5 Project alternatives and options

This chapter describes and analyses the alternatives to the project, as well as the options that were considered as part of the design development process. It explains how and why the project was selected as the preferred option for assessment in this EIS.

5.1 Strategic alternatives to the project

The project is the first stage of the F6 Extension. The merits of the F6 Extension were considered in the context of a range of other alternatives based on transport, environmental, engineering, social and economic factor performance.

The following strategic alternatives to the F6 Extension were considered:

- Alternative 1 – The base case or 'do nothing/do minimum'
- Alternative 2 – Rail infrastructure improvement options
- Alternative 3 – Bus service improvements
- Alternative 4 – Motorway option (development of the F6 Extension).

These alternatives are described in more detail in **section 5.1.1** to **section 5.1.4.**

5.1.1 Alternative 1 – The base case or 'do nothing/do minimum'

This base case would involve carrying out only currently planned and funded transport infrastructure improvements on the existing road network, such as routine road network and intersection upgrades that would be provided over time to incrementally improve capacity and traffic throughput to address specific congestion issues.

This has been developed by considering the following planned programs to improve road based transport infrastructure in southern Sydney:

- Roads and Maritime's Easing Sydney's Congestion Program, which includes:
  - the Pinch Point Programs
  - the Sydney Clearways Program
- Transport for NSW's proposed Bus Priority Infrastructure Program
- Arterial road upgrades.

Details on these programs, their relevance to southern Sydney and their assessment as an alternative or complementary program to the proposed F6 Extension are provided below.

Pinch Point Program

The Pinch Point Program aims to reduce traffic delays, manage congestion and improve travel times on Sydney's major roads, particularly during weekday peak periods. Pinch points are traffic congestion points, intersections or short lengths of road where a traffic bottleneck slows down the broader network.

In February 2015, the NSW Government committed to the Gateway to the South Pinch Point Program to address critical pinch points along the A1, A3 and A6 routes south of the M5 Motorway. More than 20 locations have been identified as part of this program for further investigations and potential improvements. Potential improvements include:

- Electronic message signs, to provide road users with real-time information on planned events and unplanned incidents
- Closed-circuit television cameras, to monitor and manage traffic
- Work to maximise capacity at key intersections, which could include lengthening or widening turn bays or implementing turn restrictions.

Pinch Point Program work is currently proposed in the vicinity of the project at the following locations:

- Princes Highway, Forest Road and Wickham Road, Arncliffe
- Princes Highway and Rockdale Plaza Drive, Rockdale
- The Grand Parade and President Avenue, Monterey (completed 2017)
- Princes Highway, Gray Street and Rocky Point Road, Kogarah (underway in 2018).

Sydney's Clearways Program

In December 2013, the NSW Government published the Sydney Clearways Strategy which identified routes on Sydney's road network that could benefit from new clearways.

Clearways are installed on key arterial roads where traffic is often heavy and congested. When vehicles are parked in the kerbside lane, fewer lanes are available to traffic and road users are forced to merge from the kerbside lane which can create significant delays and queues. Clearways help keep vehicles moving by making all lanes available to road users. The only exceptions are the stopping of buses and taxis dropping off or picking up passengers as well as emergency vehicles. Clearways:

- Reduce congestion by making an additional lane available to traffic
- Improve journey times, allowing drivers to get to their destination sooner and more reliably
- Improve safety by removing parked vehicles from the kerbside lane
- Have an immediate positive impact on traffic flow as it uses existing road space for the movement of vehicles
- Improve the efficiency of intersections along the corridor, as all lanes are used.

The Sydney Clearways Strategy identifies over 1000 kilometres of state roads on key corridors across Sydney, which may benefit from the introduction of new and extended weekday and new weekend clearways, to improve the movement of goods and people. These routes were identified as possible clearways, based on a 2013 assessment of the following criteria:

- Directional traffic flows exceed 800 vehicles per hour per lane
- Travel speeds are 30km/h or less during peak periods.

Corridors identified in the strategy are currently under further investigation. Along with detailed parking and traffic analysis, the following two areas are now being considered:

- If the roads are strategic bus or freight transport corridors for moving people and goods
- Whether alternate public parking close to local businesses can be found, taking into account the quantity and usage of customer parking removed to extend or introduce a new clearway.

Clearway hours are determined based on an analysis of traffic volumes and times along the corridor, taking into consideration a need for consistency in the clearway hours of operation both along a corridor and across the network. Since 2013, new and extended clearways have been installed on some of Sydney's busiest corridors including along the Princes Highway from President Avenue, Kirrawee to King Georges Road, Blakehurst.

Community engagement has also commenced for new weekend and extended weekday clearways on Taren Point Road between Captain Cook Bridge, Taren Point and Kingsway, Caringbah.

Other corridors for investigation in southern Sydney are identified in the 2013 Sydney Clearways Strategy, including:

- Princes Highway through Blakehurst, Kogarah , Rockdale and Wolli Creek
- Rocky Point Road from Kogarah to Sans Souci
- General Holmes Drive, The Grand Parade and Sandringham Street from Kyeemagh to Sans Souci.

The identification of possible new and extended clearways in the Sydney Clearways Strategy was based on assessment of traffic volumes and speeds in 2013 and is separate to and is not prompted by the F6 Extension Stage 1 project.

Clearways have an immediate positive impact on traffic flow as they use existing road space for the movement of vehicles and are an operational traffic management solution, intended to be implemented in the short to medium term to address current congestion.

Irrespective of the future changes to traffic flows and patterns resulting from the F6 Extension Stage 1 (if approved), clearways for certain periods would likely still be required in the future because of the expected growth in traffic volumes.

The implementation of new and extended clearways, with alternate business parking solutions, within the project area provides a response to managing current road congestion, using our existing road assets.

Bus Priority Infrastructure Program

Sydney's Bus Future: simpler, faster, better bus services[1] is the NSW Government's long-term plan to redesign Sydney's bus network to meet customer needs now and into the future. The plan sets out step-by-step actions to improve bus services, aiming to provide integrated connections to existing train services. For southern Sydney and specifically for areas in the vicinity of the project, the plan proposes improved integration with the rail network, upgraded interchanges at Arncliffe and Kogarah, and a new high frequency route between Miranda and Sydney Airport via the St George area, and various upgrades.

Arterial road improvements

Traffic modelling predicts that key arterial roads in southern Sydney will experience increased congestion and will operate near or above their capacities by 2036 during peak periods. Ongoing improvements to the broader transport network are therefore either planned or already underway. Operational traffic modelling conducted as part of the project has taken into consideration the effect of the implementation of these road improvements.

In December 2016, construction was completed on an additional right turn lane from The Grand Parade into President Avenue to improve traffic flow and safety. This provided increased capacity of the intersection to cater for growth in traffic.

However, this and other improvements to the arterial road network would only provide incremental change in the efficiency of the road network, and would not support the additional capacity required for regional traffic growth associated with the forecast increase in Sydney's population and subsequent increases in vehicle travel.

Further, continued urban development along the arterial roads in southern Sydney, including the Princes Highway, means there is limited capacity to widen and/or upgrade these roads. Future improvements to the surface road network would be challenging, potentially requiring the acquisition of a large number of properties. This could have significant negative community impact, with increased traffic flows in residential areas as well as limited land use regeneration, urban renewal opportunities or upgrades to public transport services.

Even if broader arterial road upgrades could be achieved at reasonable cost and impacts, the improvements are unlikely to match the capacity that would be provided by the project and future stages of the F6 Extension. In particular, arterial road upgrades would not provide the required separation of inter-regional and intra-regional traffic movements.

Improvements to the arterial road network alone, other than those already planned through the Easing Sydney's Congestion Program, are not a feasible or long-term alternative to the project and would not meet the project objectives. If combined with the project and future stages of the F6 Extension, arterial road upgrades including the potential enabling works for a future motorway, would provide more effective solutions to congested parts of the road network.

Summary

The planned transport improvements described above improve traffic flow by improving the capacity of intersections to cater for growth in traffic, and improve the reliability of some bus services. However, they would not provide any separation of inter-regional and intra-regional traffic movements. As a result, the do nothing/do minimum alternative would not meet the forecast traffic needs and the existing road network would need to accommodate all future traffic growth.

The project would not preclude any of the transport improvements that are currently proposed for southern Sydney.

[1] Transport for NSW (2013). *Sydney's Bus Future: Simpler, faster, better bus services*

5.1.2 Alternative 2 – Rail infrastructure improvements

The strategic alternative to improve rail infrastructure considered options to improve the existing corridor of the T4 Eastern Suburbs and Illawarra Line and/or the provision of a new mass transit line servicing southern Sydney and the Illawarra. *Future Transport 2056* identifies current government initiatives to expand existing rail infrastructure in southern Sydney including the following initiatives for investigation:

- Train improvements on the T4 Illawarra Line (0-10 years)
- Mass transit/train link CBD to South East (10-20 years)
- Parramatta to Kogarah mass transit/train link (10-20 years)
- Extension of South East mass transit/train link (20+ years).

Improvements to the existing T4 Illawarra Rail Line would likely involve the provision of additional sections of track and expansion of stations at strategic locations. A new southern mass transit line would involve the identification of a new alignment for an additional rail line servicing southern Sydney, which could include above ground and/or underground sections.

The expansion of existing or the provision of new rail infrastructure alone would not address the needs of customers to access highly dispersed locations involving longer trips, nor would rail provide the separation of inter-regional and intra-regional traffic movements. Further, with about 60 per cent of employment dispersed across the Sydney metropolitan area, public transport alone cannot viably serve many of these locations.

Demand for mobility by road travel is forecast to continue to grow. Public transport initiatives such as rail would only partially contribute to relieving congestion on arterial roads. Options to improve rail infrastructure would not considerably enhance the productivity of commercial and freight-generating land uses in isolation – and they would not address the strategic need for the project identified in **Chapter 4** (Strategic context and project need).

The project would not preclude rail infrastructure improvements from occurring as they would address different objectives. Any rail infrastructure improvements are likely to be complementary to the project as they would further reduce the number of vehicles on surface roads and would provide opportunity for place making at key strategic centres.

In June 2018, the NSW Government announced an investment into technology improvements to modernise the Sydney Trains network, including signalling upgrades along the T4 Illawarra Line. These upgrades are part of the ‘More Trains, More Services’ program and will significantly boost capacity and reliability for all train customers.

5.1.3 Alternative 3 – Bus service improvements

There is a low use of buses in the area for commuting to work, at around two per cent. It is around four per cent for trips originating or terminating in Kogarah and Rockdale. Buses nevertheless perform a critical role in the region, as they feed trunk rail services and are the main form of public transport in southern Sydney aside from trains. Alternative 3 therefore focuses on potential improvements to bus services.

