4 Project development and alternatives

This chapter describes the alternatives to the M4-M5 Link project (the project), as well as the options that were considered as part of the design development process. It explains how and why the project design was selected as the preferred option for assessment in this environmental impact statement (EIS). Design options and refinements for particular elements of the project are also addressed, noting that the project described and assessed in this EIS is based on a concept design that is subject to further refinement during detailed detail and construction planning, as described in **Chapter 1** (Introduction). This chapter aims to:

- Provide a brief history of the development of the WestConnex program of works and the project
- Describe the strategic alternatives to achieve the project objectives that were considered
- Summarise the project evolution and design refinements for the key components of the project
- Outline the approach to the staging of the project including for construction of the mainline tunnels and Rozelle interchange, and within the overall WestConnex program of works
- Describe the options development process for permanent and temporary infrastructure, facilities and processes
- Summarise the preferred option assessed in this EIS.

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project. These are referred to as the Secretary's Environmental Assessment Requirements (SEARs). **Table 4-1** sets out these requirements and the associated desired performance outcomes as they relate to the consideration of project options and alternatives, and identifies where they have been addressed in this EIS.

Table 4-1 SEARs – project development and alternatives

Desired performance outcome	SEARs	Where addressed in the EIS
2. Environmental Impact Statement The project is described in sufficient detail to enable clear understanding that the project has been developed through an iterative process of impact identification and assessment and project refinement to avoid, minimise or offset impacts so that the project, on balance, has the least adverse environmental, social and economic impact, including its cumulative impacts.	1. The EIS must include, but not necessarily be limited to, the following:	
	(e) an analysis of any feasible alternatives to the project[1]	Strategic alternatives that were considered are discussed in **section 4.4**.
	(f) a description of feasible options within the project[2], including: – alternative methods considered for the construction of the project, including the tunnels; and – staging of the proposal and the broader WestConnex scheme	Project alternatives and options considered for the construction of the project are described in **section 4.4** and **section 4.6**. Staging of WestConnex component projects and staging of the project construction, including the mainline tunnel and Rozelle interchange, is described in **section 4.3**.
	(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:	Project alternatives and options are discussed in **section 4.4** and **section 4.6**. Details of the mainline tunnel alignment and design considerations are discussed in **section**

Desired performance outcome	SEARs	Where addressed in the EIS
	– 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 – need for construction facilities and sites – a justification for the preferred proposal taking into consideration the objects of the *Environmental Planning and Assessment Act 1979* (EP&A Act)	**4.5.2**. Ventilation facility options are discussed in **section 4.6.1** and in **Chapter 9** (Air quality). Justification for the project with consideration of the objects of the NSW EP&A Act is provided in **Chapter 30** (Project justification and conclusion).
	(i) a demonstration of how the project design has been developed to avoid or minimise likely adverse impacts;	Details about the project evolution and design refinement process that has been used to avoid or minimise likely adverse impacts are included in **section 4.5** and **section 4.6**.

Notes:

1 Alternatives to a project are different projects which would achieve the same project objective(s) including the consequences of not carrying out the project.

2 Options within the project are variations of the same project.

4.1 History of WestConnex, the M4-M5 Link and related projects

WestConnex is part of the NSW Government's long-term, integrated transport and land use planning solution. The WestConnex program of works has been developed to provide an integrated transport network solution, recognising that the constraints on the current M4 Motorway and the M5 East Motorway cannot be resolved in isolation from each other.

The holistic solution builds on previous preliminary proposals for upgrade and/or expansion works along the M4 and M5 East motorways, as well as the former Marrickville Tunnel concept, and incorporates feedback from the community and stakeholders as part of the historic development of these schemes. **Figure 4-1** shows the development of the WestConnex program of works, including the M4-M5 Link, the subject of this EIS.

4.1.1 The M4 Motorway

The M4 Motorway is a 40 kilometre urban motorway which extends from Concord in Sydney's inner west to Lapstone, at the foothills of the Blue Mountains. Construction of the existing M4 Motorway occurred in several stages between the late 1960s and the mid-1980s. The original motorway was opened to traffic in 1971. An additional section, between Concord and Parramatta opened in 1992. Since then, various schemes and multiple options have been explored, developed and built to complement the M4 Motorway.

Between 2003 and 2004 a preferred option for an eastern extension of the M4 Motorway to the Sydney central business district (CBD) was developed and publicly exhibited. This option, referred to as the M4 East, proposed extending the M4 Motorway to City West Link and Parramatta Road at Ashfield as well as widening the existing motorway between Homebush Bay Drive and Concord Road. At the time, the NSW Government determined not to proceed with the M4 East scheme as publicly exhibited.

Design work resumed in 2003 to further develop and improve the M4 East scheme. This design work culminated in the concept design for the M4 East project, which together with the M4 Widening project, comprises the already approved Stage 1 of WestConnex. The M4 East project will extend the M4 Motorway, through twin underground tunnels, from Homebush Bay Drive at Homebush to Parramatta Road and City West Link (Wattle Street) at Ashfield and Haberfield. Planning approval for the M4 East project was granted by the NSW Minister for Planning on 11 February 2016 and construction of the project is underway and is scheduled to be complete in 2019.

Stage 1 of WestConnex also involves widening the M4 Motorway to up to four lanes in each direction between Pitt Street at Parramatta and Homebush Bay Drive at Homebush. Planning approval for the M4 Widening project was granted by the NSW Minister for Planning on 21 December 2014 and construction commenced in March 2015. The M4 Widening project is now open to traffic.

4.1.2 The M5 Motorway

The current M5 East Motorway was proposed in the mid-1990s to provide a motorway connection between Fairford Road at Padstow and General Holmes Drive at Mascot. The purpose of the M5 East Motorway was to improve the east–west road transportation route between south–west Sydney and the Sydney CBD, Port Botany and Sydney Airport. The M5 East Motorway received planning approval from the (then) NSW Minister for Urban Affairs and Planning in 1997 and opened to traffic in 2001.

Since its opening, the M5 East Motorway has reached its capacity and currently experiences significant levels of congestion Continued congestion on the M5 East Motorway is recognised as impeding access to and from the Sydney CBD, Port Botany and Sydney Airport, resulting in significant congestion and delays. Options to alleviate congestion and improve amenity along the M5 East Motorway and surrounding road network were considered in the M5 Transport Corridor Feasibility Study (NSW Roads and Traffic Authority 2009). The study identified a preliminary preferred option, being the M5 East Duplication scheme. This scheme broadly involved duplication of the existing M5 East motorway tunnels with connection to the east of Sydney Airport.

In response to feedback received from key stakeholders and the community on the M5 East Duplication scheme, its design has been further developed and improved. This further design development has been used to inform the motorway options development for Stage 2 of WestConnex, which includes the already approved New M5 project, to the west of Sydney Airport, and the King Georges Road Interchange Upgrade project.

The New M5 project includes twin underground motorway tunnels between the existing M5 East Motorway east of King Georges Road and a new interchange at St Peters. Planning approval for the New M5 project was granted by the NSW Minister for Planning on 20 April 2016. The New M5 project was also subject to Commonwealth approval under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act), which was obtained on 11 July 2016. Construction of the New M5 project is currently underway and is scheduled to be completed in 2020.

Stage 2 of WestConnex also includes the widening of King Georges Road at Beverly Hills, which comprises improvements to all on-ramps and off-ramps at the interchange of the M5 Motorway with King Georges Road and an additional motorway lane in each direction. Planning approval for the King Georges Road Interchange Upgrade project was granted by the NSW Minister for Planning on 3 March 2015. Construction commenced in July 2015 and the road was opened to traffic in December 2016.

4.1.3 Link between the M4 Motorway and M5 Motorway

Consideration of a motorway link between the M4 Motorway and southern Sydney began in around 2004 with the Marrickville Tunnel scheme. The Marrickville Tunnel was intended to create a direct connection between the M4 East Motorway and Mascot, to provide a direct route for traffic between Port Botany, Sydney Airport and western Sydney. One option considered for this scheme was a truck only tunnel, recognising that the main function of this link would be to enhance freight access between Port Botany, Sydney Airport and north-western Sydney. This scheme was not progressed and was never released for public comment. The Enfield Intermodal Terminal was instead developed to increase the volume of freight carried by rail to and from Port Botany (see **section 4.4.2**), with distribution by road from Enfield using existing arterial roads and the M4 Motorway. Even so, the continual requirement for road freight meant that an alternative solution was still required to resolve congestion on the arterial road network. Further development of the connection between the M4 and M5 motorways is described in **section 4.2**.

The concept of a connection between the M4 Motorway and the M5 East Motorway has progressed as the WestConnex M4-M5 Link, the subject of this EIS (refer to **Chapter 5** (Project description) for a detailed description of the project). The M4-M5 Link would complete the orbital road network between western Sydney and the eastern gateways of Port Botany and Sydney Airport.

4.1.4 Sydney Gateway

The proposed future Sydney Gateway project comprises a new road link between the St Peters interchange (which is being delivered as part of the New M5 project) and Sydney Airport, with connections towards Port Botany.

The *WestConnex Strategic Business Case Executive Summary* (Sydney Motorways Project Office 2013) identified the initial concept of a link to Sydney's international gateways and called this 'Airport Link'. The *WestConnex Updated Strategic Business Case* (Sydney Motorway Corporation 2015a) defined Sydney Gateway as including the duplication of the Port Botany Rail Line to support the Moorebank and Enfield Intermodal Terminal projects.

Given the Sydney Gateway road and Port Botany rail duplication corridors are located next to each other, these two projects have been integrated into a single initiative. The proposed future Sydney Gateway project would assist in addressing the high volumes of heavy vehicle traffic generated by the Sydney Airport and Port Botany precincts.

Options consideration and design development is continuing on the proposed future Sydney Gateway. Once a preferred option and a concept design are identified, the Sydney Gateway project will be subject to a separate environmental assessment and planning approval. For the purposes of this EIS, the Sydney Gateway project is assumed to be completed and open to traffic in 2023. Potential cumulative construction and operational impacts of the Sydney Gateway project and the M4-M5 Link project are discussed in relevant technical working papers and summarised in **Chapter 26** (Cumulative impacts).

Project development process

WestConnex

2012	WestConnex identified in the State Infrastructure Strategy 2012-2032
2013	September: WestConnex Business Case developed September: State significant infrastructure application lodged for the M4 Widening project November: State significant infrastructure application lodged for the M4 East project
2014	May: State significant infrastructure application lodged for the King Georges Road Interchange Upgrade project November: State significant infrastructure application lodged for the New M5 project November: Northern and southern extensions to WestConnex (including connections to Victoria Road and Anzac Bridge) are identified in the Updated State Infrastructure Strategy December: Planning approval granted for the M4 Widening project
2015	March: M4 Widening project construction starts March: Planning approval granted for the King Georges Road Interchange Upgrade project July: King Georges Road Interchange Upgrade project construction starts November: Proposal for the M4-M5 Link included in the WestConnex Updated Strategic Business Case
2016	January: State significant infrastructure application lodged for the M4-M5 Link project February: Planning approval granted for the M4 East project March: M4 East project construction starts April: Planning approval granted for the New M5 project July: New M5 project approved by the Australian Government Department of the Environment July: New M5 project construction starts September: Iron Cove Link included in the M4-M5 Link State significant infrastructure application report Addendum 1 December: The King Georges Road Interchange Upgrade project opens to traffic
2017	March: Removal of the Camperdown interchange and inclusion of ramps and construction ancillary facilities for the proposed future Western Harbour Tunnel project are included in the M4-M5 Link State significant infrastructure application report Addendum 2 July: M4 Widening project opens to traffic

Figure 4-1 Development of the WestConnex program of works

4.2 Development of M4-M5 Link concept

In the context of the WestConnex program of works, the M4-M5 Link project concept was first described in the NSW *State Infrastructure Strategy 2012-2023* (Infrastructure NSW 2012). This was further developed in the *WestConnex Business Case Executive Summary* (Sydney Motorways Project Office 2013) and updated in the *WestConnex Updated Strategic Business Case* (Sydney Motorway Corporation 2015a).

4.2.1 State Infrastructure Strategy

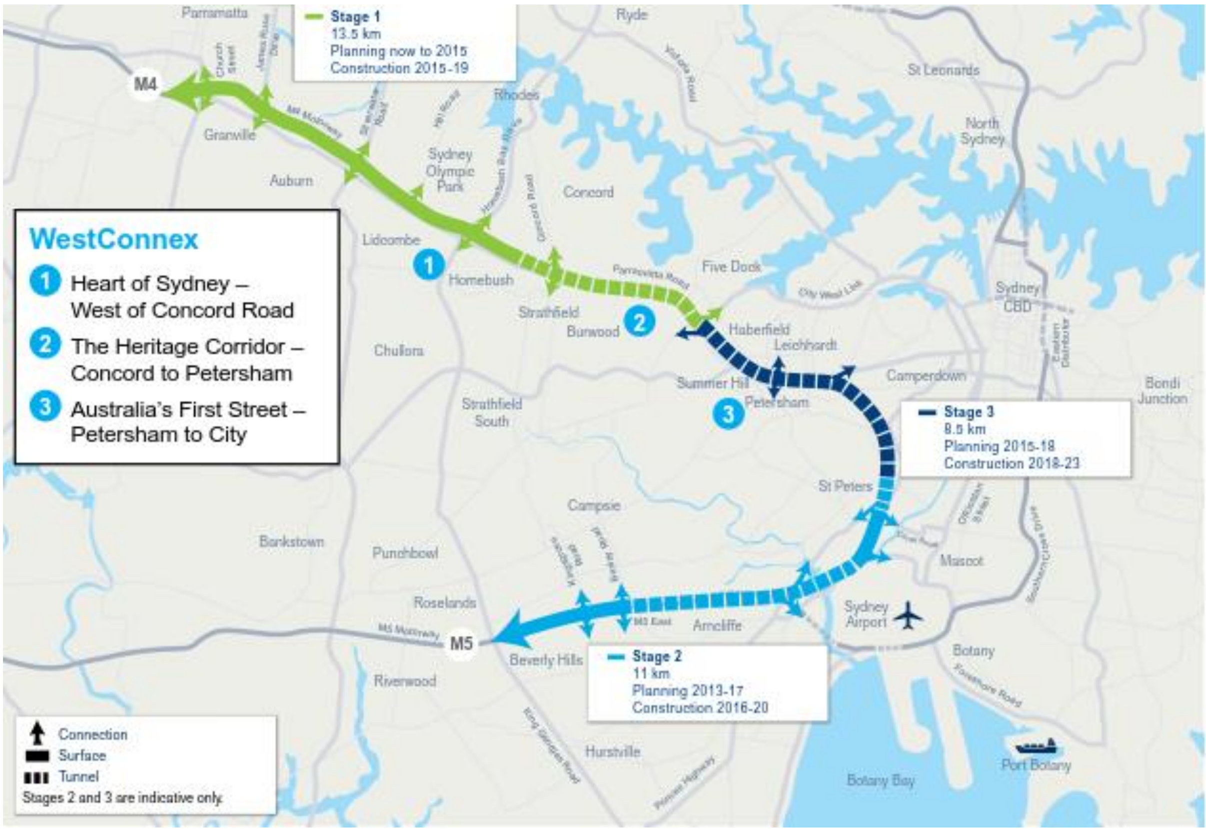
The project was included as part of the WestConnex reference scheme described in the *State Infrastructure Strategy 2012-2032* and in *WestConnex – Sydney's next motorway priority* (Infrastructure NSW 2012). The reference scheme showed an early indicative alignment for WestConnex, aligned with the strategic transport objectives at that time. The scheme included a tunnel connection from around Taverners Hill to the St Peters area via Camperdown and roughly followed the alignment of Parramatta Road before turning south to St Peters. This design provided connections to the southern part of the Sydney CBD via Camperdown. The reference scheme is shown in **Figure 4-2.**

Source: Infrastructure NSW 2012

Figure 4-2 WestConnex reference scheme from the State Infrastructure Strategy 2012-2032

4.2.2 2013 WestConnex Business Case

In September 2013, the *WestConnex Business Case Executive Summary* was released. The alignment of the project presented in this business case summary did not differ significantly from the reference scheme alignment in the *State Infrastructure Strategy 2012-2032* (see **Figure 4-3**), although the business case did include the project as a distinct component of WestConnex. The project was described as a new 8.5 kilometre twin tunnel with three lanes in each direction, following the Parramatta Road corridor and connecting Haberfield and St Peters via Camperdown.



Source: Sydney Motorways Project Office 2013

Figure 4-3 WestConnex overview 2013

4.2.3 State Infrastructure Strategy Update 2014

In March 2014, the NSW Government approved funding to commence studies for initial business cases into a number of missing links on the motorway network beyond WestConnex, including a potential connection along the historically planned F6 corridor and the proposed future Western Harbour Tunnel and Beaches Link (which comprises a new tunnel crossing of Sydney Harbour and a motorway link to Sydney's northern beaches). During initial investigations it became evident that there was an opportunity to design the WestConnex program of works to support the connectivity to these future motorways. This southern extension motorway corridor was subsequently named SouthLink and is now referred to as the proposed future F6 Extension (see **Figure 4-4**). The F6 Extension would connect to the New M5 project at Arncliffe. These extensions were described in the *State Infrastructure Strategy Update 2014* (Infrastructure NSW 2014).

The northern extension would enable:

- A connection to the Sydney CBD via Anzac Bridge, as well as to Victoria Road
- A connection to the proposed future Western Harbour Tunnel and Beaches Link, which together with the M4-M5 Link, would create a western bypass of the Sydney CBD
- Connectivity to The Bays Precinct
- Reduction in surface traffic along Parramatta Road.

In late 2014 the constructability, economic and financial feasibility and traffic impacts of the northern and southern extensions were investigated and a preliminary design put forward for the M4-M5 Link to the NSW Government. The preliminary design work for the project confirmed the viability of the northern extension (ie connections to Victoria Road, Anzac Bridge and the proposed future Western Harbour Tunnel and Beaches Link) and recommended that this future extension be considered in the alignment of the project. The mainline tunnel alignment was amended to divert from the previous Parramatta Road alignment, to instead follow a City West Link alignment to Rozelle (to connect with

Anzac Bridge) before turning south to Camperdown and continuing to St Peters. The alignment through Rozelle was amended to facilitate the connection to a future harbour crossing to the northeast (the proposed future Western Harbour Tunnel and Beaches Link project).

The revised tunnel alignment for the project also required changes to the connection with the M4 East project at Haberfield. These changes relate to the configuration of the entry and exit ramps at the Wattle Street interchange, which is where the project mainline tunnels connect with the M4 East tunnels.

The *State Infrastructure Strategy Update 2014* identified that a completed WestConnex program of works, together with the proposed future Western Harbour Tunnel and Beaches Link project, would provide a western bypass of the Sydney CBD, alleviating pressure on existing north−south corridors including Southern Cross Drive, the A1 (Princes Highway) and A3 (Centenary Drive/Roberts Road/King Georges Road) and the Sydney orbital network, as well as reducing traffic volumes on the Sydney Harbour Bridge and Sydney Harbour Tunnel. These changes would reduce journey times between Sydney's northern and southern suburbs.

Strategic and financial analysis of the new alignment for the M4-M5 Link recommended proceeding with the amended project design. Based on this advice, the NSW Government accepted the change to the mainline tunnel alignment in October 2014.

4.2.4 WestConnex Updated Strategic Business Case 2015

In November 2015, the *WestConnex Updated Strategic Business Case* was released, which consolidated the work undertaken in the 2013 business case with additional modelling, analysis and scope development. The *WestConnex Updated Strategic Business Case* described the development of a modified alignment for the M4-M5 Link with connections at Rozelle and Camperdown. The modified alignment would allow for the inclusion of a northern extension, allowing connections to the proposed future Western Harbour Tunnel and Beaches Link (see **Figure 4-4**).

Source: Sydney Motorway Corporation 2015a

Figure 4-4 WestConnex overview 2015

As part of the development of the *WestConnex Updated Strategic Business Case* a number of options which would facilitate the northern extension, while still delivering the objectives of WestConnex, were identified and evaluated. This strategic analysis evaluated the options based on expected traffic outcomes on Parramatta Road, the broader road network (including the impact on Anzac Bridge), and the impact on the M4-M5 Link itself.

