CHATSWOOD TO SYDENHAM

ENVIRONMENTAL IMPACT STATEMENT

MAY 2016

TECHNICAL PAPER 1: TRAFFIC AND TRANSPORT

Sydney Metro Chatswood to Sydenham

Transport for NSW

Technical Paper 1: Traffic and Transport

May 2016

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Project overview

Sydney Metro is a new standalone rail network identified in Sydney's Rail Future. The Sydney Metro network consists of Sydney Metro City & Southwest and Sydney Metro Northwest.

The proposed Sydney Metro City & Southwest comprises two core components:

- The Chatswood to Sydenham project (the project), the subject of this technical paper, would involve construction and operation of an underground rail line between Chatswood and Sydenham
- The Sydenham to Bankstown upgrade would involve the conversion of the 13.5 kilometre Bankstown line to metro standard and upgrade of existing stations between Sydenham and Bankstown.

The Sydenham to Bankstown upgrade will be subject to a separate environmental impact assessment.

Investigations have started on the possible extension of Sydney Metro from Bankstown to Liverpool. The potential extension would support growth in Sydney's south west by connecting communities, businesses, jobs and services as well as improving access between the south west and Sydney's CBD. It would also reduce growth pressure on road infrastructure and the rail network, including the potential to relieve crowding on the T1 Western Line, T2 South Line and T2 Airport Line.

The Sydney Metro Chatswood to Sydenham project (the project) involves the construction and operation of a metro rail line. The project would be mainly located underground in twin tunnels extending from Chatswood on Sydney's north shore, crossing under Sydney Harbour, and continue to Sydenham.

The key components of the project would include:

- About 15.5 kilometres of twin rail tunnels (that is, two tunnels located side-by-side) between Mowbray Road, Chatswood and north of Sydenham Station (near Bedwin Road, Marrickville)
- Realignment of the existing T1 North Shore Line surface track within the existing rail corridor between Chatswood Station and in the vicinity of Brand Street, Artarmon, including a new bridge for a section of the 'down' (northbound) track to pass over the proposed northern dive structure
- About 250 metres of aboveground metro tracks between Chatswood Station and the Chatswood dive structure
- A dive structure (about 400 metres long) and tunnel portal south of Chatswood Station and north of Mowbray Road, Chatswood (the Chatswood dive structure)
- A substation (for traction power supply) at Artarmon
- Metro stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street and Waterloo; and new underground platforms at Central Station
- A dive structure (about 400 metres long) and tunnel portal between Sydenham Station and Bedwin Road, Marrickville (the Marrickville dive structure)
- A services facility (for traction power supply and an operational water treatment plant) adjacent to the Marrickville dive structure.

The project would also include a number of ancillary components, including new overhead wiring and alterations to existing overhead wiring, signalling, access tracks / paths, rail corridor fencing, noise walls, fresh air ventilation equipment, temporary and permanent alterations to the road network, facilities for pedestrians, and other construction related works.

Approach to traffic and transport assessment

The construction impact assessment is based on the analysis of existing traffic movements on the local road network at each site to determine the current operational performance. Construction traffic is then added to the networks and analysed to identify potential impacts to road network performance.

The assessment of intersection performance was undertaken using LinSig (version 3.2).

Heavy vehicle routes identified for access to and egress from construction sites were developed in the context of minimising impacts on local streets and maximising use of arterial roads. The suggested heavy vehicle routes are indicative only and are subject to further refinement. The proposed construction routes for all construction sites are provided as part of the site-specific discussions in this technical paper.

A qualitative assessment of the impacts of the construction on the walking, cycling and public transport networks has also been undertaken at each construction site.

A qualitative assessment of the operation of each Metro station has been undertaken and includes assessment of the impacts and integration at each station, including any upgrades in the immediate vicinity of the station being undertaken to enable the project to operate.

The assessment uses patronage forecasts provided by Transport for NSW and includes active travel, public transport and private vehicle access to and from each station.

The patronage forecasts were produced for 2036 based on land use planning projections available from the Department of Planning and Environment. However, the design year adopted for the project is 2056 to ensure the design of the stations would be able to accommodate future growth.