Southern Sydney currently has few bus priority measures. Bus journey times are therefore heavily influenced by general traffic conditions. Several bus routes in southern Sydney include sections of ‘slow’ road links, which are defined in Roads and Maritime’s Performance Monitoring Information Management System as roads with average travel speeds during peak periods of less than 30 km/h.

The majority of bus routes in the area have average peak period speeds of between 21 km/h and 30 km/h, with the average across all bus routes around 26 km/h. All bus services in southern Sydney, with the exception of the ‘400’ line, experience more than 50 per cent variability in travel time, resulting in unreliable service operations for customers.

Sydney's Bus Future's proposed improvements to bus services in southern Sydney described in **section 5.1.1.** It would be possible to improve bus services in southern Sydney. However, in isolation, such improvements are unlikely to fully address the region's future transport needs as:

- Development across southern Sydney is relatively dispersed and typically of low density, meaning the private vehicle is the predominant form of intra-regional travel
- The reliability of bus services in southern Sydney is affected by traffic congestion and improvements in performance are likely to be limited while the area is without a motorway-level road to divert intra-regional traffic off arterial roads
- Public transport can only partially address the transport demands in the area. There are no feasible strategic transport alternatives, such as light rail or bus corridors, that would meet the diverse range of customer needs for travel in this corridor.

However, improvements to public transport, including improved bus services, would be complementary to the project. The project is aligned with the *'simpler, faster, better'* strategy of *Sydney's Bus Future* as it would:

- Improve bus travel times and travel time reliability on existing routes due to a decrease in through traffic on arterial roads
- Create opportunities to reallocate existing general traffic lanes on arterial and other roads as dedicated bus lanes at strategic locations
- Identify the opportunity for introducing new express bus routes along the project.

5.1.4 Alternative 4 – Motorway option (development of the F6 Extension)

The *State Infrastructure Strategy Update 2014*[2] recommended that the WestConnex program of works include a connection to allow for a potential future southern extension. It stated that a southern motorway that connects the New M5 Motorway to the A1 Princes Highway would remove inter-regional traffic from the existing arterial road network, which would ease traffic congestion, improve local air quality and amenity and create opportunities for urban renewal in some areas of southern Sydney that currently experience heavy traffic congestion. A southern motorway would also deliver economic benefits by reducing travel times for journeys through southern Sydney and between Sydney and the Illawarra region.

Reduced travel times would make travel to southern Sydney employment areas more feasible and therefore more attractive to employers. This would include improved travel times for bus services, which in turn would increase the reliability of these services. A motorway could also create opportunities for new express bus routes.

The motorway option (development of the F6 Extension) was chosen as the preferred option as it would:

- Improve journey times and reliability for road users travelling between the Illawarra, Southern Sydney and strategic centres in Greater Sydney, while supporting faster and more reliable journey times for local bus customers and road users in Southern Sydney
- Support the future growth and productivity of Southern Sydney and the Illawarra by improving connectivity between these regions and strategic centres in Greater Sydney
- Support urban renewal at key centres on arterial roads by reducing through traffic along corridors that perform a key place function.

[2] Infrastructure NSW (2014) NSW Infrastructure Strategy Update 2014

5.2 Strategic corridor options analysis

After deciding on the motorway option, Roads and Maritime undertook preliminary environmental investigations into the proposal to link the A1 Princes Highway at Loftus with the existing and proposed motorway network in Sydney. This included a study into several motorway corridor options and the development of a strategic business case.

Motorway corridor options were assessed based on their ability to meet the strategic need for the project (refer to **Chapter 4** (Strategic context and project need)) and the objectives of the proposal.

The key aims of the proposal to link the A1 Princes Highway at Loftus with the existing and proposed motorway network in Sydney were to:

- Provide a high standard access controlled motorway that integrates with the regional transport network
- Minimise adverse social and environmental impacts in the local area during construction and operation
- Provide opportunities for improved public transport in the (former) Rockdale and Sutherland local government areas
- Assist in a reduction in traffic congestion, particularly along A1, A3 and A6 corridors, and provide shorter travel times for road users
- Provide a motorway that is safe and reliable for road users
- Contribute towards a reduction in the number of heavy vehicles using A1, A3 and A6 corridors and local roads in the region
- Improve amenity of the western coastline of Botany Bay by reducing the number of heavy vehicles which use The Grand Parade
- Demonstrate excellence in design and environmental sustainability
- Be economically justified and affordable to Government.

Four corridor options were assessed (refer to **Figure 5-1**), being:

- F6 corridor option – broadly aligned with land previously reserved for the F6 Freeway
- A1 corridor option – broadly aligned with the existing A1/ A36 arterial road (Princes Highway)
- A3 corridor option – broadly aligned with the existing A1/ A3 arterial road (Princes Highway, King Georges Road)
- A6 corridor option – broadly aligned with the existing A6 arterial road (Heathcote Road, New Illawarra Road, Alfords Point Road, Davies Road and Fairford Road).

These four corridors are shown on **Figure 5-2**.

Each corridor was assessed against desired criteria relating to traffic and transportation benefits, environmental and social impacts and benefits, engineering requirements, geotechnical conditions, property impacts, cost and place making opportunities.

The F6 Extension corridor was broadly defined by two key drivers:

- Infrastructure NSW's recommendation to provide a connection to a southern extension from the New M5 Motorway, and the subsequent decision by Sydney Motorway Corporation to include stub tunnels for a southern extension (refer to **section 5.4.1**)
- The land previously reserved for the F6 Freeway (the F6 corridor option).

The F6 corridor was selected as the preferred corridor as it would:

- Cater for the eastern distribution of future traffic demand travelling north
- Provide a motorway solution without removing arterial roads
- Have a greater impact on reducing congestion for north-south traffic
- Create, in conjunction with the New M5 Motorway and other projects, a new north-south motorway through Sydney, completing a missing connection in the national highway.

Criteria	F6 Corridor	A1 Corridor	A3 Corridor	A6 Corridor
Traffic and transportation	🟢	🟡	🟡	🟡
Environmental and social	🟡	🟡	🔴	🟢
Engineering requirements	🟢	🟡	🟡	🟢
Geotechnical conditions	🟡	🟡	🟡	🟡
Property	🟢	🟡	🟡	🟡
Cost	🟡	🔴	🔴	🟡
Place making	🟢	🟡	🟡	🔴

Key

🟢 Option meets the desired criteria for the preferred strategic corridor

🟡 Option meets some of the desired criteria for the preferred strategic corridor

🔴 Option meets the least number of the desired criteria for the preferred strategic corridor

Figure 5-1 Strategic alternatives: corridor options analysis

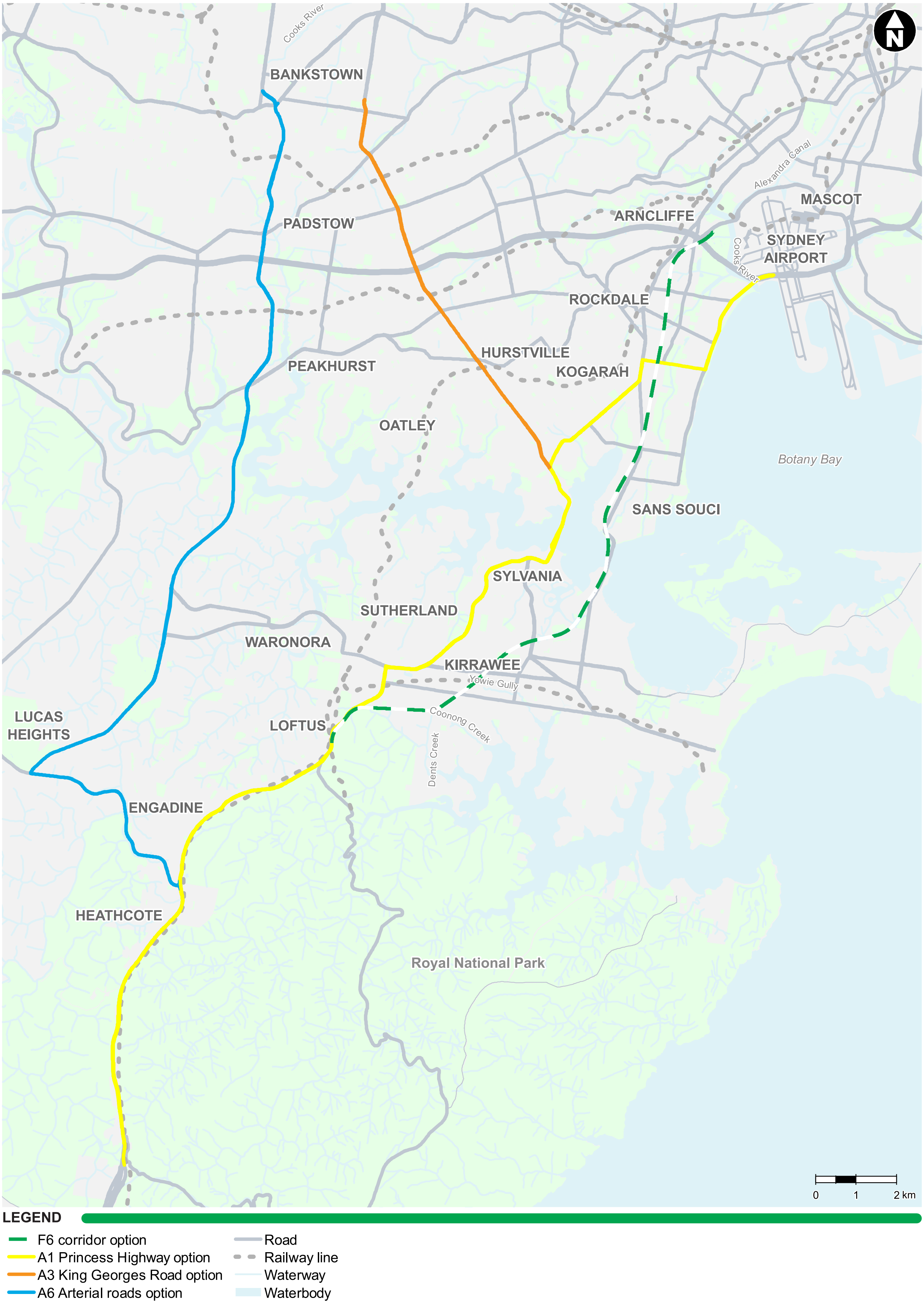


Figure 5-2 Strategic alternatives: corridor options

5.3 F6 Extension staging options

A multi-criteria analysis of staging and incremental works (refer to **Figure 5-3**) was undertaken to confirm the most appropriate area to commence construction of the F6 Extension based on the defined geographic sections (A – C) (refer to **Figure 5-4**). Each section was assessed against desired criteria relating to traffic and transportation benefits, environmental and social benefits and impacts, increase in productivity and cost benefits.