The evaluation identified two designs, with particular sets of network connectivity, for further analysis:

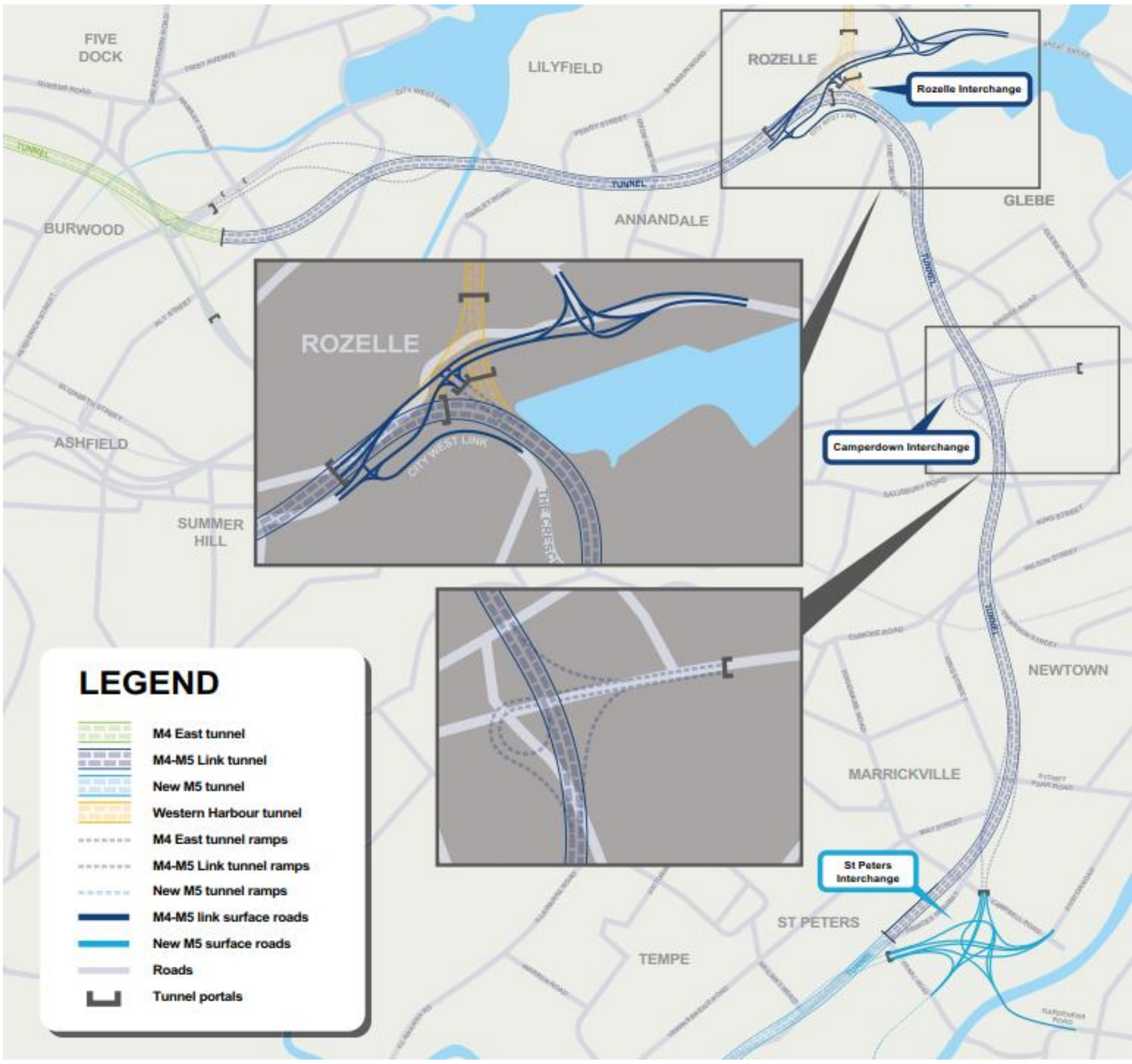
- The WestConnex reference scheme (as identified in the State Infrastructure Strategy 2012-2032), with the M4-M5 Link following the Parramatta Road corridor, and the addition of the northern and southern extensions (see **Figure 4-2**)
- An updated design with the addition of a northern and southern extension (see **Figure 4-4**).

These options for the WestConnex program of works were costed and a preliminary economic and financial evaluation was undertaken, with the original WestConnex reference scheme from the 2013 business case acting as the 'base case' for this analysis.

The analysis recommended proceeding with the updated design, which includes the northern and southern connections. This option would yield the following benefits over the project reference scheme:

- Be more cost effective, as it is a stronger economic case than delivering a northern extension (ie the proposed future Western Harbour Tunnel and Beaches Link) as a separate project to the M4-M5 Link, because the northern extension could be reduced in length if connecting to City West Link instead of to Parramatta Road further to the south
- Accommodate connectivity to the proposed future Western Harbour Tunnel and Beaches Link project without additional infrastructure investment
- Provide similar reductions in surface traffic flows by comparison to the WestConnex alignment that followed the Parramatta Road corridor.

The indicative alignment for the project in the *WestConnex Updated Strategic Business Case*, including proposed interchanges at Rozelle, Camperdown and St Peters, is shown in **Figure 4-5**.



Source: Sydney Motorway Corporation 2015a

Figure 4-5 Indicative preliminary mainline tunnel alignment and interchange locations

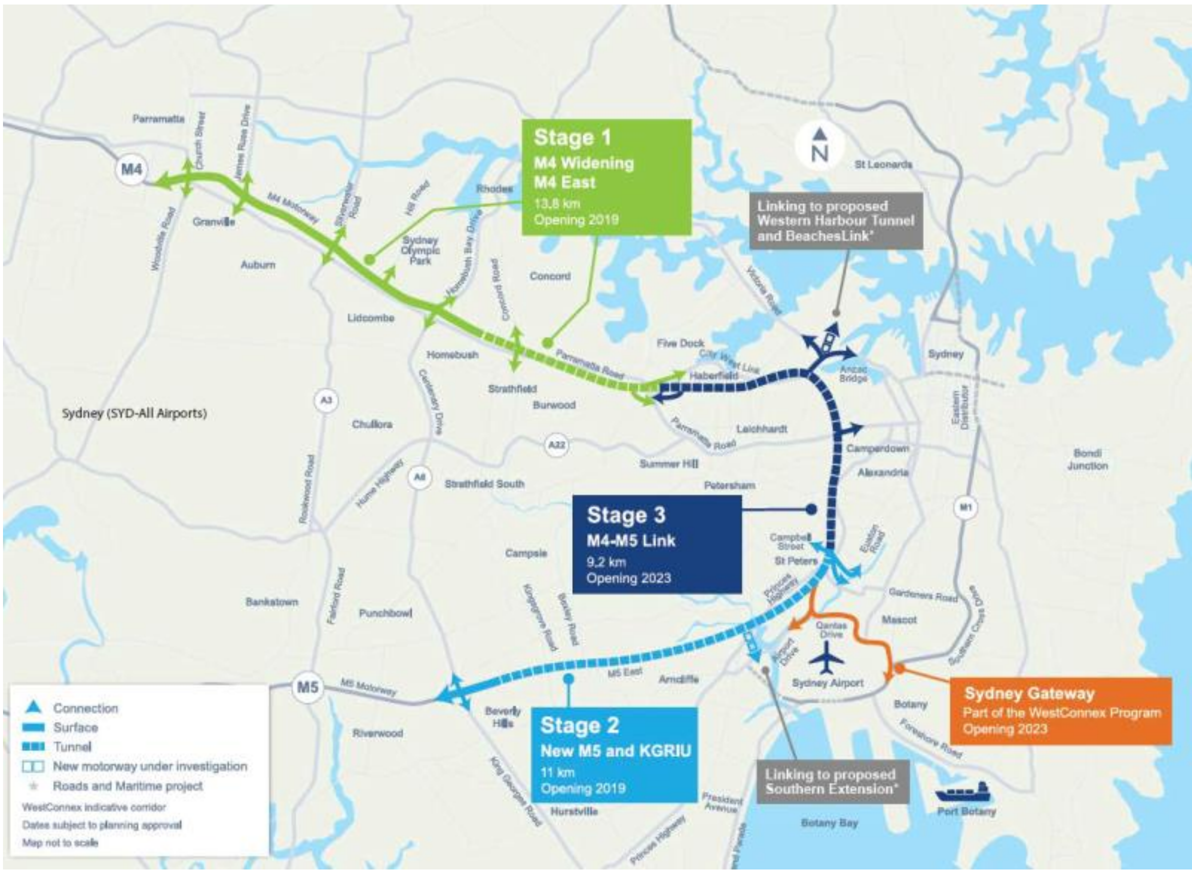
The project has evolved from the initial concept presented in the 2015 *WestConnex Updated Strategic Business Case* (see **section 4.2**), which informed the January 2016 State significant infrastructure application report (SSIAR) (NSW Roads and Maritime Services (Roads and Maritime) 2016) for the project (see **Figure 4-6**). Key design amendments to the project were described in two addenda to the SSIAR, which were subsequently published on the NSW Major Projects website:

http://majorprojects.planning.nsw.gov.au/

These addenda sought to capture the evolution of the project design, which is summarised below and broadly illustrated in **Figure 4-7** and **Figure 4-8**:

- **Addendum 1** – inclusion of the Iron Cove Link and removal of site management works at the Rozelle Rail Yards from the project scope
- **Addendum 2** – removal of Easton Park from the project footprint, removal of the Camperdown interchange, realignment of the mainline tunnel and increase in the number of traffic lanes, change to the location of the Rozelle interchange, and inclusion of infrastructure for the proposed future Western Harbour Tunnel.

The rationale for these changes to the project design and the various options that were considered are described further in **section 4.5.1** to **section 4.5.3**.

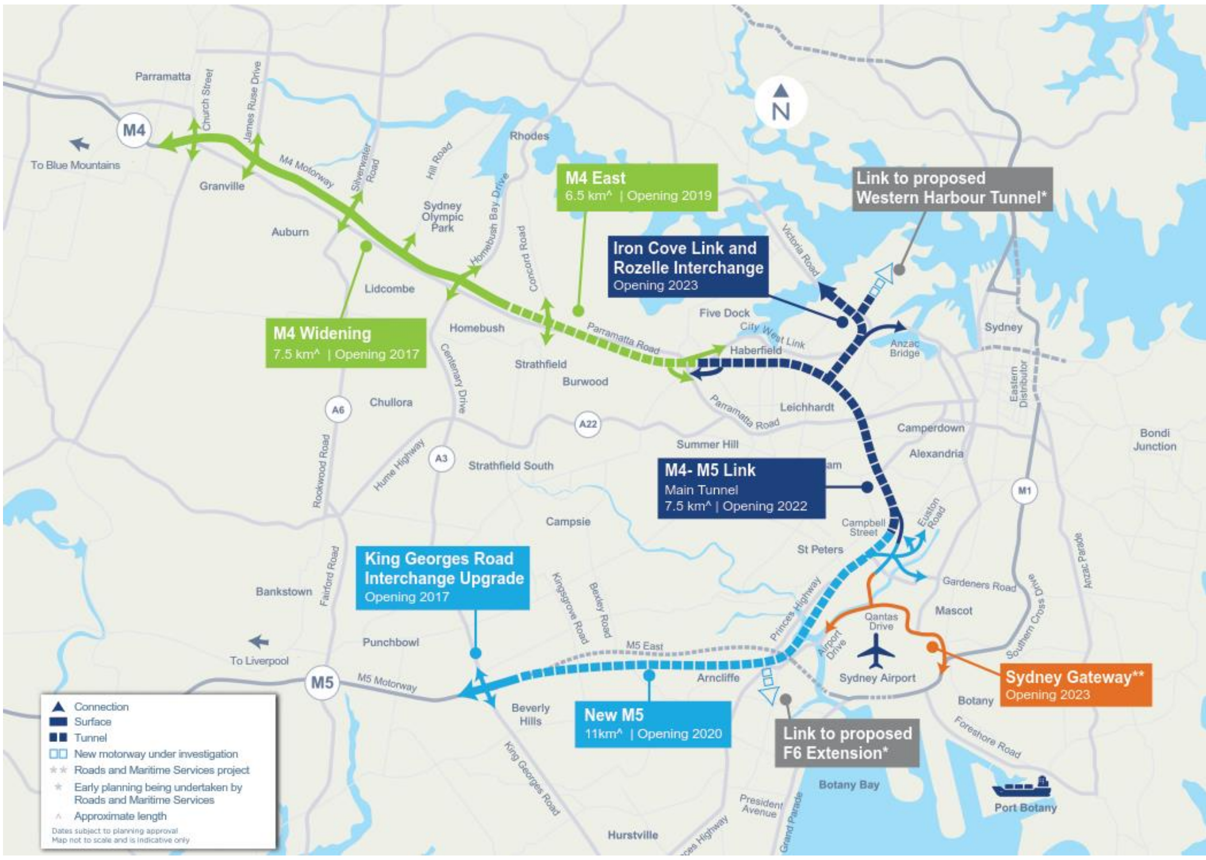


Source: Roads and Maritime 2016a

Figure 4-6 SSIAR, January 2016 – regional project context

Source: Roads and Maritime 2016b

Figure 4-7 SSIAR Addendum 1, September 2016 – regional project context



Source: Roads and Maritime 2017

Figure 4-8 SSIAR Addendum 2, March 2017 – regional project context

4.3 Staging

4.3.1 Staging of the WestConnex program of works

The staging strategy for the WestConnex program of works was outlined in the *WestConnex Updated Strategic Business Case.* An update of the timing for the various component projects is illustrated in **Figure 4-9**. Factors considered in the staging of the WestConnex component projects included:

- Transport benefits and traffic management
- Timing of pre-construction activities
- Government funding requirement
- Infrastructure market capacity.

Once work is completed for the approved WestConnex component projects (M4 Widening, M4 East, King Georges Road Interchange Upgrade and New M5), the remaining WestConnex component project to be completed would be the M4-M5 Link. The M4-M5 Link would provide the critical motorway link between the M4 East Motorway and the New M5 Motorway and would allow many of the benefits of the full WestConnex program of works to be realised. The M4-M5 Link would also provide a strategic connection to the proposed future Western Harbour Tunnel and Beaches Link project which together with WestConnex, would create a western bypass of the Sydney CBD.

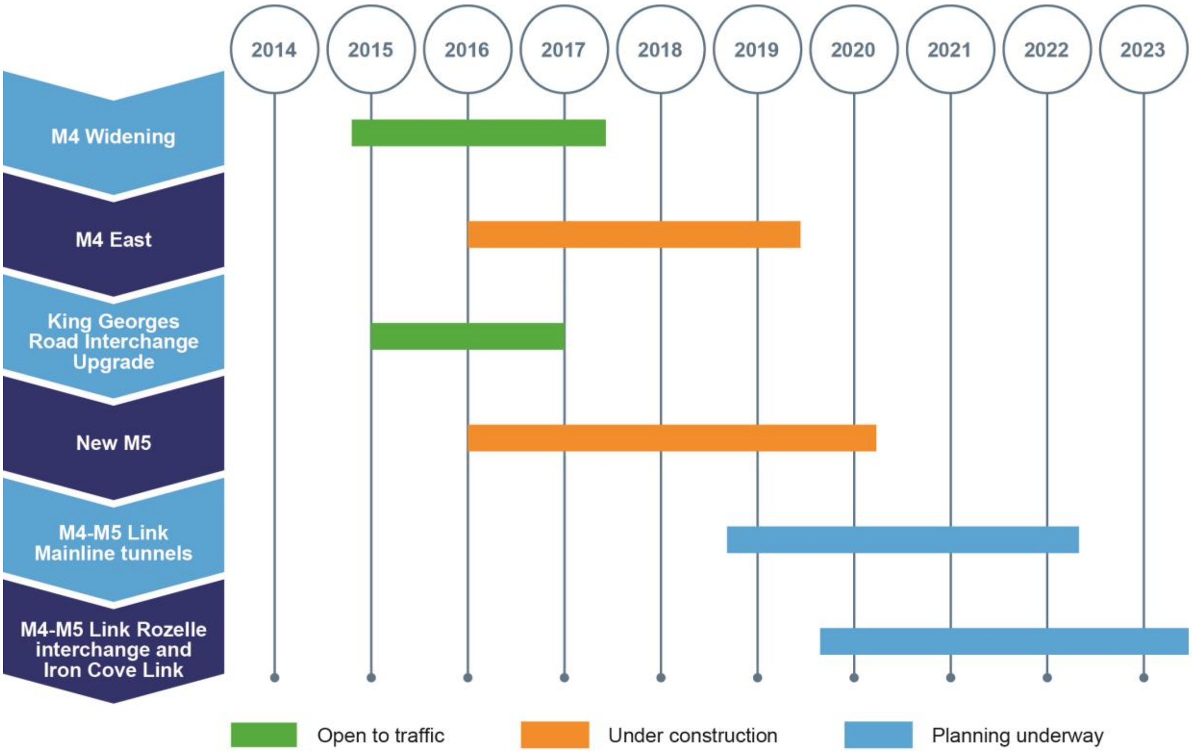


Figure 4-9 WestConnex delivery schedule

4.3.2 Staging of the M4-M5 Link

As the project design has evolved, so has the construction strategy and the proposed delivery mechanism for the project. Various options were considered for the packaging of the project works including packaging the works by major infrastructure components or by geographical location. Criteria that were considered included:

- Timing and critical path items
- Cost and affordability
- Risk allocation and transfer
- Market competition.

Following consideration of options for the construction and delivery of the project, it is anticipated that the project would be constructed in two stages:

- **Stage 1** – construction of the mainline tunnels and stub tunnels to the Rozelle interchange at the Inner West subsurface interchange
- **Stage 2** – construction of the Rozelle interchange and Iron Cove Link including:
  - Connections to the stub tunnels for the mainline tunnels (built during Stage 1)
  - Connections to the surface road network
  - Civil construction of tunnels, entry and exit ramps and infrastructure (a ventilation outlet and ancillary facilities) to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project.

The rationale for this approach was based on the following considerations:

- Easing current congestion issues along Parramatta Road and providing connectivity with the other WestConnex tunnels early
- Allowing more time to resolve the complex design and construction issues associated with the Rozelle interchange
- Making the scope of the project more manageable for delivery by dividing the works into two construction contracts.

It is expected that the mainline tunnels would be constructed and operational in 2022, with the Rozelle interchange and Iron Cove Link completing construction and commencing operations in 2023. Further details on the timing of staging and the description of works to be undertaken in each stage are provided in **Chapter 6** (Construction work). An assessment of the traffic and transport impacts associated with the staged opening of the project is provided in **Chapter 8** (Traffic and transport).

4.4 Strategic alternatives

The merits of the M4-M5 Link were considered in the context of a range of other alternatives, based on the extent to which they could meet the project objectives (refer to **Chapter 3** (Strategic context and project need)) and how well they performed with reference to other transport, environmental, engineering, social and economic factors.

The following strategic alternatives were considered:

- **Alternative 1** – improvements to the existing arterial road network
- **Alternative 2** – investment in alternative transport modes
- **Alternative 3** – demand management
- **Alternative 4** – the ‘do nothing’/’do minimum’ case
- **Alternative 5** – development of the M4-M5 Link.

These alternatives are described in more detail in **section 4.1.1** to **section 4.4.5**.

4.4.1 Alternative 1 – Improvements to the existing arterial road network

An alternative to the project could include maximising the performance of existing infrastructure by undertaking improvements to the arterial road network. Improvements could include improving intersection performance, implementing traffic calming measures, or lane closures and clearways.

Key arterial road connections such as Parramatta Road, City West Link, Victoria Road, and the A3 (Centenary Drive/Roberts Road/King Georges Road) and M1 Motorway (Eastern Distributor/Southern Cross Drive/General Holmes Drive) corridors were, without the project, predicted in the initial traffic modelling to experience increased congestion and to operate near or above their capacities by 2033 during peak periods (refer to the ‘detailed traffic modelling results in **Appendix H** (Technical working paper: Traffic and transport)).

