the road runs underground and does not cross existing watercourses or overland flow paths. However, sections of surface road have the potential to obstruct or alter the path of floodwaters (with embankments or cut or other structures intersecting an existing watercourse). Therefore, this flood assessment only focuses on sections of surface road.

Overall, potential flooding impacts identified during the operation phase of the project without the implementation of appropriate management measures, 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.

The following sections provide a summary of the assessed flood risk during the operational phase of the project. These sections demonstrate consistency with previous flood studies (Section 3.9.1) and compliance with the NSW Floodplain Development Manual (DIPNR, 2005). No additional local government floodplain risk management plans or rural floodplain management plans have been identified for the project.

### 5.2.1 Blackheath

Flood modelling of existing conditions for the PMF event (see Figure 3-14) has been carried out as a preliminary assessment of the potential extreme operational phase flooding scenario and the results indicate that further flood modelling is not required due to the project's location on a natural ridge line at Blackheath. The flood depths for the existing PMF are shown in Section 4.2.1. Based on the existing flood information, the overland flow is expected to have minimal impact on the proposed tunnel portal locations as water currently flows towards the east, away from both the tunnel portals.

The proposed surface drainage infrastructure is designed to direct all surface road runoff around or away from the Blackheath tunnel portal and towards the nearest drainage outlet and after treatment, reused or discharged to the closest waterway. The design criteria used for the surface drainage infrastructure (including pits, pipes, detention basins and underground detention tanks) at Blackheath is sufficient to capture and convey all flows up to and including the 0.05 per cent AEP storm event. This design provides flood immunity for the highway and tunnel portals at Blackheath.

Therefore, the proposed works are not expected to adversely impact existing flood characteristics (including flood hazard, hydraulic functions, downstream velocity and scour potential) and surrounding properties and infrastructure, as the drainage design is expected to effectively convey stormwater flows and manage localised flooding based on design criteria stated in Table 2-3. As the project would not impact any residential, commercial or industrial dwellings, or result in an increase in peak flood velocity, the flooding criteria (refer to Table 2-3) would be met.

### 5.2.2 Little Hartley

Flood modelling for the proposed flooding conditions has been completed for the project at Little Hartley, including five per cent, two per cent, one per cent and 0.2 per cent AEP events and the PMF event. The 0.2 per cent AEP has been adopted to represent the climate change scenario for the one per cent AEP (discussed further in Section 2.2.3). The project one per can cent AEP flood depth and flood hazard maps for Little Hartley can be found in Figure 5-1 and Figure 5-2. Figure 5-3 and Figure 5-4 shows the changes in flood level and change in flood velocity for one per cent AEP as a result of the project. Flood mapping for the remainder of the flood scenarios is included in Annexure A.

From these results, the following observations, in relation to flood characteristics (including hydraulic functions, storage areas, flood hazard, velocity and scour potential) can be made:

- for the one per cent AEP design storm event, deep water ponding is still observed upstream of the Rosedale Creek culvert crossing of the proposed highway as for the existing condition. Due to the proposed realignment and upgrade of the culvert (to be undertaken by the Little Hartley to Lithgow Upgrade), no overtopping of the Great Western Highway is observed at this location (see Figure 5-1 and Figure 5-2)

- for the one per cent AEP design storm event, overtopping of the existing Great Western Highway occurs at location one as seen in Figure 5-1. The overtopping results in around a six metre flow width and high flood velocity (around 2.5 m/s) which is not compliant with the flood immunity criteria. The overtopping is predicted to occur due to overspill from a drainage swale near this location. The drainage design will be further refined as part of design development to mitigate any overtopping of the road. This would include lowering the drainage swale to allow for increased conveyance (to contain surface water flows without overspill)

- immediately downstream of the culvert crossing at Rosedale Creek, within the project boundary, a localised high flood flow velocity of around eight metres per second for the one per cent AEP is estimated (see Figure 5-2). The drainage design and grading would be further refined as part of design development to reduce the modelled increases in flow velocity. This would be done through the introduction of energy dissipation, erosion and sediment control measures at all drainage outlets that would mitigate potential impacts of increased velocities. Further downstream of the project there is some minor velocity increase, however these increases are within a channel and are considered minor impacts as they would remain within 20 per cent of existing modelled velocities

- as stated in Section 5.2.2, the proposed surface road drainage is designed to convey up to the 10 per cent AEP for the underground pipe system and flood immunity is designed up to the one per cent AEP for overland flow. Hence, the drainage design is expected to effectively manage localised flooding based on these criteria
- 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 (see Figure A-20 in Annexure A). Compared to the one per cent AEP, the 0.2 per cent AEP modelling indicates that there would be no change to flood behaviour other than the following:
  - upstream of the Rosedale Creek culvert crossing there would be a localised flood depth increase from around 2.8 to 3.2 metres
  - downstream of the Rosedale Creek culvert crossing there would be a localised flood depth increase from around 1.5 to 1.8 metres

  Hence, the predicted effects of climate change would not alter the flood risk of the proposed design
- for the PMF, the 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).
- for the one per cent AEP (see Figure 5-3), due to the proposed design of the transverse drainage network, conveyance of surface water under the Great Western Highway, particularly at the Rosedale Creek culvert crossing, is improved. Therefore, upstream of the culvert crossing generally experiences a reduction in flood level, since the proposed culvert would have a steeper slope and as such more water can be conveyed downstream, while immediately downstream experiences a flood level increase (a localised high flood level increase of up to around 700 millimetres is identified). At the existing dam downstream of the Rosedale Creek culvert there would be an increase in afflux of between around 10 to 15 millimetres. Further downstream of the project, the modelled flood level increases are less than around 100 millimetres and no adverse flood impact or flood damage to surrounding residential areas, commercial areas or agricultural land expected (thereby complying with the flooding criteria identified in Table 2-3). The overall flood level changes at upstream and downstream of the Rosedale Creek culvert are comparable
- the flood hazard mapping for the one per cent AEP (see Figure 5-2) shows that locations which exceed a classification of 'H2' (unsafe for small vehicles) are confined to existing concentrated flow paths and water bodies, with no detrimental changes to flood hazard modelled in the project's operational phase.
- there are a number of locations which show increases in velocity (see Figure 5-4). 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 to as part of further design development and any residual increases would be managed with energy dissipation and flow control measures to minimise impacts of erosion and scour and achieve the flood criteria identified in Table 2-3.

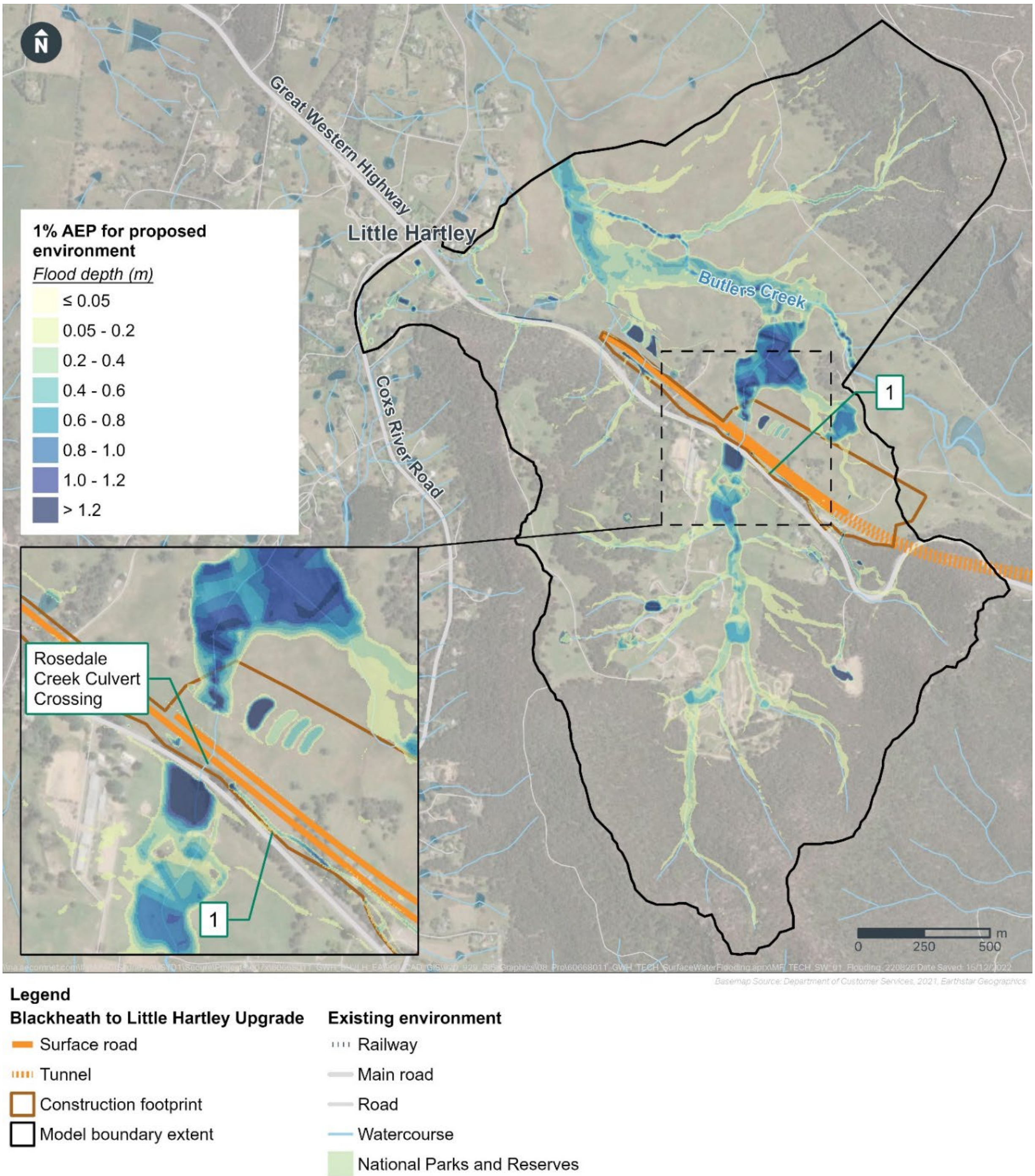



**Figure 5-1 Modelled flood depth at Rosedale Creek (Little Hartley) for the 1% AEP with the project**

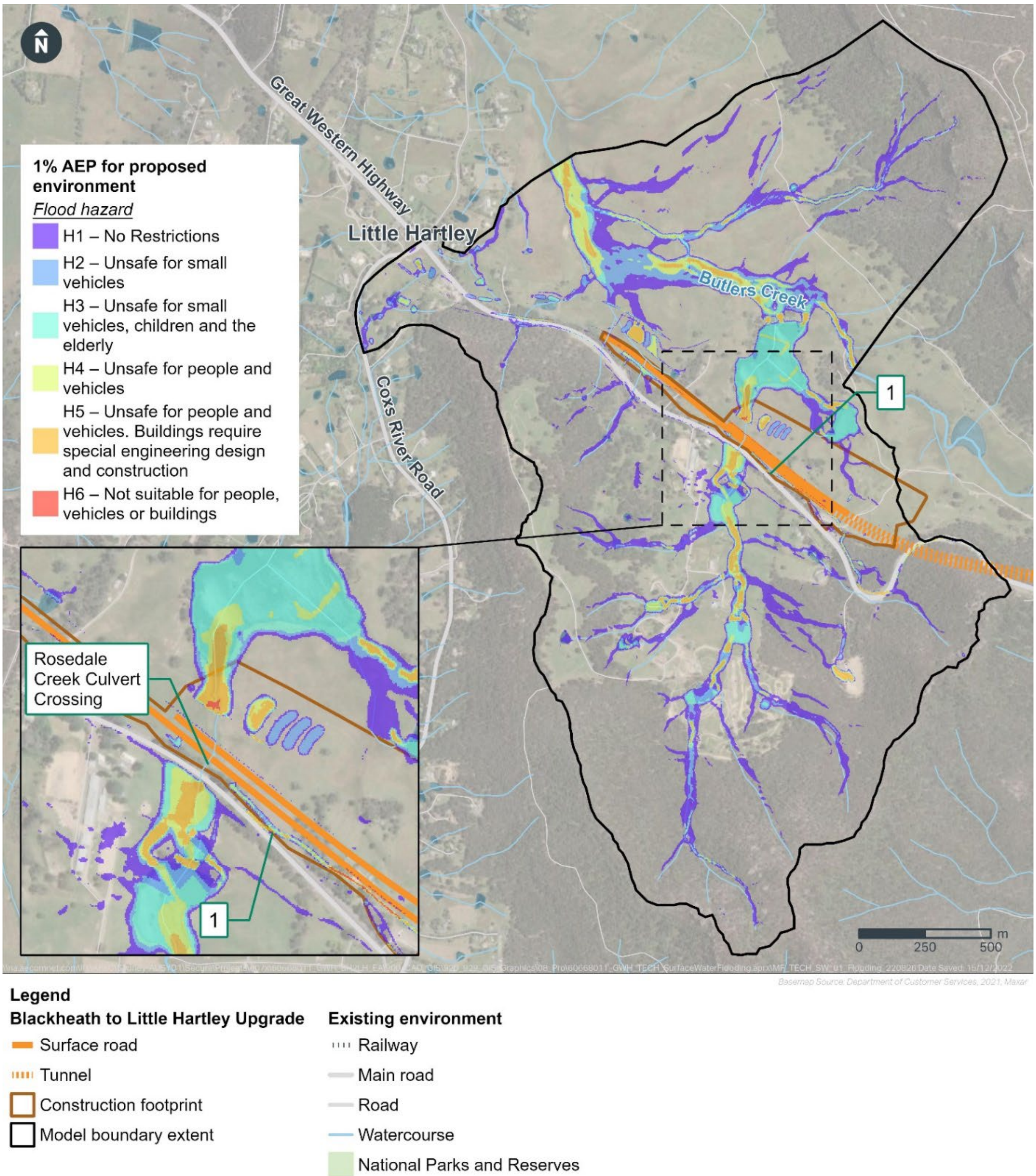
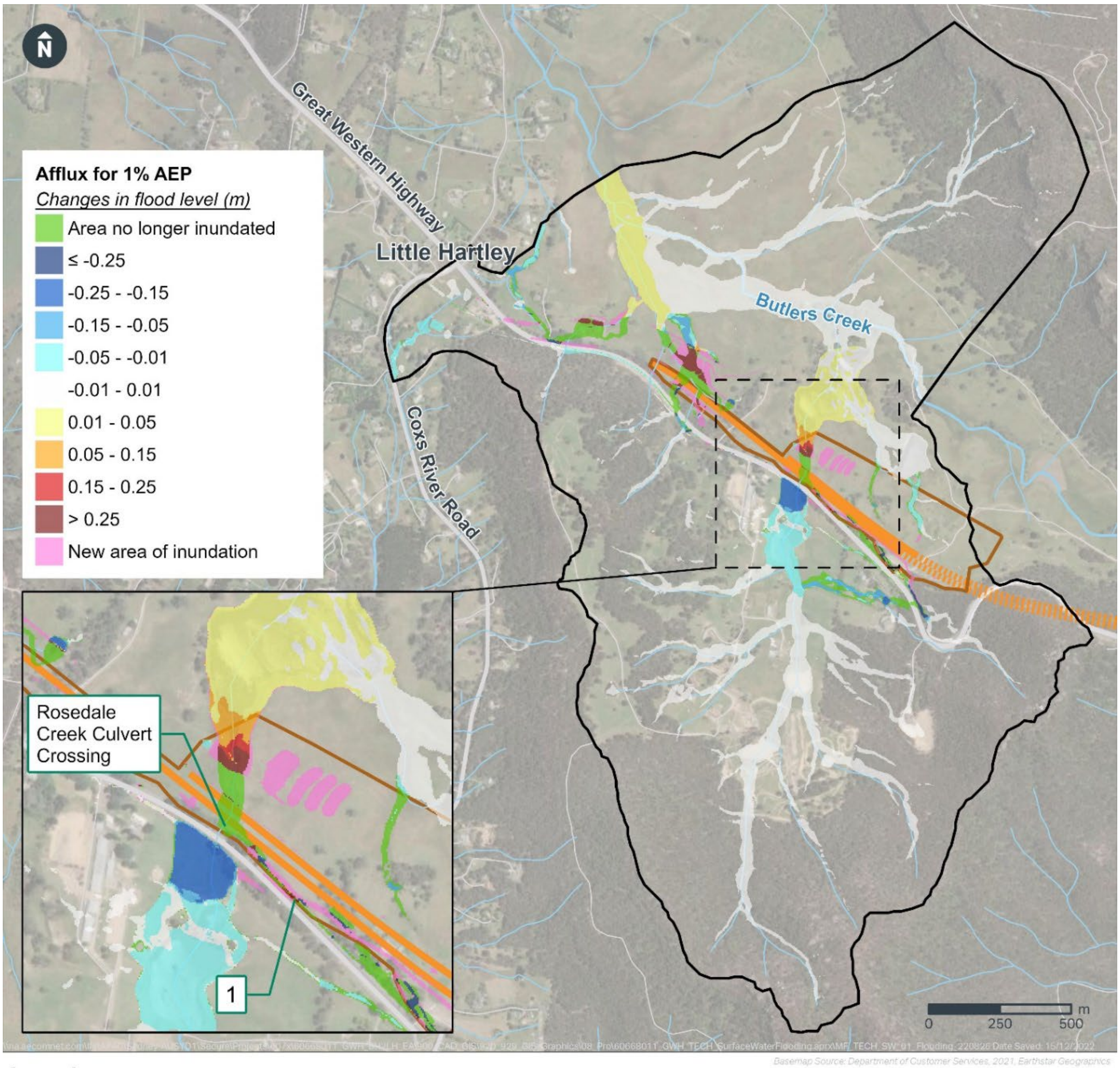



**Figure 5-2 Modelled flood hazard at Rosedale Creek (Little Hartley) for the 1% AEP with the project**




**Legend**

**Blackheath to Little Hartley Upgrade**
- Surface road
- Tunnel
- Construction footprint
- Model boundary extent

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

**Figure 5-3 Modelled changes in flood level at Rosedale Creek (Little Hartley) for the 1% AEP with the project**

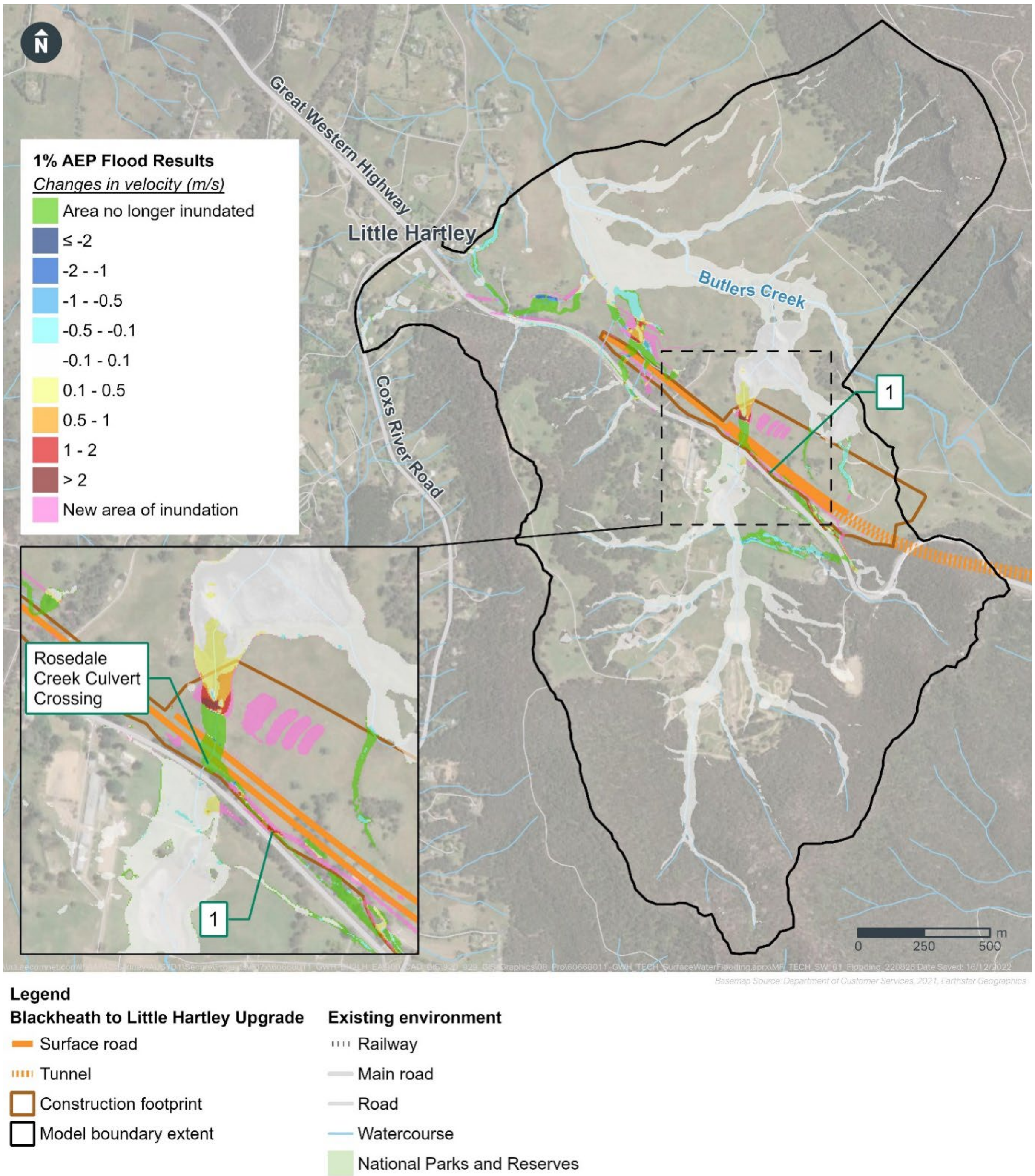



**Figure 5-4 Modelled changes in flood velocity at Rosedale Creek (Little Hartley) for the 1% AEP with the project**

Overall, based on these observations, the project meets the flood criteria and is expected to have minimal adverse impacts to flood affectation of other properties, assets or infrastructure, flood hazard, hydraulic function of flow conveyance of flood ways and storage areas of the land. Additionally, appropriate sizing and design of scour protection where increased velocities are observed would minimise the potential for scour.

### 5.2.3 Emergency, social and economic costs to the community

The flooding impacts of the project are not expected to impact transport corridors or nearby properties. Therefore, based on the assessment of potential operational flooding impacts, the impacts to existing and proposed community emergency management arrangements for flooding (including exising emergency management, evacuation and access and contingency measures) would be minimal, with improvements in flood immunity of the existing Great Western Highway within the Little Hartley footprint expected to result from the project (Figure 5-3). As such the project would achieve the flood management objective identified in Table 2-3 for emergency management.

