



Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Executive summary

Executive Summary

Beaches Link and Gore Hill Freeway Connection

Strategic context

The population of Sydney is forecast to grow from five million to eight million people over the next 40 years. To accommodate this growth, The Greater Sydney Commission's *Greater Sydney Region Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018a) proposes a vision of three cities where most residents have convenient and easy access to jobs, education and health facilities and services.

The Beaches Link and Gore Hill Freeway Connection project is located within the North District (and the Eastern Economic Corridor) and the Northern Beaches of the Eastern Harbour City region as shown in Figure E-1. The North District supports 11 per cent of the population and 20 per cent of the jobs in Greater Sydney.

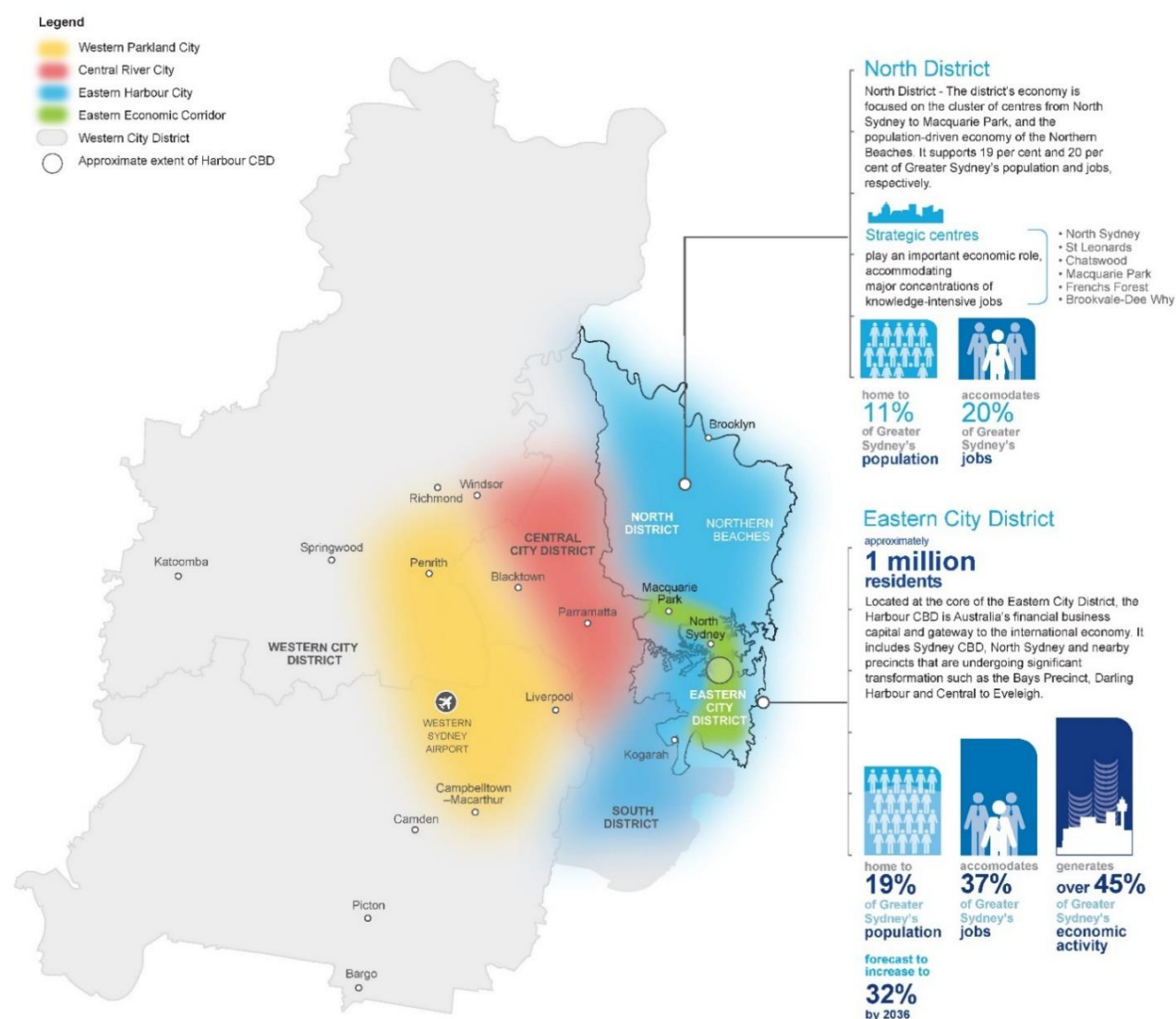


Figure E-1 Greater Sydney's Eastern City and North districts

Supporting the current needs and future growth of the North District, Eastern Harbour City and Eastern Economic Corridor through an efficient transport network is fundamental to maintaining the liveability, productivity and sustainability of Greater Sydney. Accordingly, the *Greater Sydney Region Plan* was prepared concurrently with the *Future Transport Strategy 2056* (NSW Government, 2018) and the *State Infrastructure Strategy 2018–2038* (Infrastructure NSW, 2018) to align land use, transport and infrastructure outcomes for Greater Sydney.

Project need

The Eastern Harbour City has the largest concentration of jobs in Greater Sydney, accommodates the most productive industries and is home to a highly skilled workforce. Accordingly, the eastern motorway crossings of Sydney Harbour are critical links in Sydney's motorway and arterial road network. These major transport corridors around the Harbour CBD are critical to the performance of the arterial network servicing the Northern Beaches, particularly for north-south trips and are some of the busiest in Greater Sydney and indeed in Australia. Key metrics for the Eastern Harbour City's road transport network are shown in Figure E-2.

Sydney Harbour Bridge one of the busiest roads in NSW



over
165,000 vehicles per day
79,000 bus passengers per day

Warringah Freeway one of the busiest and most complex road corridors in Australia



The Sydney Harbour Tunnel



8th busiest road in the state carrying **94,000 vehicles per day**

Spit Bridge

**10th busiest road corridor
in NSW**



over
69,500 vehicles per day
34,000 bus passengers per day
*AM Peak

Roseville Bridge

**3rd most congested road corridor
in Sydney**



over
79,000 vehicles per day
9,500 bus passengers per day
*AM Peak

Figure E-2 Key metrics for the Eastern Harbour City's transport network

The high demand and limited capacity on the Sydney Harbour crossings result in delays and unreliable journey times for a significant number of customers who directly rely on these corridors. Furthermore, the limited number of alternate routes for crossing Sydney Harbour makes these corridors critical to the performance of the broader motorway and arterial road network. Network data demonstrates that incidents on the harbour crossings and their approaches can significantly impact journey times for freight, buses and private vehicles travelling north and south on the

arterial network servicing the Northern Beaches region, with Spit Road and Military Road particularly affected. The high road demand and limited number of corridors connecting the Northern Beaches means that incidents on these corridors have significant impacts on journey times to and from the region.

As the Northern Beaches is connected to the rest of Greater Sydney by a small number of transport corridors, this contributes to high levels of congestion, long and unreliable journey times and, consequently, poor accessibility to and from the region. Just three road corridors connect the Northern Beaches with the rest of Greater Sydney: Mona Vale Road, Warringah Road and Military Road/Spit Road. All three currently experience high levels of traffic congestion. The region is particularly reliant on the most southerly corridors: Warringah Road via Roseville Bridge and Spit Road/Military Road via Spit Bridge corridors. Currently, these links carry 71 per cent of all inter-regional road journeys to and from the Northern Beaches.

Further to the large traffic volumes and limited alternative routes, a major contributor to congestion around the Harbour CBD is that many of the most critical road corridors – including Military Road, Warringah Road, the Sydney Harbour Bridge, the Sydney Harbour Tunnel, ANZAC Bridge, Western Distributor and the Warringah Freeway – perform both bypass and access functions. The dual function of these corridors is reflected in the high proportion of vehicles that use them to travel to destinations other than Sydney CBD. These conflicting functions, combined with high traffic volumes, result in congestion and poor network performance experienced by freight, public transport and private vehicle users.

Residents on the Northern Beaches rely heavily on private vehicles and public buses for travel (Northern Beaches Council, 2018). Public transport travel times to the Northern Beaches can be long and unreliable, with bus travel times between Mona Vale and the Sydney CBD in excess of 60 minutes during peak periods despite recent improvement due to the B-Line program. By reducing network congestion, the project would result in improved network resilience and reliability, particularly in peak periods, and would make bus routes to and from the Northern Beaches a more attractive transport option, supporting and encouraging a mode shift to public transport. The project would also create the opportunity for new express bus routes to be developed in response to diverse travel demands and future development.

The project is also identified as a priority initiative under Infrastructure Australia's *Australian Infrastructure Plan: The Infrastructure Priority List* (Infrastructure Australia, 2018) for its importance in addressing urban congestion on Sydney's road network, providing cross-harbour connectivity and Northern Beaches connectivity.

Further detail on these transport challenges and their influence on the proposed design for the Beaches Link and Gore Hill Freeway Connection project is provided in Chapter 3.

Project objectives

To ensure the design of the project meets the identified transport needs, the objectives summarised in Figure E-3 have been developed for the Beaches Link and Gore Hill Freeway project.

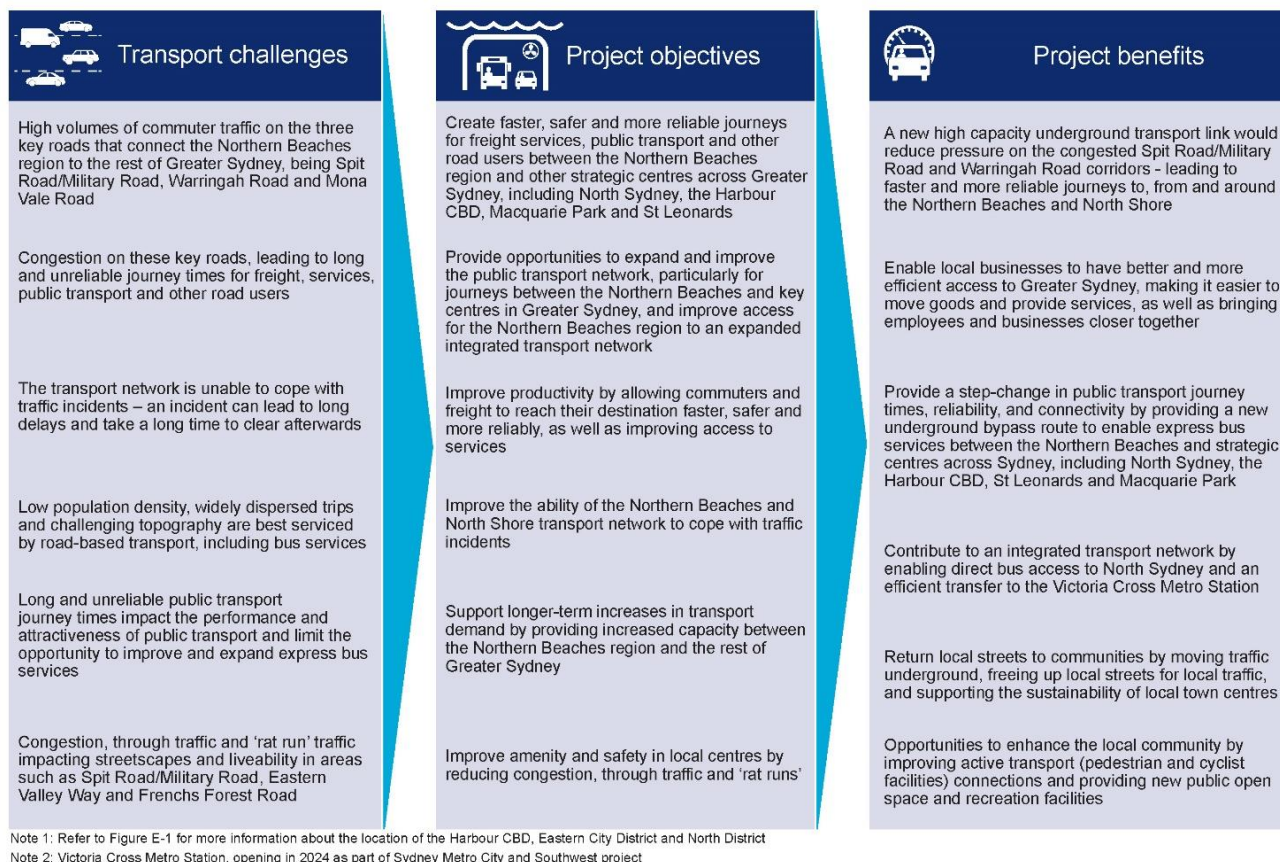


Figure E-3 Project challenges, objectives and benefits

Overview of the Western Harbour Tunnel and Beaches Link program of works

The Western Harbour Tunnel and Beaches Link program of works is a major transport infrastructure program that would make it easier, faster and safer to get around Sydney. As Sydney continues to grow, faster and more reliable trips are essential to reducing congestion and providing new levels of access to jobs, recreation, and services such as schools and hospitals. By creating a western bypass of the Sydney CBD, the Western Harbour Tunnel would take pressure off the Sydney Harbour Bridge, Sydney Harbour Tunnel and ANZAC Bridge; while Beaches Link would create an alternative to the Military Road/Spit Road and Warringah Road corridors to relieve traffic pressure on the North Shore.

The program of works has been designed as part of an integrated transport network, which has a focus on new public transport connections and improved journey times and reliability for buses. It would also provide improvements to walking and cycling routes, providing more active transport options.

The Western Harbour Tunnel and Beaches Link program of works include:

- The Western Harbour Tunnel and Warringah Freeway Upgrade project which comprises a new motorway tunnel connection across Sydney Harbour, and an upgrade of the Warringah Freeway to integrate the new motorway infrastructure with the existing road network and to enable the future connection of the Beaches Link and Gore Hill Freeway Connection project
- The Beaches Link and Gore Hill Freeway Connection project (the project) which comprises a new motorway tunnel connection across Middle Harbour from the Warringah Freeway and Gore Hill Freeway to the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Killarney Heights. The project also includes a surface upgrade of Wakehurst Parkway from Seaforth to Frenchs Forest and upgrade and integration works to connect to the Gore Hill Freeway and Reserve Road at Artarmon.

The components of the Western Harbour Tunnel and Beaches Link program of works are shown in Figure E-4.

The delivery of the Western Harbour Tunnel and Beaches Link program of works would unlock a range of benefits for freight, public transport and private vehicle users. It would support faster and more reliable travel times for journeys between the strategic centres along the Eastern Economic Corridor of Sydney – an area between Port Botany and north-west that accounts for over 40 per cent of the NSW gross State product. For example, with the combined program of works, journeys from Dee Why to Sydney Kingsford Smith Airport are expected to be 56 minutes faster. Delivering the program of works would also improve the resilience of the motorway network, given that each project provides additional capacity and an alternative to heavily congested existing harbour crossings and their approaches.

The program of works would also provide an opportunity to improve existing, and introduce new, bus services between key employment and education centres, directly and reliably linking the Northern Beaches to strategic centres including North Sydney, the Harbour CBD, St Leonards and Macquarie Park via the motorway network. This opportunity would better integrate employment, residential and education centres and provide improved road transport access to a wider range of services and facilities.

The Western Harbour Tunnel and Warringah Freeway Upgrade project and the Beaches Link and Gore Hill Freeway Connection project are subject to separate but coordinated environmental assessment and approval processes.



Legend

Operational features

- ▬▬▬ Beaches Link
- ▬▬▬ Gore Hill Freeway Connection
- ▬▬▬ Western Harbour Tunnel
- ▬▬▬ Warringah Freeway Upgrade
- ▬▬▬ M4-M5 Link tunnel fitout and commissioned as part of Western Harbour Tunnel

Connecting projects

- ▬▬▬▬▬ M4-M5 Link connections (indicative)
- ▬▬▬▬▬ Northern Beaches Hospital road upgrade project (Completed 2020)

Other projects

- ▬▬▬▬▬ Sydney Metro City & Southwest (under construction)
- ▬▬▬▬▬ Sydney Metro Northwest

Existing rail network

- ▬▬▬▬▬ Suburban rail/Sydney Trains
- ▬▬▬▬▬ Light rail

Figure E-4 Western Harbour Tunnel and Beaches Link program of works

The Beaches Link and Gore Hill Freeway Connection project

This environmental impact statement relates to the Beaches Link and Gore Hill Freeway Connection project. The project would comprise:

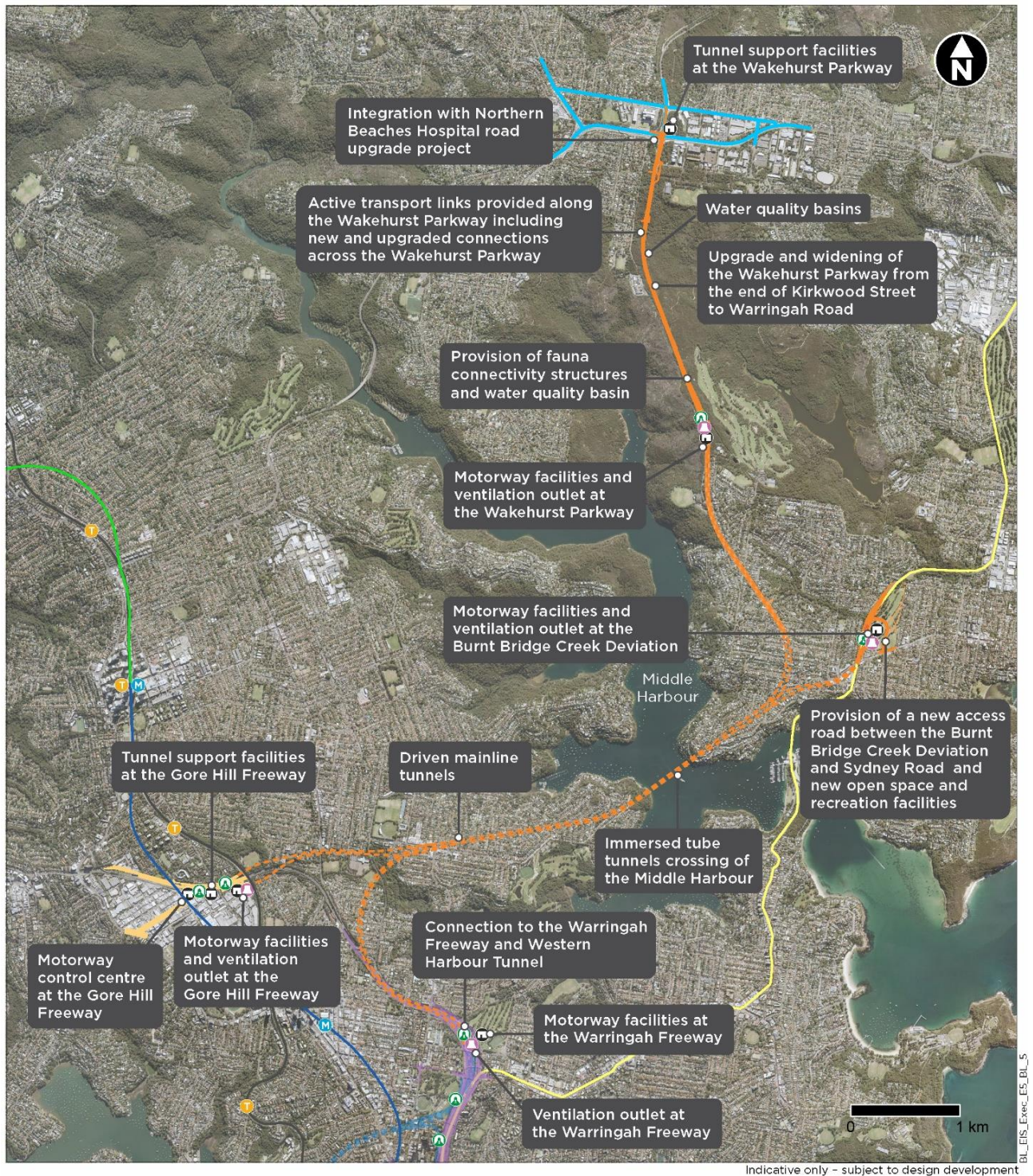
- Twin tolled motorway tunnels connecting the Warringah Freeway at Cammeray and the Gore Hill Freeway at Artarmon to the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Killarney Heights, and an upgrade of Wakehurst Parkway (the Beaches Link)
- Connection and integration works along the existing Gore Hill Freeway and surrounding roads at Artarmon (the Gore Hill Freeway Connection).

Key features of the Beaches Link component of the project are shown in Figure E-5 and would include:

- Twin mainline tunnels about 5.6 kilometres long and accommodating three lanes of traffic in each direction, together with entry and exit ramp tunnels to connections at the surface. The crossing of Middle Harbour between Northbridge and Seaforth would involve three lane, twin immersed tube tunnels
- Connection to the stub tunnels constructed at Cammeray as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project
- Twin two lane ramp tunnels:
 - Eastbound and westbound connections between the mainline tunnel under Seaforth and the surface at Burnt Bridge Creek Deviation, Balgowlah (about 1.2 kilometres in length)
 - Northbound and southbound connections between the mainline tunnel under Seaforth and the surface at Wakehurst Parkway, Killarney Heights (about 2.8 kilometres in length)
 - Eastbound and westbound connections between the mainline tunnel under Northbridge and the surface at the Gore Hill Freeway, Artarmon (about 2.1 kilometres in length).
- An access road connection at Balgowlah between Burnt Bridge Creek Deviation and Sydney Road including the modification of the intersection at Maretimo Street and Sydney Road, Balgowlah
- New and improved public open space and recreation facilities at Balgowlah including utilisation of the new access road for connectivity to the new facilities
- Upgrade and integration works along Wakehurst Parkway at Seaforth, Killarney Heights and Frenchs Forest, through to Frenchs Forest Road East
- New and upgraded active transport infrastructure (pedestrian and cyclist facilities)
- Ventilation outlets and motorway facilities at the Warringah Freeway in Cammeray, the Gore Hill Freeway in Artarmon, Burnt Bridge Creek Deviation in Balgowlah and Wakehurst Parkway in Killarney Heights
- Operational facilities, including a motorway control centre at the Gore Hill Freeway in Artarmon, and tunnel support facilities at the Gore Hill Freeway in Artarmon and Wakehurst Parkway in Frenchs Forest
- Other operational infrastructure including groundwater and tunnel drainage management and treatment systems, pavement works, surface drainage, signage, tolling infrastructure, fire and life safety systems, roadside furniture, lighting, emergency evacuation and emergency smoke extraction infrastructure, Closed-Circuit Television (CCTV) and other traffic management systems.

Key features of the Gore Hill Freeway Connection component of the project are shown in Figure E-1 and would include:

- Upgrade and reconfiguration of the Gore Hill Freeway between the T1 North Shore & Western Line and T9 Northern Line and the Pacific Highway
- Modifications to the Reserve Road and Hampden Road bridges
- Widening of Reserve Road between the Gore Hill Freeway and Dickson Avenue
- Modification of the Dickson Avenue and Reserve Road intersection to allow for the Beaches Link off ramp
- Upgrades to existing roads around the Gore Hill Freeway to integrate the project with the surrounding road network
- Upgrade and inclusion of traffic lights of the Dickson Avenue and Pacific Highway intersection
- New and upgraded pedestrian and cyclist facilities
- Other operational infrastructure, including surface drainage and utility infrastructure, signage and lighting, CCTV and other traffic management systems.



Legend

Operational features

- Beaches Link
- Gore Hill Freeway Connection
- Surface connection
- Permanent operational facility
- Ventilation outlet

Connecting projects

- Western Harbour Tunnel
- Warringah Freeway Upgrade
- Northern Beaches Hospital road upgrade project (Completed 2020)

Other projects

- Sydney Metro City & Southwest (under construction)
- Sydney Metro Northwest

Existing transport network

- Northern Beaches B-Line
- Suburban rail/Sydney Trains
- Train station

Design features

- Surface
- Tunnel

Figure E-5 Key features of the Beaches Link component of the project



Legend

Operational features

- Gore Hill Freeway Connection
- Beaches Link
- Permanent operational facility

- Surface connection
- Ventilation outlet

- Pedestrian / active transport links
- Permanent water quality basin

Existing rail network

- Suburban rail/Sydney Trains

Other projects

- Sydney Metro City & Southwest (under construction)

Figure E-1 Key features of the Gore Hill Freeway component of the project

Major transport benefits

The project would provide additional capacity across the Middle Harbour road corridor, relieving congestion on existing key road corridors and providing connections to other key existing and future proposed transport projects. By creating a bypass of both the Spit Bridge/Military Road and the Roseville Bridge/Warringah Road corridors, the project would provide direct access from the Northern Beaches to the Warringah Freeway for fast and reliable access to key commercial and employment centres at North Sydney, the Sydney CBD and beyond. It would also provide a fast, reliable link between the Northern Beaches and other key centres in the north-west including St Leonards and Macquarie Park via the direct Gore Hill Freeway connection.

The project through providing an underground bypass would also provide major benefits to public transport, enabling faster, more reliable and direct peak express services between the Northern Beaches, Harbour CBD, North Sydney, St Leonards, and Macquarie Park. It would also improve travel times and reliability on existing services along key routes such as Military Road, Warringah Road, Pacific Highway, Warringah Freeway and Sydney Harbour Bridge by relieving pressure on surface arterial roads, reducing conflicts between express and multi-stop services allowing multi-stop surface bus routes to operate more efficiently on these corridors.

The project would also deliver improved active transport infrastructure, including a new shared path along Wakehurst Parkway with overpass links to the new Northern Beaches Hospital precinct, and shared user underpasses provided beneath Wakehurst Parkway to provide safe connections from Garigal National Park and Manly Dam Reserve. Additional shared pathways would be provided in and around the new and improved open space recreation facilities at Balgowlah, integrating with existing paths to nearby commercial and community receivers. Realignment and reconstruction of the shared user path along the southern side of the Gore Hill Freeway would also be provided.

Project construction

The construction of the Beaches Link component of the project would include works underground, underwater and at the surface. The majority of the tunnel for the project would be constructed using roadheaders. The combination of the high quality Sydney Sandstone beneath most of the city, and the wide cross section required for road tunnels make this the most efficient and common method for constructing road tunnels in Sydney.

The poorer geological ground conditions at the Middle Harbour crossing requires the use of a different methodology to be adopted for the construction of the harbour crossing. Twin immersed tube tunnels, generally similar to the existing Sydney Harbour Tunnel, have been selected as the preferred solution as it would reduce the risk of deep tunnelling through poor geological ground conditions and deliver the best transport product by providing the lowest possible gradient for surface connections.

This section of the tunnel would be constructed by installing a series of pre-fabricated tunnel units to form the harbour crossing. Due to the profile of the harbour bed, the units would sit both partially within a trench closer to the shore and above the bed of the harbour towards the centre of the crossing. Given the very soft sediments at the bed of Middle Harbour, supporting piles would be required at discrete locations along the immersed tube crossing. A locking fill would be placed around the end sections of the immersed tube tunnels for stability and protection.

The shallow sand bar at the entrance to Middle Harbour prevents the transportation of fully completed tunnel units to the tunnel crossing location. The tunnel units would be partially fabricated outside of Middle Harbour then transported with the assistance of tug boats to a temporary floating immersed tube tunnel casting facility located at Spit West Reserve. The tunnel unit fabrication would be completed at a temporary construction support site at Spit West Reserve and transported by tug boats to a temporary mooring area within Middle Harbour before being placed into their final position.

Temporary cofferdams would be constructed within Middle Harbour off the shoreline at Northbridge and Seaforth. The cofferdams would be used to construct underground connection structures, called interface structures, which are required to connect the immersed tube tunnels to the land tunnels.

Although much of the construction works for the Beaches Link component of the project would be underground, surface works would also be required to support tunnelling activities and to construct the temporary construction support sites, surface connections, surface road upgrades, tunnel portals and operational facilities. Construction activities for the Gore Hill Freeway Connection would generally include surface earthworks, bridgeworks, utility works, tunnel construction of retaining walls, installation of stormwater drainage and pavement construction.

The construction of the Beaches Link and Gore Hill Freeway Connection project would require around 14 temporary construction support sites including tunnelling and tunnelling support sites, civil surface sites, cofferdams, mooring sites, wharf and berthing facilities, laydown areas, parking and workforce amenities. About four of these sites are areas within or adjacent to the existing Gore Hill Freeway corridor. An overview of these sites is provided in Figure E-2.

Tunnel spoil generated by the driven tunnels would be removed from acoustic sheds (designed to minimise noise impacts to the local community) at tunnelling temporary construction support sites. Most of the temporary construction support sites have direct access to the arterial road network, and spoil would generally be removed using trucks.

Most of the material dredged for the immersed tube tunnel crossing would be transported to the existing designated offshore disposal site managed by the Commonwealth Department of Agriculture, Water and the Environment in accordance with the *Environment Protection (Sea Dumping) Act 1981*. This disposal site is over 20 square kilometres in area, about 120 metres deep, and non-dispersive, meaning that material disposed of would stay within the disposal site. The disposal site is currently active and receiving material under permits from other marine maintenance and capital projects. An application for the project to dispose of suitable dredged material at the offshore disposal will be submitted to the Department of Agriculture, Water and the Environment.

Dredged materials not suitable for offshore disposal would be transported by barge to a loadout facility to be made spadable and then loaded onto trucks. The material would be classified according to the NSW Environment Protection Authority's *Waste Classification Guidelines* (NSW EPA, 2014a) and disposed of at a suitably licensed land-based facility.

The construction program presented within the environmental impact statement provides indicative timing only. The final construction program, and commencement of works at each construction site, may vary. Subject to planning approval and procurement, construction of the Beaches Link and Gore Hill Freeway Connection project is currently planned to commence in 2023. On that basis, completion of the main construction would be around the end of 2027 and completion of construction works for the new and improved open space and recreation facilities would be in 2028 – a total construction period of five to six years. Early works and site establishment would be the first works carried out for the project, with substantial construction starting around six months later.

For further details on the construction aspects of the project refer to Chapter 6.

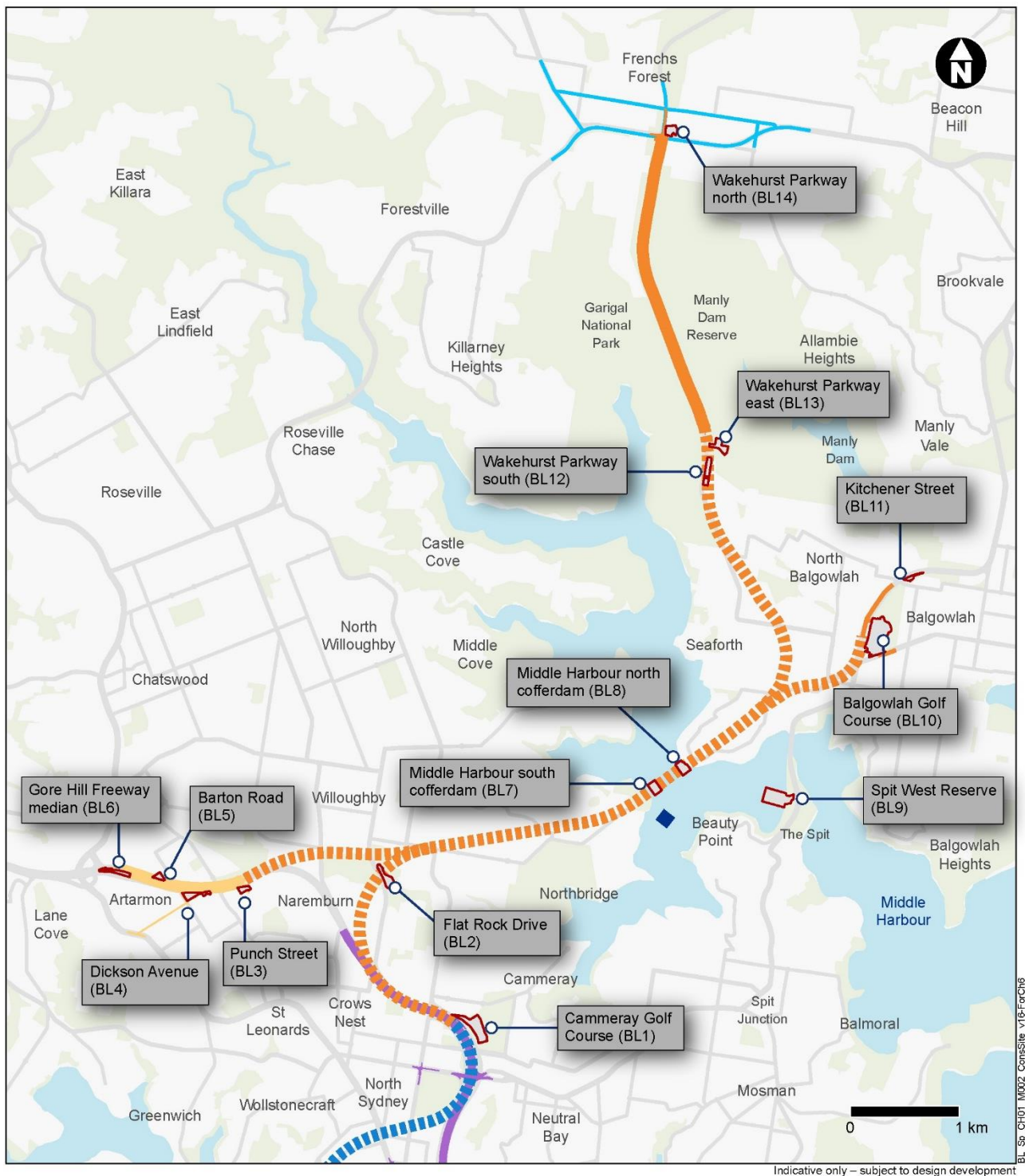


Figure E-2 Overview of the temporary construction support sites

Alternatives considered

The need for additional core motorway capacity at the crossings of Middle and Sydney Harbour was identified as key to development of an appropriate multi-modal Sydney transport network in the *NSW Long Term Transport Master Plan* (Transport for NSW, 2012) and subsequent *Future Transport Strategy 2056* (NSW Government, 2018).

Considering the requirements identified within the *NSW Long Term Transport Master Plan* and the *Future Transport Strategy 2056*, a number of strategic alternatives were considered for delivering the required road capacity at the crossing of Sydney Harbour. The project has undergone extensive evaluation of alternatives from pre-feasibility and strategic investigations through to design development and refinement. The process of developing and assessing project alternatives is outlined in Figure E-3.

The physical and urban geography of the Northern Beaches region presents barriers to the consideration of rail-based solutions in addressing the transport challenges faced by the region. The provision of rail infrastructure is also reliant on the location of and accessibility to high density residential or commercial property in close proximity to the proposed location of stations as well as along its route. Given the high cost of constructing and operating rail infrastructure and the low density nature of the Northern Beaches, it is considered that demand would not be high enough to make investing in a specific or dedicated rail link to the Sydney CBD a viable alternative.

Following identification of a new motorway tunnel as the preferred strategic alternative, a design development process was carried out to determine the most appropriate alignment and construction method to deliver the tunnel. The process for selection of the preferred tunnel alignment and construction methodologies included consideration of ten strategic corridors and over fifteen different combinations of tunnelling methods.

Options were developed and assessed by a multidisciplinary team including design engineers, construction engineers, transport planners and environmental advisors with direct experience in delivering major transport infrastructure in NSW, Australia and internationally.

Following preliminary technical and environmental analysis, five corridor alternatives were shortlisted for a new tunnelled motorway connection between Cammeray, Artarmon, Killarney Heights and Balgowlah (refer to Figure E-4). Selection of the preferred corridor required consideration of various technical, environmental and community factors including:

- Strategic traffic demands and how they define the required connectivity to achieve transport outcomes
- Results of geotechnical, groundwater and contamination investigations
- Topography along the alignment
- Basements and foundations of structures along the routes
- Maritime heritage, biodiversity and marine ecology
- Turbidity and hydrodynamic monitoring and modelling for Middle Harbour
- Opportunities for viable temporary intermediate tunnelling sites that minimise community, environmental and heritage impacts
- Physical and operational interfaces with other major infrastructure (eg Sydney Metro Tunnels, the Warringah Freeway, Northern Beaches Hospital Road Upgrade project)
- Integration with the proposed Western Harbour Tunnel and Warringah Freeway Upgrade project
- Horizontal alignments and waterway crossing methodologies that allow the tunnel to achieve acceptable vertical gradients to achieve the desired transport product, reduce whole of life emissions, operational costs, and improve safety outcomes

- Surface connections and interchanges that integrate with the arterial road network and connect bus routes and public transport nodes
- Interfaces with commercial and recreational maritime traffic
- Construction and operational efficiencies
- Potential impacts on local communities including amenity and connectivity.

The blue corridor was selected as the preferred corridor alternative for the new motorway (refer to Figure E-4). This corridor was selected as it achieves a greater alignment with transport and city-shaping objectives. This reflects the fact that it delivers more direct east-west connectivity relative to the pink corridor, while also providing strong north-south connectivity. This delivers more congestion relief to arterial roads, such as Warringah Road, and also provides the opportunity for new express bus services for customers travelling between the Northern Beaches and strategic centres such as North Sydney, St Leonards and Macquarie Park. The superior east-west connectivity means that the blue option also performs best with respect to productivity objectives. This is a result of enabling greater access to jobs for residents in the Northern Beaches and also the fact that it reduces the cost of business travel.

For further details on the development of the preferred design and the alternatives considered refer to Chapter 4.



Strategic alternatives

- Strategic alternatives assessed included:
 - » Do nothing
 - » Travel demand management
 - » Improvements to the existing arterial road network
 - » A new motorway (the project)
 - » Improvements to alternative transport modes
- New motorway selected as the preferred strategic alternative



Corridor alternatives

- Five corridor alternatives (pink, purple, green, red and blue) were assessed against:
 - » Project objectives
 - » Evaluation criteria:
 - * Technical criteria
 - * Environment and planning criteria
- Blue corridor selected as the preferred corridor alternative (the project)



Further project alternatives development

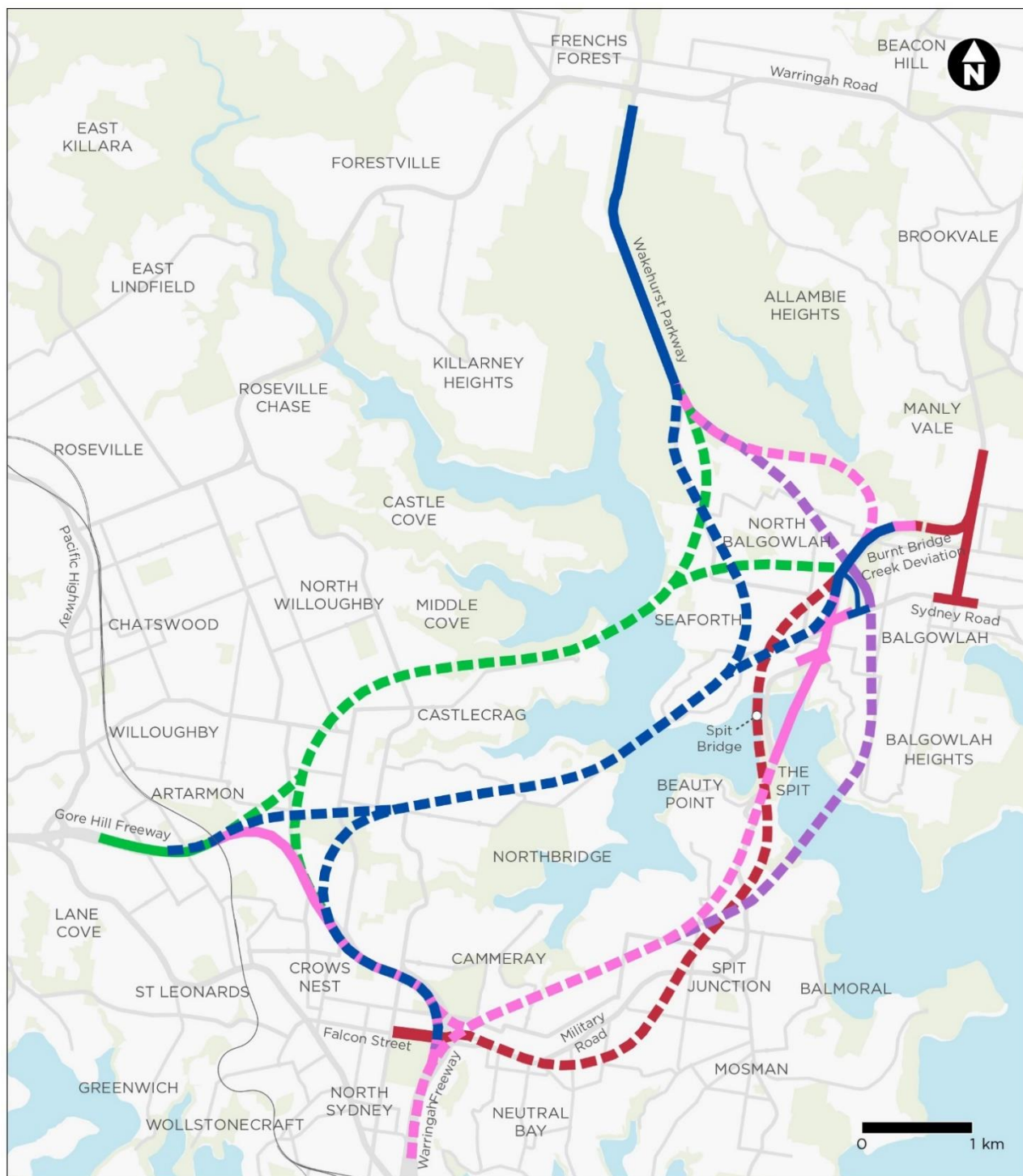
- Project development work included consideration of the following:
 - » Tunnelling method alternatives
 - » Connection alternatives to Warringah Freeway
 - » Connection alternatives to Gore Hill Freeway
 - » Connection alternatives to Wakehurst Parkway
 - » Connection alternatives to Balgowlah
 - » Ventilation alternatives
 - » Construction support site location alternatives
 - » Spoil transport alternatives
 - » Tunnelling spoil reuse and disposal alternatives
 - » Dredged material management alternatives



The project as described in this environmental impact statement

We are here

Figure E-3 Alternatives development process



Legend

- Blue corridor alternative
- Green corridor alternative
- Pink corridor alternative
- Purple corridor alternative
- Red corridor alternative
- Surface or bridge
- Tunnel
- Sydney Metro

Figure E-4 Shortlisted main corridor alternatives

The proponent

The proponent for the project is Transport for NSW. Transport for NSW is the lead agency of the NSW transport portfolio, with primary responsibility for:

- Transport coordination
- Transport policy and planning
- Transport services
- Transport infrastructure.

Transport for NSW would manage the planning, procurement and delivery of the project.

Planning approval process

Transport for NSW formed the opinion that the construction and operational impacts of the project would require an environmental impact statement. In accordance with clause 1 and clause 14 of Schedule 3 of State Environmental Planning Policy (State and Regional Development) 2011 the project is declared State significant infrastructure. Transport for NSW has also requested the Minister for Planning and Public Spaces to declare the project as critical State significant infrastructure under section 5.13 of the *Environmental Planning and Assessment Act 1979*.

This environmental impact statement is publicly exhibited to provide the community, government agencies and stakeholders with an understanding of what is proposed and to invite comment. Transport for NSW will consider the comments and submit to the Department of Planning, Industry and Environment a submissions report that documents and responds to issues raised during the exhibition period. The Secretary of the Department of Planning, Industry and Environment will then prepare an assessment report for the Minister for Planning and Public Spaces who will then determine whether to grant project approval and specify project conditions.

The assessment and approval process is shown in Figure E-5.

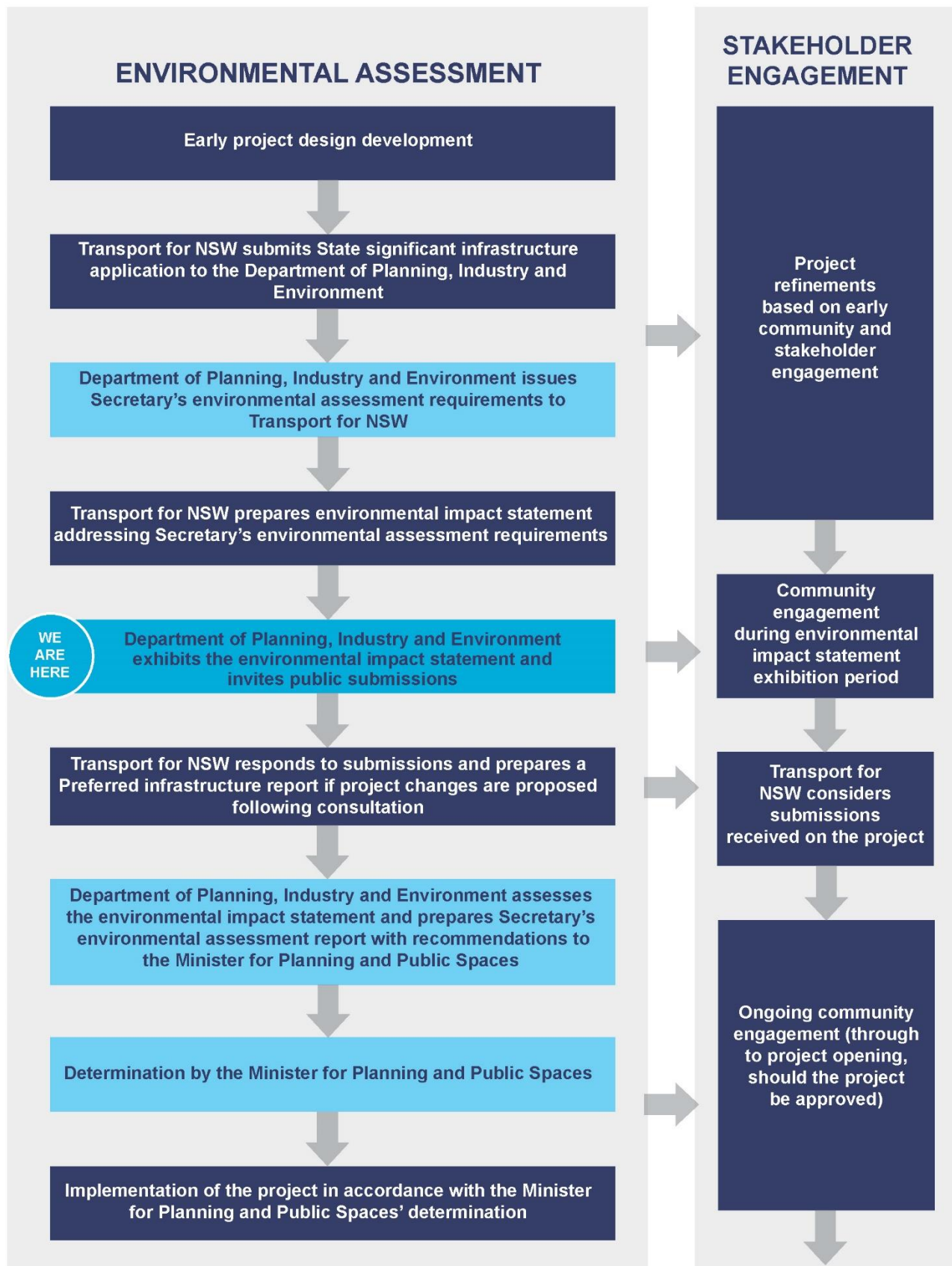


Figure E-5 The assessment and approval process for the project

Environmental assessment

This environmental impact statement has been prepared in accordance with the provisions of Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979*. In particular, it addresses the requirements of the Secretary of the Department of Planning, Industry and Environment. It also includes consideration of the issues raised by the community and stakeholders during the development of the project.

It is inevitable that delivery of a project of this scale within a heavily urbanised environment would have some adverse impacts, particularly during construction. These impacts need to be considered within the context of the overall objectives of the project and the significant transport and other benefits it would provide over the medium to longer term, and for future generations.

Key environmental issues have been considered throughout the design and development process. Consultation has been carried out with affected stakeholders to identify potential impacts at an early stage. Where possible, these would be avoided or appropriate management measures developed. These considerations have resulted in a number of design changes and refinements that have mitigated many of the potential significant impacts.

Some project impacts would be largely temporary and confined to the construction period.

Based on the results of the environmental investigations carried out for this environmental impact statement, it is considered that matters of national environmental significance and the environment of Commonwealth land are not likely to be significantly impacted by the project. Accordingly, Transport for NSW has determined that no referral is required under the *Environment Protection and Biodiversity Act 1999* at this stage.

The following sections provide an overview of the benefits and impacts identified within the environmental assessment.

Traffic and transport

Traffic and transport operational outcomes

Benefits from the project would include:

- Travel time savings and reliability benefits for users of the project, as well as for users of existing key corridors which would benefit from reduced traffic demand including Military Road, Spit Road, Warringah Road, and Eastern Valley Way
- Improved connections to North Sydney and Sydney CBD and new connections to St Leonards and Macquarie Park via the Gore Hill Freeway Connection
- Customers travelling between Frenchs Forest and Macquarie Park would be able to bypass approximately 20 sets of traffic lights by using the Beaches Link tunnel
- Improved travel times and reliability for buses travelling along existing key corridors including Warringah Road, Eastern Valley Way and Military Road
- New opportunities for public transport by providing the opportunity to operate express buses to Sydney CBD, North Sydney and beyond, with potential for direct interchange at North Sydney and St Leonards with Sydney Metro and Sydney Trains
- Better access to jobs and businesses, with direct access to the new Northern Beaches Hospital at Frenchs Forest, and better access to businesses on the Northern Beaches from Greater Sydney
- Substantial improvements in road safety, with reduced traffic demand along key road transport corridors, resulting in a 77 per cent forecast reduction in crashes for vehicles redirected to Beaches Link (equating to a reduction of around 560 crashes per year)

- Major reduction of heavy vehicle traffic on the Spit Road and Military Road corridor by up to 74 per cent
- Additional capacity for outbound traffic crossing Sydney Harbour and leaving the lower North Shore, relieving existing corridors including Military Road and Eastern Valley Way. This is illustrated by substantial improvements in average network speeds and the number of vehicle stops during evening peak periods
- Average travel speeds through the Balgowlah and surrounds study area would increase by up to 72 per cent in the morning peak and 40 per cent in the evening peak. The number of vehicle stops would reduce substantially by up to 57 per cent in the morning peak and 27 per cent in the evening peak
- Greater network resilience due to the provision of new road capacity and connectivity, and reduced rat-run traffic and congestion on existing surface roads including Miller Street (Camberay), Brook Street (Naremburn), Eastern Valley Way (Northbridge), Frenchs Forest Road (Seaforth) and the Ourimbah Road corridor
- Pedestrian and cyclist facilities would improve the overall active transport network with upgraded infrastructure providing increased connectivity and enhanced safety.

During operation of the project, potential localised impacts would include:

- Changes to access in and around North Sydney would streamline movements around North Sydney CBD but would adjust access for some residents and businesses in the area. Impacts would be minimised by ensuring all properties have reasonable alternative routes to maintain access
- Some instances of localised increases to bus travel times through the North Sydney CBD area.

For further information on operational traffic and transport, refer to Chapter 9 (Operational traffic and transport).

Traffic and transport impacts during construction

The project has been designed to minimise traffic and transport impacts during construction and ensure that traffic movement is maintained. Road closures would be carried out to minimise impacts on the community, particularly during peak periods.

During construction, temporary impacts would include:

- Increased heavy vehicle movements around work sites, and localised increases in traffic volumes and traffic delays
- Temporary, full or partial closures of roads within the Gore Hill Freeway and Artarmon area, Burnt Bridge Creek Deviation and Wakehurst Parkway for short periods of time to carry out key construction activities which are located within the road corridor
- Minor adjustments to some bus stops along the project alignment, and some potential short-term adjustments to bus priority infrastructure on Burnt Bridge Creek Deviation may be required (with minor impacts on bus services)
- Temporary adjustments to shared user paths, pedestrian and cyclist facilities along the project alignment
- Temporary impacts on maritime traffic associated with controlled navigation routes and the partial closures of Middle Harbour for recreational, commercial and government users between Northbridge and Seaforth and adjacent to Spit West Reserve to enable construction works for the immersed tube tunnel.

For further information on construction traffic and transport, refer to Chapter 8 (Construction traffic and transport).

Noise and vibration

Noise and vibration impacts during construction

Proposed temporary construction support sites and activities have been designed to minimise noise and vibration impacts on sensitive receivers. Design considerations to reduce noise and vibration impacts include the proximity of temporary construction support sites to sensitive receivers, construction of acoustic sheds and temporary noise barriers, and positioning of vehicle entrances and exits to allow access directly to and from the arterial road network where possible.

Most of the surface construction for the Beaches Link component of the project would be carried out between 7am and 6pm Monday to Friday and between 8am and 1pm on Saturdays. Tunnelling activities would be carried out 24 hours a day, seven days a week underground, supported by surface-based activities within purpose-built acoustic sheds which would be designed to minimise construction noise impacts for the local community. Spoil haulage from the Beaches Link temporary construction support sites would generally occur between 7am and 6pm Monday to Friday and between 8am and 1pm on Saturdays.

Construction of the Gore Hill Freeway Connection surface road works, and surface works associated with the tunnel connections at Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Seaforth/Killarney Heights would require extensive out of hours work, to minimise traffic disruptions and maintain safety for workers and road users and the public.

For the prediction of airborne noise impacts from construction sites, consideration was given to realistic worst case construction activities as required by the Interim Construction Noise Guideline (DECC, 2009a). While the noise levels for the realistic worst case might occur at sensitive receivers during the works, noise levels associated with the typical scenario would occur more frequently.

Key results of construction noise modelling include:

- Airborne noise from the project temporary construction support sites would generally be within the noise management levels with the exception of early works, site establishment (including cofferdam construction), site restoration works and out of hours concrete deliveries, when the noise management levels may be exceeded at some receivers for short periods
- Airborne noise levels from surface road works would generally be within the relevant noise management levels, with the exception of the operation of high noise generating equipment such as rock-hammers or concrete saws or when noisy works occur close to sensitive receivers, and works required outside of standard construction hours. Where airborne noise management levels are exceeded, there would be a requirement to implement reasonable and feasible noise mitigation
- Most of the ground-borne noise generated by roadheader tunnelling would be within the noise management levels. The use of rock-hammers for tunnelling activities has the potential to exceed noise management levels at various locations; however, such activities would be scheduled outside evening and night time periods (where feasible and reasonable) to avoid or reduce ground-borne noise level exceedances on receivers
- Vibration from tunnelling works would be generally within the vibration limits for human disturbance at most receivers. Some receivers have the potential to experience vibration levels above the human comfort criteria when rock-hammers are operating nearby. Several heritage listed structures would be within the vibration minimum working distance for cosmetic damage for an unsound heritage structure during the use of large rock hammers. For these receivers, further assessment would be carried out to determine the susceptibility of the structure to be potentially damaged by vibration, and mitigation measures from the *Construction Noise and Vibration Guideline* (Roads and Maritime, 2016) would be implemented

- Construction road traffic management and vehicle movements associated with the project are unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible. The number of maximum noise events from construction traffic that could disturb sleep are not likely to substantially increase, because the maximum number of truck movements generated by the project at night would be small compared to existing truck movements along the proposed haulage routes.