Ongoing improvements to the broader transport network are therefore planned or underway (such as Roads and Maritime's ‘Easing Sydney’s Congestion’ initiatives) including some new infrastructure and intersection improvements to improve capacity and cater for traffic growth. Examples of relevant pinch point projects include Parramatta Road and Great North Road at Five Dock and the Princes Highway and Railway Road at Sydenham. The effect of the implementation of these road improvements has been taken into consideration in the operational traffic modelling for the project. Refer to **Appendix H** (Technical working paper: Traffic and transport) for more information on the projects considered in the modelling.

There are currently no existing arterial roads that would directly link the M4 East Motorway at Haberfield with the New M5 Motorway at St Peters, both of which are currently under construction. In the absence of the project, motorists using these motorway tunnels wishing to travel north or south would be required to travel along local and sub-arterial roads or traverse the Sydney CBD to access existing key north–south corridors such as the M1 Motorway.

Examples of existing routes that would provide connectivity to the north and south (as an alternative to the project) could include Parramatta Road, City Road/Kings Street/Princes Highway, King Georges Road, M1 Motorway/Anzac Bridge/City West Link, Johnston Street/The Crescent, Edgeware Road, Shaw Street and Norton Street, as well as the local road network. The connectivity between the M4 East and the New M5 motorways provided by these routes is indirect and requires motorists to travel through many at-grade intersections and, in some cases, steep grades such as on parts of King Georges Road, or congestion and high pedestrian traffic such as in King Street Newtown, are not appropriate for freight vehicles.

Improvements to the arterial road network (such as improving intersection performance and implementing traffic calming measures, lane closures or clearways) would only provide incremental change in the efficiency of the road network, and would not support the additional capacity required for regional traffic growth, which is associated with the forecast increase in Sydney's population (from 4.3 to 5.9 million between 2011 and 2031 (NSW Government 2014) and subsequent increases in vehicle kilometres travelled.

Continued urban development along the Parramatta Road and Victoria Road corridors has resulted in limited capacity for widening and/or upgrades to these roads. Limited road reserves would mean that any future improvements to the surface road network would not be able to proceed without considerable challenges, including the acquisition of a large number of properties. Even if 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; hence the potential benefits to motorists would be limited in the longer term. As such, improvements to the arterial road network alone, other than minor improvements such as Easing Sydney's Congestion program, are not a feasible or long-term alternative to the project.

Without the project, passenger and commercial vehicles, trucks and buses travelling from Haberfield to the Sydney CBD would continue to use the already congested east–west arterial road network (ie Parramatta Road and City West Link). According to the *NSW Long Term Transport Master Plan* (Transport for NSW 2012a) (*Transport Master Plan)*, this is one of the most constrained strategic transport corridors in Sydney. Similarly, the north-south arterial road network between Drummoyne and the Sydney CBD via Victoria Road and Anzac Bridge is one of the most congested sections of the Sydney road network.

Improvements to the road network through these corridors as an alternative to the project would require significant upgrades (eg road widening or road closures) and the implementation of traffic controls (eg clearways) to accommodate projected traffic volumes. This would result in potentially significant community and environmental impacts through increased traffic flows within residential areas and potential property acquisition impacts associated with road upgrades. This would also make it difficult to achieve land use regeneration and urban renewal along parts of Parramatta Road or along Victoria Road (east of Iron Cove Bridge), or to upgrade public transport services along these corridors, as proposed by the NSW Government. Improvements to the existing arterial road network would not provide the connectivity to Sydney's international gateways at Sydney Airport and Port Botany through the St Peters interchange and the future proposed Sydney Gateway. Nor would these improvements enable connectivity to the future proposed Western Harbour Tunnel and Beaches Link and F6 Extension to provide an inner western bypass of the Sydney CBD.

Arterial road improvements alone would therefore not meet the project objectives. However, together with the project, these improvements, although limited, would provide more effective solutions to congested parts of the road network.

4.4.2 Alternative 2 – Investment in alternative transport modes

As discussed in **Chapter 3** (Strategic context and project need), WestConnex is identified as important and necessary road infrastructure in the *Transport Master Plan*, the *State Infrastructure Strategy 2012–2032* (Infrastructure NSW 2012), the *State Infrastructure Strategy Update* (Infrastructure NSW 2014) and *A Plan for Growing Sydney* (NSW Government 2014).

As part of a broader integrated transport solution, WestConnex supports a coordinated approach to the management of freight and passenger movements, and is complementary to all modes of transport including road, rail, bus, ferries, light rail, cycling and walking. There is, however, recognition that Sydney's freight, commercial and services tasks require distribution of goods and services across the Sydney basin, which relies on more diverse and dispersed point-to-point transport connections that can only be provided by the road network.

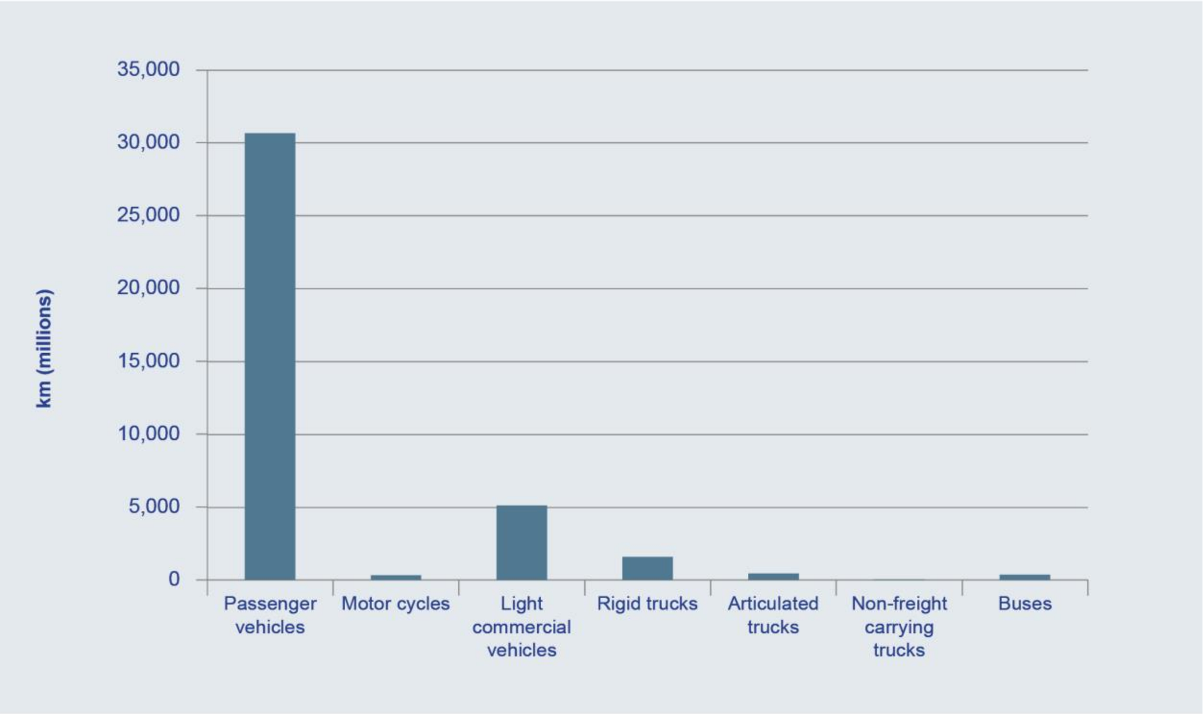
Alternative transport modes to the project, and their effectiveness in meeting the project objectives, are described in the following sections.

Public transport

The *State Infrastructure Strategy* states that, based on the economic and demographic forecasts, public transport is expected to experience strong growth, particularly around the Sydney CBD and other business centres. The Strategy also notes that the key challenges facing urban public transport relate to the following:

- The ability of the existing public transport network to serve a growing population while providing the mobility and connectivity necessary to sustain economic growth and productivity
- Improving access to the Sydney CBD
- Supporting growth in Sydney's emerging centres
- Optimising the performance of the existing public transport network
- Building future network capacity that keeps pace with demand and meets the needs of businesses and households.

Public transport in Sydney is predominantly via passenger trains (heavy rail) and buses and improvements to public transport in Sydney are focused on these two services. **Figure 4-10** illustrates the split in total motorised passenger kilometres (in billions of kilometres) travelled in Sydney in 2013.



Source: Bureau of Infrastructure, Transport and Regional Economics 2014

Figure 4-10 Total motorised passenger task for Sydney – 2013

Improvements to passenger rail services

Key existing rail services in and around the project footprint include the Western Line, Southwest Line, Airport Line and Inner West Light Rail line. The passenger rail system is often congested and demand for rail services is forecast to increase by 37 per cent over the next 20 years (Infrastructure NSW 2012). The *State Infrastructure Strategy Update* (Infrastructure NSW 2014) recognised that capital investment would be required to address projected overcrowding and maintain service reliability on key railway lines. To address these challenges, the NSW 2016-2017 budget includes more than $400 million to plan, develop and deliver enhancements to increase and improve rail services, including more express services to western Sydney. Key rail projects that have been announced, are under assessment or are underway are summarised in **Table 4-2**.

Table 4-2 Key rail projects that are under construction or have been announced

Name	Brief description	Project status	Capital cost
Sydney Metro Northwest	A 36 kilometre rapid transit railway line between Rouse Hill and Epping in Sydney's northwest including eight new metro stations and 4,000 commuter car parking spaces. Services are expected to commence in 2019.	Construction underway	$8.3 billion
Sydney Metro City and Southwest: • Stage 1 - Chatswood to Sydenham • Stage 2 - Sydenham to Bankstown	A 30 kilometre rapid transit railway line between Chatswood (from Sydney Metro Northwest) and Bankstown via the Sydney CBD including seven new metro stations, the upgrade of 11 existing stations and a new twin tunnel rail crossing under Sydney Harbour. Services are expected to commence in 2024.	Stage 1 - Approved in 2016 Stage 2 - Planning assessment underway	$11.5 to $12.5 billion
Sydney Metro West	A rapid transit, largely underground, railway line between the Sydney CBD and Parramatta servicing four key precincts: Parramatta, Sydney Olympic Park, The Bays Precinct and the Sydney CBD with up to 12 stations. Expected to be operational in the second half of the 2020s.	Early planning phase	Unknown
CBD and South East Light Rail	A 12 kilometre light rail line with 19 stops between Circular Quay and the south-eastern suburbs of Randwick and Kingsford via the Sydney CBD. Services are expected to commence in 2019.	Construction underway	$2.1 billion
Parramatta Light Rail	Stage 1 comprises a 12 kilometre light rail line with 16 stops (provisional) between Westmead and Carlingford via the Parramatta CBD. Services are expected to commence in 2023. Planning work for Stage 2 of the project from Camellia to Strathfield via Sydney Olympic Park is being developed in collaboration with Sydney Metro West.	Planning assessment underway	$3.51 billion
Western Sydney Rail Needs Scoping Study	A scoping study to better understand the need, timing and service options for rail investment to support western Sydney and the Western Sydney Airport.	Scoping study underway	N/A

Improvements to the Sydney bus network

Buses play a crucial role in Sydney's public transport system. They can be put into service more quickly, cheaply and to more places than any other type of public transport. Sydney's bus network currently includes more than 600 routes. For more than 90 per cent of residents within Sydney, 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 (Transport for NSW 2013a).

In response to changing passenger needs and an increase in demand, additional services have been added to the bus network. However, without measures to improve journey times, 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* acknowledges that improvements to the bus network are essential to meet changing customer needs, including access to major centres outside the Sydney CBD. The *Transport Master Plan* aims to connect seamlessly to other transport modes to deliver the right mix of services.

Sydney's Bus Future (Transport for NSW 2013a) proposes to redesign the Sydney bus network to meet current and future demands by providing rapid service routes to connect major centres along transport routes with mass transit demand. Suburban and local service routes would build on the foundation of the rapid routes to improve access to local, neighbourhood destinations. *Sydney's Bus Future* specifically states that new bus connections would take advantage of WestConnex to improve access east-west along Parramatta Road and north-south across Parramatta Road to the inner west and south-eastern suburbs. These changes would provide better public transport for workers and airport users.

Key bus-related infrastructure opportunities relevant to the project include the potential for bus rapid transit along Victoria Road and the proposed Parramatta Road on-street rapid transit. Other improvements to the bus network along Parramatta Road, such as the introduction of bus 'superstops' and increasing the frequency of some buses were also announced in the *Parramatta Road Corridor Urban Transformation: Infrastructure Schedule* (UrbanGrowth NSW 2016). No information was available at the time of writing this EIS on the timing or scope of the potential Victoria Road bus rapid transit program. While bus rapid transit has been identified as a potential future development, this is only viable if traffic can be diverted from these corridors. The project therefore acts as a catalyst for these potential projects, reducing the surface traffic along these major bus corridors.

Public transport constraints

Public transport is critical to urban productivity, expanding labour market catchments, reducing congestion and increasing economic and social mobility (Infrastructure NSW 2014). Employment growth in the Sydney metropolitan area is expected to increase in keeping with a growing population. While Sydney has an extensive public transport network (with rail being the most popular mode used to access the Sydney CBD), the level of service can vary significantly. With demand for rail travel in particular forecast to grow faster than other modes, the NSW Government is implementing measures (including new projects) to address this demand, especially during peak periods.

A key constraint to the expansion and development of the rail network is Sydney's geography, with large parts of the Sydney metropolitan area, such as outer western Sydney and the Northern Beaches region, being relatively poorly connected by public transport to Sydney's global employment centres. As major rail projects have a long lead time, the focus in the shorter term is to improve public transport services through the bus network, such as bus priority programs and bus rapid transit.

While the use of public transport is expected to grow with the implementation of key public transport initiatives, most growth in transport demand over the next 20 years will continue to be met by roads.

Public transport is best suited to providing concentrated, high volume flows of people to and from established centres. It is less suited to providing dispersed cross-city or local trips. In 2014, around 17.6 million trips were made each average weekday in Sydney, with around 75 per cent of these by road. Even with significant investment and high levels of patronage growth forecast for Sydney's public transport network, about 72 per cent of around 27.5 million journeys in 2031 are expected to be made on the road network each weekday by private vehicles, equal to an additional 4.3 million new trips compared to 2014 (Infrastructure NSW 2014).

With about 60 per cent of employment dispersed across the Sydney metropolitan area, public transport alone cannot viably serve most of these locations. Even under the most ambitious scenarios for land use change and growth in public transport, the absolute number of car journeys will continue to increase (Sydney Motorway Corporation 2015a).

The key customer markets identified for the project include highly dispersed and long distance passenger movements, as well as heavy and light freight and commercial services and businesses whose travel patterns are also highly dispersed and diverse in nature. These customers have highly varied requirements when it comes to the transfer of goods and services. These requirements include the transport of containerised freight by rigid and articulated trucks, light trucks, vans, utility vehicles and cars.

As it is forecast that the demand for mobility by road travel will continue to grow, public transport initiatives would only partially contribute to relieving congestion on arterial roads. The provision of additional public transport services would create opportunities for improved liveability; however, these initiatives alone would not considerably enhance the productivity of commercial and freight generating land uses.

Public transport would only partially address these customer demands. No feasible strategic transport alternatives such as heavy or light rail options or bus corridor enhancements would meet the diverse range of customer needs for travel in this corridor and address the project objectives as effectively as the project and the broader WestConnex program of works. Public transport improvements alone are therefore not a viable alternative to meeting the project objectives. As discussed in **Chapter 3** (Strategic context and project need), investment in integrated transport solutions that involve both roads and public transport is needed to cater for the concentrated population growth forecasts and associated increase in travel movements.

Rail freight

The Sydney freight network facilitates the movement of freight in Sydney and provides a link to the NSW rural and interstate rail network and intermodal network. The two main components of the network are the Southern Sydney Freight Line (SSFL) and a line from Sefton to Enfield and Port Botany. The SSFL is a freight only corridor between Macarthur in Sydney's southwest and Port Botany. South of Macarthur, the line runs to Glenfield via Ingleburn. North of Glenfield, the line crosses to the east of the existing tracks via a flyover, with potential access to the Moorebank Intermodal Terminal. The line then continues to Sefton, passes under the Bankstown Line and joins the Metropolitan Goods Line, which provides access to the Intermodal Logistics Centre at Enfield, the Cooks River Rail Depot and Empty Container Park at St Peters and the Port Botany marshalling yards.

The current situation for freight movements into and out of Port Botany, and potential future scenarios for freight movements in NSW, was considered in assessing improvements to the freight rail network as a viable alternative to the project. The recorded throughput at Port Botany was over 2.3 million 20-foot equivalent units (TEUs) (one TEU is equivalent to the dimensions of a standard shipping container) in the 2015/2016 financial year (NSW Ports 2016). By 2020, the volume of TEUs at Port Botany is forecast to grow to between three and 3.6 million, reaching between 4.9 and seven million by 2030 (Sydney Motorway Corporation 2015a).

The *NSW Freight and Ports Strategy* (Transport for NSW 2013b) (*Freight Strategy*) states that about 63 per cent of NSW's freight in 2011 was transported by road and about 33 per cent by rail. When coal-related freight is removed, road-based freight movements account for nearly 90 per cent of the NSW freight task. The relative share of container freight that was moved by rail (relative to road transport) to and from Port Botany in 2012 was about 14 per cent. To support an increased role for rail based freight movements, the NSW Government and Australian Rail Track Corporation (ARTC) are currently investigating the duplication of the rail line between Port Botany and the Cooks River.

The volumes of all commodities demanding capacity on the freight network are expected to grow as population and economic activity increases across NSW. Port Botany and Sydney Airport are predicted to accommodate much of the rapid growth forecast for containerised cargo and air travel over the next 20 years (Infrastructure NSW 2014). The implications of this growth for the road and rail network are expected to be significant, with capacity across key parts of the network, particularly the Sydney metropolitan area, already under pressure to match demand.

Although opportunities exist to shift more freight from the road network onto the freight heavy rail network, the need to transport freight by road will continue. The *Freight Strategy* notes that dedicated freight rail corridors are being planned to ensure passenger and freight rail demand can be accommodated. However, rail freight transport is more effective for long distance transport of goods to regional centres while Sydney's freight, service and business task relies upon a dispersed point-to-point transport connection to customers within the metropolitan area. *NSW 2021: A Plan to Make NSW Number One* outlines a target set by the NSW Government to double the 2011 share of container freight moved by rail through NSW Ports by 2020 (NSW Department of Premier and Cabinet 2011). Assuming this target is achieved, more than 70 per cent of Port Botany's trade would still be moved by road, requiring investment in an efficient road network to support the Port Botany and Sydney Airport precincts (NSW Department of Premier and Cabinet 2011). One of the actions arising from the *Freight Strategy* includes 'connect and complete Sydney's motorway network'. This includes the widening of the M4 and M5 West motorways, connecting the M2 and M1 motorways and delivering the WestConnex program of works.