The analysis identified that Section A would be the preferred first stage as it would provide the greatest benefits to the community across the criteria. Section A has high levels of traffic congestion, with peak hour speeds on the existing arterial network amongst the lowest in Sydney. As a first stage, it would alleviate this congestion and provide a direct connection to the motorway network in Sydney.

Section A, providing a connection between the motorway network at Arncliffe to an intersection at President Avenue, Kogarah, was developed in further detail.

In parallel, Roads and Maritime determined to continue with the investigation work along the preferred updated corridor for the F6 Extension between Kogarah and Loftus (Sections B to C) to identify any potential corridor adjustments for the future motorway.

Figure 5-3 F6 Extension: staging options analysis

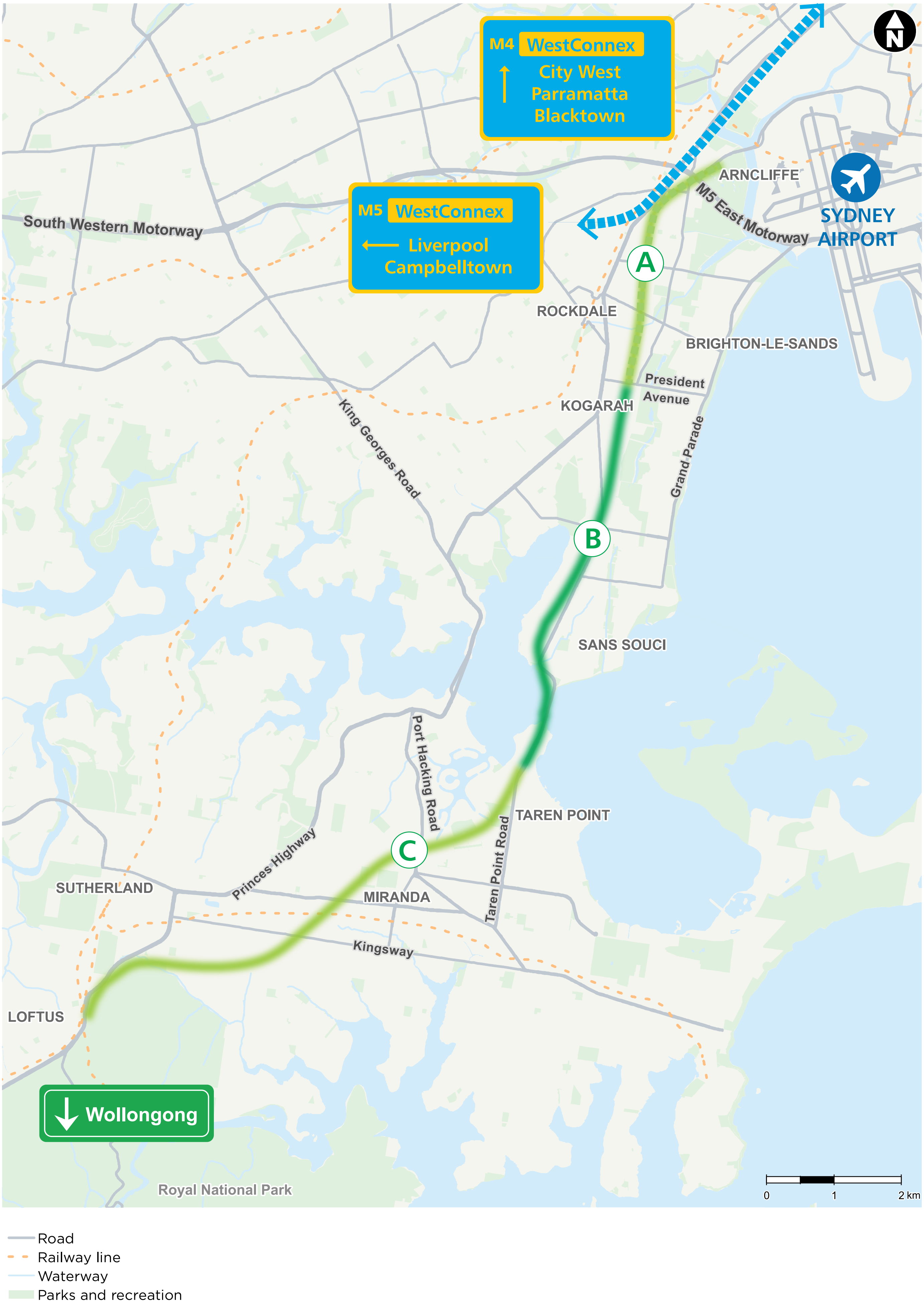


Figure 5-4 F6 Extension staging: study area

5.4 Project options and alternatives

After confirming the F6 option as the preferred corridor and deciding that Section A would be delivered as the first stage of the F6 Extension, Roads and Maritime developed the design options for the project. In doing so, the following project components were considered:

- Use of the existing F6 reserved corridor
- Northern connection
- Mainline tunnel alignment
- Southern connection
- Princes Highway / President Avenue intersection upgrade
- President Avenue surface works
- Shared cycle and pedestrian pathways.

Each of the project components was considered against option analysis criteria. Multiple alignments, infrastructure types and interchange options were generated as discussed below. Some options were readily assessed as impractical due to the inability to meet basic connectivity, constructability or other set criteria.

5.4.1 Existing F6 reserved corridor

The use of the existing F6 reserved corridor between Arncliffe and President Avenue was considered in the early stages of project development. However, it was discounted for the following reasons:

- The high value of the ecological and recreational resources within the existing F6 reserved corridor
- The social and environmental impacts of a surface motorway (either at-grade or on viaduct)
- The engineering challenge of tunnelling under the existing F6 reserved corridor given the identified poor geotechnical conditions
- The significant constraints on any northern end connection due to previous commercial and residential developments, with a lack of viability without a connection to the New M5 Motorway.

As a result of the preferred location and alignment of the project, the existing F6 reserved corridor (shown in **Figure 5-5**) would not be required for the project, aside from a small portion of land within Rockdale Bicentennial Park. Therefore, the existing F6 reserved corridor between Arncliffe and President Avenue would no longer be required for motorway purposes.

5.4.2 Northern connection

The northern connection of the project takes advantage of the significant investment made by the New M5 Motorway project, where tunnel stubs and associated infrastructure would be provided by the New M5 Motorway project at Arncliffe. The New M5 Motorway and the associated St Peters interchange have been specifically designed to facilitate this connection to the south and a future link to the international gateways of Sydney Airport and Port Botany.

The New M5 Motorway project identified that a tunnel was preferred over a surface connection for the F6 Extension at the St Peters interchange. This was on the basis that a tunnel would better integrate with the planned motorway network and have reduced impacts on community and environment aspects, than if it had been designed as a surface road alignment.

Other northern connection options for the project were considered in addition to the New M5 Motorway (northbound) connection, including a connection with the New M5 westbound tunnels, and the M5 East Motorway near General Holmes Drive. These options and the key outcomes of the options assessment are provided below.

New M5 Motorway westbound

- The New M5 project did not provide any tunnel stub connections, which would have resulted in significant modifications required to the New M5 Motorway tunnel
- Strategic traffic analysis found that there was insufficient demand for a connection to the New M5 westbound.

M5 East Motorway near General Holmes Drive

- Strategic traffic analysis identified some benefits to providing a direct connection from the project to Sydney Airport
- Strategic traffic analysis found that this option would result in:
  - a further decrease in peak hour traffic on The Grand Parade and other surface roads
  - an increase in congestion on the M5 East Motorway and M1 Southern Cross Drive
- Providing a connection from the F6 Stage 1 tunnel to the surface at this location would result in steep grades, making the connection unsuitable for heavy vehicles
- Geological conditions east of the F6 Stage 1 tunnel alignment were considered unsuitable for tunnel construction
- Construction would result in impacts to Eve Street Wetland.

Based on the preliminary options assessment, a connection to the New M5 Motorway westbound was not considered viable. A connection to the M5 East Motorway was considered, however the network traffic benefits did not outweigh the engineering and environmental constraints. Furthermore, a direct connection from the project to Sydney Airport would ultimately be provided by the proposed Sydney Gateway project.

5.4.3 New M5 Motorway lanes

The northern connection of the F6 Extension is to the New M5 Motorway with traffic continuing north to St Peters Interchange and beyond. The New M5 Motorway between the F6 Extension connection and St Peters Interchange is planned to be marked as two lanes in each direction, however the New M5 Motorway tunnel in this location has been constructed wide enough for four lanes in each direction.

Consideration has been given as to the connection of the F6 Extension to the New M5 Motorway and the number of lanes required. Two main options have been considered:

- A minimum treatment could incorporate the F6 Extension merging with the existing two lanes of the New M5 Motorway, allowing for the additional lanes to be utilised at a later date by others.
- Enable the two lanes of the F6 Extension join the two lanes of the New M5 Motorway to form a four lane motorway between the F6 Extension and St Peters Interchange.

Modelling undertaken for the F6 Extension project, within **Chapter 8** (Traffic and Transport), indicates that there is sufficient demand from both the F6 Extension and New M5 Motorway to facilitate the use of four lanes within this section. This aligns with analysis previously undertaken by the New M5 Motorway and the significant investment in constructing width in the tunnel sufficient for four lanes.

As such the F6 Extension project proposes to modify the line marking in the New M5 Motorway tunnel between the F6 Extension and St Peters Interchange to increase the lanes from two to four lanes in each direction.