Construction noise and vibration impacts would be managed using reasonable and feasible mitigation and management measures including scheduling of works, noise reduction measures for plant and equipment, and provision of respite periods or offers of alternative accommodation for sensitive receivers if appropriate. Temporary noise barriers or solid hoarding would be used at temporary construction support sites where required to minimise noise impacts on residential receivers.

For further information on construction noise and vibration, refer to Chapter 10 (Construction noise and vibration).

Noise and vibration impacts during operation

The project has been designed to include traffic noise mitigation measures where feasible and reasonable. When the Beaches Link and Gore Hill Freeway Connection are operational the noise assessment indicates that:

- The project is predicted to typically decrease road traffic noise levels at most receiver locations
- Receivers to the east of the Warringah Freeway may experience an increase in maximum noise levels compared to the existing situation. This is due to the widening of the Warringah Freeway resulting in the southbound carriageway moving closer to those receivers
- Receivers to the west and east of the new access road which forms the connection between Burnt Bridge Creek Deviation and Sydney Road may experience an increase in maximum noise levels and the number of events compared to the existing situation without the new access road
- Receivers along the Wakehurst Parkway may experience an increase in maximum noise level events and the number of events compared to the existing situation. This is due to the widening of Wakehurst Parkway resulting in both the northbound and southbound carriageways moving closer to those receivers. The magnitude of maximum noise levels events would increase where lanes (and traffic) moves closer to sensitive receivers.

Appropriate mitigation measures would be confirmed in accordance with the *Noise Mitigation Guideline* (Roads and Maritime Services, 2015b). This would include noise barriers and at-property treatments.

For permanent operational infrastructure (such as the motorway facilities and ventilation outlets, wastewater treatment plants etc), no noise criteria would be exceeded. For further information on operational noise and vibration, refer to Chapter 11 (Operational noise and vibration).

Air quality

Air quality impacts during construction

Air quality modelling has been carried out to assess the potential air quality impacts that construction of the project may generate. Air quality impacts during tunnelling and surface works would typically include dust and the effects of airborne particles on human health and amenity as well as potential odour emissions during handling and management of harbour sediments. Spoil handling within acoustic sheds would minimise dispersion of dust at tunnelling sites. Water carts would be used on surface works to wet down works areas as required to minimise dispersion of dust. A comprehensive range of mitigation measures would be used so that any residual dust and associated human health impacts would be negligible.

Air quality impacts during operation

Extensive air quality modelling has been carried out to assess the project's in-tunnel and ambient air quality outcomes. The predicted total concentrations of pollutants were usually dominated by the existing background contributions.

The tunnel ventilation system would be designed to maintain in-tunnel air quality within applicable criteria for nitrogen dioxide (NO₂), carbon monoxide and visibility for all modelling scenarios including a worst case trip scenario.

The ventilation system would be designed so that there would be no emissions from tunnel portals. All emissions would be via ventilation outlets. Under expected traffic conditions, the predicted contribution of tunnel ventilation outlets to pollutant concentrations at ground level was negligible for all receptors.

For some short-term air quality measures (1-hour NO₂ and 24-hour PM₁₀ and PM_{2.5}), exceedances of the criteria for ambient air quality in the vicinity of the project are predicted to occur both with and without the project. This is usually due to changes in traffic on surface roads and high background concentrations. Where traffic on roads is expected to reduce due to diversion to the tunnels, ambient air quality is expected to improve compared to conditions without the project.

Regarding elevated receptors, for the project's expected traffic levels, there are no adverse impacts predicted at any existing or future buildings up to a height of 30 metres. For potential future buildings above 30 metres in height and within 300 metres of the Gore Hill Freeway ventilation outlet, further assessment of potential air quality impacts may be required at rezoning or development application stage but would not necessarily preclude such development.

The independent NSW Chief Scientist and Engineer has recently released a report in relation to road tunnel air quality. The report found that emissions from well-designed road tunnels cause a negligible change to surrounding air quality, and as such, there is little to no health benefit for surrounding communities in installing filtration and air-treatment systems in such tunnels. Further information is available at www.chiefscientist.nsw.gov.au.

For further information on air quality, refer to Chapter 12 (Air quality).

Human health impacts

As the project would deliver an underground motorway, there would be a redistribution of vehicle emissions associated with a reduction of traffic on surface roads. For much of the community this would result in no change or a small improvement to local air quality (ie reduced concentrations and fewer health impacts); however, for some areas located near key surface roads, a small increase in pollutant concentration may occur. Potential health impacts associated with changes in air quality (specifically nitrogen dioxide (NO₂) and particulates) within the local community have been assessed and are considered to be acceptable.

Concentrations of pollutants from vehicle emissions would be higher within the tunnel (compared to outside the tunnel). With the completion of a number of tunnel projects (approved or proposed), there is the potential for exposures to occur within a network of tunnels over varying periods of time. However, exposure to NO₂ is expected to be well within the current health guidelines.

Congestion inside the tunnels is not considered likely to result in adverse health effects, due to the operation of the tunnel ventilation systems and the temporary nature of the potential exposure. For motorcyclists, there is the potential for higher levels of exposure to NO₂ but these exposures, under normal conditions, are not expected to result in adverse health effects.

The independent NSW Chief Scientist and Engineer has recently released a report in relation to road tunnel air quality. The report found that emissions from well-designed road tunnels cause a negligible change to surrounding air quality, and as such, there is little to no health benefit for surrounding communities in installing filtration and air-treatment systems in such tunnels. Further information is available at www.chiefscientist.nsw.gov.au.

For further information on human health, refer to Chapter 13 (Human health).

Socio-economic impacts

The project would deliver new strategic road links between Sydney's Northern Beaches and the existing motorway network near Artarmon and North Sydney, bypassing the congested Spit Road and Military Road and Warringah Road corridors. The project would provide links to both the Gore Hill Freeway and Warringah Freeway, improving north–south and east–west connectivity for the Northern Beaches region. The project would include the widening of the Wakehurst Parkway between Seaforth and Frenchs Forest to improve access to the strategic Northern Beaches Hospital precinct and areas further north.

When operational, the project would:

- Reduce traffic along key routes including Military Road, Spit Road, Warringah Road, Eastern Valley Way, Brook Street and Miller Street. The project would also improve average travel speeds through the Warringah Freeway and North Sydney area, resulting in:
 - Improved travel times, enhancing the reliability and resilience of the road network across Sydney and improve access to the north, north-west and north-east of Sydney
 - Improved access and connectivity to community services and facilities within the study area for local residents, through travel time savings and improved travel time reliability
- Provide major benefits to public transport, enabling faster, more reliable and direct peak express services between the Northern Beaches, Harbour CBD, North Sydney, St Leonards, and Macquarie Park
- Reduce rat-run traffic and congestion on existing surface roads including Miller Street (Camberay), Brook Street (Naremburn), Eastern Valley Way (Northbridge), Frenchs Forest Road (Seaforth) and the Ourimbah Road corridor
- Increase the availability of public open space and passive and active recreation facilities for the community and help to address the current shortfall in recreational facilities within the Northern Beaches Council area
- Enable local businesses to have better and more efficient access to Greater Sydney, making it easier to move goods and provide services, as well as bringing employees and businesses closer together
- Improve pedestrian and cyclist accessibility and connectivity of active transport routes, which would bring long-term benefits for community cohesion.

For further information on socio-economics, refer to Chapter 21 (Socio-economics).

Heritage impacts (Non-Aboriginal and Aboriginal)

Transport for NSW is committed to preserving heritage items along the project corridor and minimising project impacts.

There are 73 listed heritage items and four potential heritage items within the study area. These include four items listed on the State Heritage Register (North Sydney Sewer Vent, St Leonards Park, Tarella and the Walter Burley Griffin Incinerator), with the remainder being of local heritage significance. Impact to the items above the tunnel alignment or adjacent to surface work due to indirect impact from settlement, vibration or changed views related to operational facilities such as noise barriers, has predominantly been assessed as being negligible to minor.

Site-specific management measures would also be applied at specific sites that have been identified as being subject to impact due to the activities associated with construction of the project. Archival recording would be completed prior to any work that has the potential to impact upon the following items:

- Cammeray Conservation Park (including Golf Course), Cammeray (to be completed by the Western Harbour Tunnel and Warringah Freeway Upgrade)

- Item 8: Clive Park and Tidal Pool, Northbridge
- Item 10: Balgowlah Golf Course, Balgowlah
- Item 11: Frenchs Bullock Track, Killarney Heights (pending further design development confirming direct impact).

Additionally, where direct impact in the northern section of the Frenchs Bullock Track would occur due to permanent infrastructure, the Bullock Track would be reformed as close as possible to the existing alignment. Where direct impact to the southern section may occur, further detailed survey would be completed prior to construction to confirm the curtilage to determine if this section remains partially intact (noting the curtilage extends into the existing road corridor, based on available spatial data).

For further information on non-Aboriginal heritage, refer to Chapter 14 (Non-Aboriginal heritage).

Eleven Aboriginal cultural places of local significance were identified within the study area. Based on the results of this assessment and in consultation with the Registered Aboriginal Parties:

- One Aboriginal site (45-6-0662) could not be located or its condition confirmed during field work and the Aboriginal Heritage Office has advised that the site was likely covered by gravel/vegetation. The site is considered likely to be within 50 metres of the construction footprint. The site could be indirectly impacted by vibration and settlement
- Five Aboriginal sites (45-6-0655, 45-6-2940, 45-6-3362, 45-6-3361 and 45-6-3363) are located within 50 metres of surface works including two sites that may be subject to indirect impacts associated with vibration and settlement (45-6-0655 and 45-6-2940)
- Five Aboriginal sites (45-6-3032, 45-6-3012, 45-6-0654, 45-6-0996 and 45-6-3599) are located above or within 50 metres of the tunnel alignment and may be subject to indirect impacts associated with vibration and settlement
- Operational impacts are considered to be negligible

Aboriginal cultural heritage impacts will be managed through vibration monitoring at sites listed in the Aboriginal Heritage Information Management System (AHIMS) database and the implementation of additional management measures where exceedances are identified. An Aboriginal heritage interpretation strategy would be included as part of the project urban design and landscape plan.

For further information on Aboriginal heritage, refer to Chapter 15 (Aboriginal heritage).

Biodiversity (terrestrial and marine) impacts

The southern part of the construction footprint and surrounding area is highly modified and disturbed. Much of the vegetation consists of trees and shrubs in landscaped parks and reserves, private residential gardens and road verges. Native vegetation occurs in the northern parts of the construction footprint on either side of the Wakehurst Parkway (Seaforth to Frenchs Forest) and to a lesser extent, next to the Burnt Bridge Creek Deviation (Balgowlah). Construction of the project would require removal of:

- 15.44 hectares of native vegetation and native revegetation of which 1.38 hectares is consistent with the Duffys Forest Ecological Community in the Sydney Basin Bioregion (listed as Endangered under the Biodiversity Conservation Act)
- 5.48 hectares of other vegetation comprising native plantings, exotic plantings, and weeds and exotics.

The project would remove a small number of individuals of threatened flora species and impact on potential habitat for threatened fauna species. Biodiversity offsets for native vegetation would be provided for the project.

There is potential for indirect impacts to groundwater dependent ecosystems due to groundwater drawdown. Appropriate environmental management measures would be implemented to manage potential drawdown impacts to groundwater dependent ecosystems and baseflow reduction impacts.

There is potential for short-term noise impacts on the Grey-headed Flying-fox camp located in the vegetated area between Balgowlah Road and the Burnt Bridge Creek Deviation (about 120 metres from the surface road works at Balgowlah), fauna in the vicinity of the Wakehurst Parkway during excavation activities and Little Penguins that may occur in Middle Harbour on occasion.

Potential direct impacts on threatened marine species in Middle Harbour, such as the Black Rockcod and White's Seahorse, would be low. Potential impacts on marine mammals and marine turtles would also be low.

Potential underwater noise impacts on marine fauna may occur as a result of dredging and piling activities in Middle Harbour. Noise modelling carried out for the project indicates that impacts would largely be limited to the immediate vicinity of piling and dredging activities. Visual monitoring from the harbour surface would be carried out to identify any underwater noise related impacts on fish, and appropriate at source protection measures would be considered, where required.

For further information on biodiversity, refer to Chapter 19 (Biodiversity).

Geology, soils and groundwater impacts

Ground movement would occur as a result of the construction of the project or associated components. Ground movement may occur as a result of removal of existing rock to form the tunnels or from ingress into the tunnels and associated groundwater drawdown. All project components are expected to experience ground surface settlement impacts of over 10 millimetres. The maximum predicted long-term surface settlement is 85 millimetres at Flat Rock Creek Reserve. However this settlement prediction is conservative and likely to be an over-estimate as it has been based on conservative (worst case) groundwater modelling without design measures to limit groundwater inflows into the tunnel. It has been demonstrated through additional modelling that the installation of tunnel lining under Flat Rock Creek area would be effective in reducing the groundwater induced settlement, reducing settlement to 35 millimetres. The final extent of tunnel lining under the Flat Rock Creek area would be determined through additional investigations as part of further design development. A conservative estimate of maximum long-term surface settlement of over 30 millimetres is expected around the Warringah Freeway portal, Burnt Bridge Creek Deviation portal, Wakehurst Parkway portal, and the Balgowlah ventilation tunnel. All other project components are anticipated to be subject to total settlement of between 10 to 30 millimetres or less. Building settlement between 10 to 50 millimetres is considered to equate to a 'slight' degree of severity, with a typical potential impact being cosmetic cracks that can be filled. No buildings along the tunnel alignment were found to be in the 'slight' to 'very severe' severity categories.

Pre-construction building/structure condition surveys would be prepared for properties (and heritage assets) within the zone of influence of tunnel settlement (for example within the 5 millimetre predicted surface settlement contour and within 50 metres of surface works) and within the minimum working distances for cosmetic and structural damage due to vibration. Within three months of the completion of construction activities that have the potential to impact on the subject surface/subsurface structure, a post condition survey would then be offered to property owners of buildings where a pre-construction building condition survey was carried out. Any property damage caused by the project would be rectified. An Independent Property Impact Assessment Panel, comprising geotechnical and engineering experts, would be established prior to the commencement of works to independently verify building condition survey reports, resolve any property damage disputes and establish ongoing settlement and vibration monitoring requirements. The Panel would be independent of both Transport for NSW and property owners.

A reduction in groundwater baseflow due to groundwater drawdown is predicted at potentially connected surface water systems at Flat Rock Creek, Quarry Creek, and Burnt Bridge Creek.

Drawdown of up to five metres is predicted during construction at the Flat Rock Creek/Quarry Creek groundwater dependent ecosystems and up to 12 metres during operation. However, the assessment of baseflow reduction is conservative and is likely to overestimate actual baseflow reduction as impacts have been modelled without consideration of tunnel linings. A scenario was modelled that included lining of about 300 metres of tunnel below Flat Rock Creek Reserve. The predicted water table drawdown at Flat Rock Reserve for the lined tunnel option was up to eight metres less than the drawdown predicted with no tunnel lining. Tunnel linings would be designed and installed as part of the project to reduce operational groundwater inflows into the tunnels and consequently, the predicted baseflow impacts are likely to be much lower than the conservative prediction.

The project is situated adjacent to a number of areas that are considered to have a 'moderate' or 'high' contamination risk. Further investigations of these sites would be required to quantify risk of soil contamination to construction works. These investigations would be carried out before construction activities so that contamination (if present) can be adequately planned for and managed.

Water table drawdown could also result in migration of contaminants. If contaminants were mobilised from areas of environmental interest identified by the project, they would travel towards the tunnel during construction and operation. This would be managed through monitoring the water quality of tunnel inflows and monitoring groundwater levels and water quality at the existing monitoring sites. Contaminants migrating into this section of the tunnel would be collected and treated at the wastewater treatment plants.

Contaminated sediments have been identified within Middle Harbour and offshore at Spit West Reserve. These contaminated sediments would need to be managed where disturbed during construction activities to reduce the exposure risk to workers and environmental receivers. Based on the elutriate test results and the assessed available natural dilution, water quality impacts at the dredging site due to dissolved contaminants would not be expected. Construction methodologies have been developed to remove or suitably reduce the risks from contaminated sediments during construction activities as detailed in Chapter 6 (Construction work) and Chapter 16 (Geology, soils and groundwater).

Hydrodynamics and water quality impacts

Site investigations and hydrodynamic modelling has been completed to assess and refine the construction methodology for works required within Middle Harbour for the immersed tube tunnel. Dredge plume modelling indicates that the dredging would not have a significant impact on marine water quality. Dredging and construction activities for the project are likely to cause localised increases in suspended sediment concentrations, but due to the rapid dispersion in Middle Harbour it is not likely to result in significant water quality impacts. Monitoring during dredging would assess the compliance of the activities associated with the project. Where appropriate, several silt curtains would be installed to mitigate potential impacts on ecologically sensitive areas.

The behaviour of sediment-bound contaminants when re-suspended into the water column has been previously assessed (Geotechnical Assessments, 2015) for other construction projects (Sydney Metro City & Southwest). These assessments have determined that contaminants are likely to remain bound to sediment particles and not be released into the water column. As an additional control, a backhoe dredge with a closed environmental bucket would be used to remove areas of sediments with elevated levels of contaminants. This would reduce the potential for release of contaminated sediments into the water column, and it is therefore unlikely that marine water quality would be significantly impacted by contaminants.

Regarding surface water quality, the assessment shows that baseflow impacts at Flat Rock Creek and Quarry Creek during the operational phase have the potential to be substantial, noting that operational wastewater treatment plant discharges to Flat Rock Creek may offset this impact. However, baseflow impacts have been modelled conservatively without tunnel linings, which is expected to represent an over-estimated result. Tunnel linings would be designed and installed as part of the project to reduce operational groundwater inflows into the tunnels and consequently the

baseflow impacts are likely to be lower than predicted. Additional gauge data would be collected to confirm the modelled results during further design development.

For further information on hydrodynamics and water quality, refer to Chapter 17 (Hydrodynamics and water quality).

Land use and property impacts

The project has been designed to minimise the need for property acquisition. The need to reduce these impacts has been balanced with temporary and permanent impacts to areas of open space. For the Beaches Link component of the project, 41 properties would require permanent acquisition and five properties would require temporary lease. Of the 41 properties that would be permanently acquired, 37 would be full acquisitions and four would be partial acquisitions. Eight properties required for the project are already owned by Transport for NSW.

For the Gore Hill Freeway Connection component of the project, five properties would be permanently acquired and two properties would be temporarily leased. Of the five properties to be permanently acquired, four would be full acquisitions and one would be a partial acquisition. Any property acquisitions required for the project would be carried out in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* and the land acquisition reforms announced by the NSW Government in 2016.

Temporary land use changes (loss of open space) would occur during establishment and operation of temporary construction support sites and other construction areas at Flat Rock Reserve, Spit West Reserve, Manly Dam Reserve, Bantry Bay Reservoir and a vacant piece of land owned by Transport for NSW and Willoughby City Council at Artarmon.

Permanent land use changes would occur at:

- Cammeray Golf Course, for widening of the Warringah Freeway and where the motorway facilities would be established within the Cammeray Golf Course next to the Warringah Freeway as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project. The golf course would be reconfigured to ensure it remains operational
- Artarmon Park and commercial properties along Punch Street, Lambs Road and Cleg Street for widening of the Gore Hill Freeway and where motorway facilities would be established
- Balgowlah Golf Course and residential properties along Dudley Street, for widening of the Burnt Bridge Creek Deviation for the tunnel portal and where the motorway facilities would be established
- Bantry Bay Reservoir, Sydney Water site.

When completed, the project would deliver new and improved public open space and recreation facilities at Balgowlah and Bantry Bay Reservoir to improve urban amenity.

At Balgowlah, the project would return an area, equivalent to around 90 per cent of the current open space, to the community as new and improved public open space and recreation facilities. A dedicated consultation process jointly led by Transport for NSW and Northern Beaches Council would take place to give the community an opportunity to provide input on the final layout of the new and improved open space and recreation facilities. This consultation would be separate to the consultation for the Beaches Link and Gore Hill Freeway Connection environmental impact statement. This process would start after the environmental impact statement public exhibition period and well in advance of construction starting. As part of this consultation process, a community reference group would be established, with representative stakeholder groups and the community, to support Transport for NSW and Northern Beaches Council with the development of this important public space.

The Bantry Bay Reservoir site would be rehabilitated and revegetated as soon as practicable after construction completion and land that is surplus to Sydney Water's operational requirements would be transferred to the Manly Warringah Memorial State Park.

For further information on land use and property impacts, refer to Chapter 20 (Land use and property).

Cumulative impacts

When completed, the Western Harbour Tunnel and Beaches Link program of works is expected to deliver beneficial cumulative impacts including considerable improvements to travel speeds through sections of the surface road network, increased reliability and a reduction in average journey times.

Adverse cumulative impacts could occur when impacts from the project interact or overlap with impacts from other projects, potentially resulting in a larger overall impact. Cumulative impacts may also occur when projects are constructed consecutively, resulting in construction fatigue for local receivers.

The implementation of environmental management measures for the project would avoid, to the greatest extent possible, cumulative impacts with surrounding development. The project design has carefully considered minimising construction fatigue for the community as far as practical. The intent is to reduce the overall cumulative or consecutive impacts on the community over a longer period. Transport for NSW would continue to collaborate with the relevant teams on nearby projects and work with local councils on any potential cumulative impact of projects that emerge as part of their future planning.

For further information on cumulative impacts, refer to Chapter 27 (Cumulative impacts).

Management of impacts

This environmental impact statement identifies comprehensive environmental management measures to avoid, manage, mitigate, offset and/or monitor impacts during construction and operation of the project. These include best practice construction environmental planning and management techniques, urban design and landscaping treatments and noise mitigation measures. Further mitigation opportunities are likely to be identified during further design development and construction planning and in consultation with communities and relevant stakeholders.

The design, construction and operation of the project would be carried out in accordance with extensive environmental management commitments identified in this environmental impact statement as included in Appendix Y (Compilation of environmental management measures), as well as any additional measures identified in the conditions of approval for the project.

Stakeholder and community engagement

Since the initial project announcement in March 2017, there has been extensive and ongoing community and stakeholder engagement. This has included:

- Toll free community information line
- Project email
- Project website
- Interactive website portal
- Project database to record correspondence relevant to the project, including contact details and issues raised during the life of the project
- Community update newsletters and letters to residents
- Community information sessions, information displays and staffed pop-ups
- Registered stakeholder database email updates

- Stakeholder briefings, meetings, workshops and presentations
- Interest group correspondence including letters and phone calls
- Face-to-face meetings and doorknocks with individual property owners and residents of properties which may be affected by the project
- Advertisements and proactive media articles in the local press
- Letterbox drops
- Media events at key milestones of the project.

The design has been continually refined throughout the community engagement to improve transport, environmental, amenity, community, heritage and sustainability outcomes.

The project team has developed a community and stakeholder engagement program to continue to proactively engage with local communities, key stakeholders and government agencies.

Next steps

Transport for NSW is seeking approval from the Minister for Planning and Public Spaces for the construction and operation of the project. Steps in the process include:

- Exhibition of the environmental impact statement for a minimum of 28 days in accordance with statutory requirements and invitation for the community and stakeholders to make submissions
- Consideration of submissions. Submissions received by the Secretary of Department of Planning, Industry and Environment would be provided to Transport for NSW and any relevant public authorities. Transport for NSW may then be required to prepare and submit:
 - A submissions report, responding to issues raised in the submissions
 - A preferred infrastructure report, outlining any proposed changes to the project to minimise its environmental impacts or to deal with any other issues raised
- Determination of the environmental impact statement. The Minister for Planning and Public Spaces would then make a decision on the project and, if approved, set conditions of approval.

Consultation with the community and stakeholders would continue throughout the further design development and construction phases as required.

The Department of Planning, Industry and Environment will make this environmental impact statement publicly available for a minimum period of 28 days. During the exhibition period, the environmental impact statement will be available for viewing at the following locations:

- Department of Planning, Industry and Environment major project planning portal: www.planningportal.nsw.gov.au/major-projects/projects/on-exhibition
- Transport for NSW interactive project portal: <https://nswroads.work/blportal>

Due to COVID-19 restrictions, staffed displays and face to face community information sessions of the environmental impact statement are not proposed to occur during the exhibition period. However this requirement will be reviewed if restrictions are eased and safety controls allow. In order to ensure that adequate opportunities are available for the community to ask questions on the content of the environmental impact statement, Transport for NSW will be running virtual information sessions throughout January and February 2021. Transport for NSW will continue to investigate the opportunity for face to face community information sessions provided COVID-19 guidelines allow.

Details of the times and topics for the virtual information sessions, as well as any potential face to face community information sessions, would be provided through our website, email notifications to registered stakeholders, community updates, and advertisements in local and metropolitan media.

During the exhibition period, a project information line (1800 931 189) and email address (whtbl@transport.nsw.gov.au) will be available for the community and stakeholders.

Written submissions can be made to the Secretary of the Department of Planning, Industry and Environment. All submissions received will be placed on the Department of Planning, Industry and Environment website.

Submissions can be made by creating an account at www.planningportal.nsw.gov.au/major-projects/projects/on-exhibition. This allows you to save a submission in progress and stay up to date with the progress of an application.

If you are unable to make a submission online, you can send a physical copy to the Department by post to the Department office address below. Your submission must include:

- Your name and address, at the top of the letter only
- The name of the application and the application number
- A statement on whether you support or object to the proposal
- The reasons why you support or object to the proposal
- A declaration of any reportable political donations made in the previous two years.

Written postal submissions are to be directed to:

Director, Transport Assessments
Department of Planning, Industry and Environment
Application number SSI-8862
Locked Bag 5022
Parramatta NSW 2124



Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Chapter 1

Introduction

1 Introduction

This chapter provides an overview of the Beaches Link and Gore Hill Freeway Connection project (the project), including its key features and location.

1.1 Overview

The Greater Sydney Commission's *Greater Sydney Region Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018a) proposes a vision of three cities where most residents have convenient and easy access to jobs, education and health facilities and services. In addition to this plan, and to accommodate for Sydney's future growth, the NSW Government is implementing the *Future Transport Strategy 2056* (NSW Government, 2018), a plan that sets the 40 year vision, directions and outcomes framework for customer mobility in NSW. The Western Harbour Tunnel and Beaches Link program of works is proposed to provide additional road network capacity across Sydney Harbour and Middle Harbour thereby improving transport connectivity with Sydney's Northern Beaches.

The Western Harbour Tunnel and Beaches Link program of works is a major transport infrastructure program that would make it easier, faster and safer to get around Sydney. As Sydney continues to grow, faster and more reliable trips are essential to reducing congestion and providing new levels of access to jobs, recreation, and services such as schools and hospitals. By creating a western bypass of the Sydney CBD, the Western Harbour Tunnel would take pressure off the Sydney Harbour Bridge, Sydney Harbour Tunnel and ANZAC Bridge; while Beaches Link would create an alternative to the Military Road/Spit Road and Warringah Road corridors to relieve traffic pressure on the North Shore. The program of works has been designed as part of an integrated transport network, which has a focus on new public transport connections and improved journey times and reliability for buses.

The Western Harbour Tunnel and Beaches Link program of works include:

- The Western Harbour Tunnel and Warringah Freeway Upgrade project which comprises a new tolled motorway tunnel connection across Sydney Harbour, and an upgrade of the Warringah Freeway to integrate the new motorway infrastructure with the existing road network and to connect to the Beaches Link and Gore Hill Freeway Connection project
- The Beaches Link and Gore Hill Freeway Connection project which comprises a new tolled motorway tunnel connection across Middle Harbour from the Warringah Freeway and Gore Hill Freeway to Balgowlah and Killarney Heights and including the surface upgrade of Wakehurst Parkway from Seaforth to Frenchs Forest and upgrade and integration works to connect to the Gore Hill Freeway at Artarmon.

The components of the Western Harbour Tunnel and Beaches Link program of works are shown in Figure 1-1.

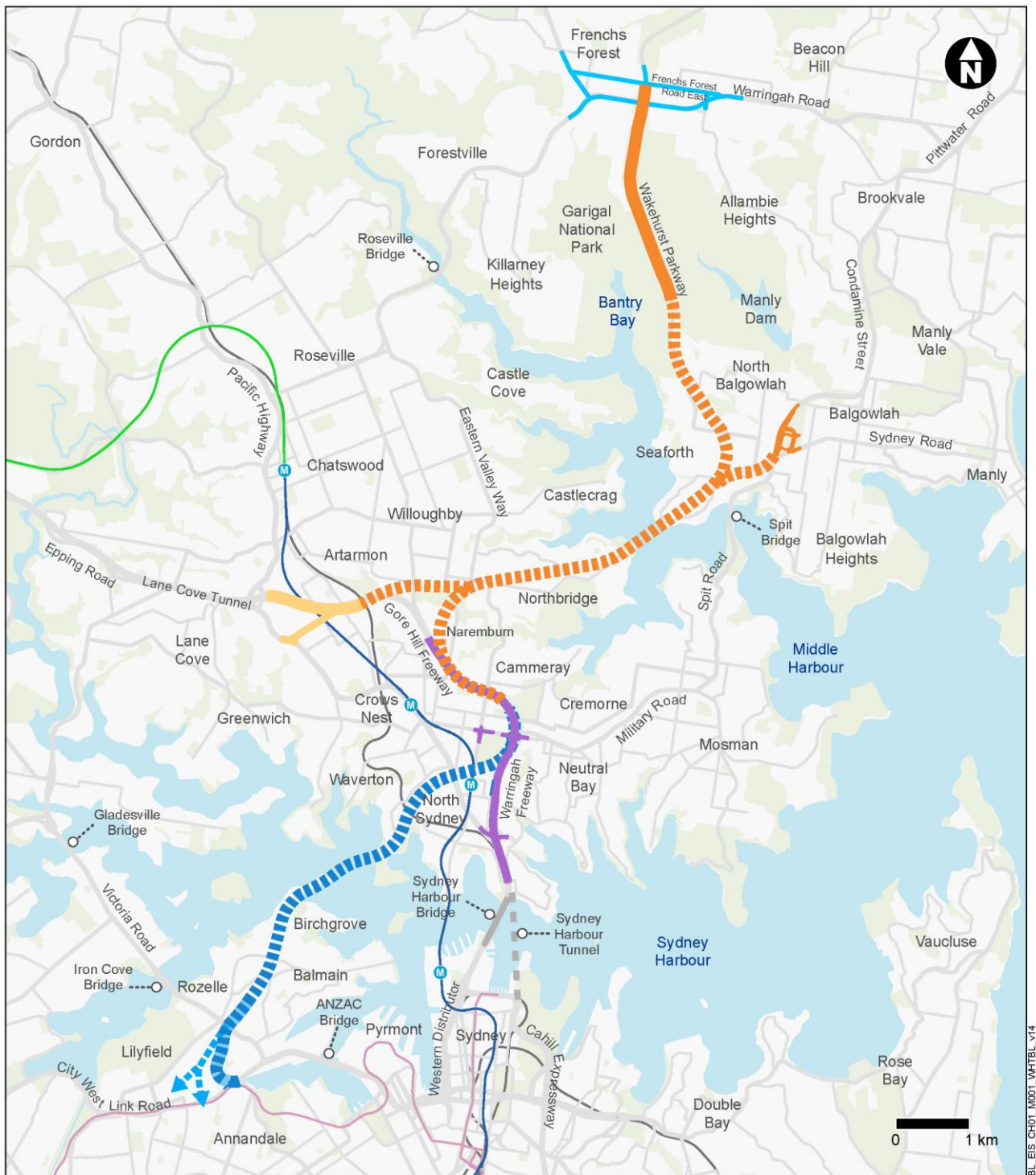
Delivery of the Western Harbour Tunnel and Beaches Link program of works would unlock a range of benefits for freight, public transport and private vehicle users. It would support faster travel times for journeys between the Northern Beaches and areas south, west and north-west of Sydney Harbour. For example, with the combined program of works, journeys from Dee Why to Sydney Kingsford Smith Airport are expected to be 56 minutes faster. Delivering the program of works would also improve the resilience of the motorway network, given that each project provides an alternative to heavily congested existing harbour crossings. These key benefits are discussed further in Chapter 3 (Strategic context and project need).

The project would provide an opportunity to improve travel times on peak express bus services by re-directing bus services from the Northern Beaches through the new motorway to North Sydney, the north west and the Sydney Central Business District (CBD). In addition, it would provide a fast, reliable link between the Northern Beaches and other key centres including St Leonards and Macquarie Park via the direct Gore Hill Freeway connection.

It would also provide an opportunity to introduce new express bus services that would use the new motorway and road connections to deliver increased direct public transport access between strategic centres across the region, reducing reliance on private vehicle travel.

The Western Harbour Tunnel and Warringah Freeway Upgrade project and the Beaches Link and Gore Hill Freeway Connection project are subject to separate and coordinated environmental assessment and approval processes.

This environmental impact statement relates to the Beaches Link and Gore Hill Freeway Connection project.



Indicative only – subject to design development

Legend

Operational features

- Beaches Link
- Gore Hill Freeway Connection
- Western Harbour Tunnel
- Warringah Freeway Upgrade
- M4-M5 Link tunnel fitout and commissioned as part of Western Harbour Tunnel

Connecting projects

- M4-M5 Link connections (indicative)
- Northern Beaches Hospital road upgrade project (Completed 2020)

Other projects

- Sydney Metro City & Southwest (under construction)
- Sydney Metro Northwest

Existing rail network

- Suburban rail/Sydney Trains
- Light rail

Figure 1-1 The Western Harbour Tunnel and Beaches Link program of works

1.2 The project

Transport for NSW is seeking approval under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* to construct and operate the Beaches Link and Gore Hill Freeway Connection project, which would comprise two components:

- Twin tolled motorway tunnels connecting the Warringah Freeway at Cammeray and the Gore Hill Freeway at Artarmon to the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Killarney Heights, and an upgrade of Wakehurst Parkway (the Beaches Link)
- Connection and integration works along the existing Gore Hill Freeway and surrounding roads at Artarmon (the Gore Hill Freeway Connection).

The project is an integrated transport solution that would address urban congestion on Sydney's road network. It would take pressure off Spit Bridge and Military Road – improving amenity in Mosman, Cremorne and Neutral Bay and relieving traffic flows on Warringah Road, Roseville and through the suburbs of Willoughby and Northbridge. It would provide direct access from the Northern Beaches to the Warringah Freeway for fast and reliable access to North Sydney, the Sydney CBD and beyond. It would also provide a fast, reliable link between the Northern Beaches and other key centres including St Leonards and Macquarie Park via the direct Gore Hill Freeway connection. For public transport there would be opportunity for express buses within the Beaches Link tunnel, additional express bus services along Military Road and improved connections to the Sydney Trains and new Sydney Metro rail networks.

A detailed discussion of the project benefits is presented in Chapter 3 (Strategic context and project need).

Key features of the Beaches Link component of the project are shown in Figure 1-2 and would include:

- Twin mainline tunnels about 5.6 kilometres long and each accommodating three lanes of traffic in each direction, together with entry and exit ramp tunnels to connections at the surface. The crossing of Middle Harbour between Northbridge and Seaforth would involve three lane, twin immersed tube tunnels
- Connection to the stub tunnels constructed at Cammeray as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project
- Twin two lane ramp tunnels:
 - Eastbound and westbound connections between the mainline tunnel under Seaforth and the surface at the Burnt Bridge Creek Deviation, Balgowlah (about 1.2 kilometres in length)
 - Northbound and southbound connections between the mainline tunnel under Seaforth and the surface at the Wakehurst Parkway, Killarney Heights (about 2.8 kilometres in length)
 - Eastbound and westbound connections between the mainline tunnel under Northbridge and the surface at the Gore Hill Freeway and Reserve Road, Artarmon (about 2.1 kilometres in length)
- An access road connection between the Burnt Bridge Creek Deviation and Sydney Road including the modification of the intersection at Maretimo Street and Sydney Road, Balgowlah
- Upgrade and integration works along the Wakehurst Parkway at Seaforth, Killarney Heights and Frenchs Forest, through to Frenchs Forest Road East
- New and improved open space and recreation facilities at Balgowlah
- New and upgraded active transport infrastructure (pedestrian and cyclist facilities)
- Ventilation outlets and motorway facilities at the Warringah Freeway in Cammeray, the Gore Hill Freeway in Artarmon, the Burnt Bridge Creek Deviation in Balgowlah and the Wakehurst Parkway in Killarney Heights

- Operational facilities, including a motorway control centre at the Gore Hill Freeway in Artarmon, and tunnel support facilities at the Gore Hill Freeway in Artarmon and Wakehurst Parkway in Frenchs Forest
- Other operational infrastructure including groundwater and tunnel drainage management and treatment systems, surface drainage, signage, tolling infrastructure, fire and life safety systems, roadside furniture, lighting, emergency evacuation and emergency smoke extraction infrastructure, Closed-Circuit Television (CCTV) and other traffic management systems.

Key features of the Gore Hill Freeway Connection component of the project are shown in Figure 1-3 and would include:

- Upgrade and reconfiguration of the Gore Hill Freeway between the T1 North Shore & Western Line and T9 Northern Line and the Pacific Highway
- Modifications to the Reserve Road and Hampden Road bridges
- Widening of Reserve Road between the Gore Hill Freeway and Dickson Avenue
- Modification of the Dickson Avenue and Reserve Road intersection to allow for the Beaches Link off ramp
- Upgrades to existing roads around the Gore Hill Freeway to integrate the project with the surrounding road network
- Upgrade and inclusion of traffic lights of the Dickson Avenue and Pacific Highway intersection
- New and upgraded active transport infrastructure (pedestrian and cyclist facilities)
- Other operational infrastructure, including surface drainage and utility infrastructure, signage and lighting, CCTV and other traffic management systems.

A detailed description of the project is provided in Chapter 5 (Project description). Construction of the project is described in Chapter 6 (Construction work).

Subject to the project obtaining planning approval, construction is anticipated to commence in 2023 and is expected to take around five to six years to complete.

1.3 Project location

The project would be located within the North Sydney, Willoughby, Mosman and Northern Beaches local government areas, connecting Cammeray in the south with Killarney Heights, Frenchs Forest and Balgowlah in the north. The project would also connect to both the Gore Hill Freeway and Reserve Road in Artarmon in the west. The regional context of the project is shown in Figure 1-1. The local context of the project is shown in Figure 1-2 and Figure 1-3.

Commencing at the Warringah Freeway at Cammeray, the mainline tunnels would pass under Naremburn and Northbridge, then cross Middle Harbour between Northbridge and Seaforth. The mainline tunnels would then split under Seaforth into two ramp tunnels and continue north to the Wakehurst Parkway at Killarney Heights and north-east to Balgowlah, linking directly to the Burnt Bridge Creek Deviation to the south of the existing Kitchener Street bridge.

The mainline tunnels would also have on ramps and off ramps from under Northbridge connecting to the Gore Hill Freeway and Reserve Road east of the existing Lane Cove Tunnel. Surface works would also be carried out at the Gore Hill Freeway in Artarmon, Burnt Bridge Creek Deviation at Balgowlah and along the Wakehurst Parkway between Seaforth and Frenchs Forest to connect the project to the existing arterial and local road networks.

1.4 Purpose of this environmental impact statement

This environmental impact statement has been prepared in accordance with the relevant provisions of the *Environmental Planning and Assessment Act 1979*. It has been prepared to address the environmental assessment requirements issued by the Secretary of the NSW Department of Planning, Industry and Environment (formerly Department of Planning and Environment) on 15 December 2017 and reissued on 22 April 2020, and the relevant provisions of Schedule 2 of the Environmental Planning and Assessment Regulation 2000.

In accordance with Division 5.2 of the *Environmental Planning and Assessment Act 1979*, this environmental impact statement presents an assessment of potential environmental issues identified during the planning and assessment of the project. The assessment considers the area directly or indirectly affected by construction and operation of the project, as relevant to each technical assessment.

This environmental impact statement will be placed on public exhibition, which will provide an opportunity for the community, government agencies and other interested parties to comment on the project. Transport for NSW will consider this feedback and respond to issues raised in a submissions report. The assessment process for the project is discussed further in Chapter 2 (Assessment process).

The Secretary's environmental assessment requirements are detailed in Appendix A, along with a reference to where these have been addressed in this environmental impact statement.

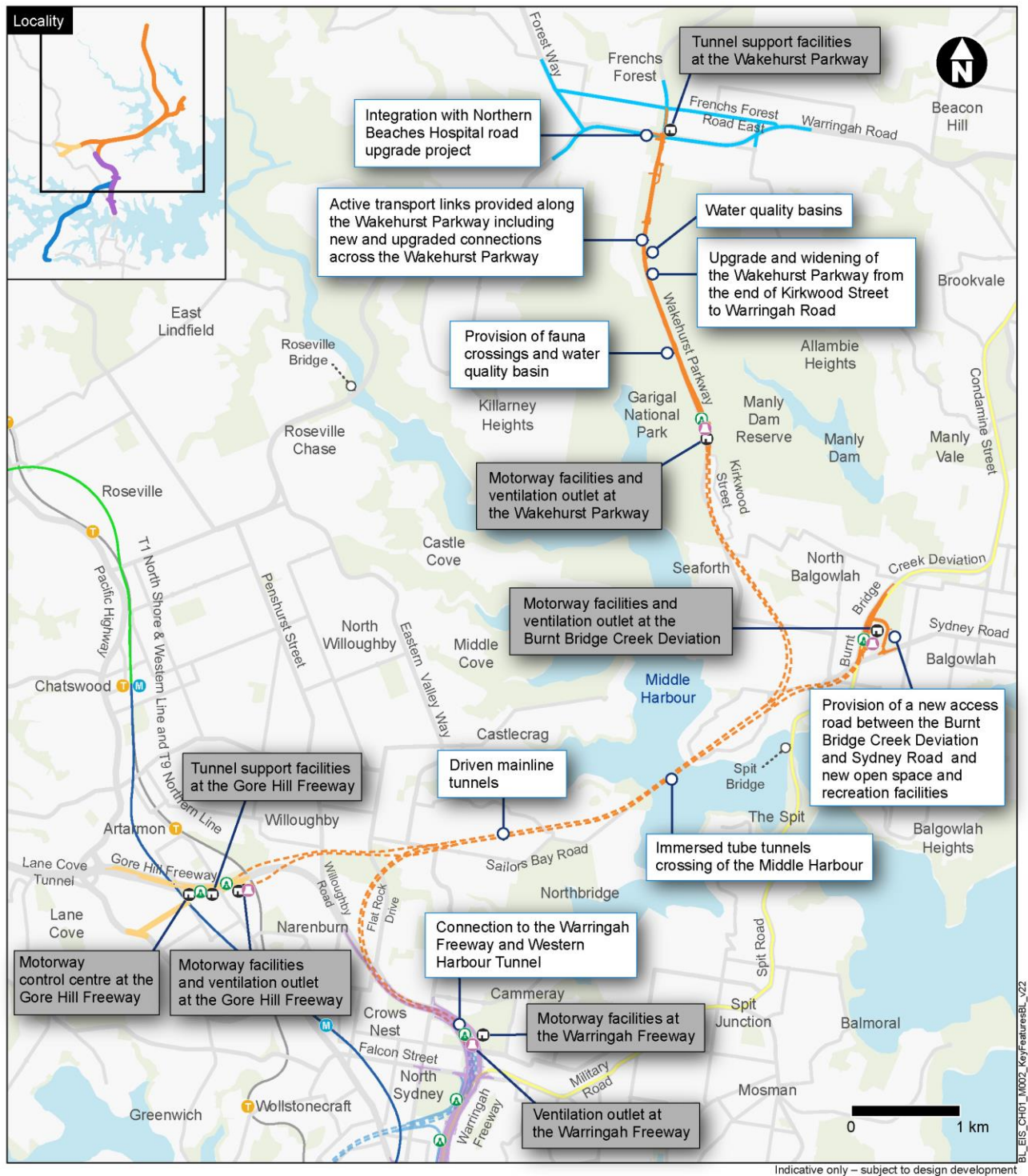


Figure 1-2 Key features of the Beaches Link component of the project

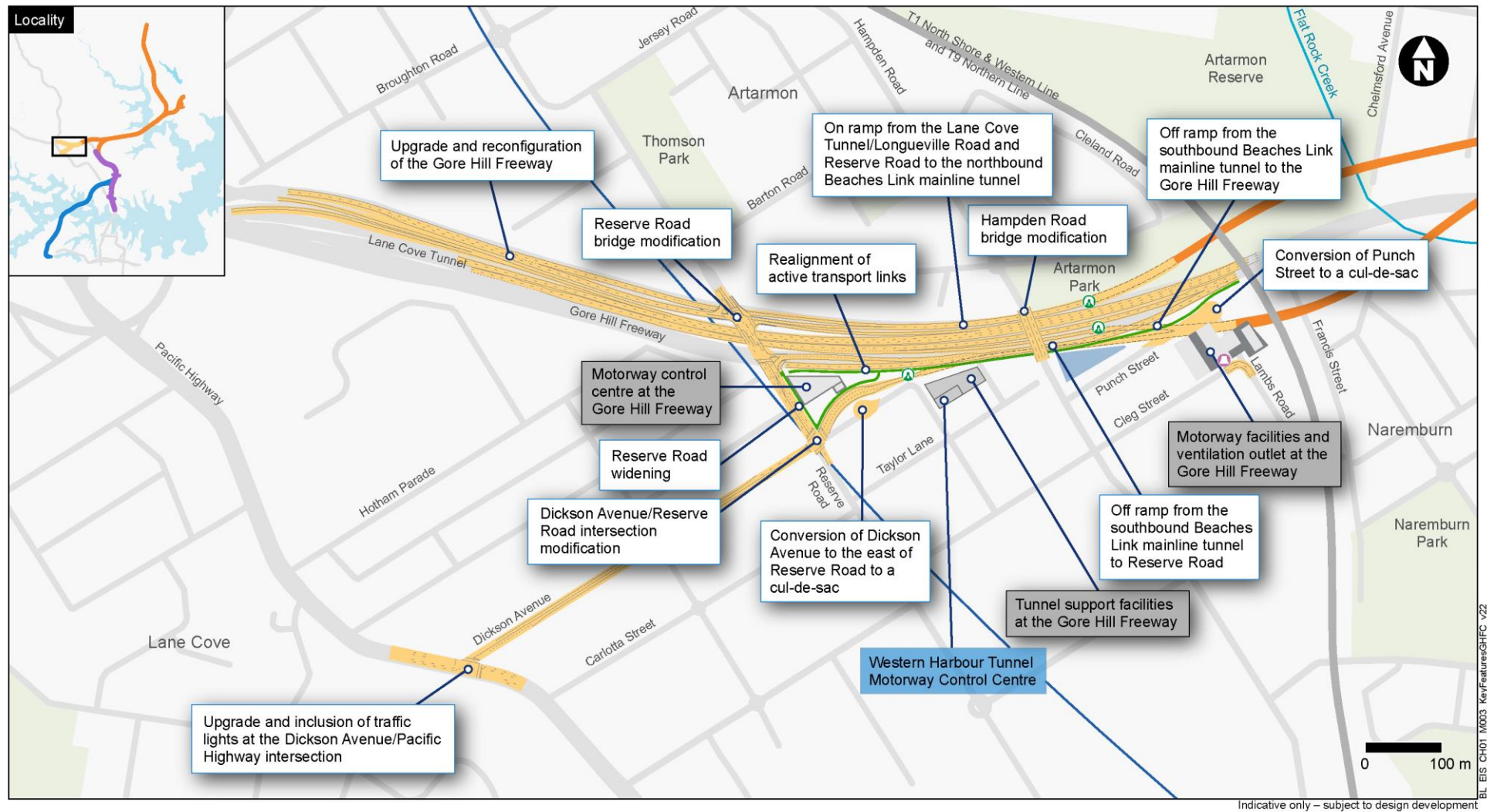


Figure 1-3 Key features of the Gore Hill Freeway component of the project



Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Chapter 2

Assessment process

2 Assessment process

This chapter describes the statutory context of the project, including the environmental impact assessment and approval process for the project as well as other relevant environmental planning and statutory approval requirements.

2.1 Assessment and approval framework

2.1.1 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* and the Environmental Planning and Assessment Regulation 2000 are the primary pieces of legislation regulating land use planning and development assessment in NSW. This legislation is supported by a range of environmental planning instruments including State environmental planning policies (SEPPs) and local environmental plans.

Transport for NSW is seeking approval for the Beaches Link and Gore Hill Freeway Connection project as State significant infrastructure under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979*.

Clause 94 of the State Environmental Planning Policy (Infrastructure) 2007 (the Infrastructure SEPP) applies to development for the purpose of a road or road infrastructure facilities and provides that these types of works are development which is permissible without consent. The project is appropriately classified as being for the purpose of a 'road' and a 'road infrastructure facility' under the Infrastructure SEPP.

Clause 14 of the State Environmental Planning Policy (State and Regional Development) 2011 (the State and Regional Development SEPP) declares development as State significant infrastructure if it is permissible without consent and specified in Schedule 3.

Transport for NSW, as the proponent for the project, formed the opinion that the construction and operational impacts of the project would require the preparation of an environmental impact statement, meaning that the project falls within clause 1 of Schedule 3 of the State and Regional Development SEPP, and the project is declared state significant infrastructure. Transport for NSW has also requested that the NSW Minister for Planning and Public Spaces declare the project as critical State significant infrastructure. Section 5.13 of the *Environmental Planning and Assessment Act 1979* provides for the declaration of critical State significant infrastructure by means of an environmental planning instrument. Clause 16 of the State and Regional Development SEPP declares development listed in Schedule 5 to be critical State significant infrastructure.

By reason of section 5.22 of the *Environmental Planning and Assessment Act 1979* the relevant environmental planning instruments that apply to the project are the Infrastructure SEPP and the State and Regional Development SEPP.

The Department of Planning, Industry and Environment (formerly the Department of Planning and Environment) issued the Secretary's environmental assessment requirements for the project on 15 December 2017 and these were reissued on 22 April 2020. A copy of the Secretary's environmental assessment requirements and where they have been addressed in this environmental impact statement is provided in Appendix A (Secretary's environmental assessment requirements checklist).

The assessment and approval process under Division 5.2 of the *Environmental Planning and Assessment Act 1979* is shown in Figure 2-1.

Further information on the assessment process is available on the Department of Planning, Industry and Environment website (www.planning.nsw.gov.au).

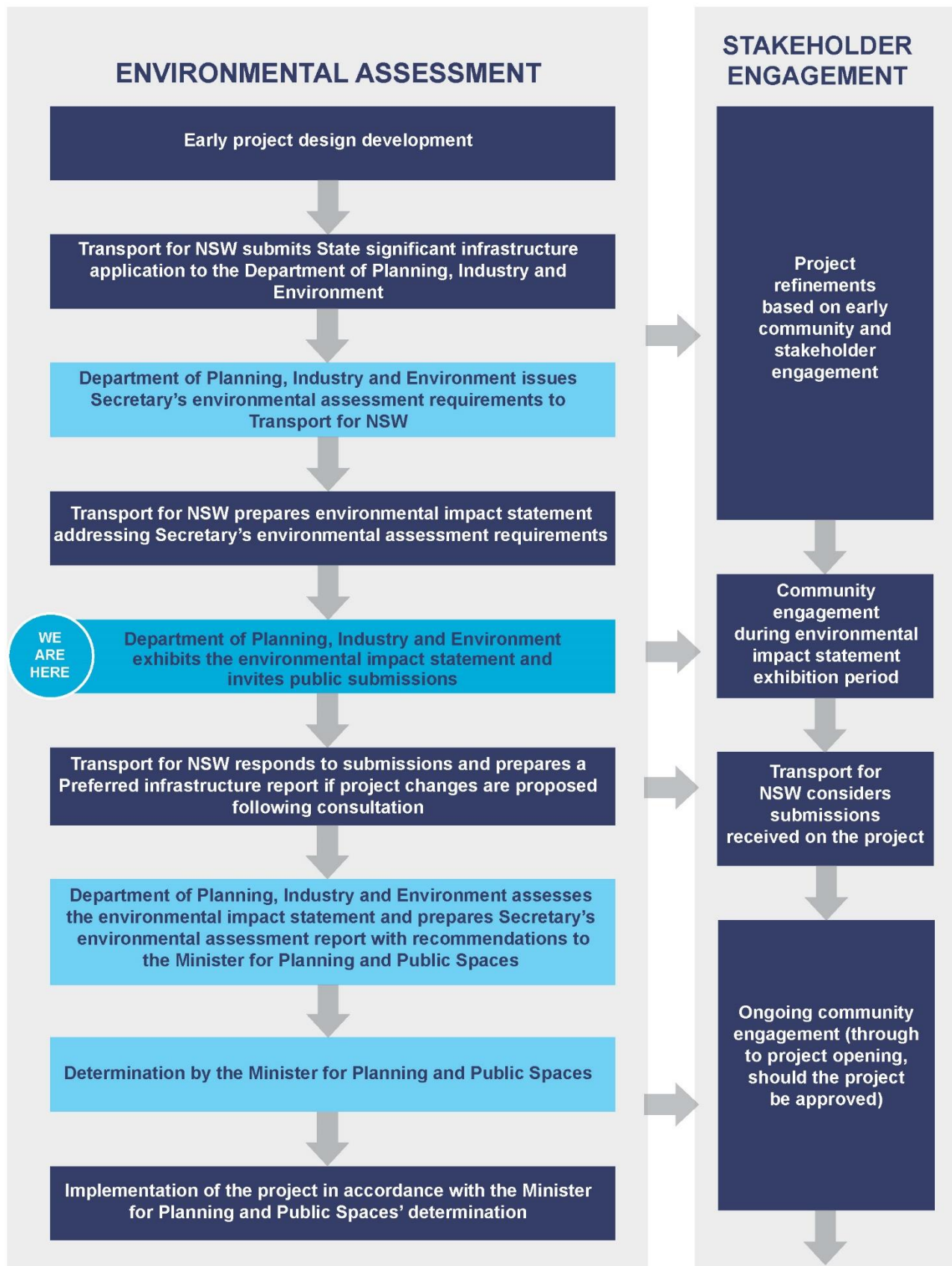


Figure 2-1 The assessment and approval process for the project

2.2 Other legislation

2.2.1 NSW legislation

Key approvals

Approvals under other NSW legislation that may apply to the project include:

- An environment protection licence for road construction and road tunnel emissions under Chapter 3 of the *Protection of the Environment Operations Act 1997*. In accordance with section 5.24 of the *Environmental Planning and Assessment Act 1979*, such a licence cannot be refused for an approved project and is to be substantially consistent with any approval under Division 5.2.