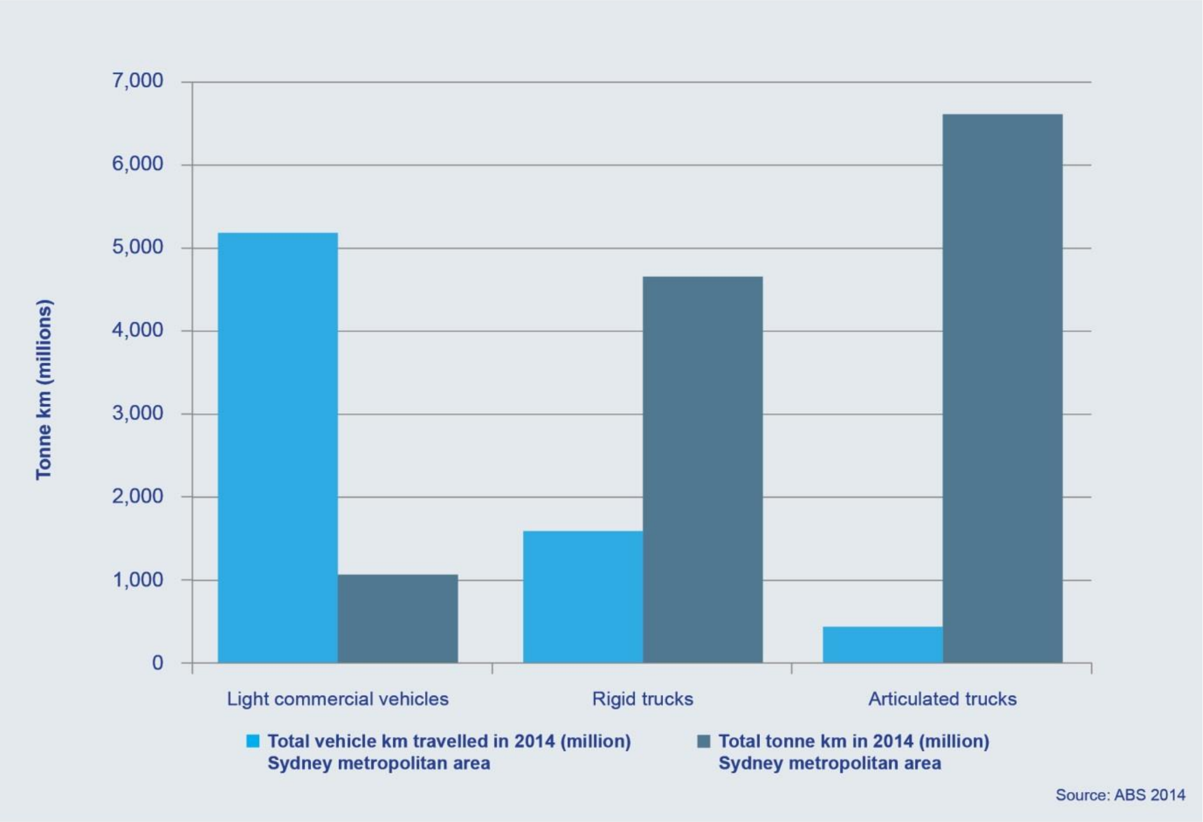
There is a need for the development of additional metropolitan intermodal terminals. Transport for NSW defines an intermodal terminal as 'an area of land used to transfer freight between at least two modes of transport'. It is typically used to describe the transfer of international shipping containers form road to rail and vice versa'. These terminals are critical to increasing rail mode share and managing the rapidly growing import container trade, as well as interstate freight. The primary function of metropolitan intermodal terminals is to facilitate the import container trade, and in this context, to serve as inland satellite ports (Transport for NSW 2013b). This would help to reduce congestion from the Sydney Airport and Port Botany precinct, which would help to increase efficiency on the road network and facilitate the improved transport of the remaining freight by road.

To cater for the growth in the container market, new intermodal terminals have recently been established at Chullora (2015), Enfield (2016) and Moorebank (to open late 2017). Strategic locations for potential future intermodal terminals and/or facilities include Eastern Creek and Western Sydney Airport to provide a connection to the Metropolitan Freight Network. However, even with new intermodal terminals, there remains a significant demand for road freight movements in the Sydney metropolitan area. Rail freight improvements alone are therefore not a viable alternative to meeting the project objectives.

Road freight

Freight rail transport predominantly forms the first leg of the freight journey for imported freight, with containerised freight broken down at distribution nodes and further distributed across Sydney. The management of the freight task from the port to distribution nodes requires a primary network for heavy commercial vehicles with high quality connections between major freight hubs. From the distribution nodes, light commercial vehicles are required, which depend on a multi-layered network with many connections to service more diverse and dispersed markets across Sydney.

This arrangement means that there are around four times as many light commercial vehicle (LCV) trips on Sydney's road network as heavy commercial vehicle (HCV) trips and this trend is forecast to continue. **Figure 4-11** shows freight-related LCVs in NSW travelled a greater distance in 2014 than rigid or articulated trucks (ie HCVs), although the amount of freight carried by LCVs was significantly lower. A key reason for this trend is that heavy freight activity precincts are concentrated in a few key locations near Port Botany and in western Sydney, and this land use pattern is set to continue.



Source: Australian Bureau of Statistics 2015

Figure 4-11 Kilometres travelled in 2014 (million) - Sydney metropolitan area

In NSW, nearly all air cargo (domestic and international) moves through the Sydney Airport. Freight access to and from the airport is exclusively via road, as consignment sizes and time sensitivity of the goods excludes the use of rail as a substitutable mode for providing access to and from the Sydney Airport precinct. Air cargo movements are forecast to grow steadily over the next 20 years to more than one million tonnes per annum. While air cargo only represents a small proportion of the freight task and movements to and from the Sydney Airport and Port Botany precinct, its value to the NSW economy is significant. Failure to address the increasing demand for air freight has the potential to increase industry costs and reduce the reliability and competitiveness of air freight (Transport for NSW 2013b). The WestConnex program of works seeks to help resolve some of these road freight issues by providing a connection between the Sydney Airport and Port Botany precinct (through the connection with the New M5 project) and areas to the north (through the connection with the proposed future Western Harbour Tunnel and Beaches Link project) and to the west of Sydney (through the connection with the M4 East project) that would improve the efficiency of road freight movements. The M4-M5 Link project would play a crucial role in connecting these ‘under construction’ and ‘proposed future’ projects.

Future freight capacity

The *Transport Master Plan* provides a framework to deliver an integrated, modern transport system by identifying NSW’s transport actions and investment priorities over the next 20 years. It identifies the key challenges that the NSW transport system must address to support the state’s economic and social performance, and identifies a planned and coordinated set of actions to address those challenges.

The *Transport Master Plan* notes that the domestic freight task across Australia is set to double by 2031 and triple by 2050, from about 504 billion tonne-kilometres in 2008 to more than 1,504 billion tonne-kilometres in 2050 (Transport for NSW 2012a). In NSW this rate of growth is supported by the *Freight Strategy,* which has identified that the freight task of around 409 million tonnes in 2011 will almost double to an estimated 794 million tonnes by 2031.

The *Freight Strategy* notes that the role of heavy vehicles in moving freight across NSW is substantial, and will continue to be so for the foreseeable future. Typically, bulk commodities such as coal and grain are moved by rail, while commodities transported in smaller quantities are moved by road. The mode share of freight varies significantly based on a range of factors, including: the type and tonnage of commodity being moved, the distance between the origin and destination, and access to other modes of transport.

As mentioned above, the NSW road network carried 63 per cent of the total freight task in 2011, or about 256 million tonnes of freight. Increases to freight are projected to impact the performance of all key NSW road freight corridors over the next 20 years, including the M5 Motorway corridor. By 2031, NSW roads are projected to remain the dominant mode for freight transport, but to carry less of the total freight task at 59 per cent (Transport for NSW 2013b). By 2031, the container trade at Port Botany is forecast by Sydney Ports Corporation to increase from the existing throughput of around two million TEUs to up to seven million TEUs. The target mode share for 2031 is to double the proportion of containers carried by rail in 2020 (NSW Department of Premier and Cabinet 2011).

The *Freight Strategy* acknowledges that even with the targeted increase in rail mode share, WestConnex alone would not be able to accommodate the additional container traffic when combined with background growth from employment and population by 2031, although as part of an integrated transport solution, it at least assists with this. With forecast congestion increasing along the M4 and M5 motorway corridors, accommodating 20 years of growth in container freight will require a package of solutions to meet the needs of road freight and other road users.

The *Freight Strategy* recognises that there are significant economic efficiency implications for NSW if major changes are not made to ports and related road and rail systems in the next 20 years. While dedicated freight rail lines are relatively well served by capacity development plans, there is limited available capacity on the shared rail network in metropolitan areas for freight traffic. One action of the *Transport Master Plan* is to implement rail freight infrastructure enhancements to increase the share of freight carried on the rail network. These enhancements would include new investment in rail pinch points, measures to improve rail competitiveness, and the development of a metropolitan intermodal terminal network.

A number of current and future freight-related projects are proposed to improve the efficiency of, and remove existing bottlenecks from, the existing freight rail network, including:

- **Proposed Port Botany rail duplication project** - about three kilometres of the Port Botany Freight Line between Mascot and the Port Botany Rail Yard to provide improved service reliability and increased capacity
- **The Southern Sydney Freight Line** (rail operations commenced in 2013) **-** a 36 kilometre length of freight rail track in the south-western suburbs of Sydney, between Macarthur and Sefton. At Sefton Junction, the line passes under the Bankstown Line and joins the Metropolitan Goods Line which provides access to the Enfield and Port Botany marshalling yards. This line would potentially tie in to the Moorebank intermodal terminal. It also links the interstate network between Sydney and Melbourne with the Metropolitan Freight Network and is managed by the Australian Rail Track Corporation (ARTC)
- Development of intermodal terminals:
  - **The Enfield intermodal logistics centre -** this logistics centre is being developed at Enfield as a key logistics hub in central-west Sydney, about 16 kilometres west of the Sydney CBD. The terminal commenced operations in March 2015. Although the intermodal terminal has assisted in mitigating the number of freight truck numbers on Sydney's road, additional rail freight capacity is needed
  - **Moorebank intermodal terminal -** the concept plan for this terminal, around 35 kilometres southwest of the Sydney CBD, was approved by the NSW Minister for Planning in December 2014. Planning approval for Stage 1 was granted in December 2016. The Moorebank intermodal terminal would involve the construction of freight terminal facilities linked to the interstate and freight rail network via a dedicated rail freight line. The project aims to increase Sydney's rail freight mode share by promoting the movement of container freight by rail between Port Botany and western and south-western Sydney. The Moorebank intermodal site is adjacent to the Southern Sydney Freight Line, the East Hills and Airport railway line and the

M5 East Motorway

  - Even with the Enfield and Moorebank intermodal terminals/logistics centres operating, which would increase freight rail capacity substantially, truck movements are still forecast to almost triple, reaching around 8,000 per day by 2031 (Sydney Motorway Corporation 2015a)

- **A proposed Western Sydney Freight Line and intermodal terminal** - a new dedicated freight line connecting the Main West Railway Line and the Southern Sydney Freight Line to a new intermodal precinct at Eastern Creek. It would service growth areas of western Sydney that connect to Port Botany and regional producers that export from Port Kembla, as well as meeting demand from businesses in the Western Sydney Employment Area, for movement of containers by rail. The Western Sydney Freight Line and intermodal terminal is listed as a corridor preservation priority in the *Freight Strategy* and *State Infrastructure Strategy Update*. The *State Infrastructure Strategy Update* anticipates that by 2036, about 4.3 million truck kilometres a year could be saved through the Western Sydney Freight Line and terminal precinct project.

While realising opportunities to shift more freight onto rail remains a priority for the NSW Government, the forecast growth in the freight task will still require investment in an efficient road network to support the Sydney Airport and Port Botany precinct. Rail freight improvements alone are therefore not a viable alternative to meeting the project objectives.

Western Sydney Airport

The Western Sydney Airport at Badgerys Creek would be developed in stages. Stage 1 would comprise a single runway, a terminal and other relevant facilities to accommodate around 10 million passengers annually in addition to freight traffic. These facilities would be developed prior to the commencement of airport operations in the mid-2020s and would be capable of supporting both domestic and international public transport services, in addition to freight.

Over time and as demand grows, the proposed airport would include an expanded terminal, further support and commercial facilities and a second runway, and would serve around 19.5 million passengers annually by around 2050. The proposed airport would also support freight aircraft, with capacity for around 7,000 dedicated freight air traffic movements annually following Stage 1, increasing to 30,000 air traffic movements per year in the longer term.

The development of the Western Sydney Airport at Badgerys Creek has the potential to change the way some freight is moved around Sydney, by providing an alternative entry or exit point for freight. The completed WestConnex program of works would connect the M4 East and New M5 motorways, encouraging efficient movement of road freight to and from Western Sydney Airport and the Sydney metropolitan area. Overall, however, the movement of freight around Sydney in the short to medium-term would not be significantly altered by the introduction of the new airport, for the following reasons:

- The operation of the Western Sydney Airport would be staged, with throughput increasing in stages over time subject to demand. Initial operations are anticipated to commence in the mid-2020s (at least two years after the expected commencement of operations of the M4-M5 Link)
- The proportion of freight transported by air is small compared to transport by road and rail. Freight arriving at the new airport would still have destinations across the wider Sydney metropolitan area, which would most likely be transported by road and therefore reliant on a resilient and efficient motorway network
- Port Botany and Sydney Airport would still be key freight entry and exit points, with the new airport to provide additional capacity, rather than replace the function these terminals currently provide.

Once the Western Sydney Airport is operational, it is expected that longer term benefits to freight movements would be experienced, primarily through providing a new terminal for incoming and outgoing goods.

Active transport improvements

Sydney's Cycling Future (Transport for NSW 2013c) 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.

The implementation of the strategy 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 to towns and centres, reduce congestion 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 'Bike and Ride' initiative will make it convenient for customers to ride to transport hubs, leave their bikes securely locked up and transfer to public transport to continue their journey.

Sydney's Walking Future (Transport for NSW 2013d) is intended to complement *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 will 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. Improvements to cyclist and pedestrian infrastructure alone would not cater for the diverse travel demands within the project footprint that are best met by road infrastructure. Further improvements to cyclist and pedestrian infrastructure alone would not support long-term economic growth through improved motorway access 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.

The project would deliver new and improved active transport links within residual land created by the project such as within the Rozelle Rail Yards and along the south side of Victoria Road. These works would be consistent with other plans for active transport improvements in the area, as outlined in the *Parramatta Road Corridor Urban Transformation Strategy*, *The Bays Precinct Transformation Plan* and various council initiatives such as Greenway, The Green Grid and the Lilyfield Road regional bike route. A brief description of these initiatives and projects is provided in **Table 4-3**.

Table 4-3 Description of active transport initiatives and improvements outside of the project scope

Project/plan title	Brief description
Parramatta Road Corridor Urban Transformation Strategy	As the Parramatta Road corridor undergoes renewal, cycling corridors will provide a viable alternative to private vehicle use, especially for shorter trips. Used in conjunction with public transport, cycling corridors will also present an attractive option for those seeking to make regional travel trips. The Strategy will focus on delivering safe, high-quality cyclist routes such as the regional cycleway between Concord and Iron Cove along Gipps Street, Patterson Street and Queens Road, and the GreenWay from the Cooks River to the Parramatta River. Safe and high-quality pedestrian access is also essential to the successful transformation of the Parramatta Road Corridor, particularly to encourage walking to public transport nodes. Plentiful walking paths and connections mean shorter walking distances and a greater choice of routes. Improving the pedestrian environment in existing areas can be achieved by the creation of quality pedestrian links and short cuts.
The Bays Precinct Transformation Plan	Transport solutions for the precinct would be based on an integrated transport system that would support the ambition of job creation and economic development. Opportunities would be explored to increase walking and cycling and to make active and public transport so efficient that it is a first-choice option would be explored. An initiative would also include working towards re-opening Glebe Island Bridge for active and public transport.

Project/plan title	Brief description
The Green Grid	A network of interlinked multipurpose, open and green spaces across Sydney connecting homes to centres, public transport, jobs and recreational areas. The initiative is aimed at creating a great place to live with communities that are strong, healthy and well-connected. The Green Grid identifies a potential primary open space corridor at Rozelle, Balmain and Annandale around Rozelle Bay and the Parramatta River.
Greenway	A green urban corridor running from the Cook's River to Iron Cove in Sydney's inner west. Currently the corridor is a bush corridor used for a range of community activities including bushcare, walking and cycling. Plans for the Greenway include the provision of an off-road shared path from the Cooks River to Iron Cove. The Greenway would then link with the Lilyfield Road cycle route.
Lilyfield Road Regional Bike Route	A well-established east-west cycle route that provides a direct connection between Anzac Bridge and Hawthorne Canal. The Inner West Council (and former Leichhardt Council) is proposing to improve the bicycle route along Lilyfield Road, which is considered an important regional route which connects people to the Cooks River, the Bay Run, Victoria Road, Anzac Bridge and further, including Newtown and the Sydney CBD.

Active transport improvements are regarded as complementary to other transport modes including roads and public transport. They are an essential component of the integrated transport solution. The project includes the development of new or improved active transport links in a number of locations, generally associated with surface works and/or residual land for the project, such as at the Rozelle Rail Yards and along Victoria Road. 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 8** (Traffic and transport) and in **Appendix N** (Technical working paper: Active transport strategy).

Summary of alternative transport modes

WestConnex is one of more than 80 projects outlined in the *Transport Master Plan* to address the state's complex transport needs. As part of a broader integrated transport and land use solution, WestConnex supports a coordinated approach to the management of freight and passenger movements, and is complementary to other modes of transport including rail, bus, ferries, light rail, cycling and walking. However, Sydney's freight, commercial and services tasks require distribution of goods and services across the Sydney basin, which relies on diverse and dispersed point-to-point transport connections that are most efficiently provided by the road network.

Not all trips in Sydney can be undertaken by public transport as customer needs are diverse, often requiring travel over long distances or dispersed across multiple destinations. Even though projects are being undertaken to significantly increase the share of freight being moved by rail, the overall growth in the freight task is outgrowing demand for the transport of freight by road. As such, the capacity and reach of the motorway and arterial road network needs to be increased to accommodate this growth. While the NSW Government is investing $41.5 billion (2016–2017 NSW Budget) in transport projects over the next four years (including roads and public transport) there are no feasible strategic public transport or freight alternatives to the project that, on their own, would meet the diverse range of needs for travel in the Sydney metropolitan area.

In addition, by reducing surface road traffic along sections of Parramatta Road and Victoria Road, the project would facilitate potential future developments in public transport and support the expansion of the active transport network to achieve the sustainability and liveability objectives of the WestConnex program (as outlined in **Chapter 3** (Strategic context and project need) and **Chapter 14** (Social and economic)).

4.4.3 Alternative 3 – Travel demand management

Travel demand management relates to minimising or avoiding the need to invest in new motorway infrastructure such as the project, by reducing individual trip lengths and making alternative transport mode options more viable. Travel demand management initiatives include the following:

- Land use planning policies that promote urban consolidation and the establishment of town 'centres' with the aim of incorporating local employment and recreational opportunities in order to reduce the need for travel. For example, the Transport Master Plan aims to prioritise the development of local growth centres to the northwest and southwest the Sydney CBD, to bring jobs closer to homes and to areas of increasing population. This policy approach is replicated in the *Parramatta Road Corridor Urban Transformation Strategy* and *The Bays Precinct Transformation Plan*, which outline proposals for urban generation, including residential development and increasing commercial opportunities
- Augmenting existing public transport and integrating urban regeneration around transport nodes. This approach is being adopted by Transport for NSW and DP&E as part of Stage 2 of the Sydney Metro City and Southwest project (Sydenham to Bankstown) and the corresponding Sydenham to Bankstown Urban Renewal Corridor (DP&E 2017), to provide a coordinated approach to infrastructure delivery and development across the corridor
- Implementing policies to restrict parking provisions in new developments to encourage alternative modes of transport.

According to the 2016 NSW population and household predictions (DP&E 2016), Sydney's population is expected to grow by more than 2.1 million people in the next 20 years, which is about 170,000 more than predicted only two years ago. This forecast growth in Sydney's population is expected to generate the need for another 726,000 new dwellings by 2036. In Parramatta, the population is expected to double from about 200,000 in 2011 to 416,000 in 2036.

While housing is more affordable in western Sydney, there is a greater demand for jobs in the eastern half of the city in areas that are part of or support the Sydney CBD, Port Botany, Sydney Airport and surrounding industrial areas. This creates a disparity in employment opportunities close to people's homes. The *Transport Master Plan* highlights that western Sydney is currently home to 47 per cent of Sydney's residents but only 37 per cent of Sydney's jobs (Transport for NSW 2012a).

As discussed in **section 4.4.2** increasing the capacity of the public transport network to assist in accommodating forecast growth in population is an imperative for the NSW Government. Coupled with urban renewal of areas around new and upgraded metro stations (such as along the Sydney Metro City and Southwest Sydenham to Bankstown corridor), integrated transport and land use planning would relieve congestion through transport upgrades and providing new homes and jobs close to stations. However, these approaches would be needed even without the project to address the demand for housing and the travel needs of Sydney's growing population. For example, around 4,500 new homes are expected to be built within the Sydenham to Bankstown corridor over the next two to three years, and development along this corridor is expected to grow with the introduction of Sydney Metro (Sydenham to Bankstown Urban Renewal Corridor Strategy 2016). Planning for this growth is critical to meeting current and future demand.