Consultation with State Emergency Services and Lithgow City Council was undertaken to review the flood behaviour and the proposed 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 LGA.

Additionally, changes to flood behaviour due to the operation of the project are not expected to impact any residential dwellings or infrastructure, as the flood assessment determined that there were no impacts beyond the project boundary. Currently the Great Western Highway overtops at a number of locations. The project provides immunity against inundation at all but one of these locations in the one per cent AEP. It is anticipated that further design development would be able to avoid this impact. Therefore, no social and economic costs are expected as a result of the project due to flooding.

## 5.3 Surface water runoff

Aquatic ecosystems are sensitive to changes in surface runoff quality, quantity and velocity. 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 (i.e. increased velocity causing greater potential for scour)
- cause 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.

Table 5-1 provides a summary of the potential soil and water related impacts during operation of this Project. The receiving waterways for the potential impacts stated below are both the Coxs and Grose River systems. Each of the potential impacts outlined in Table 5-1 is considered with respect to the environmental values and WQOs listed in Table 2-4.

**Table 5-1 Potential impacts to surface water during operation**

| ID | Activity/Source | Pollutants or factors of concern | Potential impact (without mitigation) |
|---|---|---|---|
| O1 | Stormwater runoff from hard surfaces being discharged to receiving waterways (Coxs River and Grose River systems)<br>Litter from vehicles and incorrect disposal of rubbish can increase the potential for pollutants to occur in road runoff, stormwater systems, treatment systems and receiving environments.<br>Damage to or erosion of road pavements, landscaping, batters and stormwater assets from major storm events, leading to potential pollution of the receiving environment and waterways. | Gross pollutants, TSS, nutrients, heavy metals, oil and grease | • sediments could smother receiving waterways impacting aquatic ecosystems.<br>• increased turbidity, lower dissolved oxygen levels, and increases in toxicant concentrations could impact aquatic ecosystems and livestock.<br>• nutrients in runoff could lead to algal blooms and aquatic weed growth, which could impact aquatic ecosystems, recreation, irrigation, livestock, and aquatic foods.<br>• reduced visual amenity could result from turbid water and visible gross pollutants, impacting recreation and visual amenity.<br>• potential for pollution and impacts described above to impact peat swamps identified at Blackheath, Soldiers Pinch and Little Hartley, as well as the WaterNSW Special Area at Blackheath (public access to this area is restricted to protect water quality and create a buffer of land around essential water storages).<br>• these impacts are largely mitigated by the proposed stormwater treatment devices. However, the environmental protection provided could be compromised by blockages or damage to stormwater treatment systems, leading to poor water quality improvement performance and potential increased pollution to receiving environments. |
| O2 | Accidental spills or leakage events due to vehicle movements and operation of the highway. | Oil and grease and various hazardous fuels and chemicals that may be transported by vehicles or caused by spills or road accidents | • increases in toxicant concentration in soil, surface water and groundwater, which could impact aquatic ecosystems, livestock, and aquatic foods, including the peat swamps identified at Blackheath and Little Hartley. |

| ID | Activity/Source | Pollutants or factors of concern | Potential impact (without mitigation) |
|---|---|---|---|
| O3 | Potential increase in stormwater runoff discharges due to increased imperviousness of the project | Stormwater runoff | • increase in scour and erosion due to increase in stormwater runoff rate and volume, which could impact aquatic ecosystems, amenity, and recreation<br>• these impacts are largely mitigated by the proposed stormwater treatment devices, which are designed to promote attenuation and infiltration of flows. However, the attenuation protection provided could be compromised by blockages or damage to stormwater treatment systems if not adequately maintained. |
| O4 | Maintenance of pavements, road assets, stormwater network and treatment systems, and vegetation including:<br>• repairs to pavement or other infrastructure<br>• collection of waste and pollutants<br>• disposal of waste and pollutants<br>• operation of maintenance equipment. | Gross pollutants, sediment, TSS, nutrients, odour and noise | • if waste recovered during maintenance operations is not disposed of correctly this can impact the visual amenity of the project, pollute receiving waterways, and negatively impact the downstream and surrounding environment, including potential impacts to peat swamps identified at Blackheath and Little Hartley, as well as the WaterNSW Special Area at Blackheath. |
| O5 | Change to pH of surface runoff arising from either:<br>1. Acidification of runoff from oxidation of inadequately treated acid sulfate rock (ASR) at Little Hartley<br>2. Alkalisation of runoff resulting from carbonate dissolution as rainfall comes into contact with pavements | Increased acidity or alkalinity of surface water, damage to vegetation and ecosystem | • ASR can produce sulfuric acid resulting in increased acidity of surface water impacting quality, which could impact aquatic ecosystems, killing sensitive species and leading to sparse and slow regeneration of plants leading to soil erosion. Acidification can lead to corrosion of and structural damage to surrounding steel and concrete structures. This is most likely near Little Hartley<br>• Pavement carbonate compounds react with rainfall to alkalise runoff, which can elevate the pH of stormwater to approximate neutrality. This could impact the in-stream peat swamps (especially those near Blackheath that are in largely natural catchments) as these environments are naturally acidic. |

With the safeguards outlined in Section 7, the implementation of the proposed stormwater treatment devices and procedures for spills management, potential operation impacts to surface water quality would be appropriately managed and would be considered minor. Therefore, the project would not be expected to impact the environmental values and water quality objectives of the receiving environment.

### 5.3.1 Treatment opportunities

To mitigate surface water quality impacts, opportunities for stormwater treatment were considered to protect the health of surrounding waterways by reducing pollutant loads in stormwater runoff. The types of stormwater treatment opportunities considered as part of the design are described in Table 5-2.

**Table 5-2 Stormwater treatment opportunities**

| Treatment opportunities | Description |
|---|---|
| **Flow splitters** | Flow splitters are proposed prior to every bioretention basin. Flow splitters ensure runoff that exceeds bioretention design flow rates are diverted into on-site detention basins to avoid scouring of the bioretention basin filter media and vegetation. Low flows would be diverted to the proposed bioretention basins for treatment. Flow splitters typically utilise a pit with pipes or a surface arrangement with weirs to separate flows. |
| **Gross pollutant traps (GPTs)** | Baramy Single Vane GPTs or approved equivalents are proposed at every major surface road drainage outlet, prior to discharging into a bioretention basin or filtration system. The GPTs help to capture and store any litter coming off the highway entering the underground drainage network. Note that these single vane GPTs have been excluded from the water quality modelling as they do not contribute to the WaterNSW NorBE requirements. |
| **Bioretention basins or filtration devices** | Bioretention basins and/or proprietary filtration devices are proposed at every major drainage outlet. These both incorporate a filter media that helps to remove nutrients and other pollutants as surface water slowly infiltrates the media. Filter media would also comply with the Water by Design Bioretention Filter Materials Specifications (Water by Design 2022) which specify additional organic material in the filter media to provide pH buffering.<br>Bioretention basins are nominated at every major surface road drainage outlet, except for where there is insufficient space within the project boundary. Instead, proprietary filtration devices, such as Ocean Protect StormFilter®, are proposed at these locations. |
| **Vegetated buffers and swales** | The proposed drainage network discharges to vegetated buffer strips and/or swales where possible. Vegetation within these buffer strips and swales helps to trap sediment and any other nutrients bound to the sediment particles.<br>These vegetated buffers and swales are located at a number of drainage outlets, where they can then direct flows into a bioretention basin or filtration device. They also provide treatment for some catchments which bypass the bioretention basins or filtration devices, due to physical constraints. |
| **Detention basins** | Detention basins are proposed at every bioretention basin outlet. These reduce the downstream flow rate by attenuating peak flow which reduces erosion and sediment mobilisation downstream.<br>In future design stages, the base of the detention basin may be removed to allow for infiltration and reduce flow volume for more frequent storm events. |
| **Scour protection, energy dissipation devices and/or flow spreaders** | Energy dissipation devices and/or flow spreaders are proposed at the detention basin outlets to slow down and spread discharge flows. This helps reduce the risk of sediment mobilisation which would reintroduce pollutants downstream of the proposed treatment train.<br>Flow spreaders or level spreaders are drainage discharge outlets designed to discharge runoff as sheet flow in order to reduce flow velocities and to uniformly distribute flow across the discharge environment. |

Assumed water quality control measures, their locations and indicative discharge locations have been incorporated into the design and support the NorBE assessment. The water quality control measures would be subject to ongoing design development and would be required to achieve NorBE requirements.

Indicative water quality treatment measure locations to meet NorBE requirements and discharge locations for Blackheath and Little Hartley are shown in Figure 5-5 and Figure 5-6, respectively. Engineered treatment train measures would be located at each discharge location to treat stormwater runoff from the project which includes bioretention basins, detention basins and flow spreaders. Swales would also contribute to treatment of stormwater runoff to meet NorBE requirements. Treatment measures are sized to achieve pollutant load reduction performance for NorBE and this is typically a smaller size requirement than the design flow for the one year ARI. All events up to one year ARI design flow would be directed to treatment devices. The water treatment plant (WTP) at Little Hartley shown in Figure 5-6 discharges to the nearby farm dam via the detention basin and then ultimately to Butlers Creek.

Overall, several of these treatment measures would also contribute to the water quality treatment of the baseline environment as they would be constructed by the adjacent projects immediately to the east and west of this project.

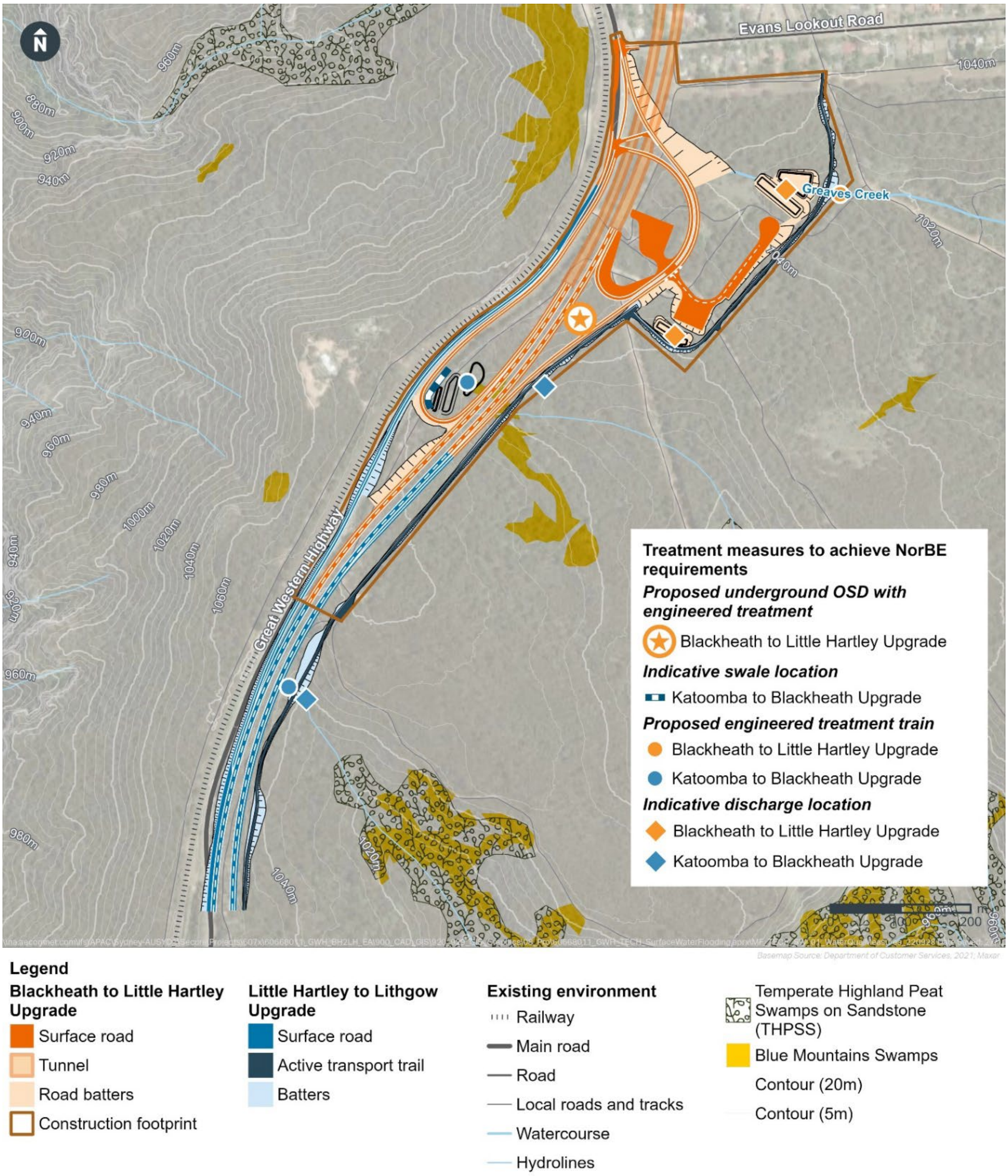



**Figure 5-5 Treatment measures at Blackheath**

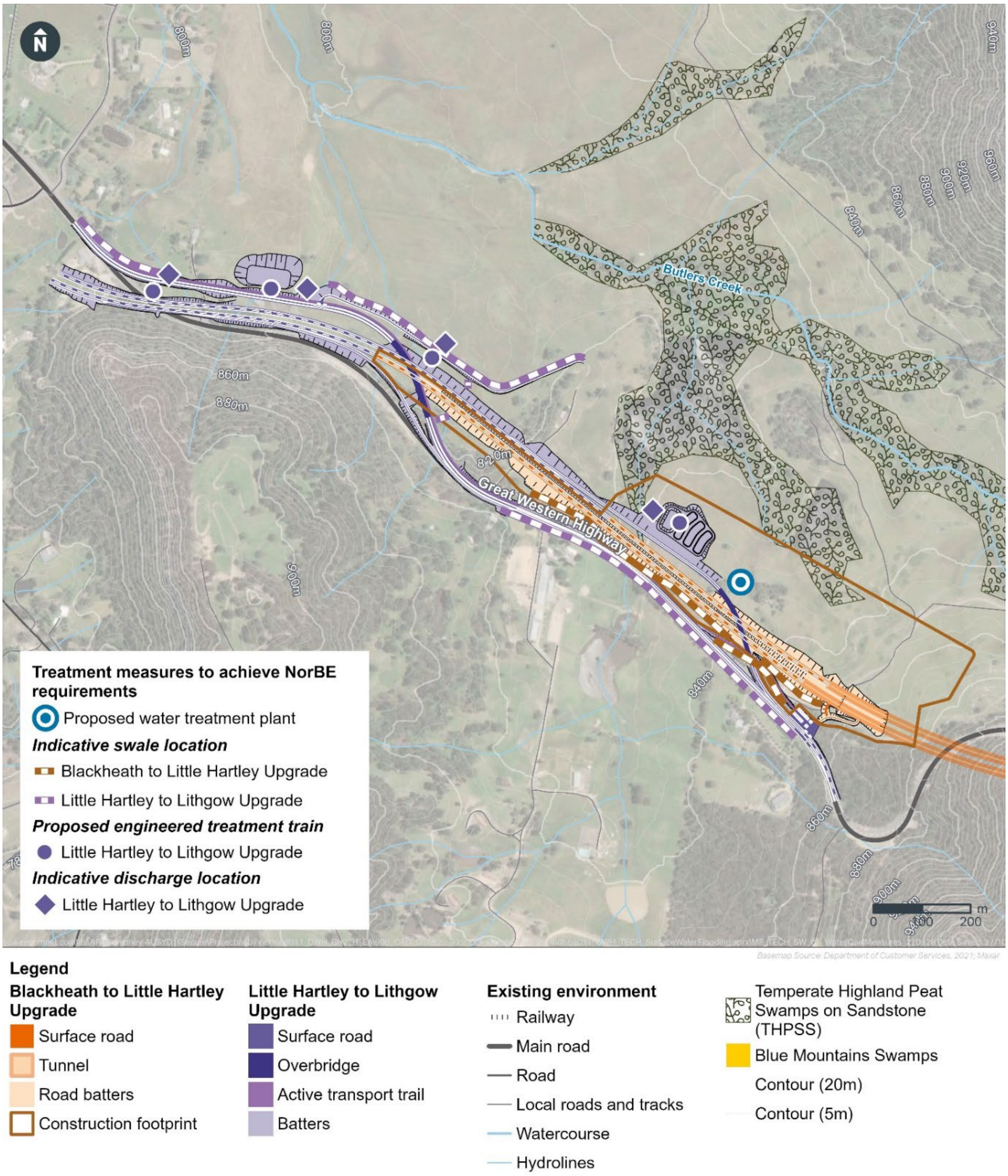



**Figure 5-6 Treatment measures at Little Hartley**

### 5.3.2 NorBE assessment

#### Pollutant targets

As per the WaterNSW Guideline (WaterNSW 2019), to meet NorBE the modelled pollutant loads for the post-development (proposed operation) case should aim to achieve the target of 10 per cent less than the pre-development (existing) case for total suspended solids (TSS), total phosphorus (TP) and total nitrogen (TN). For gross pollutants (GP), the modelled existing scenario load only needs to be equal to or less than the existing load.

Additionally, to meet NorBE the concentration of Total Nitrogen and Total Phosphorus pollutants for the post-development case should be equal to or less than the concentration for the pre-development case. NorBE would be deemed to be met if the target post-development pollutant concentrations are equal to or less than the pre-development case concentrations between the 50th and 98th frequency percentiles.

**MUSIC model setup**

To evaluate the pollutant concentration levels generated by the project, eWater's MUSIC software package was used. The pre- and post-development case source node parameters were setup based on the WaterNSW Standard *Using MUSIC in Sydney Drinking Water Catchments* (WaterNSW, 2019).

**MUSIC model results for pollutant loads**

NorBE requirements were assessed using MUSIC at the Blackheath and Little Hartley operational areas of the project. MUSIC modelling to assess NorBE is not necessary for the Soldiers Pinch construction footprint as it is a construction phase only site. The annual pollutant loads of total suspended solids, total phosphorus, total nitrogen and gross pollutants leaving the site under both pre-development, unmitigated post-development and mitigated post-development conditions are summarised for Blackheath and Little Hartley in Table 5-3. The results indicate the adopted treatment opportunities from Table 5-2 (shown on Figure 5-5 and Figure 5-6) successfully achieve the set NorBE criteria in relation to annual pollutant loads by demonstrating pollutant load reductions of at least 10 per cent.

**Table 5-3 MUSIC annual pollutant load results at the Blackheath and Little Hartley end of the project**

| Location | Criteria | Annual pollutant load (kg/year) | | | |
|---|---|---|---|---|---|
| | | Total Suspended Solids (TSS) | Total Phosphorus (TP) | Total Nitrogen (TN) | Gross Pollutants (GP) |
| **Blackheath (discharge locations are within the Sydney Drinking water Catchment and the Greaves Creek sub-catchment which is a tributary of Grose River)** | Pre-development | 38400 | 29 | 145 | 1440 |
| | Post-development (unmitigated) | 26000[1] | 44 | 220 | 2460 |
| | Post-development (mitigated) | 3250 | 21 | 125 | 0 |
| | Improvement compared to existing | 92% | 29% | 14% | 100% |
| | **NorBE targets achieved? (Yes/No)** | **Yes** | **Yes** | **Yes** | **Yes** |
| **Little Hartley (discharge locations are within the Sydney Drinking Water Catchment and the Butlers Creek sub-catchment which is a tributary of Coxs River)** | Pre-development | 14000 | 25 | 140 | 824 |
| | Post-development (unmitigated) | 285000 | 47 | 235 | 2660 |
| | Post-development (mitigated) | 1330 | 15 | 106 | 0 |
| | Improvement compared to existing | 91% | 42% | 24% | 100% |
| | **NorBE targets achieved? (Yes/No)** | **Yes** | **Yes** | **Yes** | **Yes** |

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, and unsealed road produces approximately four times as much TSS as sealed road.

## 5.4 Baseflow changes

Aquatic ecosystems within in the stream environment are sensitive to changes in surface runoff quantity and quality. 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 – groundwater interactions may be impacted during the project operational phase due to continued groundwater inflow to the drained features (portals and mid-tunnel caverns), potentially causing some long-term reduction in stream baseflow at surface water features.

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.

The numerical groundwater modelling assessed the potential for reduction in baseflow to surface water catchments during operation of the project. These results are provided in Table 5-5 of Appendix I (Technical report – Groundwater) of the EIS and indicate that minor losses to baseflow may occur along the tunnel.

The numerical groundwater modelling indicates that ongoing dewatering is predicted to have the largest impact on baseflow reduction at Greaves Creek which is located immediately east of the drained (unlined) Blackheath portals and flows east towards Greaves Lake. Reductions in baseflow are predicted for Greaves Creek near the Blackheath Portal (post-construction). Predictions for a 95$^{th}$ percentile year (dry year) range from around 15 to 17 per cent reduction.

During average rainfall years the reduction in baseflow would be offset by increases in surface runoff (due to the increase in impervious pavement introduced by the project). Therefore sufficient moisture is likely to be available to the peat swamps in average weather years.

However, in drier years, baseflow would supply the higher proportion of water to the peat swamps. Potential impacts related to a reduction in baseflows during dry years could include:

- drying of the margins of the valley floor infill peat swamps leading to a reduction in the area of the swamp (loss of biodiversity)
- minor loss of integrity in the swamp vegetation leading to increased susceptibility to erosion from surface/stream flows following dry periods
- increased susceptibility to bushfires. Wet peat material is likely to be more resistant to bushfire. Dry peat material may have a higher likelihood of burning, resulting in permanent loss of some of the swamp, likely followed by erosion in subsequent rainfall, and potentially substantial impacts to the integrity of the swamp.

The impacts and management measures for aspects related to aquatic ecology and groundwater are discussed further in Appendix H (Technical report – Biodiversity) and Appendix I (Technical report – Groundwater) of the EIS.

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 including the recommendations of Commonwealth of Australia (2014) where appropriate.

## 5.5 Water use and wastewater

During the operation phase, the project to have a minimal impact on surface water availability and flows. This is discussed further in the following sections.

### 5.5.1 Water use

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 tunnels where possible 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)
- rainwater harvesting (non-potable water)
- raw water and potable water.

Indicative volumes of water for each operational activity are provided in Table 5-4, with additional detail for operational amenity water demands provided in Table 5-5. Connection to and supply of mains water would be confirmed during further design development, in consultation with relevant stakeholders. A new pipeline connecting the project with the Lithgow town water supply would provide operational water supply for the project at Little Hartley (noting that use of recycled water sourced from the project would be prioritised).