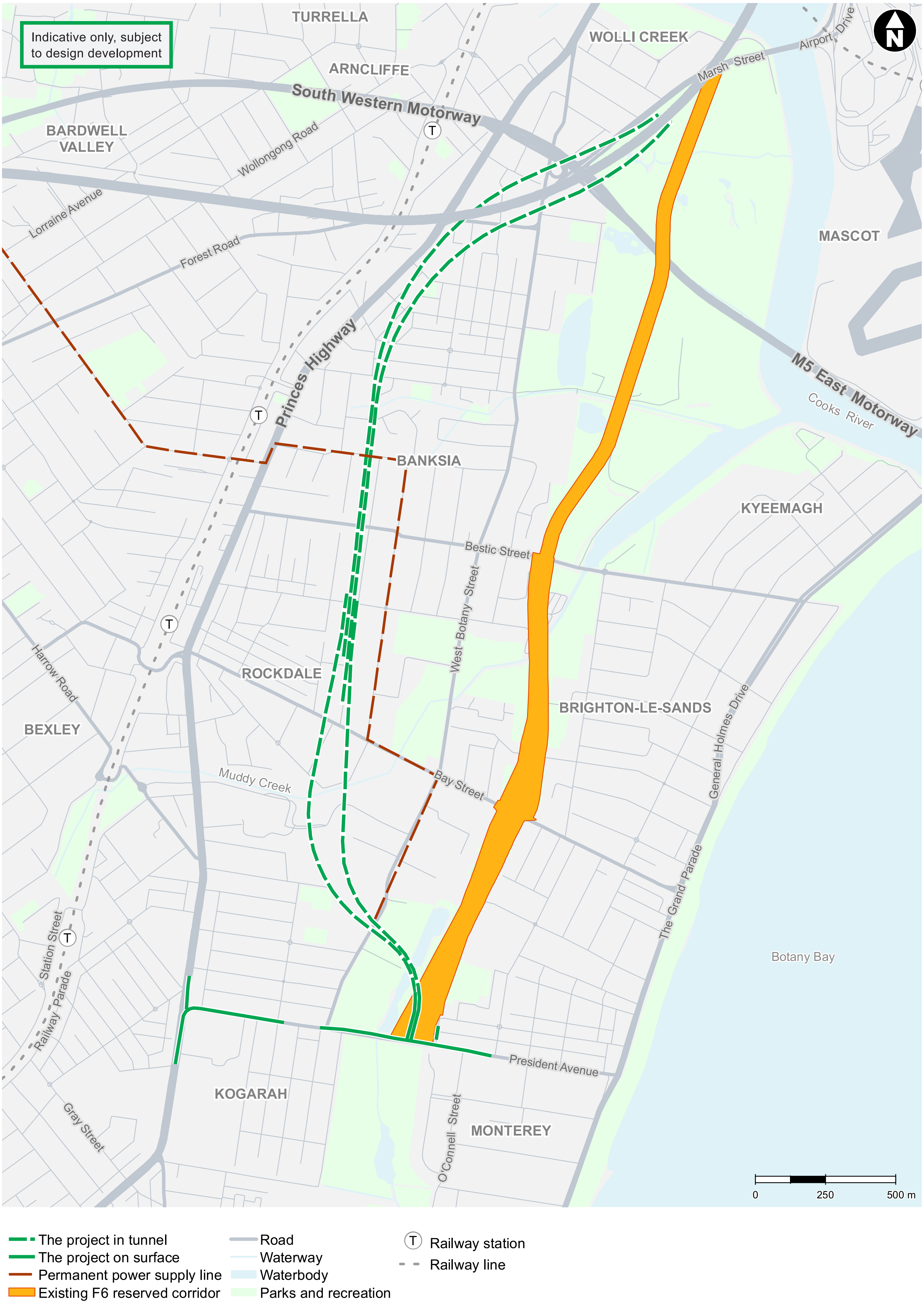


Figure 5-5 Existing F6 reserved corridor

5.4.4 Mainline tunnel

Tunnel alignment

The mainline tunnel alignment was chosen based on the following considerations:

- **New M5 Motorway stub tunnels -** The stub tunnels at Arncliffe were built specifically for a connection to a southern motorway. The stub tunnels face in a south-westerly direction at a depth of approximately 75 metres. This set the following parameters for the tunnel alignment:
  - The location of the stub tunnels precluded a surface connection at Arncliffe
  - The depth of the stub tunnels meant the project's mainline tunnel needed to cross below the New M5 Motorway tunnel.
- **Geological conditions** - Analysis of geotechnical conditions to the east of West Botany Street found that it was not optimal for tunnel construction. Geological conditions improved west of West Botany Street, indicating that a tunnel alignment closer to the Princes Highway would reduce construction risk and cost. The refinement of the horizontal and vertical alignment of the tunnel corridor has also been heavily influenced by a combination of new geological information, improvements in road alignment and preliminary ventilation requirements.

Three options were considered for the mainline tunnel alignment. These were an east, a central and a west option.

All three options commenced at President Avenue and met the New M5 Motorway stub tunnels at Arncliffe. **Figure 5-6** shows the mainline tunnel alignment options. The central option was chosen for the following reasons:

- Favourable geological conditions when compared to the east option, minimising the need for the cut-and-cover construction to extend west of West Botany Street
- Shorter tunnel length when compared to the west option, resulting in reduced costs and resource use.

Further refinement of this alignment may occur during detailed to achieve an optimal tunnel alignment.

Number of tunnel lanes

The project consists of twin mainline tunnels extending through to stubs for connection to a future stage of the F6 Extension; north facing interchange ramps connecting with the surface road network; and associated upgrade works to President Avenue and Princes Highway to facilitate the new motorway connection.

Originally, three options were considered within each of the mainline tunnels. These options were of two, three or four lanes in each direction, plus merges and tie-ins. The preferred project option is two lanes for the following reasons:

- The New M5 Motorway stub tunnels will be constructed as two lanes (as part of the New M5 Motorway)
- The southern entry and exit ramps of the project would be constructed as two lanes (for operational and safety reasons)
- Three kilometres was considered too short a length of motorway to introduce a third lane in each direction.

It was determined that the mainline tunnels would be constructed to allow a future third lane in each direction to allow for future stages of the F6 Extension.

Refer to **Chapter 8** (Traffic and transport) for further details on lane functionality. Further details on lane configurations and the direction of traffic flow within the tunnels, is provided in **Chapter 6** (Project description).

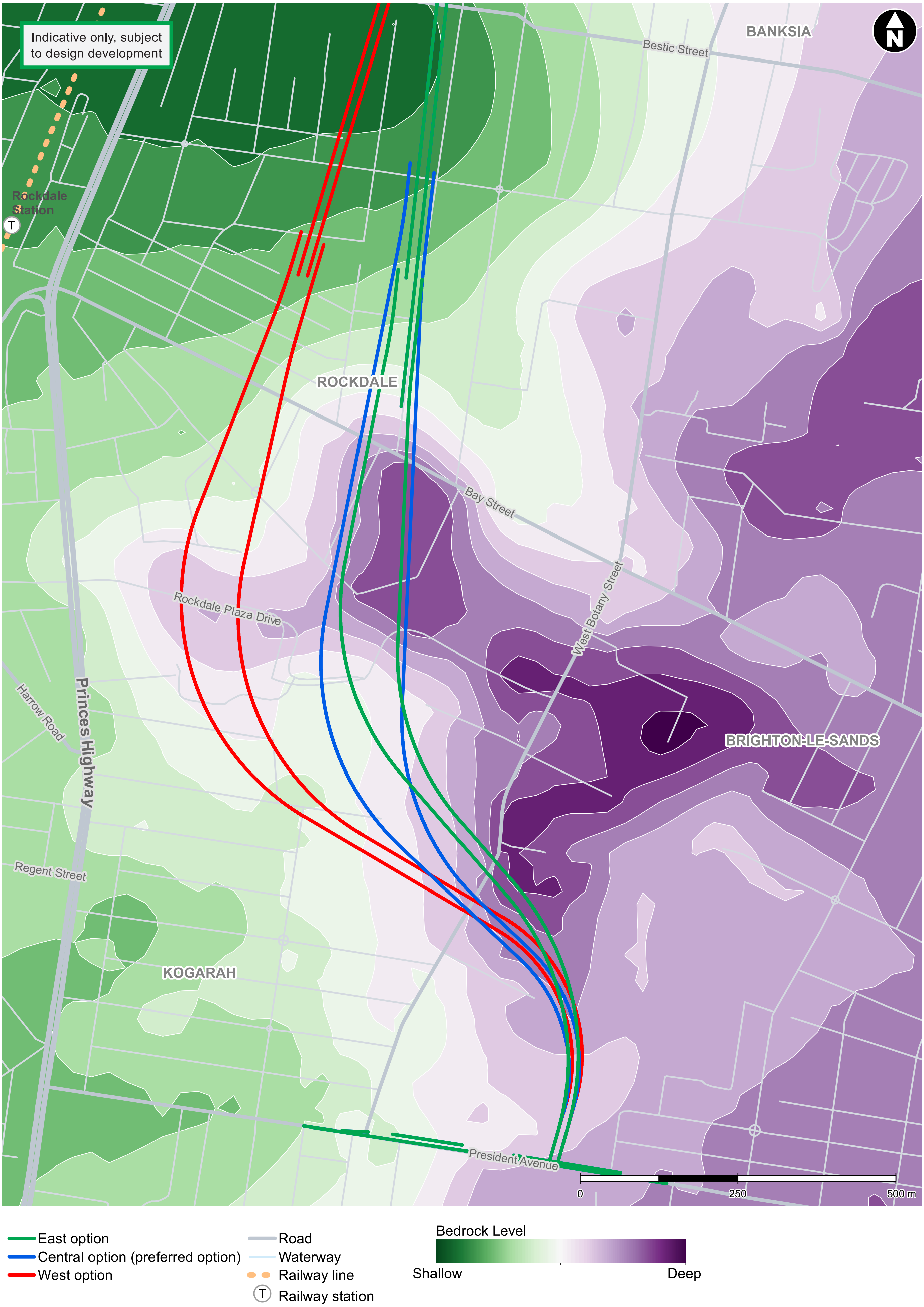


Figure 5-6 Mainline tunnel alignment options

5.4.5 Southern connection

There were a number of options considered to provide a southern connection between the project and the surrounding road network. These options included interchanges at Bay Street, President Avenue, Ramsgate Road, Sandringham Street and Rocky Point Road/Princes Highway. The viability of these connections is based on the potential surface/tunnel alignments, impacts of these intersections to land uses and traffic performance of the surrounding road network.

Sandringham Road and Ramsgate Road are local roads with a low level of traffic demand and limited connectivity. Bay Street is unsuitable due to its closeness to the tunnel structure and the New M5 Motorway connection. The entry and exit ramps would need to have tight curves and maximum grading (i.e. incline) as it approaches the surface. A southern connection at Bay Street would also require a larger amount of property acquisition than at President Avenue.

A connection within the vicinity of the Rocky Point Road/Princes Highway intersection was considered. However, the design was not developed given the proximity of St George Private Hospital, Moorefield Girls High School, James Cook Boys Technology High School and large multi-unit dwellings close to the Princes Highway. It would also reduce the accessibility for the Kogarah, Rockdale and surrounding suburbs.