Other relevant legislation

Other NSW legislation that would apply to the project includes:

- The *Aboriginal Land Rights Act 1983* (NSW) was established to return land in NSW to Aboriginal peoples through a process of lodging claim for certain Crown Lands. As such, the management and disposal of Crown Lands is a key issue for Aboriginal Land Councils as it provides a compensatory mechanism for the dispossession of traditional lands from Aboriginal peoples
- The *Land Acquisition (Just Terms Compensation) Act 1991* (NSW), which applies to the acquisition of any land by an Authority of the State which is authorised to acquire the land by compulsory process. Acquisition is discussed in Chapter 5 (Project description) and Chapter 20 (Land use and property)
- The *Contaminated Land Management Act 1997* (NSW) outlines the circumstances in which the notification of the NSW Environmental Protection Authority is required in relation to contamination of land. This is discussed in Chapter 16 (Geology, soils and groundwater)
- The *Heritage Act 1977* (section 146) requires that the Heritage Council be notified if a relic is uncovered during construction and if it is reasonable to believe that the Heritage Council is unaware of the location of the relic. This provision has been incorporated into mitigation measures for the project, summarised in Chapter 28 (Synthesis of the environmental impact statement). Non-Aboriginal heritage is further discussed in Chapter 14 (Non-Aboriginal heritage)
- The *Crown Land Management Act 2016* provides for the ownership, use and management of Crown land in NSW. Ministerial approval is required to grant a 'lease, licence, permit, easement or right of way over a Crown Reserve'. Crown land is further discussed in Chapter 20 (Land use and property)
- The *Local Government Act 1993* includes provisions for leases and permits in respect to works on community land that has not been acquired by the project
- The *Native Title (New South Wales) Act 1994* provides for the recognition of native title in NSW in accordance with the Commonwealth *Native Title Act 1993* (see Section 2.2.2). Native title is further discussed in Chapter 15 (Aboriginal cultural heritage) and Chapter 20 (Land use and property)
- The *Fisheries Management Act 1994* (section 199) aims to manage dredging and reclamation works to conserve marine biodiversity and fish habitats. Under section 199, a public authority is required to give the Minister for Primary Industries written notice of proposed dredging or reclamation work prior to carrying out or authorising the carrying out of such work, and to consider any matters raised by the Minister in response to the notification. Dredging work in Middle Harbour would be required during installation of the immersed tube tunnels for the project

- The *Marine Pollution Act 2012* includes provisions to protect the sea and waters from pollution by oil and other noxious or harmful substances discharged from vessels. The use of marine vessels in the construction of the project would comply with the requirements of this Act and the Marine Pollution Regulation 2014 to prevent marine pollution. Works requiring access by boat or barge are further discussed in Chapter 6 (Construction work) and Chapter 17 (Hydrodynamics and water quality)
- The provisions in the *Marine Safety Act 1998*, Marine Safety Regulation 2016, *Ports and Maritime Administration Act 1995* and Ports and Maritime Administration Regulation 2012 aim to ensure the safe operation of vessels in ports and other waterways in NSW. A number of authorisations, approvals or permits may be required with respect to the placement of any structures in the water in Middle Harbour and/or with respect to obstruction to navigation. Permission of the Harbour Master would be required prior to the disturbance of the bed of the harbour under Part 6D of the Ports and Maritime Administration Regulation 2012. Construction activities within Middle Harbour and potential impacts to navigation are further discussed in Chapter 6 (Construction work) and Chapter 8 (Construction traffic and transport) respectively
- The *Waste Avoidance and Resource Recovery Act 2001* encourages the most efficient use of resources in order to reduce environmental harm in accordance with the principles of ecological sustainable development. Resource use and waste management are further discussed in Chapter 24 (Resource use and waste management)
- The *Sydney Water Act 1994* establishes Sydney Water as a State owned corporation in relation to the supply of water, the provision of sewerage and stormwater drainage systems and the disposal of wastewater in Sydney and other regions. The project would comply with this Act's requirements in relation to connections or impacts to Sydney Water's assets and approval requirements. Water supply utilities management and water supply utilities impacted during construction are further discussed in Chapter 5 (Project description) and Chapter 6 (Construction work).

Approvals not required for State significant infrastructure

A number of approvals are not required for a project approved under section 5.23 of Division 5.2 of the *Environmental Planning and Assessment Act 1979*. Those approvals not required for the project are:

- Permits under sections 201, 205 and 219 of the *Fisheries Management Act 1994*
- Approvals under Part 4 and excavation permits under section 139 of the *Heritage Act 1977*
- Aboriginal heritage permits under section 90 of the *National Parks and Wildlife Act 1974*
- Various approvals under the *Water Management Act 2000*, including water use approvals under section 89, water management work approvals under section 90, and activity approvals (other than aquifer interference approvals) under section 91.

Special dispensations for critical State significant infrastructure

If the project is declared as critical State significant infrastructure, section 5.23(3) of the *Environmental Planning and Assessment Act 1979* precludes the following directions, orders or notices being made to prevent or interfere with the carrying out of the project once approved:

- An interim protection order (within the meaning of the *National Parks and Wildlife Act 1974*)
- An order under Division 1 (Stop work orders) of Part 6A of the *National Parks and Wildlife Act 1974* or Division 7 (Stop work orders) of Part 7A of the *Fisheries Management Act 1994*
- A remediation direction under Division 3 (Remediation directions) of Part 6A of the *National Parks and Wildlife Act 1974*
- An order or direction under Part 11 (Regulatory compliance mechanisms) of the *Biodiversity Conservation Act 2016*

- An environment protection notice under Chapter 4 of the *Protection of the Environment Operations Act 1997*
- An order from a council to demolish or move a building, to repair or make structural alterations to a building, or to do or refrain from doing things under section 124 of the *Local Government Act 1993*.

2.2.2 Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999

Under the *Environment Protection and Biodiversity Act 1999* proposed 'actions' that have the potential to significantly impact on matters of national environmental significance, the environment of Commonwealth land, or that are being carried out by a Commonwealth agency must be referred to the Australian Government. If the Australian Minister for the Environment determines that a referred project is a 'controlled action', the approval of that Minister would be required for the project in addition to the NSW Minister for Planning and Public Spaces' approval.

Based on the results of the environmental investigations carried out for this environmental impact statement, it is considered that matters of national environmental significance and the environment of Commonwealth land are not likely to be significantly impacted by the project. Accordingly, Transport for NSW has determined that no referral is required at this stage.

Environment Protection (Sea Dumping) Act 1981

The *Environment Protection (Sea Dumping) Act 1981* aims to regulate permitted sea (offshore) disposal activities to ensure environmental impacts are minimised and prohibit the disposal of harmful waste at sea. Offshore disposal is regulated by permits issued by the Commonwealth Department of Agriculture, Water and the Environment and informed by detailed environmental assessments.

Dredged material associated with the construction of the crossing of Middle Harbour would be eligible for offshore disposal under the Act. This would comprise dredged sediments and rock that are considered suitable for offshore disposal which have been removed during the construction of cofferdams and immersed tube tunnels within Middle Harbour. Transport for NSW will submit an application to the Department of Agriculture, Water and Environment for an offshore disposal permit relating to sediments dredged from Middle Harbour. The application proposes offshore disposal at a designated disposal site, which is located about 10 to 15 kilometres offshore of Sydney Heads. A detailed assessment has been completed and will be submitted to the Department of Agriculture, Water and the Environment, which documents sediments suitable for offshore disposal and details impacts associated with the disposal activity, as required by the permit application process.

Offshore disposal of sediments would be conducted outside NSW and is therefore not regulated under the *Environmental Planning and Assessment Act 1979*. As the offshore disposal grounds, excavation activity and transport to the disposal grounds are regulated by the Department of Agriculture, Water and the Environment, further details of the offshore disposal assessment, contained within the submission to the Department of Agriculture, Water and the Environment, are not included in this environmental impact statement.

Daily maximum construction maritime traffic volumes and routes to navigational channels that lead to Sydney Heads, including barge movements for offshore disposal of suitable dredged sediment and rock, are summarised in Chapter 6 (Construction work) and considered in Chapter 8 (Construction traffic and transport) and Section 5.5 of Appendix F (Technical working paper: Traffic and transport). It is anticipated that six barge movements per day would be required for transportation of dredged sediment and rock to the offshore disposal site.

Measures to manage noise from barges would be included in construction noise and vibration planning to be developed during further design development. Barges would be operated and maintained to comply with the Protection of the Environment Operations (Noise Control)

Regulation 2017, particularly Clauses 37 and 38 of the regulation which require vessels to have properly maintained noise controls. Noise impacts related to the loading and unloading of barges at water-based construction support sites have been considered in Chapter 10 (Construction noise and vibration) and Appendix G (Technical working paper: Noise and vibration).

Sediments that are not suitable for offshore disposal would be brought to land. These sediments would be managed and, if necessary, made suitable for land disposal before being directed to an appropriately licensed waste facility. Further discussion of dredged sediments not suitable for offshore disposal is provided in Chapter 24 (Resource use and waste management).

Native Title Act 1993

The main objective of the *Native Title Act 1993* is to recognise and protect native title. A successful native title claim results in the recognition of the particular rights, interests or uses claimed by the registered party. If a native title claim is recognised under the Act, any actions by Government on that land must be consistent with the claim.

Searches of the register maintained by the National Native Title Tribunal indicate there are no native title claims registered with respect to the land within the project footprint.

Airports Act 1996 and Civil Aviation Act 1986

Under the *Airports Act 1996*, 'prescribed airspace' is the airspace above any part of either an obstruction limitation surface (OLS) or procedures for air navigation systems operations (PANS-OPS) surface for Sydney Airport. Approval is required from the Secretary of the Commonwealth Department of Infrastructure, Transport, Regional Development and Communications if the project affects 'prescribed airspace', either by a structure physically protruding into the airspace or activities that result in disturbance to the airspace, such as turbulence caused by emissions from a ventilation outlet. Through provisions under the *Civil Aviation Act 1988*, the Civil Aviation Safety Authority can stipulate requirements for the design, construction and operation of new infrastructure that has the potential to influence aviation safety that support the provisions of the *Airports Act 1996*.

The emissions from the ventilation outlet and motorway facilities at the Warringah Freeway, Gore Hill Freeway, Burnt Bridge Creek Deviation and Wakehurst Parkway have the potential to affect prescribed airspace.

A plume rise assessment was carried out in accordance with the *CASA Advisory Circular Plume Rise Assessments AC 139-5(1) November 2012* to determine whether plume rise resulting from the operation of these ventilation outlets and motorway facilities would be a controlled activity as defined in section 183 of the *Airports Act 1996*. This assessment considered an expected case, reflective of typical operational conditions of the project, and a capacity case, based on the maximum theoretical airflow that could be discharged from each ventilation outlet. In addition, the assessment also considered the merged ventilation outlets at the Warringah Freeway for the Western Harbour Tunnel and Beaches Link program of works.

The plume extent from the ventilation outlets and motorway facilities would not interfere with the OLS and PANS-OPS surfaces under the expected and capacity case scenarios, except for the ventilation outlet at the Warringah Freeway. For this ventilation outlet, the plume velocities would exceed the OLS under the capacity case when considered in conjunction with the ventilation outlet for the Western Harbour Tunnel at the Warringah Freeway. As such, a plume rise application would be prepared for approval under the *Airports Act 1996* for the ventilation outlet and motorway facilities at the Warringah Freeway where it may constitute a controlled activity.

Further discussion of potential impacts on prescribed airspace is provided in Chapter 23 (Hazards and risks).

2.3 Next steps

As is normally the case for a complex major infrastructure project progressing through an environmental planning and assessment process, the design and construction approach presented in this environmental impact statement is at planning stage and is indicative only. It is subject to refinement once project approval is obtained and the contractor(s) delivering the project have further developed the design and construction methodologies (commonly referred to as detailed design).

Issues raised during exhibition of the environmental impact statement may result in changes to the project design and construction approach, and if so, these would be identified in a preferred infrastructure report (refer to Figure 2-1).

Any refinements to the approved project during the contractor's detailed design would be reviewed for consistency with the approval. This consistency review would be carried out to consider whether the refinement would:

- Result in any of the conditions of approval not being met
- Be consistent with the objectives and operation of the project as described in the environmental impact statement
- Result in a significant change to the approved project
- Result in any potential environmental or social impacts of a greater scale or impact than that considered by the environmental impact statement.

Where design refinements do not meet these criteria, approval for a modification would be sought from the Minister of Planning and Public Spaces in accordance with the requirements of Division 5.2 of the *Environmental Planning and Assessment Act 1979*.

2.3.1 Western Harbour Tunnel and Warringah Freeway Upgrade interface

The project would include a tunnel connection with the Western Harbour Tunnel and a surface connection with the Warringah Freeway Upgrade at Cammeray. The Western Harbour Tunnel and Warringah Freeway Upgrade project is subject to separate planning approval and the environmental impact statement is currently being assessed by the Department of Planning, Industry and Environment.

It is assumed that the Western Harbour Tunnel and Warringah Freeway Upgrade project would commence construction before the Beaches Link and Gore Hill Freeway Connection project. Should timeframes for the Beaches Link and Gore Hill Freeway Connection project be advanced, some elements of the Beaches Link component may be delivered as part of the Western Harbour Tunnel and Warringah Freeway Upgrade works to maximise construction efficiency and minimise impacts in particular areas.

Delivery of any elements of the Beaches Link component as part of the Western Harbour Tunnel and Warringah Freeway Upgrade works would be subject to the conditions of approval for the Beaches Link and Gore Hill Freeway Connection project and the requirements of this environmental impact statement, including relevant environmental management measures provided in Appendix Y (Compilation of Environmental Management Measures) and any other documents incorporated by reference in the approval.

The interface of the Beaches Link project with the Western Harbour Tunnel reflects the arrangement as presented in the environmental impact statement for the Western Harbour Tunnel and Warringah Freeway Upgrade project. The contractor for the Western Harbour Tunnel and Warringah Freeway Upgrade has not yet been appointed and detailed design has not yet been carried out.



Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Chapter 3

Strategic context and project need

3 Strategic context and project need

This chapter outlines the strategic context and need for the project, taking into account the current and future transport challenges Sydney is facing, and describes the benefits of the project for people across Greater Sydney. It also describes how the project aligns with national and State strategic planning and transport policies.

The Secretary's environmental assessment requirements as they relate to the strategic context and project need, and where in the environmental impact statement these have been addressed, are detailed in Table 3-1.

Table 3-1 Secretary's environmental assessment requirements – Strategic context and project need

Secretary's requirement	Where addressed in EIS
Environmental impact statement	
1. The EIS must include, but not necessarily be limited to, the following: b. a description of the project and all components and activities (including ancillary components and activities) required to construct and operate it, including: - the relationship and/or integration of the project with existing and proposed public and freight transport services	The relationship and integration of the project with existing and proposed public and freight transport services is described in Section 3.6 and Section 3.7 . Additional information about the relationship and integration of the project with existing and proposed public and freight transport services is in Chapter 8 (Construction traffic and transport), Chapter 9 (Operational traffic and transport) and Chapter 27 (Cumulative impacts).
c. a statement of the objective(s) of the project	Section 3.4 states the project objectives.
d. a summary of the strategic need for the project with regard to its State significance and relevant State Government policy	Section 3.2 outlines the strategic need for the project. References to the project's State significance and relevant State Government policies are provided in Section 3.7 .

3.1 Sydney's present and future

Greater Sydney is expanding and the NSW Government is working hard to deliver an integrated transport network that meets the community's needs now and into the future. The population of Greater Sydney is forecast to grow from five million to eight million people over the next 40 years. To accommodate this growth, the Greater Sydney Commission's *Greater Sydney Region Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018a) envisages a global metropolis of three liveable, productive and sustainable cities. The Beaches Link and Gore Hill Freeway Connection project (the project) would be located in the North District of the Eastern Harbour City - an area of strategic economic importance for Sydney. The cities and districts of the *Greater Sydney Region Plan* and their key metrics are shown in Figure 3-1.

Sydney's key employment and economic areas are clustered along a corridor that runs from Port Botany and Sydney Airport to Macquarie Park; this is known as the Eastern Economic Corridor. The Eastern Economic Corridor contributed two thirds of the NSW economic growth for the 2015/16 financial year (Greater Sydney Commission, 2018b), and provides jobs in a range of

knowledge-based sectors including education, financial and other business services, communications, high-tech manufacturing and biotechnology (NSW Government, 2014). The *Greater Sydney Region Plan* is built on a vision of three cities where most residents live within a 30 minute journey of their jobs, education and health facilities, and services.

Supporting the current needs and future growth of the North District, Eastern Harbour City and Eastern Economic Corridor through an efficient transport network is fundamental to maintaining the liveability, productivity and sustainability of Greater Sydney. Accordingly, the *Greater Sydney Region Plan* was prepared concurrently with the *Future Transport Strategy 2056* (NSW Government, 2018) and the *State Infrastructure Strategy 2018–2038* (Infrastructure NSW, 2018) to align land use, transport and infrastructure outcomes for Greater Sydney.

The North District's economy is focused on the cluster of strategic centres along the Eastern Economic Corridor, including North Sydney, St Leonards, Chatswood, Macquarie Park, and centres further north in the district including Frenchs Forest and Brookvale-Dee Why. These centres play an important economic role in supporting the growth of Sydney as a global city.

The North District is home to 886,550 residents (or 19 per cent of Greater Sydney's population), which is forecast to increase by 18 per cent by 2036. The North District accommodates 483,300 jobs (or 20 per cent of Greater Sydney's jobs) (Greater Sydney Commission, 2018b). The highest share of employment in the North District is in knowledge-intensive and professional jobs (35 per cent compared to the Greater Sydney average of 32 per cent) and health and education (21 per cent compared to the Greater Sydney average of 19 per cent) (Greater Sydney Commission, 2018b). These sectors are among the fastest growing in the North District, reinforcing their significance in the North District's economy and, more broadly, to Greater Sydney (Greater Sydney Commission, 2018b).

Access between the North District and employment hubs along the Eastern Economic Corridor is primarily provided by private vehicle and bus services using the Military Road/Spit Road (A8) and Warringah Road (A38)/Eastern Valley Way corridors. These arterial links are highly congested and unreliable during peak periods. As a result, a small proportion of jobs within Greater Sydney are accessible to North District residents within 30 minutes by private vehicle or public transport during the morning peak.

The Greater Sydney Commission's *Greater Sydney Region Plan* focuses on concentrating jobs and education facilities around strategic centres. Within the North District, this includes Frenchs Forest, Chatswood, St Leonards and North Sydney. The Greater Sydney Commission lists Frenchs Forest as a key catalyst to attract complementary health services and develop as a major employment hub for the Northern Beaches. This has been supported by the Northern Beaches Hospital road upgrade project, which has improved access to the Northern Beaches Hospital and increased the capacity of the broader road network, particularly along Warringah Road.

The Northern Beaches is the largest population centre within the North District and has a population of about 273,000. Since 1981, annual residential population growth on the Northern Beaches has been below the Greater Sydney average, typically tracking at about one per cent, or half the growth rate of Greater Sydney (Bureau of Transport Statistics, 2016). Jobs growth on the Northern Beaches is also below average relative to other parts of Sydney, with jobs forecast to grow by 0.8 per cent per annum compared to a metropolitan average of 1.1 per cent (excluding the Harbour CBD and Parramatta).

The COVID-19 pandemic is an unprecedented event that has changed the way people work and their travel patterns, while creating some uncertainty about the future of the NSW economy. While it is difficult to fully assess the impact of the event, evidence of Greater Sydney's resilience to such disruptions is already apparent. In Greater Sydney, traffic levels on most roads have returned to those experienced before NSW Government restrictions for COVID-19 were put in place. This indicates a relatively rapid response to the event by the city, and suggests that the movement of people, goods and services and demand for road capacity is returning to conditions similar to those prior to the COVID-19 pandemic. The NSW Government is demonstrating its commitment to supporting the recovery from the COVID-19 pandemic through its guaranteed infrastructure pipeline to drive the creation of jobs and contribute to economic growth. The project is part of this

pipeline. While the COVID-19 pandemic (along with other unprecedented events such as bushfires) presents short to medium-term challenges for Sydney (and NSW more broadly), the project has been developed with a long-term view to address the challenges Greater Sydney will face over the next 40 years, and to deliver long-lasting benefits for road users, communities and businesses. As such, the need for the project and other strategic transport projects to meet the demands of a growing population and economy remains critical to ensuring the future success of Sydney.

Additional key strategic planning and policy documents relevant to the project are discussed in Section 3.7.

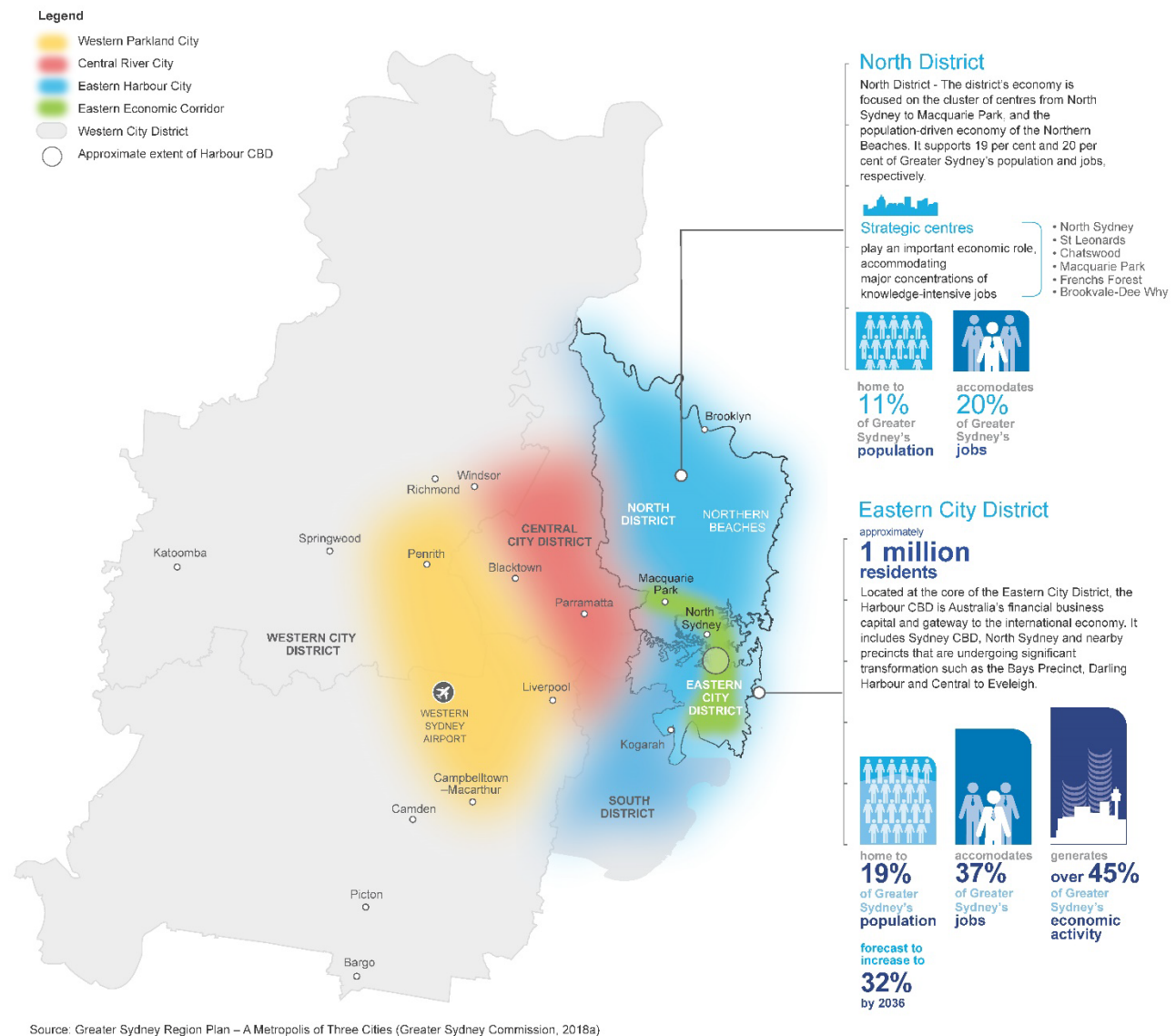


Figure 3-1 Key metrics of Sydney's Eastern City and North District

3.2 The North District's road transport challenge

Freight services, public transport and other road users travelling to and from the Northern Beaches region currently experience some of the slowest and most unreliable journey times across Greater Sydney. The transport challenges for the North District and Northern Beaches region are the product of a number of key issues, summarised below:

- *High traffic volumes and limited capacity at the eastern Sydney Harbour and Middle Harbour crossings, and roads around the Harbour CBD*
 - Network data demonstrates that incidents on the Sydney Harbour crossings and their approaches heavily impact journey times for freight, buses and private vehicles travelling on the arterial network across the Northern Beaches region
 - The limited alternative routes and high demand for the eastern Sydney Harbour and Middle Harbour crossings result in high levels of congestion, and make these cross-harbour corridors critical to the performance of the broader motorway and arterial road network
 - The performance of the road crossings of Sydney Harbour and Middle Harbour are critical to the performance of the arterial network servicing the Northern Beaches (refer to Figure 3-4) – particularly for north-south trips
 - It has long been understood that the benefits of upgrading road capacity to the Northern Beaches region would not be realised without addressing downstream capacity constraints at the Sydney Harbour crossings and beyond.
- *Limited arterial road capacity servicing the Northern Beaches region*
 - The Northern Beaches is connected to the rest of Greater Sydney by a small number of transport corridors. Just three road corridors, including only two Middle Harbour crossings, connect the Northern Beaches with the rest of Greater Sydney:
 - Mona Vale Road (A3)
 - Military Road/Spit Road (A8)
 - Warringah Road (A38)/Eastern Valley Way.

These three corridors are required to accommodate journeys to and from strategic centres across Greater Sydney, as well as local and intraregional trips, including a large number of bus trips.

 - The Mona Vale Road, Military Road/Spit Road and Warringah Road/Eastern Valley Way road corridors generally operate well over capacity during peak periods. This contributes to high levels of congestion, long and unreliable journey times and, consequently, poor accessibility to and from the region. This poor accessibility hinders daily access for people and goods travelling to, from, and within the region, increasing the time people spend commuting and restricting opportunities for growth in the strategic centres
 - The limited number of corridors connecting the Northern Beaches to the rest of Greater Sydney means that the network is very susceptible to major delays caused by incidents. Network data demonstrates that an incident on one corridor servicing the region can have major impacts on journey times across the broader road network.
- *Low population density across the Northern Beaches region*
 - While the Northern Beaches region is home to a large population, the population density is relatively low. This results in a wide variety of origins and destinations for transport journeys that are not well suited to high-frequency mass transit modes
 - Accordingly, the most appropriate transport modes for the region continue to be road based, including high-quality express bus services such as the B-Line. These modes provide the greatest flexibility to service the diverse trip needs of the dispersed Northern Beaches population

- However, the effectiveness of express bus services will diminish without appropriate improvements to road capacity and travel reliability.
- *Travel time reliability and speed of public transport journeys constrained by a congested road network*
 - The effectiveness and travel time reliability of the public transport network servicing the region is constrained by the capacity of the arterial road network, particularly the Military Road/Spit Road corridor which is the primary bus corridor between the Northern Beaches and Harbour CBD
 - The Military Road/Spit Road corridor also serves as the key corridor for all other road traffic for both interregional journeys between the Northern Beaches and Harbour CBD as well as local trips, resulting in heavy and conflicting road transport demands on this corridor and consequently, poor travel speeds during peak periods.

Further detail on these transport challenges and their influence on the proposed design for the Beaches Link and Gore Hill Freeway Connection project is provided in the following sections of this chapter.

3.2.1 High traffic volumes and limited capacity at the eastern crossings of Sydney Harbour and roads around the Harbour CBD and North District

The Eastern Harbour City has the largest concentration of jobs in Greater Sydney, accommodates the most productive industries and is home to a highly skilled workforce. Accordingly, the eastern motorway crossings of Sydney Harbour and crossings of Middle Harbour are critical links in Sydney's motorway and arterial road network. These major transport corridors around the Harbour CBD are critical to the performance of the arterial network servicing the Northern Beaches, particularly for north-south trips, and are some of the busiest in Greater Sydney and indeed in Australia, including:

- Spit Road/Spit Bridge – a critical connection to and from the Sydney CBD and Northern Beaches, carrying 69,500 vehicles per day and over 34,000 bus passengers per day (Transport for NSW, 2019)¹
- Warringah Road/Roseville Bridge – a critical connection between employment centres at Chatswood and Macquarie Park and the Northern Beaches, carrying 79,000 vehicles per day and over 9,500 bus passengers per day (Transport for NSW, 2019)²
- Sydney Harbour Bridge (Bradfield Highway and Cahill Expressway) – one of the busiest roads in NSW, carrying 165,000 vehicles a day and over 79,000 bus passengers per day (Roads and Maritime, 2017)
- Sydney Harbour Tunnel – the eighth busiest road in NSW, carrying 94,000 vehicles a day (Roads and Maritime, 2017)
- The Warringah Freeway – the busiest road in NSW, carrying over 240,000 vehicles per day and over 100,000 bus passengers per day (Roads and Maritime, 2017)
- Sydney Harbour Bridge railway crossing – an essential link on the Sydney Trains network, accommodating the T1 North Shore and Western Line and T9 Northern Line services (Sydney Trains, 2015)

Key metrics for the Eastern Harbour City's road crossings of Middle Harbour are shown in Figure 3-2.

¹ Note: Existing traffic data sourced prior to the COVID-19 pandemic

² Note: Existing traffic data sourced prior to the COVID-19 pandemic

Spit Bridge

**10th busiest road corridor
in NSW**



over
69,500 vehicles per day
34,000 bus passengers per day

Current average travel speeds
below 30 km per hour*
on Spit and Military Roads



Travel speeds are expected to fall
by about 40 to 60% by 2037

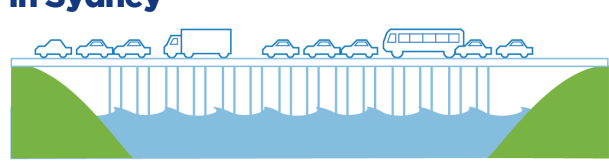
1587 unplanned incidents
each year on the Spit Bridge
and Military Road corridor



*AM Peak

Roseville Bridge

**3rd most congested road corridor
in Sydney**



over
79,000 vehicles per day
9,500 bus passengers per day

Current average travel speeds below
28km per hour* on Warringah Road
and Roseville Bridge



Travel speeds are expected to fall
by about 50% by 2037

370 unplanned incidents
each year on the Warringah
Road corridor



Figure 3-2 Key metrics for the critical Middle Harbour road crossings

The *Australian Infrastructure Audit 2019* (Infrastructure Australia, 2019) listed the Eastern Distributor, Sydney Harbour Bridge, Warringah Freeway and Gore Hill Freeway among Australia's most congested road corridors, generating a congestion cost of \$65,000 per day in 2016. If no action is taken, this is forecast to rise to \$98,000 per day by 2031, indicating that as congestion on these corridors increases, so too would the costs.

Infrastructure NSW has estimated that the economic risk to growth and productivity posed by traffic congestion in the Eastern City District is about \$5 billion a year and is forecast to increase to about \$8 billion annually by 2020. Infrastructure NSW has observed that *"without corrective action, congestion will worsen – and the costs to business and the community will escalate – as the city's population grows"* (Infrastructure NSW, 2014).

In addition to the large number of customers who rely on these corridors, the limited capacity and number of alternative routes for crossing Sydney Harbour make these corridors critical to the performance of the broader motorway and arterial road network. Network data demonstrates that incidents on the harbour crossings and their approaches can greatly impact journey times for freight, buses and private vehicles travelling north and south on the arterial network servicing the Northern Beaches region, with Military Road and Spit Road particularly affected.

During 2019, there were 1149 incidents on the Sydney Harbour Bridge and its approaches (including the Warringah Freeway), further impacting journey times for vehicles travelling to and from the North District and Northern Beaches region. Without intervention, the predicted growth in traffic demand over time would result in further increases in journey time delays and deterioration of road travel reliability.

In addition to high traffic volumes, a major contributor to congestion around the Harbour CBD and North District is that many of the most critical road corridors, including the Sydney Harbour Bridge, Sydney Harbour Tunnel, ANZAC Bridge, Western Distributor, Military Road, Spit Road, Warringah Road and Eastern Valley Way, perform both bypass and access functions. The dual function of these corridors is reflected in the high proportion of vehicles that use them to travel to destinations

other than the Sydney CBD (see Figure 3-3). This contributes to high levels of congestion as well as poor network outcomes, as bypassing traffic is impacted by congested collector/distributor roads.

Supplementing capacity and reducing the conflict between access and bypass functions for the Sydney Harbour Bridge, Sydney Harbour Tunnel, ANZAC Bridge, Western Distributor, Military Road, Spit Road, Warringah Road and Eastern Valley Way is therefore a key element of the integrated transport network required to support the liveability and productivity of the Eastern Economic Corridor and its connections with international gateways and their surrounds. This is also a key step in supporting and enabling future strategic links, including Beaches Link.

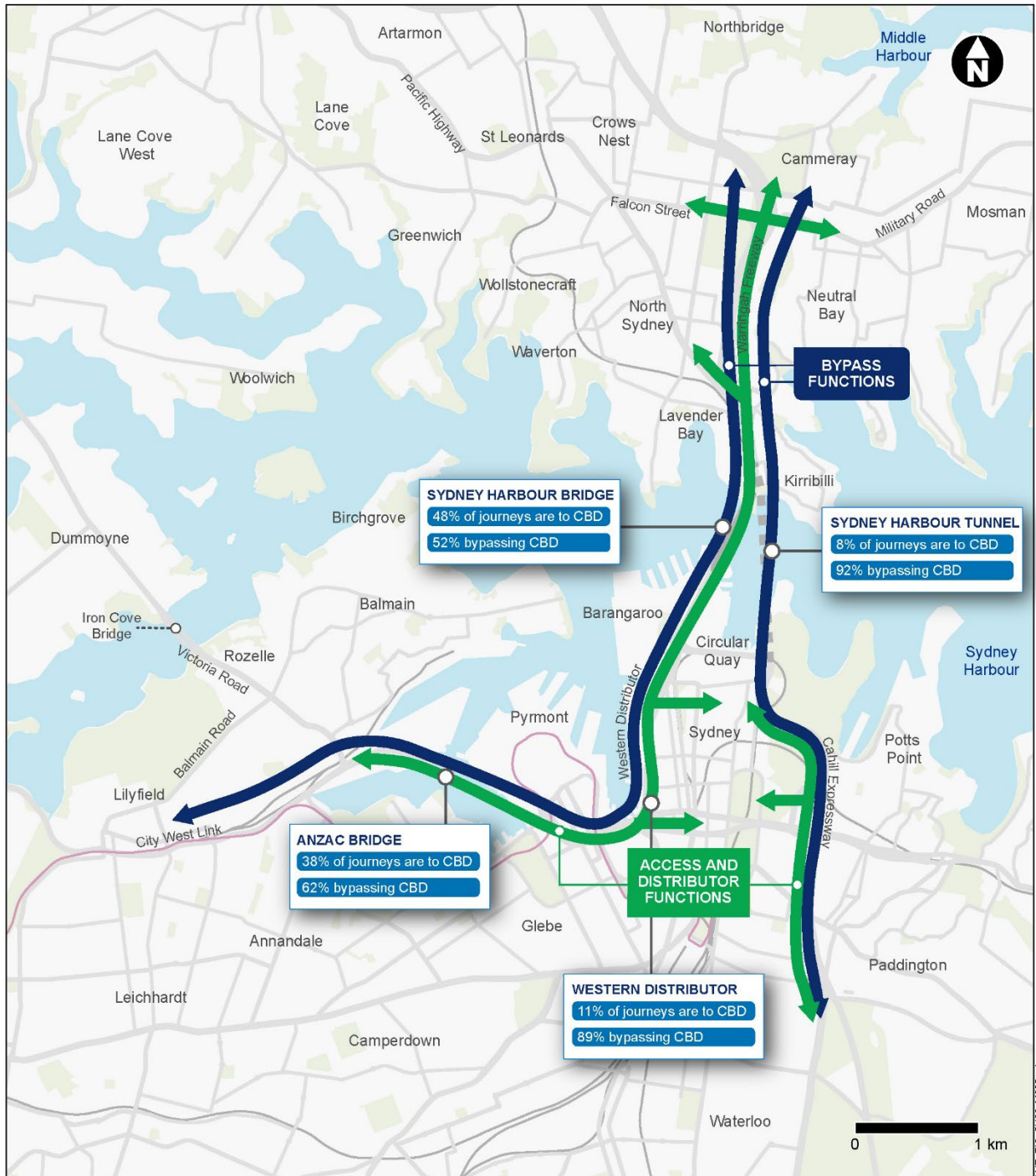


Figure 3-3 Function of critical road corridors around the Harbour CBD

3.2.2 Limited transport corridors connecting the region

The Northern Beaches is connected to the rest of Greater Sydney by a small number of transport corridors, which contributes to high levels of congestion, long and unreliable journey times and, consequently, poor accessibility to and from the region. Just three road corridors connect the Northern Beaches with the rest of Greater Sydney:

- **Mona Vale Road (A3)** is the most northerly road corridor. It is an arterial road from Mona Vale to North Ryde and onward, to the South, Central City and Western City Districts.

Mona Vale Road carries about 60,000 vehicles per day, with around 4850 vehicles during the morning peak and 4700 vehicles during the afternoon peak, and is used by private vehicles, heavy vehicle freight, light commercial vehicles and several bus routes by both public and private operators connecting Mona Vale with Gordon and Macquarie Park.

- **Warringah Road (A38)** is an east–west part-arterial and part-motorway connection from Brookvale to Chatswood via Frenchs Forest.

Carrying about 80,000 vehicles per day, including 5850 vehicles during the morning peak and 5800 vehicles during the evening peak, Warringah Road is the third most congested road in Sydney. This route serves private vehicles and freight, including journeys to and from the Harbour CBD via Eastern Valley Way and to Chatswood, Macquarie Park and other centres to the west.

Given the pressure on the Military Road/Spit Road corridor, Warringah Road also carries vehicles that are making north-south journeys via Eastern Valley Way and using local sub-arterial roads including Willoughby Road, Flat Rock Drive, and Strathallen Avenue to access the Warringah Freeway and North Sydney.

Warringah Road also carries several bus routes connecting Manly with Chatswood via Brookvale-Dee Why and Frenchs Forest, with about 18 buses traveling on this corridor in the AM peak one hour (Transport for NSW, 2016d). About 9500 bus passengers travel along Warringah Road per day (Transport for NSW, 2019). Planning is underway for a rapid bus system from Dee Why to Chatswood which would benefit from reduced congestion on Warringah Road.

- **Military Road/Spit Road (A8)** is the most southerly road corridor and is a north–south arterial road from Seaforth to North Sydney and the Warringah Freeway. This corridor is the primary route for private vehicles and buses travelling between the Northern Beaches, Harbour CBD and North Sydney.

Military Road and Spit Road are the seventh and tenth busiest roads, respectively, in NSW in the AM peak, carrying about 70,000 vehicles per day, including about 4250 vehicles during the morning peak and 4750 vehicles in the evening peak.

A total of 43 bus routes connect the Northern Beaches via the Spit Bridge, with 117 bus movements across the bridge in the AM peak one hour. The number of bus routes increases to 56 on Military Road. The corridor is serviced by the B-Line which would benefit from reduced congestion on the route. About 66,000 bus passengers travel along Military Road per day, with the Spit Bridge remaining a critical connection to and from the Sydney CBD and Northern Beaches, carrying over 34,000 bus passengers per day (Transport for NSW, 2019).

The region is particularly reliant on the most southerly corridors: the Warringah Road via Roseville Bridge and the Military Road/Spit Road via Spit Bridge corridors. Currently, these links carry 71 per cent of all interregional road journeys to and from the Northern Beaches, with traffic volumes forecast to increase by about 10 per cent by 2037 (see Figure 3-4).

Sydney's worst road congestion occurs between Balgowlah and Sydney Harbour through Mosman and Cremorne (Grattan Institute, 2017). The Spit Bridge opens regularly to allow boats to navigate Middle Harbour, resulting in traffic delays. However, even with the bridge down, morning delays on this route are greater and more unpredictable than other routes in Greater Sydney. As a result,

Balgowlah commuters to the Sydney CBD need to allow 40 minutes to get to work on time; or 23 minutes longer than the trip would take without traffic (Grattan Institute, 2017).

The *Australian Infrastructure Audit 2015* (Infrastructure Australia, 2015), identified the east–west corridor (Warringah Road between Chatswood and Narraweena) as generating the third highest congestion cost of all road corridors across Sydney, Wollongong and Newcastle. This is based on a delay cost per lane kilometre of \$2.18 million. The Audit estimates that by 2031 this will increase to \$6.16 million, making it the second-most costly corridor for congestion behind the Warringah Freeway (Infrastructure Australia, 2015).

The heavy reliance on these corridors results in them being highly congested and journeys that rely on them are highly susceptible to delays caused by incidents. Current average travel speeds in the AM peak are below 30 km/h on Military Road and Spit Road. Travel speeds are expected to fall by about 40 to 60 per cent in the southbound direction and about 20 per cent in the northbound direction by 2037. Similarly, average travel speeds for trips on Warringah Road in the westbound direction between Frenchs Forest and North Sydney are expected to drop below 15 km/h in the AM peak (a decrease of about 54 per cent) by 2037.

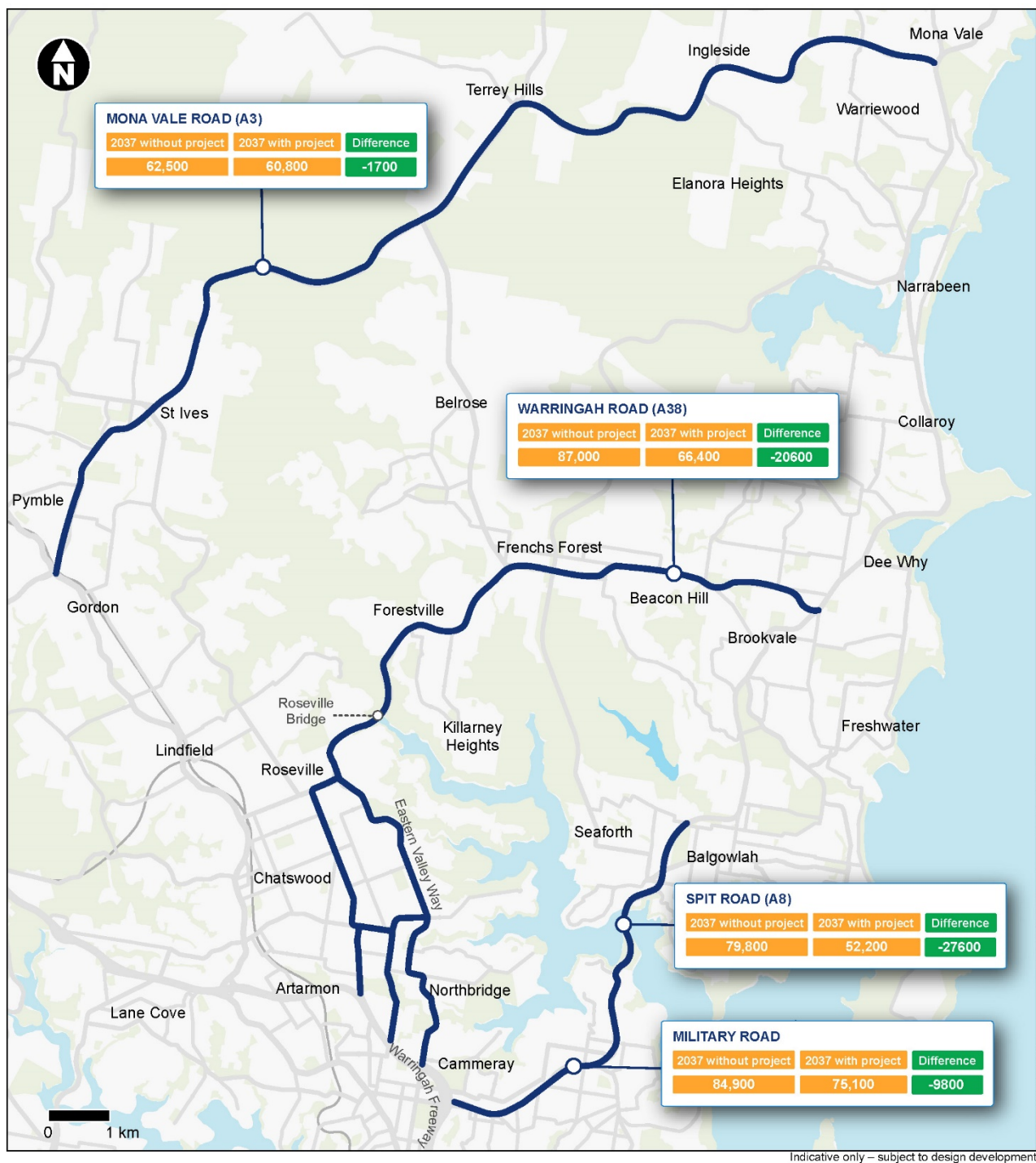


Figure 3-4 Forecast change in weekday traffic volumes average (two-way) in the AM peak on key Northern Beaches corridors by 2037

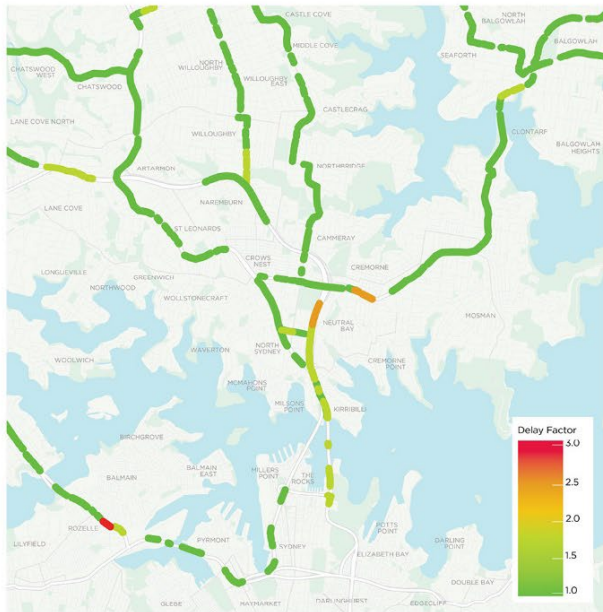
3.2.3 Low resilience in the transport network connecting the Northern Beaches

The high road demand and limited number of corridors connecting the Northern Beaches means that incidents on these corridors have significant impacts on journey times to and from the region. In 2019, there were 1587 unplanned incidents on the Military Road/Spit Road corridor, and 370 unplanned incidents on Warringah Road.

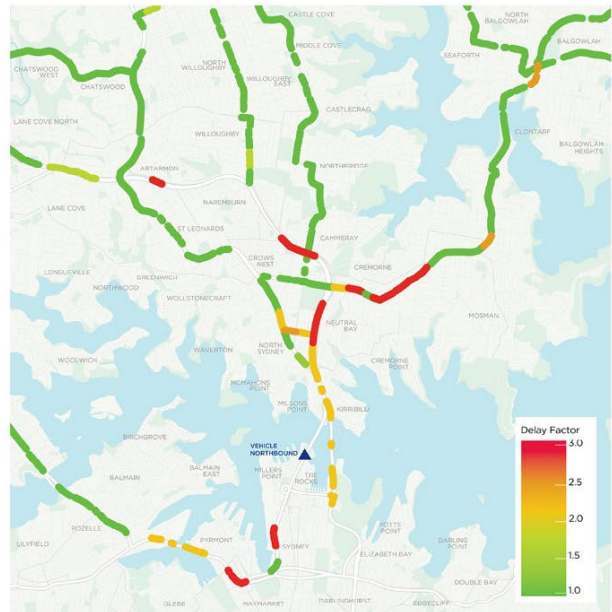
In 2036, on a network wide level, the lack of network resilience to incidents on the Military Road/Spit Road corridor is estimated to cost \$13 million annually. As congestion on this route increases, so too would the costs to the economy of the North District.

The low resilience of the network to incidents is demonstrated by the case study presented in Figure 3-5 which traces the delay impacts of an incident that occurred on the Sydney Harbour Bridge during peak hour in 2016. The incident resulted in the closure of four lanes of the Sydney Harbour Bridge which caused major delays across large parts of the network, including for motorists in the Sydney CBD, the Lane Cove Tunnel on the Eastern Distributor and along Military Road at Mosman. Delays resulting from the incident persisted along the Gore Hill Freeway and Military Road for more than 90 minutes following the incident, with traffic conditions returning to normal about two hours after the incident.

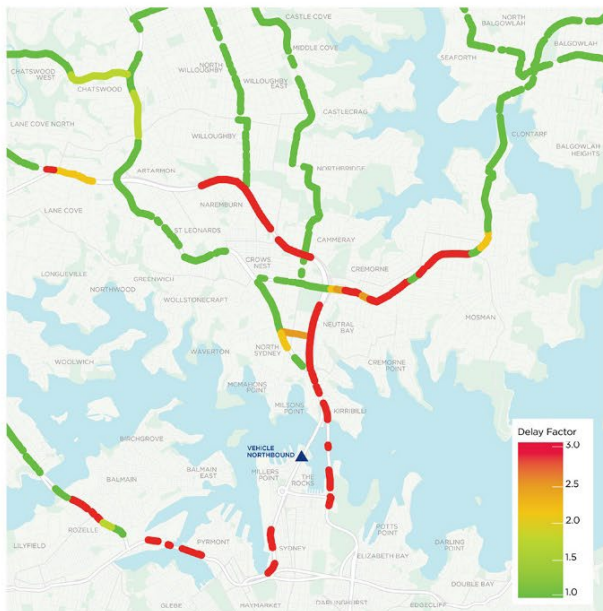
5.15pm – before the incident



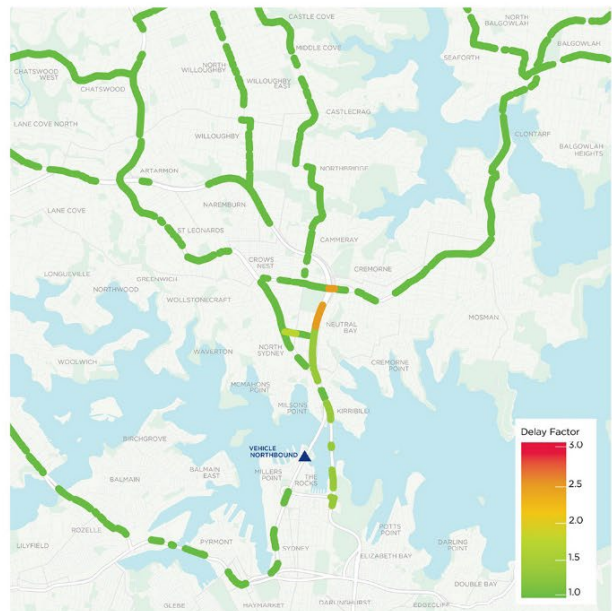
5.45pm – 15 minutes after the incident



7.15pm – 1.5 hours after the incident



8.15pm – 2.5 hours after the incident



Traffic incident occurring on northbound lane of Sydney Harbour Bridge at 5.30pm

1. Traffic flow 15 minutes before the incident is relatively normal.
2. Traffic flow 15 to 30 minutes after the incident is delayed, with tailbacks developed north of the bridge to the Warringah Freeway and Military Road, and south of the bridge near Western Distributor and ANZAC Bridge.
3. Traffic flow 90 to 105 minutes after the incident, tailbacks continue and worsen north and south of the bridge, extending to Gore Hill Freeway to the north and Victoria Road (at Rozelle) to the south.
4. Traffic flow 2.5 hours after the incident has returned to normal.

Figure 3-5 Delay impacts of an evening incident on Sydney Harbour Bridge

3.2.4 Travel time reliability and speed of public transport journeys constrained by a congested road network

As outlined in the *Northern Beaches Transport Strategy 2038* (Northern Beaches Council, 2018a), residents on the Northern Beaches rely heavily on private vehicles and public buses for travel. With the exception of the Manly ferry, bus transport is the only means of public transport in the region. The travel time reliability and speed of public transport journeys for Northern Beaches bus passengers is strongly linked to the capacity of the road network the buses use and the road network's ability to cope with incidents.

The primary suburban bus routes to and from the Northern Beaches use both the Military Road/Spit Road (A8) and Warringah Road(A38)/Eastern Valley Way corridors to connect with the Harbour CBD and employment centres in Chatswood and Macquarie Park respectively. As outlined in Section 3.2.1, these roads are some of the most utilised bus routes with the Spit Bridge (A8) carrying over 34,000 bus passengers per day, while the Roseville Bridge (A38) carries over 9500 bus passengers per day.

The commencement of the B-Line program in 2017 has successfully improved public transport capacity and journey times to and from the Northern Beaches region, with travel times reduced by about 20 minutes for passengers using the service from Mona Vale to the Sydney CBD during peak periods. Despite these improvements to bus performance, bus travel times between Mona Vale and the Sydney CBD remain in excess of 60 minutes during peak periods. The key constraint in peak periods is the capacity of the Military Road/Spit Road corridor which serves both interregional journeys between the Northern Beaches and Sydney CBD as well as local trips. This places heavy and conflicting road transport demands on the corridor, resulting in poor travel speeds during peak periods. The lack of spare capacity on this corridor also amplifies the impacts of incidents, resulting in poor travel speed reliability.

Buses continue to be the most appropriate public transport mode for the Northern Beaches area given the low population density and subsequently wide variety of origins and destinations for the commuters in the area. Buses provide the ability for flexibility and will be critical in supporting predicted future demand in the area. However, without measures to relieve capacity constraints on the arterial road network, the ongoing success of the B-Line as well as opportunities to implement new express bus services, would be limited in the future as a result of continuing growth in traffic and particularly as express and limited stop services continue to clash with more local bus routes.

There are multiple local and express bus services, contributing to competition for road space and bunching

A key contributor to low bus speeds, particularly in corridors like Military Road/Spit Road, is the high number of buses that also mix with cars and other traffic, competing for limited road space and resulting in increased congestion and lengthy delays. Each day, 43 bus routes traverse the Spit Bridge, with 117 buses crossing it in the period 8am to 9am alone. A further 13 bus routes use Military Road, most carrying passengers to and from Mosman, Cremorne and Neutral Bay.

Bus journey times are unreliable

The journey times for bus services connecting the Northern Beaches to the Sydney CBD are affected by the capacity and conflicts on the existing arterial road network, resulting in some journey times being unreliable. The variability in journey times means that some customers need to incorporate additional time into their schedule, which affects the customer experience and imposes a cost on the productivity of Greater Sydney.

With the streamlining of bus services delivered through the B-Line program, bus service performance and travel time reliability has improved, and bus patronage has increased – with over 2000 weekly services providing enhanced services between Mona Vale and Wynyard. However, for these benefits to be sustained over the long term, investment in additional road capacity through alternative routes or modes for corridors at capacity, is critical to improve the transport performance of the network in this area. To support opportunities for further improvements,

including new express services to strategic centres such as North Sydney, Sydney CBD, Macquarie Park and St Leonards, a new motorway standard link is required.