**Table 5-4 Indicative operational water requirements summary**

| Operational activity | Indicative total water demand (kL/year) |
|---|---|
| Deluge testing | 7,300 |
| Washdown and cleaning | 530 |
| Amenities | 5,500 |
| Landscaping | 8,980[1] |

Table notes:
1. For planting/establishment in the first year only

**Table 5-5 Indicative operation phase water demand – amenities**

| Location | Indicative average daily usage (kL/day) |
|---|---|
| Blackheath Control Centre | 3.0 |
| Blackheath Workshop | 7.5 |
| Little Hartley WTP (waste stream) | 4 |
| Little Hartley Switching Station | 0.5 |
| **Total** | **15 kL/day (equates to around 5500 kL/year)** |

### 5.5.2 Wastewater from project facilities

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 that may contain a variety of pollutants (such as fuel, oil grease, and fire suppressants) requiring different treatment before discharge.

Table 5-6 summarises the estimated wastewater produced by the tunnel amenities requiring discharge to the sewer network or disposal by other suitable means. Table 5-7 provides a summary of the annual water treatment plant discharges. Note that estimates of water use and discharges from the project facilities are preliminary and conservative at this stage and will be refined as design progresses.

**Table 5-6 Indicative operational water discharge – amenities sewer / trade waste**

| Location | Indicative average daily discharge (kL/day) |
|---|---|
| Blackheath Control Centre | 3 |
| Blackheath Workshop | 1 |
| Little Hartley WTP (waste stream) | 15 |
| Little Hartley Switching Station | 0.5 |
| **Total** | **19.5 kL/day (equates to around 7140 kL/year)** |

**Table 5-7 Indicative operational water discharge – WTP treated water discharge**

| Source | Indicative annual volume (kL/year) |
|---|---|
| Fire System Testing | 7300 |
| Tunnel Washing | 530 |
| WTP process water | 1500 |
| **Total** | **9830** |

Note: This table does not include the treated tunnel water

### 5.5.3 Wastewater from treatment of tunnel seepage

A summary of the predicted groundwater inflows during operation is provided in Table 5-8 and further detail is provided in Appendix I (Technical working paper – Groundwater) of the EIS. The average daily inflows of 24 kilolitres per day during operations is markedly lower than the average inflow estimates of 108 kilolitres per day during construction.

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 that may contain a variety of pollutants (such as fuel, oil grease, and fire suppressants) requiring different treatment before discharge.

**Table 5-8 Summary of modelled groundwater inflows during operation phase (Q4 2030 to 2130)**

| Project feature | Indicative operation phase groundwater inflows (year 2031) (kL/day) | |
|---|---|---|
| | Average[1] | Maximum[2] |
| | $95^{th}$ | $95^{th}$ percentile |
| Blackheath portal | 2.0 | 14.0 |
| Little Hartley portal | 4.2 | 12.8 |
| Mid-tunnel caverns | 18.2 | 37.7 |
| **Total** | **24.4** | **64.5** |

Table notes:

1. Average estimates are based on the $50^{th}$ percentile of many model runs of average conditions
2. Maximum estimates are based on the $95^{th}$ percentile of many model runs of average conditions

### 5.5.4 Wastewater discharge criteria

Due to the potentially saline nature of the groundwater that may be encountered within the project locality (particularly coal seams) and the potential for other pollutants present that could contaminate surface waters, groundwater would need to be treated prior to discharge/re-use to avoid impacts to receiving environments.

Treatment of contaminated groundwater is a scheduled activity under Schedule 1 of the *NSW Protection of the Environment Operations Act (1997).* The POEO Act contains pollution controls and requirements for granting Environment Protection Licences (EPLs) for scheduled activities under Schedule 1 of the POEO Act. The project therefore includes a permanent water treatment plant at Little Hartley which would treat groundwater inflows and wastewater so that water is of adequate quality prior to discharge or re-use. Transport would be required to obtain and hold an EPL for treatment of contaminated groundwater during both the construction and operation phases. The EPL would specify the performance criteria that the water treatment plant would need to achieve in order to be able to discharge.

It is expected that appropriate discharge criteria would be based on measured water quality and the water quality requirements of the receiving aquatic environments, in addition to the environmental values for the various uses for water in the catchment.

Discharge criteria should be based on Table 2-4, which describes key water quality indicators for the Hawkesbury-Nepean River system and related numerical criteria for environmental values using ANZG (2018) Water Quality Guidelines. However, due to the specific nature of the aquatic ecosystems within proximity to the proposed discharge location at Little Hartley, the water quality parameter for pH would be between 4.2 and 8.0.

Swamps are generally naturally acidic environments and therefore discharges with pH values as low as 4.2 are within the normal range of water chemistry for these environments (Belmer, 2015). Discharge parameters may be modified if site-specific water quality data for the receiving environment becomes available.

Discharges to the environment are to be designed to control the velocity and energy of discharged flows to avoid scour. Discharges should be designed in accordance with industry recognised guidelines such as Catchments and Creeks Pty Ltd (2010) to achieve the requirements for poor soils.

### 5.5.5 Water licensing

Groundwater modelling developed for the project has estimated that groundwater would enter the tunnel in places, and would be diverted from groundwater to the tunnel drainage system, eventually to be treated by water treatment plants and likely reused by the project with any remainder discharged to Rosedale Creek. Baseflows to some streams would be reduced, resulting in a reduction in surface flows in the impacted streams. The impacted streams are currently managed by the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011*. This Plan is made under section 50 of the Water Management Act 2000.

Groundwater modelling estimates of the losses to surface water flows during operation are summarised in **Table 5-9** and would be revised once project design is confirmed and in consultation with DPE Water.

An aquifer interference approval under Section 91(3) of the WM Act is not required for the project as a proclamation has not been made under section 88A of the WM Act.

**Table 5-9 Indicative water abstraction for licensing**

| Water Source / Management Zone | Estimated Take^ (ML/yr) | Comment |
|---|---|---|
| | Post-construction | |
| **Surface Water:** Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011 | | |
| Upper Nepean & Upstream Warragamba Water Source – Dharabuladh Management Zone (west of the project) | 24 to 43 | Maximum surface water take calculated from sub-catchment reductions in baseflow (Section 4.8). |
| Hawkesbury and Lower Nepean Rivers Water Source: Grose River Management Zone (west of the project) | 11 to 16 | |
| * This will depend on pre-treatment options at cross-passages and further data acquisition.<br>^ Ranges are the annualised $50^{th}$%ile and $95^{th}$%ile maximum take. | | |

(Watershed HydroGeo, 2022, Great Western Highway – Blackheath to Little Hartley Groundwater Modelling Report)

# 6 Assessment of 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 effect (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 interrelate may enhance the project and create positive cumulative benefits.

Four projects were reviewed against the following screening criteria for this cumulative impact assessment:

- spatially relevant (i.e., the development or activity overlaps with, is adjacent to or within two 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 and on the 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).

Projects identified as contributing to potential cumulative impacts have met these criteria and include:

- Katoomba to Blackheath Upgrade (including Medlow Bath Upgrade)
- Little Hartley to Lithgow Upgrade.

Given the regional setting of the project primarily within the Blue Mountains Local Government Area (LGA) and a small portion within the Lithgow LGA, there are few major projects within the locality.

Figure 1-9 and Figure 1-10 shows the interface of the Katoomba to Blackheath Upgrade (including Medlow Bath) and the Little Hartley to Lithgow Upgrade with the project. Chapter 24 (Cumulative impacts) details the full cumulative impact assessment methodology adopted for the project.

## 6.1 Construction

### 6.1.1 Surface water quality

The project and the adjacent Katoomba to Blackheath Upgrade discharge to tributaries of the Grose River and Coxs River catchments. Overland flow at the construction footprint of the Katoomba to Blackheath Upgrade could wash construction materials, fuels and chemicals into the natural drainage line 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). Both projects would be required to implement guidelines and principles from the Blue Book, which deem the projects to have a neutral effect on water quality in the construction phase i.e. a deemed-to-comply solution to demonstrate NorBE. Therefore, there would be no cumulative impacts expected to surface water quality.

Rosedale Creek is within the project study area and the Little Hartley to Lithgow Upgrade study area. Construction works that have a high risk of impacting surface water may lead to water quality impacts such as increased turbidity in receiving waterways 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 the construction phase must meet the requirements of the Blue Book (Landcom, 2004) for the project and the Little Hartley to Lithgow Upgrade. With the implementation of safeguards and management measures the Little Hartley to Lithgow Upgrade would have minimal impact on existing water quality and therefore there would be no cumulative impacts on surface water quality at Rosedale Creek.

The operation of the adjacent Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade also potentially presents a risk to water quality during the construction of the project. Impacts could result from increased runoff due to increased impervious areas from the adjacent projects that may result in erosion of newly disturbed areas within the project construction footprint. However, the risk is low since stormwater runoff from both of the adjacent upgrades would be managed using on-site detention basins to attenuate peak flows and stormwater treatment devices, including several Gross Pollutant Traps (GPT), water quality basins and swales. The adjacent projects would drain to the Sydney Drinking Water Catchment, and have been designed to meet requirements for NorBE as outlined by Water NSW. As such the risk of cumulative water quality impact to the receiving waterways, such as Greaves Creek and Rosedale Creek, is low.

### 6.1.2 Flooding

At the eastern extent of the project, the Katoomba to Blackheath Upgrade is located on a natural ridgeline, hence flooding is not expected to have a substantial impact on the project during the construction phase. It is possible but unlikely that the adjacent Katoomba to Blackheath Upgrade may cause blockage to downstream existing waterways and drainage lines due to erosion and sedimentation from earthworks or other activities during the construction phase of the upgrade. This may lead to localised flooding and changes to the ultimate discharge location of overland flows into the receiving environment prior to the commencement of the Blackheath to Little Hartley Upgrade. However, these temporary impacts are expected to be minor and would be managed through implementation of mitigation measures in accordance with the Blue Book (Landcom, 2004) resulting in no cumulative impacts on flood behaviour.

At the western extent of the project, the adjacent Little Hartley to Lithgow Upgrade would cross several drainage lines and there is potential for drainage lines to be temporarily blocked or diverted during construction works. Standard construction techniques would be implemented so that these temporary impacts are minor and hence it is expected that there would be no cumulative impacts on flood behaviour arising from the construction of the adjacent project.

## 6.2 Operation

### 6.2.1 Surface water quality

The treatment of surface runoff from the upgrade meets NorBE requirements of achieving at least a 10 per cent improvement on pollutant loads for the post-development case compared to the pre-development case as outlined by Water NSW. As such the risk of cumulative water quality impact to the receiving waterways, such as tributaries of Grose River and Coxs River catchments, is low.

### 6.2.2 Flooding

Adjacent to the eastern extent of the project, the Katoomba to Blackheath Upgrade is not located within a floodplain and would hence not have any impacts on flood behaviour or additional flood impacts during the operation phase. Therefore, there would be no cumulative impacts on flood behaviour.

At the western extent of the project, the design of the adjacent Little Hartley to Lithgow Upgrade was included in the flood modelling for the project and therefore assesses potential cumulative flooding impacts. The modelling shows there would be no cumulative impacts on flood behaviour in the operation of the project as it improves upon existing and baseline conditions.

# 7 Management of impacts

## 7.1 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 7-1 and identify measurable, performance-based standards for environmental management.

**Table 7-1 Performance outcomes for the project – surface water and flooding**

| SEARs desired performance outcome | Project performance outcome | Timing |
|---|---|---|
| **Flooding**<br>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**<br>Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised.<br>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:<br>• minimising the volume and rate of groundwater inflow to the project during operation<br>• minimising the magnitude and extent of groundwater drawdown around the project during operation<br>• minimising the reduction in baseflow volumes in watercourses affected by groundwater drawdown around the project during operation<br>• 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 |
| **Water – Quality**<br>The project is designed, constructed and operated to protect the NSW Water Quality Objectives where they are currently being achieved, and | 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 | Design, construction and operation |

| SEARs desired performance outcome | Project performance outcome | Timing |
|---|---|---|
| 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). | catchments, taking into account relevant Water Quality Objectives. | |

## 7.2 Management of impacts

A construction environment management plan (CEMP) would be prepared for the project. CEMP would detail the proposed approach to environmental management, monitoring and reporting during construction. A number of sub-plans (and other supporting documentation, as required) would also be prepared as part of the CEMP. These sub-plans would address issues relating to (but not limited to):

- clearing and boundaries
- chemical and fuel storage and use
- spills and incident management
- waste management
- soil and water management
- erosion and sediment control
- air quality management
- residual and unexpected contamination, and contaminated land management.

A community and stakeholder engagement plan (Engagement Plan) 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 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.

Since the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade adjoin the project to the east and west respectively and would be under construction when construction of the project commences, some of the construction mitigation measures used for the adjoining upgrades may be repurposed to support construction of the project. For example, sediment basins are expected to be established during the construction phase at the proposed locations for ‘operational’ water quality control infrastructure (bioretention systems) shown in Figure 1-3 for Katoomba to Blackheath, and Figure 1-4 for Little Hartley to Lithgow. These sediment basins would be retained until the project earthworks have been completed and the landscape is stabilised. Retained sediment basins would need to meet the minimum sizing requirements for the project area runoff estimates that they would be used to treat.

Construction mitigation measures to manage potential surface water and flooding impacts of the project are outlined in Table 7-2 and other relevant measures are presented in Appendix I (Technical working paper – Groundwater) (specifically GW1, GW2 & GW3 which relate to drawdown and baseflow loss) and Appendix K (Technical working paper – Contamination). All the mitigation measures for the project have been compiled in Appendix R of the EIS.

**Table 7-2 Management and mitigation measures for the construction and operation phase– surface water and flooding**

| ID | Environmental mitigation measure | Timing |
|---|---|---|
| SW1 | To meet the WaterNSW NorBE requirements, 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 control soil erosion (including sedimentation) and pollutant movement downstream , 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:<br>• 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:<br>    • diversion of runoff from undisturbed areas of the catchment around project disturbance areas<br>    • diversion of existing drainage lines disturbed by construction, or establishment of an alternative drainage line<br>    • 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.<br>    • use of sediment management devices such as fencing, sandbags, coir logs and graded or lined earth or sandbag diversion bunds and banks<br>    • measures to divert or capture and filter water prior to discharge, such as drainage diversion channels to flush and sediment sumps or traps<br>    • scour protection and energy dissipaters at locations of high erosion risk<br>    • location and storage of construction materials, fuels, and chemicals, including controls where possible to minimise the risk of leaks, spills and other unintended releases<br>    • storage of materials clear of frequently flooded low-lying areas<br>    • stabilisation of the surface of batters and drains, including temporary works and diversions<br>    • 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.<br>• planning and management of stockpile areas in accordance with *Stockpile Site Management Guideline* (RMS, 2015)<br>• 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) | Construction |

<table>
<tr><th>ID</th><th>Environmental mitigation measure</th><th>Timing</th></tr>
<tr><td></td><td><ul><li>a spill management procedure to minimise the risk of release of construction materials, fuels, and chemicals from construction sites. The procedure will include:<ul><li>management of chemicals, fuels and potentially polluting materials</li><li>any specialised containment, security and bunding requirements (refer to environmental mitigation measure HR02)</li><li>maintenance of plant and equipment</li><li>emergency management, including notification, response, and clean-up procedures</li></ul></li><li>measures to manage construction activities in areas prone to flooding or inundation, particularly around Rosedale Creek, including:<ul><li>daily monitoring of weather conditions, including rainfall forecasts, to provide advance warning of potential flooding or inundation</li><li>cessation of relevant works and site security and stabilisation requirements in the event of a severe weather warning</li><li>site clean-up and recovery measures in the event of flooding or inundation</li></ul></li><li>measures to manage acid sulfate rock, consistent with the Acid Sulfate Rock Management Plan (ASRMP) for the project (refer to environmental mitigation measure SC3).</li></ul></td><td></td></tr>
<tr><td>SW2</td><td>A surface water monitoring network will be maintained for the project to:<ul><li>continue to gather baseline surface water monitoring data to inform ongoing design development, and the updated numerical groundwater model for the project</li><li>characterise the hydrological environment along and around Greaves Creek and associated groundwater dependent ecosystems</li><li>monitor surface water, including surface water quality, prior to, during and for two years after completion of construction of the project</li><li>complement the groundwater monitoring network for the project (refer to environmental mitigation measure GW3).</li></ul>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.<br><br>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.</td><td>Design, construction and operation</td></tr>
<tr><td>SW3</td><td>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).</td><td>Design and construction</td></tr>
</table>

| ID | Environmental mitigation measure | Timing |
|---|---|---|
| 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 |

## 7.3 Surface water quality monitoring

### 7.3.1 Objectives

Rainfall events during construction activities can result in the transport of sediments and pollutants through stormwater runoff to the surrounding environment. Therefore, a Water Quality Monitoring Program would be implemented to monitor the effectiveness of the mitigation measures to manage this potential impact to surface water quality. This program would form part of the CEMP developed for the project. Construction Water Quality Monitoring will be undertaken in accordance with the Guideline for Construction Water Quality Monitoring (RTA undated).

### 7.3.2 Monitoring parameters

A risk to water quality during the construction phase is the mobilisation of sediments from erosion of exposed soil during earthworks. This could result in high turbidity, decreases in dissolved oxygen and increases in salinity, which could have flow-on effects for aquatic flora and fauna. The following parameters would be monitored as part of the Water Quality Monitoring Program:

- pH
- turbidity (NTU)
- electrical conductivity (EC)
- dissolved oxygen (DO)
- oils and grease (visual assessment).

Provided that monitoring can demonstrate that these parameters remain within the water quality criteria and trigger levels for the project, it is expected that the mitigation measures proposed for the construction phase are adequate.

Any discharges from sediment basins would be monitored for compliance with the Blue Book (Landcom, 2004). The Blue Book criteria for discharges is < 50 mg/L suspended solids. A site-specific relationship between suspended solids concentration (also reported as mg/L) and turbidity (measured in nephelometric turbidity units (NTU)) will be established to allow a more rapid assessment of stormwater quality at the site. Other criteria for pH, EC and DO would be in compliance with the criteria in Table 2-4, unless it can be demonstrated and agreed that alternative criteria are more appropriate for the receiving environments in proximity to the project.

### 7.3.3 Sampling locations

Preliminary water quality monitoring locations are shown in Figure 7-1, Figure 7-2 and Figure 7-3 for Blackheath, Soldiers Pinch and Little Hartley construction footprints, respectively. These indicative sample locations were selected at an upstream and downstream location of the proposed discharge points and are intended where possible to allow an assessment of any changes to water quality as flows pass through the construction sites.

The Blackheath construction footprint has almost no upstream catchment due to its location on a ridgeline and hence no adequate locations for upstream water quality testing were identified. An upstream location at Adams Creek could be used as a proxy to measure existing water quality to compare to the downstream locations impacted by surface runoff from the project. Similarly, no adequate upstream sampling location was identified at Soldiers Pinch, however a proxy comparable upstream sample could be used from Boyce Gully. The downstream samples from Blackheath and Soldiers Pinch could also be compared to the ANZG (2018) Water Quality Guidelines and environmental values for the Hawkesbury-Nepean River catchment. Samples at Little Hartley would be collected from the upstream and downstream of the Rosedale Creek culvert crossing.