President Avenue was selected as the best option against the criteria (listed below) for a number of reasons, including:

- **Motorway gradient:** given the depth of the connection at the New M5 Motorway and the need to have a uniform grade of alignment according to relevant design standards, the surface connection could not occur until south of Bestic Street, Kogarah
- **Network connectivity:** the project should connect with the arterial road network associated with the existing A1, including Princes Highway and the Grand Parade. A President Avenue connection provides a connection to the arterial State road within an appropriate road environment with capacity to absorb additional traffic, providing optimal connectivity in the St George area and improving connectivity to both Princes Highway and The Grand Parade
- **Community and Environment:** this option recognises the value of community and environmental assets and minimises impacts on land or property, including providing the opportunity for amenity improvements along The Grand Parade and the Bay Street cultural precinct. It is acknowledged that this option would result in temporary impacts to Rockdale Bicentennial Park
- **Land use:** A President Avenue connection would allow for the majority of the surface works to be located within the existing F6 reserved corridor within Rockdale Bicentennial Park East.

5.4.6 President Avenue surface works

The project would involve upgrade and widening works at President Avenue in order to ensure safe and efficient connections with the road infrastructure proposed as part of the project. President Avenue would also be raised by up to three metres to improve its level of flood immunity to the one per cent Annual Exceedance Probability (AEP) level.

The surface works in the vicinity of the President Avenue intersection would include changes to local traffic and access including:

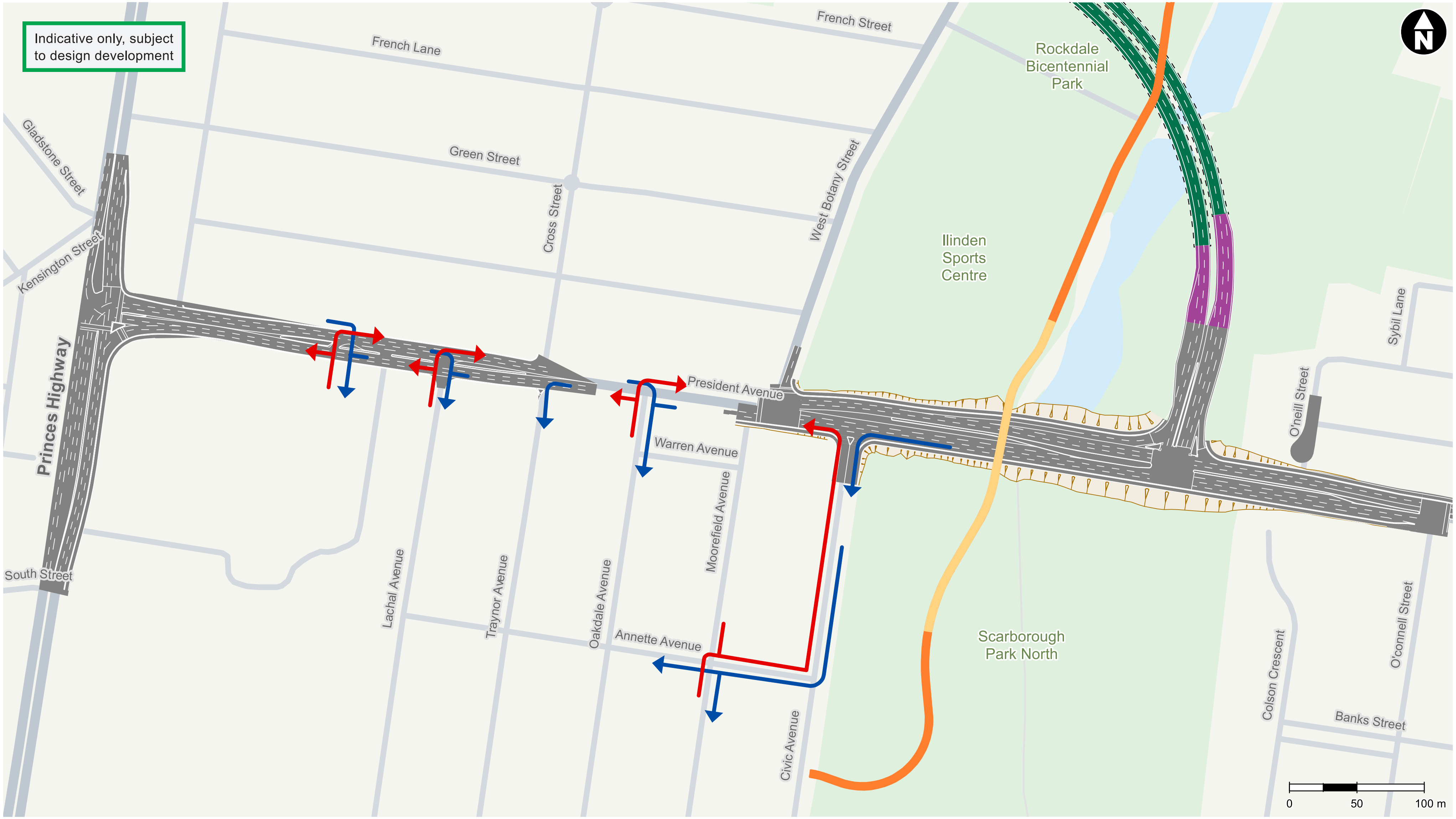
- Changes to O'Neill Street
- Changes to the currently priority controlled movements in and out of the Moorefield Estate access roads (Lachal Avenue, Traynor Avenue, Cross Street, Oakdale Avenue, Moorefield Avenue and Civic Avenue) and the TAFE car park on President Avenue.

Options for these works were reviewed to identify the most appropriate arrangements from a road safety and traffic operations perspective. The options and rationale for the preferred option are outlined in **Table 5-1**. Proposed local access arrangements for the preferred option are shown on **Figure 5-7**.

Roads and Maritime would work with Bayside Council to refine the traffic arrangements at these locations and address potential impacts as a result of the proposed access changes.

Table 5-1 Justification for changes in local access along President Avenue

Proposed surface works	Current situation	Options considered and rationale for preferred option
O'Neill Street – cul-de-sac at President Avenue	Currently allows all movements to and from President Avenue	O'Neill Street would need to be converted to a cul-de-sac at President Avenue given the proximity of the new President Avenue intersection to ensure safe movements for vehicles as they turn in or out of the upgraded President Avenue. Due to these reasons, other options, including a 'do nothing' option, were not considered. Residents and drivers would still maintain access in and out of O'Neill Street via Crawford Road, about 200 metres to the east.
Lachal Avenue: conversion to two-way and formalise right turn movements.	Currently one-way northbound	Converting Lachal Ave to two-way operation is proposed due to: • Available space: which would allow for the addition of a right turn bay from President Avenue into Lachal Avenue • Location: being situated about halfway between Princes Highway and West Botany Street means that allowing all movements at the President Avenue / Lachal Avenue intersection would minimise impacts to those two signalised intersections • Combined arrangement with the TAFE carpark: formalising the right turn movements at Lachal Avenue would also allow formalised right turns in and out of the TAFE car park. Traynor Avenue and Cross Street were also considered for formalising right turn movements into and out of Moorefield Estate. However, due to the reasons listed above, the Lachal Avenue option was considered to perform better than providing right turn movements at Traynor Avenue or Cross Street.
Traynor Avenue	Currently one-way southbound. Allows left-in	At Traynor Avenue, a formalised right turn into Traynor Avenue would not be possible, due to the right turn arrangements at Lachal Avenue, but the left-in movement would remain. Vehicles wanting to turn right in to the Moorefield Estate would be able to use Lachal Avenue, about 75 metres to the west.
Oakdale Avenue	Currently allows left-in, left-out and right-in, right-out movements	No options were considered for changing the traffic arrangements at Oakdale Avenue as the current arrangement would remain suitable with the project.
Moorefield Avenue	Currently allows left-in, left-out access	Options of closing Moorefield Avenue at President Avenue or maintaining the left-in, left-out movements were reviewed and it was considered that, due to the close proximity to West Botany Street, a cul-de-sac option provided improved safety with the project.
Civic Avenue	Currently allows left-in, left-out and right-out movements	The existing right-out movement at this location would not be accommodated by the project due to the proposed lengthening of the right turn lane on the westbound President Avenue approach to the West Botany Street intersection. Vehicles wanting to turn right onto President Avenue would be able to use the Oakdale Avenue / President Avenue intersection, located about 150 metres to the west, at which all turning movements are allowed. Options of closing Civic Avenue at President Avenue or maintaining the left-in, left-out movements were reviewed and it was considered that maintaining the left-in, left-out movements provided better overall access and improved safety with the project.



LEGEND

- The project in tunnel
- The project on surface
- The project as an open slot
- Shared cycle and pedestrian pathways
- President Avenue shared cycle and pedestrian bridge
- Access into Moorefield Estate
- Access from Moorefield Estate

Figure 5-7 Proposed local access arrangement for residents around President Avenue

5.4.7 Princes Highway / President Avenue intersection

Preliminary traffic modelling indicated that upgrades at the Princes Highway / President Avenue intersection would be required to accommodate the additional traffic anticipated as a result of the project. Three options were considered to meet the traffic demand:

- Do nothing: this option would retain the existing arrangement at the Princes Highway / President Avenue intersection
- Right turn overpass: this option would include a northbound, single lane right turn overpass from Princes Highway into President Avenue
- Surface works: this option would include the addition of a right turn lane from Princes Highway northbound into President Avenue.

An assessment of each of these three options was undertaken and the outcomes were as follows:

- Do nothing: traffic modelling indicated that adopting this option would result in increased waiting times at the Princes Highway / President Avenue intersection due to additional traffic accessing the tunnel portals for the project
- Right turn overpass:
  - Traffic modelling indicated that this option would improve the traffic performance at the Princes Highway / President Avenue intersection by removing an at grade movement in the signal phasing. However, traffic modelling indicated that the single lane overpass would provide insufficient capacity for the projected traffic volumes and therefore would result in extended queues.
  - A review of environmental and social costs indicated that the visual impacts to the streetscape of this option would be undesirable for local residents and users of the intersection.
- Surface Works:
  - Traffic modelling indicated that providing an additional right turn to the intersection would increase capacity for the right turn movement giving opportunity for more vehicles to exit the intersection per cycle, therefore improving the overall performance of this intersection.
  - A review of environmental and social costs identified the social cost of strip acquisition along President Avenue.

A multi-criteria analysis assessed these options against desired criteria relating to traffic, environmental and social, engineering and cost. A summary of the multi-criteria analysis of the three options is shown in **Figure 5-8**. The preferred option for the project was to undertake surface works at the intersection, in order to meet the projected traffic demand.