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. Therefore, while travel demand management could help reduce demand on the road network during peak times, its effectiveness would be limited by other constraints, such as:

- Land use patterns, in particular the location of new jobs relative to areas of residential growth
- The availability of alternative travel modes at the user's origin and destination such as public transport and active transport
- Flexibility of working arrangements to take advantage of 'time of day' tolling or transport pricing benefits.

Travel demand management changes alone are therefore not a viable alternative to meeting the project objectives. They are, however, viewed as complementary initiatives, together with the project, to reduce the impacts of road traffic on Sydney's road network.

Population growth, combined with the growing road freight task in the Sydney metropolitan area, would result in a continued demand for use of roads providing east-west and north-south connections such as the M4 Motorway, M5 Motorway, M1 Motorway and A3 and A6 corridors (see **Figure 4-12**). Without infrastructure investment or significant changes to how people travel, the continued demand and use of these corridors would result in additional, prolonged congestion.

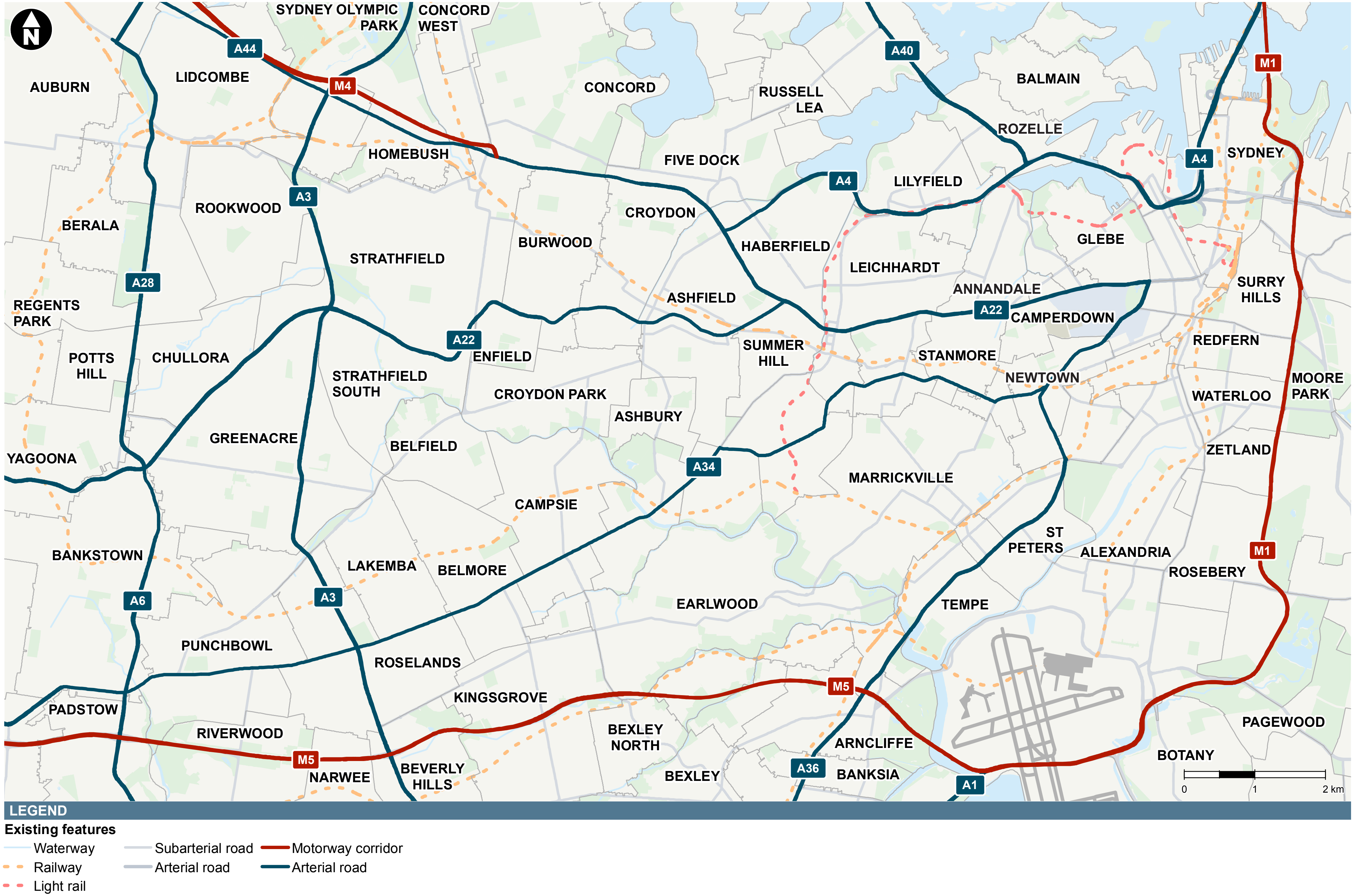


Figure 4-12 Existing motorway and arterial road corridors

4.4.4 Alternative 4 – The 'do nothing'/'do minimum' case

The 'do nothing'/'do minimum' alternative assumes that the approved components of WestConnex are completed (ie M4 Widening, M4 East, King Georges Road Interchange Upgrade and New M5) but that the M4-M5 Link does not proceed.

This scenario is referred to as 'do nothing'/'do minimum' because even without the project, it is expected that a number of other road network improvements are already approved, planned or underway to address traffic conditions on key arterial road connections such as Parramatta Road, City West Link, Victoria Road, the M1 corridor (Eastern Distributor/Southern Cross Drive/General Holmes Drive), King Street and the Princes Highway. These traffic improvements are described further in **section 4.4.1**.

As identified in **Chapter 3** (Strategic context and project need), the M4-M5 Link is a key component of the WestConnex program of works. The project would provide a motorway standard, tunnel alternative to the congested surface road network for passenger, commercial and freight traffic traveling between the M4 East and New M5 motorways. Not proceeding with the project would mean that that the full benefits of WestConnex would not be realised, including linking, by road, major employment centres that are critical in supporting the creation of jobs and businesses. These include the 'global economic corridor', which encompasses: the Sydney Airport and Port Botany precincts, Sydney CBD, Sydney Olympic Park, Parramatta CBD and Norwest Business Park.

Traffic modelling for the project (refer to **Chapter 8** (Traffic and transport) and **Appendix H** (Technical working paper: Traffic and transport)) shows that the overall forecast growth in traffic demand is consistent with the forecast growth in population in the Sydney Metropolitan Area. Importantly, this growth in traffic is not confined to major routes. Increased traffic on many roads in Sydney is forecast without the project in the 2023 and 2033 peak periods, as vehicles seek to avoid the congested arterial road network by travelling along lower order roads.

A reduction in daily traffic is forecast along Parramatta Road (west of the M4 East Parramatta Road ramps) in 2023 and 2033 as a result of the M4 East, and on the M5 East as a result of the New M5. However, increased daily traffic is forecast along Parramatta Road (east of the M4 East Parramatta Road ramps), Southern Cross Drive, Sydney Harbour Tunnel, Sydney Harbour Bridge, Western Distributor and Anzac Bridge, as well as other urban arterial roads, such as Victoria Road, City West Link, Hume Highway, Canterbury Road, Stoney Creek Road, Olympic Drive, Centenary Drive and Anzac Parade approaching the Sydney CBD in both 2023 and 2033.

With forecast traffic growth, the network performance in Haberfield around the Wattle Street interchange, in Rozelle around the Rozelle interchange and in St Peters around the St Peters interchange is forecast to deteriorate over time without the project. These increases in traffic demand would occur on parts of the surface road network that already experience significant congestion, especially during the peak hours.

As a result of an expanding future population, employment and urban growth, Sydney can expect worsening road network and traffic conditions if integrated transport solutions are not implemented. However, while public transport, integrated transport and land use planning is part of the overall transport plan, not all trips across Sydney can be served by public transport, especially trips to dispersed destinations, commercial trips requiring the movement of large or heavy goods/materials, or trade and service-related journeys. In addition, Sydney is home to two-thirds of NSW's manufacturing sector, with the many of the state's major aviation, pharmaceuticals, biotechnology, electronics and automotive industries based in western Sydney. These businesses rely on the road network and its connectivity to the port and airport precincts.

The addition of the M4-M5 Link would provide a significant overall improvement to network productivity. A number of key benefits and improvements are forecast as a result of the project (when compared to not proceeding with the project):

- Non-motorway roads in the Inner West LGA are forecast to experience faster trips with the daily average speed increasing by about 10 per cent. Similarly, the vehicle distance travelled on non-motorway roads is forecast to reduce by about 12 per cent. This indicates that on average, these trips are fewer in number and faster

- Improved network productivity on the metropolitan network, with more trips forecast to be made or longer distances travelled on the network in a shorter time. The forecast increase in vehicle kilometres travelled (VKT) and reduction in vehicle hours travelled (VHT) is mainly due to traffic using the new motorway, with reductions in daily VKT and VHT also forecast on non-motorway roads
- Reduced travel times are forecast on key corridors, such as between the M4 Motorway corridor and the Sydney Airport/Port Botany precinct
- Reduced traffic is forecast on sections of major arterial roads including City West Link, Parramatta Road, Victoria Road, King Street, King Georges Road and Sydenham Road
- Almost 2,000 heavy vehicles are forecast to be removed from Parramatta Road, east of the M4 East Parramatta Road ramps, each weekday.

Where the project would connect to the existing road network, increased congestion is forecast in parts of Mascot, along Frederick Street at Haberfield, Victoria Road north of Iron Cove Bridge, Johnston Street at Annandale and on the Western Distributor. A number of these areas are forecast to improve when the WestConnex program of works and the proposed future Western Harbour Tunnel and Beaches Link are completed.

The lost opportunities from not proceeding with the project mean that the 'do nothing'/'do minimum' case is not a feasible or realistic alternative. Notwithstanding this, the M4-M5 Link, as part of the WestConnex program of works, is one part of a broader solution to these pressures. For these reasons, the NSW Government is also investigating and investing in light rail, metro, bus rapid transit and motorways to provide a multi-modal response to the future challenges.

4.4.5 Alternative 5 – Development of the M4-M5 Link

The *State Infrastructure Strategy* notes that investment in Sydney's strategic road network can be sustainable if complemented by strategies to manage congestion and environmental impacts, and should be undertaken in tandem with investment in public transport and demand management measures.

The WestConnex program of works (including the M4-M5 Link) forms part of a broader integrated transport solution which supports a coordinated approach to the management of freight, commercial and passenger movements, across all modes of transport. As described in **Chapter 3** (Strategic context and project need), the primary objective of the project is to link the other key component projects of WestConnex (which have already been approved and are currently under construction), so that the broader benefits of, and opportunities arising from WestConnex can be realised.

The delivery of freight, commercial and services tasks would continue to rely on more diverse and dispersed point-to-point transport connections that can only be provided by the road network, which also supports private passenger movements. The project is therefore a necessary component of the WestConnex program of works.

The project is forecast to provide:

- More reliable trips, both in terms of travel time and safety, between south-western and western Sydney and the inner west
- Additional motorway capacity through a north-south corridor to support Sydney's freight and commercial task
- Traffic flow reductions along sections of major arterial roads, including Parramatta Road, Victoria Road (east of the Iron Cove Link portals), City West Link, King Street, Sydenham Road and King Georges Road
- A reduction in heavy vehicles on sections of the surface road network, including around 2,000 heavy vehicles forecast to be removed from Parramatta Road, east of the M4 East Parramatta Road ramps, each weekday.

The need for the project is described in detail in **Chapter 3** (Strategic context and project need). Details of the evolution of the project and the initial design options are described in **section 4.3**. Further detail on the project concept is provided in **Chapter 5** (Project description).

4.5 Project evolution and design refinements

Since the inception of the M4-M5 Link and the WestConnex program of works, various options have been considered in the development of the key components of the project, including:

- Interchanges
- Mainline tunnels (including numbers of lanes)
- The Iron Cove Link.

A comprehensive options identification and evaluation process using multi-criteria analysis (MCA) was carried out in 2016 to define the optimal project concept design for the Rozelle interchange and the Iron Cove Link. The MCA was undertaken for the Rozelle interchange and the Iron Cove Link as these are complex project components with a number of potential concept design options that could meet project objectives (compared to the mainline tunnels, which have fixed endpoints and therefore fewer viable concept design options). The criteria for the MCA, and their performance attributes, are listed in **Table 4-4.**

Table 4-4 MCA criteria and performance attributes for the Rozelle interchange and Iron Cove Link

MCA criteria	Performance attributes
Road network operation and safety	• Route connectivity • Road hierarchy • Network efficiency • Wayfinding • Contingency for growth.
Urban design	• Opportunities for multiple site uses • Clear road hierarchy • Opportunities for increased connectivity to public transport • Opportunities to facilitate improved active transport connectivity/linkages.
Constructability	• Construction complexity • Relocation of significant services • Spoil disposal • Flooding risk and drainage capability.
Environment and heritage	• Impact on state listed non-Aboriginal heritage items • Impact on local listed heritage items and heritage conservation areas • Impact on visual amenity • Impact from noise generation • Air emissions • Direct impact on endangered ecological communities, threatened flora and fauna species or groundwater dependent ecosystems • Area of vegetation removal • Impact on open space.
Programme and cost	• Estimate of construction program • Estimated capital construction cost • Estimated 50-year operation and maintenance cost • Estimate of future capacity enhancement cost.
Community and stakeholders	• Community benefits • Impact on business • Stakeholders impacted.

Various options for the components of the Rozelle interchange and the Iron Cove Link were scored and ranked against the MCA criteria with suitable options taken further for more in-depth technical and engineering investigation and analysis.

The sections below provide further detail on the evolution of the key project components.

4.5.1 Interchanges

Suitable interchange locations were identified for assessment based on the following criteria:

- Optimising the benefits to and minimising the adverse impacts on local communities and businesses, including minimising property acquisitions and impacts on heritage items and/or conservation areas and providing new and improved active transport outcomes
- Reducing impacts on open space/recreation areas and creating opportunities for new open space/recreation areas
- Integrating with existing and proposed public transport services
- Meeting the project objective to reduce traffic on Parramatta Road, between Haberfield and Camperdown
- Maximising connectivity with, and effectively integrating into, the road network and nearby areas of potential urban development
- Facilitating connections to proposed future road projects
- Minimising impacts on the road network during construction.

Rozelle interchange

The SSIAR included the Rozelle interchange within the Rozelle Rail Yards and provided a link between the Sydney CBD and the mainline tunnels via connections to City West Link, Victoria Road and Anzac Bridge.

The Rozelle Rail Yards are part of a disused former rail corridor owned by the NSW Government. Use of this site was considered beneficial to minimise environmental impacts and acquisition requirements while meeting constructability, connectivity and urban design objectives for the project. However, initial designs of the interchange were predominantly aboveground and included significant elevated structures to achieve connectivity.

The design of the interchange considered:

- Using NSW Government owned land and minimising property acquisition
- Maximising positive urban design solutions for residual land including new open space areas and new and improved active transport links
- Minimising impact on public open space and recreational land
- A connection to the proposed future Western Harbour Tunnel and Beaches Link project
- Maximising connectivity to the surrounding road network and The Bays Precinct
- Minimising impacts on surface water and groundwater
- Minimising impacts on utilities.

Three main concept designs have been considered for the Rozelle interchange:

- Predominantly above ground within the Rozelle Rail Yards
- Predominantly below ground within the Rozelle Rail Yards
- Predominantly below ground and extending north of the Rozelle Rail Yards (subject of this EIS).

Each of these options for the Rozelle interchange is shown in **Figure 4-13**.

Predominantly above ground within the Rozelle Rail Yards

The Rozelle Rail Yards are part of a disused former rail corridor owned by the NSW Government. Use of this site was considered beneficial to minimise environmental impacts and acquisition requirements whilst meeting constructability, connectivity and urban design objectives for the project. However, initial designs of the interchange were predominantly aboveground and included significant elevated structures to achieve connectivity. Key features of these above ground design options included:

- A number of roads at or above the existing ground level of the Rozelle Rail Yards
- A number of bridge structures would be required to enable the various roadway movements to occur. These structures were up to 20 metres above existing ground levels
- More natural drainage flow paths from the north and west of the Rozelle Rail Yards with roads above the drainage channels
- Less contiguous open space opportunities with some parks developed beneath road bridges (with associated shadowing and horticultural impacts and challenges)
- Closure of Easton Park (immediately north of the Rozelle Rail Yards) during construction to enable the Iron Cove Link to be constructed
- Full closure of Lilyfield Road for the duration of construction
- Difficulty achieving the urban design connectivity principals for the project
- Difficulties with flooding and drainage management
- Social and economic impacts
- Reduced area, quality and amenity of residual land.

The large number of constraints associated with the above ground options necessitated refinements to the Rozelle interchange design.

Predominantly below ground within the Rozelle Rail Yards

A decision was made to relocate most of the Rozelle interchange underground and minimise the extent of surface infrastructure within the Rozelle Rail Yards, which provided an opportunity at the Rozelle Rail Yards for improved urban design outcomes and community benefits (consistent with the NSW Government announcement in July 2016 for the development of up to 10 hectares of open space at the Rozelle Rail Yards).

Key features of this design option included:

- Around 95 per cent of infrastructure below the existing ground surface
- Complex ground conditions (a palaeochannel traverses the Rozelle Rail Yards site)
- A very deep interchange (up to 22 metres in some places) requiring significant underground barrier walls to exclude groundwater intrusion
- Significant volume of heavy duty (concrete) deck structure required to cover the roads
- Extensive landscaping above the deck structure to achieve suitable parkland/open space
- Constructability impacts on Easton Park
- Full closure of a section of Lilyfield Road at Easton Park during construction
- Complex road connections that would not be easy for motorists to navigate
- Large volumes of stormwater runoff with high flooding risk, and constrained drainage north–south through the Rozelle Rail Yards
- Opportunities for public open space, subject to loss of usable space for open drains
- Improvements to community connectivity
- Poor sustainability outcomes for construction and operational maintenance.

Of these features above, the construction of and landscaping of a concrete deck to cover the roads was associated with a number of major constraints, including constructability, cost and amenity of the final landform. Design refinements for the Rozelle interchange therefore continued to be investigated.

Predominantly below ground and north of the Rozelle Rail Yards

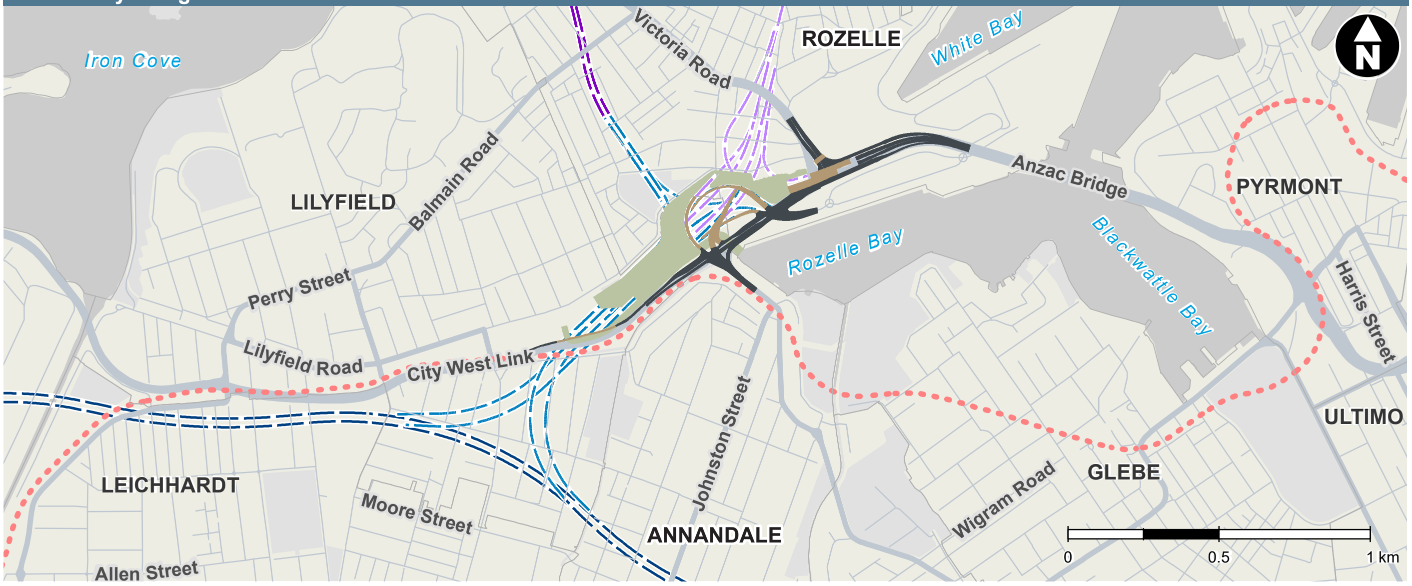
The design of the Rozelle interchange progressed to an option that meets the connectivity requirements and also considers stakeholder and community expectations for the future use of the Rozelle Rail Yards, consistent with the NSW Government announcement in 2016. While the concept design proposes to use part of the Rozelle Rail Yards for surface connections and infrastructure, the tunnel connections as part of the interchange would extend underground beyond the boundaries of the site.