3.3 Congestion impacting urban amenity across the Eastern City and North Districts

In addition to the transport challenges created by the limited arterial roads servicing the North District and Northern Beaches region, the current situation also has urban amenity implications. High through traffic and congestion along the arterial roads servicing the Northern Beaches undermines efforts to improve liveability in several inner urban areas along and next to these routes.

Across the Harbour CBD and Northern Beaches, several parts of the road network perform a 'place' function. This means that, as well as being transport corridors, parts of the road network are destinations in their own right, including for shopping and dining. These places play an important role in supporting the liveability, productivity and sustainability of Greater Sydney, and the transport network has an important role in supporting this objective, as reflected in 'Successful Places' being one of the six NSW-wide outcomes established by the *Future Transport Strategy 2056* (NSW Government, 2018).

The Military Road/Spit Road corridor is one of the busiest and most congested road corridors in NSW. In addition to local trips, about one third (33 per cent) of interregional journeys to and from the Northern Beaches pass through the corridor every day. Through traffic and congestion are a key cause of poor urban amenity along the corridor, impacting areas such as Neutral Bay, The Spit and Mosman. These impacts include restricted parking, reduced pedestrian and cyclist amenity, limited vegetation, and traffic noise and air quality impacts.

Congestion of these corridors also results in broader urban amenity impacts beyond the arterial corridors themselves, with drivers moving to local routes in an attempt to avoid congestion. Transport for NSW customer research carried out in 2017 indicates that 73 per cent of motorway users 'rat-run' to avoid congestion. Improving the core motorway and arterial capacity, resilience and reliability is a key part of the multi-modal transport network required to improve the amenity of local communities and reduce 'rat running'.

3.4 The Western Harbour Tunnel and Beaches Link program of works

The Western Harbour Tunnel and Beaches Link program of works is a major transport infrastructure program that would make it easier, faster and safer to get around Sydney. As Sydney continues to grow, faster and more reliable trips are essential to reducing congestion and providing new levels of access to jobs, recreation, and services such as schools and hospitals. By creating a western bypass of the Sydney CBD, the Western Harbour Tunnel would take pressure off the Sydney Harbour Bridge, Sydney Harbour Tunnel and ANZAC Bridge; while Beaches Link would create an alternative to the Military Road/Spit Road and Warringah Road corridors to relieve traffic pressure on the North Shore.

The program of works has been designed as part of an integrated transport network, with a focus on new public transport connections and improved journey time reliability for buses. It would also provide improvements to walking and cycling routes, providing more shared transport options.

The Western Harbour Tunnel and Warringah Freeway Upgrade project and the Beaches Link and Gore Hill Freeway Connection project are being delivered as separate projects, but have been developed as an integrated program of works known as the Western Harbour Tunnel and Beaches Link program.

The Western Harbour Tunnel and Beaches Link program of works comprises three core elements as illustrated in Figure 3-6.



Figure 3-6 Elements of the Western Harbour Tunnel and Beaches Link program of works

- **Warringah Freeway Upgrade** – An upgrade to about four kilometres of the Warringah Freeway to integrate with the Western Harbour Tunnel and Beaches Link and optimise the way the three harbour crossings will function into the future
- **Western Harbour Tunnel** – A new 6.5 kilometre cross-harbour motorway tunnel linking the Rozelle Interchange to the Warringah Freeway and Beaches Link near North Sydney. This new crossing will change the way people move around Sydney, creating a western bypass of the Sydney CBD, easing pressure on the congested Sydney Harbour Bridge, Sydney Harbour Tunnel and ANZAC Bridge, and enabling the new Beaches Link
- **Beaches Link** – A new seven kilometre motorway tunnel from the Warringah Freeway at Cammeray and the Gore Hill Freeway at Artarmon to Burnt Bridge Creek Deviation at Balgowlah and the Wakehurst Parkway at Killarney Heights, under Middle Harbour. Beaches Link also includes underground connections to and from the Western Harbour Tunnel and widening of the Wakehurst Parkway to two lanes each way between Killarney Heights and Frenchs Forest along with connection and integration works along the existing Gore Hill Freeway and surrounding roads at Artarmon.

In conjunction with the other road, rail, bus and light rail projects outlined in the *Future Transport Strategy 2056* (NSW Government, 2018), the Western Harbour Tunnel and Beaches Link program of works has been developed to meet the current and future transport needs of Sydney. The program of works represents an important step in the long-term development of Greater Sydney's strategic transport network. The program of works has been developed to address critical transport constraints in the motorway and arterial road network, and support the growth of the city and NSW, by improving the capacity, reliability, and journey time performance of the critical cross-harbour transport corridors near the Harbour CBD.

As well as relieving road congestion for freight operators and private vehicle commuters who are affected by limited road capacity to and from the Northern Beaches, the program of works has been designed as part of an integrated transport network with a focus on new public transport connections and improved journey times and journey time reliability for buses to provide major benefits to public transport commuters. This includes opportunities for new express bus services between the Northern Beaches, North Sydney, Sydney CBD, St Leonards and strategic centres to the south west and north west.

To ensure the design for the program of works addresses the transport challenges of the North District and Eastern Harbour City, the following objectives have been developed for the Western Harbour Tunnel and Beaches Link program of works:

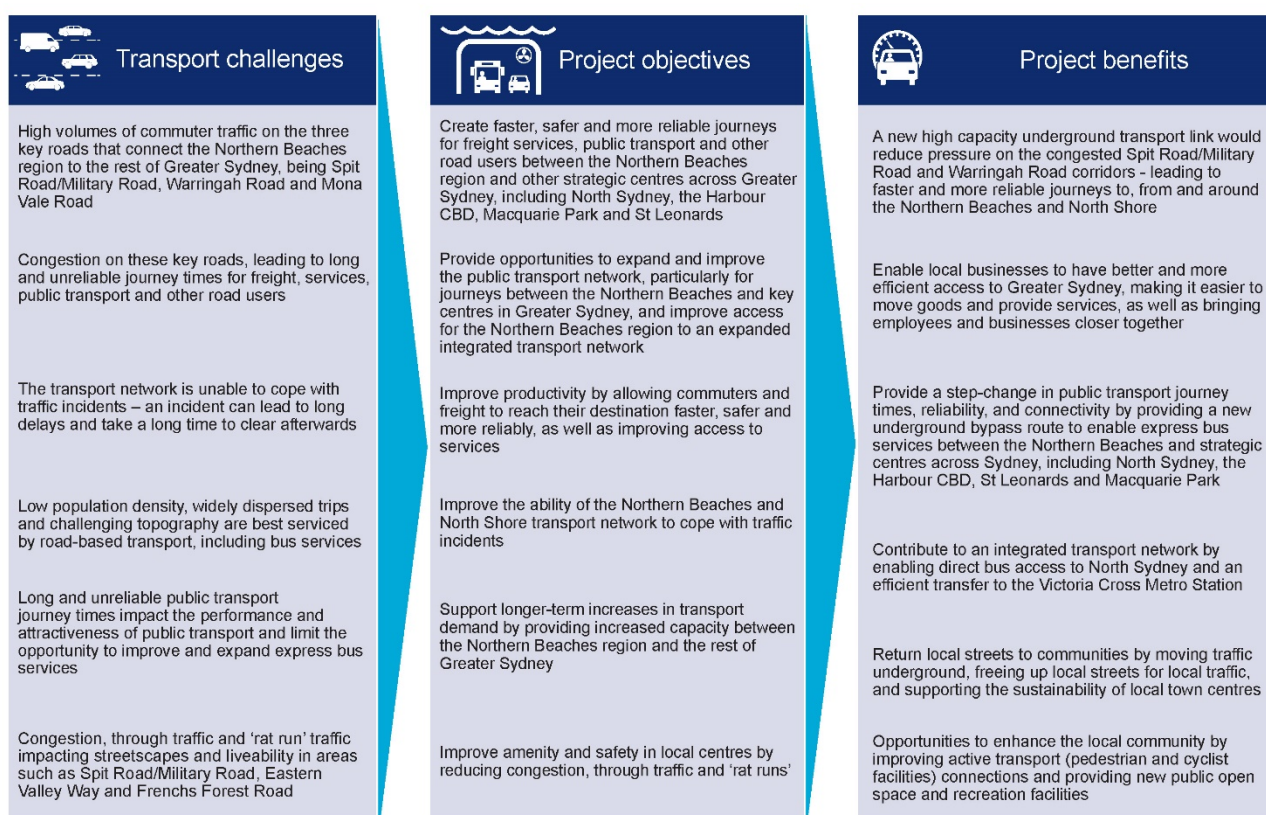
- Reduce congestion on distributor roads around the Harbour CBD, including the Sydney Harbour Bridge, Western Distributor and ANZAC Bridge
- Create faster, safer and more reliable journeys across Sydney Harbour, particularly for traffic bypassing the Harbour CBD to the west
- Improve productivity by allowing commuters and freight to reach their destination faster, safer and more reliably
- Increase the ability for the Harbour CBD road network to cope with traffic incidents

- Reduce travel times, delays and queuing on the Warringah Freeway by improving cross-harbour capacity and reducing merges and weaves, supporting long-term increased demand
- Improve streetscapes, sustainability and liveability across the Eastern City and North Districts by reducing congestion and through traffic in local centres.

The overarching objectives of the program of works translate into the following project specific objectives for the Beaches Link and Gore Hill Freeway Connection project:

- Provide increased capacity on the road network connecting the Northern Beaches region and Greater Sydney by reducing congestion and through traffic on arterial roads
- Create faster, more reliable journey times for freight services, public transport and other road users between the Northern Beaches region and other strategic centres across Greater Sydney, including North Sydney, the Harbour CBD, Macquarie Park and St Leonards
- Provide opportunities to expand and improve public transport journeys between the Northern Beaches and key centres across Greater Sydney, and improve access for the Northern Beaches region to an expanded transport network, including Victoria Cross Metro Station (opening 2024)
- Improve productivity and access to services by facilitating faster and more reliable journey times for commuters and freight to reach their destinations
- Increase the resilience of the Northern Beaches and North Shore road network to traffic incidents
- Improve urban amenity by reducing congestion, through traffic and rat-running on surface corridors.

A summary of the project challenges, corresponding objectives and overall project benefits are shown in Figure 3-7 and discussed in more detail in Section 3.6.



Note 1: Refer to Figure 3-1 for more information about the location of the Harbour CBD, Eastern City District and North District
 Note 2: Victoria Cross Metro Station, opening in 2024 as part of Sydney Metro City and Southwest project

Figure 3-7 Project challenges, objectives and benefits

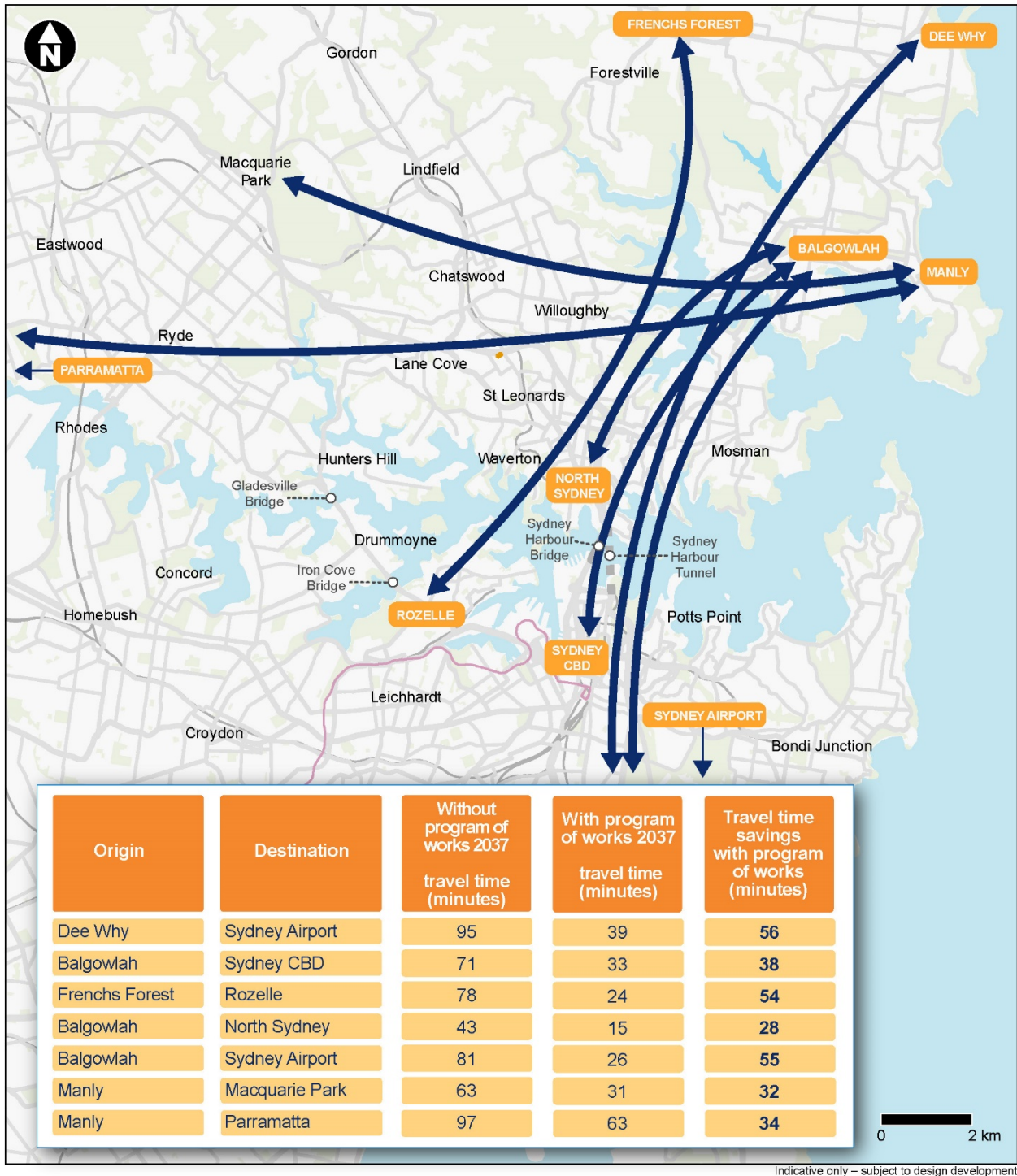
3.5 Key benefits of the Western Harbour Tunnel and Beaches Link program of works

The Western Harbour Tunnel and Beaches Link program of works would deliver new strategic road links for Greater Sydney, improving journey times for freight services, public transport and other road users and alleviating pressure on some of the city's most critical transport corridors. The program of works is designed to improve the capacity, reliability, and journey times on cross-harbour transport corridors near the Harbour CBD and improve connectivity to the Northern Beaches.

Key benefits of the program of works include:

- Delivering a new motorway crossing of Sydney Harbour, taking pressure off critical corridors including the Sydney Harbour Bridge, Sydney Harbour Tunnel, Western Distributor and ANZAC Bridge, and enabling the Beaches Link
- Improving the efficiency and safety of Australia's busiest road, the Warringah Freeway
- Providing a new motorway link between the Northern Beaches and the existing network near North Sydney and Artarmon, bypassing the congested Military Road/Spit Road and Warringah Road/Eastern Valley Way corridors
- Delivering faster and more reliable journey times for freight services, public transport and other road users who rely on the critical cross-harbour road corridors and arterial corridors connecting to the Northern Beaches region
- Increasing the ability for the Harbour CBD arterial road network to cope with traffic incidents by providing additional capacity and an alternative route to the heavily congested existing harbour crossings
- Enabling substantial improvements for public transport customers currently using some of Sydney's busiest road corridors – allowing for quicker and more reliable journey times for express bus services between the Northern Beaches and strategic centres including North Sydney, Sydney CBD, Macquarie Park and St Leonards via the motorway network
- Benefits to users of existing surface corridors by reducing congestion.

The program of works would support faster and more reliable travel times for journeys between the Northern Beaches region and key centres south and west of Sydney Harbour. For example, journeys from Dee Why to Sydney Airport are expected to be 56 minutes faster (total travel time 39 minutes) in the AM peak by 2037 (via the proposed Beaches Link, Western Harbour Tunnel, WestConnex and Sydney Gateway). Other key journey time improvements in the AM peak as a result of the program of works are shown in Figure 3-8.



Indicative only – subject to design development

Figure 3-8 Change in journey times in the AM peak as a result of the program of works by 2037

3.6 Key benefits of the Beaches Link and Gore Hill Freeway Connection project

The Beaches Link and Gore Hill Freeway Connection project is a vital part of the overall Western Harbour Tunnel and Beaches Link program of works.

The Northern Beaches and its strategic centres suffer from poor accessibility caused by limited transport capacity connecting the region and the resulting flow on effects for bus performance during peak periods. The project would provide a step-change in journey times and reliability, and resilience for the critical road network servicing the Northern Beaches region. This would deliver considerable benefits for freight services, public transport, and other users of the new and existing links and also enable amenity improvements in areas along and adjacent to the congested surface corridors.

Further detail on some of the key benefits of the project is provided in the following sections. Further information on the consistency of the project outcomes with strategic local, State and Australian Government objectives is provided in Section 3.7.

3.6.1 Reducing pressure on congested road corridors servicing the Northern Beaches and North Shore

The Beaches Link and Gore Hill Freeway Connection project would provide a new underground motorway bypass of the Military Road/Spit Road (A8) and Warringah Road (A38)/Eastern Valley Way corridors. The project would substantially improve journey times and trip reliability for millions of freight vehicles, public transport users and other commuters who rely on these transport links each year.

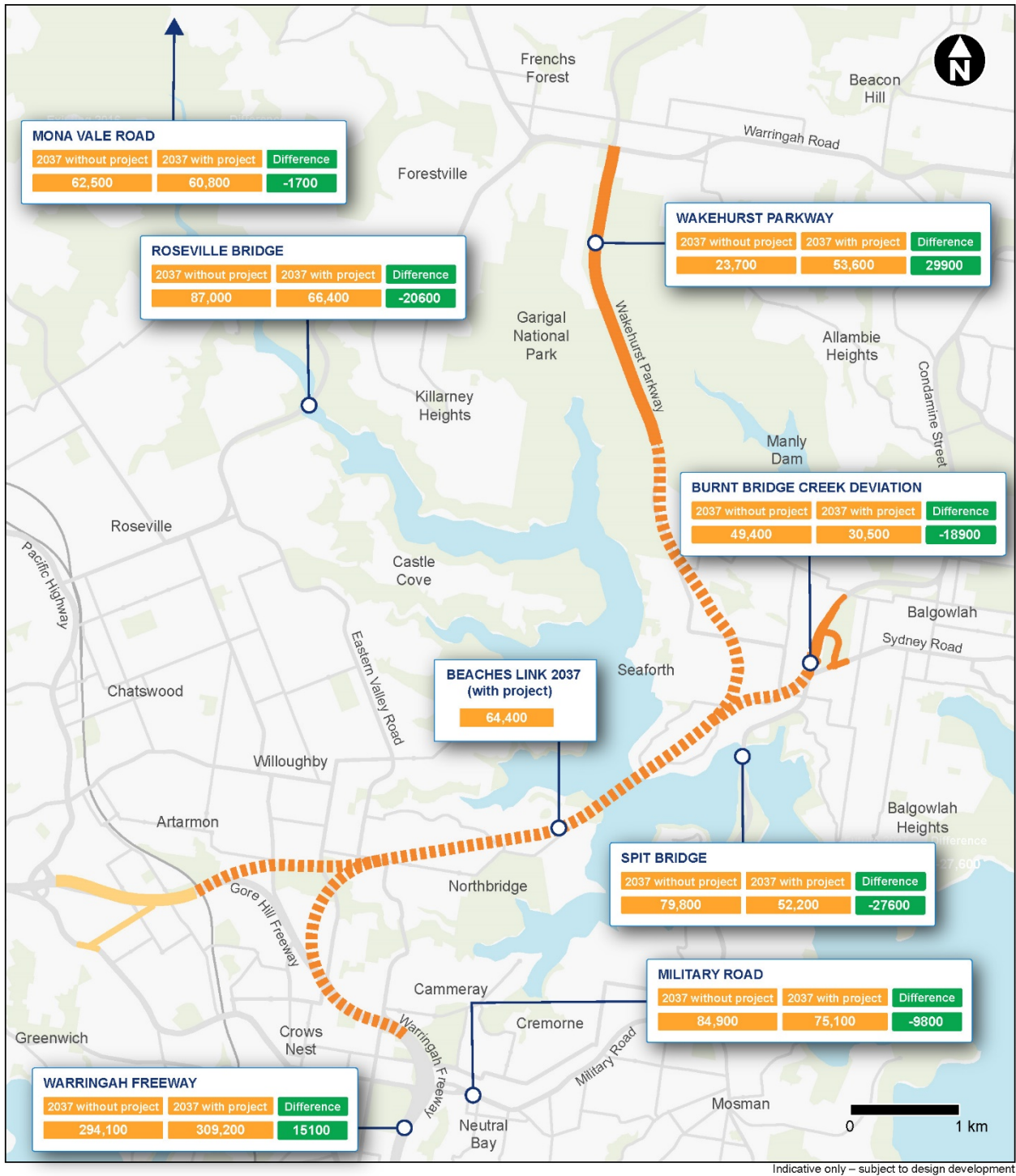
The project has been designed to provide motorway standard connectivity for both east-west journeys between the Northern Beaches and employment centres such as Chatswood and Macquarie Park, and north-south journeys including to and from the Sydney CBD. This is achieved by providing tunnelled connections to and from the Gore Hill Freeway and Warringah Freeway and the Western Harbour Tunnel. This is key to improving travel times for both north-south and east-west road journeys to and from the Northern Beaches, and alleviating congestion on a number of arterial roads in northern Sydney that are used for these journeys, including Military Road, Spit Road, Warringah Road, Boundary Street, and Eastern Valley Way.

The forecast major reductions in traffic volumes on major arterial routes around northern Sydney that are expected due to the project are shown in Figure 3-9. Analysis of the modelled forecast traffic demands across Middle Harbour with the project in 2037 indicates that:

- Peak period traffic demand on Military Road and Spit Road would decrease as a result of the project, by up to 11 per cent and 33 per cent respectively
- Peak period traffic demand on Warringah Road would decrease as a result of the project by up to 23 per cent
- Peak period traffic demand on Mona Vale Road would decrease by up to eight per cent as a result of the project
- Daily traffic demand on Eastern Valley Way would decrease substantially as a result of the project, by up to 40 per cent.

The overall reduction in traffic on the above surface arterial routes would result in improved travel speeds on these routes as a result of the project by 2037. This would deliver improved journey times for freight services, public transport and other road users that continue to use these routes.

Furthermore, reduced congestion on these surface arterial routes is expected to reduce the attractiveness of rat-running on existing surface roads including Eastern Valley Way, Frenchs Forest Road and Ourimbah Road, reducing traffic through surrounding urban and residential areas.



Legend

- Beaches Link
- Gore Hill Freeway Connection

Figure 3-9 Change in average weekday traffic volumes (two-way) on key road corridors by 2037

3.6.2 Creating faster, more reliable journeys for freight services and other road users between the Northern Beaches region and other strategic centres across Greater Sydney

Freight services and private vehicle commuters would benefit from the project through faster and more reliable road journey times between the Northern Beaches region and key centres across Greater Sydney. By connecting the Northern Beaches to the Sydney motorway network, the project would provide faster connections to strategic commercial and industrial centres across Greater Sydney. For example, customers travelling between Frenchs Forest and Macquarie Park would be able to bypass about 20 sets of traffic lights by using the Beaches Link tunnel.

The expected travel time savings for specific journeys in the AM peak are shown in Figure 3-8 which indicates shorter journey times when comparing the 2037 'with program of works' and 'without program of works' cases. Key improvements as a result of the project (in conjunction with the Western Harbour Tunnel and Warringah Freeway Upgrade) would include:

- Journeys from Frenchs Forest to Rozelle would experience a travel time saving of about 31 minutes. This shorter journey time would particularly benefit freight vehicles connecting to the M4-M5 Link at Rozelle
- Journeys to the west, from Manly to Macquarie Park, would experience a travel time saving of about 34 minutes
- Journeys from Balgowlah to North Sydney would experience a travel time saving of about 28 minutes
- Journeys from Dee Why to Kingsford Smith Airport would experience a 27 minute travel time saving.

The above travel time savings would provide the opportunity to investigate new high-quality express bus services to employment centres including Chatswood and Macquarie Park, as well as resulting in improved connectivity to the Sydney Trains network and new Victoria Cross Metro Station at North Sydney.

3.6.3 Creating faster, more reliable travel times and more direct routes for bus journeys between the Northern Beaches, the Harbour CBD and other strategic centres

In addition to the journey time and reliability benefits provided for freight services and private vehicle commuters, the project would unlock considerable improvements for public transport users travelling on some of Sydney's busiest road corridors. The project has been designed to complement and enhance the existing and future public transport network servicing the Northern Beaches region. The project would materially improve the capacity, efficiency and journey time reliability of bus services for the Northern Beaches region and ensure the longer-term success of the B-Line. The project would deliver this by:

- Relieving pressure on surface arterial roads, allowing surface bus routes to operate more efficiently
- Providing an underground bypass route, which would enable express bus services to travel via the tunnel and motorway network to destinations like North Sydney, the Harbour CBD, Macquarie Park and St Leonards, as shown in Figure 3-10. This would result in more rapid and reliable journey times and more direct routes for express bus services, while simultaneously improving the capacity and efficiency of existing surface corridors by reducing conflicts between express and multi-stop services.

The public transport network servicing the Northern Beaches region, including B-Line, is constrained by the performance of the existing surface arterial corridors, particularly the Military Road/Spit Road and Warringah Road/Eastern Valley Way corridors. By relieving pressure on these existing surface arterial road corridors, the project would support the operation of the B-Line as

well as local and interregional buses, by improving travel times and travel time reliability on these roads as a result of reduced traffic demand and congestion. Improvements in the capacity of the road network would encourage opportunities for new express bus services, as evidenced by the new rapid bus service from Dee Why to Chatswood which is currently being planned, which would benefit from reduced congestion on the Warringah Road corridor.

By reducing network congestion, and therefore improving network resilience and reliability, particularly in peak periods, the project would make bus routes to and from the Northern Beaches a more attractive transport option, supporting and encouraging a mode shift to public transport. New and improved bus priority infrastructure, dedicated bus bays and shared user underpasses offering access to bus stops that would be provided by the project would also improve efficiency and safety for road users and bus passengers.

By providing a new underground bypass route, the project offers the opportunity for express bus services in the Beaches Link tunnel between the Northern Beaches and strategic centres such as North Sydney, Sydney CBD, Macquarie Park and St Leonards via the new motorway network. These bus services would provide links to strategic stations on the Sydney Trains network, while also facilitating efficient access and interchange with the new Victoria Cross Metro Station at North Sydney, improving connectivity across the broader public transport network. Expansion of express bus services to take advantage of these opportunities would greatly improve the journey times, travel time reliability and connectivity for public transport services both within the Northern Beaches, and between the region and key centres across Greater Sydney.

The potential benefits outlined above only account for the diversion of express bus services to the Beaches Link tunnel and motorway network and improved surface conditions along existing key routes, meaning it is a conservative estimate of the overall public transport benefits and opportunities delivered by the project. It is expected that the bus network could be re-optimised to take advantage of broader opportunities (including provision of new services) unlocked by the project. The project would enable these opportunities for new services to be developed in response to diverse travel demands and future development.

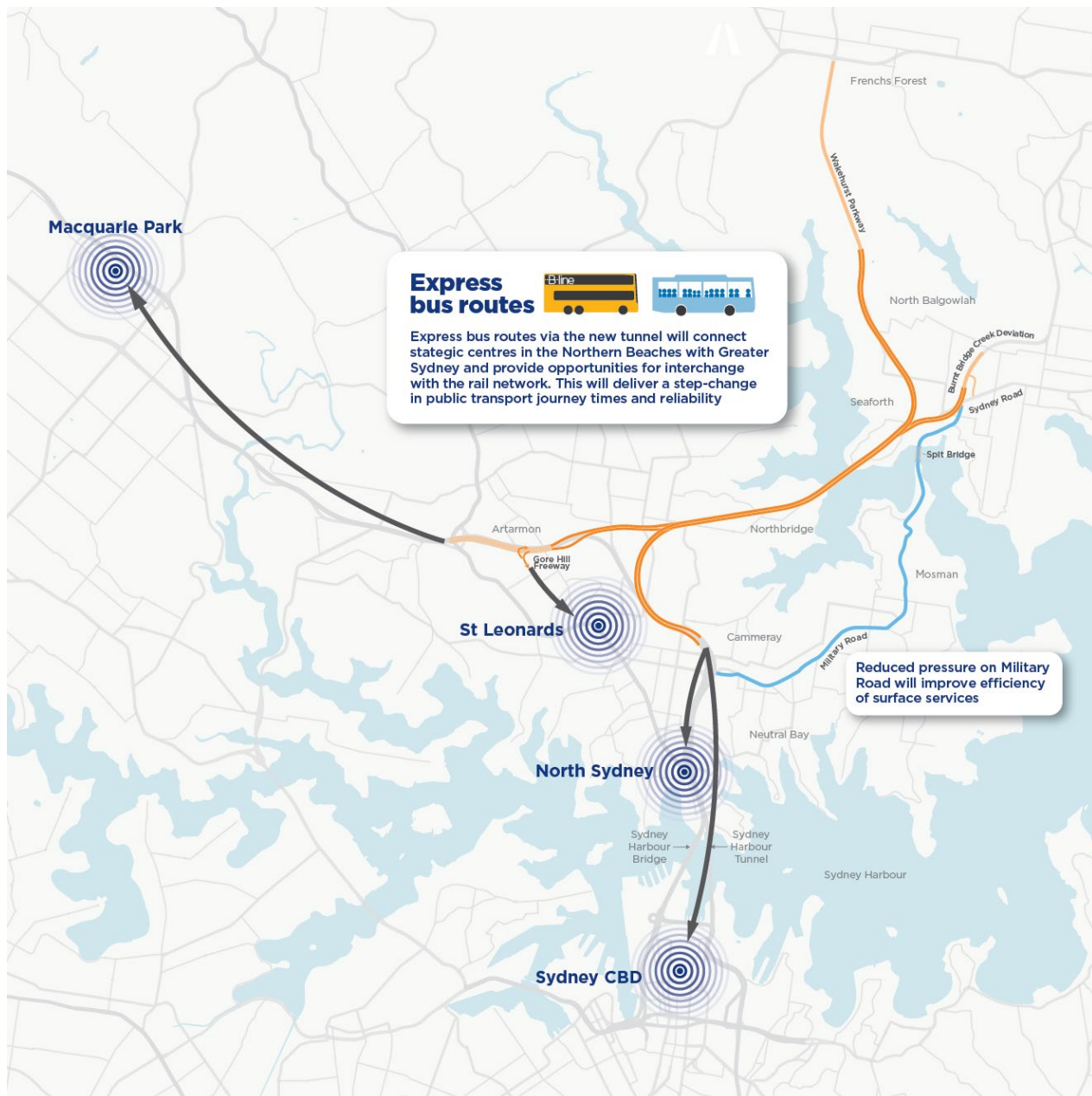


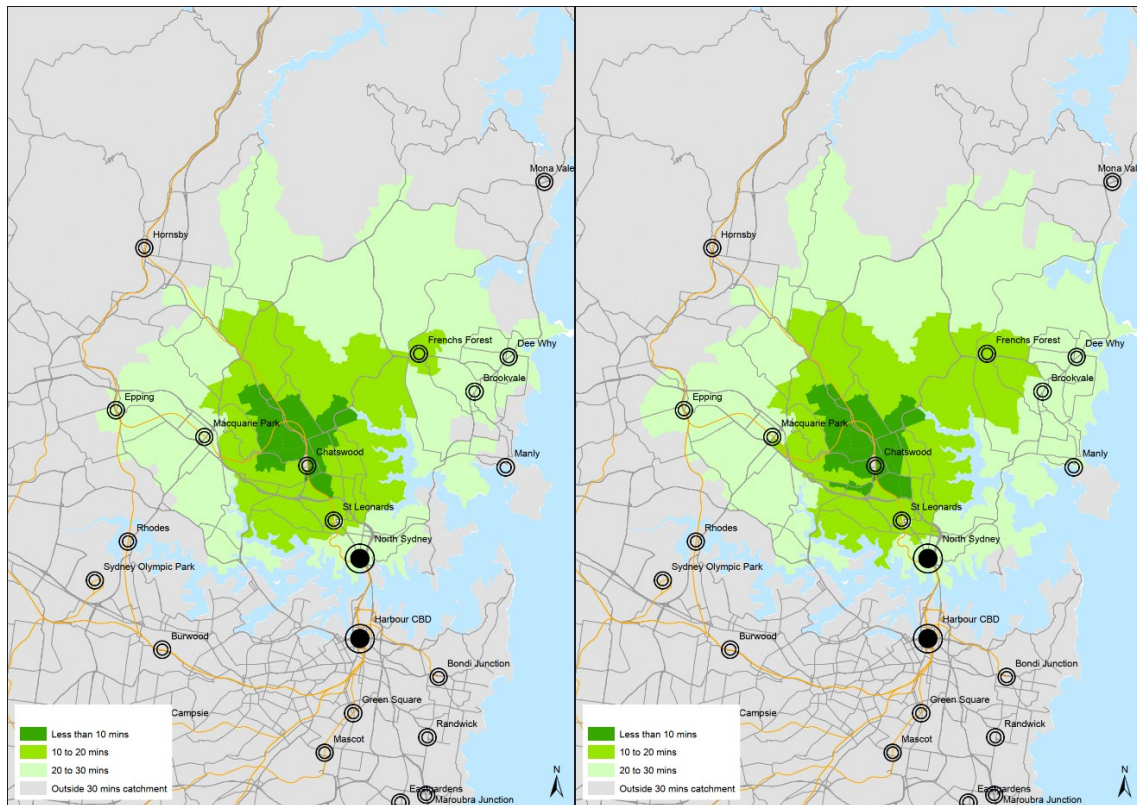
Figure 3-10 Express bus routes and connections to strategic centres

3.6.4 Improving productivity and enabling greater access to jobs and services for northern Sydney businesses and residents

The project would deliver labour supply benefits, including higher employment and better matching of skills and jobs, by improving accessibility. For workers, this is demonstrated by improved accessibility to employment. Once the project is operational, residents of the Northern Beaches and lower North Shore would enjoy improved access to jobs in other parts of Greater Sydney, in particular to jobs in the Harbour CBD and North Sydney CBD.

Given the contribution of the Harbour CBD to New South Wales' gross state product, supporting the future growth and productivity of the Eastern Economic Corridor by enabling greater business-to-business connections would deliver substantial benefits for NSW and the national economy.

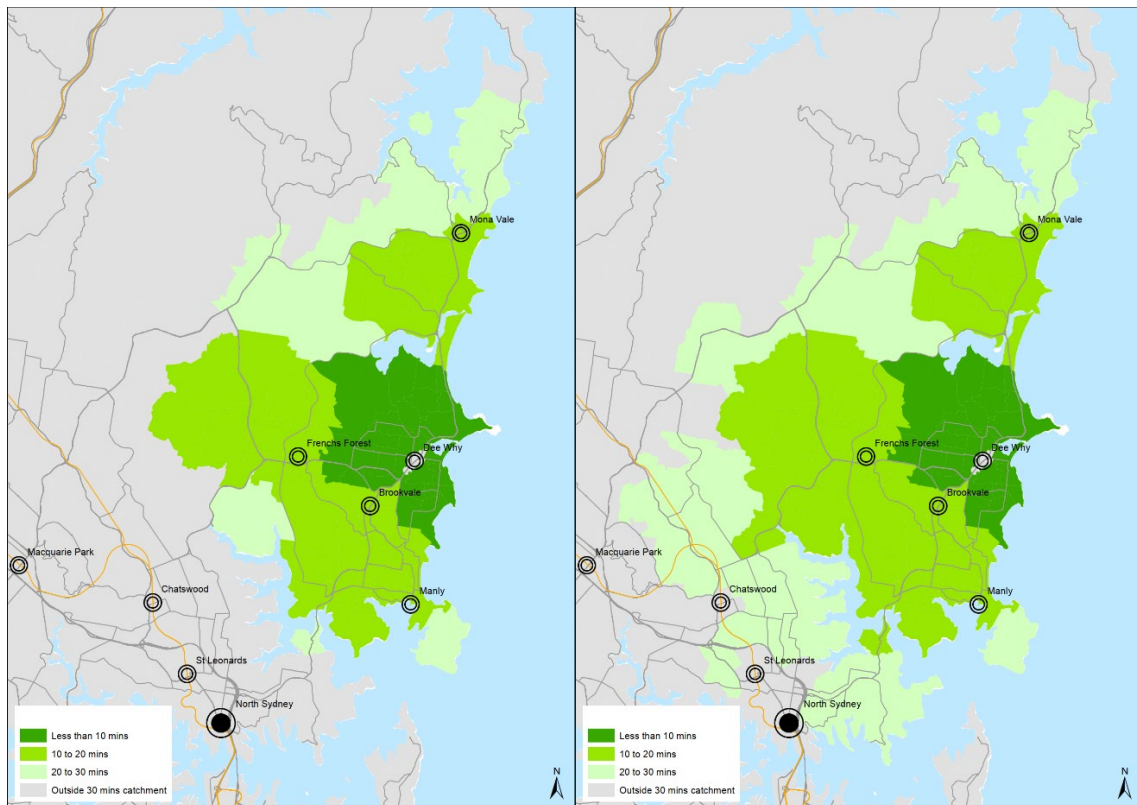
Forecast 30-minute catchments by road for strategic centres in the vicinity of the project are provided in Figure 3-11, Figure 3-12 and Figure 3-13. These figures indicate that the project would result in the employment centres of North Sydney and Chatswood being much more accessible for workers residing in the Northern Beaches region, including Manly and Dee Why.



2037 'Do minimum'

2037 'Do something'

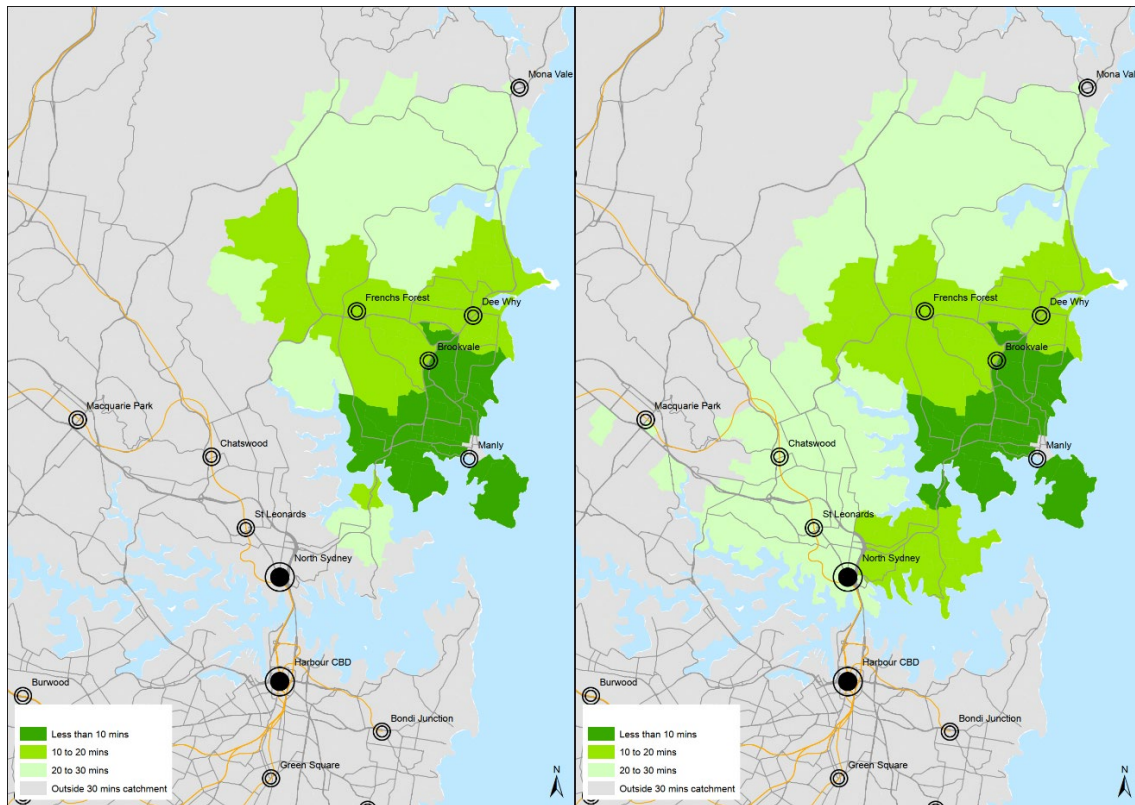
Figure 3-11 Modelled 2037 'Do something' morning peak 30-minute catchment by road from Chatswood



2037 'Do minimum'

2037 'Do something'

Figure 3-12 Modelled 2037 'Do something' morning peak 30-minute catchment by road from Brookvale-Dee Why



2037 'Do minimum'

2037 'Do something'

Figure 3-13 Modelled 2037 'Do something' morning peak 30-minute catchment by road from Manly

3.6.5 Increasing the resilience of the Northern Beaches transport network

The limited number of arterial road corridors, such as the Military Road/Spit Road corridor, connecting to the Northern Beaches means that the North District transport network lacks resilience, with incidents on these corridors impacting the performance across the wider transport network.

The project would boost the resilience of the Eastern Harbour City by providing a new underground motorway bypass of the Military Road/Spit Road and Warringah Road/Eastern Valley Way corridors. This would improve the ability of the arterial network servicing the Northern Beaches and North Shore regions to cope with traffic incidents by:

- Substantially increasing capacity
- Providing a new alternate bypass route for many trips currently reliant on the Military Road/Spit Road and Warringah Road/Eastern Valley Way corridors
- Reducing pressure on the existing surface arterial roads, leaving them better placed to accommodate minor incidents without major deterioration or failure.

The resilience benefit resulting from the project is estimated to be \$89 million per year (present value). This benefit reflects the travel time and vehicle operating cost savings that would be derived by providing an additional transport route, which would limit the impacts of an incident on the Military Road/Spit Road corridor alone.

3.6.6 Improving urban amenity and safety in local centres

The *Future Transport Strategy 2056* identifies 'Successful Places' as one of the six outcomes for NSW and sets out a vision for better balancing 'movement and place' needs, particularly in major centres such as the Sydney CBD (NSW Government, 2018). Certain roads in and around the Harbour CBD and Northern Beaches perform important 'place' functions, meaning they are destinations in their own right, such as shopping or dining precincts. However, some of these places are adversely affected by amenity issues linked to the performance of the road network, including Military Road and Spit Road (The Spit to Neutral Bay) and some streets in the Sydney CBD.

By providing additional motorway capacity and bypassing communities underground, the project would reduce through traffic volumes in many areas. This would result in reduced noise and improved amenity in these areas. The project would facilitate improvements to urban amenity in the Harbour CBD and Northern Beaches by reducing through traffic in a number of urban areas and by reducing pressure on arterial roads. Specific benefits would include:

- Diversion of through-traffic from Military Road and Spit Road, improving the amenity of local town centres along the corridor, including Mosman, Cremorne and Neutral Bay
- Reduced rat-running on local streets including Ourimbah Road
- Reduced through traffic on Eastern Valley Way and down through Willoughby, Naremburn, Cammeray and Northbridge
- Reduced traffic within Seaforth town centre (due to traffic using the Wakehurst Parkway to access the Spit Bridge).

The project would also provide several new or upgraded shared user paths and underpasses in the Balgowlah, Killarney Heights and Frenchs Forest areas (refer to Chapter 5 (Project description)). These facilities would support safer and easier access for pedestrians and cyclists, helping to encourage increased walking and cycling.

In addition, the project would return an area, equivalent to around 90 per cent of the current open space, to the community as new and improved public open space and recreation facilities at Balgowlah. A dedicated consultation process jointly led by Transport for NSW and Northern Beaches Council will take place to give the community an opportunity to provide input on the final layout of the new and improved open space and recreation facilities at Balgowlah. This consultation will be separate to the consultation for the environmental impact statement. This process would start after the environmental impact statement public exhibition period and well in advance of construction starting. As part of this consultation process, a community reference group would be established, with representative stakeholder groups and the community, to support Transport for NSW and Northern Beaches Council with the development of this important public space. Opportunities for new public open space are discussed further in Chapter 5 (Project description).

3.7 Strategic planning and policy framework

The project has been developed to align with the objectives of a number of strategic plans for transport, freight, and city planning that have been prepared at a national and State level. Table 3-2 provides an overview of relevant strategic plans, policies and strategies and their relationship to the project.

Table 3-2 Strategic planning and policy framework

Policy	Description
Australian Infrastructure Plan	<p>The <i>Australian Infrastructure Plan: Priorities and Reforms for Our Nation's Future</i> (Infrastructure Australia, 2016) identifies priority infrastructure investments that Australia needs over the next 15 years.</p> <p>The <i>Infrastructure Priority List</i> (Infrastructure Australia, 2018) is a reference point for Australia's most important infrastructure investment needs and currently identifies 100 major infrastructure projects and initiatives. The projects and initiatives have been assessed by Infrastructure Australia for their economic viability, deliverability and strategic compliance with the principles detailed in the <i>Australian Infrastructure Plan</i>.</p> <p>The <i>Infrastructure Priority List</i> identifies the Western Harbour Tunnel and Beaches Link program of works as a priority initiative in recognition of its importance in addressing urban congestion on Sydney's arterial road network, augmenting critical cross-harbour capacity and Northern Beaches connectivity. This aligns with the Australian Infrastructure Audit's identification of road corridors to the Northern Beaches and across Sydney Harbour as among the top 30 most congested corridors in Australia.</p>
NSW State Priorities	<p>The NSW Government set out 18 State priorities to create a stronger, healthier and safer NSW (NSW Government, 2015). State priorities include improving road travel reliability, with a target of ensuring that 90 per cent of peak travel on key road routes is on time.</p> <p>The project would contribute to achieving a number of these priorities including:</p> <ul style="list-style-type: none"> • Encouraging business investment – by improving east–west and north–south connectivity, and reducing congestion around the Eastern Harbour City, more people would be able to access key employment centres such as Chatswood and Macquarie Park and strategic centres in the Northern Beaches in less time. Freight transport would also benefit from improved cross-harbour connectivity • Improving road travel reliability – by delivering travel time savings for freight services, public transport and other road users, and improving the resilience and efficiency of the existing road network • Reducing road fatalities – by providing a free-flowing cross-harbour alternative for through traffic, reducing traffic on surface roads and improving traffic flows, which is correlated with a lower number of road incidents.
State Infrastructure Strategy	<p>The <i>State Infrastructure Strategy 2018-2038</i> (Infrastructure NSW, 2018) is a 20 year strategy which identifies and prioritises the delivery of critical public infrastructure to drive productivity and economic growth.</p> <p>The <i>State Infrastructure Strategy 2018-2038</i> identified the Beaches Link as a near-term priority for the Sydney motorway network to provide an alternative to the Military Road/Spit Road corridor and bypass the Spit Bridge.</p> <p>The NSW Government is committed to commencing work on a new crossing of Middle Harbour. The Beaches Link and Gore Hill Freeway Connection project, as part of the Western Harbour Tunnel and Beaches Link program of works, is the result of that commitment.</p> <p>The <i>NSW Infrastructure Pipeline</i> (Infrastructure NSW, 2017) was prepared by Infrastructure NSW to outline infrastructure proposals under development by the NSW Government. This includes the opportunity to develop the Beaches Link and Gore Hill Freeway Connection project.</p>

Policy	Description
Future Transport Strategy 2056	<p>The <i>Future Transport Strategy 2056</i> (NSW Government, 2018) builds on the <i>NSW Long Term Transport Master Plan</i> (Transport for NSW, 2012a) and sets the 40-year vision, strategic directions and outcomes for customer mobility in NSW. <i>Future Transport Strategy 2056</i> identifies the transport challenges that will need to be addressed to support NSW's economic and social performance over the next 20 years and establishes a number of short, medium and long-term actions to address those challenges. These actions provide the overall framework for how the NSW transport system should develop, in terms of services and infrastructure.</p> <p>The <i>Greater Sydney Services and Infrastructure Plan</i> forms part of the <i>Future Transport Strategy 2056</i>. Building on the state-wide transport outcomes identified in the <i>Future Transport Strategy 2056</i>, the <i>Greater Sydney Services and Infrastructure Plan</i> establishes the specific outcomes that transport customers in Greater Sydney can expect and identifies the policy, service and infrastructure initiatives to achieve these. The <i>Greater Sydney Services and Infrastructure Plan</i> identifies the Western Harbour Tunnel and Beaches Link program of works as a committed services and infrastructure initiative and a city shaping transport corridor.</p> <p>In addition, the <i>Future Transport Strategy 2056</i> identifies 'Successful Places' as one of the six outcomes for NSW, and sets out a vision for better balancing 'movement and place' needs, particularly in major centres such as the Sydney CBD.</p> <p>The Western Harbour Tunnel and Beaches Link program of works is identified in the <i>Future Transport Strategy 2056</i> as a 'Committed' project (within the next ten years, subject to final business case) forming part of the vision for the future strategic road network for Greater Sydney that would support key movements by road, including freight, public transport and private vehicles.</p>
Greater Sydney Region Plan	<p>The <i>Greater Sydney Region Plan – A Metropolis of Three Cities</i> (Greater Sydney Commission, 2018a) is built on a vision of three cities where most residents live within 30 minutes of their jobs, education and health facilities, and services. To meet the needs of a growing and changing population, the vision seeks to transform Greater Sydney into a metropolis of three liveable, productive and sustainable cities: the Western Parkland City, Central River City and Eastern Harbour City.</p> <p>The project is located in the Eastern Harbour City and contains Australia's global gateway (Sydney Airport and Port Botany) and financial capital, the Harbour CBD, as its metropolitan centre.</p> <p>One of the key roles of the <i>Greater Sydney Region Plan</i> is to provide appropriate infrastructure in the right places to support the continued growth of Greater Sydney. The <i>Greater Sydney Region Plan</i> also identifies the importance of investing in and delivering efficient and effective transport systems including road infrastructure that would improve business to business connections and support the 30-minute city vision.</p> <p>Objective 18 of the <i>Greater Sydney Region Plan</i> references the Western Harbour Tunnel and Beaches Link program of works as infrastructure that would further improve accessibility from the Northern Beaches to the Harbour CBD and reduce through traffic in the Harbour CBD ensuring the economic strength and global competitiveness of the Harbour CBD.</p> <p>As part of the <i>Greater Sydney Region Plan</i>, the Greater Sydney Commission also prepared District Plans which provide a basis for strategic planning at a district level. The District Plan relevant to the project is discussed below.</p>

Policy	Description
North District Plan	The <i>North District Plan</i> (Greater Sydney Commission, 2018b) sets out priorities and actions for Greater Sydney's North District, which includes the project-based local government areas of the Northern Beaches, North Sydney and Willoughby. The <i>North District Plan</i> addresses issues influencing Greater Sydney to 2056 with one of the overarching priorities for a productive North District including improved access to local jobs, goods and services within 30 minutes. The <i>North District Plan</i> includes the Western Harbour Tunnel and Beaches Link program of works as a transport initiative that would provide improved connections and access for the Northern Beaches and North Shore regions.
Directions for a Greater Sydney	<i>Directions for a Greater Sydney 2017-2056</i> (Greater Sydney Commission, 2017) aims to better integrate land use and infrastructure in Greater Sydney to accommodate a population that will grow from five to eight million people over the next 40 years. It builds upon the <i>Greater Sydney Region Plan – A Metropolis of Three Cities</i> (Greater Sydney Commission, 2018a) and <i>Towards our Greater Sydney 2056</i> (Greater Sydney Commission, 2016). The project would support this vision by improving road network performance, resilience and efficiency, enabling sustained growth and productivity across Greater Sydney. The project would also improve access to the strategic centres of North Sydney, Sydney CBD, Macquarie Park and St Leonards, resulting in more people having access to jobs and services.
NSW Freight and Ports Plan	The <i>NSW Freight and Ports Plan</i> (Transport for NSW, 2018) supports the <i>Future Transport Strategy 2056</i> and provides direction to business and industry for managing and investing in freight into the future. The project in conjunction with the Western Harbour Tunnel and Warringah Freeway Upgrade and M4-M5 Link would benefit the freight industry by providing a western bypass of the Harbour CBD, greatly improving the quality of the freight connection through the Eastern Economic Corridor. The project would address key priority areas in the <i>NSW Freight and Ports Plan</i> such as strengthening the freight industry, increasing access for freight across the road and rail network, protecting existing freight precincts and ensuring safe, efficient and suitable freight access would meet the needs of Greater Sydney.

Additional relevant local government strategic plans and their relationship to the project are outlined in Table 3-3.

Table 3-3 Local strategic plans

Policy	Description
North Sydney Integrated Transport Program	The North Sydney Integrated Transport Program (the North Sydney Program) is an ongoing multi-agency collaboration between Transport for NSW, North Sydney Council, Greater Sydney Commission and the Government Architect of NSW, to guide future integrated transport planning and investment in the North Sydney CBD and interconnected areas. Led by Transport for NSW since 2018, it aims to deliver a shared place-based vision for the North Sydney CBD. A key focus of the North Sydney Program is to ensure major projects, such as the Western Harbour Tunnel and Beaches Link program of works, integrate with the North Sydney CBD in a manner that supports the globally connected 'Harbour CBD' and enables delivery of befitting place-based outcomes. Transport for NSW would continue to work with North Sydney Council and key stakeholders through agreed governance structures to investigate options to improve

Policy	Description
	movement and place outcomes within North Sydney, further leveraging the strategic benefits of the program of works. Community consultation would also be carried out. Issues raised by the community would be considered in any final decision to refine the project.
Northern Beaches Council: Towards 2040	<p><i>Towards 2040</i> (Northern Beaches Council, 2020) is Northern Beaches Council's local strategic planning statement which guides planning for the Northern Beaches over the next 20 years. Along with the 20 year vision, <i>Towards 2040</i> includes planning priorities and options to guide local land use and planning along with measures of success to determine whether priorities have been achieved. <i>Towards 2040</i> aligns with the <i>North District Plan</i> and <i>Greater Sydney Region Plan</i> and acts as the bridge between strategic land use planning at the district level and local statutory planning.</p> <p><i>Towards 2040</i> outlines the strategic importance that the implementation of the Beaches Link has for the Northern Beaches region and identifies the need for infrastructure to be delivered with predicted employment and housing growth within the Northern Beaches Council area.</p>
Mosman Local Strategic Planning Statement	<p>The <i>Mosman Local Strategic Planning Statement</i> (Mosman Council, 2020) (LSPS) sets out Mosman Council's 20-year vision for land use planning in Mosman, along with a suite of planning priorities and actions relating to housing, local centres, infrastructure and the environment.</p> <p>The LSPS identifies reimagining the Military Road/Spit Road corridor to improve function, amenity and accessibility in response to the Western Harbour Tunnel and Beaches Link program of works as a planning priority. The LSPS also acknowledges that poor road capacity on Military and Spit Roads presents a barrier to future growth, limiting future opportunities for Mosman, while noting the Western Harbour Tunnel and Beaches Link program of works would result in traffic reduction along this corridor. The LSPS identifies an action of supporting the construction of the Western Harbour Tunnel and Beaches Link program of works as a key method of achieving the planning priority of ensuring that Mosman is supported by infrastructure.</p>
Military Road Corridor Planning Study	<p>North Sydney Council is currently finalising the preparation of the <i>Military Road Corridor Planning Study</i> (North Sydney Council, 2020) in response to strong development interest along Military Road.</p> <p>The project would support the objectives outlined in the <i>Military Road Corridor Planning Study</i> through reducing traffic volumes and congestion along the Military Road/Spit Road corridor, enhancing the connectivity and amenity of Military Road.</p>



Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Chapter 4

Project development and alternatives

4 Project development and alternatives

This chapter describes the alternatives that were considered as part of the project development process and explains the selection of the preferred alternative. The preferred alternatives presented in this chapter are based on technical, environmental and planning considerations. Stakeholder and community considerations which have been incorporated into the project development process are outlined in Chapter 7 (Stakeholder and community engagement). Design refinements for particular elements of the project are also outlined.