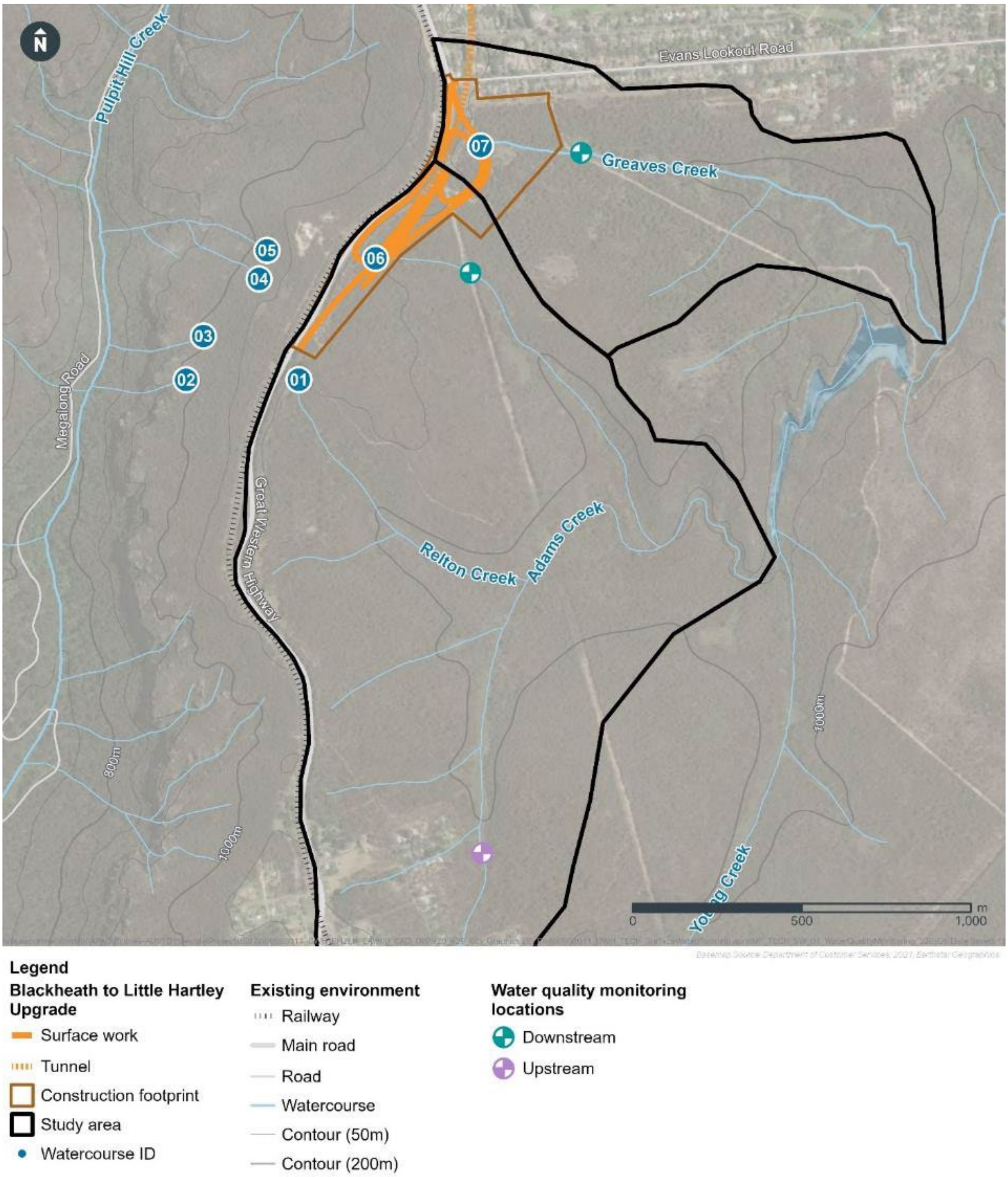



**Figure 7-1 Proposed surface water quality monitoring locations at Blackheath**

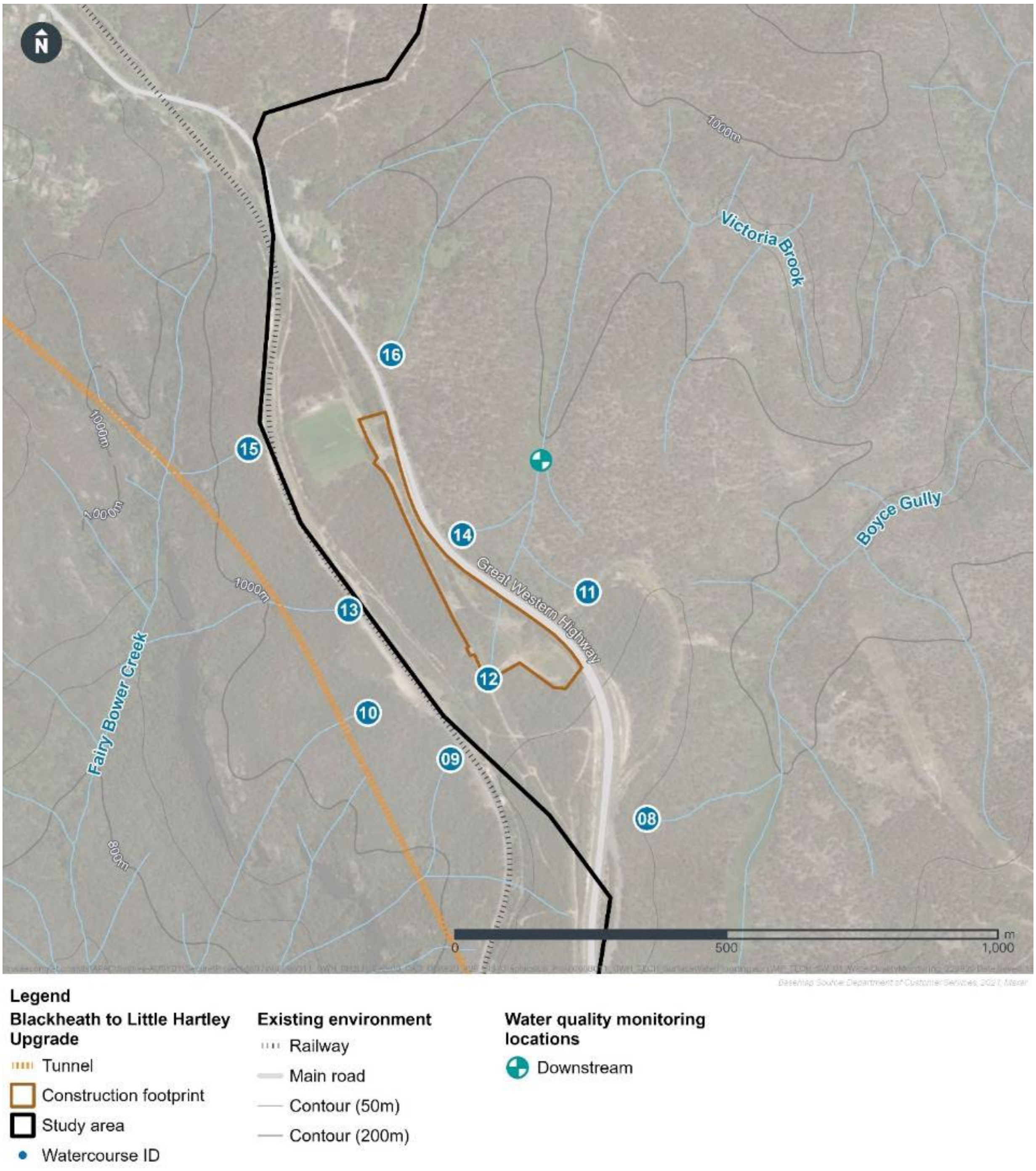



**Figure 7-2 Proposed surface water monitoring locations at Soldiers Pinch**

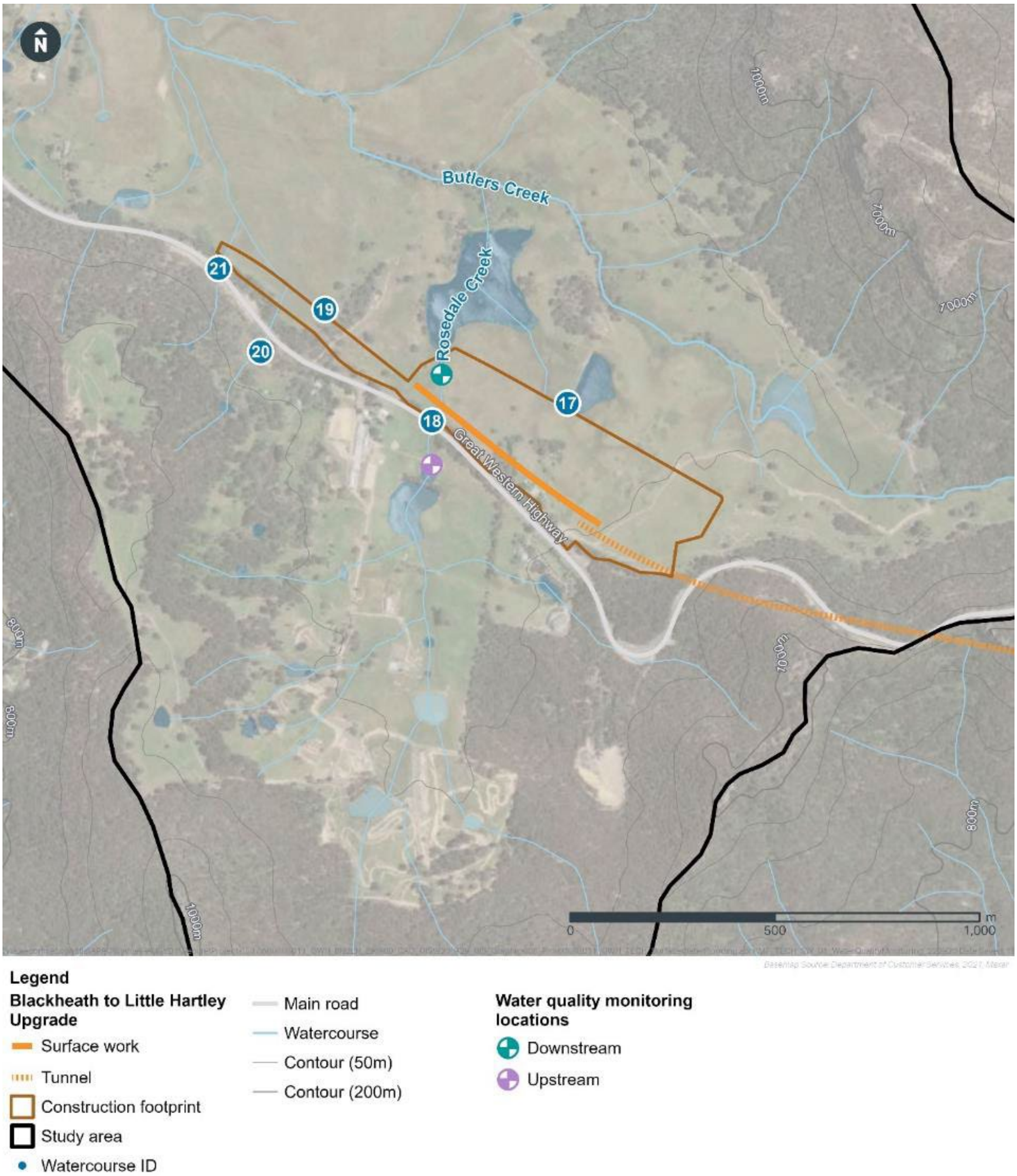



**Figure 7-3 Proposed surface water quality monitoring locations at Little Hartley**

The surface water monitoring program methodology would include the following requirements:

- surface water quality samples are to be collected in accordance with industry-accepted standards and quality assured procedures, including the Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DECC 2008).
- representative background monitoring data (including but not necessarily limited to representative data collected by the relevant councils, where readily available) for surface water quality would be used to inform an understanding of baseline water conditions prior to the commencement of construction

- a risk management framework, for the evaluation of the risks to surface water resources and ecosystems in the receiving environment, including definition of impacts that trigger contingency and ameliorative measures
- identification of works and activities during construction and operation of the project, including runoff, emergencies and spill events, that have the potential to impact on surface water quality of potentially affected watercourses and riparian land
- the identification of environmental management measures relating to surface waters during construction including erosion and sediment control and stormwater management measures
- contingency and ameliorative measures in the event that adverse impacts to water quality are identified, with reference to the impact triggers defined as part of the water quality monitoring program.

# 8 Conclusion

This Surface Water and Flooding Technical Report has been prepared as part of the Environmental Impact Statement (EIS) for this project. This report has assessed the potential impacts of the construction and operational phases of the project on surface water and flooding. The project's Secretary's Environmental Assessment Requirements (SEARs) have been considered to ensure that all potential impacts have been adequately assessed.

Construction of the project is expected to take around eight years. Subject to planning approval, construction is planned to commence in 2024 and be completed by late 2031; however, the project would be open to traffic by 2030.

The key potential construction phase surface water and flooding impacts without mitigation identified in this assessment include:

- increased surface water runoff (e.g. due to removal of vegetation) and associated impacts to surface water quality due to the increased mobilisation of sediments (soil erosion) and contaminant laden stormwater
- accidental spills and leaks of substances (e.g. fuel and oils) and associated impacts to surface water quality
- concreting activities impacting receiving waterways in the result of accidental runoff of concrete washout water and spills of excess or waste concrete
- earthworks and changes to the construction footprint resulting in concentrated flows, as opposed to sheet flow, that have potential to disrupt existing surface water flow paths, scour the earth and increase sediment loads carried by surface waters
- activities related to discharges potentially resulting in increased erosion and scouring due to increased discharged volumes and impacts to ambient water quality due to poorly treated discharges which may contain sediments and other mobilised pollutants
- disturbance and oxidisation of acid sulfate rock (ASR) around Little Hartley during construction excavation and earthworks leading to acidification of runoff
- flooding leading to inundation and damage to construction sites, machinery, equipment and stockpiles and delays in construction programming
- diversion of existing flow paths leading to 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.

The key potential operational phase surface water and flooding impacts without mitigation identified in this assessment include:

- changes to surface water runoff to waterways (Coxs River and Grose River systems) due to the increase in impervious surfaces, which could lead to increases in runoff flow rates and pollutant loads washing off the impervious surfaces
- litter, accidental spills or leaks of substances (e.g. fuels and oils), during routine operation and maintenance activities, have the potential to contaminate surface water runoff into waterways and impact visual amenity
- potential for pollution in runoff and increases in runoff volume to damage the peat swamps at Blackheath, Soldiers Pinch and Little Hartley
- acidification of runoff from oxidation of inadequately treated acid sulfate rock (ASR) around Little Hartley
- diversion of existing flow paths leading to increased velocity and ponding

- increase in velocity, scour potential and flood hazard due to floodwaters
- impacts to adjacent property due to changes in flood behaviour
- groundwater drawdown, due to permanently drained mid-tunnel caverns resulting in potential baseflow reductions at creeks and impacts to hanging swamps.

The construction and operation of this project has the potential to impact surface water and flooding without the implementation of adequate mitigation measures. Mitigation measures for the identified potential impacts are outlined in this report to minimise impacts of the project on surface water and flooding. Stormwater treatment devices would be implemented for the operation phase to meet or exceed Neutral or Beneficial Effect (NorBE) criteria for runoff water quality, thus meeting the requirements of WaterNSW for Section 8.8 of the Biodiversity and Conservation SEPP.

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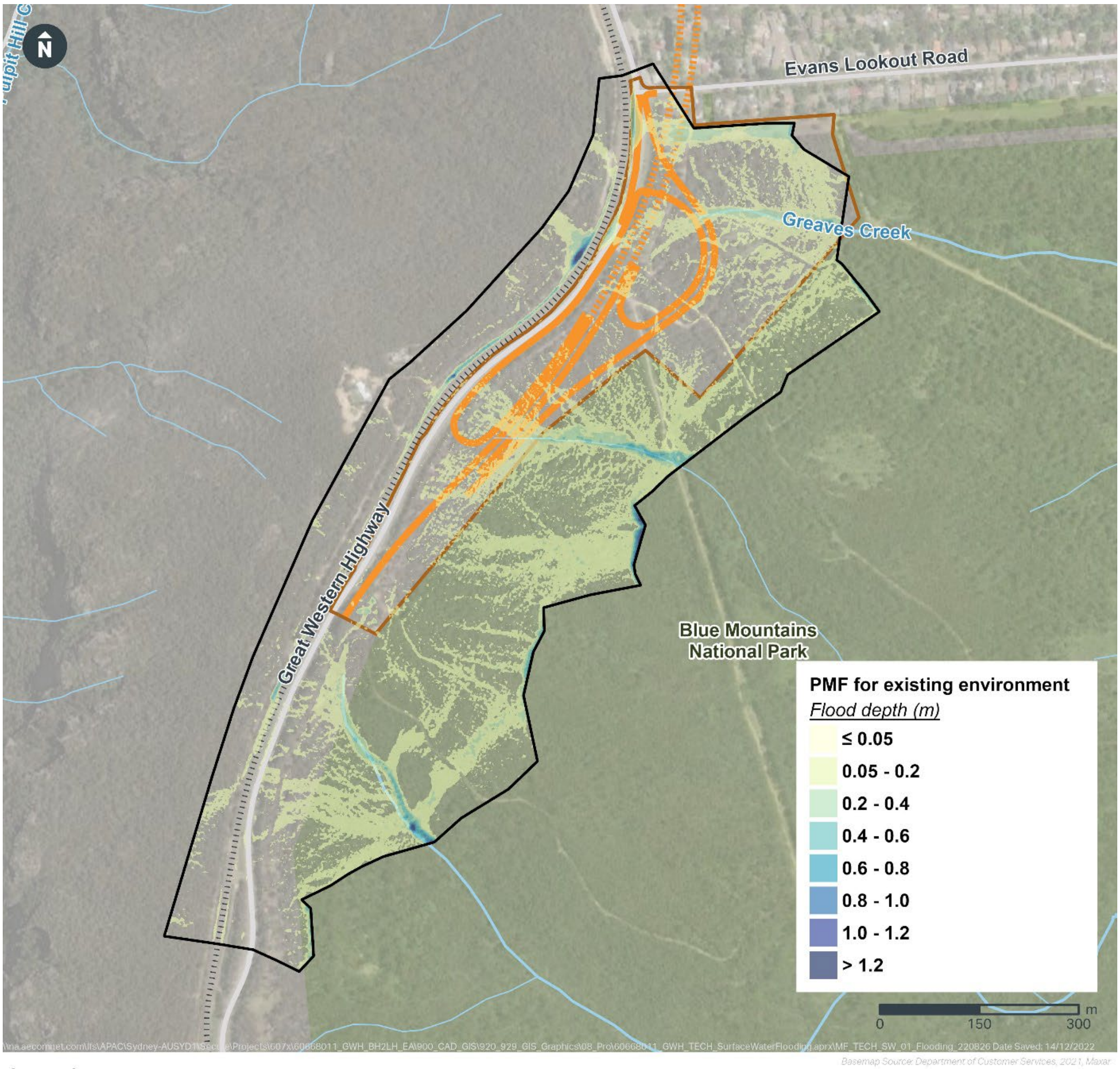
# Annexure A