Revising the design in this way takes advantage of favourable ground conditions north of the Rozelle Rail Yards that are more suitable for tunnelling. The concept design of the Rozelle interchange (assessed in this EIS) would provide a safe and easily navigable network of roads, at the surface and below ground. An Urban Design and Landscape Plan (UDLP) would be prepared to facilitate the establishment of landscaping and open space initiatives within the Rozelle Rail Yards. Key features of this design option included:

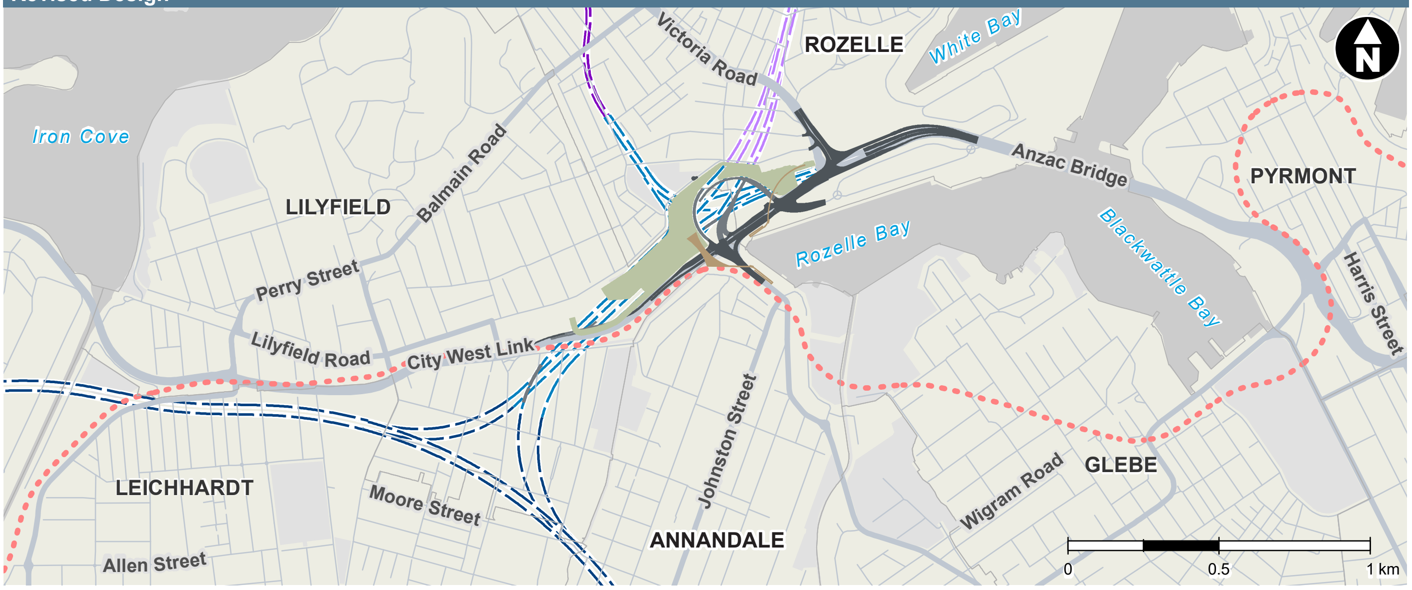
- Predominantly below-ground allows for improved residual land outcomes
- Better open space/recreational land outcome
- Tunnelling in better geotechnical conditions
- A more natural drainage solution that respects existing flow paths
- Constructability activities contained within the Rozelle Rail Yards with no impact on Easton Park
- More easily implemented active transport links
- More extensive tunnelling under residential areas, although at depth.

Other design refinements that were incorporated included the provision of a pedestrian bridge at the western end of the Rozelle Rail Yards. The pedestrian bridge at this location was included to improve active transport connectivity and public access to and across the Rozelle Rail Yards.

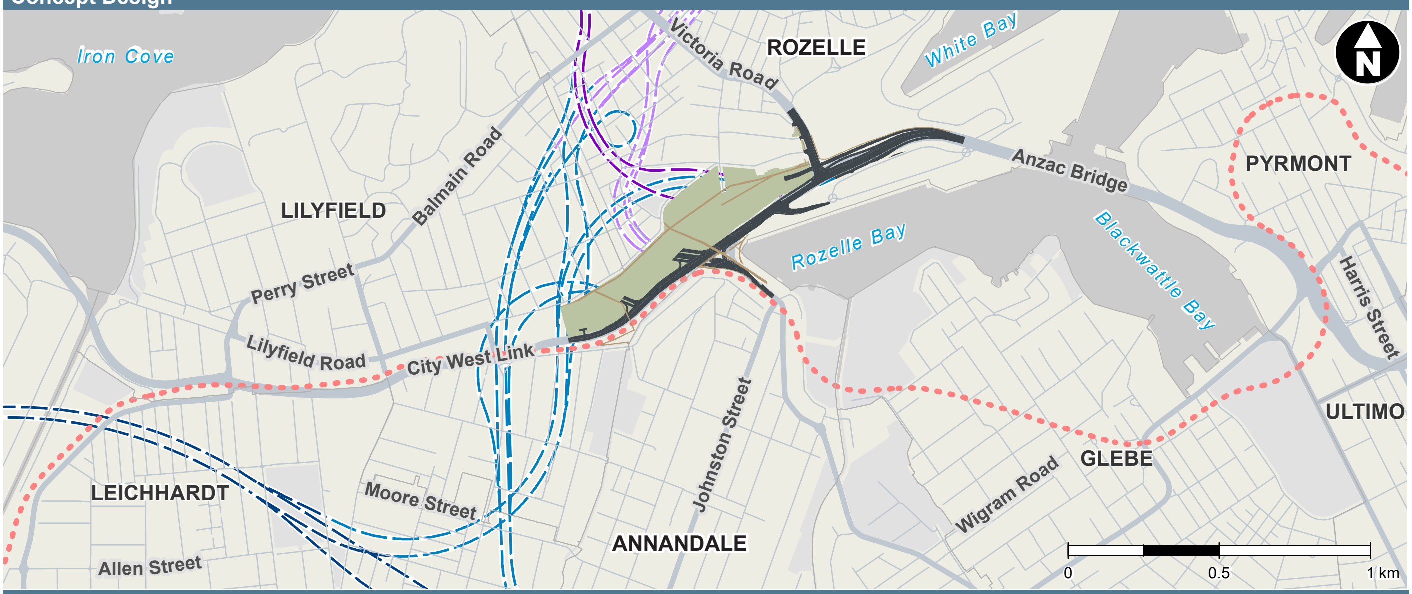
Preliminary Design



Revised Design



Concept Design



LEGEND

M4-M5 Link

- Mainline tunnel
- Iron Cove Link tunnel
- Rozelle interchange tunnel
- Proposed future Western Harbour Tunnel and Beaches Link connections (civil construction only)
- Proposed new open space
- New and upgraded bridge structures
- Surface road upgrade and improvement works
- Potential land bridge and new active transport links

Figure 4-13 Evolution of the Rozelle interchange concept design

Camperdown interchange

The Camperdown interchange is no longer a component of the project. This section provides an outline of the options considered for the interchange and the reasons for removing the interchange from the project.

The preference for a connection at Camperdown was first identified in the WestConnex reference scheme in the *State Infrastructure Strategy*. The Camperdown interchange was intended to provide entry and exit ramps connecting to Parramatta Road for drivers travelling to and from the Sydney CBD. A number of localities were examined for potential ramp locations. Evaluation of alternative locations included potential impacts on open space, heritage items and residential and other sensitive land uses, potential requirements for property acquisition, challenges integrating with the surface road network, constructability and potential impacts on future public transport initiatives and active transport links.

The key difference between the alternative interchange locations related to how future public transport services would be provided for within the road space (including bus rapid transit along Parramatta Road). Following an options evaluation process, the construction of ramps at Arundel Street near the University of Sydney and Royal Prince Alfred (RPA) Hospital was identified in the SSIAR as the preferred outcome.

As the project design progressed, a review of the functionality and potential impacts of the interchange was carried out as part of the design development process and to address feedback received from stakeholders and local communities. The review of the Camperdown interchange identified a number of issues and considerations, including:

- Updated traffic forecasts and land use information reflecting a projected increase in development along Parramatta Road
- Impacts on traffic on other parts of the road network without the Camperdown interchange
- Transport for NSW confirmed its requirements to accommodate current kerb side public transport along Parramatta Road
- Availability of space within the road corridor to avoid property acquisition
- Minimising impacts on heritage items and heritage conservation areas
- Potential impacts from vibration from tunnelling on sensitive equipment at the RPA Hospital and University of Sydney.

Following an assessment of traffic, environmental and community impacts, the Camperdown interchange was removed from the project. The benefits of removing the Camperdown interchange from the project included:

- Avoiding increased traffic demands on Parramatta Road and Broadway (east of the portals) in comparison to an interchange at this location
- By avoiding increasing traffic demand along this section of Parramatta Road, opportunities for future public transport improvements along Parramatta Road would be able to be implemented in a less constrained infrastructure corridor
- Avoiding impacts (direct and indirect) on heritage conservation areas and heritage items such as the University of Sydney and Victoria Park (both nominated for state heritage listing) and a locally listed sandstone retaining wall on the northern side of Parramatta Road
- Avoiding impacts on residential and commercial properties at Camperdown and Forest Lodge from surface works and property acquisition as well as removal of street trees along Arundel Street
- Avoiding potential vibration impacts from tunnelling on sensitive equipment at the University of Sydney and the RPA Hospital
- Avoiding increased traffic demand along Parramatta Road would also support the desired future character of the area along Broadway, including the University of Sydney, Victoria Park and

Broadway Shopping Centre. This area has the potential to be a more public transport and pedestrian-oriented environment.

Traffic that would otherwise have entered or exited the M4-M5 Link via the Camperdown interchange is forecast to redistribute to sections of the surface road network, including on the Anzac Bridge/Western Distributor, sections of Parramatta Road and sections of the St Peters road network. As part of the traffic assessment undertaken for the project, an assessment of the redistribution of traffic and the impact on traffic volumes resulting from the removal of the Camperdown interchange was undertaken (refer to Annexure C of **Appendix H** (Technical working paper: Traffic and transport)).

4.5.2 Mainline Tunnel

Mainline tunnel corridor alignment

The mainline tunnel corridor alignment shown in the *WestConnex Updated Strategic Business Case* and the January 2016 SSIAR for the project was around 9.2 kilometres long (see **Figure 4-6**). The alignment was influenced by underground connections to the Wattle Street interchange at Haberfield and the St Peters interchange at St Peters (fixed locations) and by the location of the proposed Rozelle interchange.

The horizontal and vertical alignment of the tunnel corridor between the fixed points (ie the interchanges) was influenced by the following considerations:

- Investigations into geology, geotechnical (ie ground conditions) and groundwater conditions, especially at tunnel portals and crossings under creeks
- Potential for contamination
- Facilitating drainage
- Avoiding long, steep road gradients that would slow heavy vehicles and increase vehicle emissions
- Location of sensitive receivers above the tunnels (including heritage items, educational institutions, places of worship, hospital and medical facilities) that may be potentially affected during construction of the tunnels
- Location of major underground utilities and services (such as water and sewer mains and fibre optic telecommunications cables) that may be costly to relocate and would substantially extend the duration of construction of the project
- Location of existing or proposed subsurface infrastructure (such as for the Sydney Metro City and Southwest tunnels and the Sydney Water City and Pressure tunnels)
- Future connections to the Sydney motorway network
- Fire and life safety considerations (including emergency egress points from the tunnels).

Geotechnical conditions are a major consideration for tunnelling projects as they determine ground stability to support tunnel infrastructure and the potential for ground movement or settlement at the surface. Geotechnical conditions also affect constructability, including, how difficult, how long and how costly it would be to construct the tunnels.

The decision to remove the Camperdown interchange (see **section 4.5.1**) provided a trigger to review and confirm the suitability of the alignment of the mainline tunnels.

A number of alignment options for the mainline tunnels were considered to achieve optimal connectivity between the M4 East and New M5 as well as with the Rozelle interchange. Issues considered as part of the alignment review included:

- The suitability of geological conditions
- The provision of the shortest travel distance/travel time
- The location of state heritage listed items at Camperdown
- The orientation of the Wattle Street ramps being constructed for the M4 East project

- The proximity of the mainline tunnels to potential construction sites for tunnelling
- Potential vibration and settlement impacts on sensitive equipment at the RPA Hospital and University of Sydney
- The location of the Sydney Metro City and Southwest tunnels
- The location of the Sydney Water Pressure Tunnel and Sydney Water City Tunnel
- The design of the Rozelle interchange.

The alignment review resulted in a shorter mainline tunnel length of around 7.5 kilometres with a more direct connection between the Rozelle interchange and the St Peters interchange. The east–west section of the alignment, between the Wattle Street interchange (being constructed as part of the M4 East project) and the Rozelle interchange, was moved slightly north, while the north–south section between the Rozelle interchange and the St Peters interchange moved further west. These changes to the alignment mean that the mainline tunnels are located around 450 metres and 700 metres west of the RPA Hospital and the University of Sydney at Camperdown respectively.

A detailed description of the mainline tunnel alignment, including connections to the M4 East Motorway at Haberfield, the New M5 Motorway at St Peters, with the Rozelle interchange and the proposed future Western Harbour Tunnel and Beaches Link, is provided in **Chapter 5** (Project description).

Number of tunnel lanes

Three options (two, three or four lanes in each direction, plus merges and tie-ins) were originally considered for the number of traffic lanes within each of the mainline tunnels, and assessed against the project objectives.

The key considerations for selection of the optimal lane configuration are outlined in **Table 4-5**.

Table 4-5 Key considerations for the mainline tunnel lane options

Number of lanes in each direction	Key considerations
Two	• Not sufficient to carry the expected traffic volumes • Costly and disruptive to upgrade to three lanes, which would likely be required not long after project opening.
Three	• Would not allow for long-term capacity for forecast traffic volumes • Would integrate with the M4 East mainline tunnel and New M5 mainline tunnel.
Four	• Would allow for long term capacity for forecast traffic volume • Satisfactory levels of performance in the mainline tunnels • Ensures efficient and safe merging and diverging.

While the initial project concept described in the SSIAR included up to three lanes in each direction, revised traffic modelling, which incorporated updated land use inputs, indicated that amendments to the original three lane configuration were required to maintain acceptable lane functionality and traffic flow within the mainline tunnels in future years. Traffic modelling demonstrated that the mainline tunnels would operate more efficiently under a four-lane configuration, to allow for future demand increases. However, while the majority of the mainline tunnels are designed for four lanes (plus merges and tie-ins, they reduce to three lanes at the M4 East mainline tunnel interface and to two lanes at the New M5 mainline tunnel interface. Where the mainline tunnels connect to the Inner West subsurface interchange, they would be two lanes.

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 5** (Project description).

Connection to the Wattle Street interchange

The initial project concept described in the SSIAR did not specify the nature of the entry ramps to the Wattle Street interchange. The initial design comprised one entry ramp consisting of two traffic lanes. During the project development the design was refined to divide the entry ramp into two one-lane entry ramps.

The Wattle Street interchange entry ramp would divide into two, one-lane entry ramps about midway along the entry ramp around Alt Street at Haberfield. These tunnels would then join with the southbound mainline tunnel before the Inner West subsurface interchange. Motorists traveling to the Rozelle interchange would join on the left side of the southbound mainline tunnel, while motorists traveling to the New M5 Motorway would join on the right side of the southbound mainline tunnel.

By giving motorists the ability to choose a merge location dependent on their destination, this arrangement would make driving in the tunnel safer by reducing the amount of lane changes that motorists may need to carry out on the approach to the Inner West subsurface interchange. Further detail on operational traffic is provided in **Chapter 8** (Traffic and transport) and **Appendix H** (Technical working paper: Traffic and transport).

4.5.3 Iron Cove Link

During the design development process for the Rozelle interchange, a tunnel connection of about one kilometre in length between the Rozelle interchange and Victoria Road, at the eastern abutment of Iron Cove Bridge (the 'Iron Cove Link'), was identified. This link would direct surface traffic travelling from northwest of Rozelle or from the Sydney CBD (via Anzac Bridge) to the Rozelle interchange, allowing vehicles to by-pass Victoria Road (between Iron Cove Bridge and City West Link), which is a corridor that experiences high traffic volumes and congestion.

The inclusion of the Iron Cove Link to the project has the following benefits:

- Reducing traffic along sections of Victoria Road through Rozelle
- Bypassing six sets of traffic lights at intersections along Victoria Road
- Facilitating future urban renewal opportunities and amenity benefits for properties along Victoria Road, east of Iron Cove Bridge
- Enabling an opportunity for improved public transport reliability and future public transport improvements along Victoria Road, east of Iron Cove Bridge
- Creating a motorway standard link for regional traffic from the northwest, including heavy vehicles, to access the New M5 Motorway (once operational) and the Sydney Airport and Port Botany precinct via the project and the future proposed Sydney Gateway
- Assisting with constructability and staging of works for the Rozelle interchange
- Indirectly creating a number of potential opportunities for the local surface road network including public transport, amenity and active transport improvements along Victoria Road as well as improving east-west connectivity across Victoria Road.

During community consultation for the project in August 2016, the possibility was raised of extending the link further to the north to the south side of the Gladesville Bridge at Drummoyne, rather than to Iron Cove Bridge at Rozelle. The rationale for this extension of around 2.5 kilometres was to reduce surface traffic along Victoria Road at Drummoyne and facilitate additional opportunities for urban renewal and public transport improvements in the future. This extension was not further considered as part of the M4-M5 Link project as it:

- Could not be delivered within the existing project budget
- Is not currently identified as a policy priority of the NSW Government
- Would likely require additional property acquisition
- Would require further investigation, including a cost/benefit analysis.

Although this option is outside the scope of the project and was not considered further, the development of the Iron Cove Link does not preclude a further tunnel connection to the north at some stage in the future. Such a proposal would be subject to further investigation, business case and design development, community/stakeholder consultation and environmental assessment.

Tunnel portal locations

Options for the alignment of the Iron Cove Link were determined by the two terminal points, namely the Rozelle interchange and Victoria Road. Potential portal locations along Victoria Road included:

- Between Crystal Lane and Wellington Street, near the site of the current United Petroleum service station
- In the vicinity of Terry Street.

Of the two options, tunnel portals at Crystal Lane were considered to be less desirable as this option would:

- Be in potential conflict with future infrastructure in the reserved CBD Metro corridor. The corridor includes an underground metro station between Darling Street and Wellington Street, immediately to the east of Crystal Street
- Require relocation of a local utilities substation
- Be located within a mixed residential and light industrial zone which, given the nature of existing and historical land uses, is likely to represent a contamination risk
- Compromise the right turn from Victoria Road into Terry Street, which is a significant local traffic movement
- Result in portals further south along Victoria Road which would reduce the desirability of the Iron Cove Link as an alternative route option for motorists and potentially impact traffic flow.

The preferred portal location to the east of Terry Street would maintain the right turn access to Terry Street, allow for a pedestrian crossing across Victoria Road and avoid an additional set of traffic lights on Terry Street.