The Secretary's environmental assessment requirements as they relate to the project development and alternatives, and where in the environmental impact statement these have been addressed, are detailed in Table 4-1.

Table 4-1 Secretary's environmental assessment requirements – Project development and alternatives

Secretary's requirement	Where addressed in EIS
Environmental impact statement	
1. The EIS must include, but not necessarily be limited to, the following: e. an analysis of any feasible alternatives to the project;	An analysis of strategic alternatives is provided in Section 4.3 .
f. a description of feasible options within the project, including: – alternative methods considered for the construction of the project, including the tunnels; and – staging of the proposal;	Alternative construction methods are detailed in Section 4.5.1 . Further detail on staging is included in Chapter 6 (Construction work).
g. a description of how alternatives to and options within the project were analysed to inform the selection of the preferred alternative/option. The description must contain sufficient detail to enable an understanding of why the preferred alternative to and options(s) within, the project were selected, including: – details of the alternative construction methods that were considered for tunnel construction, particularly those areas spanning Sydney Harbour (Middle) Harbour; – details of the short-listed route and tunnel options considered, and the criteria that was considered in the selection of the preferred route and tunnel design; – the alternative tunnel design and ventilation options considered to meet the air quality criteria for the proposal; and – a justification for the preferred proposal taking into consideration the objects of the <i>Environmental Planning and Assessment Act 1979</i> ;	<p>The assessment of route alternatives is detailed in Section 4.4 and construction alternatives in Section 4.5. Alternative tunnel construction methods and ventilation system designs considered are discussed in Section 4.5.1 and Section 4.5.6 respectively.</p> <p>A description of the benefits of the overall program of works and the justification for the project is provided in Chapter 3 (Strategic context and project need).</p> <p>Justification for the preferred proposal taking into consideration the objects of the <i>Environmental Planning and Assessment Act 1979</i> is presented in Chapter 28 (Synthesis of the environmental impact statement).</p>

Secretary's requirement	Where addressed in EIS
i. a demonstration of how the project design has been developed to avoid or minimise likely adverse impacts during construction and operation of the project;	Project design development is detailed in Section 4.4 and Section 4.5 , and Chapter 5 (Project description).

4.1 Overview

The project has undergone extensive evaluation of alternatives from pre-feasibility and strategic investigations through to design development and refinement, as outlined in Figure 4-1.



Figure 4-1 Alternatives development process

4.2 Historical context

Middle Harbour is a natural feature fundamental to the liveability and amenity of the Northern Beaches area. However, this waterway has historically presented a substantial challenge to the region's transport network, constraining north-south and east-west journeys to and from the Northern Beaches to limited corridors utilising only two waterway crossings being the Roseville Bridge and the Spit Bridge.

Addressing this transport challenge has been considered since the late 1930s, when a plan for a new road crossing of Middle Harbour, supported by an additional western crossing of Sydney Harbour, was first considered.

While the nature and shape of the city has changed considerably since the 1930s, the fundamental transport challenge for freight services, public transport, and other road users presented by Middle Harbour remains. Advancements in tunnelling technology coupled with the plan for investment in additional crossing capacity at Sydney Harbour have also worked to overcome many of the community and technical challenges associated with the original surface road proposal.

A timeline for the historical development of the Warringah Transport Corridor and additional cross harbour capacity as precursors to the Western Harbour Tunnel and Beaches Link program of works is provided in Figure 4-2.



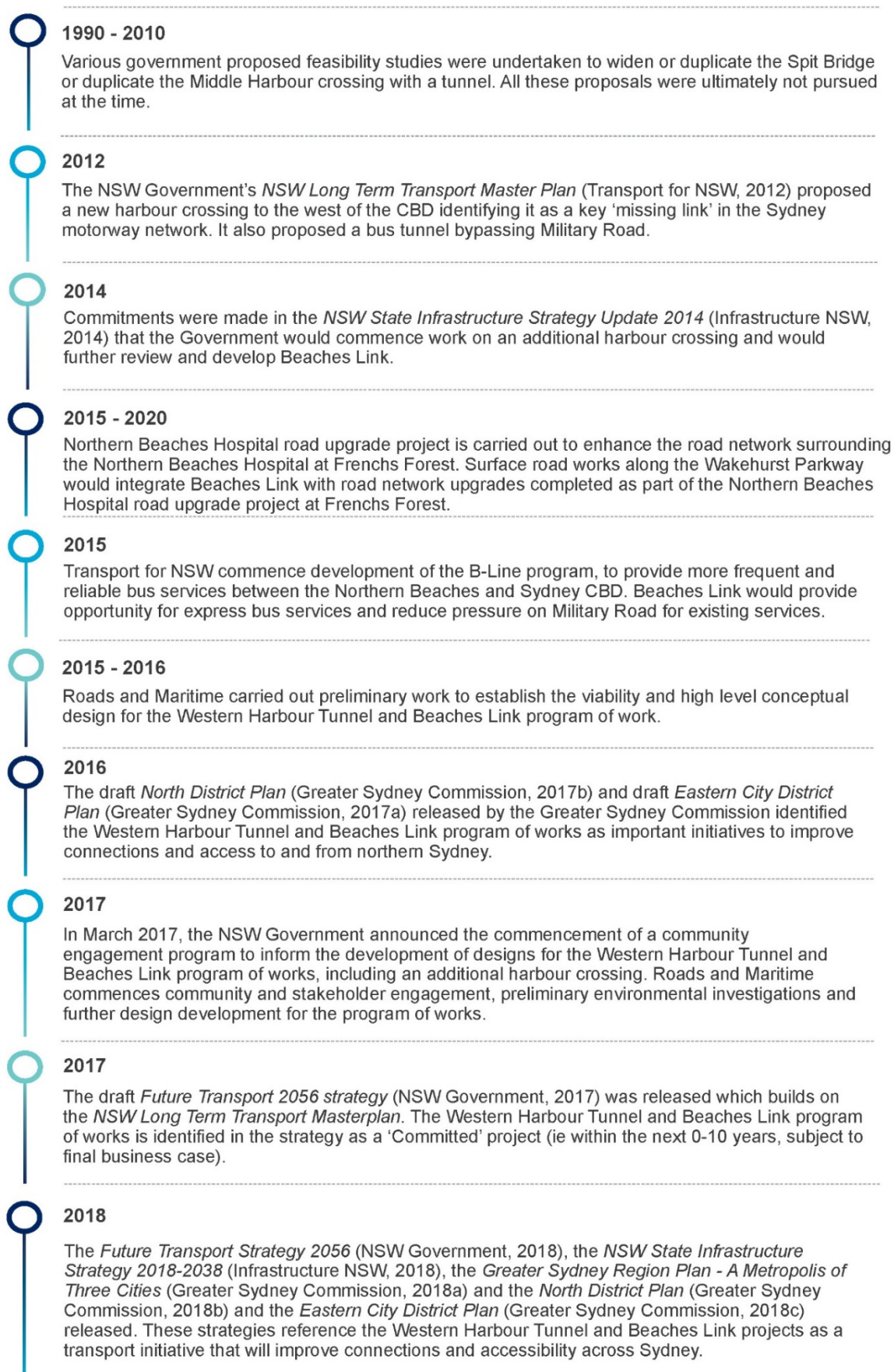


Figure 4-2 Historical development of additional cross-harbour capacity

4.3 Strategic alternatives

The project aims to provide additional transport capacity across Middle Harbour to improve journey times and journey time reliability for trips between the Northern Beaches and key economic and employment centres. Further information on the strategic context for the project, and the transport needs addressed, is provided in Chapter 3 (Strategic context and project need).

The *NSW Long Term Transport Master Plan* (Transport for NSW, 2012a) and subsequent *Future Transport Strategy 2056* (NSW Government, 2018) set the 40 year vision, strategic directions and outcomes for customer mobility in NSW. These plans identify the transport challenges that would need to be addressed to support NSW's economic and social performance and establish a number of short, medium and long-term actions to address those challenges.

Giving consideration to future land use, population density and transport requirements, both of these strategic plans identified road based transport, including improvements to bus services, as important modes to meet the needs of the Northern Beaches region. Furthermore, the need for additional core motorway capacity at the crossings of Middle Harbour and Sydney Harbour was identified as key to development of an appropriate multi-modal Sydney transport network – and specifically identified the Western Harbour Tunnel and Beaches Link program of works as transport projects required to support the plan.

The Greater Sydney Commission's *Greater Sydney Region Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018a) describes the Northern Beaches region as having a very low population growth rate coupled with a low density urban environment. This makes high capacity and high frequency transport options less appropriate for this region. A more appropriate solution is strategic improvement to road based modes, which would also facilitate substantial improvements to express bus service connections between the Northern Beaches and strategic centres including North Sydney, Sydney Central Business District (CBD), Macquarie Park and St Leonards.

Considering the identified requirements of the *NSW Long Term Transport Master Plan* (Transport for NSW, 2012a) and the *Future Transport Strategy 2056* (NSW Government, 2018), a number of strategic alternatives were considered for delivering the required road capacity, as follows:

- Do nothing
- Travel demand management
- Improvements to the existing arterial road network
- A new motorway crossing of Middle Harbour (the project)
- Improvements to alternative transport modes.

These strategic alternatives are described and evaluated in the following sections.

4.3.1 Do nothing

This alternative is to do nothing to the existing crossings of Middle Harbour and the adjoining motorway network and rely on the continued operation of existing transport networks and other transport projects currently proposed to meet future transport demands.

The limited number of existing arterial road connections to the region, including the Military Road/Spit Road, Mona Vale Road and Warringah Road/Eastern Valley Way corridors, currently experience high levels of congestion – particularly during peak periods. This congestion adversely affects travel times, travel time reliability, economic productivity and local amenity.

Excluding the Manly ferry link, bus services are the only mode of public transport for the Northern Beaches region, accounting for about 53 per cent of journeys to the Sydney CBD. However, the performance of bus services to and from the Northern Beaches region, particularly during peak periods, is constrained as a consequence of congestion on the Military Road/Spit Road and Warringah Road/Eastern Valley Way corridors that connect the Northern Beaches to strategic centres across Greater Sydney. The implementation of B-Line services in 2017 has resulted in

faster and more reliable journey times between Mona Vale and the Sydney CBD, with travel times reduced by about 20 minutes for passengers using the service during peak periods. Nevertheless, without measures to relieve pressure on the surface arterial road network, the capacity of Military Road/Spit Road would place pressure on the effectiveness of B-Line and other express bus services in the future, while also limiting opportunities to develop new express bus services. Capacity constraints on the Warringah Road/Eastern Valley Way corridor would also place pressure on the effectiveness of a new rapid bus service between Chatswood and Dee Why which is currently being planned. Further detail on these transport challenges is provided in Chapter 3 (Strategic context and project need).

As well as hindering daily access for residents, businesses and public transport users, the capacity and geometry of the limited arterial corridors servicing the Northern Beaches region restricts freight connectivity to the Northern Beaches. Vehicles over 19 metres are currently prohibited from using the Military Road/Spit Road corridor and the eastern portion of Warringah Road. For these larger vehicles, journeys to areas such as Dee Why and Brookvale via Mona Vale Road and Pittwater Road can be up to 20 kilometres longer in each direction than the most direct road route.

The do nothing alternative has been rejected as an undesirable strategic alternative because it would not address the identified project need. For example, future traffic modelling (refer to Chapter 9 (Operational traffic and transport)) indicates that without the project, this alternative would be unable to accommodate forecast growth during the peak periods without substantial and unacceptable delays across the Sydney road network. Without the additional capacity for trips into and out of the Northern Beaches that would be provided by the project, accessibility to and from the Northern Beaches would become substantially restricted in the future. Overall, by 2037 in the do-nothing scenario, traffic growth on the road network would result in travel time increases for road users that would make many nearby strategic centres no longer accessible within a 30 minute trip. For example, trips between Frenchs Forest and Balgowlah and North Sydney which currently take about 30 minutes would increase to 50 minutes and 45 minutes respectively by 2037 in the do nothing scenario. This growth in traffic volumes would also result in longer travel times for public transport, with delays to bus services attributed to increased queuing on key bus route corridors between the Northern Beaches region and the North Sydney and Sydney CBDs. The do nothing alternative would adversely impact on:

- Travel time and travel time reliability for freight services, public transport and other road users
- Public transport performance and connectivity for the region, with limited opportunity to deliver new and improved express bus services
- Amenity and environment for local communities, including air quality, noise, visual and traffic related impacts resulting from traffic congestion
- Economic performance of the region, particularly with regard to ongoing congestion costs and access to jobs and services.

These impacts would result in a reduction in the region's productivity and amenity, and Sydney's performance as a global city.

4.3.2 Travel demand management

Travel demand management is a measure that focuses on minimising or avoiding the need to invest in new motorway infrastructure, such as the project, by reducing individual trip lengths, reducing peak traffic volumes and making alternative transport mode options more viable. Demand management initiatives may include:

- Land use planning policies which promote urban consolidation and the establishment of town 'centres' to reduce the need for travel. For example, the *NSW Long Term Transport Master Plan* (Transport for NSW, 2012a), *Future Transport Strategy 2056* (NSW Government, 2018), *Greater Sydney Regional Plan: A Metropolis of Three Cities* (Greater Sydney Commission, 2018a) and *Northern Beaches Transport Action Plan* (Transport for NSW, 2016) aim to bring jobs closer to homes and to areas of increasing population, where feasible

- Augmenting existing public transport and integrating urban regeneration around transport nodes
- Implementing policies which restrict parking provisions in new developments to encourage alternative modes of transport
- Road use charges – such as the congestion charging applied for vehicles accessing central London
- Flexible working arrangements to reduce the number of trips during peak hours.

Sydney's population is forecast to grow from five million to eight million people over the next 40 years. Given the current road network servicing the Northern Beaches is already highly congested, even with considerably reduced per-capita travel demand through demand management and improvements to public transport, an expanded road network would be required to accommodate population growth.

Further, to have a major impact on road traffic, travel demand management measures would require considerable changes in social attitudes, travel behaviour and government policy and can take many years to achieve. Travel demand management changes alone are therefore not a viable strategic alternative to the project. They are, however, viewed as complementary initiatives, together with the project, to reduce the level of congestion on Sydney's road network as the city's population grows.

4.3.3 Improvements to the existing arterial road network

Improvements to the existing arterial road network to provide additional transport capacity from the lower North Shore to the Northern Beaches have been considered.

Options to provide additional capacity without major widening schemes have included investigations into various operational changes to the Military Road/Spit Road corridor, including tidal flow, peak period parking restrictions, introduction of bus lanes and T3 lanes and reductions in Spit Bridge opening times. Given the conflicts with existing signalised intersections, such initiatives only provide minor and short-term benefits.

Ways to increase road capacity across Middle Harbour have been considered for many years (refer to Section 4.2). Aside from the challenges associated with augmenting the existing aging structure, increasing capacity across the Spit Bridge would deliver limited benefit to the Military Road/Spit Road corridor without large investment in widening and reprioritisation schemes along the entire corridor from Mosman through to the Warringah Freeway.

The scale of surface solutions required to provide meaningful improved travel times along the existing surface arterial routes would result in unreasonable amounts of land acquisition and environmental and social impact. These works would heavily impact business and communities along the entire route during construction and operation. Users of the existing surface corridors would also be considerably impacted during construction of these upgrades.

Accordingly, substantial new improvements to the existing arterial road network connecting to the Northern Beaches have been rejected as a strategic alternative.

Transport for NSW has an extensive program of upgrades to the existing road infrastructure across Sydney to address congestion and improve travel times. Information on these projects can be found on the Transport for NSW website (<https://www.transport.nsw.gov.au/projects/current-projects>). These projects are considered complementary because they would improve the capacity of Sydney's existing motorway and arterial road network, but they would not provide the necessary additional transport capacity between the Northern Beaches and other key centres (refer to Chapter 3 (Strategic context and project need) for additional details on this function).

4.3.4 A new motorway crossing of Middle Harbour

Options for a motorway connection to the Northern Beaches requiring a new bridge over Middle Harbour have been discussed since the 1930s when a new surface road corridor was contemplated in the Cumberland Plan. The concept of building a surface motorway was abandoned some 40 years ago, with the principal concerns being the environmental and community impacts of a surface alignment, and the limited benefits offered given the downstream capacity constraint at the Sydney Harbour crossing. At this time, tunnelling technology was not sufficiently advanced to allow a road tunnel to be cost-effectively implemented.

The release of the *NSW Long Term Transport Master Plan* (Transport for NSW, 2012a) and *State Infrastructure Strategy Update 2014* (Infrastructure NSW, 2014) confirmed new motorway crossings of Sydney Harbour and Middle Harbour as transport priorities for the city and State.

In combination with the Western Harbour Tunnel and Warringah Freeway Upgrade project, a new motorway crossing of Middle Harbour would address the project need by:

- Providing a new, safer, more efficient and reliable motorway link for freight services, public transport and other road users travelling between the Northern Beaches and strategic centres across Greater Sydney
- Increasing arterial road network capacity between the Northern Beaches region and strategic centres across Greater Sydney by 60 per cent - reducing pressure and congestion on existing arterial routes that run over capacity during peak periods
- Delivering travel time savings and travel time reliability benefits for users of existing surface routes, including freight delivery and bus services, by reducing pressure on surface arterial routes
- Increasing the resilience of the North District transport network to incidents by providing a new alternative motorway standard road corridor between strategic centres
- Creating opportunity for new express bus services between the Northern Beaches region and strategic centres such as North Sydney, Sydney CBD, Macquarie Park and St Leonards via the new motorway – including opportunities for efficient interchange with the new Victoria Cross Metro Station at North Sydney.

4.3.5 Improvements to alternative transport modes

The NSW Government, through Transport for NSW, is currently planning and delivering a series of new and upgraded transport projects and initiatives, consistent with the *Future Transport Strategy 2056* (NSW Government, 2018). The key public transport projects in the Greater Sydney area are shown in Figure 4-3.

Alternative transport modes to the project, and their effectiveness in meeting the project need, are described in the following sections.

Information on these projects can be found on the Transport for NSW website (transport.nsw.gov.au/projects/current-projects).

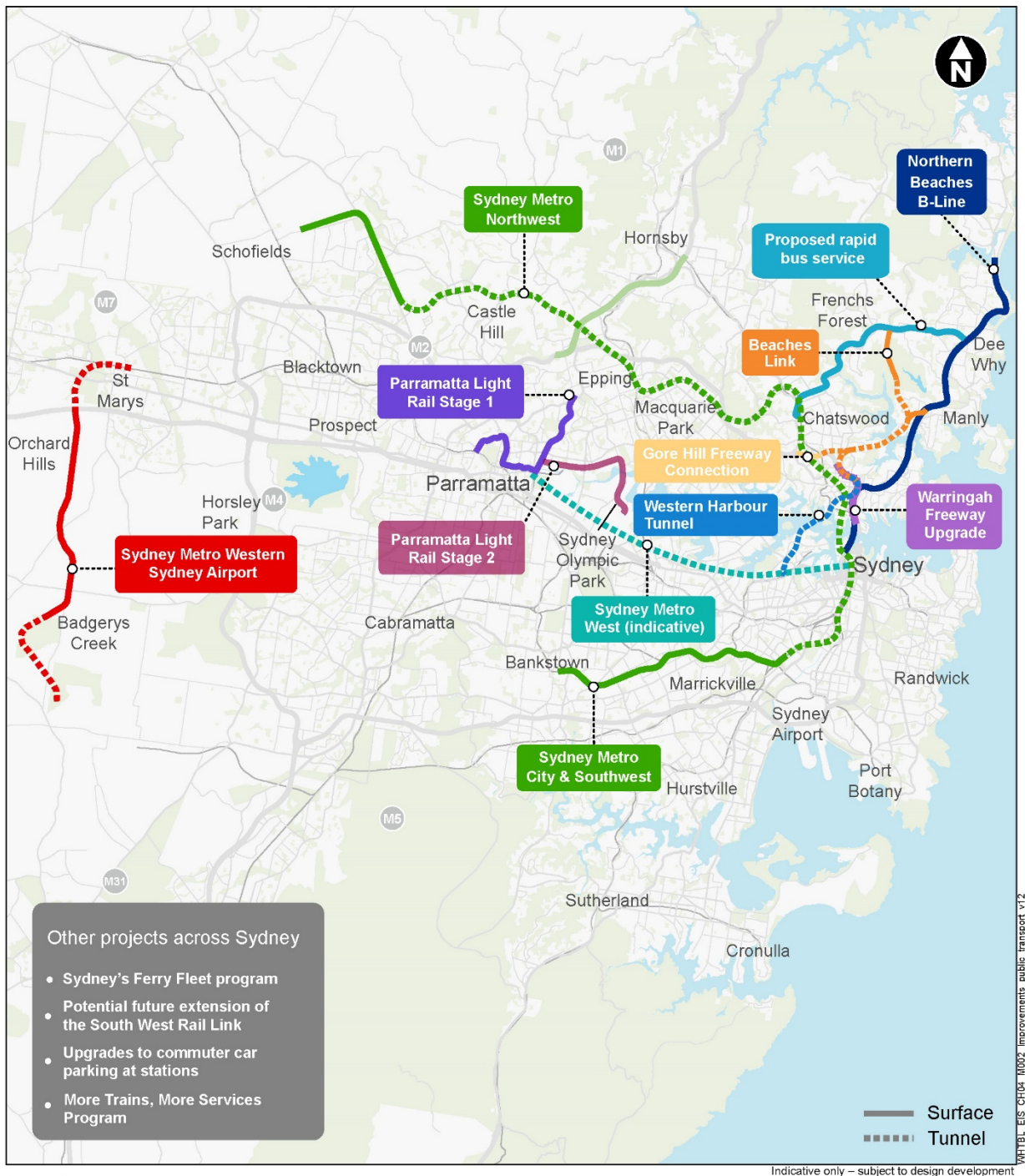


Figure 4-3 Key public transport projects in the Greater Sydney area

Improvements to the Sydney bus network

Improvements to the Sydney bus network as a strategic alternative to the project include additional bus routes, additional buses on existing routes and bus priority measures.

Buses play a crucial role in Sydney's public transport system. Sydney's bus network currently includes more than 600 routes. For more than 90 per cent of Sydney residents, local bus routes are within 400 metres of home and offer connections to neighbourhood shops and services, major centres and the wider public transport system.

A well planned bus network is the most efficient means of providing public transport in areas where there is a less dense population, meaning that origins and destinations of commuters are more dispersed, as is the case for the Northern Beaches region. Bus services can also be put into service more rapidly and with considerably less infrastructure and disruption than any other type of public transport.

Furthermore, recent advancements in technology have provided the opportunity to develop fully electric buses – reducing noise generation, eliminating at source emissions, and providing a much smoother journey for passengers. Electric buses are already operating on several routes in Sydney's Inner West. The NSW Government plans to introduce additional electric buses in the Inner West, as well as other areas of Greater Sydney over the coming 12 months.

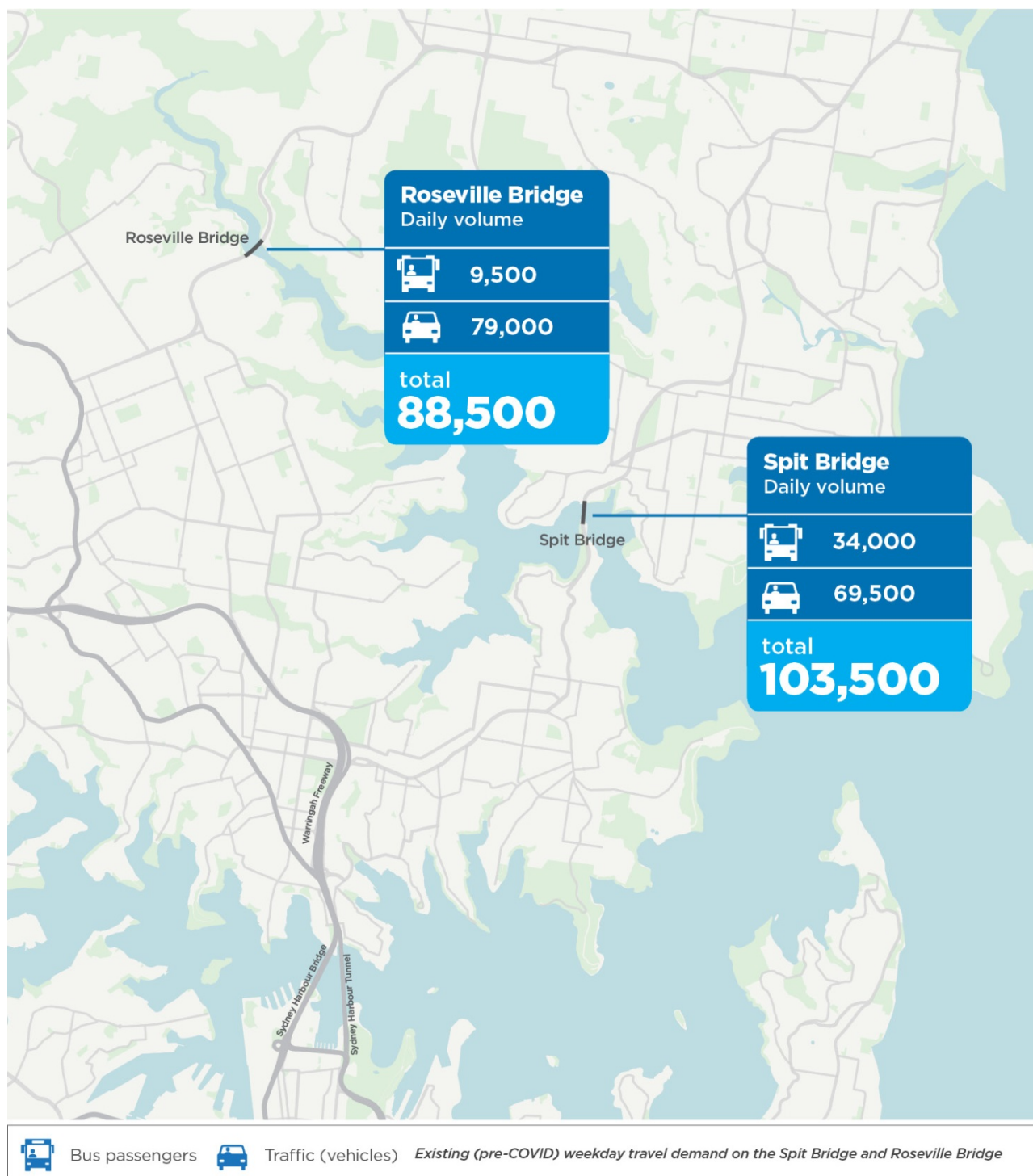


Figure 4-4 Average weekday trips via key transport corridors (existing conditions)

Sydney's Bus Future (Transport for NSW, 2013a) acknowledges that improvements to the bus network are essential to meet changing customer needs, including access to major centres outside the Sydney CBD. *Sydney's Bus Future* aims for seamless connection to other transport modes to deliver the right mix of services. In response to changing passenger needs and an increase in demand, additional services have already been added to the Sydney bus network. However, without measures to improve journey times by increasing the road efficiency or capacity, the addition of more buses to the network can contribute to congestion, making bus services less effective at meeting customer needs.

Sydney's Bus Future proposes major changes to the Sydney bus network to meet current and future demands by providing express service routes to connect major centres along transport routes with mass transit demand. Suburban and local service routes would build on the foundation of these express service routes to improve access to local, neighbourhood destinations. An example of the major changes to the Sydney bus network as a result of *Sydney's Bus Future* is the B-Line program. Its success to date has encouraged the planning of a rapid bus service between Dee Why and Chatswood.

Despite the complementary nature of the aforementioned projects, improved bus services on existing surface corridors alone would not be sufficient to provide the level of additional transport capacity that is required for the Northern Beaches region. The ability for the bus network to provide extra capacity is strictly limited by the capacity of the road network itself – particularly the Military Road/Spit Road and Warringah Road/Eastern Valley Way corridors.

While the B-Line program has been successful in improving capacity and travel times in the short to medium-term, additional road capacity is required to deliver long-term benefits for bus services and unlock the opportunity for new and improved express services between key centres.

Improvements to the rail network

The physical and urban geography of the Northern Beaches region presents barriers to the consideration of rail-based solutions in addressing the transport challenges faced by the region. The hilly, harbour-based Eastern Harbour City with its established urban area and therefore limited available space to develop a rail corridor, means that provision of rail infrastructure would be expensive with a long lead time to development. The topography on either side of Middle Harbour introduces challenges for constructing a tunnel with a gradient that would be acceptable in terms of engineering design and safety for rail infrastructure, with steep elevation changes as well as geology characterised by substantial rock fracturing. The necessity to build deep station boxes for a tunnelled rail link under Middle Harbour was another key consideration when developing the preferred solution. These physical constraints would result in substantial challenges for engineering, with large implications for cost and amenity during construction.

The provision of rail infrastructure is also reliant on the location of and accessibility to high density residential or commercial property close to the proposed location of stations as well as along its route. Given the high cost of constructing and operating rail infrastructure and the low density nature of the Northern Beaches, it is considered that demand would not be high enough to make investing in a specific or dedicated rail link to the Sydney CBD a viable alternative.

Similarly, provision of light rail would entail high capital and operating costs which would require high passenger demand in order to be a viable solution. Due to the low population density and population growth rate for the Northern Beaches region, when considering the distances proposed, light rail would not be considered a suitable mass transit solution. Light rail also performs best when completely separated from other road traffic, so that the introduction of light rail into an already congested road transport network would have the potential to further reduce road capacity where a segregated light rail corridor would replace traffic lanes.

Due to the high cost and long lead time for a heavy or light rail solution, the alternative approach for public transport improvement is to focus on improving the speed and reliability of road based public transport such as bus services – for example, by implementing bus priority measures and developing rapid bus services. Such investment can be delivered as part of a long-term, staged approach to increasing corridor capacity, as and when required, at substantially lower cost than heavy and light rail infrastructure. With a relatively high carrying capacity, rapid or express bus services offer a mass transit solution for bus corridors where a rail based solution is unsuitable. As such, adequate, reliable and efficient public transport using road infrastructure (ie rapid and express bus services) is considered a more suitable and appropriate public transport solution for the area.

The *Northern Beaches Transport Action Plan* (Transport for NSW, 2016), outlined proposed rail initiatives of relevance to the project. These included a second harbour rail crossing as well as a new rail line to the Sydney CBD. Subsequently, this new rail line to the CBD was realised by the Sydney Metro City & Southwest project, which is a 30 kilometre extension of metro rail line from

the end of the existing Sydney Metro Northwest terminus at Chatswood. The Sydney Metro City & Southwest project will travel from Chatswood, under Sydney Harbour, through newly established stations in the Sydney CBD through to Bankstown in the south west of the city. The Sydney Metro City & Southwest project will enhance the Sydney rail network and enable it to carry an additional 100,000 people per hour in peak periods, delivering sufficient capacity to serve the city well into the future.

Supplemented by a rapid bus service between Dee Why and Chatswood that is currently being planned, this means more people are likely to travel by rail, helping to reduce the number of buses travelling into the Sydney CBD from locations north of Sydney Harbour. This would also provide increased capacity for buses and cars travelling from the Northern Beaches to the Sydney CBD.

While these projects would contribute to reducing congestion on the existing road network, they would not be sufficient to resolve the existing road network capacity constraints between the lower North Shore and the Northern Beaches. This is due to the complexity of journey patterns and trip purposes within Greater Sydney and the dispersed nature of origin and destination points for an individual journey. This means that roads remain a critical element in the integrated transport network, servicing buses, freight, commercial and many other individual journey needs.

Improvements to the freight rail network would assist with the efficient distribution of freight particularly for freight travelling longer distances. However, a large proportion of Greater Sydney's freight, commercial, and services tasks require distribution of goods and services to customers within the Sydney basin. This requires a diverse and dispersed point-to-point transport system that is most efficiently provided by the road network.

Improvements to the ferry network

Additional ferry services on Sydney Harbour were considered as a strategic alternative to the project. Additional ferry services would provide an improved cross-harbour public transport link and would contribute to relieving congestion on existing cross-harbour road connections. While this would contribute to reducing congestion on the existing road network, it would not resolve the existing cross-harbour road congestion and capacity constraints. This is due to comparatively small number of journeys currently using these crossings that would be transferable to the ferry network.

Improvements to active transport

Improvements to active transport infrastructure (cyclist and pedestrian facilities) that were considered as strategic alternatives to the project included additional cycling and pedestrian routes and facilities as identified in *Sydney's Cycling Future* (Transport for NSW, 2013b) and *Sydney's Walking Future* (Transport for NSW, 2013c).

Sydney's Cycling Future aims to make cycling a safe, convenient and enjoyable transport option for short trips by:

- Investing in separated cycle ways and providing connected bicycle networks to major centres and transport interchanges
- Promoting better use of the existing network
- Engaging with stakeholders across government, councils, developers and bicycle users.

Sydney's Cycling Future aims to increase the mode share of cycling in the Sydney metropolitan area for short trips that can be an easy 20 to 30 minute ride. The strategy aims to improve access between suburbs and major centres, reduce congestion on the road network and increase capacity on the public transport system by investing in connected bike routes within five kilometres of major centres and public transport interchanges. The strategy commits to expanding bike route connectivity within 10 kilometres of major centres in the longer term. The 'Bike and Ride' initiative would make it convenient for customers to cycle to transport hubs, leave their bikes securely locked up and transfer to public transport to continue their journey.

Sydney's Walking Future complements *Sydney's Cycling Future*. The actions set out in *Sydney's Walking Future* propose to make walking the transport choice for quick trips under two kilometres and help people access public transport. Encouraging and enabling more people to make walking

trips would ease pressure on public transport, reduce congestion on roads and promote a healthier transport alternative.

As outlined in *Sydney's Cycling Future* and *Sydney's Walking Future*, journeys made by cycling and walking are generally for short trips only, which would not meet the project need of improving existing capacity constraints between the strategic centres across Greater Sydney and the Northern Beaches. For example, it takes about 30 minutes to cycle from Manly Beach to the Spit Bridge at Mosman. Improvements to active transport alone would not cater for the diverse travel demands within the North District that are best met by road infrastructure. Improvements to active transport alone would not be sufficient to support long-term economic growth or enhance the productivity of commercial and freight generating land uses. The active transport network is therefore complementary to other modes of transport as part of an integrated transport solution.

As part of an overarching integrated transport network, the project includes the development of new or improved active transport links in a number of locations, generally associated with surface works for the project. These links would improve connectivity between communities, open space areas, public transport modes and the existing active transport network. This is described in further detail in Chapter 5 (Project description) and Chapter 9 (Operational traffic and transport).

Summary

As detailed in the previous sections, alternative transport modes, including bus, rail, light rail and active transport, could be considered as strategic alternatives to the project. While many of these modes and upgrades are complementary to the project as part of a broader integrated transport network, none would be as effective in providing improvements to journey times and journey time reliability for freight services, public transport and other road users, while improving efficiency and amenity along existing surface road corridors.

The array of journey patterns and trip purposes within Sydney, and the dispersed nature of origin and destination points for an individual journey mean that roads remain a critical element in the integrated transport network, servicing freight, commercial, bus and many other journey needs.

While improvements to the freight rail network would reduce pressure on the core motorway network, Sydney's freight, commercial and services tasks require distribution of goods and services within the Sydney basin, which relies on diverse and dispersed point-to-point transport network that is most efficiently provided by the road network. Providing high-quality motorway links to meet this need is key to growing Sydney's economic prosperity while reducing surface traffic through communities.

Extending the tunnelled motorway network to address capacity, efficiency and reliability issues on critical road corridors would not only provide faster, more efficient and more reliable journeys for users of the network, but would also deliver much broader benefits through reduced congestion on existing local and arterial road networks.

The project would materially improve the functionality and performance of the bus network, providing opportunities for faster and more reliable express bus services to travel via the tunnel and motorway network from the Northern Beaches to strategic centres including North Sydney, the Sydney CBD, Macquarie Park and St Leonards. The design for Beaches Link would also allow for these services to interchange with the new Victoria Cross Metro Station at North Sydney. Furthermore, the use of the Beaches Link tunnel for express bus services would reduce pressure on the Military Road/Spit Road and Warringah Road/Eastern Valley Way bus corridors, allowing for further optimisation of surface services.

The project would improve active transport links through the provision of new and upgraded shared user paths in Artarmon, Balgowlah, Killarney Heights, Seaforth and Frenchs Forest, as well as a number of new shared user underpasses and new shared user and pedestrian bridges which would provide connectivity across the Wakehurst Parkway.

4.3.6 Preferred strategic alternative

When considering the strategic alternatives and complementary projects discussed in previous sections, it was concluded that the construction and operation of a new tunnelled motorway crossing of Middle Harbour (the project) was the preferred solution. This, in combination with the Western Harbour Tunnel, Warringah Freeway Upgrade, and WestConnex network would provide a step-change in transport capacity between the Northern Beaches and strategic centres across Greater Sydney. This would materially improve journey times and journey time reliability for freight services, public transport and other road users on both the new motorway link and bypassed surface routes. Reduced pressure on existing surface routes would also improve the safety, efficiency and amenity of these corridors.

The project is part of a suite of current and future transport initiatives outlined in *Future Transport Strategy 2056* (NSW Government, 2018) that together, would provide the cross-harbour transport capacity required to cater for a diverse array of journeys and future population growth. Further, as discussed in Chapter 3 (Strategic context and project need), a new tunnelled harbour crossing would allow new public transport routes to be developed in response to diverse travel demands and support new social and economic development such as the emerging Northern Beaches Hospital Precinct in Frenchs Forest.

4.4 Corridor alternatives

Following identification of a new tunnelled motorway as the preferred strategic alternative, a design development process was carried out to determine the most appropriate alignment and construction method to deliver the tunnel. This began with consideration of the broad corridors that would best service the road transport demands between the Northern Beaches and strategic centres across Greater Sydney.

The process for selection of the preferred tunnel alignment and construction method included consideration of five strategic corridors and over seven different combinations of tunnelling methods.

Options were developed and assessed by a multidisciplinary team including design engineers, construction engineers, transport planners and environmental advisors with direct experience in delivering major transport infrastructure in NSW, Australia and internationally. Selection of the preferred corridor required consideration of various technical, environmental and community factors including:

- Strategic traffic demands and how they define the required connectivity to achieve transport outcomes
- Physical and operational interfaces with other major infrastructure (eg Sydney Metro, the Warringah Freeway and Northern Beaches Hospital Precinct and associated road upgrades)
- Integration with the proposed Western Harbour Tunnel and Warringah Freeway Upgrade project in the future
- Horizontal alignments and waterway crossing methodologies that allow the tunnel to achieve acceptable vertical gradients to achieve the desired transport product, reduce whole of life emissions, operational costs, and improve safety outcomes
- Surface connections and interchanges that integrate with the arterial road network and connect bus routes and public transport nodes
- Interfaces with commercial and recreational maritime traffic
- Construction and operational efficiencies
- Topography along the alignment
- Potential impacts on local communities including amenity and connectivity
- Results of geotechnical, groundwater and contamination investigations

- Basements and foundations of structures along the routes
- Maritime heritage, biodiversity and marine ecology
- Turbidity and hydrodynamic monitoring and modelling for Middle Harbour.

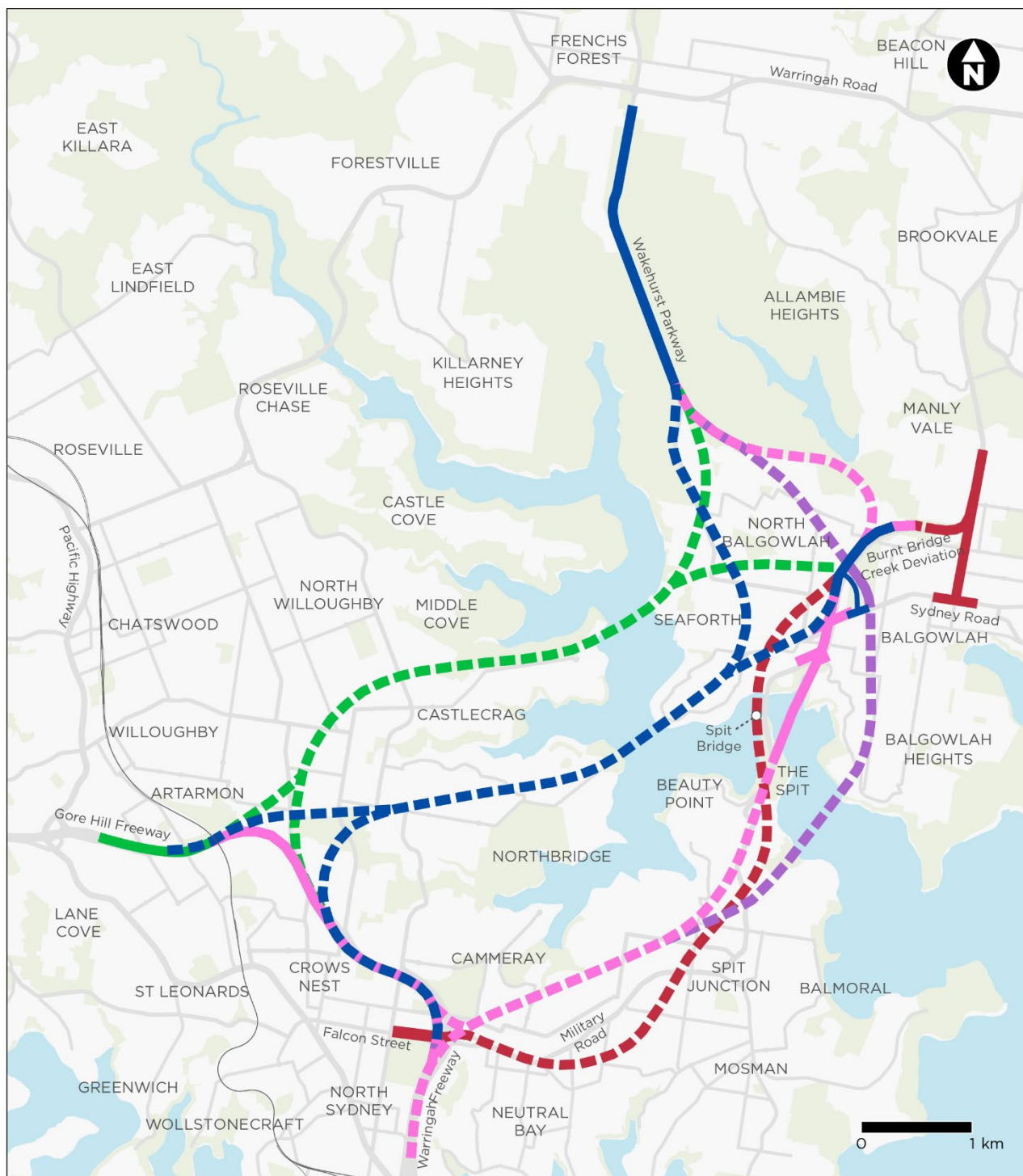
4.4.1 Description of shortlisted corridor alternatives

Following preliminary technical and environmental analysis, five preferred corridor alternatives were shortlisted for a new tunnelled motorway connection to the Northern Beaches (refer to Table 4-2 and Figure 4-5). The shortlisted corridor alternatives were termed the green, red, purple, pink and blue alternatives.

Table 4-2 Shortlisted corridor alternatives

Corridor alternative	Summary of alternative
Green	<ul style="list-style-type: none"> • Tunnelled alignment between Burnt Bridge Creek Deviation, Balgowlah and the Gore Hill Freeway, Naremburn – passing beneath Castlecrag • Tunnelled crossing of Middle Harbour between Pickering Point and Sugarloaf Point • Tunnelled ramps to and from the Gore Hill Freeway at Artarmon • Tunnelled ramps to and from the Wakehurst Parkway at Killarney Heights • Wakehurst Parkway upgraded to two lanes in each direction between tunnel connection and Warringah Road interchange, Frenchs Forest • Connectivity: <ul style="list-style-type: none"> – Signalised connection to and from Burnt Bridge Creek Deviation at Balgowlah – Ramps to and from the Wakehurst Parkway at Killarney Heights – Ramps to and from the Gore Hill Freeway at Artarmon – Ramps to and from the Warringah Freeway at Naremburn.
Red	<ul style="list-style-type: none"> • Tunnelled alignment broadly following the Military Road/Spit Road corridor • Tunnelled crossing of Middle Harbour located immediately west of Spit Bridge • Connectivity: <ul style="list-style-type: none"> – Ramps to and from Condamine Street at Manly Vale – Connection to North Sydney and Sydney CBD via signalised intersection at Falcon Street interchange.
Purple	<ul style="list-style-type: none"> • Tunnelled alignment to the east of the Military Road/Spit Road corridor • Tunnelled crossing of Middle Harbour between Rosherville Reserve and Clontarf • Wakehurst Parkway upgraded to two lanes in each direction between tunnel connection and Warringah Road interchange, Frenchs Forest • Connectivity: <ul style="list-style-type: none"> – Signalised connection to and from Burnt Bridge Creek Deviation at Balgowlah – Ramps to and from the Wakehurst Parkway at Killarney Heights – Connection to North Sydney and Sydney CBD via signalised interchange at Falcon Street – Tunnelled ramps at Cammeray providing access to and from the Gore Hill Freeway corridor – Underground connections to and from the Western Harbour Tunnel at Neutral

Corridor alternative	Summary of alternative
	Bay/Cammeray.
Pink	<ul style="list-style-type: none"> • Alignment identified in Strategic Business Case, with surface connection from Burnt Bridge Creek Deviation (with onward tunnel from the Wakehurst Parkway), connecting to a tunnelled alignment broadly following the Military Road/Spit Road corridor • High-level bridge over Middle Harbour east of the existing Spit Bridge • Open trough structure under the Sydney Road/Burnt Bridge Creek Deviation junction • Diamond interchange at the Sydney Road/Burnt Bridge Creek Deviation junction • Tunnelled ramps between Burnt Bridge Creek Deviation at Balgowlah and the Wakehurst parkway at Killarney Heights • The Wakehurst Parkway upgraded to two lanes in each direction between tunnel connection and Warringah Road interchange at Frenchs Forest • Connectivity: <ul style="list-style-type: none"> – Signalised connection to and from Sydney Road/Burnt Bridge Creek Deviation junction at Balgowlah – Ramps to and from the Wakehurst Parkway at Killarney Heights – Connection to North Sydney and Sydney CBD via signalised interchange at Falcon Street – Tunnelled ramps at Cammeray providing access to and from the Gore Hill Freeway corridor – Tunnelled ramps at North Sydney providing access to and from the Sydney Harbour Bridge – Underground connections to and from the Western Harbour Tunnel at Neutral Bay/Cammeray.
Blue	<ul style="list-style-type: none"> • Tunnelled alignment between Burnt Bridge Creek Deviation, Balgowlah and the Warringah Freeway at Cammeray – passing beneath Northbridge • Tunnelled crossing of Middle Harbour between Clive Park and Seaforth Bluff • Tunnelled ramps to and from the Gore Hill Freeway at Artarmon and from the Wakehurst Parkway at Killarney Heights • The Wakehurst Parkway upgraded to two lanes in each direction between the tunnel connection and Warringah Road interchange at Frenchs Forest • New access road between Burnt Bridge Creek Deviation and Sydney Road • Connectivity: <ul style="list-style-type: none"> – Free-flow connection to Burnt Bridge Creek Deviation northbound – signalised connection southbound – Signalised connection to and from Sydney Road (via new access road) – Ramps to and from the Wakehurst Parkway at Killarney Heights – Ramps to and from the Gore Hill Freeway and Reserve Road at Artarmon – Ramps to and from the Warringah Freeway at Cammeray – Underground connections to and from the Western Harbour Tunnel at the Warringah Freeway.



Legend

- | | |
|---|---|
| — Blue corridor alternative | — Surface or bridge |
| --- Green corridor alternative | --- Tunnel |
| --- Pink corridor alternative | --- Sydney Metro |
| --- Purple corridor alternative | |
| --- Red corridor alternative | |

Figure 4-5 Main corridor shortlisted alternatives

4.4.2 Evaluation of corridor alternatives

The five shortlisted corridor alternatives were evaluated by a multidisciplinary team including design engineers, construction engineers, transport planners and environmental advisors to identify the solution that best balanced technical, community and environmental outcomes while meeting the transport objectives. The evaluation criteria used were an expansion of the project objectives with the addition of design and constructability criteria to reflect the more detailed comparison required (Figure 4-6).

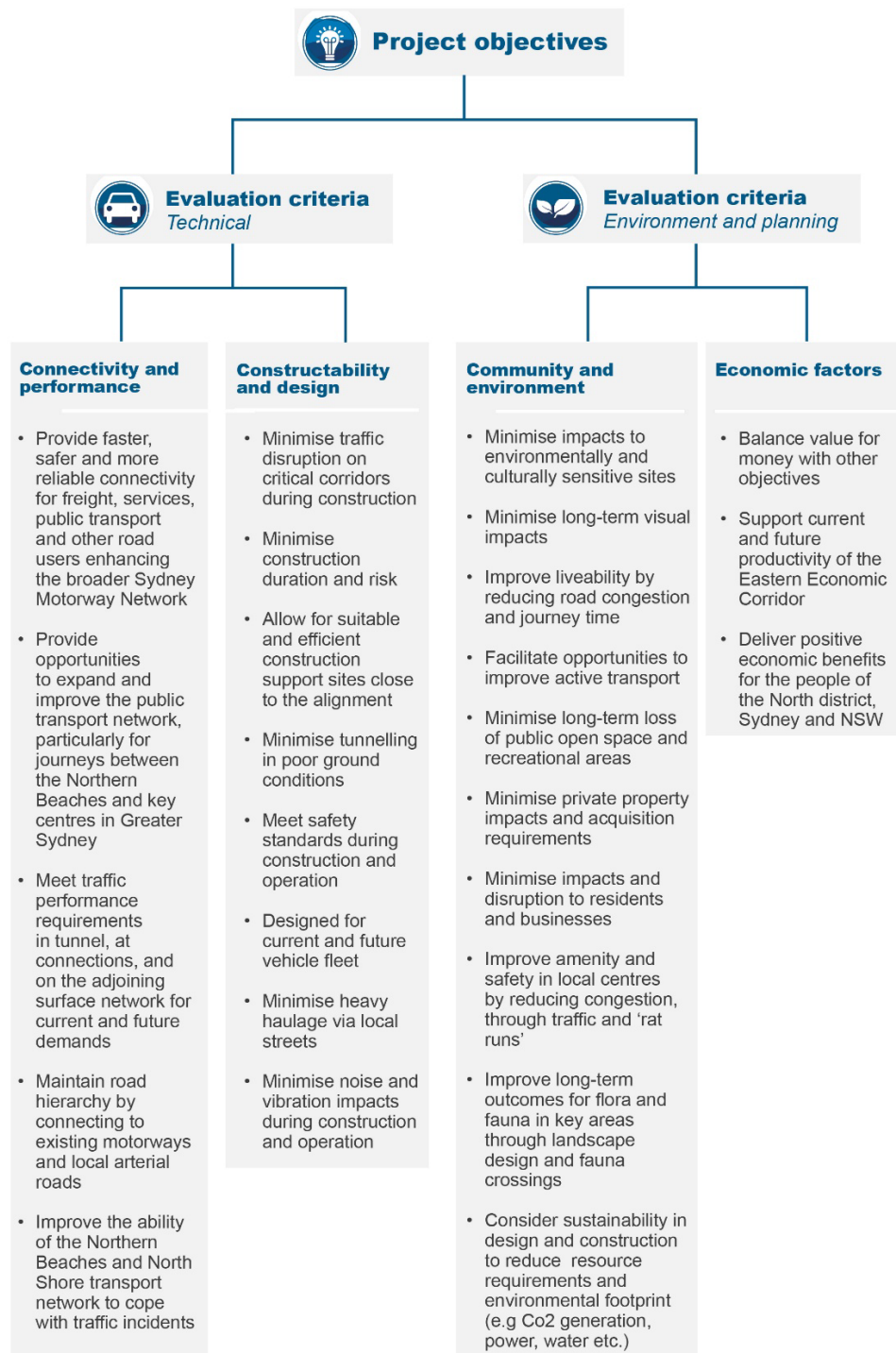


Figure 4-6 Evaluation criteria for corridor alternatives

A summary of the key strengths and weaknesses of each corridor alternative with respect to the evaluation criteria, are shown in Figure 4-7 to Figure 4-13.