## Flood maps

# A. Flood Maps

## Table of Figures




**Legend**

**Blackheath to Little Hartley Upgrade**
- Surface road
- Tunnel
- Construction footprint
- Model boundary extent

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

**Figure A-1 Modelled flood depth for the PMF with the project at Blackheath – Existing**

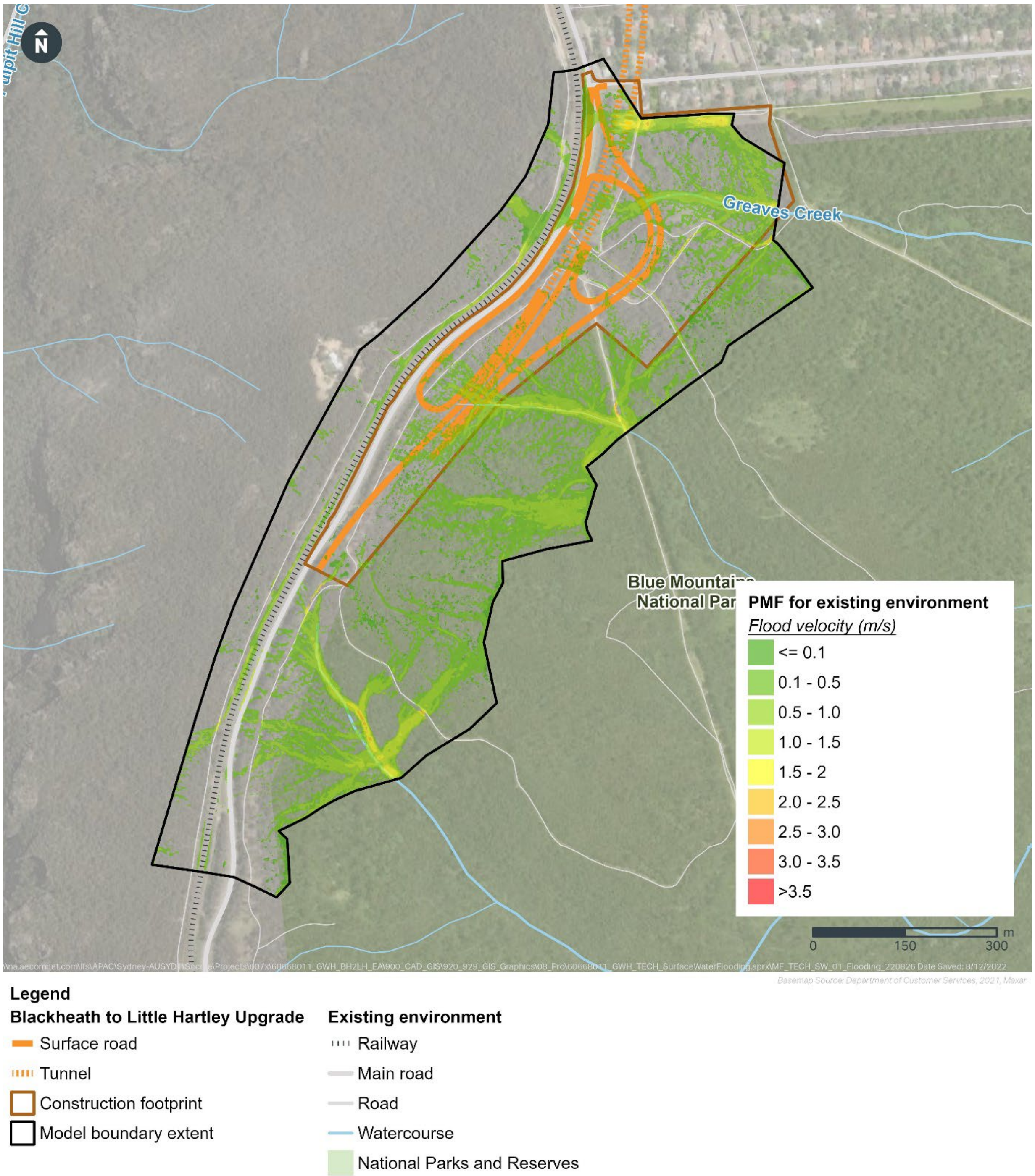



**Figure A-2 Modelled flood velocity for PMF in Blackheath - Existing**

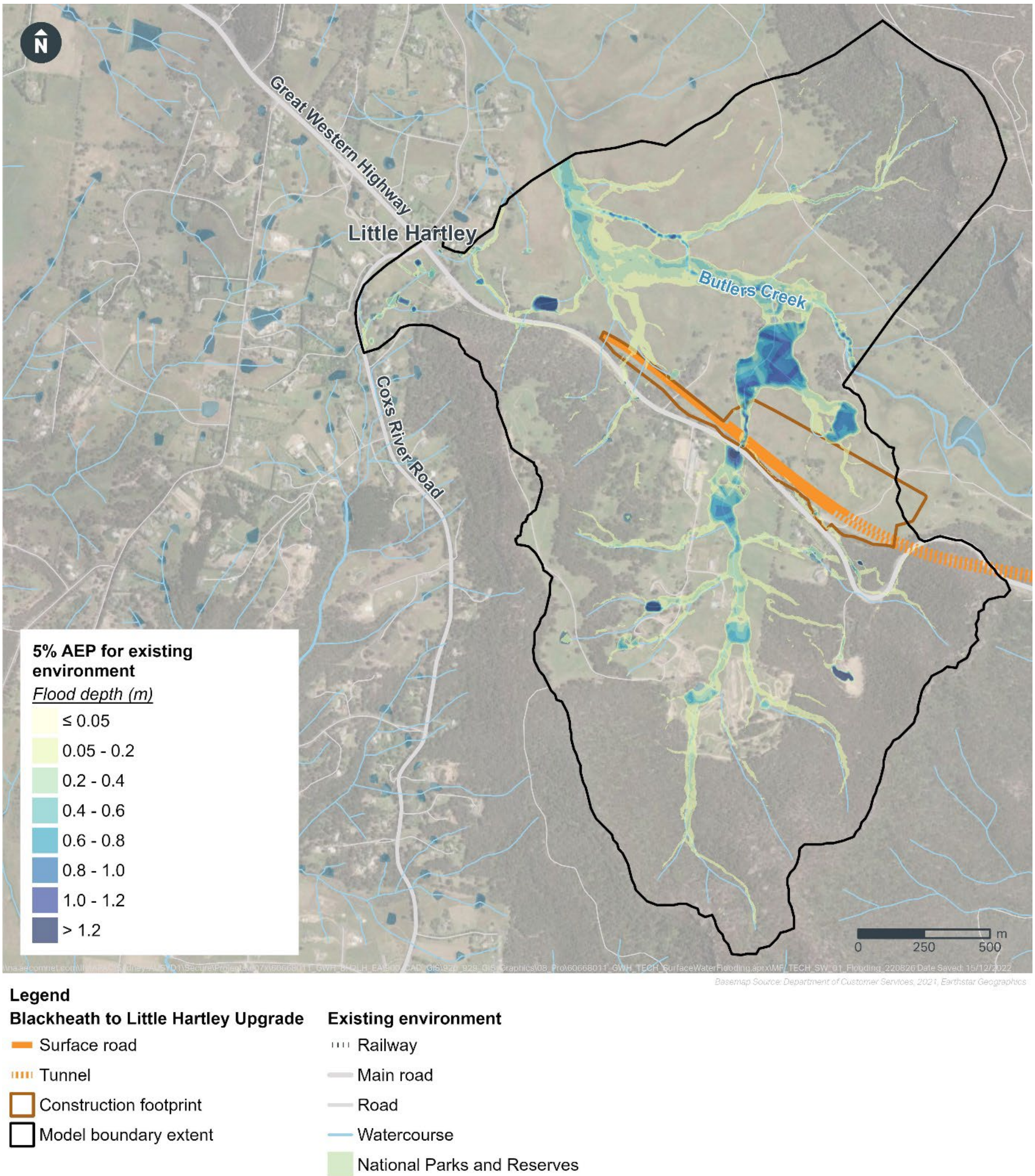



**Figure A-3 Modelled flood depth for the 5% AEP with the project at Little Hartley – Existing**

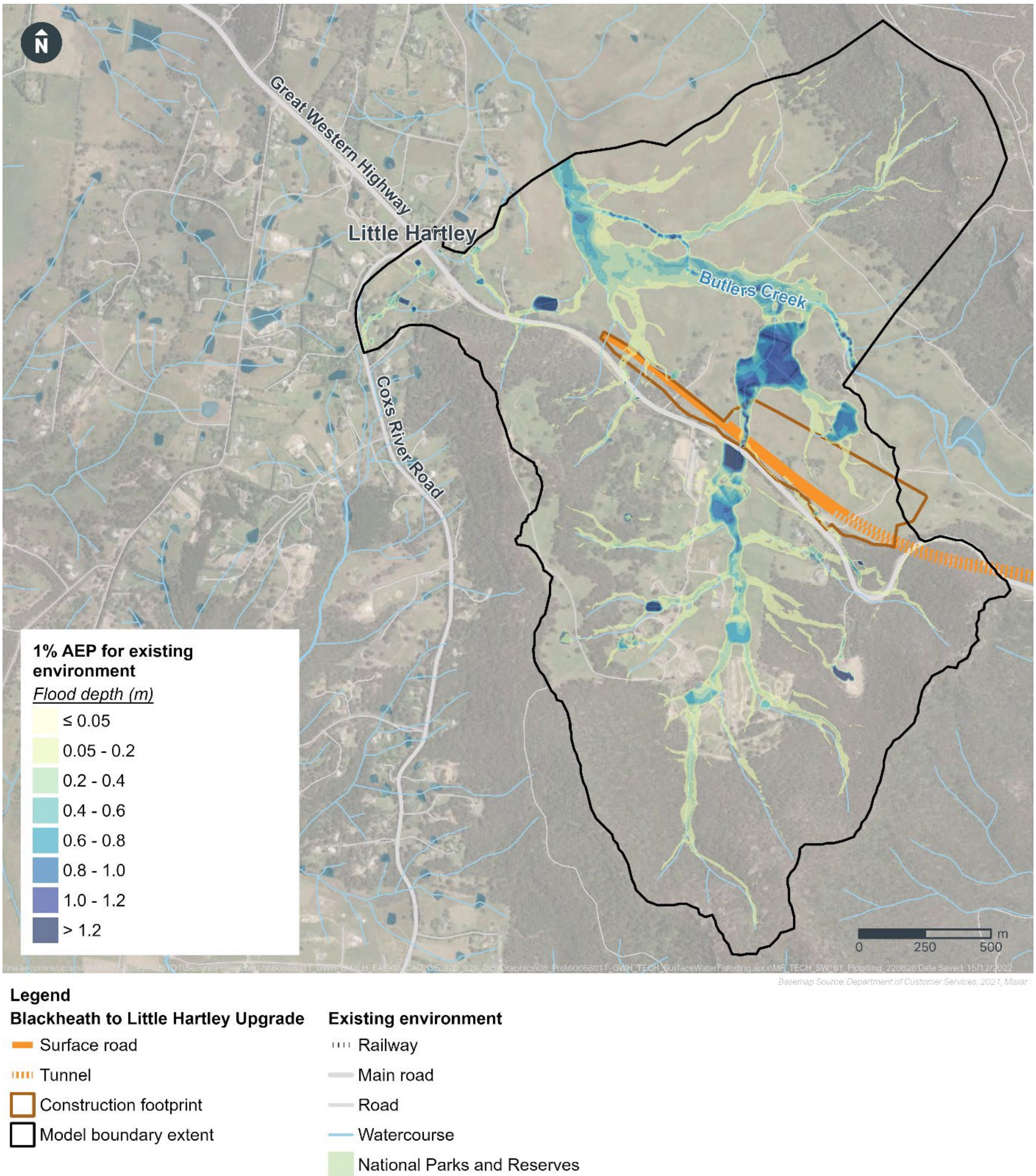



**Figure A-4 Modelled flood depth for the 1% AEP with the project at Little Hartley – Existing**

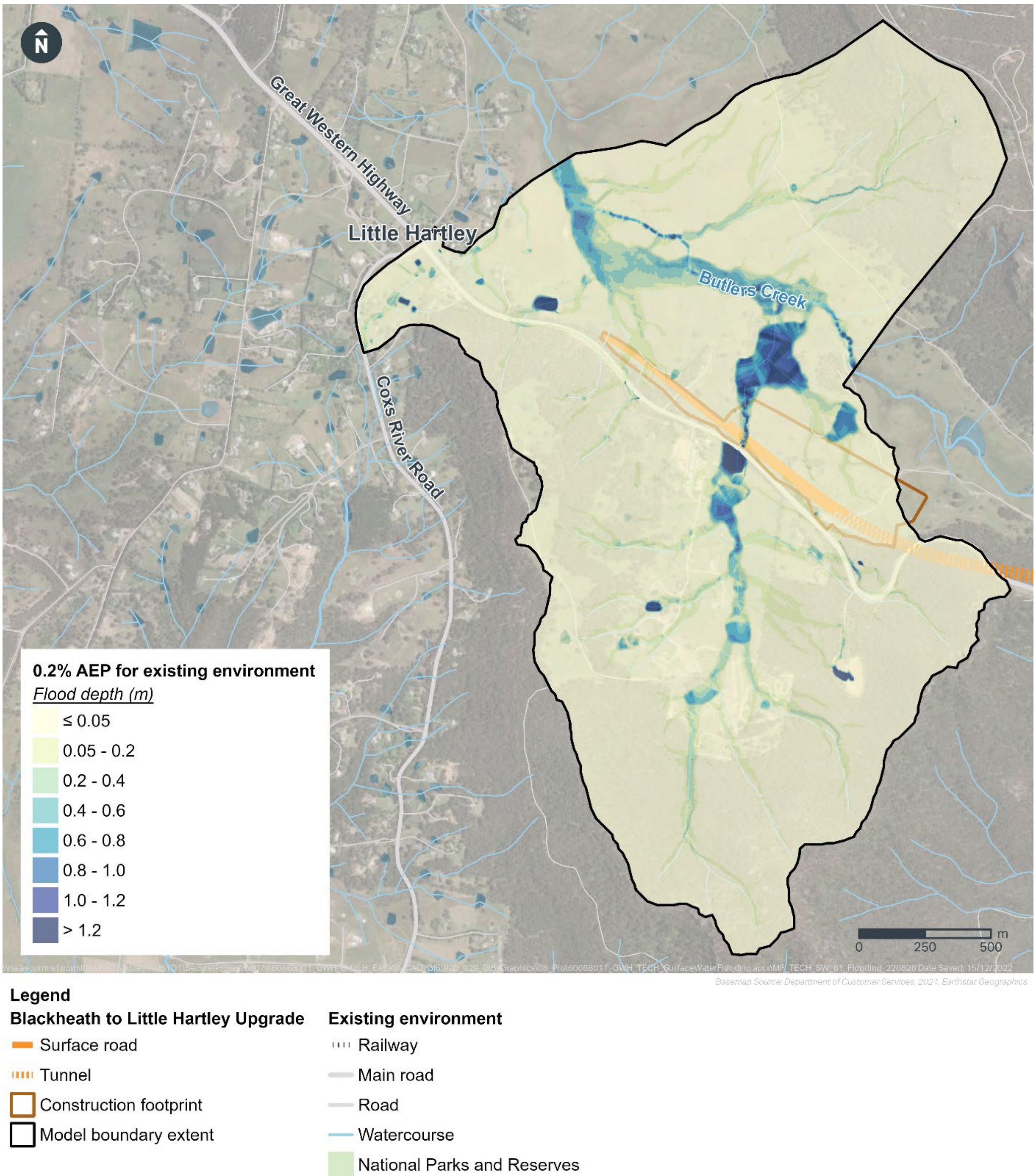



**Figure A-5 Modelled flood depth for the 0.2% AEP with the project at Little Hartley – Existing**

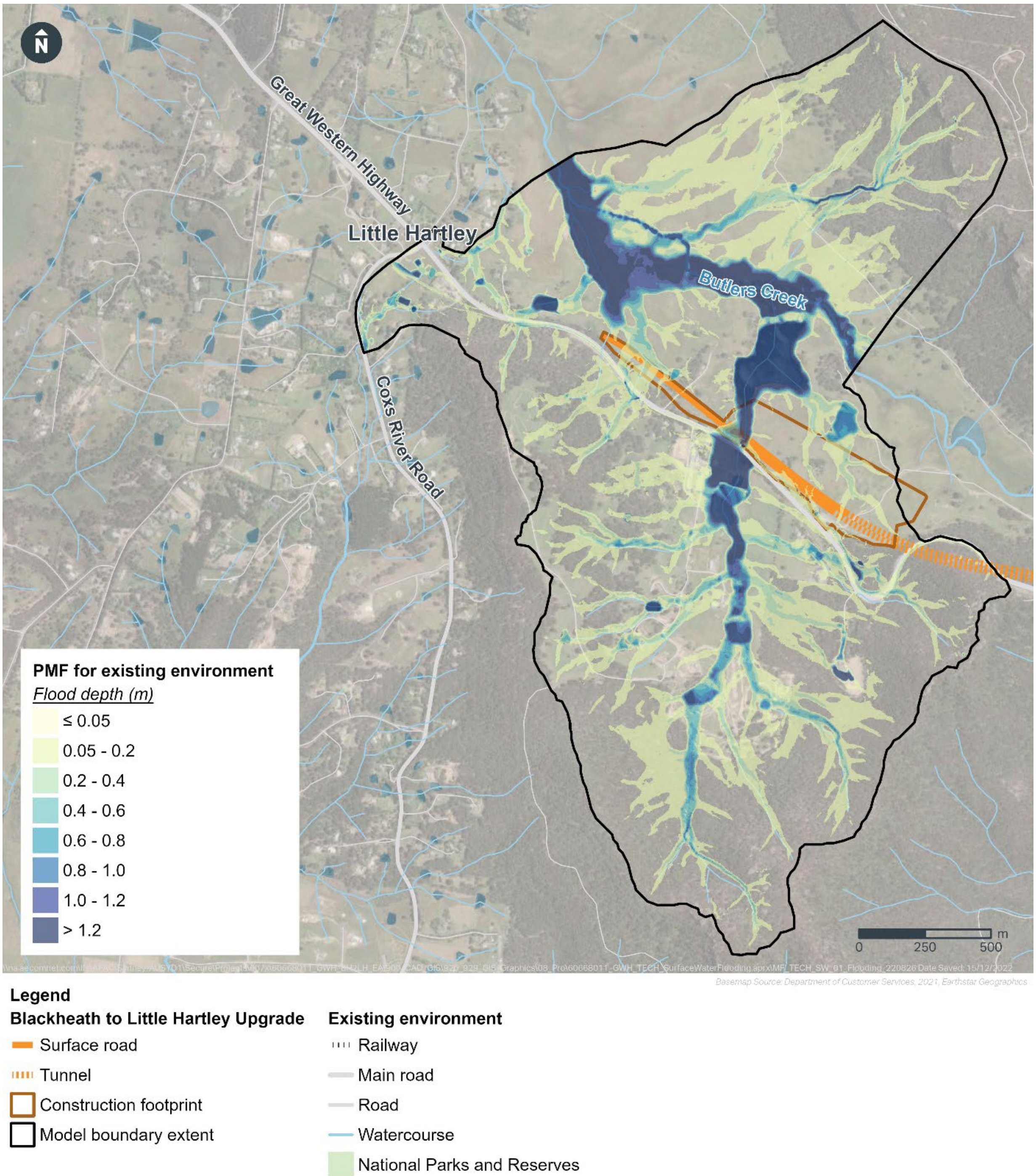