A more detailed description of the Iron Cove Link is provided in **Chapter 5** (Project description).

4.5.4 Construction of connections to the proposed future Western Harbour Tunnel and Beaches Link at Rozelle

The WestConnex program of works objectives includes providing the ability to connect an additional harbour road crossing and northern beaches motorway, the proposed future Western Harbour Tunnel and Beaches Link, to the WestConnex motorway. This objective builds on the recommendation of the *State Infrastructure Strategy Update 2014* (Infrastructure NSW 2014) to prioritise the proposed future Western Harbour Tunnel and Beaches Link in tandem with, or immediately after, the M4-M5 Link. The location and design of the Rozelle interchange have been selected in consideration of this objective (see **section 4.2**).

To further support this objective and the policy setting from which this objective has been derived, the construction of tunnels, ramps and associated infrastructure at the Rozelle interchange would be carried out to provide connections to the proposed future Western Harbour Tunnel and Beaches Link.

Constructing tunnels, ramps and associated infrastructure as part of the M4-M5 Link project would allow for orderly planning of these respective projects, and would minimise cumulative construction impacts on the community around the Rozelle interchange. This approach would also avoid or minimise potential delays to the delivery of the urban design and landscaping outcome at the Rozelle Rail Yards proposed as part of the project, which may otherwise be delayed and/or staged due to extended use of a portion of this land for construction activities associated with the proposed future Western Harbour Tunnel and Beaches Link.

The proposed future Western Harbour Tunnel and Beaches Link project would be delivered by Roads and Maritime and is currently in the early stages of environmental investigations and design development to support a separate consultation, assessment and approvals process in the future.

4.6 Other project options considered

The following section outlines options considered within the project including:

- Ventilation facilities
- Construction ancillary facility locations
- Construction methodologies
- Spoil transport and disposal.

4.6.1 Ventilation facilities

Ventilation system design

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 is 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 around one-kilometre-long, air flow resulting from the piston effect of the vehicles is adequate to manage in-tunnel air quality. Emission levels increase as vehicles travel through the tunnel. As a result, 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 dispersion of emissions complies 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 4-14**.

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 (ie 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. For these reasons natural ventilation is not practical for longer road tunnels such as those proposed for the project. 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, 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 NorthConnex, M4 East and New M5 tunnels, which are all approved and 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.

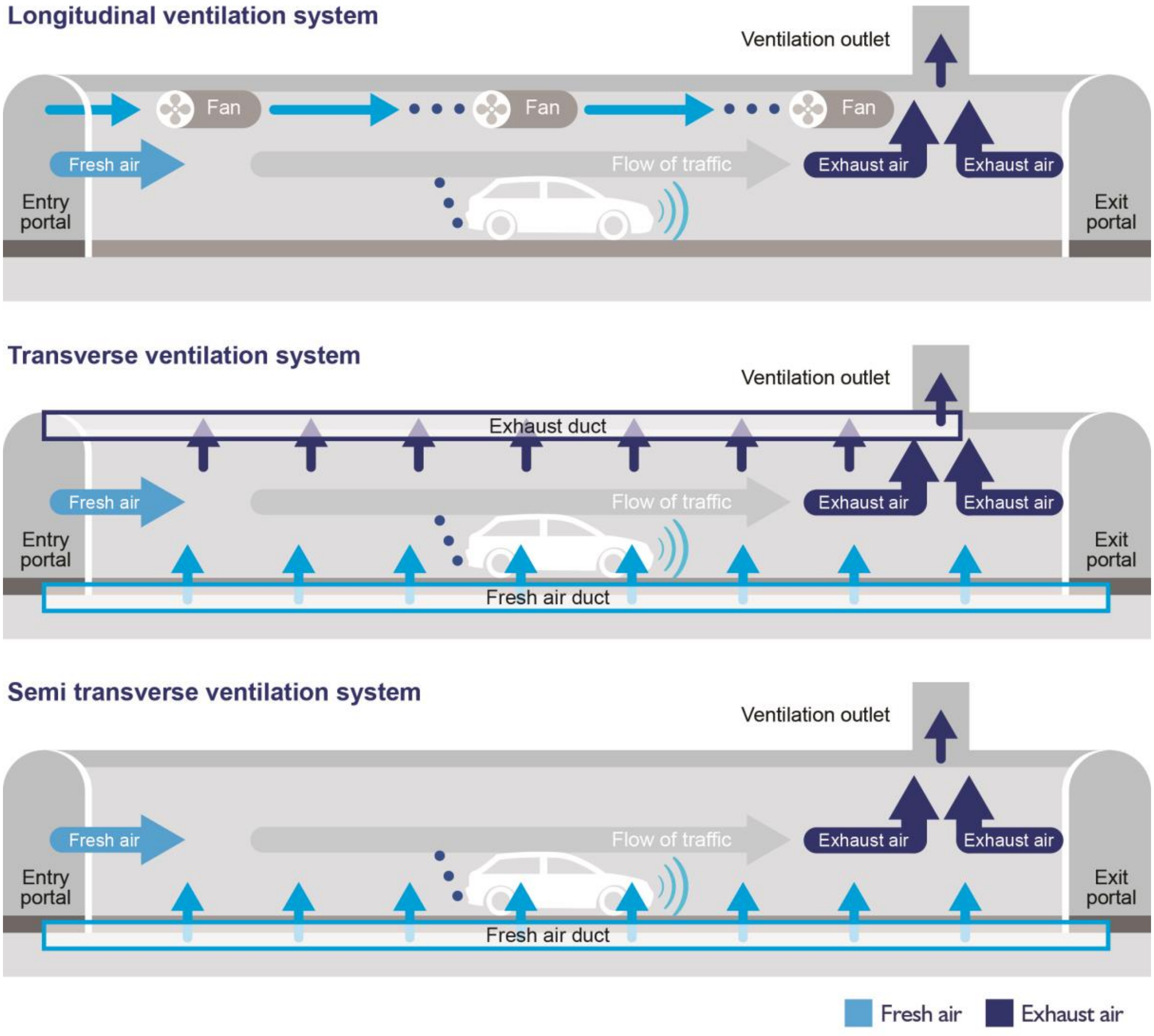


Figure 4-14 Mechanical ventilation system design options

Preferred option

The development of cleaner vehicles in response to cleaner fuel and emissions standards has led to a significant 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) 2014).

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, and the other tunnel projects forming part of the WestConnex program of works, for the following reasons:

- It is less costly to construct and operate than transverse systems
- It is able to ensure emissions are dispersed and diluted so that there is minimal or no effect on ambient air quality
- It is more effective for the management of smoke in a tunnel in the event of a fire
- It is able to meet the requirement to minimise portal emissions as far as practicable.

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 5** (Project description).

Ventilation outlets and portal emissions

Since 1998, a key operating requirement for road tunnels longer than one kilometre in Sydney has been to minimise emissions through the portals, or tunnel exits. Essentially, this means that the ventilation systems are designed to have zero portal emissions, with all air being drawn in from the exit portals against the flow of traffic, and expelled through an elevated ventilation outlet. The ventilation system needed to achieve this requires more fans than it would if portal emissions were permitted, with higher capital and operational costs.

Drawing air from the exit portal increases the quantity of ventilation air to be discharged through the ventilation outlet and can increase the diameter of the outlet required, or require an additional outlet close to the exit portal. The need for zero portal emissions also means that the ventilation fans in the exit ramps need to operate all the time, regardless of whether in-tunnel or ambient air quality warrants this operation. This incurs higher energy usage than if portal emissions were permitted.

The feasibility of allowing portal emissions for the Iron Cove Link was investigated on the basis that it is a short tunnel (about one kilometre) with only two traffic lanes in each direction and therefore it would generate lower pollution concentrations than the larger and longer mainline tunnels. If portal emissions were acceptable, then the construction of at least one and potentially two outlets (ie one at each end of the tunnel), and associated infrastructure including ventilation tunnels, could be avoided. Health impact risk factors applied to the change in concentration of fine particles with a diameter less than 2.5 micrometres (ie $PM_{2.5}$) were used as the criterion for acceptability of portal emissions. This initial screening assessment demonstrated that the criterion would be exceeded and there was therefore no further consideration of portal emissions for the Iron Cove Link.

Air filtration at the ventilation outlet

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 2014; National Health and Medical Research Council 2008). 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 undertaken demonstrates that the ventilation system would be effective in ensuring compliance with the in-tunnel air quality criteria. If in-tunnel air quality levels could not be achieved with the ventilation system proposed, the most effective solution would be the introduction of additional ventilation outlets and additional locations for fresh air supply. The inclusion of tunnel filtration was evaluated and found not to provide any material benefit to air quality or community health, and is discussed in the air quality impact assessment in **Appendix I** (Technical working paper: 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 driven by changes in the surface road traffic.

Ventilation facility locations

The main considerations in relation to ventilation facilities include minimising local air quality impacts on nearby receptors and maximising the operational efficiency of the tunnel ventilation system. Minimising local air quality impacts is primarily achieved through the design and operation of the ventilation outlet. However, the location of road tunnel ventilation outlets is very important for the efficiency of the tunnel ventilation system. The project includes ventilation outlets at Haberfield, St Peters (Campbell Road) and Rozelle (in two locations). More detail on the location of the ventilation facilities is provided below and in **Chapter 5** (Project description).

Background and design considerations that affect location of ventilation facilities

As described above, a longitudinal ventilation system is proposed for the project. A longitudinal system relies on single directional traffic flow; therefore, separate tunnels for northbound and southbound traffic would be required. This also results in the need for a ventilation outlet at each end of the mainline tunnels, with at least one outlet for each tunnel. The location of the project ventilation facilities is shown in **Figure 4-15**.

The ventilation outlets ideally need to be located close to the end of the tunnels, before the exit portals. This allows some air to be drawn into the portals against the traffic flow. This forced reverse flow is achieved by jet fans within the exit ramp and tunnel. Minimising the use of these fans increases the performance of the tunnels and reduces operational power consumption and cost, while providing environmental benefits, by reducing greenhouse gas emissions associated with energy generation.

The locations of ventilation facilities for the project were influenced by the design of the approved M4 East and New M5 projects. Both of these projects take into account the development of ventilation facilities for the M4-M5 Link by providing space in their respective project footprints for the development of these facilities. The construction of the ventilation facility at Haberfield (the Parramatta Road ventilation facility) that would be shared by the M4 East and M4-M5 Link projects was approved and is being constructed as part of the M4 East project, however the fitout and use of the M4-M5 Link section of the ventilation facility is subject to assessment and approval through the M4-M5 Link project. At St Peters, the ventilation facility would be located at the northern end of the project footprint of the New M5 project at the St Peters interchange, however the approval for the construction, fitout and operation of a new ventilation facility for the M4-M5 Link is subject to assessment and approval through the M4-M5 Link project. Locating ventilation facilities within the project footprints of the previous WestConnex projects minimises land acquisition requirements and streamlines the design and construction process for the M4-M5 Link.

The project also includes construction of a ventilation outlet for the proposed future Western Harbour Tunnel and Beaches Link project, as part of the Rozelle ventilation facility at the Rozelle Rail Yards (further detail is provided in **Chapter 6** (Construction work)).

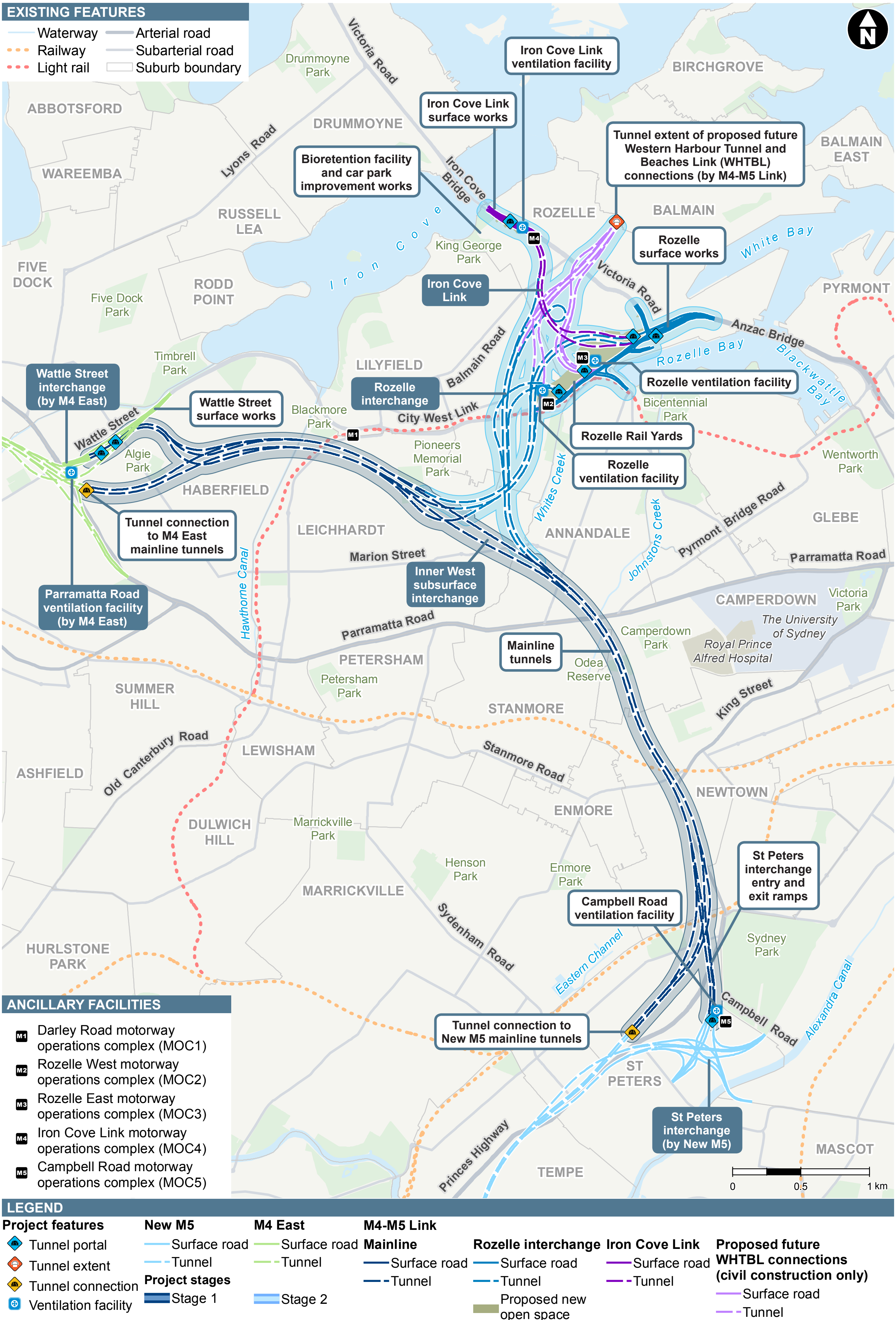


Figure 4-15 Ventilation facility locations

Campbell Road ventilation facility at the St Peters interchange

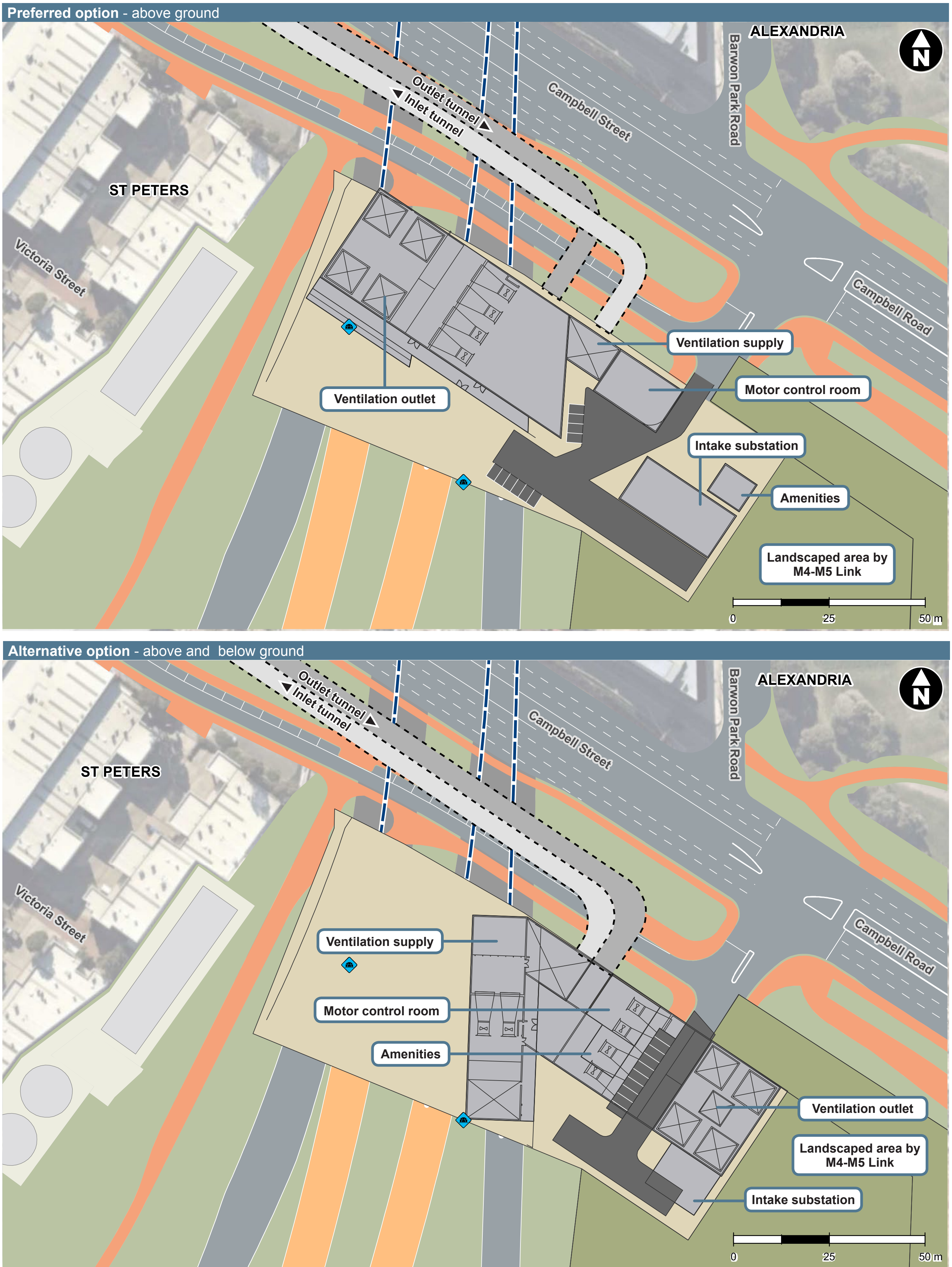
Suitable options for a ventilation facility at the St Peters interchange were investigated to inform the EIS and ongoing design development of the project. A number of options were identified and subject to a screening assessment against a number of criteria, including:

- Proximity to mainline tunnel and entry and exit ramps
- Ventilation facility functional requirements such as proximity to the mainline tunnels and entry and exit ramps
- Future open space and landscaping requirements at the site (as detailed by conditions of approval for the New M5 project)
- Civil Aviation Safety Authority requirements
- Maintenance and operation requirements
- Proximity to the Alexandria Landfill
- Constructability and construction program
- Access for maintenance
- Meeting relevant ambient air quality criteria at closest sensitive receivers.

Two suitable options were identified, as illustrated in **Figure 4-16**, including:

- **A combined underground and surface facility** – this option includes an underground ventilation exhaust facility with an above ground ventilation outlet and ventilation supply building. The ventilation outlet would be around 22 metres high above existing ground level and is located at the north-eastern end of the St Peters interchange
- **An above ground facility** – in this option the ventilation exhaust facilities are on top of the southbound St Peters interchange tunnel portal cover along with the ventilation supply structure. The ventilation outlet would have a height of around 22 metres above existing ground level and is located slightly west of the combined facility location.

The preferred option assessed in this EIS is the above ground facility; however, both options are subject to further engineering investigation and design.