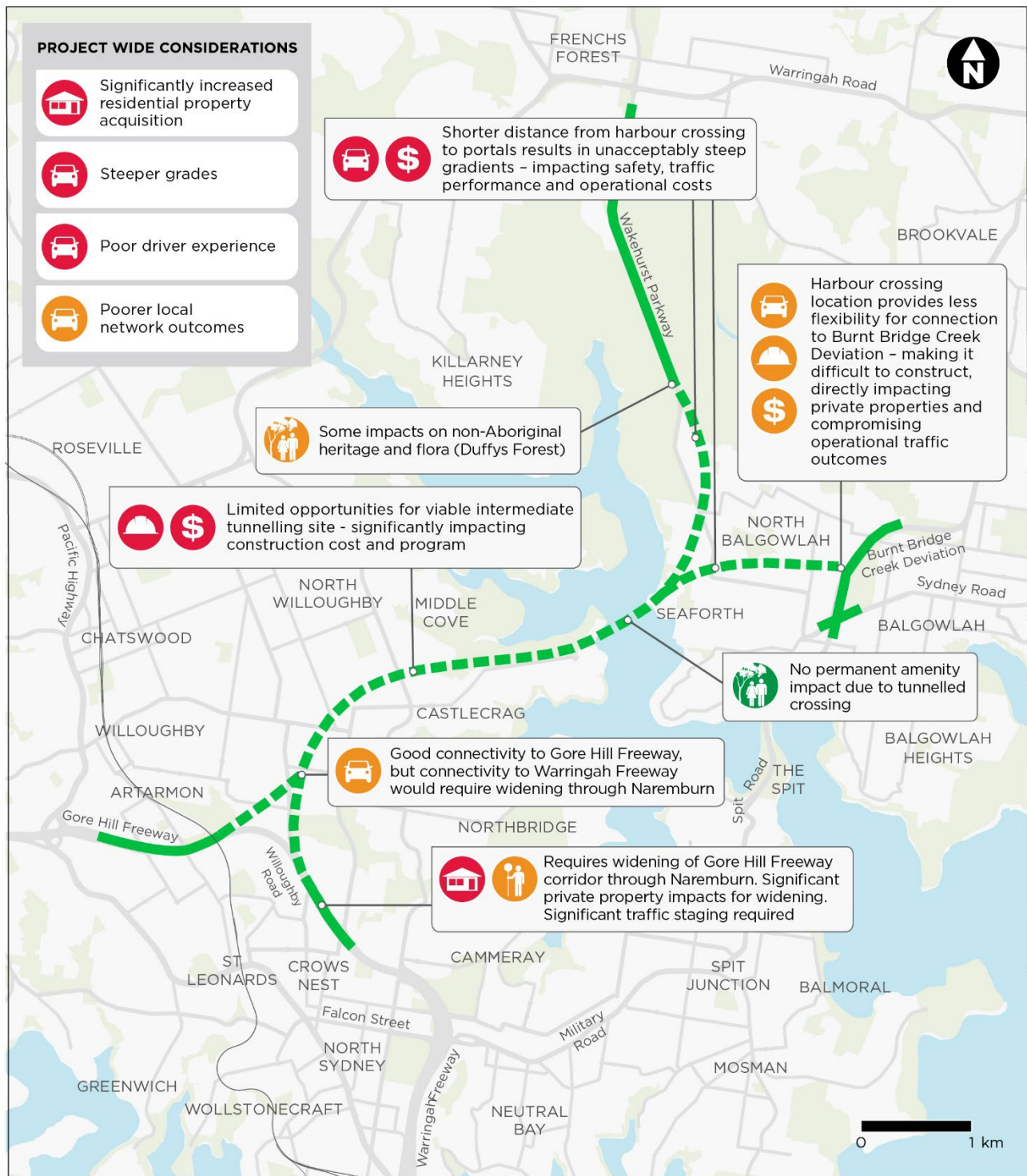


Figure 4-7 Green corridor alternative

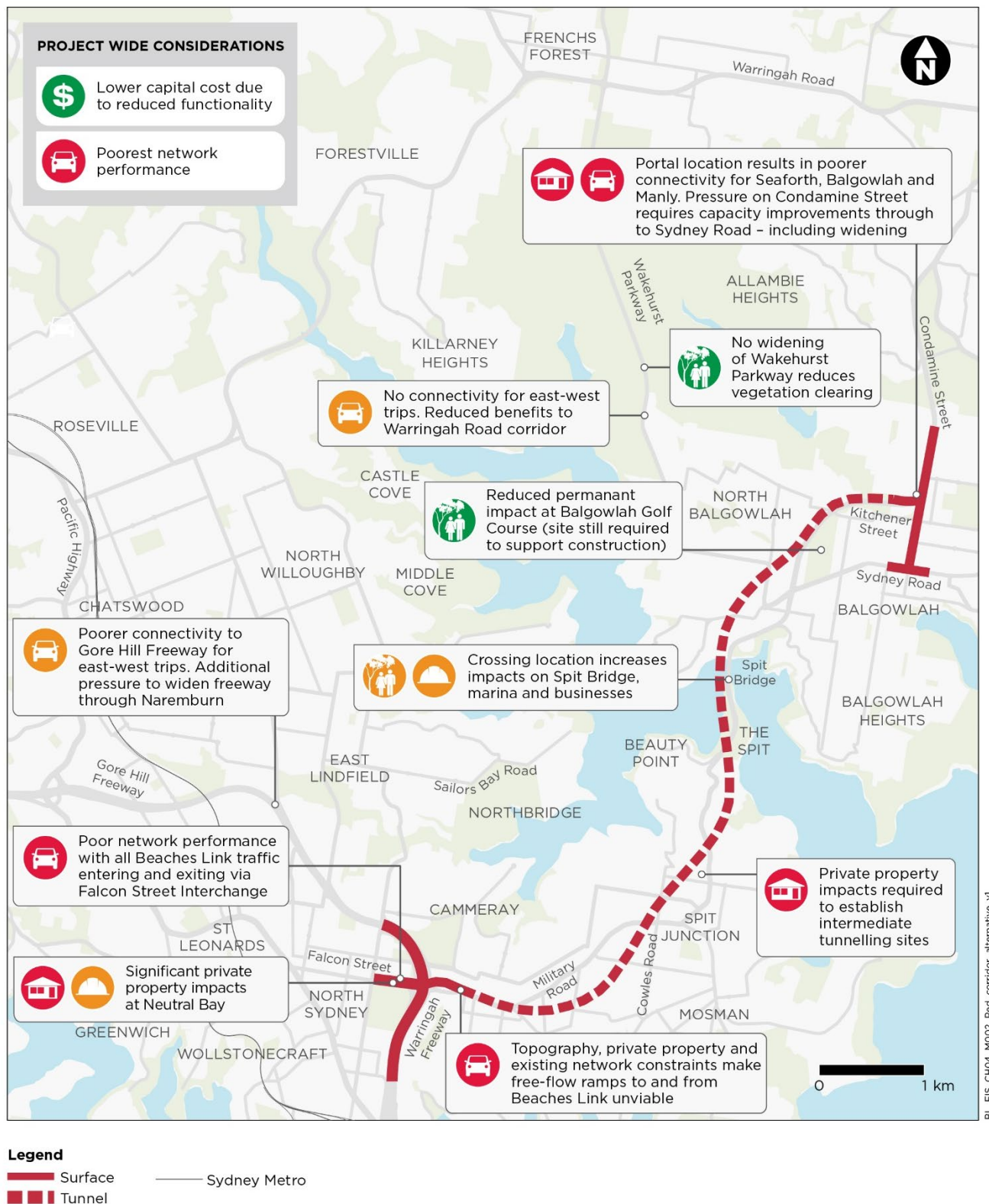


Figure 4-8 Red corridor alternative

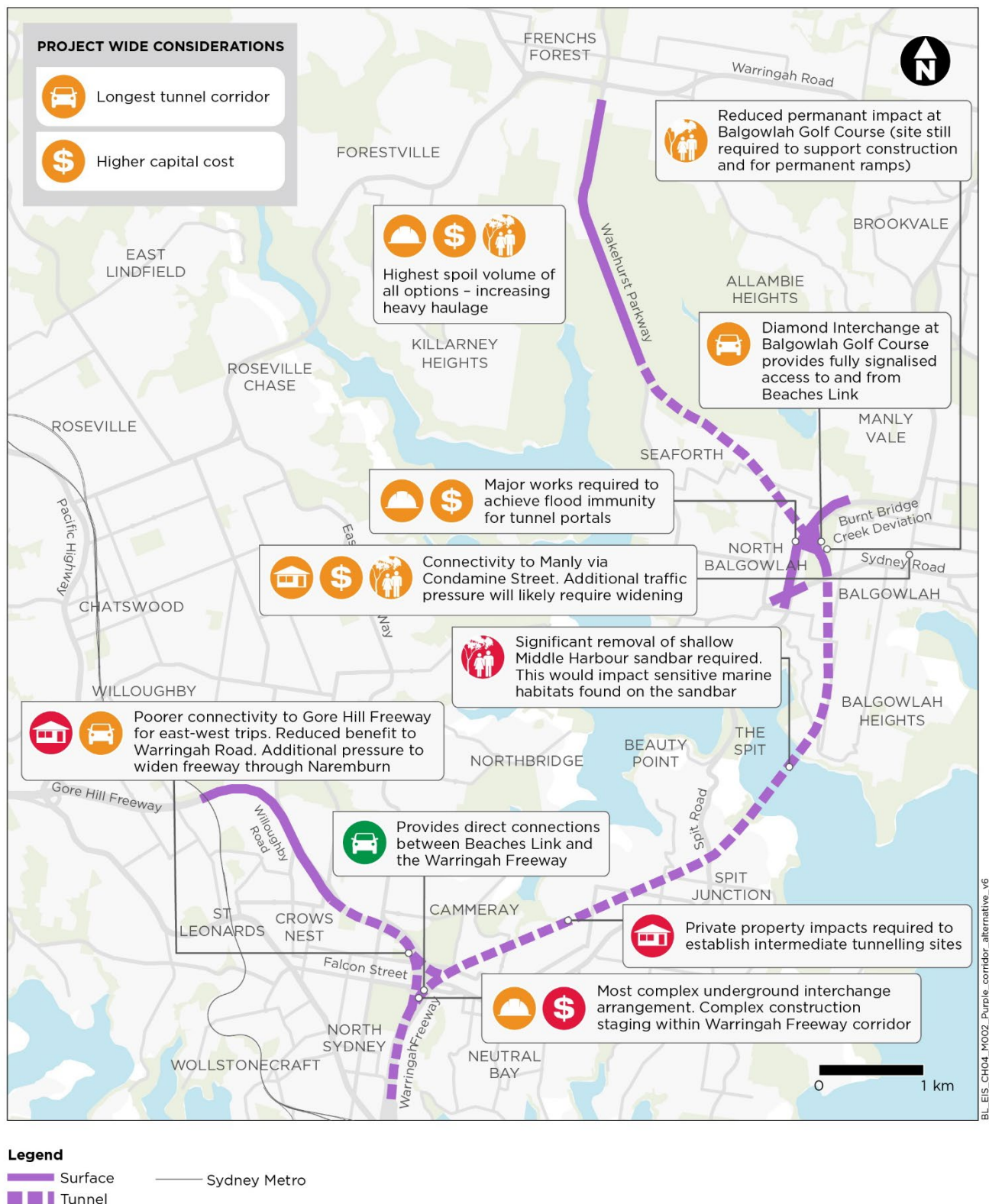
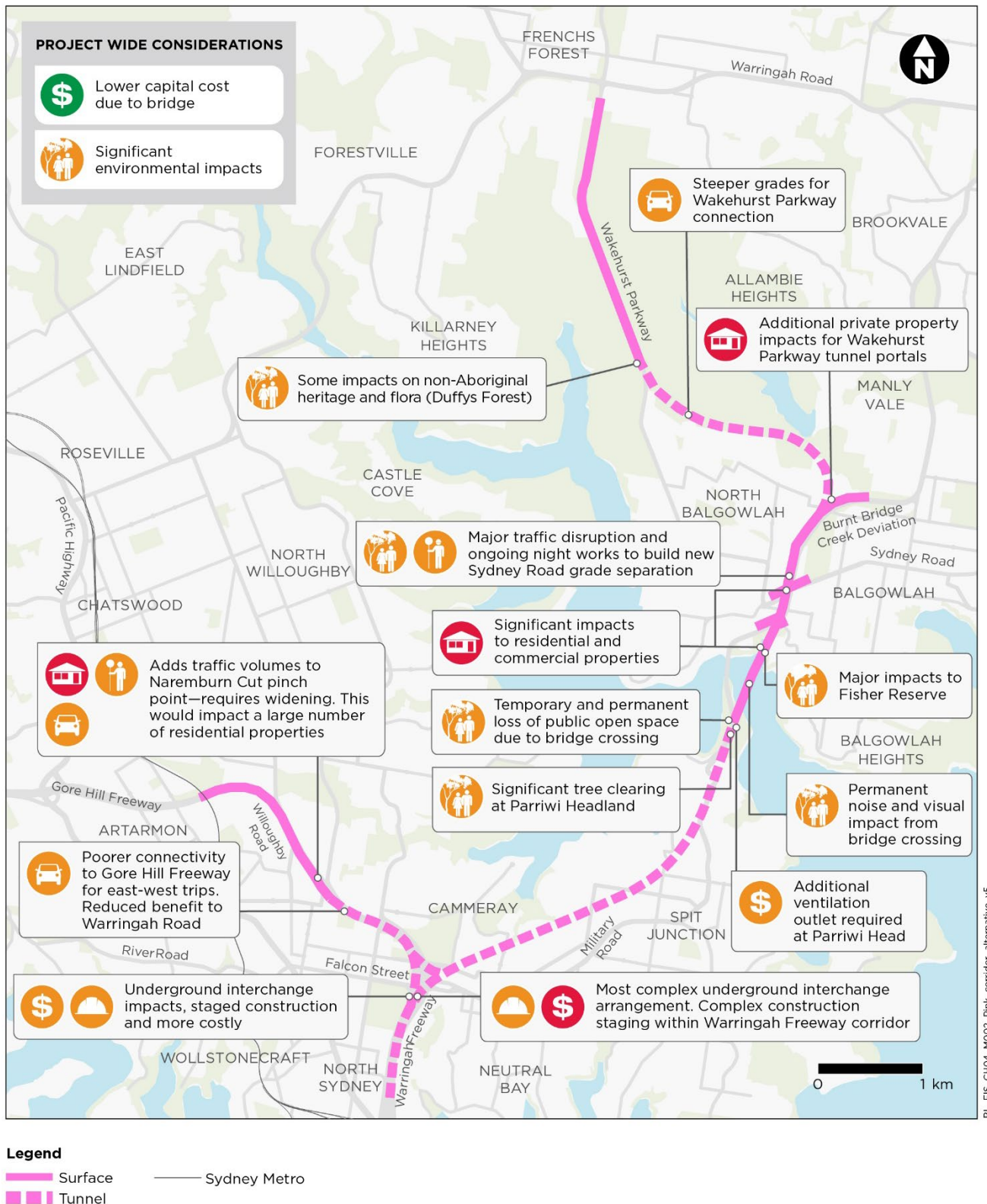


Figure 4-9 Purple corridor alternative



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Figure 4-10 Pink corridor alternative



Figure 4-11 Indicative concept design for bridge over Spit Bridge (aerial view) – Pink corridor alternative (image 1)



Figure 4-12 Indicative concept design for bridge over Spit Bridge (aerial view) – Pink corridor alternative (image 2)

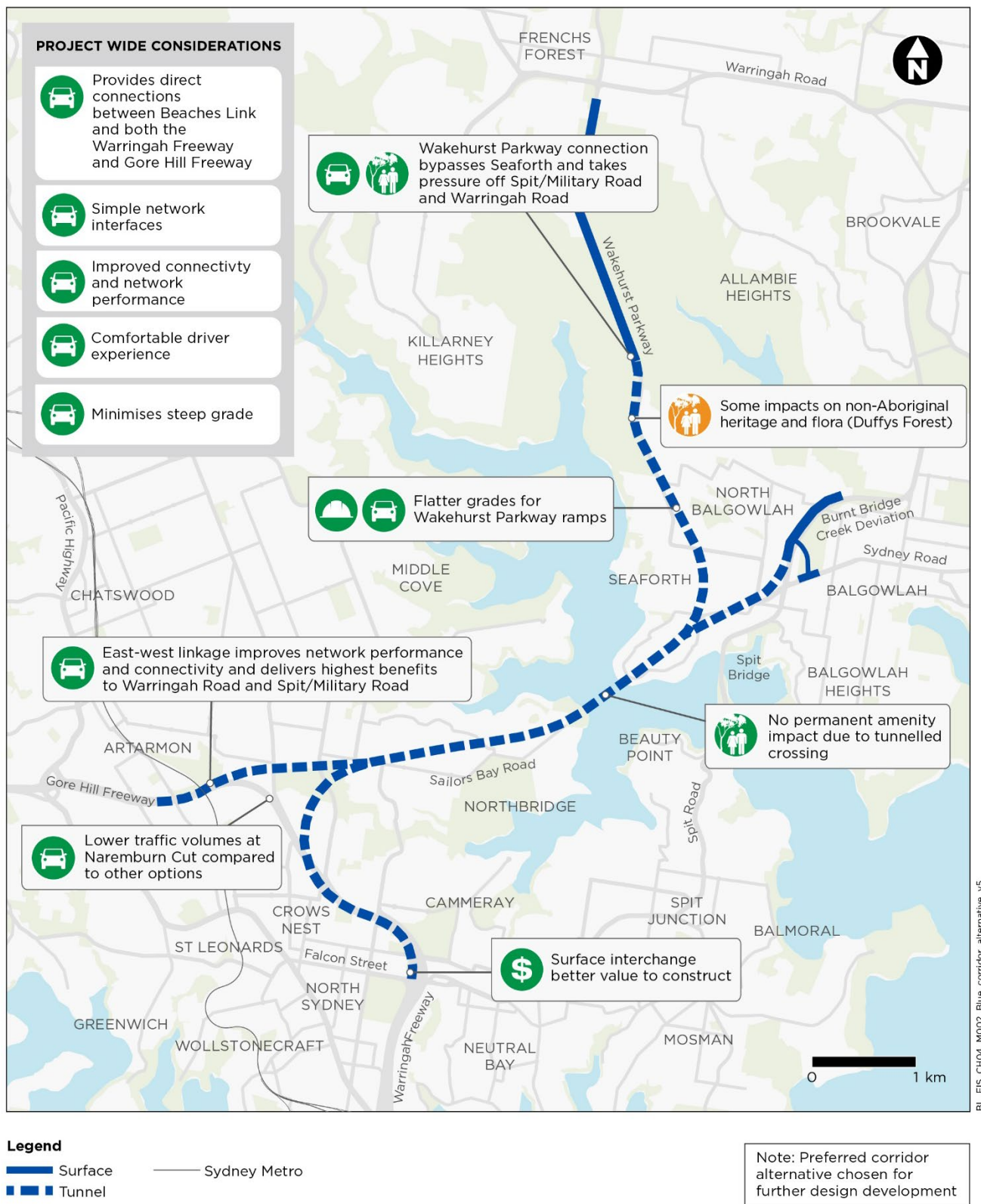


Figure 4-13 Blue corridor alternative

A summary of the evaluation of each of the corridor alternatives is outlined below:

- Green corridor – Not shortlisted on the basis of steep grades required to connect to the Wakehurst Parkway and Burnt Bridge Creek Deviation, impacting journey experience and efficiency of the road and the number of residential properties that would need to be acquired
- Red corridor – Not shortlisted on the basis of unacceptable construction impacts associated with construction method across Middle Harbour, traffic management issues associated with Sydney CBD-bound traffic at Falcon Street and widening of Sydney Road as well as private property impacts
- Purple corridor – Not shortlisted on the basis of having a higher capital cost than the other options without offering additional connectivity or constructability benefits. Also has substantial environmental impacts associated with dredging of the Middle Harbour sandbar that would be required to be traversed
- Pink corridor – Shortlisted for further analysis on the basis of having a lower capital cost to a tunnelled crossing of Middle Harbour
- Blue corridor – Shortlisted for further analysis on the basis of providing strong connectivity and also having lower amenity and environmental impacts compared to the other corridor options, including the pink corridor.

4.4.3 Preferred corridor

Both the pink and blue corridor alternatives provide connections to the Wakehurst Parkway and Burnt Bridge Creek Deviation, providing connectivity for residents and businesses in the north and south of the Northern Beaches peninsula. However, the blue corridor alternative has a number of connectivity and network performance advantages relative to the pink corridor, as outlined in the following sections.

Consistency with project objectives

The blue corridor alternative achieves a greater alignment with transport and city-shaping objectives. This reflects the fact that it delivers more direct east-west connectivity relative to the pink corridor alternative, while also providing strong north-south connectivity. This delivers more congestion relief to arterial roads, such as Warringah Road, and also provides the opportunity for new express bus services for customers travelling between the Northern Beaches and strategic centres such as North Sydney, the Sydney CBD, Macquarie Park and St Leonards.

The superior east-west connectivity means that the blue corridor alternative also performs better with respect to productivity objectives. This is a result of enabling greater access to jobs for residents in the Northern Beaches and associated reductions in the cost of business travel.

Connectivity and network performance

The evaluation of how the blue corridor outperforms the pink corridor in regard to connectivity and network performance is as follows:

- More direct connectivity between the Northern Beaches and strategic centres west of North Sydney, including Macquarie Park and St Leonards through an alignment that enables direct ramps to Lane Cove Tunnel and Reserve Road at Artarmon. Journeys between the Northern Beaches and Lane Cove Tunnel would be four kilometres longer each way via the pink corridor alternative – an extra 40 kilometres or 30 minutes travel each week per bus or car commuter
- Alleviating the requirement to widen the Gore Hill Freeway through the Naremburn Cut – a key pinch point on the motorway network. The pink corridor alternative would require widening of this section of motorway as a result of users travelling between Beaches Link and Lane Cove Tunnel needing to travel through the Naremburn Cut. This widening work would present substantial engineering challenges and related community impacts. The blue corridor alternative diverts about 25,500 vehicles per day from this section of motorway relative to the pink corridor alternative

- Enabling a surface interchange at Warringah Freeway rather than an underground interchange (pink corridor alternative), improving legibility for drivers
- Providing a more direct connection between the Wakehurst Parkway and the mainline carriageways under Seaforth, rather than requiring users of the Wakehurst Parkway to first connect to Burnt Bridge Creek Deviation.

Constructability and engineering

The blue corridor alternative also ranks higher overall with respect to constructability and engineering, particularly given it has a smaller construction footprint at Middle Harbour compared to the pink corridor alternative (ie bridge construction). The pink corridor alternative entails less direct construction with respect to the Middle Harbour crossing, as it is a bridge rather than a tunnelled crossing – notwithstanding that it would require major marine works to construct bridge supports with access by water. Construction of an immersed tube tunnel west of Spit Bridge would require passage of steel shell immersed tube tunnel units across the Middle Harbour sandbar and through Spit Bridge. A constructability assessment carried out for the project indicates this is feasible, based on steel shell immersed tube tunnel units being used with final fit out with reinforced concrete being carried out adjacent to Spit West Reserve.

The blue corridor alternative has a number of constructability advantages relative to the pink corridor alternative, including:

- An alignment further west of the Spit Bridge enabling a connection to the Warringah Freeway that alleviates the need for a complex underground interchange within Western Harbour Tunnel. Removing the need for an underground interchange also facilitates staging of Western Harbour Tunnel and Beaches Link
- A tunnelled crossing of Middle Harbour alleviates the requirement to grade separate Beaches Link and Sydney Road north of the Spit Bridge under live traffic. This would be required as part of the pink corridor alternative to facilitate passage of the motorway between the bridge crossing and Burnt Bridge Creek Deviation
- A tunnelled crossing alleviates the requirement to establish substantial work sites on both sides of Middle Harbour to enable bridge construction as part of the pink corridor alternative. The blue corridor alternative would require a work site at Spit West Reserve; however, work would primarily be carried out from the tunnel portal sites.

With respect to grades, the blue corridor alternative achieves about a four per cent mainline and off ramp grade to Burnt Bridge Creek Deviation. A four percent grade is also required for the off ramp connecting the mainline carriageway and the Wakehurst Parkway. The pink corridor alternative necessitates a higher grade of five per cent for the connection to the Wakehurst Parkway.

Community and environment

In terms of community and environmental considerations, the blue corridor alternative performs better than the pink corridor alternative. Of particular note are the greater residential property, heritage, flora and fauna, public open space and visual amenity impacts associated with the pink corridor alternative compared to the blue corridor alternative. The pink corridor alternative would require bridge infrastructure to be installed in Parriwi Park and Fisher Bay Bushland Reserve. These sites are known to contain Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions, which is listed as endangered under the *Biodiversity Conservation Act 2016* and critically endangered under the *Environment Protection and Biodiversity Conservation Act 1999*, and other threatened ecological communities and flora species.

From a community perspective, the pink corridor alternative introduces a visually dominant bridge structure and associated elevated operational noise source that does not currently exist. The blue corridor alternative does not introduce permanent impacts at these sites.

Property

The pink corridor alternative would permanently impact a large number of residential properties, many of which would require acquisition. Residential properties at Clontarf would need to be acquired to allow for construction of the northern bridge abutment and associated cutting, in addition to residences at Sydney Road within the footprint for the grade separated interchange. The connection with Burnt Bridge Creek Deviation would also require permanent acquisition of some of the land occupied by the Balgowlah Golf Course, along with some nearby residential properties.

The blue corridor alternative would impact fewer residential properties than the pink corridor alternative. Residential properties to the east of Burnt Bridge Creek Deviation would need to be acquired to enable construction of tunnel portal structures for the blue corridor alternative, and Balgowlah Golf Course would be permanently closed. At the Wakehurst Parkway connection, both blue and pink corridor alternatives would impact a number of residential properties, although it should be noted that Transport for NSW owns the affected properties. The blue corridor alternative would also impact 12 apartments adjacent to the Cammeray Golf Course due to widening required to connect the Beaches Link portal to the Warringah Freeway. In designing the project, the aim has been to minimise further property impacts by connecting at one of the widest points on the Warringah Freeway. The blue corridor alternative would also require some commercial properties to be acquired at Artarmon as part of the Gore Hill Freeway Connection.

Capital cost

As part of the optioneering process, strategic estimates were prepared for both alignments. Based on these estimates, the P90 Total Outturn Cost of the pink corridor alternative is estimated to be marginally less expensive than the blue corridor alternative.

The key differences in the underlying cost build up for the pink and blue corridor alternatives are as follows:

- Higher construction cost of a tunnel under Middle Harbour (blue corridor alternative) compared to a bridge (pink corridor alternative)
- Higher property impacts of the bridge option (144 residential properties under the pink corridor alternative compared to 54 under the blue corridor alternative).

Given the substantial property, environmental and amenity impacts associated with the pink corridor alternative, it was determined that a decision between either corridor alternative should not be made on the basis of cost difference.

As such, on the basis of its superior performance in these other areas of consideration, the blue corridor alternative was identified as the preferred corridor to be carried forward for further design development, including refinement of interchange options (refer to Section 4.5).

Summary of key advantages of preferred corridor

Key advantages of the blue corridor alternative include:

- Reduced environmental and amenity impacts:
 - The blue corridor alternative would avoid impacts to the areas around Parriwi Park and Fisher Bay Bushland Reserve, where endangered and threatened species have been recorded. Large areas of vegetation would be required to be cleared at these sites to construct the bridge crossing for the pink corridor alternative, and a sizeable portion of these areas would become part of the permanent motorway corridor
 - The blue corridor alternative would avoid major dredging and piling within the Middle Harbour sandbar, which is one of the most sensitive marine habitat areas within Middle Harbour
 - The blue corridor alternative would avoid permanent visual and noise impacts within Middle Harbour

- The blue corridor alternative would avoid major impacts to heavily utilised areas of Middle Harbour, including areas around The Spit, the Spit Bridge and the Middle Harbour Yacht Club.
- Connectivity and network performance:
 - The blue corridor alternative would result in fewer vehicles relying on the section of the Gore Hill Freeway through Naremburn (known as the Naremburn Cut). This reduces pressure on this constrained section of the existing motorway network, reducing the pressure to widen the corridor in an area where widening would present substantial engineering challenges and associated community impacts. This would result from providing a direct connection between Beaches Link and the Lane Cove Tunnel and Reserve Road at Artarmon, which would avoid the need for east–west journeys between these corridors to travel through the Naremburn Cut
 - Journeys between the Northern Beaches and north-west centres including St Leonards, Chatswood and Macquarie Park would be shorter via the blue corridor alternative compared to all others considered, with the exception of the green corridor alternative, which would be equivalent. This would deliver greater congestion relief to key east-west arterial roads, such as Warringah Road, and would also provide the opportunity for new express bus services for passengers travelling between the Northern Beaches and strategic centres such as North Sydney, Sydney CBD, Macquarie Park and St Leonards
 - With the blue corridor alternative, freight services, public transport, and other road users would save an average of 30 minutes travel time per week for journeys between the Northern Beaches and the lower North Shore when compared to the pink, red and purple alternatives – a large time saving, particularly when extrapolated annually across all users making this journey
 - Journeys between the Northern Beaches and North Sydney, the Sydney CBD and centres to the south and south-west would see considerable improvements delivered by the blue corridor alternative. The challenging topography and highly constrained freeway corridor south of Ernest Street at Cammeray mean that providing non-signalised connectivity to and from the Warringah Freeway is a key challenge for all alignment options, which is achieved by the blue corridor alternative
 - The superior connectivity means that the blue option would also perform best with respect to productivity objectives. This would be a result of enabling greater access to jobs for residents in the Northern Beaches and reducing the cost of business travel.

4.5 Further project development

Following identification of the blue corridor alternative as the preferred corridor for the project, further detailed project development work has been carried out, including:

- Extensive community and stakeholder engagement to identify key local issues to be taken into account in the development of the project (refer to Chapter 7 (Stakeholder and community engagement))
- Detailed environmental and other site investigations along the corridor, including desktop and field investigations to obtain additional data and identify further environmental considerations
- Design development and value engineering of multiple options within the blue corridor alignment to ensure benefits are realised, while reducing costs, program, constructability risks and community and environmental impacts where possible. This process also included consideration of community and stakeholder feedback and the outcomes of environmental and other site investigations.

This project development work included detailed consideration of the following, with further detail on these key issues provided in sections 4.5.1 to 4.5.10:

- Tunnelling methodology, both land-based and the preferred harbour crossing method, including alternatives to reduce the extent of dredging in Middle Harbour
- Location and configuration of the surface connections
- Ventilation alternatives, including the ventilation system design and outlet locations
- Temporary construction support site locations, layouts and alternatives
- Spoil transport, reuse and disposal alternatives.

Other factors considered during design development included:

- Detailed construction staging within the Warringah Freeway corridor to minimise disruption and optimise the corridor for future operations
- Construction staging and work methodologies at all surface connection locations to reduce impacts on surrounding communities, the environment, and the transport network
- Integration with and enhancements to existing public transport infrastructure, particularly along the Warringah Freeway corridor
- Opportunities to integrate with, and enhance, walking and cycling routes
- Utilities impacts and relocation requirements
- Minimising interfaces with heritage items
- The opportunity to improve long-term functionality and amenity at Balgowlah post construction by delivering new and improved open space and recreation facilities (subject to further community consultation)
- The opportunity for additional new and improved open space and recreation facilities would also be supplemented post construction by the re-purposing of residual land from the acquisition of Dudley Street private properties used for the Balgowlah Golf Course construction support site (BL10) and staging of the Balgowlah connection portal.

The development and evaluation of detailed components of the preferred corridor included consideration of options against a localised set of criteria that was consistent with the project objectives. These included connectivity, transport network performance, constructability, design, community, environmental, and economic criteria specific to the scope item and area being considered.

4.5.1 Tunnelling method alternatives

The methods used to deliver tunnels at different locations around the world varies greatly, primarily in response to the geology encountered and the cross-section that is required along the alignment. Roadheaders, tunnel boring machines, immersed tube tunnels, cut and cover tunnels, and the drill and blast methods are all used to deliver tunnels in different conditions around the world.

The process for selection of the preferred tunnel alignment and tunnel construction method for the project included the development and evaluation of over seven different combinations of tunnelling methods.

These options were developed and assessed by a multidisciplinary team of design, constructability, and environmental specialists with direct experience in delivering major tunnels in NSW, Australian and international contexts.

The assessment considered various technical and environmental factors including:

- Strategic traffic demands and how the vertical alignment and gradients might impact connectivity and performance

- Results of geotechnical and groundwater investigations
- Maritime heritage investigations
- Biodiversity and marine ecology surveys
- Lessons from domestic and international tunnelling projects with comparable constraints
- Turbidity and hydrodynamic monitoring and modelling of Middle Harbour
- Opportunities for viable temporary intermediate tunnelling sites that minimise impacts on sensitive vegetation, heritage sites, private property, local communities and the functionality of public open space
- Implications for physical and operational interfaces with other major infrastructure (for example Sydney Metro City & Southwest tunnels, the Northside Storage tunnel, the Western Harbour Tunnel and Warringah Freeway Upgrade project and building foundations in Artarmon and Seaforth)
- Horizontal alignments and waterway crossing methods that allow the tunnel to achieve acceptable vertical gradients to achieve the desired transport product, reduce whole of life emissions, operational costs, and improve safety outcomes
- Interfaces with commercial and recreational maritime stakeholders
- Market engagement, including technical engagement with 14 construction contractors
- Construction and operational costs.

The major change in geology beneath Middle Harbour introduces a constructability challenge that is very different to the alignment north and south of the harbour. Compared to the bedrock either side of the harbour, the rock beneath Middle Harbour is characterised by fracturing and is therefore prone to major water ingress under pressure. Given the depth and pressure, this creates a challenging tunnelling environment. Without suitable mitigation measures, major water ingress issues would be likely to arise during construction using a driven or bored tunnelling method. Accordingly, the following sections discuss the methodologies for the harbour crossing and the tunnels north and south of Middle Harbour separately.

Tunnelling north and south of Middle Harbour

Favourable tunnelling conditions are expected north and south of Middle Harbour, with the majority of the tunnel alignment expected to be constructed in high-quality Hawkesbury Sandstone. These geotechnical conditions typically make the use of roadheaders the most efficient and effective tunnelling methodology for delivery of road tunnels. Notwithstanding this, the challenge introduced by the Middle Harbour crossing also led to the consideration of tunnel boring machine construction methods for these segments. Examples of roadheaders and tunnel boring machines are shown in Figure 4-14.

Roadheaders are made up of rotating cutting heads mounted on a boom or similar structure. They are typically used where the rock being tunnelled through is very sound without being too hard. In these conditions roadheaders can be used to efficiently cut away the rock to form a tailored cross-section to match the exact cross-sectional area of the tunnel, minimising spoil generation and internal structure.

When using the roadheader method, multiple roadheaders are typically deployed via intermediate construction support sites along the alignment. This allows the tunnel to be constructed from multiple fronts, typically providing substantially reduced construction durations when compared to tunnelling from a single site.

The roadheader tunnelling method has been the preferred construction technique for all major motorway tunnels in Sydney, with the exception being the existing Sydney Harbour Tunnel, which was delivered mainly using the immersed tube tunnel technique and limited driven tunnelling on the northern approach to the immersed tube tunnel. The favourable Hawkesbury Sandstone geology combined with the requirement for a wide but short cross-section are the key variables

that have combined to make roadheaders the most efficient and cost effective method for delivering motorway tunnels in Sydney.

Tunnel boring machines are much larger than roadheaders, and use a circular rotating cutting head that houses many individual cutting tools. Due to the circular cutting head, tunnel boring machines excavate and produce a circular tunnel cross-sectional area.

To allow for tunnelling in many different types of geology, there are many different types of tunnel boring machines. With no one type of machine ideally suited to tunnelling through both rock and soft ground, major changes in geology, such as the transition to the soft sediments found beneath Middle Harbour, or the highly fractured rock below this, would require a different type of tunnel boring machine to the landside tunnels being constructed through Hawkesbury Sandstone.

This is best demonstrated by the construction method adopted for construction of the new Sydney Metro crossing of Sydney Harbour, where the poor geology under Sydney Harbour required a different type of tunnel boring machine to the landside tunnels. Accordingly, the Sydney Metro City & Southwest project used five tunnel boring machines – two north and two south of the harbour to complete tunnelling through rock, with one specialised machine for the crossing of Sydney Harbour. This required the establishment of large shafts at Barangaroo and Blues Point either side of Sydney Harbour to launch, retrieve and support the tunnel boring machine for the harbour crossing.



Figure 4-14 Examples of a roadheader (left) and tunnel boring machine (right)

At about seven metres in diameter, the tunnel cross-section required to deliver a metro rail tunnel is well suited to a small diameter tunnel boring machine. In contrast, at 15.5 metres wide, a modern three lane motorway tunnel requires a wide, but stout cross-section. This does not fit very efficiently into a circular cross-section, meaning that delivering a motorway with a tunnel boring machine requires considerably larger machines than employed on metro rail projects. This means that the tunnel boring machine required to deliver each Beaches Link tunnel would have an area five times that of a machine used to construct the Sydney Metro City & Southwest tunnels.

The indicative cross-sections of the Beaches Link tunnel if roadheaders or tunnel boring machines are used are shown in Figure 4-15. This diagram demonstrates that the cross-section required for a modern motorway does not fit efficiently within the circular cross-section provided by a tunnel boring machine. This geometric challenge creates several practical obstacles to the deployment of tunnel boring machines for the Beaches Link tunnel:

- Large increase in spoil generation, increasing heavy haulage
- Increased structural costs, as the pavement level within the tunnel needs to be raised to the widest point in the cross-section
- Tunnel boring machines 16 metres in diameter and larger are not a common tunnelling solution, increasing construction cost and risk
- Tunnel boring machines are typically not preferred where there are multiple major changes in cross-section or geology. These occur at several locations along the Beaches Link alignment.

This means that roadheaders would still be required to build access tunnels from intermediate sites to construct the caverns where ramps merge and diverge from the tunnels under Northbridge and Seaforth, and at either side of the harbour crossing.

When considering the above, roadheaders emerge as the preferred tunnelling methodology for all tunnelling north and south of the Middle Harbour crossing.

Options to build multi-level roadways within a single cross-section were also considered (for example two lanes above two lanes), but these would require tunnel boring machines with even larger diameters.

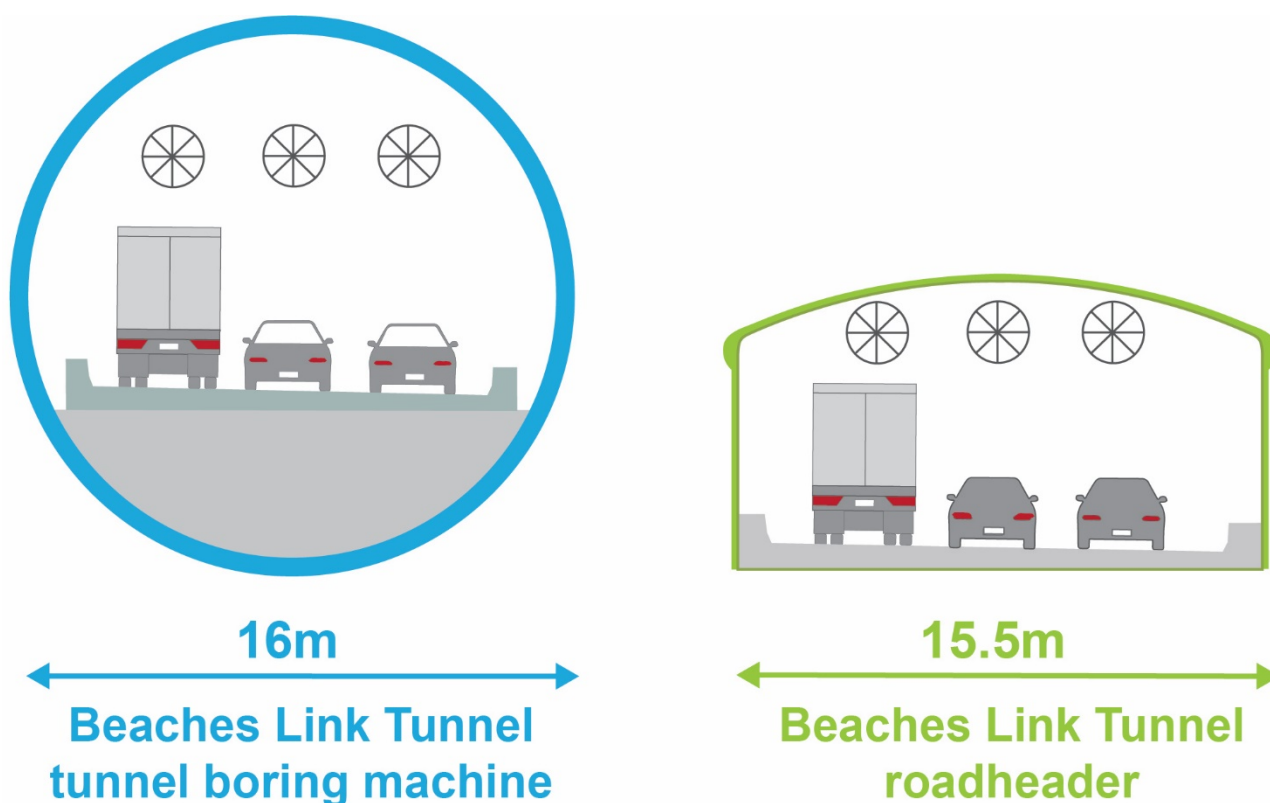


Figure 4-15 Comparison of tunnel cross-sections using a tunnel boring machine and a roadheader

A comparative evaluation of alternative tunnelling methods for tunnelling north and south of Middle Harbour is summarised in Table 4-3.

Table 4-3 Alternative tunnelling methods

Method	Summary of evaluation
Roadheader (preferred method)	<p>Advantages:</p> <ul style="list-style-type: none"> • The technology required is well understood and has been proven to be most efficient and cost-effective for motorways in Sydney's geological conditions • All major motorway tunnels in Sydney to date have been built successfully by roadheader (excluding the Sydney Harbour Tunnel) • Reduced construction risk relative to using a tunnel boring machine for a three lane road tunnel (further details below) • Ability to cut an exact cross-section reduces infrastructure or fill

Method	Summary of evaluation
	<p>required within the tunnel to achieve desired road level</p> <ul style="list-style-type: none"> • Substantially lower spoil volumes and heavy vehicle movements relative to using a tunnel boring machine • Machines are relatively inexpensive and readily available in the Sydney market • Roadheaders can generally be deployed much faster than tunnel boring machines, due to shorter procurement, establishment and commissioning times. <p>Disadvantages:</p> <ul style="list-style-type: none"> • Tunnelling rate of roadheaders is less than tunnel boring machines when both reach peak production • Depending on the length of tunnel, roadheaders may require intermediate surface construction and access sites.
Tunnel boring machine	<p>Advantages:</p> <ul style="list-style-type: none"> • If the geology and cross-section are consistent, tunnel boring machines can usually construct much longer tunnels with fewer intermediate surface access points • Provides for faster excavation rates than roadheaders when the machine is ideally matched to the project geology and major changes in cross-section or geology along the tunnel are minimised • Provides safer tunnelling conditions in poor ground conditions when compared to roadheaders. <p>Disadvantages:</p> <ul style="list-style-type: none"> • Require larger tunnelling and access sites than roadheaders • Tunnel boring machines are considerably more expensive to procure and operate than roadheaders • The timeframe for procuring, commissioning and launching tunnel boring machines would be much longer than for roadheaders • A three lane motorway cross-section would require tunnel boring machines about 16 metres in diameter. These would be within the top five largest globally. Given that mega diameter machines are uncommon, machines of such size are likely to pose considerably more construction risk than a roadheader solution • Being a circular excavation, tunnel boring machines require much greater over-excavation compared to roadheader construction. This results in substantially increased spoil volumes for the rock tunnelling and associated heavy vehicle hauling or barging and disposal, as well as a need to backfill within the tunnel to build the road level back up • Tunnel boring machines require long stretches of tunnel to outperform roadheaders on a cost and production basis. The maximum drive length for the Beaches Link tunnel would be two kilometres; therefore, there would be minimal efficiencies from using tunnel boring machines • Roadheaders and intermediate sites would still be required to excavate caverns and ramp connections ahead of tunnel boring machine arrival, as tunnel boring machines cannot accommodate these changes in cross-section • Major intermediate sites would be required at the northern and

Method	Summary of evaluation
	southern shorelines of Middle Harbour to retrieve landside machines and launch specialised machines if the project was to select tunnel boring machines that are matched to geology. The sites would need to be large to accommodate tunnel boring machines of the size and type required.

Middle Harbour crossing

While the majority of the tunnelling for the project is expected to be constructed through high-quality Hawkesbury Sandstone, the portion of tunnel crossing Middle Harbour presents particular challenges. These include:

- **Large changes in elevation:** Middle Harbour is a trench formed in bedrock, at its deepest being 60 metres below the water surface and 30 metres below the deepest rock level of the bed of the harbour. The bedrock is covered by up to 30 metres of clay, cobbles and silty sands. The tunnel would rise about 145 metres in elevation to connect from 30 metres below Middle Harbour with the Wakehurst Parkway at 115 metres in elevation. Considering the elevation change between the rock level under the bed of the harbour and the surface road connections at Cammeray, Artarmon, Balgowlah and Killarney Heights, it becomes apparent that the vertical grade of the proposed tunnel would be a key challenge – with gradient having implications for long-term operations of the tunnel in terms of safety and generation of emissions). A tunnel boring machine would be required to travel deep under Middle Harbour and travel underground for a long distance, producing steep tunnel gradients. This would present implications for safety and emission generation
- **Poor geology and rock fracturing at the harbour crossing:** Geotechnical testing has been conducted for the proposed harbour crossing. Unlike the bedrock either side of the harbour, the rock beneath the bed of the harbour is generally highly fractured. Without mitigation measures like forward probing and pre-grouting, this fracture zone is likely to cause major water ingress issues during construction using a driven or bored tunnelling method. This was observed during construction of the Northside Storage Tunnel beneath Middle Harbour in the late 1990s using a tunnel boring machine. These water ingress issues are normally controlled and managed through pre-grouting ahead of tunnelling operations where required and installing appropriate waterproof linings following tunnel excavation. Despite utilising forward grouting on the Northside Storage Tunnel project, the project encountered considerable water ingress during construction due to cracking of grout from initial rock relaxation along with substantial water pressures at depth. Utilisation of this knowledge would allow for a specialist tunnel boring machine to be designed to accommodate this risk in the future. Above the layer of fractured rock are layers ranging from stiff clay through to sand and sediment. Depending on the vertical alignment of the tunnels, they may need to be constructed through rock, through sediment, or a combination of these. Generally tunnelling through sediment is undesirable as it is prone to instability. However, high-quality Hawkesbury Sandstone is very deep beneath the harbour, giving rise to the need to balance between the preference to tunnel through rock and the gradient of the tunnels – with the gradient of the tunnels affecting traffic performance, emission generation, ventilation design, and long-term operational costs for the tunnels
- **Limited intermediate sites:** For most of its alignment, the proposed Beaches Link tunnels would pass beneath the suburbs of Willoughby, Naremburn, Northbridge, Seaforth and Balgowlah, which are characterised by highly urbanised areas with narrow streets. This presents a sizeable challenge to the establishment of viable intermediate tunnelling sites as these would likely require acquisition of a large number of private properties and/or unacceptable haulage routes via narrow local streets. This is a particular challenge when considering the scale of sites required to support large diameter slurry shield or tunnel boring machines for the harbour crossing. Furthermore, the topography means that the Beaches Link tunnels would generally be very deep, meaning that very deep shafts would be required to provide access at intermediate sites. Given the depth of the tunnels, establishment of

intermediate shafts near the harbour would take a long time to construct, and would be very inefficient points for construction access and egress

- **Cross-section:** The cross-section required for a modern three lane motorway crossing of Middle Harbour is about 15.5 metres wide. Given the poor geology (refer to Figure 4-16), this creates a considerable challenge for tunnel boring machines or roadheaders. If using a tunnel boring machine, this would require one of the largest machines of its type ever used in the world – substantially increasing construction cost, engineering and safety risk.

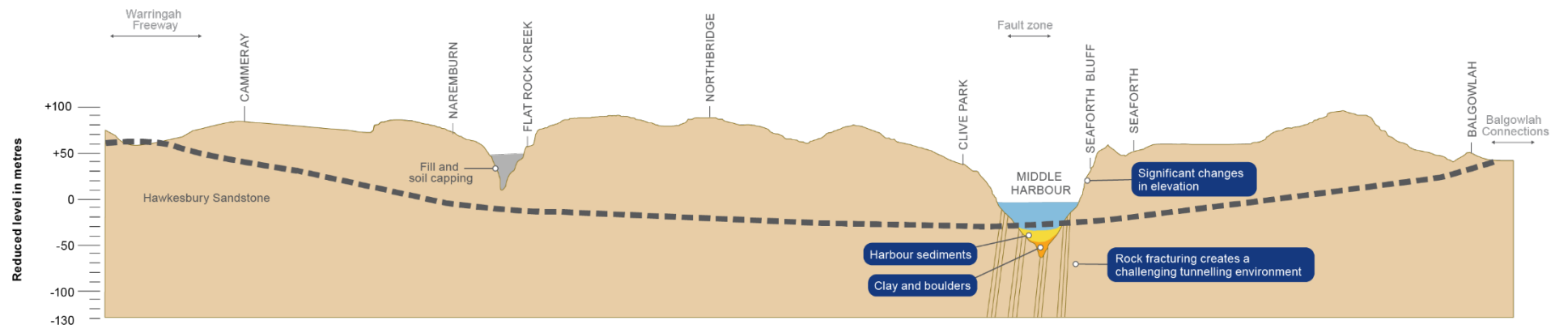


Figure 4-16 Indicative vertical alignment of the mainline and ramp tunnel

Design development for the project included a strong focus on evaluation of potential tunnelling methods for the crossing of Middle Harbour. This analysis was carried out by a multidisciplinary team including design, construction, transport planning, and environmental specialists to ensure a comprehensive analysis. It included the consideration of the roadheader method, specialised slurry shield tunnel boring machines, and an immersed tube tunnel (similar to the existing Sydney Harbour Tunnel).

Roadheader options for the Middle Harbour tunnel crossing were discounted early in the process for the following reasons:

- The tunnel depth required to deliver this method beneath Middle Harbour would compromise the gradients of the mainline tunnel, affecting traffic performance, emissions generation, and construction and operational costs
- The highly fractured geology beneath Middle Harbour, which creates a risk of major water ingress during construction if using the roadheader method.

Although tunnel boring machines are a viable alternative, the diameter and type of machines required for the crossing of Middle Harbour cannot be considered a conventional solution. Depending on the depth of the alignment, the tunnel boring machines required to cross Middle Harbour would need to be very large diameter slurry shield machines, as shown in Figure 4-17.

Slurry shield tunnel boring machines use clay slurry and compressed air to carefully control the pressure at the tunnelling face. This is required to maintain stability ahead of construction of the permanent concrete lining when tunnelling through poor ground conditions, such as those expected beneath Middle Harbour. The pressure at the tunnelling face needs to be carefully controlled as the machine advances to respond to the ground conditions as they vary.

These are highly sophisticated and specialised machines, and have rarely been used for sub-sea tunnelling at the diameter that would be required for the project. Slurry shield tunnel boring machines also require large landside sites, likely needing additional land acquisitions to accommodate these additional facilities which are not required for roadheader tunnelling:

- Segment production and storage
- Clay slurry production and processing.

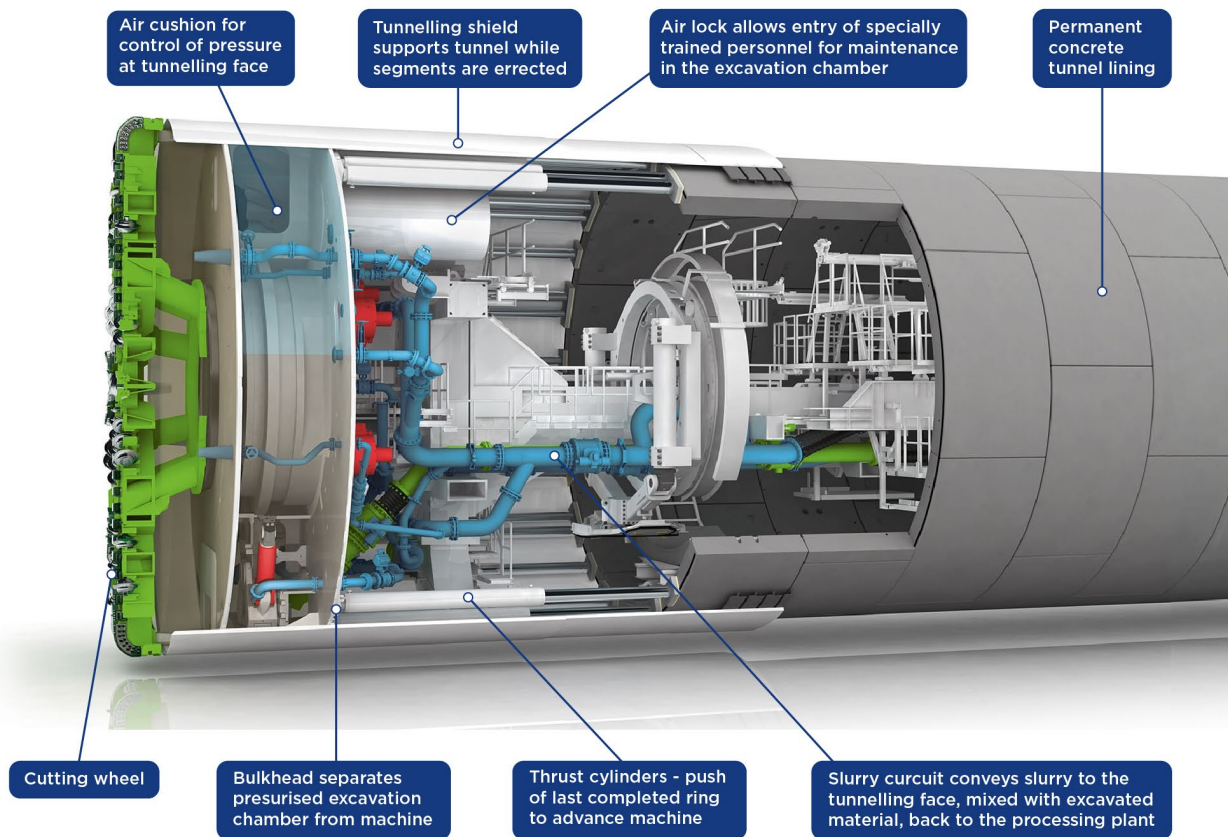


Figure 4-17 Example of a slurry shield tunnel boring machine

An alternative to tunnelling through rock or sediment using roadheaders or tunnel boring machines would be to place precast tunnel units on top, or within, the top layers of harbour rock and sediments. This method is known as an immersed tube tunnel and has been applied to over 150 major road and rail tunnels around the world to overcome similar combinations of geology, topography and cross-sectional challenges, including the existing Sydney Harbour Tunnel.

This alternative would involve excavation of the bed of the harbour and placement of immersed tube tunnel units within the excavated trench of varying depth as shown in Figure 4-18.