**Figure A-6 Modelled flood depth for the PMF with the project at Little Hartley – Existing**

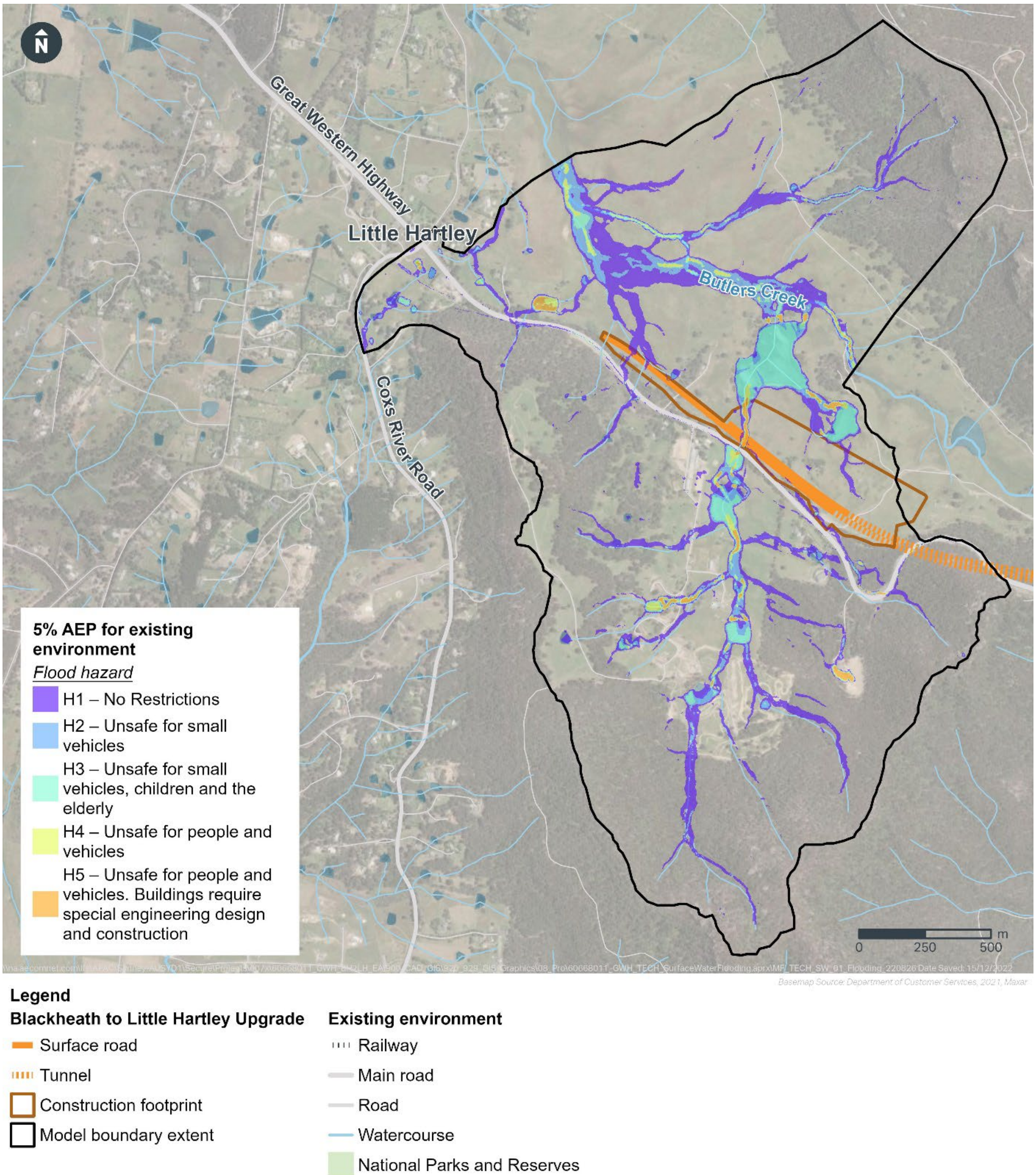



**Figure A-7 Modelled flood hazard for the 5% AEP with the project at Little Hartley – Existing**

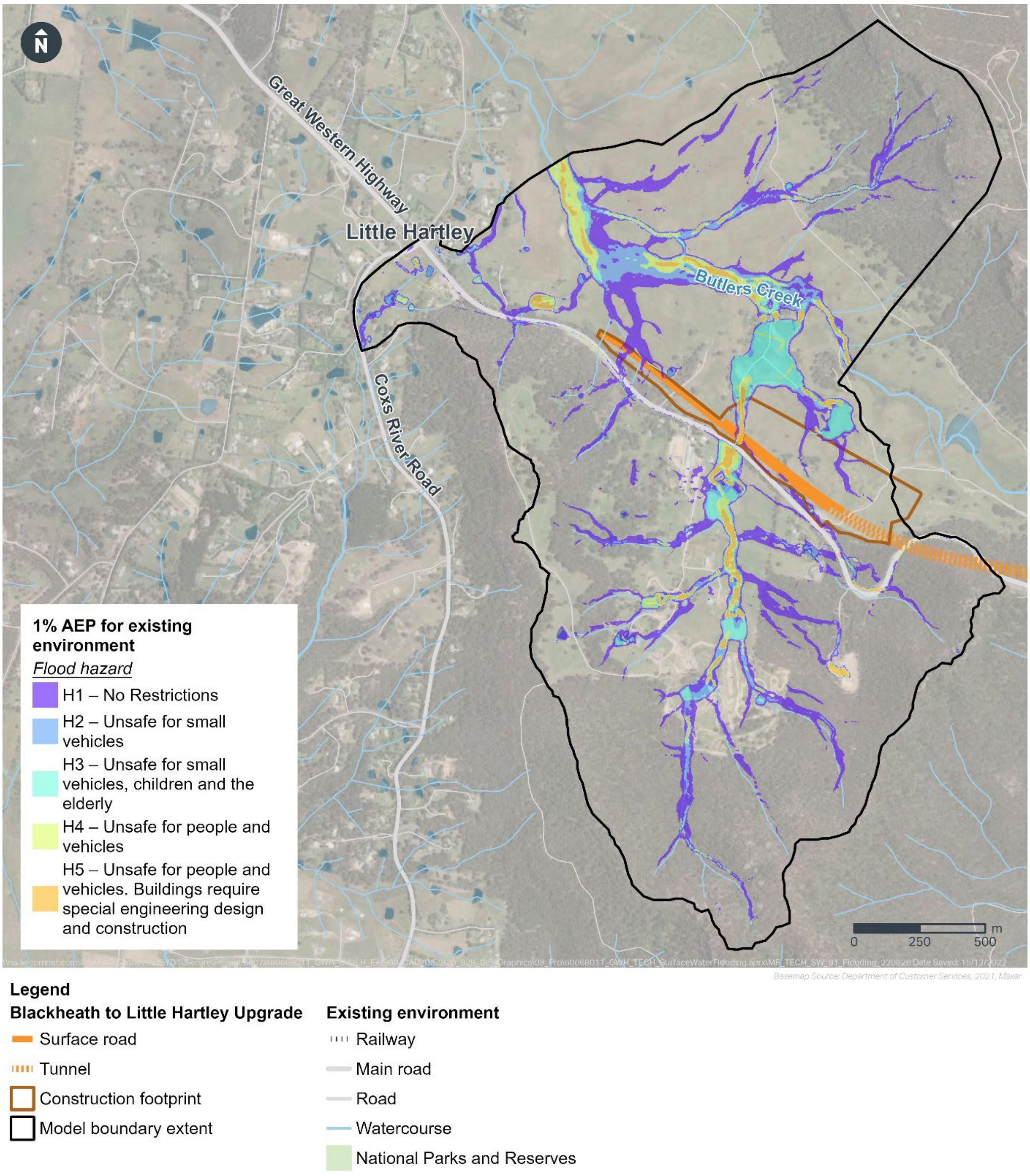



**Figure A-8 Modelled flood hazard for the 1% AEP with the project at Little Hartley – Existing**

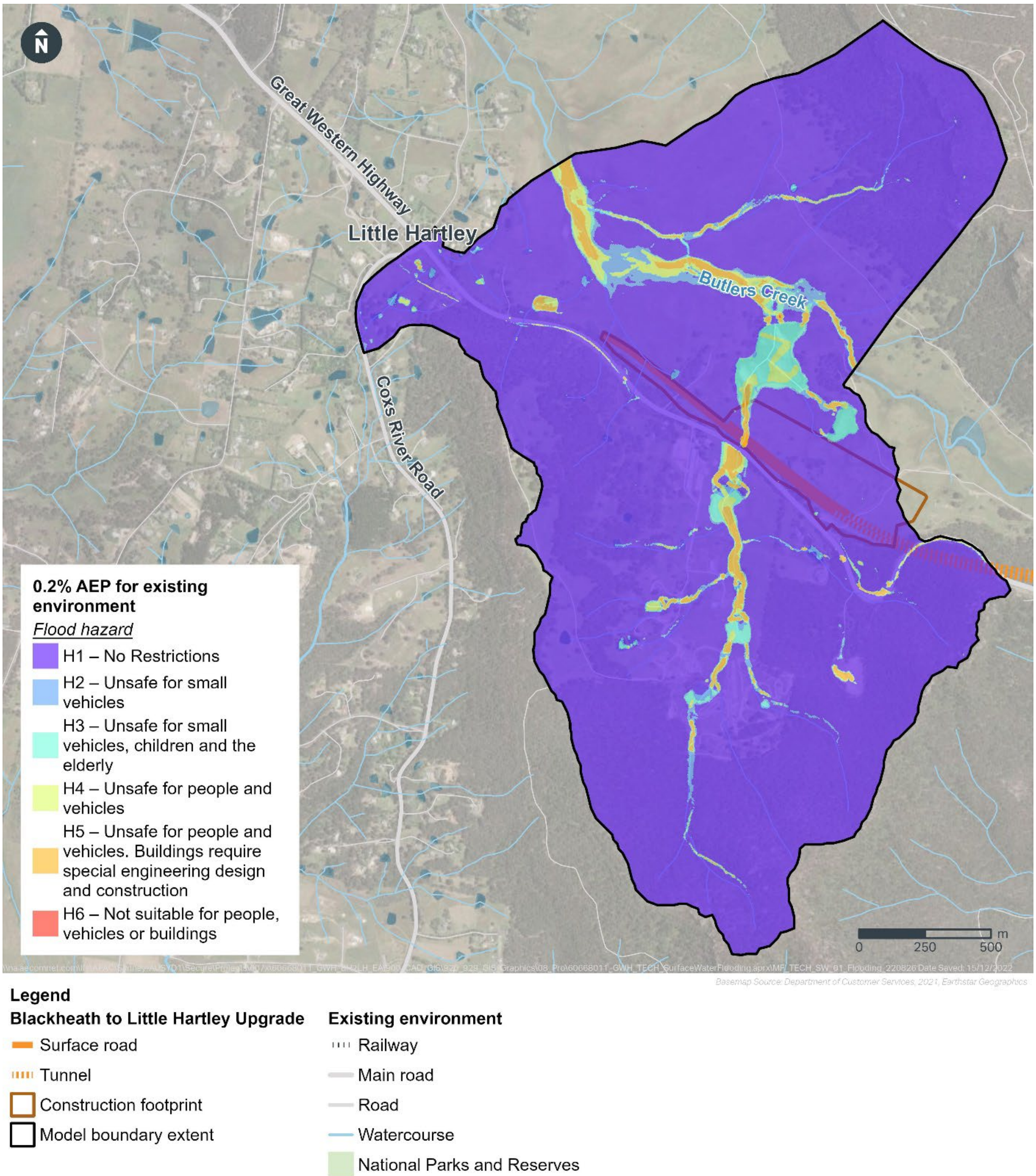



**Figure A-9 Modelled flood hazard for the 0.2% AEP with the project at Little Hartley – Existing**

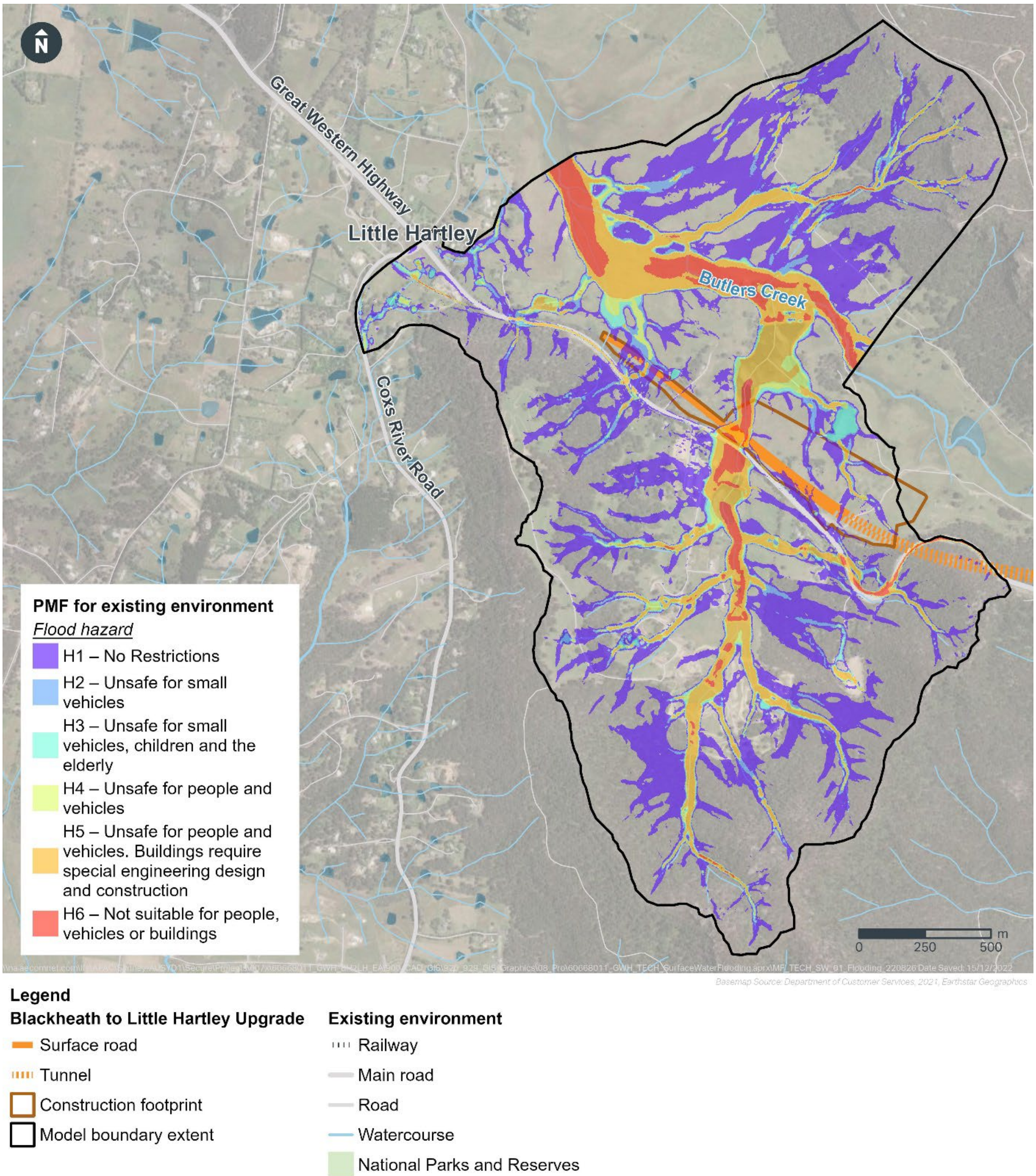



**Figure A-10 Modelled flood hazard for the PMF with the project at Little Hartley – Existing**

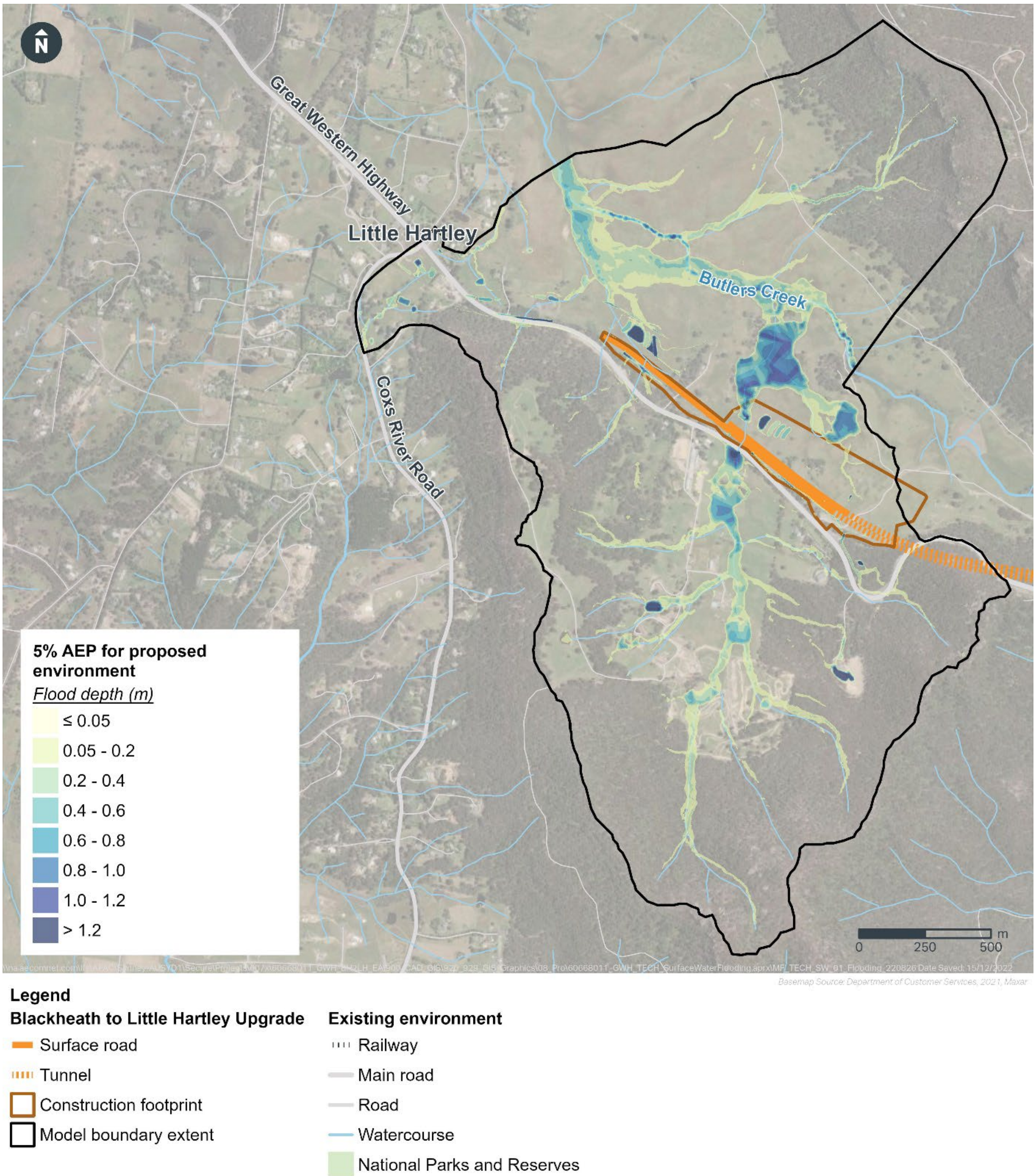



**Figure A-11 Modelled flood depth for the 5% AEP with the project at Little Hartley – Proposed**

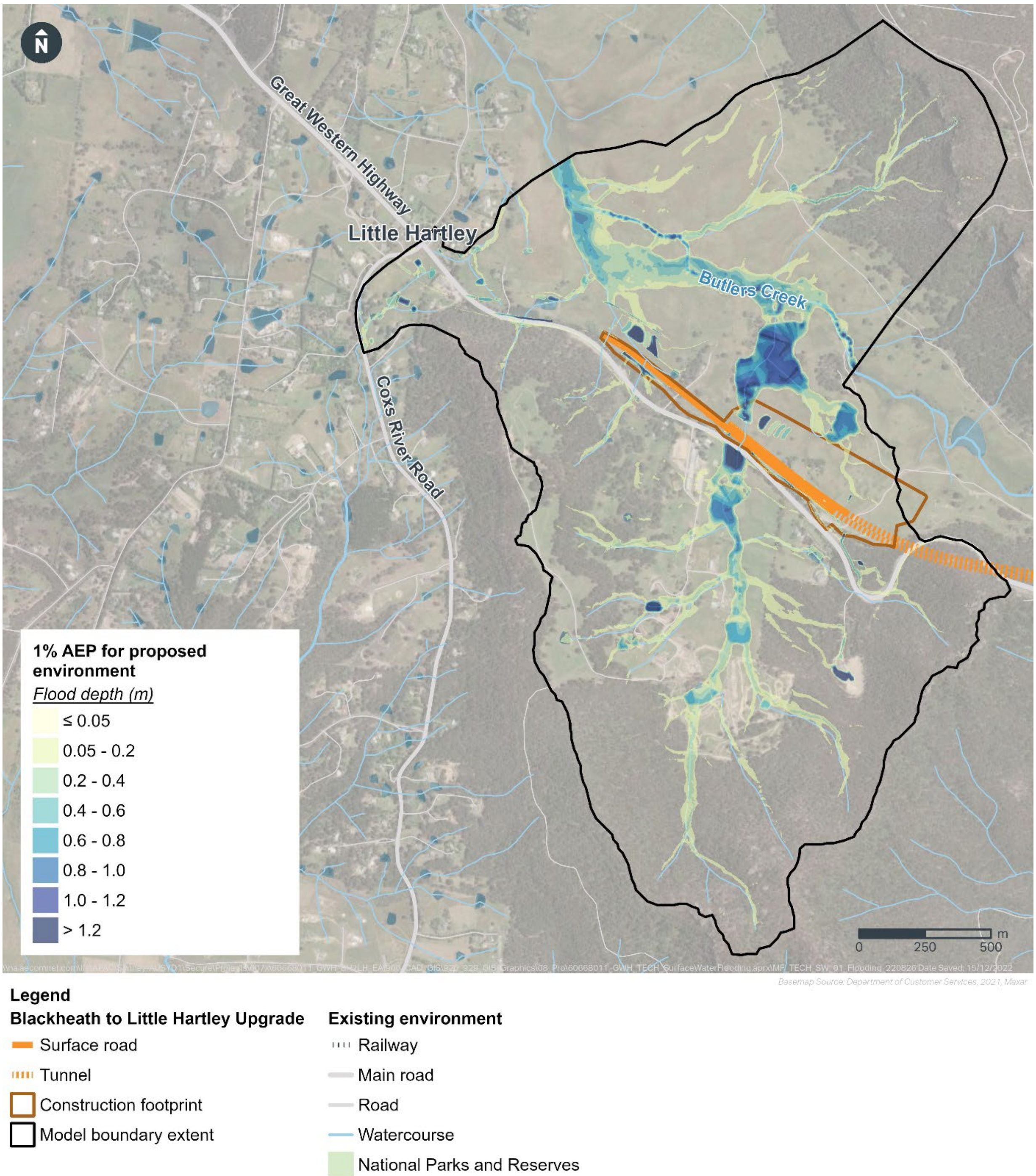



**Figure A-12 Modelled flood depth for the 1% AEP with the project at Little Hartley – Proposed**

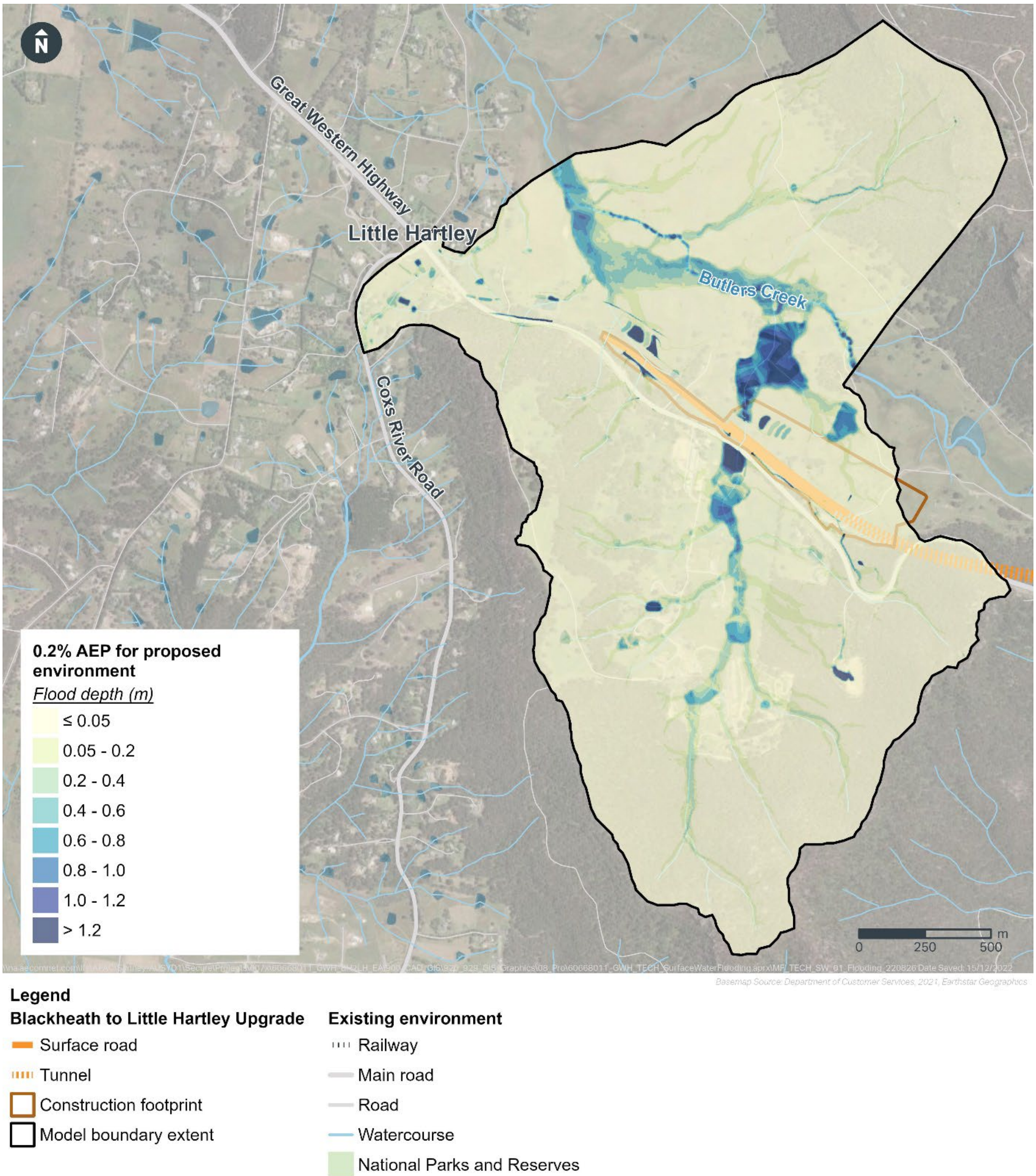
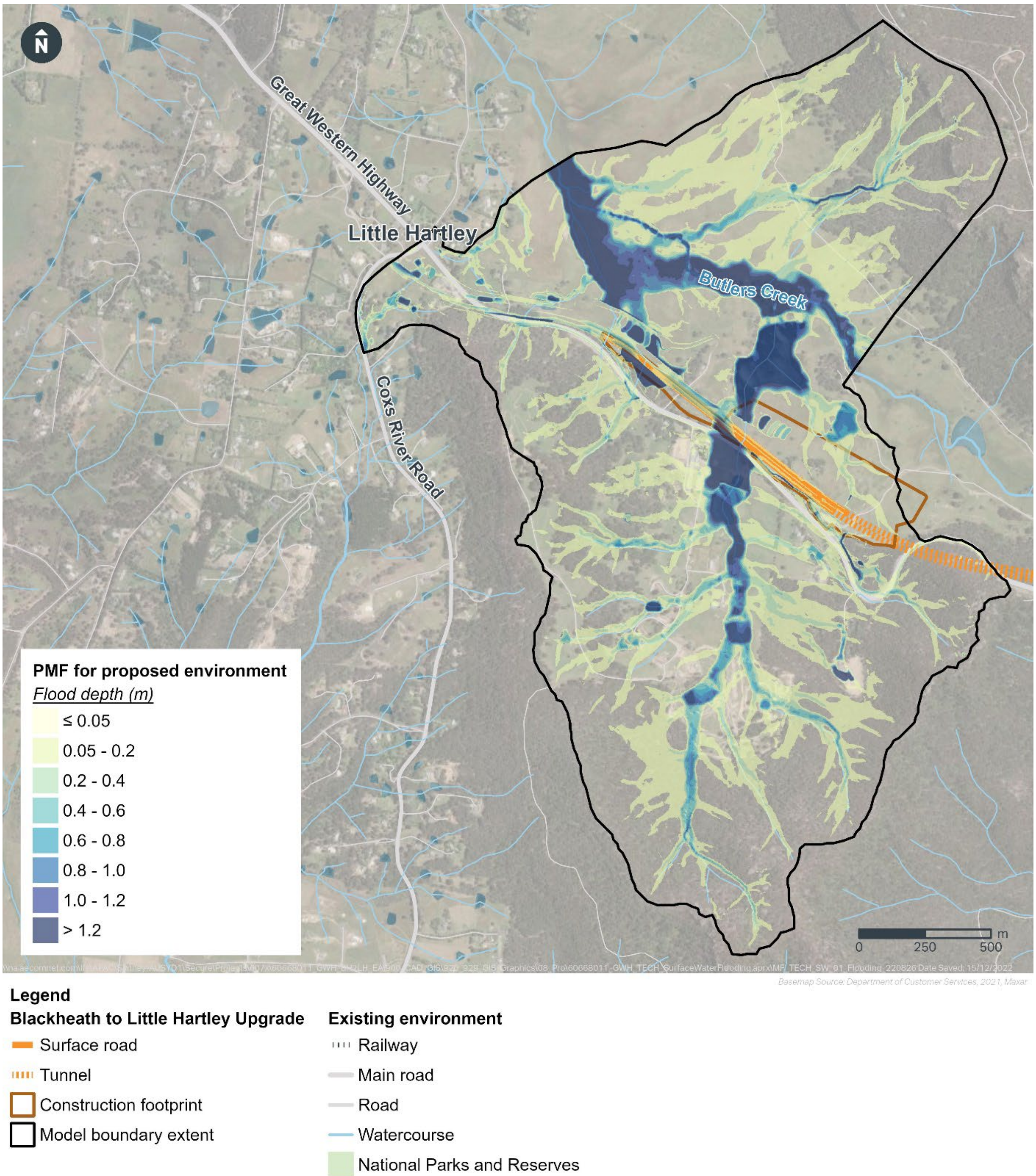