LEGEND

New M5
- Building
- Surface road
- Shared path
- Landscaping
- Proposed future Sydney Gateway connections (non-operational as part of M4-M5 Link)

M4-M5 Link

Mainline tunnel
- Tunnel

Project features
- Tunnel portal

Ventilation facility
- Building
- Car parking
- Ventilation site
- Landscaping
- Ventilation supply tunnel
- Ventilation exhaust tunnel

Figure 4-16 Feasible Campbell Road ventilation facility options

Rozelle ventilation facility at the Rozelle interchange

The Rozelle ventilation facility would be located within the Rozelle interchange at the Rozelle Rail Yards. Locating the ventilation facility within the Rozelle Rail Yards provides a ventilation facility location that would be suitable for both northbound and southbound tunnels. The facility includes three outlets in one location at a height of around 35 metres above existing ground level. The ventilation outlet was initially designed to be a height of around 20–22 metres (as for the Iron Cove Link and Campbell Road ventilation outlets), however in order to meet project air quality objectives in this location while minimising aviation risks, the design was refined to increase the height of the ventilation outlets to around 35 metres above existing ground level.

A number of locations within the Rozelle Rail Yards were considered, having regard to a range of criteria, including:

- The location relative to the mainline tunnels, entry and exit ramps and surface connections including those for the Western Harbour Tunnel and Beaches Link project
- Location of residential receivers to the north along Lilyfield Road (which sit at a higher elevation than the rail yards) and to the south across City West Link
- Location of other infrastructure including water treatment plants, wetlands, drainage channels, and active transport links
- The urban design principles for the project including the provision of open space
- Potential impacts on air quality.

The exact location of the ventilation facility would be determined during the detailed design of the project.

Iron Cove Link ventilation facility at Victoria Road

Two locations have been identified for the Iron Cove Link ventilation facility including:

- **On the southern side of Victoria Road** – this location at Springside Street is within the footprint of residual land created by the project. It is also close to residences and both the outlet (around 20 metres above existing ground level) and the ventilation building (around 12 metres above ground level) would be visible from Victoria Road and from a number of local roads at Rozelle
- **In the centre of Victoria Road** – this location was identified to increase the distance of the ventilation outlet from residences and to provide a more optimal urban design solution by creating a feature in the Victoria Road corridor and the local landscape. The outlet is expected to be around 20 metres above existing ground level. The ventilation building is the same size and in the same location as for the option on the southern side of Springside Street. This is the preferred option assessed in the EIS and described in more detail in **Chapter 5** (Project description).

4.6.2 Construction ancillary facility locations

Twelve construction ancillary facilities have been identified to support the construction of the project. These are sites that would be used during construction of the project for a mix of civil surface works, tunnelling support and administrative purposes. The locations identified for the construction ancillary facilities also give consideration to the following criteria:

- **The locations of key project infrastructure** – where feasible, the construction ancillary facilities would be located within or adjacent to land which would be used for permanent operational infrastructure
- **Co-locating sites with other WestConnex projects where possible** – the project would use construction ancillary facilities approved for use by the M4 East and New M5 projects at Haberfield and St Peters respectively
- **Land is suitable for use** – this included consideration of surrounding land uses, biodiversity and heritage values and minimising disruption to communities
- **Accessibility** – sites would be located close to arterial routes for spoil haulage and would minimise use of local roads through residential areas

- **Minimising private property acquisition** – the aim is to utilise government owned properties where possible
- **Construction program implications** – site selection that would enable construction works to be completed as efficiently as possible.

Twelve construction ancillary facilities are described and assessed in this EIS. The number, location and layout of construction ancillary facilities would be finalised as part of detailed construction planning during detailed design and would meet the environmental performance outcomes stated in the EIS and the Submissions and Preferred Infrastructure Report and satisfy criteria identified in any relevant conditions of approval.

To assist in informing the development of a construction methodology that would manage constructability constraints and the need for construction to occur in a safe and efficient manner, while minimising impacts on local communities, the environment, and users of the surrounding road and other transport networks, two possible combinations of construction ancillary facilities at Haberfield and Ashfield have been assessed in this EIS (see **Table 4-6**). The construction ancillary facilities that comprise these options have been grouped together in this EIS and are denoted by the suffix *a* (for Option A) or *b* (for Option B) eg C1a Wattle Street civil and tunnel site.

Table 4-6 Possible construction ancillary facility combinations at Haberfield and Ashfield assessed in this EIS

Option A	Option B
Wattle Street civil and tunnel site (C1a)	Parramatta Road West civil and tunnel site (C1b)
Haberfield civil and tunnel site (C2a)	Haberfield civil site (C2b)
Northcote Street civil site (C3a)	Parramatta Road East civil site (C3b)

While the Option A sites were identified to minimise the project footprint of the M4-M5 Link and to maximise the use of facilities and infrastructure to be constructed by the M4 East project, the Option B sites provide a number of benefits over the Option A sites including:

- Avoid or minimise impacts to the timing of delivery of the M4 East Urban Design and Landscape Plan and the M4 East Legacy Project around Walker Avenue at Haberfield, by minimising the amount of land at the surface that would be used for construction of the M4-M5 Link project
- Avoid construction fatigue for receivers adjacent to the Option A sites such as along Wattle Street, Walker Avenue and Northcote Street due to concurrent project construction for the M4 East and M4-M5 Link projects. Notwithstanding this, the Parramatta Road West civil and tunnel site (C2b) would be adjacent to a construction site for the M4 East project, which would mean nearby receivers, particularly around Bland Street at Ashfield, would be subject to cumulative construction impacts (such as construction fatigue)
- Safeguard the project program by limiting dependence on the completion of M4 East works at the Option A sites before these sites can be made available for use for construction of the project.

Throughout the development of the project, a number of potential construction ancillary facility sites were investigated but were excluded from the project for various reasons. These sites and the reasons they do not form part of the project are outlined in **Table 4-7**. The location of these sites is shown in **Figure 4-17**. Other design refinements related to construction ancillary facilities included limiting construction activities at Darley Road civil and tunnel site (C4) to standard construction hours only, where out-of-hours works were initially proposed. The refinement was included to minimise noise impacts on surrounding receivers and minimise heavy vehicle movements on local roads outside standard construction hours. This refinement was made following consultation with relevant stakeholders and the community.

Chapter 5 (Project description) includes details of the locations of the construction ancillary facilities that do form part of the project. Refer to **Chapter 6** (Construction work) for further information on the anticipated works planned at each site and the indicative timing for these works. The potential impacts associated with the construction ancillary facility sites are presented in the relevant technical impact assessment chapters in this EIS.

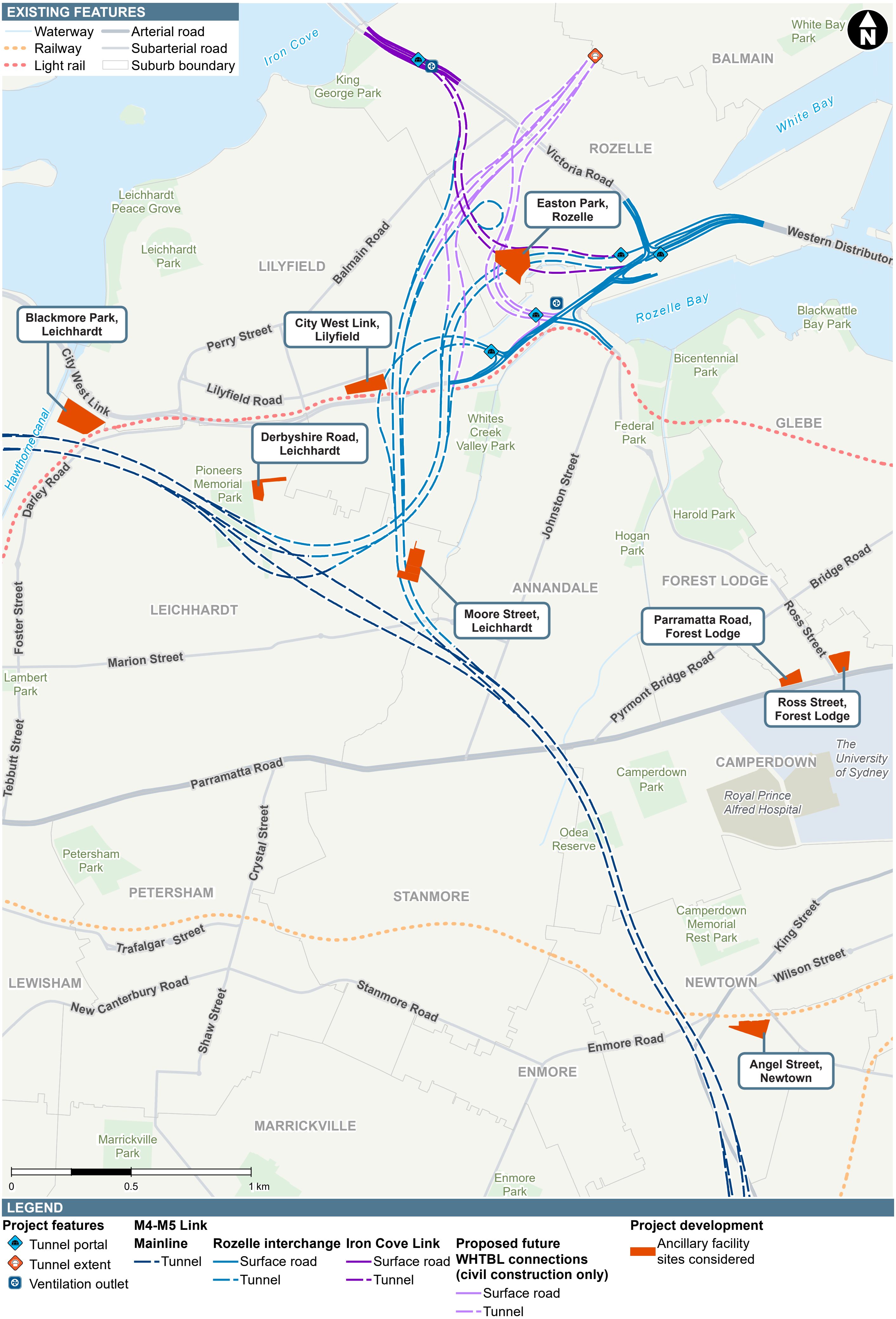


Figure 4-17 Construction ancillary facility sites that were investigated but do not form part of the project

Table 4-7 Construction ancillary facility options that were investigated but do not form part of the project

Site name	Works proposed	Reasons for excluding this site	Project function provided by
Blackmore Park, Leichhardt	Tunnel and civil site – support tunnelling of the mainline tunnels including launching road headers and spoil management and haulage	Would require temporary loss of passive and active open space and vegetation removal. Community and stakeholder feedback requesting that impacts on public open space be avoided was also taken into consideration during relocation of the ancillary facility site. Access to the site was constrained by a narrow road (Canal Road) and the restricted height clearance under the light rail bridge.	Darley Road civil and tunnel site (C4)
Easton Park, Rozelle	Tunnel and civil site - construct the dive and cut and cover tunnel portals to connect the surface roads at the Rozelle interchange to the Iron Cove Link tunnel	Would require temporary loss of passive and active open space, vegetation removal and impacts on heritage items (Easton Park and Sydney Water sewage pumping station). Community and stakeholder feedback requesting that impacts on public open space be avoided was also taken into consideration during relocation of the ancillary facility site. Design optimisation led to the relocation of cut-and-cover tunnel structures to within the Rozelle Rail Yards, therefore this site could be avoided. Community and stakeholder feedback requesting that impacts on public open space be avoided were also taken into consideration during relocation of the ancillary facility site. Use of this site also required closure of part of Lilyfield Road.	Rozelle civil and tunnel site (C5)
Moore Street, Leichhardt	Tunnel and civil site – support tunnelling of the mainline tunnels including launching road headers and spoil management and haulage	There is the potential for the site to be contaminated given current and previous land uses. Alternative sites in the vicinity that would result in less property impacts were identified. Potential access constraints for heavy vehicles between the site and the arterial road network, and the associated amenity impacts on nearby receivers along the haulage route, were also taken into consideration.	Darley Road civil and tunnel site (C4)
Ross Street, Forest Lodge	Tunnel and civil site – support tunnelling of the mainline tunnels including launching road headers and spoil management and haulage	Removal of the Camperdown interchange and subsequent change to the mainline tunnel alignment meant that the length of the temporary construction access tunnel from this site increased, which would have resulted in significant delays to the construction program. Limitations on access for heavy vehicles between this site and the arterial road network were also taken into consideration during relocation of the	Pyrmont Bridge Road tunnel site (C9)

Site name	Works proposed	Reasons for excluding this site	Project function provided by
		construction ancillary facility. Proximity to heritage items and the education precinct of University of Sydney were raised as concerns by stakeholders.	
Parramatta Road, Forest Lodge	Tunnel and civil site – support tunnelling of the mainline tunnels including launching road headers and spoil management and haulage	Removal of the Camperdown interchange and subsequent change to the mainline tunnel alignment meant that the length of the temporary construction access tunnel from this site increased, which would have resulted in significant delays to the construction program. Limitations on access for heavy vehicles between this site and the arterial road network were also taken into consideration during relocation of the construction ancillary facility. Proximity to heritage items and the education precinct of University of Sydney were raised as concerns by stakeholders.	Pyrmont Bridge Road tunnel site (C9)
City West Link, Lilyfield	Tunnel and civil site – support tunnelling of the mainline tunnels including launching road headers and spoil management and haulage	The temporary access tunnel between the site and the mainline tunnels would be around 750 metres in length. Constructing this temporary access tunnel before tunnelling of the mainline could begin from this site would have resulted in substantial construction program delays. There is the potential for the site to be contaminated given current and previous land uses. The site is in proximity to active light rail corridor facilities and would require tunnelling under the light rail line. There are level differences between the site and surrounding roads which would constrain access.	Rozelle civil and tunnel site (C5)
Angel Street/ Railway Lane, Newtown	Tunnel and civil site – support tunnelling of the mainline tunnels including launching road headers and spoil management and haulage	The site, including the buildings associated with the former Newtown Tram Depot, is listed on the state heritage register. There is the potential for the site to be contaminated given current and previous land uses. Heavy vehicles would need to use narrow, one-way local roads to access the site, which would have resulted in amenity impacts on nearby receivers. There was a high potential for the site to be contamination, given its previous land uses. The site was in close proximity to an active rail corridor and residential areas. Distance of this site to the arterial	Campbell Road civil and tunnel site (C10)

Site name	Works proposed	Reasons for excluding this site	Project function provided by
		road network posed constraints for spoil haulage.	
Derbyshire Road, Leichhardt	Tunnel and civil site – support tunnelling of the mainline tunnels including launching road headers and spoil management and haulage Subsequently, construction workforce parking	The site was immediately adjacent to Sydney Secondary College Leichhardt Campus, a sports oval, the State Transit – Leichhardt Depot and Pioneers Memorial Park. Heavy vehicles would have to utilise Derbyshire Road. A locally listed heritage item (Former State Rail Authority cable store and traffic office, including interiors, which includes two buildings) would be required to be demolished. Community and stakeholder feedback requested that consideration be given to relocating this site.	Darley Road civil and tunnel site (C4)

4.6.3 Tunnel construction methodologies

A number of tunnel construction methods were considered and are described in the following sections.

Tunnel boring machine

A tunnel boring machine (TBM) is a specialist machine that excavates a circular bore of fixed diameter by rotary action. The machine comprises a rotating head fitted with disc cutters, drag bits and clay spade. Soft ground TBMs include a facility for the fixing of fabricated permanent wall lining panels (generally precast concrete) immediately behind the cutting face. Hard ground (rock) TBMs include a gripper facility that allows the TBM to push off the wall of the excavation. TBMs 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.

Drill and blast

The drill and blast excavation method involves a sequence of drilling holes, charging the holes with explosive, 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. This method offers the shortest exposure to noise and vibration for residents and businesses above the tunnels, compared to other methods of tunnel excavation.

Roadheader excavation

Roadheaders are commonly used for excavation in sandstone and have been successfully used in other tunnel projects in Sydney, including other WestConnex projects. A roadheader is specialised tunnelling equipment that excavates with picks mounted on a rotary cutter head attached to a hydraulically operated boom. In areas of very hard rock, ripper dozers and rock breakers would also be used to assist with the excavation. The excavated material would be continually removed by conveyors onto dump trucks designed to operate underground. The excavated material would then be stockpiled near the tunnel entrance, from where it would be removed via truck for disposal or reuse. As the excavation advances, temporary or permanent ground support would be installed behind the excavation face. The support could be permanent or temporary and would normally include rock bolts, steel mesh and sprayed concrete.

Roadheaders offer advantages over tunnel boring machines for:

- The excavation of varying cross sections, caverns and niches

- The excavation of cross passages
- The ease by which roadheaders can be moved to different parts of the tunnel alignment.

Preferred tunnel construction method

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

- The combination of methods speeds up excavation compared to work being undertaken solely with roadheaders
- It is more economic because it takes less time and generates less spoil than a tunnel boring machine
- The road geometry and cross-sectional dimensions of the project tunnels precludes the use of TBMs for excavation
- It reduces the noise and vibration impacts on residential and commercial properties due to the shorter duration impacts associated with blasting compared to other tunnel construction methods
- Geological conditions along the alignment are suitable for both roadheader excavation and drill and blast methods.

Further detail on the tunnelling construction approach is provided in **Chapter 6** (Construction work).

4.6.4 Spoil storage, transport and disposal options

Construction of the project would generate around 4.5 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

The development of the project identified and incorporated the opportunity to store spoil within the M4 East project tunnels at Haberfield. The refinement was included to reduce heavy vehicle movements on surface roads (and associated traffic congestion and noise impacts on adjacent receivers) and minimise potential for dust mobilisation and associated air quality impacts.

Spoil transport options

Rail

The benefit of rail as a spoil transport option is the ability to move large volumes, while reducing the number of heavy vehicle movements on the wider road network. However, this method presents the following issues:

- There are very few spare train paths on the Sydney rail network, which presents logistical challenges
- The material would need to be double (or possibly 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, if this does not have rail access
- Infrastructure upgrades would potentially be required at rail yards which are part of the Sydney Metropolitan Freight Network (at Port Botany or Enfield) to allow the 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. However, this option presents a number of issues including:

- 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 potentially be required to allow the barge loading facility to receive the material.

Notwithstanding this, further investigations would be undertaken of spoil transport options, including the potential barging of spoil, during detailed design.

Heavy vehicle

Spoil removal using heavy vehicles (ie 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 (around 25–30 cubic metres per truck), a large number of truck movements would be required. The use of trucks would therefore streamline the handling of spoil as no double or triple handling would be required, but would result in a higher number of trucks on the road. This increase is considered acceptable given trucks are the most appropriate transport option for the location of the spoil disposal sites. Transport by other transport options (rail and barging) would still require trucks to initially move material to the loading facility and, potentially, to the final destination.

Heavy vehicles are the preferred spoil transport option for the project. **Chapter 8** (Traffic and transport) provides a summary of heavy vehicle movements, including spoil related haulage. A summary of spoil haulage routes from the various construction sites is provided in **Chapter 23** (Resource use and waste minimisation). Use of local roads would be avoided where possible, with the main haulage routes being via major arterial roads such as City West Link, Parramatta Road, the M4 Motorway, the Princes Highway and the M5 Motorway. There may be an opportunity for spoil generated at the Haberfield and St Peters ends of the mainline tunnel to be transported via the completed M4 East and New M5 tunnels rather than via surface roads, where practicable. This option would be investigated further by the construction contractor.

Spoil reuse and disposal options

As described in **Chapter 23** (Resource use and waste minimisation), spoil would be beneficially reused as part of the project before alternative spoil disposal options, such as other infrastructure or development projects, were pursued. Residual spoil waste which cannot be reused or recycled would be disposed of to 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 shafts and declines. At least 95 per cent of usable (eg uncontaminated) construction and demolition waste is anticipated to be reused and/or recycled as part of the project.

Six potential spoil management sites, ranging from between 25 to 50 kilometres from the project footprint, have been identified as possible receiving sites for excess spoil from the project. During the development of the project, the proposed Western Sydney Airport was also identified as a potential spoil management site. Determination of the final destination(s) for spoil from construction of the project would be made 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.