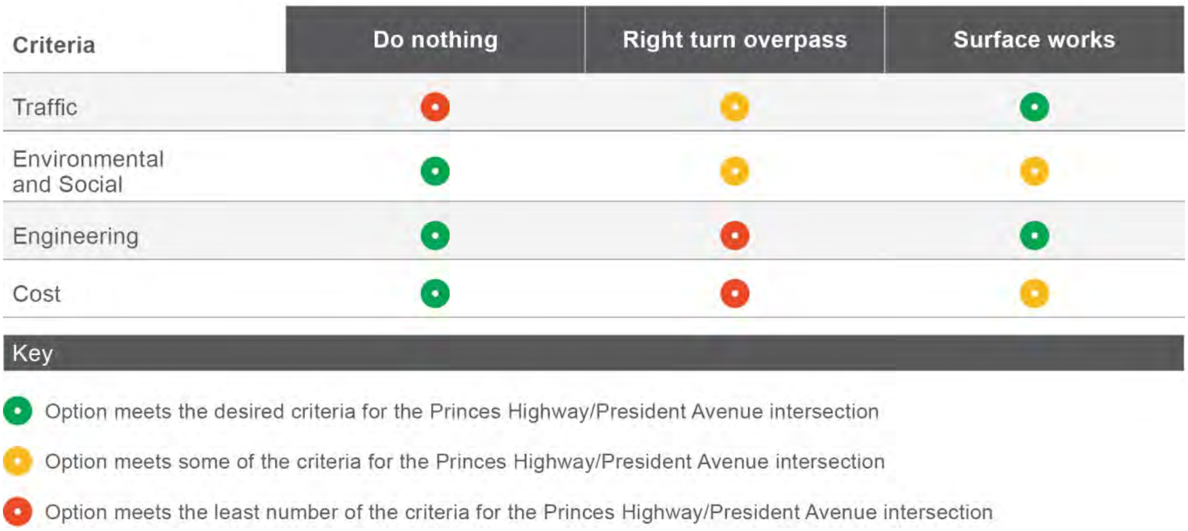


Figure 5-8 Princes Highway / President Avenue intersection improvement options

5.4.8 Shared cycle and pedestrian pathways

The following route options for the shared cycle and pedestrian pathways were considered and discounted for reasons as described below:

- A route that finished at Bay Street did not provide a connection with the cycleway north of Bestic Street
- Shared cycle and pedestrian pathways that provided a direct route (i.e. predominately off-street) between Rockdale Bicentennial Park and Bruce Street required property acquisition
- A route that traversed the eastern side of Rockdale Wetlands did not provide a connection to West Botany Street and would preclude a bridge crossing over President Avenue
- A route that followed Muddy Creek would not have utilised land within the existing F6 reserved corridor.

The preferred shared cycle and pedestrian pathway route has been designed to provide a safe and direct connection between Bestic Street and Civic Avenue, via a shared bridge over President Avenue, whilst minimising impacts on property and utilising the existing F6 reserved corridor.

Further details on the shared cycle and pedestrian pathways are provided in **Chapter 6** (Project description).

The detailed design of the shared cycle and pedestrian pathways would be developed in consultation with Bayside Council and other key stakeholders such as Sydney Water. Additional options that would be considered include:

- Extension of the pathways west towards Rockdale Plaza and Kogarah Station
- Extension of the pathways north, such as along Cooks Cove
- Extension of the pathways east along Bay Street towards the beach.

5.4.9 Dedicated shared cycle and pedestrian bridge

There were two main options for the location of the dedicated shared cycle and pedestrian bridge, each addressed the aim to provide a connection between Rockdale Bicentennial Park north of President Avenue, and the area south of President Avenue (refer to **Figure 5-9**). The two options were:

- East of the proposed President Avenue intersection (eastern option)
- West of the proposed President Avenue intersection (western option).

There were four variations of the eastern option. Due to the proposed raising of President Avenue at the location of the intersection, each of the eastern options would have been higher than the roof line of nearby residential dwellings. This would have resulted in visual impacts and reduction in privacy for residents along President Avenue and Colson Crescent. In addition, the residential catchment east of Scarborough Park North is already served by a shared pedestrian and cycle network along The Grand Parade and Brighton-Le-Sands foreshore.

The western option is considered the preferred option because it would:

- Follow the existing path alignment within Rockdale Bicentennial Park north
- Provide a direct connection between Council owned open space/recreation areas
- Minimise the visual impacts of the project
- Provide a connection to a shared pedestrian and cycle network for the residential catchment west of Scarborough Park North.

5.4.10 Permanent power supply connection

The route of the permanent power supply connection was developed based on the most direct and efficient connection between the Ausgrid Canterbury substation and the Rockdale Motorway Operations Complex south (MOC3). It has also been developed so that it follows arterial roads where possible in order to minimise impacts on the local traffic and transport network during construction. The route is located within the road reserve where possible in order to minimise impacts to open space, private property, vegetation and heritage items.

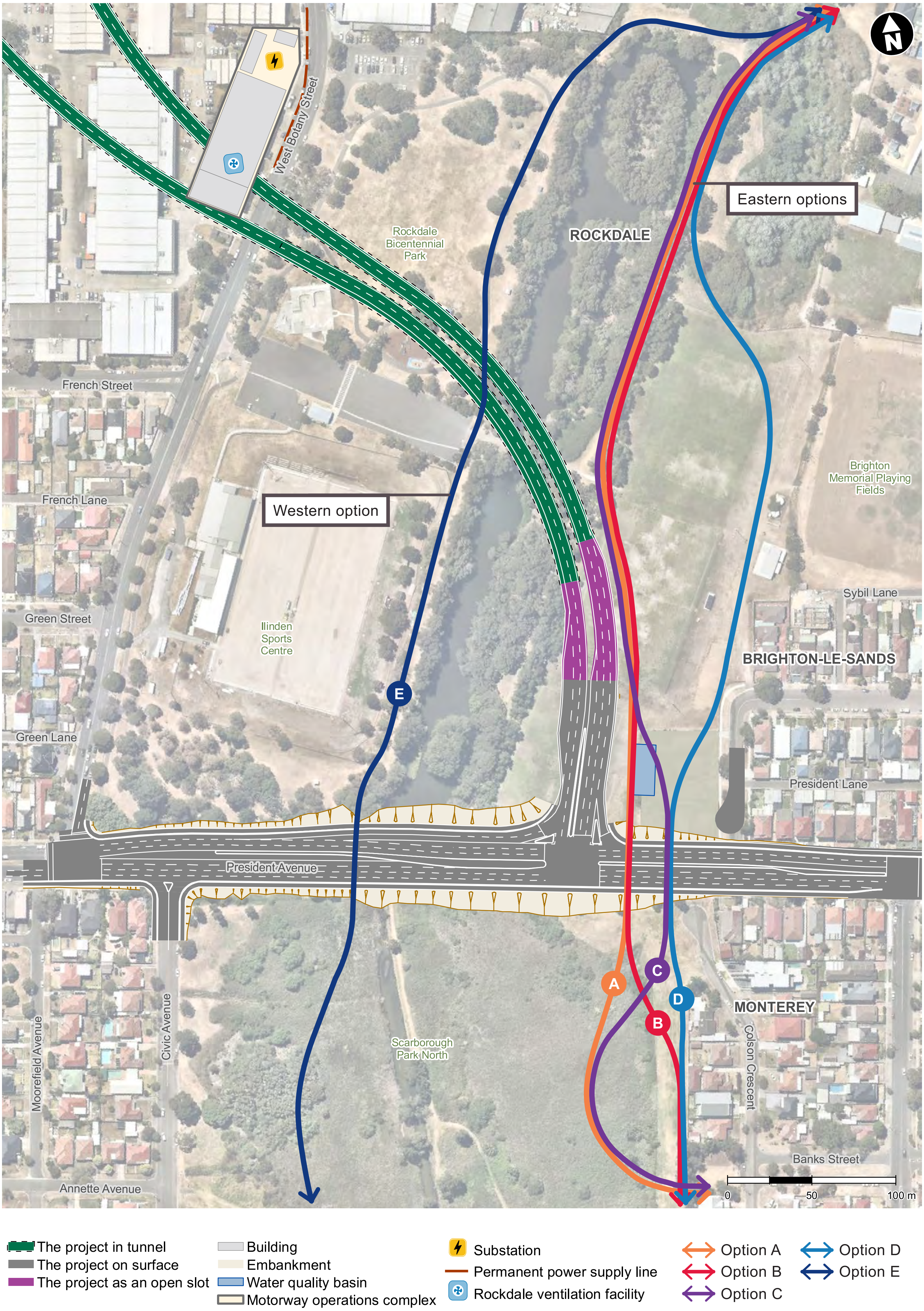


Figure 5-9 Dedicated shared cycle and pedestrian bridge options

5.5 Other project options considered

This section outlines options considered within the project including ventilation facilities, construction ancillary facility locations, tunnel construction methodologies, as well as spoil transport and disposal.

5.5.1 Ventilation

Ventilation system design

The mainline tunnel would be unidirectional, in common with all long tunnels in NSW, meaning that traffic travels in one direction only within the tunnel. In order to have travel in both directions, two tunnels could be constructed side by side such as the Lane Cove Tunnel, or one on top of the other, such as the Eastern Distributor.

On an open roadway, vehicle emissions are diluted and dispersed by natural surface air flows. However, in a tunnel, mechanical ventilation is required to ensure the maintenance of air quality standards and to control smoke in the rare case of fire. Tunnel ventilation requirements are determined by the air flows, the forecast 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 and balances the air removed through the elevated ventilation outlets. Elevated ventilation outlets are used for tunnels longer than about one kilometre in Australia's urban areas to disperse tunnel air at a height that ensures compliance with ambient air quality criteria. A number of options for the design of the ventilation system were considered. These systems are described below and illustrated in **Figure 5-10**.

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, such as 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.

In NSW, natural ventilation is only acceptable for use in relatively short tunnels (i.e. less than one kilometre) as 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 is not practical for the longer road tunnels proposed for the project, as it would not achieve acceptable in-tunnel air quality under low vehicle speed conditions or during emergencies. It is therefore not an appropriate 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, the air flow is supplemented by fans that are used when traffic is moving too slowly to maintain adequate air flow, or to draw air back from the exit portals against the flow of exiting traffic. 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 Eastern Distributor, Lane Cove and Cross City Tunnels in Sydney.