**Figure A-13 Modelled flood depth for the 0.2% AEP with the project at Little Hartley – Proposed**

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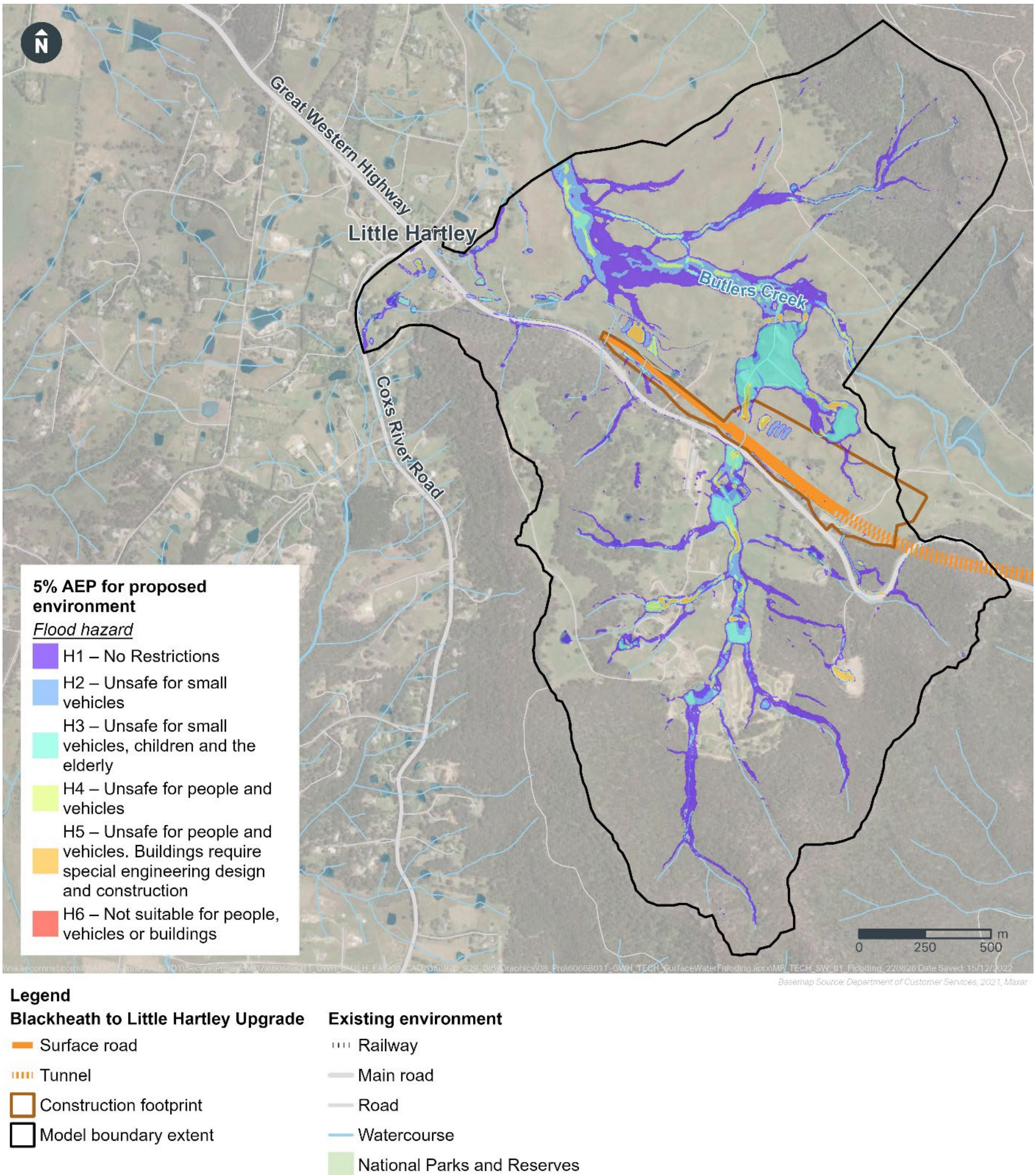
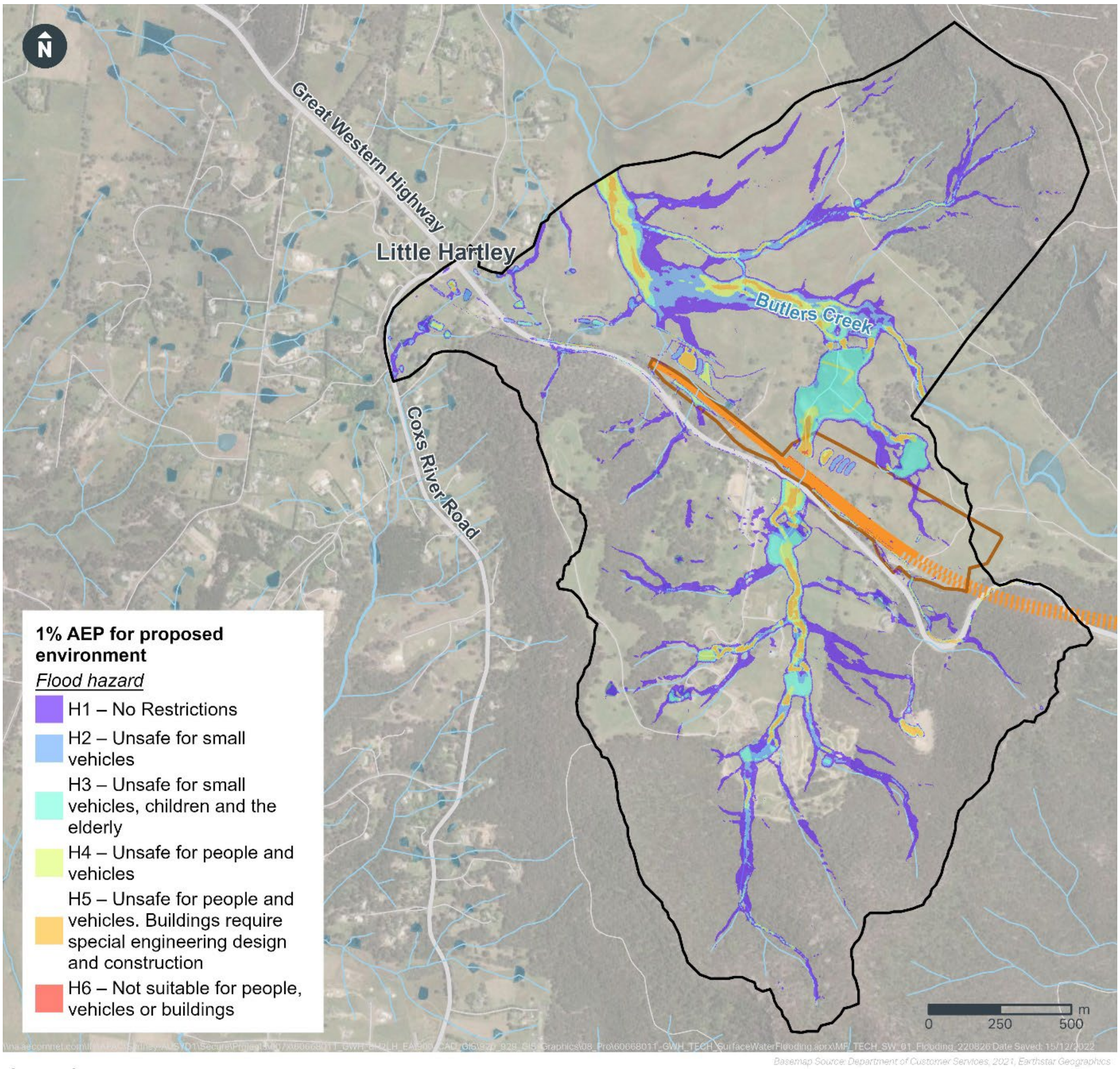



**Figure A-15 Modelled flood hazard for the 5% AEP with the project at Little Hartley – Proposed**




**Legend**

**Blackheath to Little Hartley Upgrade**
- Surface road
- Tunnel
- Construction footprint
- Model boundary extent

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

**Figure A-16 Modelled flood hazard for the 1% AEP with the project at Little Hartley – Proposed**

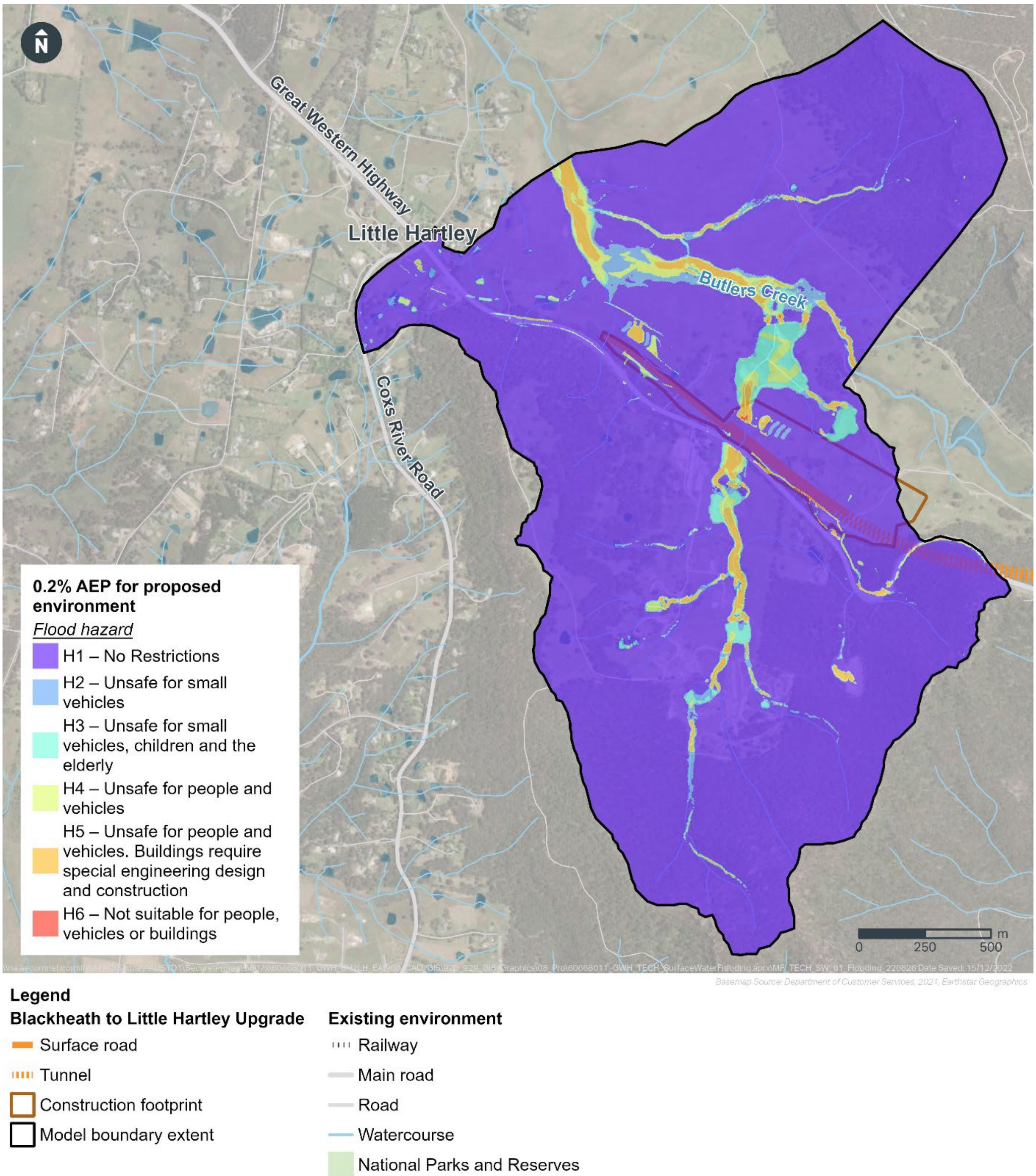
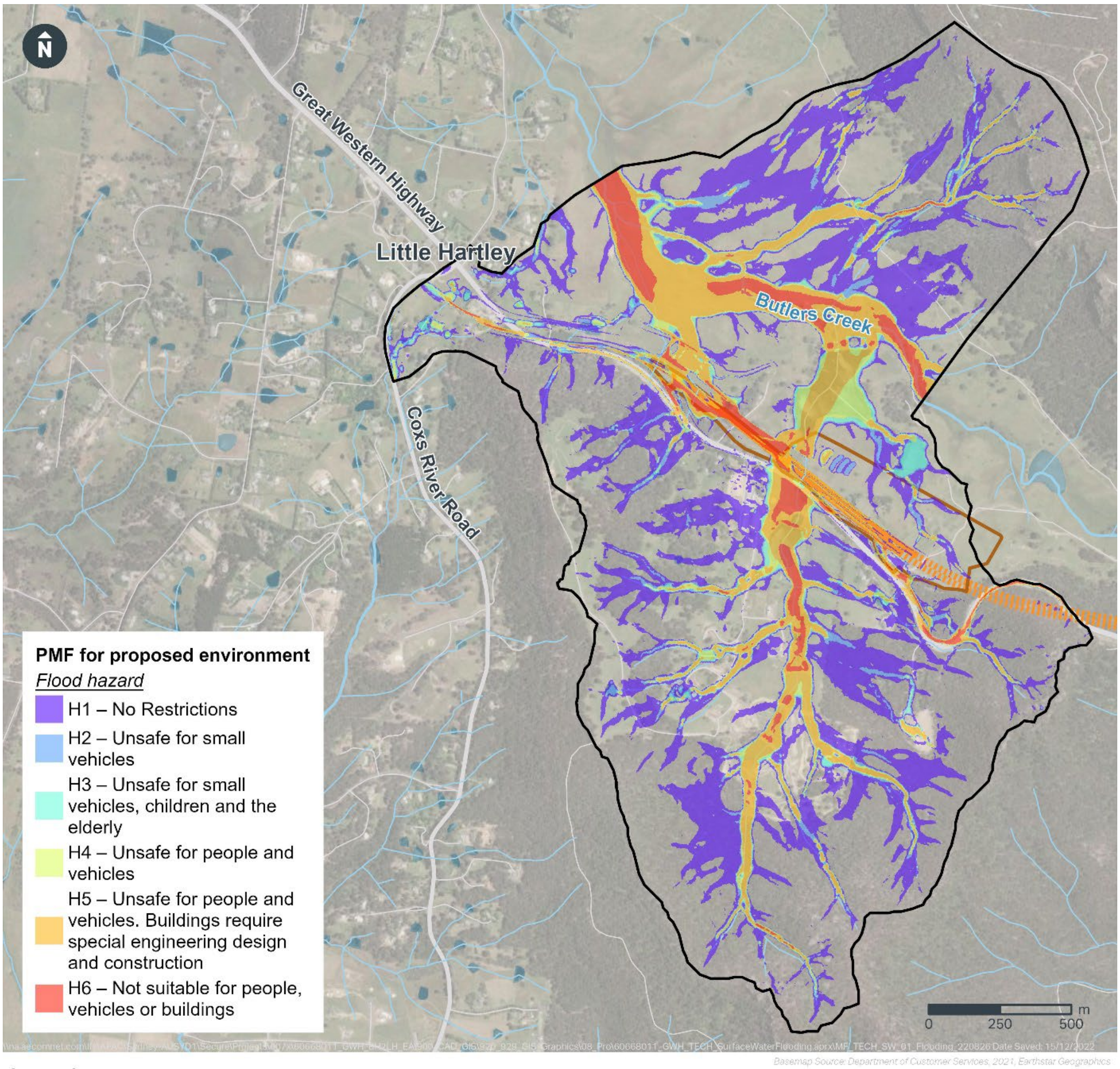