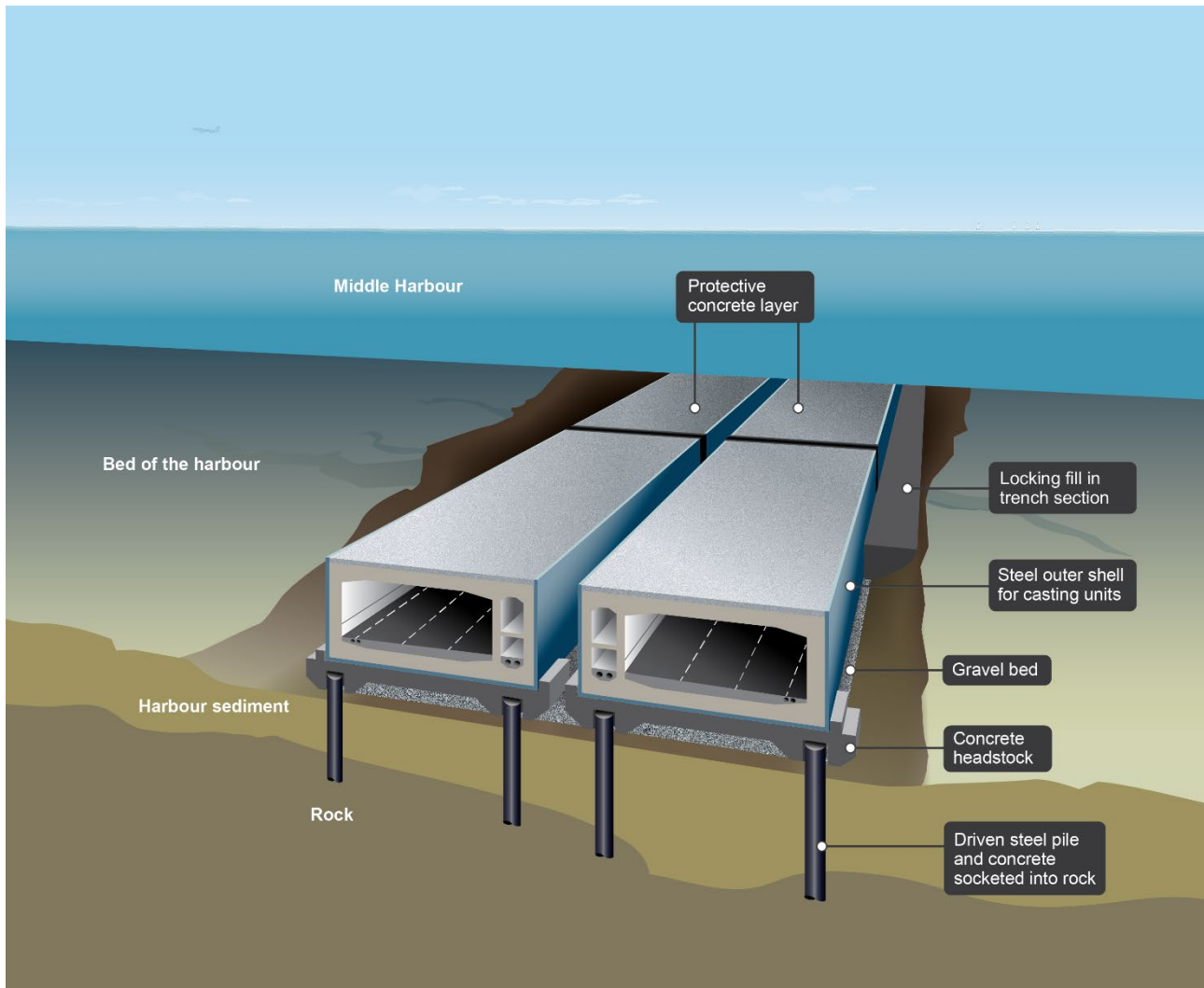


Figure 4-18 Example of an immersed tube tunnel

Figure 4-19 shows the four main options considered for the vertical alignment of the Middle Harbour tunnels:

- A deep driven roadheader tunnel, completely within rock (green)
- A shallower tunnel boring machine tunnel, with parts of the tunnel in softer, weathered rock or sediment (blue and purple)
- An immersed tube tunnel lying on top, or within the top layers, of softer, weathered rock and sediments (grey).

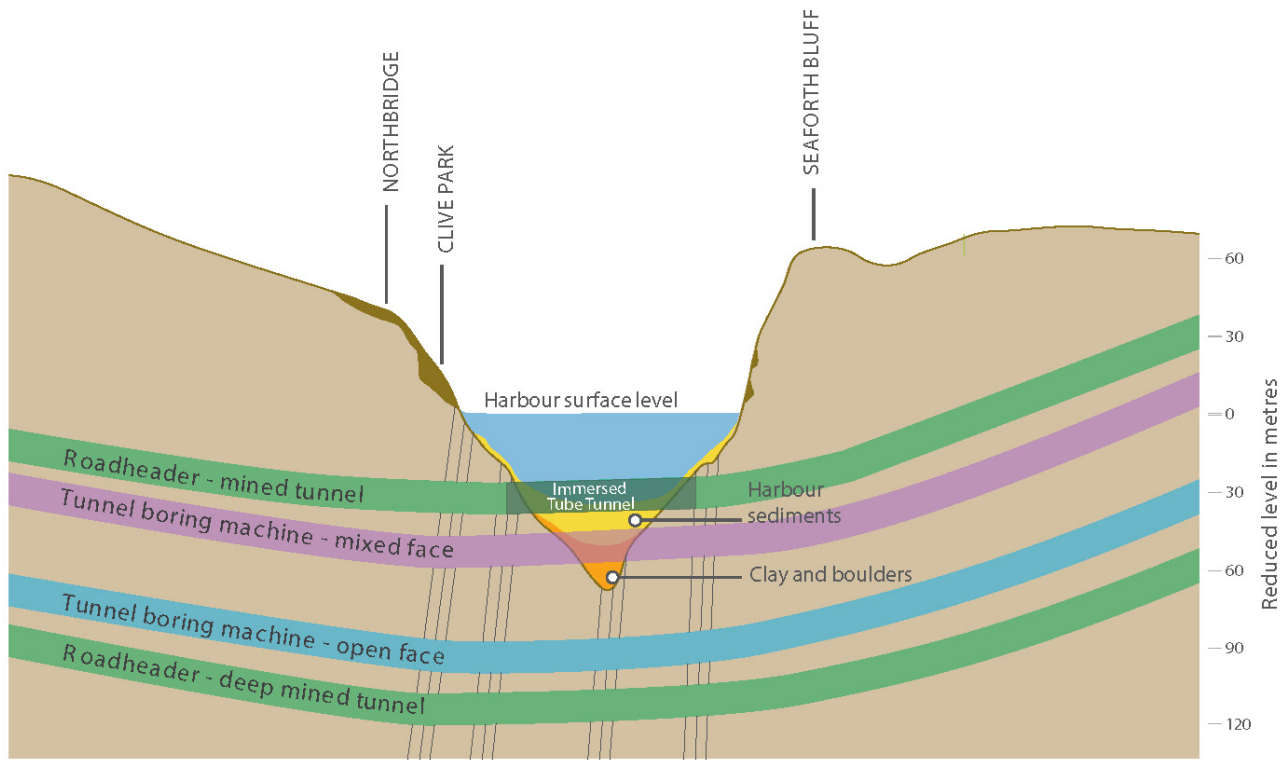


Figure 4-19 Main vertical alignment options for the Middle Harbour tunnels

When considering the performance of each of the potential methodologies against design, constructability, traffic performance, environmental and social criteria, the preferred method for crossing Middle Harbour is via an immersed tube tunnel. The justification for selecting this alternative is summarised in Table 4-4.

Table 4-4 Preferred tunnelling method for the Middle Harbour crossing

Method	Summary of evaluation
Immersed tube tunnel	<p>Advantages:</p> <ul style="list-style-type: none"> • The technology required is proven, having been used on major contemporary infrastructure projects around the world, including the Sydney Harbour Tunnel • Provides the shallowest possible tunnel alignment at the Middle Harbour crossing enabling the best possible gradient and associated performance outcomes (eg safety, vehicle speeds, journey experience, long-term emissions) • Minimises tunnelling risks by reducing exposure to tunnelling through poor geology and reducing the time workers need to spend in high risk tunnelling environments • Lower construction and operational costs when compared to alternative methodologies • Minimises the size of waterside sites when compared to those required to launch, support, and retrieve large diameter tunnel boring machines • Substantially reduces haulage on land when compared to tunnel boring machine solutions • Takes advantage of marine logistics to minimise heavy haulage on roads • The preferred alignment avoids interfaces with substantial sensitive marine ecology at the sand bar at the entrance to Middle Harbour (immersed tube tunnel proposed for the purple corridor alternative). <p>Disadvantages:</p>

Method	Summary of evaluation
	<ul style="list-style-type: none"> Requires measures to be implemented to prevent migration of material during excavation of sediments, particularly areas with elevated levels of contaminants within the surface layer (about 0.5 metres to one metre) of the bed of Middle Harbour Interfaces with commercial and recreational maritime traffic during construction.

4.5.2 Warringah Freeway connection alternatives

The Warringah Freeway connection would provide connectivity between Beaches Link, the Western Harbour Tunnel and Gore Hill Freeway. Initially, considerations of possible alternatives for such a connection included an underground interchange option as well as a contemporary surface interchange. Ultimately, the underground interchange was found to be incompatible with the preferred corridor alternative (blue corridor alternative), while also being considered to be cost prohibitive. The underground interchange would require the reconfiguration of the Warringah Freeway corridor for surface infrastructure and portals, given the increase in vehicles that would use the corridor, and some form of connection to the surface for vehicles leaving the Beaches Link tunnel.

As such, a surface connection in the form of a surface interchange, was considered the preferred connection alternative for linking the Beaches Link and Warringah Freeway. However, there were severe limitations for the location for a surface interchange, given the intense land use in the surrounding area and the resulting environmental and community impacts, including property acquisition. Therefore, the preferred alternative for the Warringah Freeway connection has been developed to remain primarily within the existing road corridor.

With this in mind, the consideration of alternatives for the surface connection of Beaches Link and Warringah Freeway included:

- Locations and configurations of ramp connections to and from the Warringah Freeway
- Connections between the Beaches Link and the Western Harbour Tunnel, North Sydney and, more broadly, the Sydney Harbour Bridge (cut and cover or mined-tunnel solutions)
- Minimising environmental, community and property impacts.

Informed by these considerations, it was determined that the preferred connection alternative for the Warringah Freeway would be that the Beaches Link tunnel portals would be located south of the Miller Street overpass within the road corridor. This location would take advantage of the wide road corridor and more sympathetic topography compared to road corridor availability and topography for tunnel portal locations south of Ernest Street. The tunnel portal locations would also enable many of the proposed road connections to largely occur aboveground, thereby avoiding more underground caverns and tunnels. The location would require utilisation of some land currently used by Cammeray Golf Course in order to achieve the optimal staging of the surface connection.

The surface connection would also integrate with the Western Harbour Tunnel and Warringah Freeway Upgrade project, ensuring that the location and extent of ramp connections and portals, as well as the preferred construction methodology, could be optimised between the projects, reducing disruption as much as possible.

4.5.3 Gore Hill Freeway Connection alternatives

The Gore Hill Freeway Connection would provide the strategic east–west link for movements between the Northern Beaches and strategic centres accessed via the Gore Hill Freeway/Lane Cove Tunnel and Reserve Road at Artarmon, including Macquarie Park and St Leonards. Three alternatives have been considered for this connection as shown in Figure 4-20.

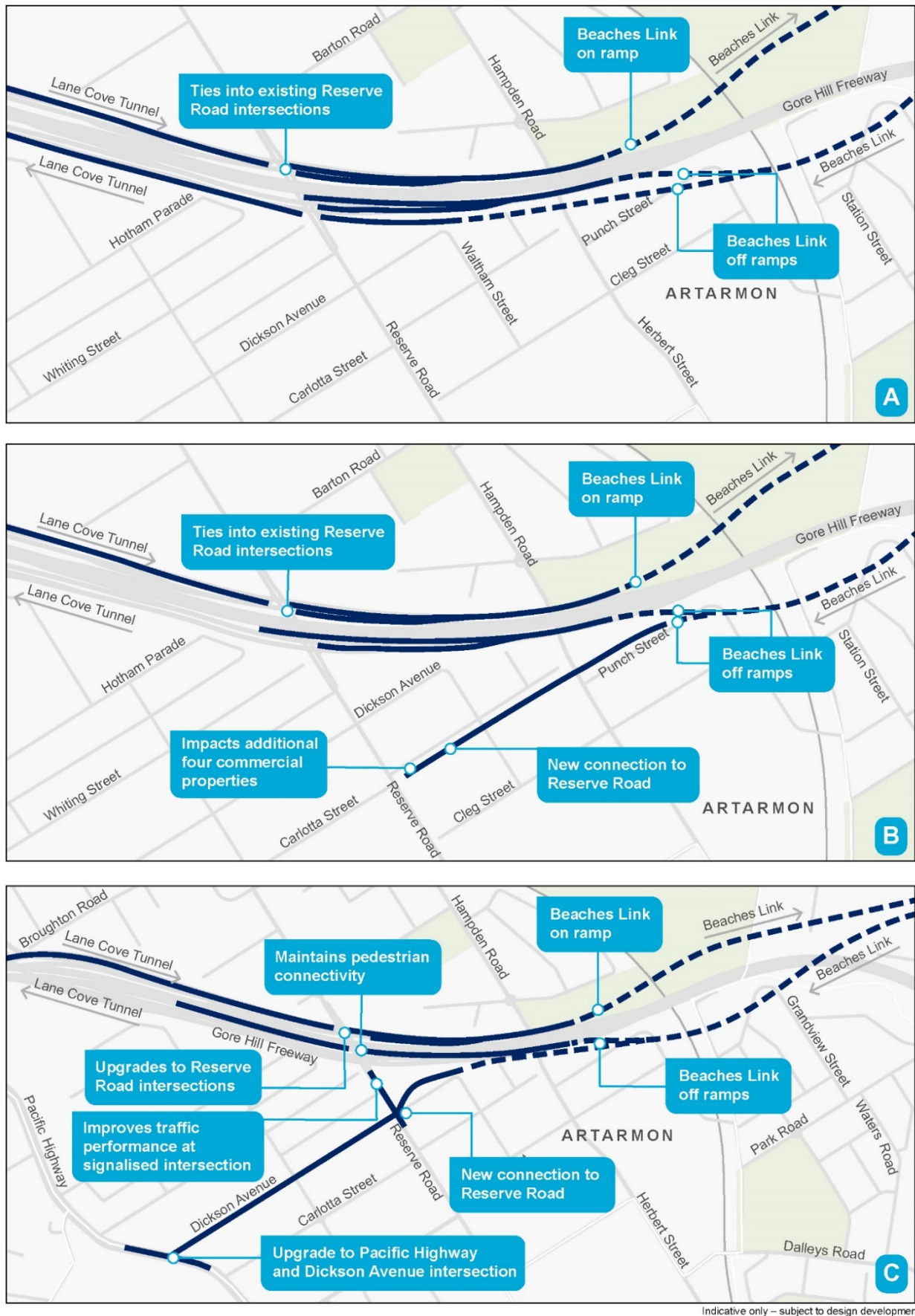


Figure 4-20 Alternatives considered for the Gore Hill Freeway Connection

An overview of the justification for selecting option C (refer to Figure 4-20) as the preferred connection alternative is summarised in Table 4-5.

Table 4-5 Summary of evaluation of Gore Hill Freeway Connection preferred alternative

Evaluation criteria	Reason for preferred alternative (option C)
Connectivity and network performance	<ul style="list-style-type: none"> • Provides connectivity between Beaches Link and the Gore Hill Freeway/Lane Cove Tunnel, supporting the strategic east–west connectivity to and from the Northern Beaches • Provides connectivity between Beaches Link and Reserve Road, enabling convenient access to and from the Artarmon industrial area, employment centres such as St Leonards and Chatswood, and Royal North Shore Hospital precinct. The direct motorway standard link between Royal North Shore Hospital and the Northern Beaches Hospital Precinct would be an important benefit of Beaches Link • Provides connectivity to Chatswood via Dickson Avenue and the Pacific Highway • Reduces pressure on the Reserve Road interchange compared to options that introduce westbound off ramps into this node.
Constructability and design	<ul style="list-style-type: none"> • Reduces impacts on the Gore Hill Freeway and Lane Cove Tunnel during construction, given the works would be on both the inside and outside of the existing corridor • Challenges largely relate to the construction of the works under Hampden Road and adjacent to live traffic on the Gore Hill Freeway • Probable maximum flood immunity achieved.
Community and environment	<ul style="list-style-type: none"> • Minimises impacts on bushland to the north • Minimises impacts to private property, notably residential property acquisition requirements • Major construction sites located to the south of the Gore Hill Freeway in the Artarmon industrial area – reducing exposure to residential receivers.

4.5.4 Wakehurst Parkway connection alternatives

Following the unveiling of the *County of Cumberland Planning Scheme* (1948), it was proposed that the Wakehurst Parkway become the main road between the Sydney CBD and the Northern Beaches via a Warringah Freeway extension to Seaforth. The Wakehurst Parkway's intended function as a motorway receiver is reflected in the fact that it is an arterial, limited access road with an 80 km/h posted speed and is located within a road reservation that is about 80 metres wide. The current Wakehurst Parkway corridor is a key arterial road link for the northern and western areas of the Northern Beaches, including Frenchs Forest, Narrabeen and Mona Vale. However, its current utility is diminished by its southern terminus, which links through the Seaforth town centre before connecting to Manly Road/Spit Road/Military Road.

New tunnelled connections to and from the Wakehurst Parkway would provide a strategic link between the Northern Beaches Hospital Precinct and centres in the upper Northern Beaches, and key centres across Greater Sydney. This would greatly improve connectivity for the northern areas of the Northern Beaches and assist in reducing demand for the Warringah Road, Roseville Bridge and Eastern Valley Way corridors.

A range of alternatives have been considered for this connection, including the location of the tunnel portals along the Wakehurst Parkway. Three alternative locations (portal location option A, portal location option B and portal location option C) were considered, as shown in Figure 4-21.

All portal location alternatives were located within the Wakehurst Parkway road corridor, which is much wider than the current road.

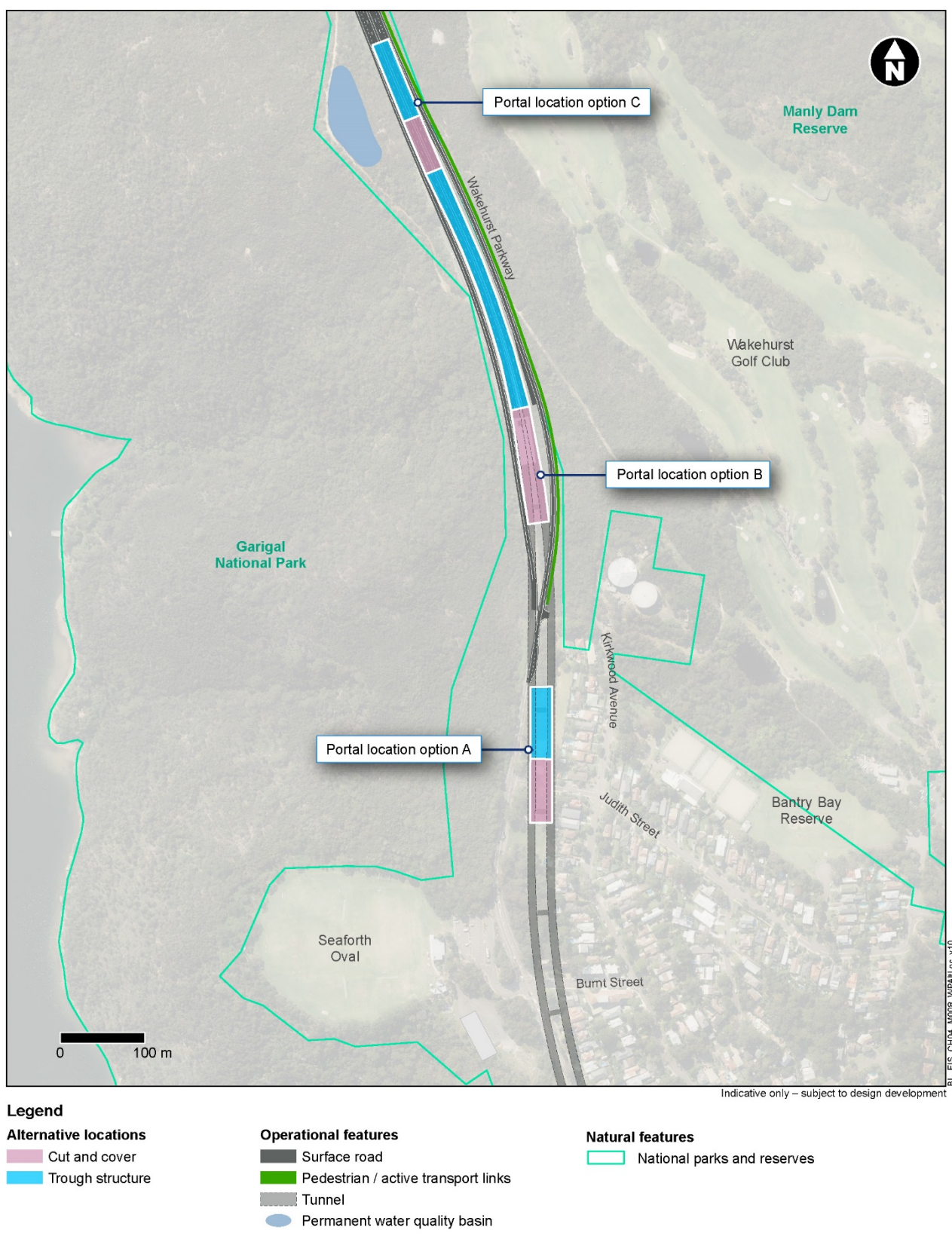


Figure 4-21 Connection alternatives at the Wakehurst Parkway

Following assessment of the options by a multidisciplinary team, portal location option B (refer to Figure 4-21) was selected as the preferred location of the connections to and from the Wakehurst Parkway. The justification for selecting this alternative is summarised in Table 4-6.

Table 4-6 Summary of evaluation of the Wakehurst Parkway connection preferred alternative

Evaluation criteria	Reason for preferred alternative (option B)
Connectivity and network performance	<ul style="list-style-type: none"> • Portal location option B would provide high-quality connectivity to and from the Wakehurst Parkway within the 80 km/h speed zone, avoiding interfaces between the limited access portion and residential streets • Connectivity to and from the Wakehurst Parkway south of the portals would be maintained but converted to on and off ramps – making the new tunnel connections the main route and downgrading the southern portion of the Wakehurst Parkway which is bypassed • A ‘turn around’ option was considered to provide access to and from the northern part of Seaforth. This option would involve an underpass near portal location option C and ramps that would allow Seaforth residents to get to and from the tunnels. This option was tested, however the demand was extremely low due to the distance to be travelled combined with the bypass of the southern portion of Wakehurst Parkway and its connection at Balgowlah, making portal location option B more attractive from a travel time perspective.
Constructability and design	<ul style="list-style-type: none"> • Portal location option B would enable traffic to be diverted around the outside of a central work zone • Portal location option B would result in a reduction of about 450 metres of surface works compared to portal location option A • Portal location option B would include a tunnelling length of 200 metres at a maximum grade of six per cent compared to 750 metres at a maximum grade of six per cent at portal location option A • Portal location option B would require about 450 metres less tunnelling than portal location option C.
Community and environment	<ul style="list-style-type: none"> • There would be a reduced impact on Duffys Forest endangered ecological community compared to portal location option A • The community impact would be less than at portal location option A, as the tunnel portal would be located further from residential properties • Option B would still require the Option A site area for a temporary construction support site • Access to Seaforth Oval would no longer be impacted during construction • Reduced visual impact and landscape impacts compared to portal location option A • Avoided impacts on Garigal National Park and Manly Dam Reserve.
Economic factors	<ul style="list-style-type: none"> • Offers economic efficiencies due to reducing the length of tunnel at maximum grade, thus lowering associated costs. These economic efficiencies offset the additional capital cost of increased driven tunnelling for option B.

4.5.5 Balgowlah connection alternatives

The Balgowlah connections would link the Beaches Link tunnels and the eastern area of the Northern Beaches peninsula, including Seaforth, Manly and Brookvale. These suburbs are accessed via Condamine Street and Sydney Road, which both connect to Burnt Bridge Creek Deviation where the Balgowlah connection alternatives have been explored, based on:

- Tunnelled connections to both Burnt Bridge Creek Deviation and Sydney Road (alternatives 1 and 2)
- Tunnelled connections to Burnt Bridge Creek Deviation with a surface connection to Sydney Road via a new access road (alternatives 4a, 4b and 4c)
- Tunnelled connections to Burnt Bridge Creek Deviation with a surface connection via an upgraded Burnt Bridge Creek Deviation to Sydney Road (alternatives 3, 6 and 7)
- Tunnelled connections to Burnt Bridge Creek Deviation with a surface connection to Sydney Road via an upgraded Condamine Street (alternatives 5, 8 and 9).

A summary of the assessment of each of the connection alternatives against the key objectives of the project for the Balgowlah area (as shown in Table 4-7) are outlined below.

Table 4-7 Key objectives of the project for the Balgowlah area

Category	Consideration
Traffic and transport	<ul style="list-style-type: none"> • Improve key travel times for the region • Improve local traffic performance • Meet predicted strategic demand with connectivity and gradients to deliver a high-quality transport product • Integrate with existing bus lanes to provide for express bus services via Beaches Link • Integrate with the local road network to minimise impacts and optimise performance • Minimise traffic impact to Burnt Bridge Creek Deviation, Condamine Street and Sydney Road during construction • Minimise impacts to existing active transport corridors and identify opportunities for improvements.
Environment and heritage	<ul style="list-style-type: none"> • Minimise impacts to existing vegetation, particularly intact portions of the Burnt Bridge Creek corridor west of the Burnt Bridge Creek Deviation and east of Kitchener Street • Minimise impacts on Burnt Bridge Creek • Minimise impacts to grey-headed flying fox habitat north of Kitchener Street • Ventilation design and effectiveness to meet Department of Planning, Industry and Environment and NSW Environment Protection Authority requirements.
Community	<ul style="list-style-type: none"> • Minimise impacts to existing recreation areas • Minimise direct and indirect impacts on sensitive receivers, for example, schools, childcare centres, aged care facilities, etc. • Identify opportunities for amenity improvements both during and after completion (active transport, open space and recreation areas, etc.)

Category	Consideration
	<ul style="list-style-type: none"> Minimise direct private property impacts Minimise indirect private property impacts Ensure pedestrian safety during construction and operation.
Flooding	<ul style="list-style-type: none"> Maintain flood immunity of Beaches Link ramps Avoid potential increases to flooding in surrounding properties associated with location of Beaches Link infrastructure.
Constructability and engineering	<ul style="list-style-type: none"> Designs to meet Australian Standards and Transport for NSW design and safety standards Access to suitable temporary construction support sites Minimise construction staging works in busy road corridors Ensure solution can be constructed and maintained safely and efficiently Minimise program duration Minimise haulage via local roads Minimise interfaces with pedestrians during construction Minimise exposure to poor geology Minimise impacts on existing utilities.
Cost	<ul style="list-style-type: none"> Ensure a value for money solution, considering both construction and operational costs and risks.

Each alternative was assigned a ranking for each category to identify whether it aligns with the project development considerations, as per the colour coding shown below:



Aligns with project development considerations



Mostly aligns with project development considerations



Partially aligns with project development considerations



Does not align with project development considerations

The proposed reference design (New Access Road option) is used as the base for comparison of alternatives in the following text.


Alternative 1 - Ramps emerging in Sydney Road





Alternative 1 would comprise tunnel ramps emerging within Burnt Bridge Creek Deviation to provide connectivity to and from the Pittwater Road/Condamine Street corridor. Single lane ramps to Sydney Road would provide connectivity for traffic travelling to and from the Manly area.




Figure 4-22 Alternative 1 – Ramps emerging in Sydney Road

Table 4-8 Evaluation summary of 'Alternative 1 - Ramps emerging in Sydney Road'

Category	Consideration	Assessment
Traffic and transport	<ul style="list-style-type: none"> Poor connectivity to Seaforth/North Balgowlah as east-facing ramps to Sydney Road do not service the catchment west of Burnt Bridge Creek Deviation Direct tunnel connection to Sydney Road reduces pressure on Burnt Bridge Creek Deviation/Sydney Road/Manly Road intersection Reduced traffic signal controls for southbound traffic on Burnt Bridge Creek Deviation Challenging to integrate tunnel ramps into Sydney Road Impacts to local access at Pickworth Avenue and Maretimo Street due to emerging tunnel ramps Lanes from tunnel not able to fully integrate ahead of Wanganella Street intersection. Existing right turn to Wanganella Street (south) would need to be removed Existing eastbound queuing capacity at this intersection reduced – likely to impact performance Major construction staging works within Sydney Road corridor. 	

Category	Consideration	Assessment
Environment and heritage	<ul style="list-style-type: none"> Requires realignment of Burnt Bridge Creek but this impact would be limited to the portion of the creek previously realigned during original Burnt Bridge Creek Deviation construction and Balgowlah Golf Course construction works. 	
Community	<ul style="list-style-type: none"> Increased property impacts – 12 residences and businesses impacted along Sydney Road between Burnt Bridge Creek Deviation and Wanganella Street Temporary impact to the majority of Balgowlah Golf Course (excluding Balgowlah Oval and scout hall) during construction for: <ul style="list-style-type: none"> Burnt Bridge Creek Deviation and Sydney Road staging and widening works Tunnel and surface works temporary construction support site Motorway facilities Reduced permanent impacts to golf course; motorway facilities still located on golf course land Impact to Balgowlah Oval due to widening of Sydney Road Permanent road infrastructure further away from residents on eastern side of golf course; but closer to residents and schools on Sydney Road Impact to existing pedestrian bridge over Sydney Road due to road widening and construction of cut and cover ramps in Sydney Road Kitchener Street bridge would require replacement to facilitate changed lane arrangements on Burnt Bridge Creek Deviation resulting in disruption impacts to local traffic during staging works. 	
Flooding	<ul style="list-style-type: none"> Increased risk of flooding impacts during construction. 	
Constructability and engineering	<ul style="list-style-type: none"> Large increase in tunnelling (2.9 kilometres) due to: <ul style="list-style-type: none"> Additional tunnel ramps to Sydney Road not included in the proposed reference design. The length of these ramps is driven by the substantial level difference between Sydney Road and where the Burnt Bridge Creek Deviation ramps dive underground Additional tunnelling would also be required to provide ventilation tunnels from the Sydney Road ramps to the Burnt Bridge Creek Deviation motorway facility/ventilation outlet Increase in tunnelling quantities would necessitate an increased number of roadheaders, increased spoil volumes, and hence increased heavy haulage from this site - over 40,000 truck movements for spoil haulage alone Increased construction complexity and disruptions to local traffic, including major staging within Sydney Road corridor 	

Category	Consideration	Assessment
	<ul style="list-style-type: none"> Additional impacts to utilities on Sydney Road. This may result in temporary impacts to local utilities in the area during relocation works. 	
Cost	<ul style="list-style-type: none"> Increased construction and operational costs due to additional: <ul style="list-style-type: none"> Infrastructure and fans required to move air through longer ventilation tunnels, with increased maintenance costs Major construction staging works within Sydney Road. 	






Alternative 2 - Tunnel loop ramps to Sydney Road


Alternative 2 would comprise tunnel ramps emerging within Burnt Bridge Creek Deviation to provide connectivity to and from the Pittwater Road/Condamine Street corridor. Single lane ramps to Sydney Road would use an underground loop within the Balgowlah Golf Course to connect to a signalised intersection on Sydney Road near Maretimo Street.



Figure 4-23 Alternative 2 - Tunnel loop ramps to Sydney Road

Table 4-9 Evaluation summary of 'Alternative 2 - Tunnel loop ramps to Sydney Road'

Category	Consideration	Assessment
Traffic and transport	<ul style="list-style-type: none"> Local network performance as per proposed reference design alternative 4c Traffic signals for an access road no longer required at Burnt Bridge Creek Deviation. 	
Environment and heritage	<ul style="list-style-type: none"> Requires realignment of Burnt Bridge Creek but this impact would be limited to the portion of the creek previously realigned during original Burnt Bridge Creek Deviation construction and golf course construction works. 	
Community	<ul style="list-style-type: none"> Direct private property impacts as per proposed reference design alternative 4c Temporary impact to the majority of Balgowlah Golf Course (excluding Balgowlah Oval and scout hall) during construction for: <ul style="list-style-type: none"> Burnt Bridge Creek Deviation and Sydney Road staging and widening works Tunnel and surface works temporary construction support site Tunnel loop construction works Motorway facilities Permanent impacts to the golf course for the loop ramps and motorway facilities Increased residual land for community use post construction Balgowlah Oval closed during construction due to loop ramp construction Permanent road infrastructure further from residents on eastern side of golf course Kitchener Street bridge would require replacement to facilitate changed lane arrangements on Burnt Bridge Creek Deviation resulting in disruption impacts to local traffic during staging works. 	
Flooding	<ul style="list-style-type: none"> Increased risk of flooding impacts during construction. 	
Constructability and engineering	<ul style="list-style-type: none"> Large increase in tunnelling (additional 3.3 kilometres) due to: <ul style="list-style-type: none"> Additional tunnel ramps to Sydney Road not included in the proposed reference design alternative 4c. The length of these ramps is determined by the substantial level difference between Sydney Road and the location where the Burnt Bridge Creek Deviation ramps dive underground Additional tunnelling to provide ventilation tunnels from the Sydney Road ramps to the Burnt Bridge Creek Deviation motorway facility/ventilation outlet 	

Category	Consideration	Assessment
	<ul style="list-style-type: none"> Increase in tunnelling quantities would necessitate an increased number of roadheaders, increased spoil volumes, and hence increased heavy haulage from this site - over 40,000 truck movements for spoil haulage alone. 	
Cost	<ul style="list-style-type: none"> Increased construction and operational costs due to additional infrastructure and fans required to move air through longer ventilation tunnels, with higher maintenance costs. 	

Alternative 3 - Connection partially controlled by traffic signals at Burnt Bridge Creek Deviation

Alternative 3 would comprise a single set of tunnel ramps to Burnt Bridge Creek Deviation, emerging near Serpentine Crescent. This would provide free-flow connection to and from the tunnel for traffic travelling to and from the Pittwater Road/Condamine Street corridor.

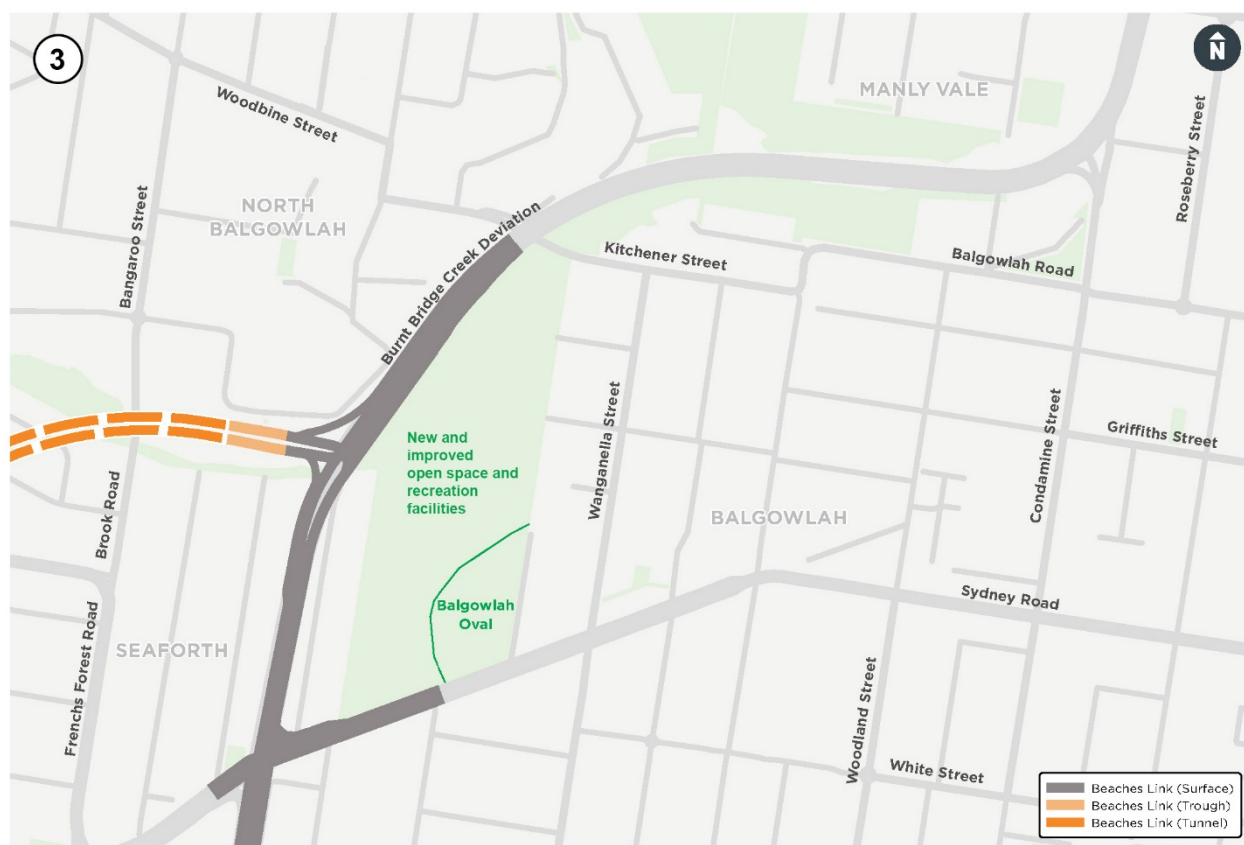








Figure 4-24 Alternative 3 - Connection partially controlled by traffic signals at Burnt Bridge Creek Deviation

Table 4-10 Evaluation summary of 'Alternative 3 - Connection partially controlled by traffic signals at Burnt Bridge Creek Deviation'

Category	Consideration	Assessment
Traffic and transport	<ul style="list-style-type: none"> Reduced traffic signal phases for southbound traffic from Burnt Bridge Creek Deviation to the tunnel Traffic signals for the access road no longer required at the Maretimo Street/Sydney Road intersection Increased risk of queuing into tunnel due to additional conflicting signalised movements Poorer local network performance as a result of: <ul style="list-style-type: none"> Additional traffic signal phasing to the Sydney Road/Burnt Bridge Creek Deviation/Manly Road intersection to allow for right turn for westbound traffic to Burnt Bridge Creek Deviation (currently not permitted). This would place additional pressure on the performance of this intersection New traffic signals for northbound surface traffic on Burnt Bridge Creek Deviation (not signalised in proposed reference design alternative 4c). 	
Environment and heritage	<ul style="list-style-type: none"> Major impacts to the section of Burnt Bridge Creek west of Burnt Bridge Creek Deviation – likely to be redirected into culverts Additional 13,000 square metres of vegetation clearing along the Burnt Bridge Creek corridor to the west of Burnt Bridge Creek Deviation Increased tunnel infrastructure in Burnt Bridge Creek floodplain. 	
Community	<ul style="list-style-type: none"> Permanent road infrastructure located further from residents on eastern side of golf course Increased property impacts: <ul style="list-style-type: none"> 17 additional properties impacted for tunnel ramp construction and intersection upgrade at Sydney Road Permanent road infrastructure closer to residents on Serpentine Crescent, Hope Street and Kempbridge Avenue and closer to Seaforth Public School Temporary impact to the majority of Balgowlah Golf Course (excluding Balgowlah Oval and scout hall) during construction for: <ul style="list-style-type: none"> Burnt Bridge Creek Deviation staging and widening works Tunnel and surface works temporary construction support site Permanent impacts to Balgowlah Golf Course for the Burnt Bridge Creek Deviation widening Longer construction program. 	

Category	Consideration	Assessment
Flooding	<ul style="list-style-type: none"> Increased tunnel infrastructure in Burnt Bridge Creek floodplain to ensure the tunnels are not flooded during major flood events. These measures would be likely to impact flow-path and flood levels on nearby properties Additional risk of flooding during construction. 	
Constructability and engineering	<ul style="list-style-type: none"> Complex construction staging resulting in: <ul style="list-style-type: none"> Slow productivities due to constrained cut and cover site and tunnel construction access in creek valley Major disruption to Burnt Bridge Creek Deviation during construction of intersection and cut and cover structure Risk of flooding during construction due to portal location in creek valley. 	
Cost	<ul style="list-style-type: none"> Considerably increased construction cost due to: <ul style="list-style-type: none"> Increased staging in busy Burnt Bridge Creek Deviation corridor Increased exposure to flooding risk Highly constrained construction site. 	

Alternative 4a - North facing tunnel ramps to Burnt Bridge Creek Deviation with access road to distribute traffic and provide connection to new open space and recreation facilities

Alternative 4a would comprise a single set of tunnel ramps to Burnt Bridge Creek Deviation, emerging south of Kitchener Street to provide connectivity to and from the Pittwater Road/Condamine Street corridor. Connectivity between the tunnel and Sydney Road corridor would be provided via a surface access road aligned to the eastern boundary of the golf course to distribute traffic across the network. The access road would also provide connection to the new and improved open space and recreation facilities.

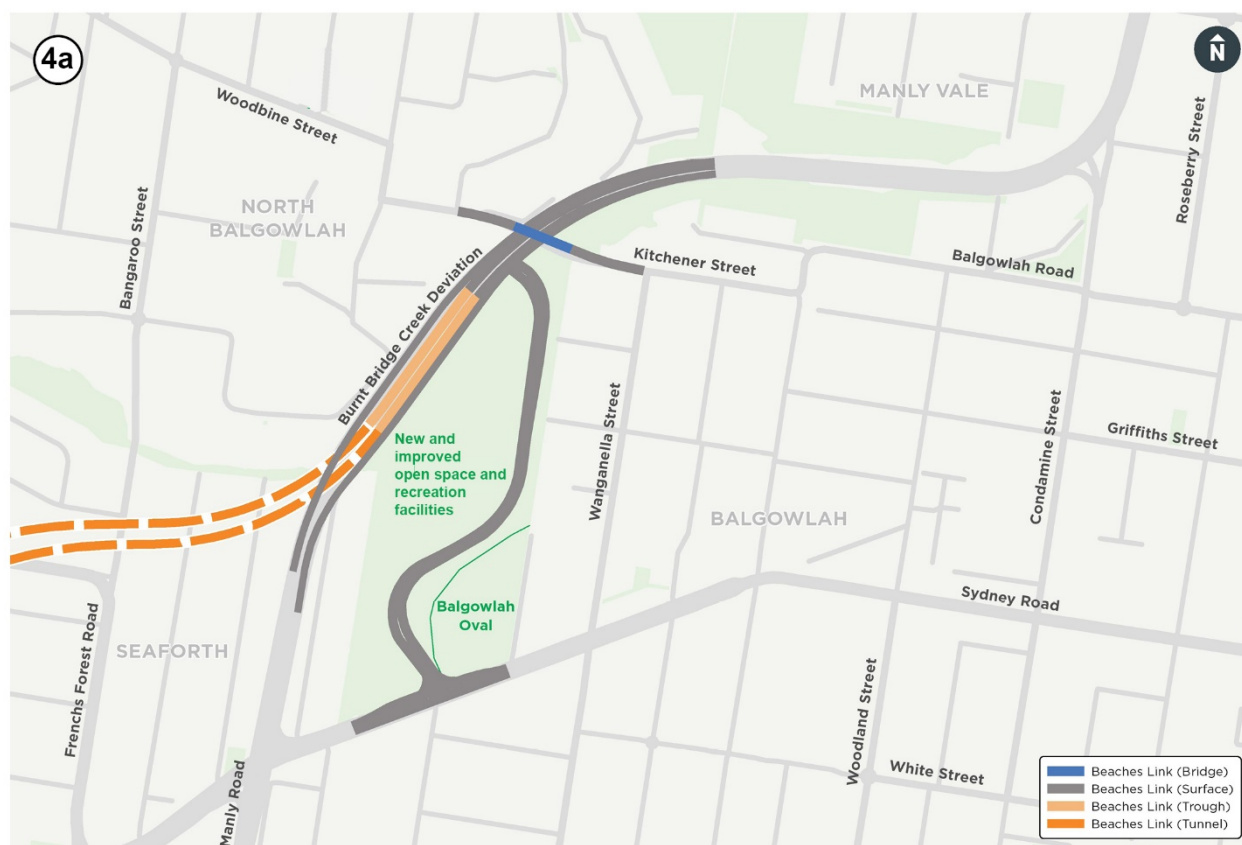






Figure 4-25 Alternative 4a - North facing tunnel ramps to Burnt Bridge Creek Deviation with access road to distribute traffic and provide connection to new and improved open space and recreation facilities

Table 4-11 Evaluation summary of ‘Alternative 4a - North facing tunnel ramps to Burnt Bridge Creek Deviation with access road to distribute traffic and provide connection to new and improved open space and recreation facilities’

Category	Consideration	Assessment
Traffic and transport	<ul style="list-style-type: none"> Access road connection to Sydney Road along eastern boundary improves long-term network performance by: <ul style="list-style-type: none"> Reducing pressure on Burnt Bridge Creek Deviation/Sydney Road/Manly Road intersection and Condamine Street between Burnt Bridge Creek Deviation and Sydney Road Eliminating traffic weaving inherent in many other options Improving traffic performance and road safety outcomes Minimises staging and construction works in Sydney Road corridor Requires traffic lights for southbound traffic on Burnt Bridge Creek Deviation Provides connection to the new and improved open space and recreation facilities. 	●
Environment and heritage	<ul style="list-style-type: none"> Requires realignment of Burnt Bridge Creek but this impact would be limited to the portion of the creek previously 	●

Category	Consideration	Assessment
	realigned during original Burnt Bridge Creek Deviation construction and golf course construction works.	
Community	<ul style="list-style-type: none"> • Small number (six) of private property acquisitions. Acquisitions on Sydney Road and Serpentine Crescent not required as for several other alternatives • Balgowlah Oval and the pedestrian bridge over Sydney Road remain open during construction • Temporary impact to the majority of Balgowlah Golf Course (excluding Balgowlah Oval and scout hall) during construction for: <ul style="list-style-type: none"> – Burnt Bridge Creek Deviation widening works – Tunnel and surface works temporary construction support site – Motorway facilities and access road construction • Opportunity to re-purpose Balgowlah Golf Course as new and improved open space and recreation facilities in a staged manner both during and after construction • Kitchener Street bridge would require replacement to facilitate changed lane arrangements on Burnt Bridge Creek Deviation resulting in disruption impacts to local traffic during staging works • Permanent road infrastructure closer to residents near the eastern boundary of the golf course • Permanent noise and visual impacts would require mitigation during operation. 	
Flooding	<ul style="list-style-type: none"> • Increased risk of flooding impacts during construction. 	
Constructability and engineering	<ul style="list-style-type: none"> • Motorway facilities close to the tunnel ramps reduces the length of ventilation tunnels and maximises the efficiency of the system • Less tunnelling and haulage of spoil compared to other alternatives • Minimises construction in the Sydney Road corridor • Minimises construction within the Burnt Bridge Creek Deviation corridor • Relatively low cover tunnelling required under residential properties in Hope Street, increasing settlement risk. 	
Cost	<ul style="list-style-type: none"> • Reduced construction staging in the Sydney Road corridor, reducing construction costs • Reduced scope of local road works required to integrate the project, reducing construction costs. 	

Alternative 4b - North facing tunnel ramps to Burnt Bridge Creek Deviation with access road aligned to the golf course's western boundary to distribute traffic and provide connection to the new and improved open space and recreation facilities

Alternative 4b would comprise a single set of tunnel ramps to Burnt Bridge Creek Deviation, emerging south of Kitchener Street to provide connectivity to and from the Pittwater Road/Condamine Street corridor. Connectivity between the tunnel and Sydney Road corridor would be provided via a surface access road to distribute traffic, similar to that outlined for 'Alternative 4a', however differing in alignment as the access road would run parallel to the western boundary of the golf course. The access road would also provide connection to the new and improved open space and recreation facilities.




Compared to alternative 4a, an additional 29 residential properties would be acquired on Dudley Street to facilitate:




- Locating of the temporary construction support site partially near Dudley Street and partially on golf course land
- The opportunity for a staged hand over of new and improved open space and recreation facilities on the eastern side of the new access road
- Additional new open space and recreation facilities on residual land near Dudley Street after construction works are completed.



Figure 4-26 Alternative 4b – North facing tunnel ramps to Burnt Bridge Creek Deviation with access road aligned to the golf course's western boundary to distribute traffic and provide connection to the new and improved open space and recreation facilities

Table 4-12 Evaluation summary of 'Alternative 4b – North facing tunnel ramps to Burnt Bridge Creek Deviation with access road aligned to the golf course's western boundary to distribute traffic and provide connection to the new and improved open space and recreation facilities'

Category	Consideration	Assessment
Traffic and transport	<ul style="list-style-type: none"> Access road connection to Sydney Road along eastern boundary improves long-term network performance by: <ul style="list-style-type: none"> Reducing pressure on Burnt Bridge Creek Deviation/Sydney Road/Manly Road intersection and Condamine Street between Burnt Bridge Creek Deviation and Sydney Road Eliminating traffic weaving inherent in many other options Improving traffic performance and road safety outcomes Minimises staging and construction works in Sydney Road corridor Requires traffic lights for southbound traffic on Burnt Bridge Creek Deviation Provides connection to the new and improved open space and recreation facilities. 	
Environment and heritage	<ul style="list-style-type: none"> Requires realignment of Burnt Bridge Creek but this impact would be limited to the portion of the creek previously realigned during original Burnt Bridge Creek Deviation construction and golf course construction works. 	
Community	<ul style="list-style-type: none"> Additional 29 private property acquisitions compared to alternative 4a Balgowlah Oval and the pedestrian bridge over Sydney Road remain open during construction Temporary impact to the majority of Balgowlah Golf Course (excluding Balgowlah Oval and scout hall) during construction for: <ul style="list-style-type: none"> Burnt Bridge Creek Deviation widening works Tunnel and surface works temporary construction support site Motorway facilities and access road construction Opportunity to re-purpose Balgowlah Golf Course as new and improved open space and recreation facilities in a staged manner both during and after construction Kitchener Street bridge would require replacement to facilitate changed lane arrangements on Burnt Bridge Creek Deviation resulting in disruption impacts to local traffic during staging works Permanent road infrastructure further from residents near the eastern boundary of the golf course Permanent noise and visual impacts would less require mitigation during operation. 	

Category	Consideration	Assessment
Flooding	<ul style="list-style-type: none"> Increased risk of flooding impacts during construction. 	
Constructability and engineering	<ul style="list-style-type: none"> Motorway facilities close to the tunnel ramps reduces the length of ventilation tunnels and maximises the efficiency of the system Less tunnelling and haulage of spoil compared to other alternatives Minimises construction in the Sydney Road corridor Minimises construction within the Burnt Bridge Creek Deviation corridor Relatively low cover tunnelling required under residential properties in Hope Street, increasing settlement risk. 	
Cost	<ul style="list-style-type: none"> Reduced construction staging in Sydney Road, reducing construction costs Reduced scope of local road works required to integrate the project, reducing construction costs. 	


Alternative 4c - North facing tunnel ramps to Burnt Bridge Creek Deviation with shortened, centralised access road to distribute traffic and provide connection to the new and improved open space and recreation facilities





Alternative 4c is similar in design and arrangement as alternatives 4a and 4b. Alternative 4c would comprise a single set of tunnel ramps to Burnt Bridge Creek Deviation that would emerge south of Burnt Bridge Creek, rather than further north as in alternatives 4a and 4b. Connectivity to and from Pittwater Road/Condamine Street is maintained. Given the positioning of the tunnel ramps south of Burnt Bridge Creek there would be no requirement to alter the current alignment of the Kitchener Street bridge. Connectivity between the tunnel and the Sydney Road corridor would be provided via a surface access road through the existing Balgowlah Golf Course to distribute traffic demand across the local network and provide connection to the new and improved open space and recreation facilities. The alignment of this surface access road would differ and be notably shorter to alternatives 4a and 4b.




Figure 4-27 Alternative 4c - North facing tunnel ramps to Burnt Bridge Creek Deviation with shortened, centralised access road to distribute traffic and provide connection to the new and improved open space and recreation facilities

Table 4-13 Evaluation summary of 'Alternative 4c – North facing tunnel ramps to Burnt Bridge Creek Deviation with shortened, centralised access road to distribute traffic and provide connection to the new and improved open space and recreation facilities'

Category	Consideration	Assessment
Traffic and transport	<ul style="list-style-type: none"> Access road connection to Sydney Road along eastern boundary improves long-term network performance by: <ul style="list-style-type: none"> Reducing pressure on Burnt Bridge Creek Deviation/Sydney Road/Manly Road intersection and Condamine Street between Burnt Bridge Creek Deviation and Sydney Road Eliminating traffic weaving inherent in many other options Improving traffic performance and road safety outcomes Access road is shorter than for alternatives 4a and 4b Minimises staging and construction works in Sydney Road corridor Tunnel portal is moved to the south Requires traffic lights for southbound traffic on Burnt Bridge Creek Deviation Provides connection to the new and improved open space 	

Category	Consideration	Assessment
	<p>and recreation facilities</p> <ul style="list-style-type: none"> • Longer two lane ramp tunnels to Balgowlah and Wakehurst Parkway connections. Shorter three lane mainline tunnels • Existing Kitchener Street/Myrtle Street traffic arrangements no longer impacted with bridge replacement works eliminated • Extensive utility works and associated local traffic interruptions eliminated in streets west of Burnt Bridge Creek Deviation. 	
Environment and heritage	<ul style="list-style-type: none"> • Requires only minor works to Burnt Bridge Creek and eliminates extensive diversion works within the existing creek, reducing impacts on flora and fauna, including potentially reduced impact on mature trees in the golf course compared to alternatives 4a and 4b • Scope of staged construction within the Burnt Bridge Creek Deviation reduced • Reduced impact likely on grey-headed flying fox habitat north of Kitchener Street bridge compared to alternatives 4a and 4b • Reduced risk of potential impact to Aboriginal heritage due to reduced creek diversion works. 	
Community	<ul style="list-style-type: none"> • Additional 29 private property acquisitions compared to alternative 4a • Balgowlah Oval and the pedestrian bridge over Sydney Road remain open during construction • Temporary impact to the majority of Balgowlah Golf Course (excluding Balgowlah Oval and scout hall) during construction for: <ul style="list-style-type: none"> – Burnt Bridge Creek Deviation widening works – Tunnel and surface works temporary construction support site – Motorway facilities and access road construction • Opportunity to re-purpose Balgowlah Golf Course as new and improved open space and recreation facilities in a staged manner both during and after construction • Permanent road infrastructure more centrally aligned within the golf course site, reducing potential amenity, noise and vibration impacts when compared to alternatives 4a and 4b • Permanent noise and visual impacts would less require mitigation during operation. 	
Flooding	<ul style="list-style-type: none"> • Location of tunnel portal reduces risk of flooding impacts during construction and operation. 	
Constructability and	<ul style="list-style-type: none"> • Overall construction footprint reduced in comparison to alternatives 4a and 4b due to elimination of Kitchener Street 	

Category	Consideration	Assessment
engineering	bridge works <ul style="list-style-type: none"> • Motorway facilities close to the tunnel ramps reduces the length of ventilation tunnels and maximises the efficiency of the system • Less tunnelling and haulage of spoil compared to other alternatives • Minimises construction in the Sydney Road corridor • Minimises construction within the Burnt Bridge Creek Deviation corridor • Elimination of impacts on multiple utilities required for alternatives 4a and 4b • Relatively low cover tunnelling eliminated under residential properties in Hope Street eliminating settlement and ground-borne noise impacts • Scope of staged construction within the Burnt Bridge Creek Deviation reduced with cut and cover staging works now located close and adjacent to the temporary construction support site at Dudley Street. 	
Cost	<ul style="list-style-type: none"> • Reduced construction staging in Sydney Road corridor, reducing construction costs • Reduced scope of local road works required to integrate the project, reducing construction costs. 	