Transverse ventilation

Emissions can be adequately diluted with the provision of 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 can 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. This option would be slightly less energy intensive than transverse ventilation, however it would still require the construction of some additional fresh air ducts and would not be as effective as a longitudinal system for controlling smoke in the tunnel in the case of a fire. The Sydney Harbour Tunnel uses a semi-transverse ventilation system.

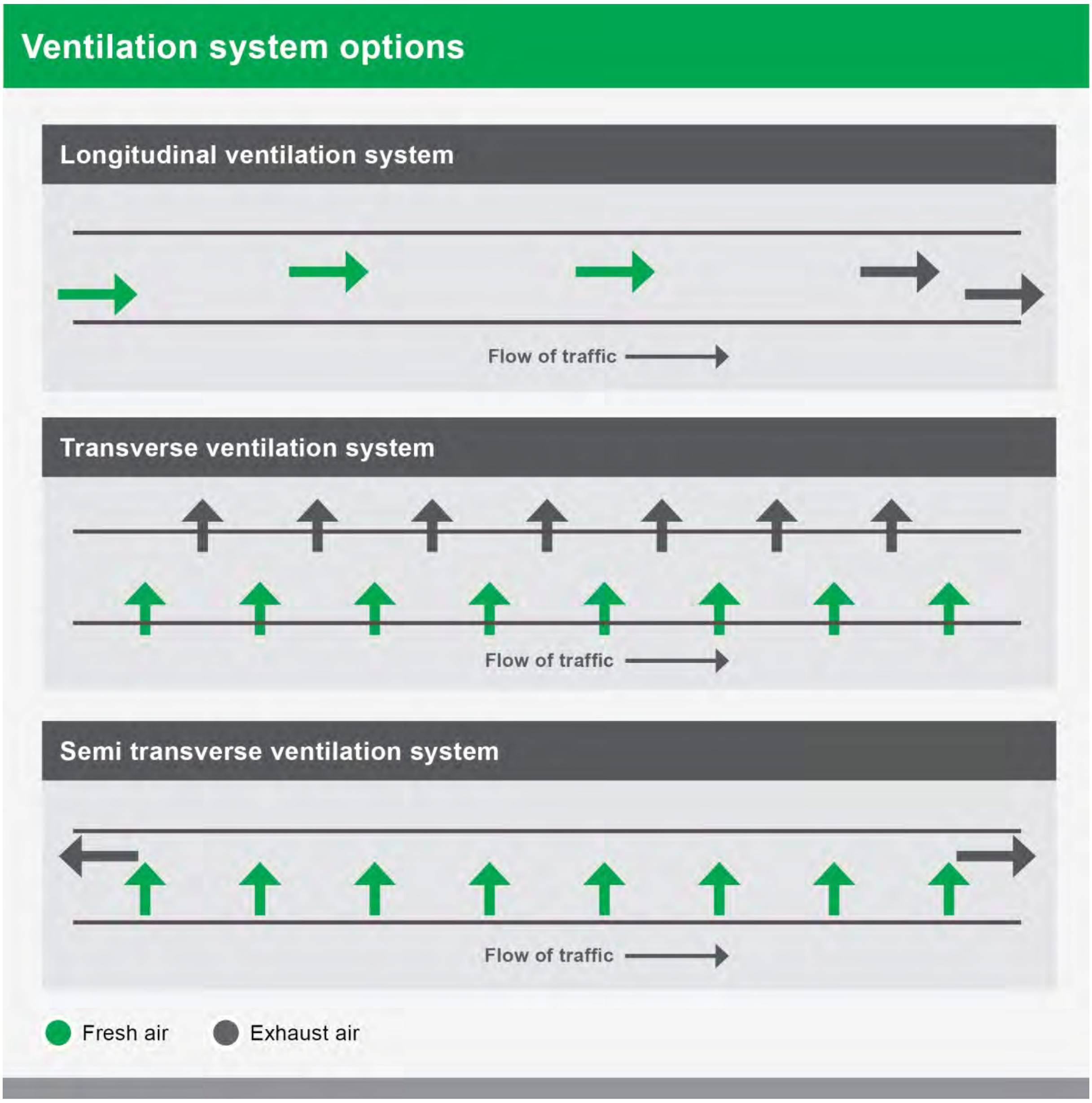


Figure 5-10 Ventilation options

Preferred ventilation system design

The development of new vehicle technologies in response to cleaner fuel and emissions standards has led to a significant reduction in vehicle emissions over the past 20 years. Consistent with other motorway tunnels in Sydney, a longitudinal ventilation system was chosen as the preferred ventilation system for the project.

Although other mechanical ventilation systems (such as natural ventilation, transverse ventilation and semi-transverse ventilation as discussed above) could be designed to meet in-tunnel air quality criteria, a well-designed longitudinal ventilation system is considered most suitable as it can maintain acceptable air quality in long tunnels and would provide the most efficient and effective tunnel ventilation[3].

The effectiveness of elevated ventilation outlets in dispersing emissions is well established. **Chapter 9** (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 6** (Project description).

Ventilation facility locations

Main considerations in relation to ventilation facilities included co-location with other approved projects where possible; minimising local air quality impacts on nearby receptors; and maximising the operational efficiency of the tunnel ventilation system.

Arncliffe ventilation facility

The location selected for a northern ventilation facility was based on co-location with other projects. In this instance, there was the option to fitout the New M5 Motorway Arncliffe ventilation facility for the project. Alternative locations were considered, however they were not chosen as they would have required a more complex ventilation system, increased operating costs, and unnecessary property and visual impacts.

Rockdale ventilation facility

Three options were considered for the southern ventilation facility in Rockdale. These options were:

- Rockdale Bicentennial Park, above the tunnel portal
- Roads and Maritime Depot at West Botany Street, Rockdale
- West Botany Street.

These options were assessed against desired criteria relating to the proximity to the tunnel portal, environmental impacts, social impacts, engineering requirements and cost. A summary of the multi-criteria analysis is shown in **Figure 5-11**.

A key design requirement for ventilation facilities is to locate them as close as possible to the tunnel portal, to minimise the ongoing power requirements and operational costs associated with pumping air from the tunnel portal to the ventilation outlet. This design arrangement ensures there are no unmanaged emissions at the portal location. Given this requirement, Rockdale Bicentennial Park, above the tunnel portal was considered as a location. However, this location would increase the social impacts of the project by requiring additional open space to be permanently required for the project.

The Roads and Maritime Depot at West Botany Street was also considered which would avoid the need for acquisition of private property. However, locating the facility at the depot would require the construction of a cut-and-cover tunnel through poor ground conditions, resulting in additional impacts to shallow groundwater and further impacting on the open space and ecological attributes of this area. Furthermore, this site is located about 500 metres from the tunnel portal, increasing the power requirements over the operational life of the project. For these reasons, this location was not chosen as the preferred option.

The preferred location for the ventilation facility is on West Botany Street, opposite Rockdale Bicentennial Park. This was chosen as it is located above the tunnel, close to the portal and would not require additional open space to be taken for the project.

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[3] Advisory Committee on Tunnel Air Quality (2014). *Technical Paper 04: Road Tunnel Ventilation Systems NSW Government*

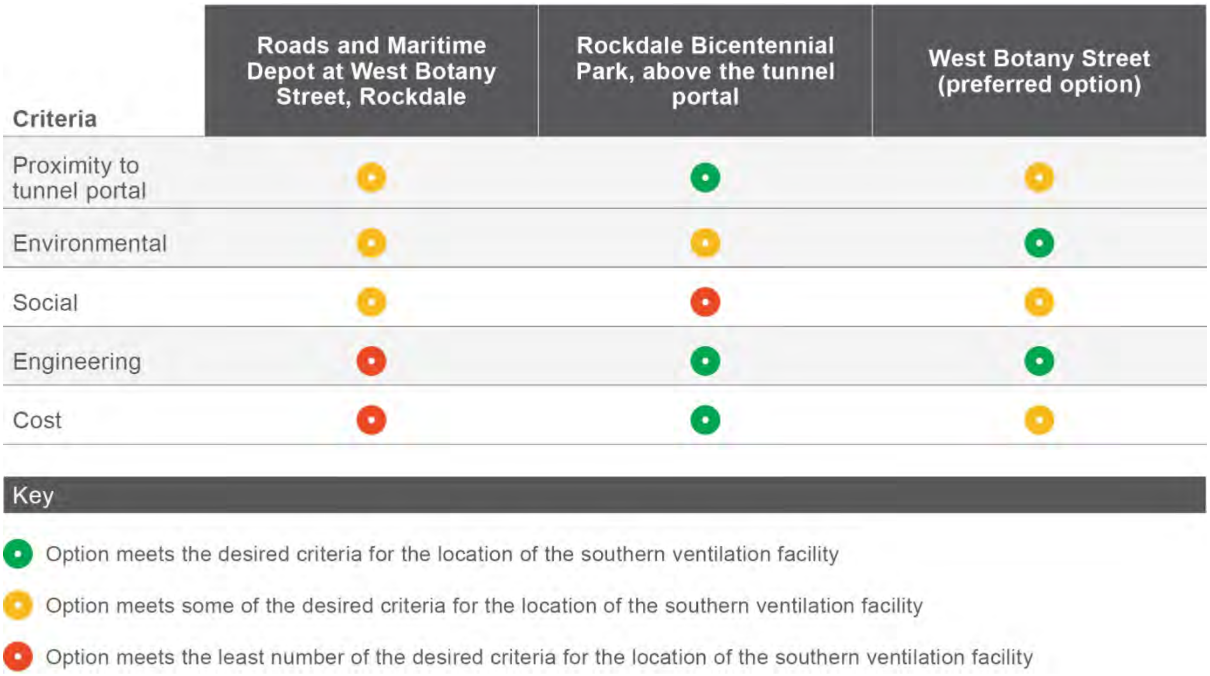

Figure 5-11 Southern ventilation facility options assessment

Air filtration

Modelling demonstrates that the proposed ventilation system would be effective in ensuring compliance with in-tunnel air quality criteria and with the external air quality around the outlets (**Chapter 9** (Air Quality)).

In-tunnel air quality

There are several in-tunnel air filtration options, these include the electrostatic precipitator, filtering, denitrification and biofiltration, agglomeration and scrubbing. These are described in (**Chapter 9** (Air Quality)). Around the world, there are relatively few road tunnels with installed filtration systems. There are no Australian road tunnel projects that have installed air filtration systems, these projects rely on the primary approach of dilution of air pollution, through ventilation systems.

The inclusion of in-tunnel air filtration was evaluated and found not to provide any material benefit to air quality or community health. If the proposed ventilation system does not achieve the required in-tunnel air quality levels, the most effective solution would be the introduction of additional ventilation outlets and additional locations for fresh air supply. This discussion is provided in the air quality impact assessment in **Appendix E** (Air quality technical report). As a result, an in-tunnel filtration system is not proposed for the project.