**Figure A-17 Modelled flood hazard for the 0.2% AEP with the project at Little Hartley – Proposed**




**Legend**

**Blackheath to Little Hartley Upgrade**
- Surface road
- Tunnel
- Construction footprint
- Model boundary extent

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

**Figure A-18 Modelled flood hazard for the PMF with the project at Little Hartley – Proposed**

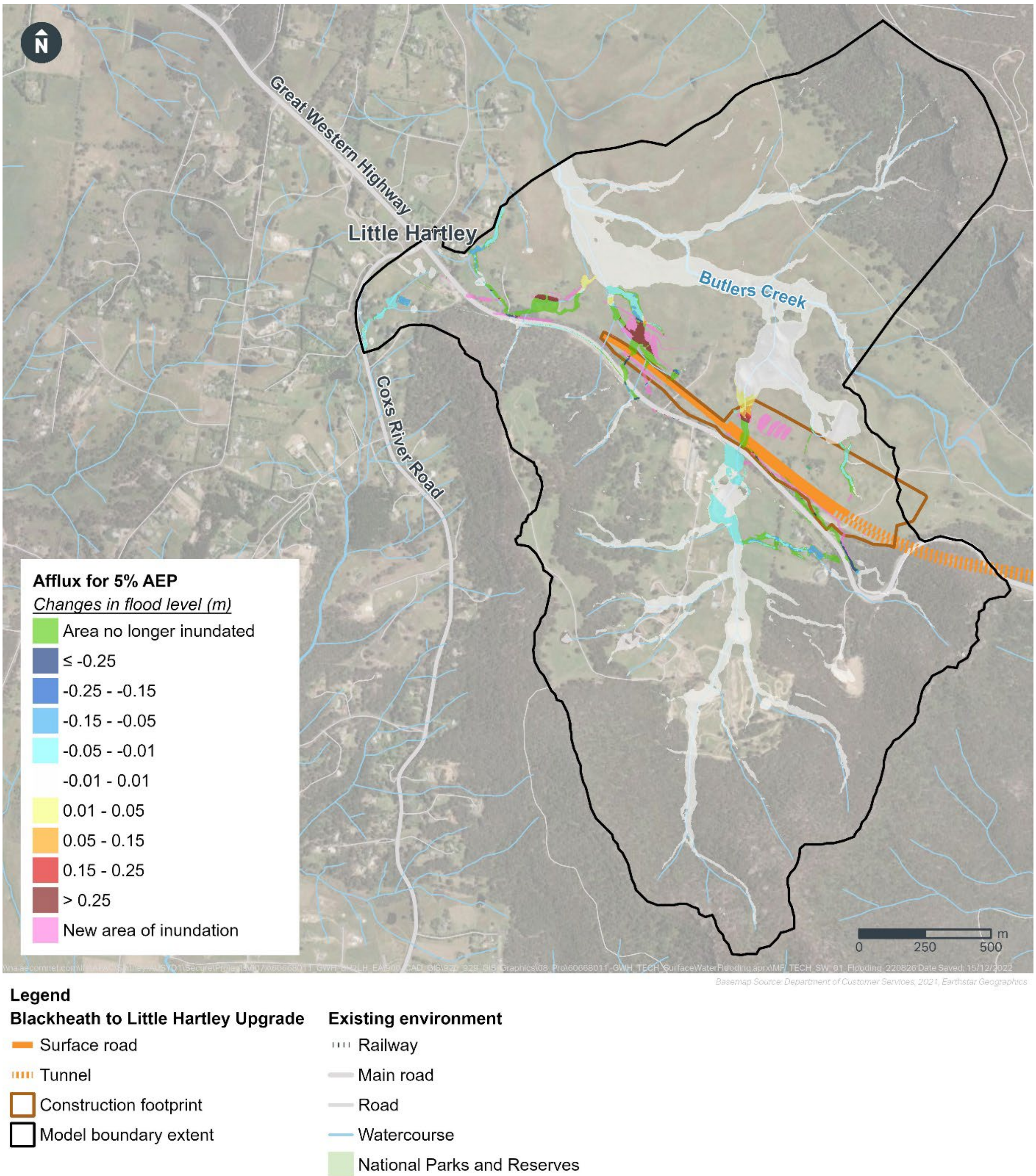



**Figure A-19 Modelled flood changes in flood level for the 5% AEP with the project at Little Hartley**

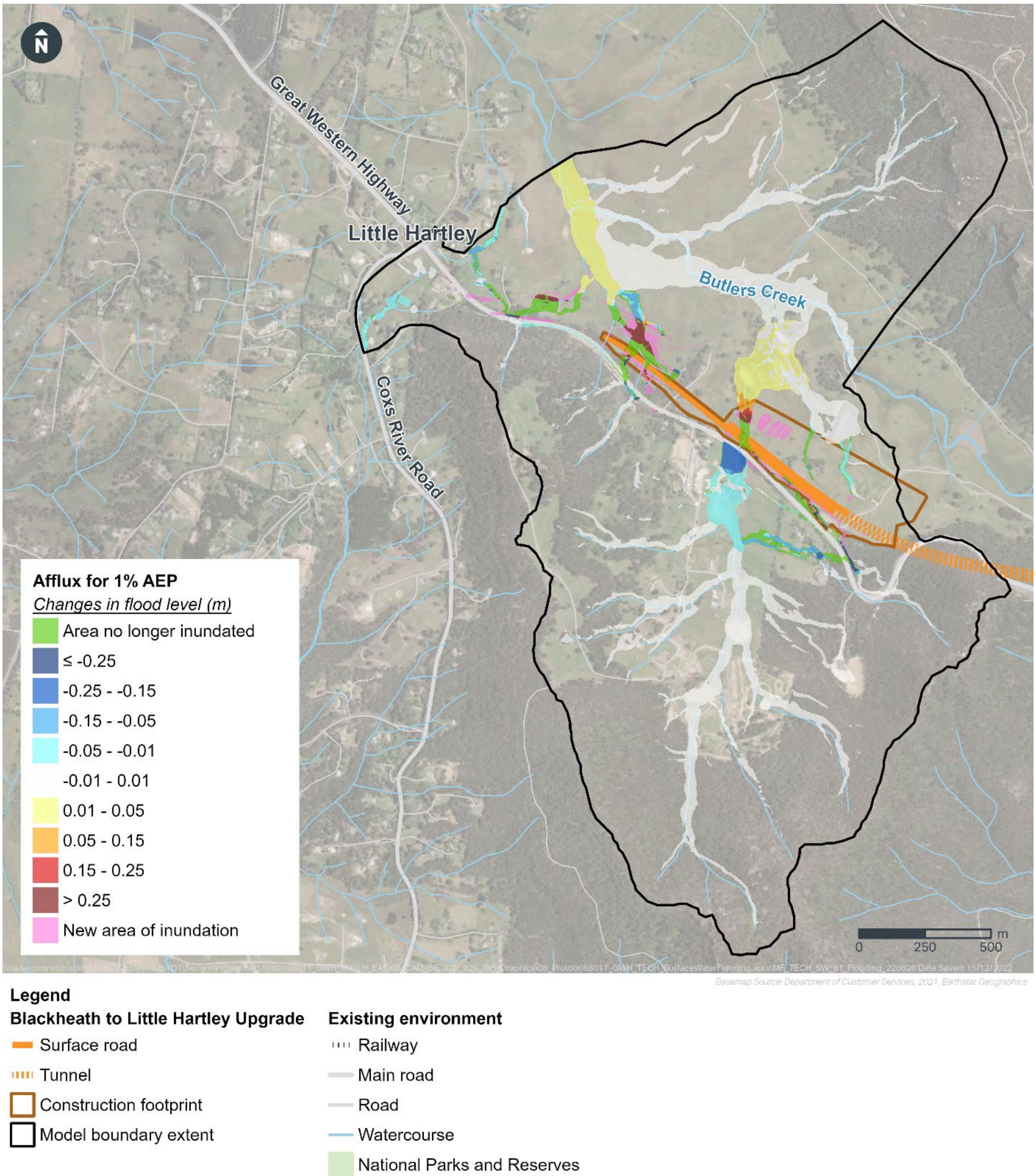



**Figure A-20 Modelled flood changes in flood level for the 1% AEP with the project at Little Hartley**

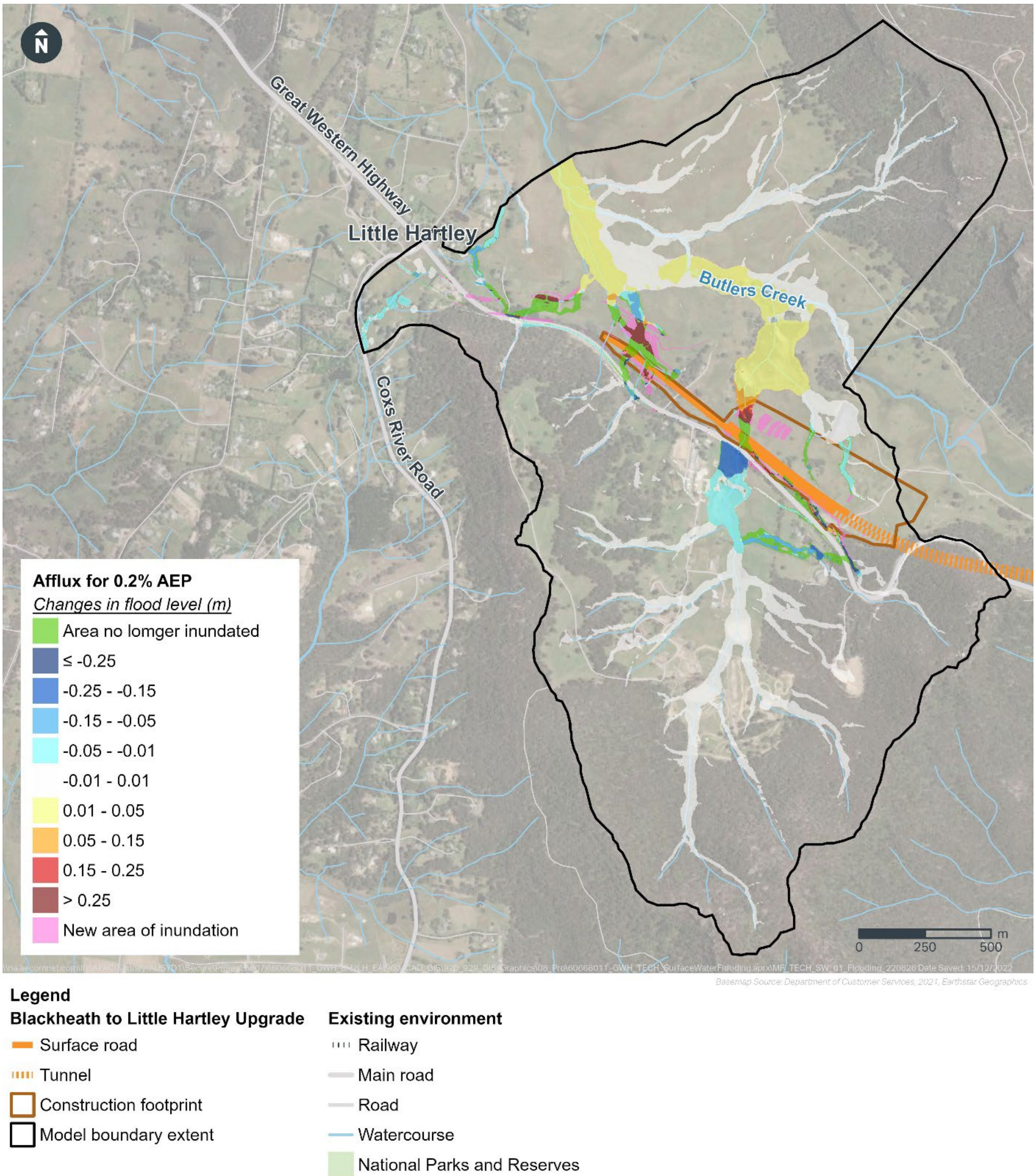



**Figure A-21 Modelled flood changes in flood level for the 0.2% AEP with the project at Little Hartley**

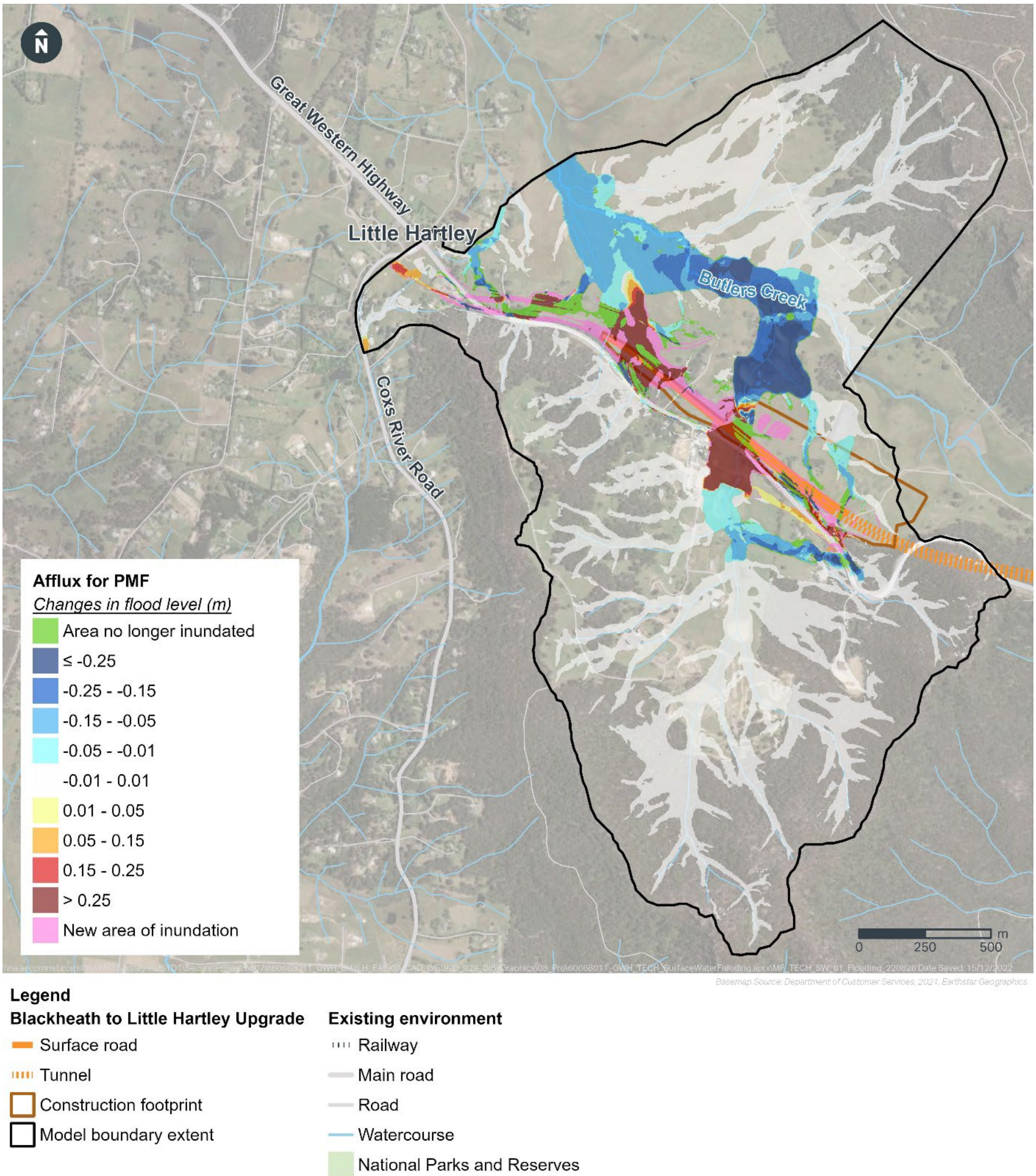



**Figure A-22 Modelled flood changes in flood level for the PMF with the project at Little Hartley**

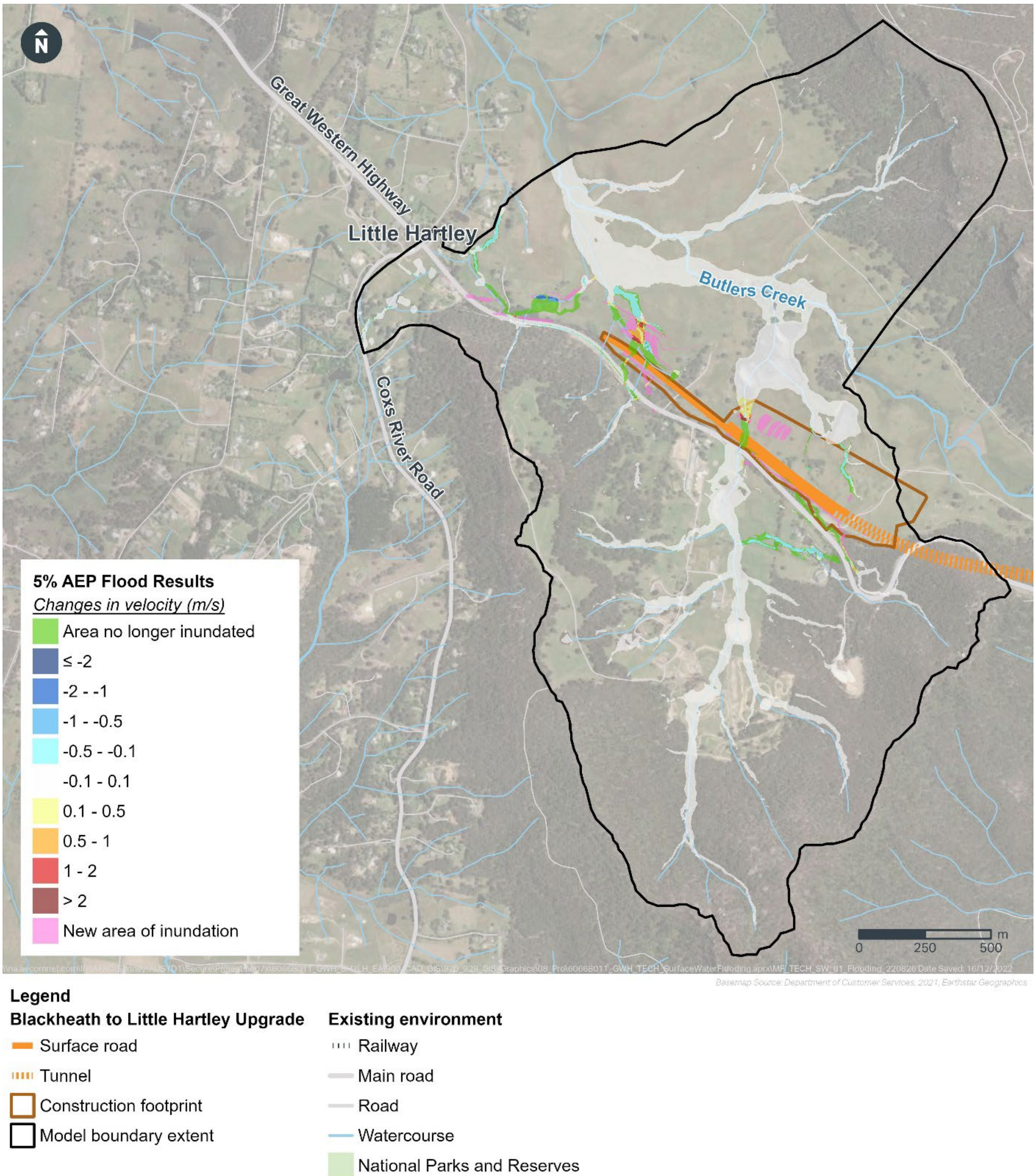



**Figure A-23 Modelled change in velocity for 5% AEP in Little Hartley - Proposed vs Existing**

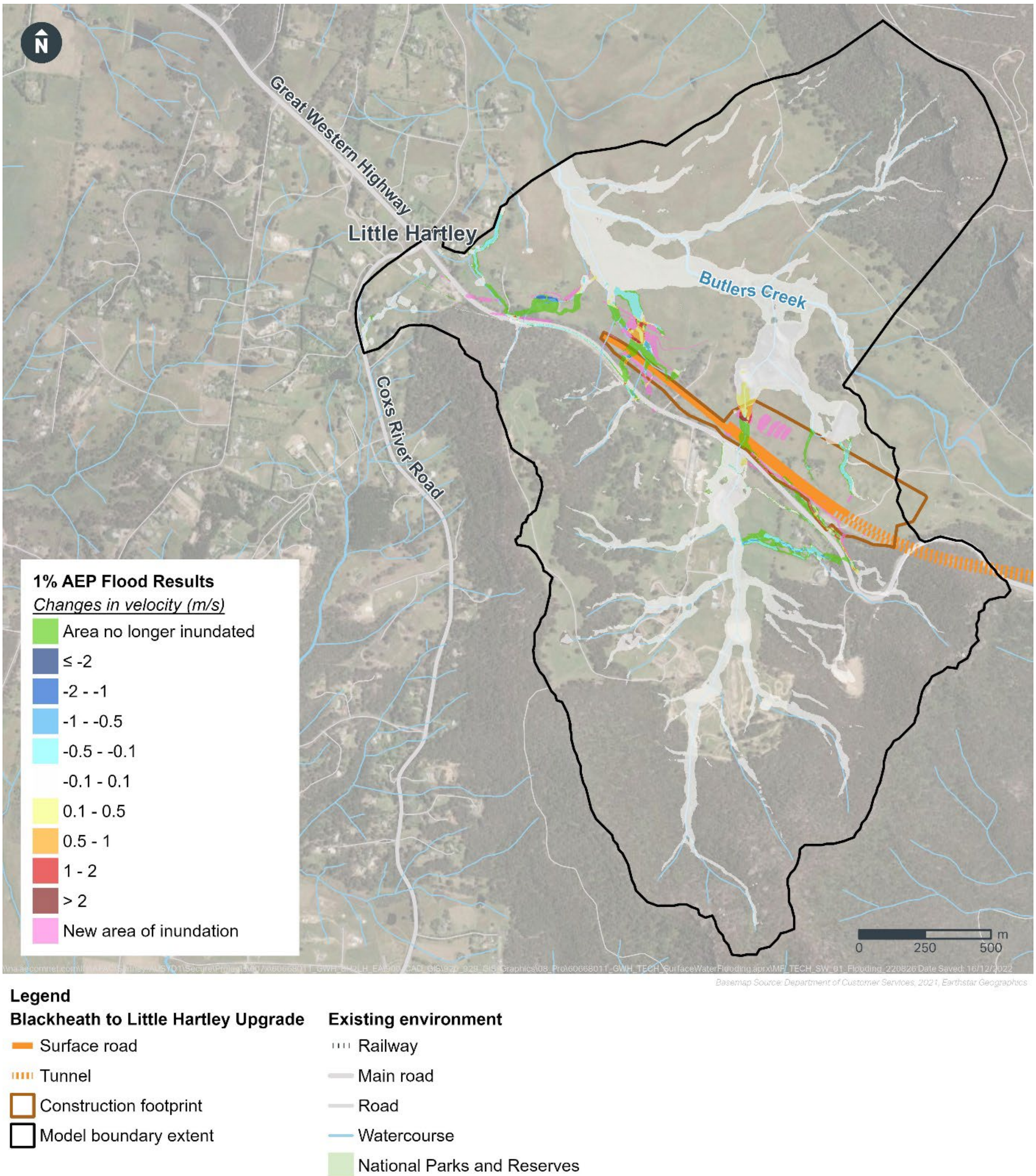



**Figure A-24 Modelled change in velocity for 1% AEP in Little Hartley - Proposed vs Existing**

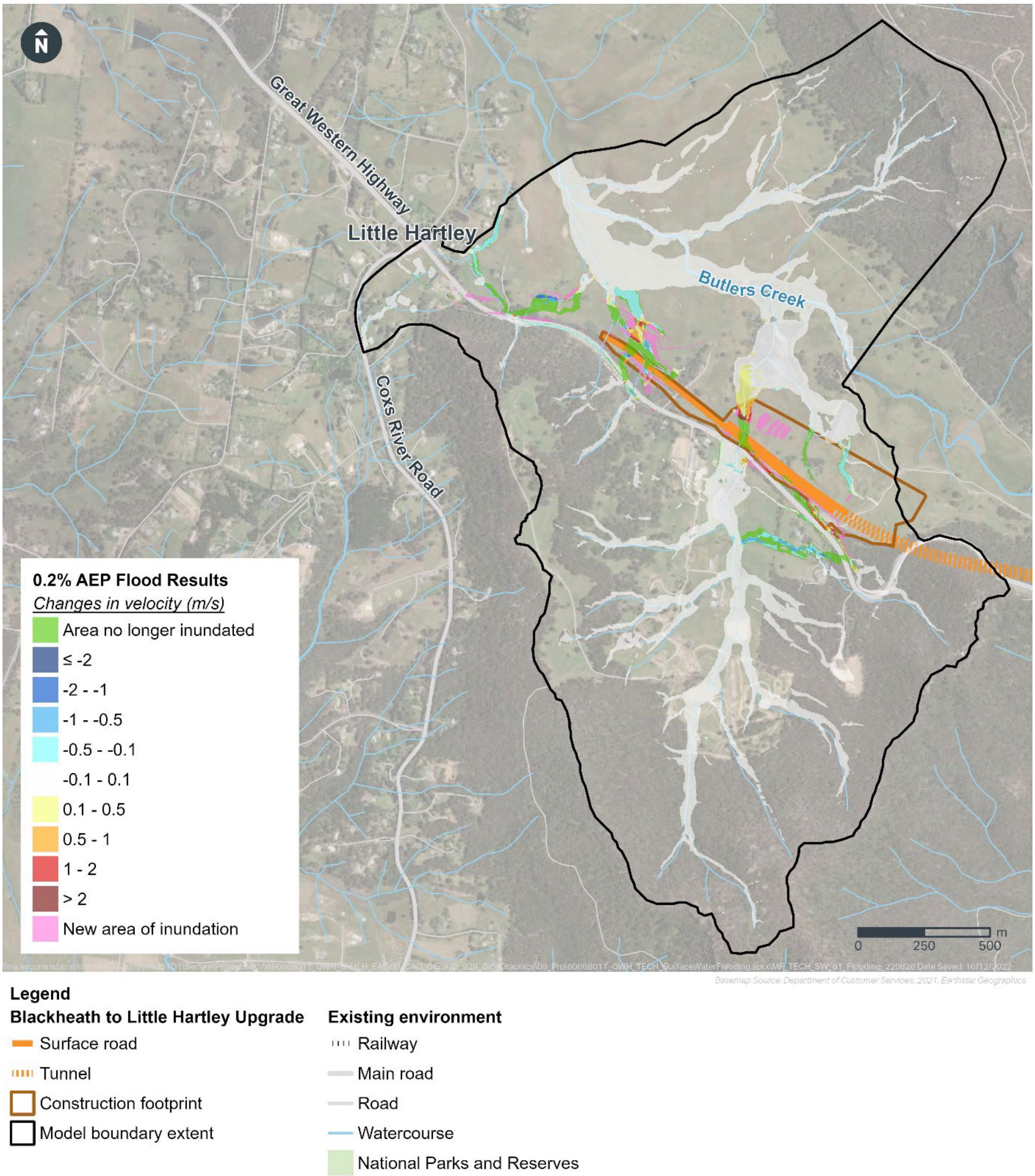



**Figure A-25 Modelled change in velocity for 0.2% AEP in Little Hartley - Proposed vs Existing**

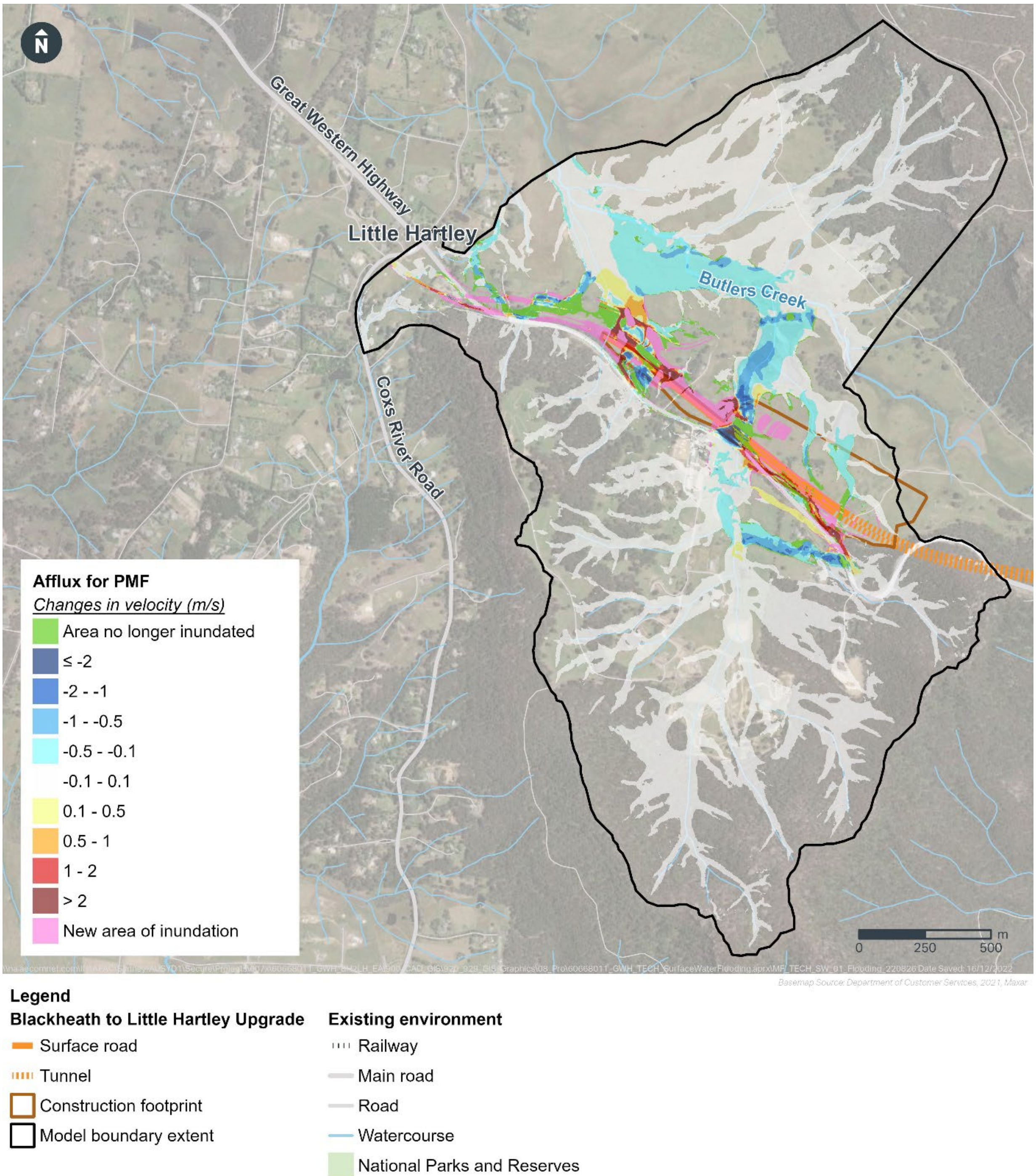



**Figure A-26 Modelled change in velocity for PMF in Little Hartley - Proposed vs Existing**