Alternative 5 - North facing tunnel ramps to Burnt Bridge Creek Deviation including Condamine Street upgrade

Alternative 5 would comprise a single set of tunnel ramps to Burnt Bridge Creek Deviation, emerging south of Kitchener Street to provide connectivity to the area. Surface road upgrades to Condamine Street at intersections with Sydney Road and Balgowlah Road would provide surface road access to the tunnel.

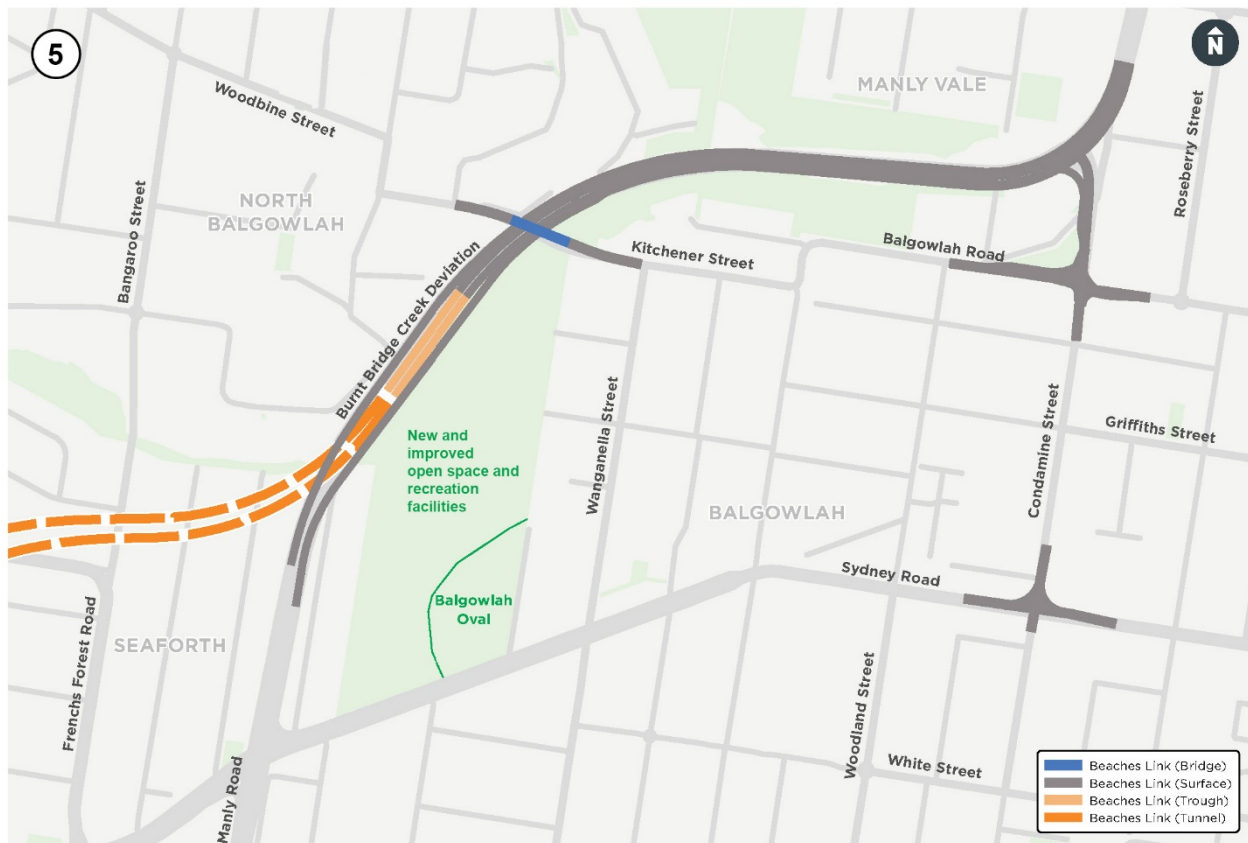








Figure 4-28 Alternative 5 - North facing tunnel ramps to Burnt Bridge Creek Deviation including Condamine Street upgrade

Table 4-14 Evaluation summary of 'Alternative 5 - North facing tunnel ramps to Burnt Bridge Creek Deviation including Condamine Street upgrade'

Category	Consideration	Assessment
Traffic and transport	<ul style="list-style-type: none"> Widening of Burnt Bridge Creek Deviation into the golf course allows traffic flow to be maintained during construction, as per the proposed reference design alternative 4c Traffic signals for the access road no longer required on Burnt Bridge Creek Deviation or the Maretimo Street/Sydney Road intersection Local network impacts and poorer long-term traffic performance, including: <ul style="list-style-type: none"> Local traffic impacts concentrated on Kenneth Road and Condamine Street as they become primary access roads for the tunnel Kitchener Street/Balgowlah Road would be used by traffic attempting to access the tunnel from Seaforth Potential rat run on local streets, such as Wanganella Street and West Street for traffic accessing Kitchener Street and Balgowlah Road Existing residential accesses, multiple intersections with 	

Category	Consideration	Assessment
	<p>traffic signals and bus stops along the Condamine Street corridor mean capacity of existing lanes would not be realised even with parking removed</p> <ul style="list-style-type: none"> – Increased demand on these roads is likely to result in poor long-term performance, eroding travel time benefits • Considerably increased traffic volumes on Kitchener Street, Balgowlah Road and Condamine Street would increase impacts on residents and businesses along these corridors. 	
Environment and heritage	<ul style="list-style-type: none"> • Requires realignment of Burnt Bridge Creek but this impact would be limited to the portion of the creek previously realigned during original Burnt Bridge Creek Deviation construction and golf course construction works. 	
Community	<ul style="list-style-type: none"> • Minimises permanent impacts to Balgowlah Golf Course by eliminating 18,000 square metres of impact associated with access road • Temporary impact to the majority of Balgowlah Golf Course (excluding Balgowlah Oval and scout hall) during construction for: <ul style="list-style-type: none"> – Burnt Bridge Creek Deviation widening works – Tunnel and surface works temporary construction support site – Motorway facilities construction • Reduced indirect impacts on residents on eastern side of golf course • Kitchener Street bridge would require replacement to facilitate changed lane arrangements on Burnt Bridge Creek Deviation resulting in disruption impacts to local traffic during staging works • Increased private property impacts: <ul style="list-style-type: none"> – Increased demand on Condamine Street would require a road upgrade. This would likely result in removal of parking and property impacts along Condamine Street and Sydney Road to provide turning movements – Properties impacted along Condamine Street and Sydney Road due to intersection upgrades and associated widening in this area. 	
Flooding	<ul style="list-style-type: none"> • Increased risk of flooding impacts during construction. 	
Constructability and engineering	<ul style="list-style-type: none"> • Minimises construction in Sydney Road corridor • Minimises construction within the Burnt Bridge Creek Deviation corridor • Traffic staging for road upgrades on Condamine Street in narrow existing busy road corridor • Less tunnelling and haulage of spoil compared to other 	

Category	Consideration	Assessment
	<p>longer driven tunnel options</p> <ul style="list-style-type: none"> Motorway facilities close to the tunnel ramps reduces the length of ventilation tunnels and maximises the efficiency of the system. 	
Cost	<ul style="list-style-type: none"> Additional property and road upgrade costs on Condamine Street and Sydney Road exceed savings of not constructing access road. 	




Alternative 6 - Burnt Bridge Creek Deviation loop interchange




Alternative 6 would comprise two sets of tunnel ramps to Burnt Bridge Creek Deviation to provide connectivity to and from the Pittwater Road/Condamine Street corridor and Sydney Road east and west. The south facing ramps would be in a loop arrangement to transition to and from the tunnel within the Balgowlah Golf Course site.



Figure 4-29 Alternative 6 - Burnt Bridge Creek Deviation loop interchange

Table 4-15 Evaluation summary of 'Alternative 6 - Burnt Bridge Creek Deviation loop interchange'

Category	Consideration	Assessment
Traffic and transport	<ul style="list-style-type: none"> Undesirable road geometry: <ul style="list-style-type: none"> Tight radius tunnel loops (potentially a major road safety hazard) at the exit and entry from an 80 km/h road (Burnt Bridge Creek Deviation and Beaches Link tunnels) Road design and safety standards generally suggest this design should be avoided as it increases the risk of accidents, including heavy vehicle rollovers Northbound tunnel includes a decision point for drivers very close to the exit of the tight radius curve (east or west on Sydney Road) Traffic signals for the access road no longer required on Burnt Bridge Creek Deviation or the Maretimo Street/Sydney Road intersection Poorer local network performance: <ul style="list-style-type: none"> The proximity of southern ramp to the Sydney Road intersection would create a weave – degrading the performance of this intersection Requires additional phase for traffic signals to the Sydney Road intersection to allow for right turn to Burnt Bridge Creek Deviation (currently not permitted). This would place additional pressure on the performance of this intersection. 	
Environment and heritage	<ul style="list-style-type: none"> Requires realignment of Burnt Bridge Creek but this impact is limited to portion of creek previously realigned during original Burnt Bridge Creek Deviation construction and golf course construction works Increased tunnel infrastructure in Burnt Bridge Creek floodplain. 	
Community	<ul style="list-style-type: none"> Permanent road infrastructure located further from residents living near the golf course, however the main access ramp would be closer to some residents on the eastern boundary Increased property impacts, with 13 properties impacted to facilitate south-facing ramps and upgrade of Sydney Road intersection Temporary impact to the majority of Balgowlah Golf Course (excluding Balgowlah Oval and scout hall) during construction for: <ul style="list-style-type: none"> Burnt Bridge Creek Deviation staging Tunnel and surface works temporary construction support site Motorway facilities Permanent impacts to the golf course site, including: <ul style="list-style-type: none"> Burnt Bridge Creek Deviation widening 	

Category	Consideration	Assessment
	<ul style="list-style-type: none"> – Trough structures for loop ramps – Motorway facilities. • Kitchener Street bridge would require replacement to facilitate changed lane arrangements on Burnt Bridge Creek Deviation resulting in disruption impacts to local traffic during staging works 	
Flooding	<ul style="list-style-type: none"> • Increased risk of flooding during construction and operation. 	
Constructability and engineering	<ul style="list-style-type: none"> • Substantial increase in tunnelling (additional 635 metres and two additional caverns) for the additional south-facing tunnel ramps not included in the proposed reference design alternative 4c • Increased volumes of heavy haulage from tunnelling • Increased staging in Burnt Bridge Creek Deviation corridor for the additional set of tunnel ramps and bridge structure • Surface works in Burnt Bridge Creek Deviation corridor would be increased to bring multiple ramps to surface • Increased tunnel infrastructure in Burnt Bridge Creek floodplain to ensure the tunnels are not flooded in major flood events. These measures would be likely to impact flow-paths and flood levels on nearby properties during operational phase • Additional risk of flooding during construction. 	
Cost	<ul style="list-style-type: none"> • Considerably higher construction cost due to increased: <ul style="list-style-type: none"> – Tunnelling complexity – Staging in busy Burnt Bridge Creek Deviation corridor – Exposure to flooding risk. 	


Alternative 7 - North and south facing tunnel ramps to Burnt Bridge Creek Deviation





Alternative 7 was suggested as an alternative through community consultation. This alternative would comprises two sets of tunnel ramps to Burnt Bridge Creek Deviation to connect to and from the Pittwater Road/Condamine Street corridor and Sydney Road.




Figure 4-30 Alternative 7 - North and south facing tunnel ramps to Burnt Bridge Creek Deviation

Table 4-16 Evaluation summary of 'Alternative 7 - North and south facing tunnel ramps to Burnt Bridge Creek Deviation'

Category	Consideration	Assessment
Traffic and transport	<ul style="list-style-type: none"> Traffic signals for the access road no longer required on Burnt Bridge Creek Deviation or the Maretimo Street/Sydney Road intersection Poor local network performance due to: <ul style="list-style-type: none"> Proximity of northern ramps to Condamine Street intersection creating weave issues and removal of the right-turn movement to Condamine Street south. This would likely place additional pressure on Burnt Bridge Creek Deviation/Sydney Road/Manly Road intersection to allow for right turn for westbound traffic to Burnt Bridge Creek Deviation (currently not permitted). This would place additional pressure on the performance of this intersection Increased risk of queuing into tunnel compared to the proposed reference design alternative 4c, which avoids access road signals and is about one kilometre from Condamine Street intersection Increased heavy haulage due to increased number of roadheaders, spoil volumes and tunnelling. 	

Category	Consideration	Assessment
Environment and heritage	<ul style="list-style-type: none"> Increased impacts to Burnt Bridge Creek with an additional 300 metres of Burnt Bridge Creek to be realigned Large increase in vegetation clearing required. Additional 13,000 square metres of vegetation clearing, including in the area behind Kitchener Street identified as grey-headed flying-fox habitat. 	
Community	<ul style="list-style-type: none"> Permanent road infrastructure further from residents near the eastern boundary of golf course Temporary impact to the majority of Balgowlah Golf Course (excluding Balgowlah Oval and scout hall) during construction for: <ul style="list-style-type: none"> Burnt Bridge Creek Deviation staging Tunnel and surface works construction Permanent impacts to the golf course site due to Burnt Bridge Creek Deviation widening Reduced permanent impacts to the existing open space at Balgowlah Golf Course by 18,000 square metres due to removal of access road and motorway facilities Greater private property impacts, with the acquisition of an additional 20 properties: <ul style="list-style-type: none"> At Burnt Bridge Creek Deviation/Sydney Road intersection and Dudley Street to allow for intersection augmentation Along Kitchener Street and Balgowlah Road to allow for creek realignment and construction of north-facing tunnel ramps. 	
Flooding	<ul style="list-style-type: none"> North-facing tunnel ramps in Burnt Bridge Creek floodplain: <ul style="list-style-type: none"> Places tunnels and surface widening in worst affected area of Burnt Bridge Creek floodplain Would require substantial infrastructure to ensure the tunnels are not flooded during major flood events. These measures are likely to impact flow-paths and flood levels on nearby properties Additional risk of inundation during construction. 	
Constructability and engineering	<ul style="list-style-type: none"> Substantial increase in tunnelling (additional 1.9 kilometres, three additional caverns and 400 metres of ventilation tunnel) due to: <ul style="list-style-type: none"> Additional tunnel south-facing ramps not included in the proposed reference design alternative 4c Additional tunnelling to provide ventilation tunnels from the north-facing ramps to the Burnt Bridge Creek Deviation motorway facility Increased truck haulage due to increased tunnelling and spoil – over 23,000 truck movements for spoil haulage 	

Category	Consideration	Assessment
	<p>alone.</p> <ul style="list-style-type: none"> Increased staging in Burnt Bridge Creek Deviation corridor for the: <ul style="list-style-type: none"> Additional set of tunnel ramps Cut and cover structures across Burnt Bridge Creek Deviation which are complex to build north of Kitchener Street in a significant flood zone with limited area for staging creek diversion works Length of surface works in Burnt Bridge Creek Deviation corridor greatly increased. 	
Cost	<ul style="list-style-type: none"> Considerably greater construction cost due to increased: <ul style="list-style-type: none"> Tunnelling Increased staging in the busy Burnt Bridge Creek Deviation corridor Exposure to flooding risk in the most affected area of the floodplain during construction and operational phases. 	


Alternative 8 - North facing tunnel ramps and surface ramps to Kitchener Street




Alternative 8 was suggested as an alternative through community consultation and would comprise a single tunnel ramp to Burnt Bridge Creek Deviation, emerging south of Kitchener Street to provide connectivity to and from the Pittwater Road/Condamine Street corridor. A separate set of ramps to the Kitchener Street bridge would provide access to North Balgowlah, Seaforth and Balgowlah Road/Condamine Street for access to Sydney Road.





Figure 4-31 Alternative 8 - North facing tunnel ramps and surface ramps to Kitchener Street

Table 4-17 Evaluation summary of 'Alternative 8 - North facing tunnel ramps and surface ramps to Kitchener Street'

Category	Consideration	Assessment
Traffic and transport	<ul style="list-style-type: none"> Traffic signals for the access road no longer required on Burnt Bridge Creek Deviation or the Maretimo Street/Sydney Road intersection Poor local network performance due to: <ul style="list-style-type: none"> Proximity of northern ramps to Condamine Street intersection creating weave issues and removal of the right-turn movement to Condamine Street south. This would likely place additional pressure on Sydney Road and Kenneth Road intersections Requires additional traffic signal phasing for the Burnt Bridge Creek Deviation/Sydney Road/Manly Road intersection to allow for right turn westbound traffic to Burnt Bridge Creek Deviation (currently not permitted). This would place additional pressure on the performance of this intersection Local traffic impacts would be concentrated on Kitchener Street, and Balgowlah Road would become a sub arterial road with increased demand on Kitchener Street, Balgowlah Road and Condamine Street, reducing travel time benefits 	

Category	Consideration	Assessment
	<p>and impacting residents and businesses</p> <ul style="list-style-type: none"> Increased risk of queuing into tunnel compared to the proposed reference design alternative 4c, which avoids access road signals and is about one kilometre from Condamine Street. 	
Environment and heritage	<ul style="list-style-type: none"> Additional 350 metres of Burnt Bridge Creek to be realigned north of Kitchener Street Additional 13,000 square metres of vegetation clearing, including in the area behind Kitchener Street identified as grey-headed flying-fox habitat. 	
Community	<ul style="list-style-type: none"> Motorway ramps to Kitchener Street would result in increased traffic noise being generated at a higher elevation in this area Kitchener Street bridge would require replacement to facilitate changed lane arrangements on Burnt Bridge Creek Deviation resulting in disruption impacts to local traffic during staging works Permanent road infrastructure further from residents near to the eastern boundary of golf course Reduced permanent impacts to the existing open space at the golf course by 18,000 square metres due to removal of access road and motorway facilities Greater private property impacts, with the acquisition of more than 20 additional properties: <ul style="list-style-type: none"> At Burnt Bridge Creek Deviation/Sydney Road/Manly Road intersection and Dudley Street to allow for intersection upgrade Along Kitchener Street and Balgowlah Road to allow for creek realignment and construction of north-facing tunnel ramps Kitchener Street, Balgowlah Road and Condamine Street would need to be upgraded resulting in the removal of parking and property impacts Temporary impact to the majority of Balgowlah Golf Course (excluding Balgowlah Oval and scout hall) during construction for: <ul style="list-style-type: none"> Burnt Bridge Creek Deviation staging Tunnel and surface works temporary construction support site Motorway facilities Permanent impacts to the golf course site due to Burnt Bridge Creek Deviation widening. 	
Flooding	<ul style="list-style-type: none"> North-facing tunnel ramps in Burnt Bridge Creek floodplain: <ul style="list-style-type: none"> Places tunnels and surface widening in worst affected areas of the floodplain 	

Category	Consideration	Assessment
	<ul style="list-style-type: none"> – Would require substantial infrastructure to ensure the tunnels are not flooded during major flood events. These measures are likely to impact flow-paths and flood levels on nearby properties • Additional risk of inundation during construction. 	
Constructability and engineering	<ul style="list-style-type: none"> • Motorway facilities close to tunnel ramps • Increased staging in Burnt Bridge Creek Deviation corridor for the: <ul style="list-style-type: none"> – Additional set of surface ramps to the new Kitchener Street Bridge – Complex cut and cover structures across the Burnt Bridge Creek Deviation • Length of surface works in Burnt Bridge Creek Deviation corridor substantially increased. 	
Cost	<ul style="list-style-type: none"> • Greater construction cost due to increased: <ul style="list-style-type: none"> – Staging in busy Burnt Bridge Creek Deviation corridor – Exposure to flooding risk. 	



Alternative 9 - North facing tunnel ramps to Burnt Bridge Creek Deviation with dual U-turn overpass facility





Alternative 9 was suggested as an alternative through community consultation. This alternative would comprise tunnel ramps emerging within Burnt Bridge Creek Deviation to provide connectivity to and from the Pittwater Road/Condamine Street corridor, with a U-turn overpass over Burnt Bridge Creek Deviation, north of Kitchener Street. The U-turn overpass would provide movements to and from the tunnel portal and the suburbs of Seaforth, North Balgowlah and Balgowlah.



Figure 4-32 Alternative 9 - North facing tunnel ramps to Burnt Bridge Creek Deviation with dual U-turn overpass facility

Table 4-18 Evaluation summary of 'Alternative 9 - North facing tunnel ramps to Burnt Bridge Creek Deviation with dual U-turn overpass facility'

Category	Consideration	Assessment
Traffic and transport	<ul style="list-style-type: none"> Traffic signals for an access road no longer required on Burnt Bridge Creek Deviation or at the Maretimo Street/Sydney Road intersection Poor local network performance: <ul style="list-style-type: none"> Condamine Street would be a much shorter route for traffic coming from Manly via Sydney Road under this option (1780 metres compared to 3200 metres via the proposed U-turn) This would increase traffic pressure on Condamine Street, triggering the need for substantial surface works to integrate into the local network Increased traffic impacts during construction due to additional staging and temporary works within the Burnt Bridge Creek Deviation corridor for the new U-turn facility and upgraded Burnt Bridge Creek Deviation/Condamine Street intersection. 	
Environment and heritage	<ul style="list-style-type: none"> Increase in vegetation clearing. Additional 13,000 square metres of vegetation clearing, including in the area behind 	

Category	Consideration	Assessment
	<p>Kitchener Street identified as grey-headed flying-fox habitat</p> <ul style="list-style-type: none"> Increased visual impact associated with two elevated structures Noise and light generation from traffic on elevated structures. 	
Community	<ul style="list-style-type: none"> Reduces permanent impacts to the existing open space at the golf course Increased property impacts: <ul style="list-style-type: none"> Alternative places substantial additional pressure on Condamine Street. Large number of additional private property acquisitions, including multiple large commercial properties, would be required to facilitate the upgrade of Condamine Street to accommodate additional Manly-bound traffic Additional permanent project footprint north of Kitchener Street Temporary impact to the majority of Balgowlah Golf Course (excluding Balgowlah Oval and scout hall) during construction for: <ul style="list-style-type: none"> Burnt Bridge Creek Deviation widening Tunnel and surface works temporary construction support site Motorway facilities. 	
Flooding	<ul style="list-style-type: none"> Tunnel portals constructed clear of the worst affected flood zone, but large ramp structure in flood plain would impact flows and require mitigation. 	
Constructability and engineering	<ul style="list-style-type: none"> Substantial additional construction within Burnt Bridge Creek Deviation corridor to build multiple ramps and overpasses. 	
Cost	<ul style="list-style-type: none"> Considerably greater construction cost due to: <ul style="list-style-type: none"> Substantial additional upgrades at Burnt Bridge Creek Deviation/Sydney Road/Manly Road intersection for additional turn lanes, the Burnt Bridge Creek Deviation/Condamine Street new overpass and Sydney Road/Condamine Street turning lanes Increased staging within the busy Burnt Bridge Creek Deviation corridor. 	

Preferred alternative

An overall summary table comparing the connection alternatives to Balgowlah described above is presented in Figure 4-33.

Project development considerations	Balgowlah connection alternatives											
		Ramps emerging in Sydney Road (1)	Tunnel loop ramps to Sydney Road (2)	Connection partially controlled by traffic signals at BB CD (3)	North facing tunnel ramps to BB CD with east access road to distribute traffic (4a)	North facing tunnel ramps to BB CD with west access road to distribute traffic (4b)	North facing tunnel ramps to BB CD with shorter access road to distribute traffic (4c)	North facing tunnel ramps to BB CD including Condamine Street upgrade (5)	BB CD loop interchange (6)	North and south facing ramps to BB CD (7)	North facing tunnel ramps and surface ramps to Kitchener Street (8)	North facing tunnel ramps to BB CD with dual U-turn overpass facility (9)
	Traffic and transport	●	●	●	●	●	●	●	●	●	●	●
	Environment and heritage	●	●	●	●	●	●	●	●	●	●	●
	Community	●	●	●	●	●	●	●	●	●	●	●
	Flooding	●	●	●	●	●	●	●	●	●	●	●
	Constructability and engineering	●	●	●	●	●	●	●	●	●	●	●
	Cost	●	●	●	●	●	●	●	●	●	●	●

Note: BB CD = Burnt Bridge Creek Deviation

- Aligns with project development considerations
- Mostly aligns with project development considerations
- Partially aligns with project development considerations
- Does not align with project development considerations

Figure 4-33 Balgowlah connection alternatives – project development considerations

Based on the assigned ratings and overall scores, the preferred alternative for the Balgowlah connection is the access road alternative 4c. The justification for selecting this alternative is summarised in Table 4-19.

Table 4-19 Summary of evaluation of Balgowlah connection preferred alternative

Evaluation criteria	Reason for preferred alternative
Traffic and transport	<ul style="list-style-type: none"> • Access road connection to Sydney Road improves long-term network performance by: <ul style="list-style-type: none"> – Reducing pressure on Burnt Bridge Creek Deviation/Sydney Road/Manly Road intersection and Condamine Street between Burnt Bridge Creek Deviation and Sydney Road – Eliminating traffic weaving inherent in many other options – Improving traffic performance and road safety outcomes – Access road is shorter than for alternatives 4a and 4b • Provides connection to the new open space and recreation facilities • Minimises construction in Sydney Road corridor • Requires traffic lights for southbound traffic on Burnt Bridge Creek Deviation and new access road/Sydney Road/Maretimo Street intersection • Shorter operational access road compared to alternatives 4a and 4b • Longer two lane ramp tunnels to Balgowlah and Wakehurst Parkway connections. Shorter three lane mainline tunnels compared to alternatives 4a and 4b • Extensive utility works and associated local traffic interruptions greatly reduced in streets west of Burnt Bridge Creek Deviation.
Environment and heritage	<ul style="list-style-type: none"> • Requires only localised adjustment to Burnt Bridge Creek and eliminates extensive diversion works within the existing creek, reducing impacts on flora and fauna, including potentially reduced impact on mature trees in the golf course precinct compared to alternatives 4a and 4b • Scope of staged construction within the Burnt Bridge Creek Deviation reduced • Reduced impact likely on grey-headed flying fox habitat north of Kitchener Street bridge compared to alternatives 4a and 4b • Reduced risk of potential impact to Aboriginal heritage with reduced creek diversion works.
Community	<ul style="list-style-type: none"> • Substantial increase to private property impacts compared to alternative 4a. Large portion of Dudley Street subject to property acquisitions (same as for alternative 4b) • Acquisitions on Sydney Road and Serpentine Crescent not required as for several other alternatives • Reduced substratum acquisitions under residential properties in Seaforth compared to alternatives 4a and 4b • Existing Kitchener Street/Myrtle Street local traffic arrangements no longer impacted with bridge replacement works eliminated • New and improved open space and recreation facilities, including (subject to

Evaluation criteria	Reason for preferred alternative
	<p>further consultation):</p> <ul style="list-style-type: none"> – Land not required for the construction or operation of the project would be progressively re-purposed and handed over to Northern Beaches Council for the community – Potential for new and improved open space and recreation facilities in residual land primarily to the east and north of the new access road, to be available for use earlier than alternative 4a • Along with a shorter access road, permanent road infrastructure is more centrally aligned within the golf course site, reducing potential amenity, noise and vibration impacts when compared to alternatives 4a and 4b.
Flooding	<ul style="list-style-type: none"> • Location of cut and cover tunnel portal moved to the south away from floodplain therefore reducing potential flooding impacts during construction and operation.
Construction and engineering	<ul style="list-style-type: none"> • Overall construction footprint reduced in comparison to alternatives 4a and 4b due to elimination of Kitchener Street bridge works • Less tunnelling and haulage of spoil compared to several other options with direct tunnel access to Sydney Road or additional south facing ramps on Burnt Bridge Creek Deviation • Appropriately sized temporary construction support site with arterial road access, allowing the project to be delivered efficiently, reducing construction duration along with allowing repurposed new and improved open space and recreation facilities to be available earlier than for alternatives 4a and 4b • Minimises construction in the Sydney Road corridor • Scope of staged construction works within the Burnt Bridge Creek Deviation reduced with cut and cover portal moved to the south and now located close and adjacent to the temporary construction support site at Dudley Street/Balgowlah Golf Course • Greatly reduces impacts on multiple utilities required for alternatives 4a and 4b • Relatively low cover tunnelling eliminated under residential properties in Hope Street, eliminating settlement risk and ground-borne noise risk.
Cost	<ul style="list-style-type: none"> • Reduced construction staging in busy road corridors, reducing construction costs • Reduced scope of local road works required to integrate project, reducing construction costs.

4.5.6 Ventilation alternatives

Ventilation system design

Tunnel ventilation systems must continuously, reliably and efficiently provide a safe environment for tunnel users and communities surrounding the infrastructure. The basic objectives of tunnel ventilation systems are to:

- Maintain in-tunnel air quality
- Avoid portal emissions
- Manage smoke during fire incidents.

Most tunnels in NSW are unidirectional, meaning that traffic travels in one direction only within the tunnel. Usually two tunnels are constructed side by side (for example, the Lane Cove Tunnel), or one on top of the other (for example, the Eastern Distributor), to enable traffic to travel in both directions.

On an open roadway, vehicle emissions are diluted and dispersed by natural surface air flows. However, in a tunnel, mechanical ventilation can be required to ensure that air quality standards are maintained. This is achieved by providing fresh air to, and removing exhaust air from, the tunnel. The requirements for tunnel ventilation are determined by the vehicle emissions in the tunnel and the limits of pollutant levels set by regulatory authorities. Air quality is managed by ensuring that the volume of fresh air coming into the tunnel adequately dilutes emissions.

The movement of vehicles through a tunnel drives air flow, called the 'piston-effect', drawing fresh air in through the tunnel entrance, diluting the vehicle exhaust emissions. In short tunnels up to about one kilometre long, air flow resulting from the piston effect of the vehicles may be adequate to manage in-tunnel air quality.

In longer tunnels, the flow of fresh air can be supplemented by ventilation facilities which remove exhaust air and/or supply additional fresh air. The need for these features is dependent on tunnel size and length, and the number and mix of vehicles using the tunnel. Fans may also be required when the piston effect is insufficient to maintain adequate air flow, such as during periods of low traffic or congested traffic conditions.

Elevated ventilation outlets are used for longer tunnels in urban areas in Australia to disperse tunnel air at a height that ensures compliance with ambient air quality criteria.

There are four broad types of road tunnel ventilation systems, and each of these was considered for application to the project:

- Natural ventilation
- Longitudinal ventilation
- Transverse ventilation
- Semi-transverse ventilation.

A number of alternatives for design of the ventilation system were considered. The advantages and disadvantages of the various systems are described below and shown in Figure 4-34.

Natural ventilation

Road tunnels with natural ventilation rely on vehicle movements, prevailing winds and differences in air pressure between the tunnel portals to move air through the tunnels without the assistance of mechanical ventilation (for example, through the use of fans). In the case of unidirectional naturally ventilated tunnels, the piston effect generated by traffic using the tunnels also assists in the movement of air. Because naturally ventilated tunnels do not have mechanical ventilation outlets, all air from within the tunnels is emitted via the tunnel portals.

Natural ventilation is only acceptable for use in relatively short tunnels (that is less than one kilometre). This is because, without the assistance of mechanical ventilation, vehicle emissions can

build up within the tunnels leading to unacceptable in-tunnel air quality under some traffic scenarios. Emergency smoke management considerations may also dictate a mechanical solution. Natural ventilation would not achieve acceptable in-tunnel air quality under low vehicle speed conditions or during emergencies and is therefore not a viable ventilation design for the project.

Longitudinal ventilation

The simplest form of ventilation for road tunnels is longitudinal ventilation, in which fresh air is drawn in at the entry portal and passes out through the exit portal with the flow of traffic. For longer tunnels, during normal operating conditions, most air would be forced through the tunnels by the movement of vehicles (the piston effect) and jet fans would be used to assist with the movement of tunnel air, to maintain acceptable in-tunnel air quality. The air pressure inside the exit portals would be maintained below atmospheric pressure to avoid the release of tunnel air from the portals. This air is then exhausted through an elevated ventilation outlet to maximise dispersion. All road tunnels longer than one kilometre built in Australia in the last 20 years have been designed and operated with longitudinal ventilation systems. This includes the recently completed NorthConnex, New M4 and M8 tunnels and the M4-M5 Link tunnels currently under construction.

Transverse ventilation

Another way to ensure adequate dilution of emissions is to provide fresh air inlets along the length of the tunnel along one side, with outlets on the opposite side. This system requires two ducts to be constructed along the length of the tunnel: one for the fresh air supply and one for the exhaust air. Transverse ventilation has been used in the past when vehicle emissions produced greater levels of pollutants than they do today. A transverse ventilation system is more expensive to construct because of the additional ducts that need to be excavated for each tunnel. This type of system is less effective than a longitudinal system for controlling smoke in the tunnel in case of a fire. It is also more energy intensive as more power is consumed to manage air flows.

Semi-transverse ventilation

Semi-transverse ventilation combines both longitudinal and transverse ventilation. Fresh air can be supplied through the portals and be continuously exhausted through a duct along the length of the tunnel. Alternatively, fresh air can be supplied through a duct and exhausted through the portals.

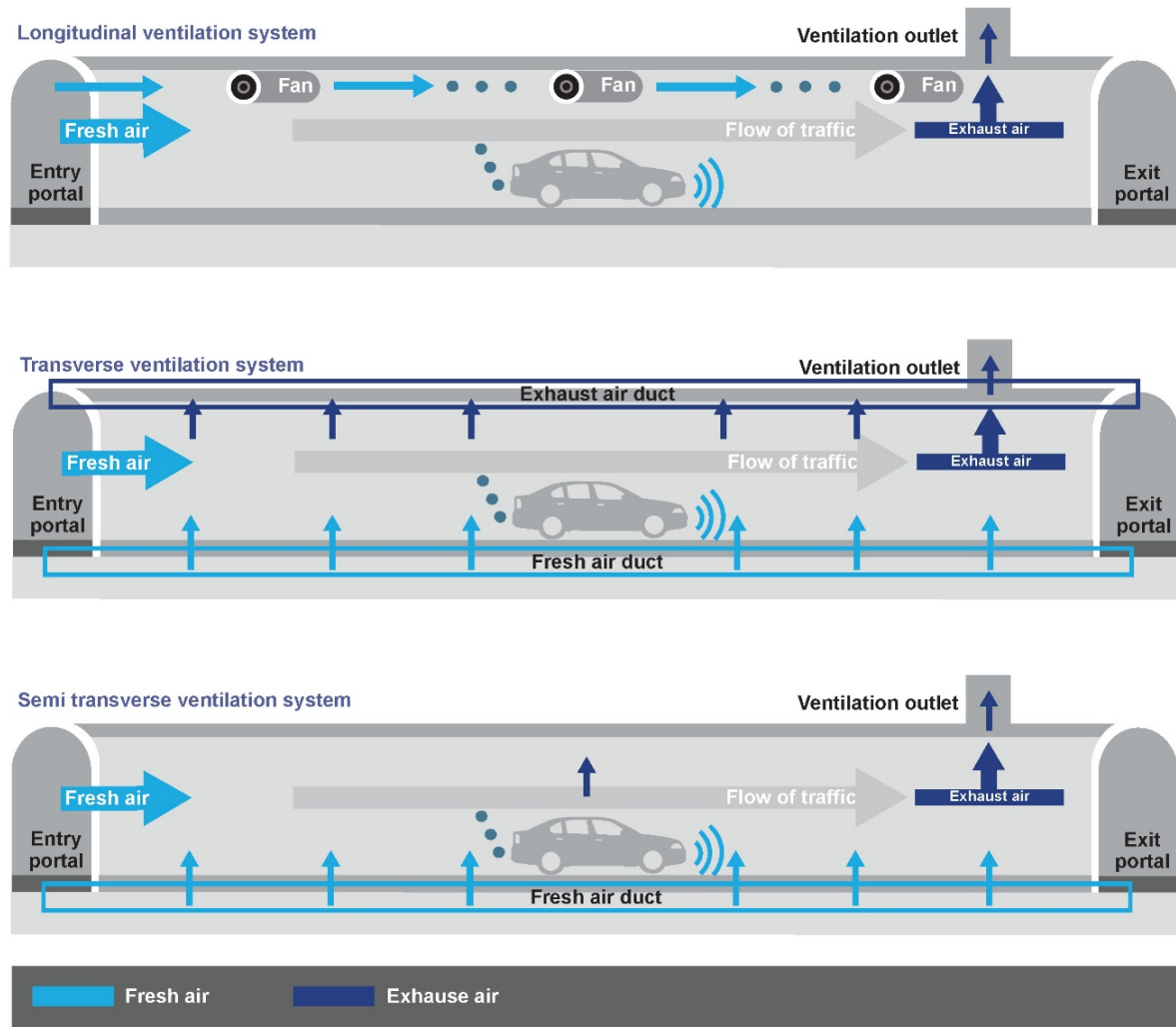


Figure 4-34 Ventilation system design alternatives

Preferred alternative

The development of cleaner vehicles in response to cleaner fuel and emissions standards has led to a substantial reduction in vehicle emissions over the past 20 years. Where longitudinal ventilation was once not suitable for long tunnels, due to the need to supply large volumes of fresh air to dilute vehicle emissions, a well-designed longitudinal ventilation system can maintain acceptable air quality in long tunnels and is considered the most efficient and effective tunnel ventilation system (Advisory Committee on Tunnel Air Quality (ACTAQ), 2019).

Although all three mechanical ventilation systems described above could be designed to meet in-tunnel air quality criteria, a longitudinal system with elevated ventilation outlets has been selected as the preferred option for the project as it is:

- Able to ensure emissions are dispersed and diluted so that there is minimal or no effect on ambient air quality
- Considered to be more effective for the management of smoke in the tunnel in the event of a fire
- Able to meet the requirement to avoid portal emissions
- Less costly to construct and operate than transverse systems.

The effectiveness of elevated ventilation outlets in dispersing emissions is well established. Chapter 12 (Air quality) presents the air quality assessments for both in-tunnel and external air

quality. An overview of the ventilation system design and operation is provided in Chapter 5 (Project description).

Consideration of air filtration at the ventilation outlets

Only a small proportion of road tunnels around the world are fitted with air treatment systems. It has been shown that control of pollutants at the source is significantly more effective in improving local and regional air quality (ACTAQ, 2019; NHMRC, 2008a). Control measures include minimising road gradients, increasing tunnel height and providing a large tunnel cross-sectional area. The tunnel ventilation system for the project would be designed with appropriate levels of conservatism and redundancy to ensure compliance with air quality goals and limits.

No in-tunnel filtration system is proposed for the project because the modelling carried out demonstrates that the ventilation system would be effective in ensuring compliance with the in-tunnel air quality criteria. The inclusion of tunnel filtration was evaluated and found not to provide any material benefit to air quality or community health, as discussed in Chapter 12 (Air quality).

The inclusion of filtration would result in no material change in air quality in the surrounding community when compared to the current project ventilation system and outlet design. Any predicted changes in the concentration of pollutants would be largely driven by changes in the surface road traffic.

The independent NSW Chief Scientist and Engineer also released a report in relation to road tunnel air quality. The report found that emissions from well-designed road tunnels cause a negligible change to surrounding air quality, and as such, there is little to no health benefit for surrounding communities in installing filtration and air-treatment systems in such tunnels. Further information is available at www.chiefscientist.nsw.gov.au.

Ventilation outlet locations

The contribution of the ventilation outlets is negligible for the expected traffic scenarios. This outcome can be achieved at nearly any location through appropriate outlet design. Therefore, the main factors when considering the location of the ventilation facilities and outlets were maintaining in-tunnel air quality, maximising operational efficiency and minimising surface disturbance.

Vehicles travelling through the tunnels create a piston effect which draws air in the direction of travel. As a result, the most efficient location for a ventilation outlet is above or adjacent to tunnel portal locations (that is, near the exit portals of the tunnel in Cammeray, Artarmon, Balgowlah and Killarney Heights). This minimises the length of tunnel where the air flow must be forced, by jet fans within the tunnels against traffic flow back to the ventilation point. The reduced use of tunnel ventilation fans also increases the performance of the tunnels and reduces operational power consumption, thereby reducing the operational costs of the project and enhancing the sustainability outcomes.

The proposed ventilation outlets for the project would be located at Warringah Freeway at Cammeray, Gore Hill Freeway at Artarmon, Burnt Bridge Creek Deviation at Balgowlah and the Wakehurst Parkway at Killarney Heights. The ventilation outlet locations at Artarmon, Balgowlah and Killarney Heights were driven by the locations of the tunnel portals and the motorway facilities. For the ventilation outlet at Cammeray, the Warringah Freeway corridor was identified as the preferred location for the ventilation outlet. This location would provide the following key advantages:

- It would minimise the total project footprint, noting alternatives would require additional property acquisition external to the existing road corridor
- It would be immediately above the tunnel, with associated efficiencies.

Refer to Chapter 5 (Project description) for an overview of the key features of the project, including the location of the ventilation outlets, which are shown in Figure 5-1 to Figure 5-7.

4.5.7 Temporary construction support site location alternatives

In addition to the surface disturbance areas required for the operation of the project, a number of temporary construction support sites would be required along the project corridor. The temporary construction support sites would be needed to support both tunnelling and surface works.

Temporary construction support sites would accommodate construction activities such as construction material and equipment storage and staging areas, spoil handling, component casting facilities, worker amenities and car parking.

In addition to the construction requirements, environmental investigations and community and stakeholder feedback were used to inform the identification and configurations of appropriate temporary construction support sites. The primary driver for the location of these sites was the objective of minimising environmental and community impacts, while being suitably located to facilitate the construction activities of the project.

Key factors applied to identification of potential temporary construction support sites included:

- Locating the temporary construction support sites as close as possible to project construction areas
- Avoiding sensitive environments and community locations where possible
- Avoiding material impacts on heritage sites or items
- Maximising opportunities for direct access to motorways and arterial roads or water transport opportunities for construction traffic, and avoiding the need to use local residential streets if possible
- Minimising direct and indirect property impacts and acquisition requirements, particularly in residential areas.

Where the identified temporary construction support sites could not meet the criteria listed above, additional specific mitigation measures were identified to manage impacts associated with their use. Details of temporary construction support sites are provided in Chapter 6 (Construction work) of this environmental impact statement.

Two temporary construction support sites in particular have been subject to more detailed alternative evaluation. These are the:

- Wakehurst Parkway tunnel temporary construction support site at Seaforth/Killarney Heights
- Flat Rock Drive tunnel temporary construction support site at Willoughby/Northbridge.

Wakehurst Parkway tunnel temporary construction support site

Initial planning for this temporary construction support site was associated with the initial preferred connection to and from the Wakehurst Parkway at portal location option A (refer to Section 4.5.4) with the temporary construction support site located at Seaforth Oval overflow carpark area on the western side of the Wakehurst Parkway.

Further community consultation and design development determined the selection of portal location option B as the preferred location of the tunnel portal and connections to and from the Wakehurst Parkway (refer to Section 4.5.4). A preferred temporary construction support site location was then selected on Sydney Water property on Kirkwood Street on the eastern side of the Wakehurst Parkway.

The eastern option was identified as the preferred location for this temporary construction support site, as it:

- Avoids impact to the operation of Seaforth Oval
- Minimises potential impacts on the nearby community precinct
- Uses land owned by the NSW Government

- Allows tunnelling to occur in both a northerly and southerly direction (reducing construction duration).

This site is referred to in Chapter 6 (Construction work) as the Wakehurst Parkway east construction support site (BL13).

Flat Rock Drive tunnel temporary construction support site

For tunnelling in the area from Naremburn to Middle Harbour, two tunnelling sites would be the preferred strategy for tunnelling logistics. This would be the preference for the safety of construction workers, to maximise the efficiency of tunnelling and to limit project costs. Due to the highly urbanised nature of the suburbs between Naremburn and Middle Harbour, and the depth of the tunnel through this area, limited viable intermediate tunnelling sites were considered to be suitable for the project. Due to these limiting factors, although not ideal for tunnelling construction efficiencies, only one tunnelling site has been proposed between Naremburn and Middle Harbour.. With no intermediate tunnelling site be provided between Naremburn and Middle Harbour, all tunnelling for this area is proposed to be completed from Flat Rock Drive. This would result in the longest one-way drive carried out for a motorway tunnel in Hawkesbury Sandstone, additional cost and an increase in the intensity and duration of construction activities.

Multiple sites were considered, and two sites were shortlisted as options to support tunnel construction from Flat Rock Drive:

- On the Flat Rock baseball diamond located on the western side of Flat Rock Drive
- Within part of Flat Rock Reserve on the eastern side of Flat Rock Drive in land that was revegetated post 1998.

Other alternative sites as well as potential additional intermediate tunnelling sites to improve tunnelling efficiency were considered unfavourable as they would have required haulage of spoil on local streets (some of which are narrow), caused local amenity impacts and resulted in the acquisition of a substantial number of private residential and/or commercial properties.

The Flat Rock Reserve option was identified as the preferred location for this tunnel temporary construction support site, primarily because it avoids direct impacts to the local operational recreation facilities of Willoughby Recreation Centre, netball courts, the baseball diamond and other recreation spaces on the western side of Flat Rock Drive, which are in high demand for local community use.

Additionally, the preferred site would provide direct arterial road access, avoiding haulage through local streets and town centres and direct impacts to private properties. The size of the preferred site would allow the construction of an access decline and the ability to tunnel in three different directions, reducing the number of required intermediate tunnelling sites.

The Flat Rock Reserve site includes native vegetation which will be impacted, however the majority of this vegetation has been established relatively recently as part of the progressive rehabilitation of a former landfill over the last twenty years. This site is referred to in Chapter 6 (Construction work) as the Flat Rock Drive construction support site (BL2).

4.5.8 Spoil transport alternatives

Most of the spoil generated by major transport infrastructure projects currently under delivery and development would be Virgin Excavated Natural Material (VENM). VENM is considered a desirable material for clean fill in development sites and major earthworks projects across Greater Sydney.

Securing spoil disposal sites to meet production throughout construction and during bad weather is critical to the delivery program of tunnelling projects. Most reuse arrangements are directly negotiated between construction contractors and councils or private developers – with major projects often using many sites to optimise haulage and cost.

Tunnel spoil generated from major projects in Sydney is generally transported via road due to the majority of reuse sites being within the Sydney basin and the desire to minimise double handling of material.

Options to reduce impacts of spoil haulage on the surface road network were considered during development of the project. The spoil transportation strategy for the project includes road haulage from all sites.

In addition to the mitigation measures adopted within the proposed construction strategy, additional options to reduce spoil haulage impacts have been considered, including rail or barge as outlined below.

Rail

Freight rail was considered as a mode of spoil transport that may offer the opportunity to move large volumes of material and reduce the number of heavy vehicle movements on the Greater Sydney road network. However, when considering the location of the project and associated temporary construction support sites, this method presents the following issues:

- The material would need to be at least double and, most likely, triple handled. Trucks would be required to move material from temporary construction support sites to a suitable train loading facility, and from the rail terminus to the final disposal location. This would greatly undermine the benefits of any such arrangement, as heavy vehicles are typically on the motorway network shortly after leaving the proposed tunnelling temporary construction support sites. Analysis of haulage to potential train loading facilities concluded that heavy haulage distances on non-motorways would actually increase if this option was adopted
- There are few spare timeslots for freight trains on the Sydney rail network, which presents a considerable construction risk. If the material cannot be reliably moved, large spoil storage facilities would be required to ensure tunnelling operations are not interrupted
- Infrastructure upgrades would be necessary to develop an appropriate train loading facility to receive the material.

Barge

As with rail, the main benefit of barge transport is the ability to move large volumes of spoil, while reducing the number of heavy vehicle movements on the wider road network.

Barges would be used for the transport of material excavated from Middle Harbour south cofferdam (BL7) and Middle Harbour north cofferdam (BL8), and for deliveries and staff transport to the cofferdam sites. Barges would also be used for the transport of dredge material from the Middle Harbour crossing to the offshore disposal site (further detailed in Section 4.5.10).

However, beyond this, use of barges for handling spoil presents a number of issues, including:

- As none of the Beaches Link tunnelling sites are located adjacent to the harbour or a navigable waterway, the use of barges would require tunnel spoil to be trucked to a harbourside transfer site where it would need to be transferred to barges
- The material would need to be double (or possibly triple) handled, as trucks would be required to move material to a harbourside barge loading facility, possibly through local streets and from the barge to its final disposal location
- Infrastructure upgrades would potentially be required to allow the barge loading facility to receive the material
- Given the requirement to haul material from tunnelling sites to the harbour and from the final barge point to the disposal site, this option is unlikely to materially decrease heavy haulage impacts.

Truck

Spoil removal using trucks would involve transporting material from the construction sites directly to its final destination and would occur primarily via the arterial road network. However, as trucks would be limited to transporting relatively small volumes of spoil (about 25 to 30 tonnes per truck), a large number of truck movements would be required. The use of trucks would streamline the handling of spoil as minimal double or triple handling would be required, but would result in a higher number of trucks on the road. Transport by other transport options (rail and barge) would still require trucks to move material to or from the loading facility and, potentially, to the final destination.

Preferred alternative

A combination of mostly trucks and some barging for Middle Harbour dredging operations is the preferred spoil transport option for the project. With the major temporary construction support sites for Beaches Link all located close to the arterial road network, this solution minimises impacts on the local road network while delivering an efficient and value for money spoil transport solution.

Chapter 6 (Construction work) provides a summary of heavy vehicle movements, including spoil related haulage.

4.5.9 Tunnelling spoil reuse and disposal alternatives

As described in Chapter 24 (Resource use and waste management), spoil would be beneficially reused as part of the project before alternative spoil disposal options, such as other infrastructure or development projects, would be pursued.

Most of the spoil generated by the project would be VENM, which is considered a desirable material for clean fill in development sites and major earthworks projects across Greater Sydney. Generally, VENM is not disposed of at licenced landfills, primarily due to the high cost of doing so in comparison to reuse at development sites. It is proposed that such material generated from the construction works at Balgowlah Golf Course would partly remain on site and be reused to create a landform to support its re-purposing as new and improved open space and recreation facilities.

Residual spoil waste which cannot be reused or recycled would be disposed of at a suitably licensed landfill or waste management facility. Potential opportunities for reuse of spoil within the project include use for the formation of embankments and earth mound noise barriers, site rehabilitation and landscaping, road upgrades and infill for temporary tunnel access declines.

Alternative and/or additional spoil reuse options may be identified by the construction contractor as the project progresses.

Determination of the final destination(s) for spoil from construction of the project would be made during further design development and may include more than one disposal site.

4.5.10 Dredged and excavated harbour bed material management alternative

The project would require material to be dredged and excavated from Middle Harbour to allow for the construction of the immersed tube tunnel crossing between Northbridge and Seaforth. A number of options for the disposal and reuse of these dredged and excavated materials have been considered as part of the development of the project, including:

- Land disposal at a licensed waste management facility
- Offshore disposal.

A summary of the alternatives considered for the disposal and reuse of these materials is provided below.

Land disposal at a licenced waste management facility

Disposal of all dredged and excavated materials from Middle Harbour only to a licensed waste management facility would require:

- Dewatering to a spadable condition prior to disposal, potentially requiring mixing of the material with additives to alter the consistency of the material, enabling it to be transferred to land. Dewatering may require large areas of land, depending on the quantity of material, which may result in additional property acquisition, large and noisy machinery and potential impacts to nearby receivers
- Large volumes of marine vessel movements to transfer dredged and excavated materials to a loadout facility for treatment
- Large volumes of heavy vehicle movements to transfer material (once spadable) to a licensed waste management facility.

Disposal of this material at a licensed waste management facility would likely be at a landfill and would therefore require the use of landfill space. Given the potential environmental impacts associated with the disposal of all dredged and excavated material to a licensed waste management facility, this option was not considered feasible.

However, it is expected that a relatively small amount of material dredged and excavated from Middle Harbour as part of the project may not be suitable for offshore disposal. The reuse of this material is not an option and, given the small amount of material, disposal at a licensed waste management facility is considered an appropriate option.

Offshore disposal

Transport for NSW will submit an application for offshore disposal of suitable dredged and excavated materials from Middle Harbour to the Australian Government Department of Agriculture, Water and the Environment. Offshore disposal is regularly used by marine excavation projects in NSW, with licenced disposal grounds in operation off Sydney Harbour and Newcastle. These sites have been carefully selected by the Australian Government to provide suitable disposal grounds for dredge and marine excavation material and minimise impacts on sensitive marine ecology. The proposed designated offshore disposal site is located about 10 to 15 kilometres offshore of Sydney Heads. The site is over 20 square-kilometres in area and is a non-dispersive ground, meaning that material placed within the area generally does not migrate from that area.

Material disposed of at the designated offshore disposal site (in accordance with legislative requirements) would comprise sediments and rock removed from Middle Harbour during the construction of the Middle Harbour south (BL7) and Middle Harbour north (BL8) cofferdams, and dredged sediment and rock material removed from Middle Harbour as part of the construction of the immersed tube tunnels.

Disposal of suitable dredged and excavated materials at the designated offshore disposal site would:

- Avoid disposal of spoil to land-based sites
- Avoid additional heavy vehicle movements on the road network
- Minimise some environmental impacts such as noise, odour and dust at sensitive receivers, by avoiding the need to carry out treatment, dewatering and land-based transport of all dredged and excavated material
- Avoid the creation of a sizeable waste stream on land.

Material would be required to satisfy the requirements of the *National Assessment Guidelines for Dredging* (Department of Environment, Water, Heritage and the Arts, 2009) before being considered suitable for disposal at the designated offshore disposal site.

Preferred dredged and excavated materials management option

The preferred option for the disposal and/or reuse of dredged and excavated materials is a combination of mostly offshore disposal and some disposal at a licensed land based waste facility. To minimise the potential environmental impacts associated with the disposal and reuse of dredged material, where dredged material complies with the *Environment Protection (Sea Dumping) Act 1981*, it would be disposed of at the designated offshore disposal site. Where material is not suitable for offshore disposal, it would be barged to a loadout facility for treatment to be made spadable and then loaded onto trucks and disposed of at a suitably licensed land-based facility (at a location yet to be determined), and classified according to the NSW Environment Protection Authority's *Waste Classification Guidelines*.

Chapter 6 (Construction work) provides a summary of heavy vehicle and vessel movements relating to the transport of dredged and excavated materials to land for disposal at a licensed waste management facility. Chapter 24 (Resource use and waste management) details the indicative quantities of material requiring disposal at a licensed waste management facility and suitable for disposal at the designated offshore disposal site.

Offshore disposal of dredged and excavated materials would be conducted outside NSW and is therefore not regulated under the *Environmental Planning and Assessment Act 1979* or considered further in this environmental impact statement. Daily maximum construction maritime traffic volumes and routes to navigational channels that lead to Sydney Heads, including barge movements for offshore disposal of suitable dredged and excavated materials, are summarised in Chapter 6 (Construction work) and considered in Chapter 8 (Construction traffic and transport) and Section 5.5 of Appendix F (Technical working paper: Traffic and transport). Noise impacts related to the use of barges at water-based temporary construction support sites have been considered in Chapter 10 (Construction noise and vibration) and Appendix G (Technical working paper: Noise and vibration).