Ambient air quality

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

5.5.2 Construction ancillary facility locations

Five construction ancillary facilities listed in **Table 5-2** and described in further detail in **Chapter 7** (Construction) have been identified to support project construction. The sites would be used for a mix of civil surface works, tunnelling support and administrative purposes. Locations were based on:

- Proximity to location of key project infrastructure
- Co-location of sites with other approved projects where possible
- Minimisation of impacts on land use, biodiversity and heritage values
- Access to key arterial routes for spoil haulage
- Minimisation of private property acquisition
- Construction efficiency.

The following alternative facilities were not chosen as they failed to meet the criteria listed above:

- Industrial sites north of Rockdale Bicentennial Park and south of Muddy Creek as property acquisition would have been required and local streets may have been impacted
- Ilinden Sports Centre as this would have resulted in a loss of a permanent sporting facility
- A construction ancillary facility mid-way along the tunnel alignment was considered for a third tunnelling site, however it would have required additional property acquisition.

Table 5-2 Reasons for the selection of construction ancillary facilities

Ancillary facility	Reason for location of construction ancillary facility
Arncliffe construction ancillary facility	• Co-located with New M5 Motorway construction ancillary facility • Provides access to the stub tunnels via the existing shaft or decline constructed as part of the New M5 Motorway project • No requirement to use additional private or public land.
Rockdale construction ancillary facility	• Within land owned by Roads and Maritime (Roads and Maritime depot) • No requirement to use private or public land • Located within an industrial area, with limited sensitive receptors • Direct access to West Botany Street.
President Avenue connection construction ancillary facility	• Location of cut-and-cover and surface works within Rockdale Bicentennial Park • Location of Rockdale ventilation facility • Direct access to West Botany Street and President Avenue for spoil haulage.
Princes Highway construction ancillary facility	• Location of Princes Highway and President Avenue intersection upgrade works • Land is also partially required for the operation of the project, reducing the need for additional property acquisition.
Two ancillary facilities for the shared cycle and pedestrian pathways construction	• Direct access to either side of Muddy Creek recreation area, the location of the proposed shared cycle and pedestrian pathways.

5.5.3 Tunnel construction methods

A number of tunnel construction methods were considered for the construction of the mainline tunnel and entry and exit ramp tunnels. These options are listed in **Table 5-3**.

It is anticipated that the project would require a combination of roadheader excavation and drill and blast methods, for the following reasons:

- Roadheaders offer advantages over tunnel boring machines such as:
  - Ease of excavation of varying cross sections, caverns, niches and cross passages
  - They can be moved to different parts of the tunnel alignment
  - It is more economic because it takes less time and generates less spoil
  - They are more suited to the road geometry and cross-sectional dimensions
- The combination of roadheader excavation and drill and blast methods speeds up excavation compared to work being undertaken solely with roadheaders
- Noise and vibration impacts are reduced for residential and commercial properties given the shorter duration impacts associated with blasting compared to other tunnel construction methods
- Geological conditions along the preferred alignment are suitable for both roadheader excavation and drill and blast methods.

Further detail on the mainline tunnelling construction approach is provided in **Chapter 7** (Construction).

Table 5-3 Mainline tunnel construction method options

Method	Description
Tunnel boring machine	A tunnel boring machine is a specialist machine that excavates a circular bore of fixed diameter by rotary action. Tunnel boring machines are normally custom made to suit the particular requirements of the project and require considerable time to deliver and mobilise for full operation. They also require a large open area on site to assemble and align in position for driving. Tunnel boring machines are typically used for underground rail projects where a set width is required for the length of the tunnel. Tunnel boring machines are less preferred for underground motorway projects due to the cross section of the tunnel necessitating a very large tunnel boring machine. Other considerations are the lack of cost effectiveness (when compared to road header excavation) due to the excess of spoil generated and that Sydney geological conditions (sandstone) generally do not require the support or waterproofing benefits of tunnel boring machine construction.
Drill and blast	The drill and blast excavation method involves a sequence of drilling holes, charging the holes with explosives, blasting, mucking out, and installing roof and wall ground support. The method is an efficient and cost effective way of excavating in rock, and provides an effective tunnel excavation method which assists in achieving an overall shorter project delivery.
Road header excavation	Roadheaders are commonly used for excavation in sandstone and have been successfully used in other tunnel projects in Sydney. A roadheader is specialised tunnelling equipment that excavates with picks mounted on a rotary cutter head attached to a hydraulically operated boom. As the excavation advances, temporary or permanent ground support would be installed behind the excavation face.

The entry and exit ramp tunnels, east of West Botany Street and extending beneath Rockdale Bicentennial Park to the President Avenue intersection, would not be constructed using the methods discussed above. These sections of the alignment would be constructed using a cut-and-cover structure and, closer to President Avenue, a slot structure (refer to **Chapter 7** (Construction)). These methods, as opposed to roadheader excavation and drill and blast methods, are required at these locations for the following reasons:

- Poor geological conditions east of West Botany Street, which preclude driven tunnel construction options
- Shallow depth of the tunnel at this location due to the need to connect the underground motorway with the surface at President Avenue.

5.5.4 Spoil storage, transport and disposal options

Construction of the project would generate around 1.4 million cubic metres of spoil, which allows for numerous spoil reuse and disposal options. Consideration has been given to the various modes available to store and transport spoil, as outlined below.

Spoil storage options

Selection of the construction ancillary facilities (refer to **section 5.5.3**) was the main driver for the location of spoil storage. Spoil would be stored within each of the three construction ancillary facilities. This provides direct access to each of the tunnelling sites and the cut-and-cover sites. Furthermore, each of the construction ancillary facilities has been located based on their proximity to arterial roads for the transport of spoil.

Spoil transport options

Rail as a spoil transport option allows large volumes of spoil to be moved while reducing the number of heavy vehicle movements on the wider road network. However, this transport option was not selected as the preferred option because there are very few spare train paths on the Sydney rail network, which presents logistical challenges. Chullora would be the closest appropriate intermodal terminal, which is over 10 kilometres from the construction ancillary facilities. The material would also need to be double or triple handled as trucks would be required to move material to the train loading facility and potentially from the rail facility to its final location.

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. However, this option presents a number of issues including that the material would need to be double (or possibly triple) handled, as trucks would be required to move material to the barge loading facility, and potentially from the barge to its final location, if this does not have barge access. Infrastructure upgrades would also potentially be required to allow the barge loading facility to receive the material.

Spoil removal using heavy vehicles (i.e. trucks) is the preferred transport option for the project and would involve transporting material from the construction sites directly to the spoil's final destination. This would be primarily via the arterial road network. The use of trucks would avoid the need for double or triple handling, as would be the case with rail or barging options, but would result in a higher number of trucks on the road. This increase is considered acceptable given the transport options.

Notwithstanding the current preferred option, further investigations would be undertaken into spoil transport options, including the potential transport by barge, during detailed design.

Chapter 8 (Traffic and transport) provides a summary of heavy vehicle movements, including spoil related haulage. This transport of spoil would be investigated further by the construction contractor.

Spoil disposal options

As described in **Chapter 21** (Waste management), there would be a beneficial reuse of as much spoil as possible as part of the project before pursuing any alternative spoil disposal options, such as use in other infrastructure or development projects.

Potential opportunities for reuse of spoil within the project include for the formation of embankments, site rehabilitation and landscaping, and infill for temporary tunnel access shafts and declines.

The majority of usable (e.g. uncontaminated) construction and demolition spoil is anticipated to be reused and/or recycled. Residual spoil waste which cannot be reused or recycled would be disposed of to a suitably licensed landfill or waste management facility.

Several spoil management sites have been identified to receive project spoil (refer to **Chapter 21** (Waste management)). These range from between 40 to 70 kilometres from the project. Final destination(s) for construction spoil would be determined during the detailed design stage, and may include more than one disposal site.

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

5.5.5 Other operational ancillary facilities

Operational Motorway Control Centre

The Operational Motorway Control Centre would manage all motorway controls for operation of the project. This would be located at West Botany Street in Rockdale, within the motorway operations complex. This land is currently used, and will continue to be used, as a Roads and Maritime depot.

Alternative locations for the Operational Motorway Control Centre were considered but were not chosen as they:

- Required additional property acquisition
- Resulted in a loss of public open space
- Had insufficient space at other operational infrastructure sites (namely the Rockdale ventilation facility).

Water treatment facilities

The operational water treatment facility would be located next to the existing Arncliffe Motorway Operations Complex. A number of options were considered for the location of the plant and for the infrastructure which would transport the tunnel water to the treatment plant.

These options included utilising the New M5 Motorway water treatment plant and constructing a new plant at a location next to the Cooks River. These options were not selected as they would have not provided sufficient capacity for the volumes of water anticipated to be treated, or would have required additional undisturbed land.

5.6 Staging the project

The project is the first stage of the F6 Extension. However, it is also considered a stand-alone project given its own objectives and project benefits. Future stages of the F6 Extension would be subject to separate planning approval.

The construction of the project would occur in one stage, with road header excavation occurring from the northern and southern extents, and the cut-and-cover construction being undertaken simultaneously.

The project is anticipated to be open by the end of 2024.

5.7 Justification of the preferred option

The project would facilitate improved connections between southern Sydney, the Sydney CBD and Port Botany, as well as better connectivity between key employment hubs and local communities. Together with future stages of the F6 Extension, it would also provide improved connections between the Sydney CBD and the Illawarra Region.

The project would ease congestion on surface roads by providing an underground motorway alternative. This would allow for increased use of surface roads by pedestrians and cyclists due to a reduction in through traffic, including freight vehicles, along The Grand Parade and Princes Highway. The project would support opportunities for place-making at key locations along these routes. In addition, the project would provide shared cycle and pedestrian pathways aimed at improving north-south active transport movements between Bestic Street and Civic Avenue.

The merits of the project were considered in the context of a range of strategic alternatives, based on the extent to which they could meet the project objectives. Design options for the project were also assessed on how well they performed with reference to transport, environmental, engineering, social and economic factors. The project concept design was determined based on these outcomes.

The project is aligned with the objectives for the overall F6 Extension, which aim to achieve similar outcomes for the entire length of the F6 Extension, linking the A1 Princes Highway at Loftus with the existing and proposed motorway network in Sydney.

The project is consistent with the project objectives and is consistent with, or does not preclude, the strategies and recommendations identified in **Chapter 4** (Strategic context and project need).

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