Overview of potential impacts

The potential impacts of the project would primarily occur during the construction phase and have been identified as the following:

- Potential deterioration of intersection performance around construction sites
- Potential safety implications for pedestrians, cyclists and motorists especially around construction access and egress points
- Temporary closure of pedestrian and cyclists facilities during construction at Chatswood, Crows Nest, Martin Place and Central
- Temporary closure of access and egress points to the Sydney Trains Martin Place Station
- Temporary relocation of bus stops and minor delays to bus services on routes around the construction sites
- Delays for customers during track possessions required for construction
- Temporary loss of parking spaces, especially at the Barangaroo Station construction site.

Summary of mitigation response

Haul routes for the project have been developed with the following aims:

- Minimise the use of local or residential streets and maximise the use of arterial roads
- Minimise potential safety implications for pedestrians, cyclists and other road users
- Avoid the need to pass through or under the Sydney CBD for the construction sites external to the Sydney CBD
- Exit the Sydney CBD as efficiently as possible for the Sydney CBD construction sites
- Minimise the cumulative use of roads by trucks accessing different Sydney CBD construction sites.

In addition, a summary of the main mitigation measures is as follows:

- Road Safety Audits would be carried out at each construction site. Audits would address vehicular access and egress, and pedestrian, cyclist and public transport safety.
- Vehicle access to and from construction sites would be managed to ensure pedestrian, cyclist and motorist safety. Depending on the location, this may require manual supervision, physical barriers, temporary traffic signals and modifications to existing signals or, on occasions, police presence.
- Any relocation of bus stops would be carried out by Transport for NSW in consultation with Roads and Maritime Services, the CBD Coordination Office (for relevant locations), the relevant local council and bus operators. Wayfinding and customer information would be provided to notify customers of relocated bus stops.
- Construction site traffic would be managed to minimise movements in the AM and PM peak periods.
- Construction site traffic immediately around construction sites would be managed to minimise movements through school zones during pick up and drop off times.
- Pedestrian and cyclist access would be maintained at Crows Nest during the temporary closure of Hume Street, and at Martin Place during the temporary partial closure of Martin Place. Wayfinding and customer information would be provided to guide pedestrians and cyclists to alternative routes.
- Timing for the temporary closure of the Devonshire Street tunnel would avoid periods of peak pedestrian demand. Wayfinding and customer information would be provided to guide pedestrians to alternative routes.
- During the closure of existing entrances to Martin Place Station, marshalls would be provided during the AM and PM peak periods to direct customers to available access and egress points.
- Consultation would occur with the Harbour Master to ensure shipping channels are maintained during the Sydney Harbour ground improvement works.

Glossary of terms and acronyms

Term	Meaning
½ P, 1P or 2P	Parking restrictions for various lengths of time, for example ½ hour, 1 hour or 2 hours.
Average Delay	Duration, in seconds, of the average vehicle waiting time at an intersection
CBD	Central Business District
DoS	Degree of Saturation – the ratio between traffic volumes and capacity (v/c) of the intersection used to measure how close to capacity an intersection is operating. The DoS is a direct measure of the congestion level at the intersection. As DoS approaches 1.0, both queue length and delays increase rapidly. Satisfactory operations usually occur with a DoS range between 0.8-0.9 or below
EIS	Environmental Impact Statement
ETCM	Enhanced Train Crowding Model
LinSig	Multi-intersection modelling software for corridor or small network analysis
LOS	Level of Service – An index of the operational performance of traffic on a given traffic lane, carriageway or road when accommodating various traffic volumes under different combinations of operating conditions.
NYE	New Year's Eve
PCU	Passenger Car Unit
PTPM	Public Transport Project Model
RMS	Roads and Maritime Services
SCATS	Sydney Coordinated Adaptive Traffic System - An urban traffic control system that optimises traffic flow. SCATS responds automatically to fluctuations in traffic flow through the use of vehicle detectors.
SEARs	Secretary's Environmental Assessment Requirements
Single Unit Truck	Construction vehicle – 10 cubic metre capacity, maximum length 12.5 metres or 8.8 metres.
T1 North Shore & Northern Line	Sydney Trains line - City to Berowra via Gordon, City to Hornsby via Macquarie University
T2 Inner West & South Line	Sydney Trains line - Campbelltown or Leppington to City
T3 Bankstown Line	Sydney Trains line - Liverpool or Lidcombe to City via Bankstown
T3 Lane	Transit lane to provide improved travel for buses, taxis and other vehicles carrying multiple occupants. They can also be used by emergency vehicles, motorcycles and bicycles.
Transport for NSW	Transport for New South Wales
Truck and Dog	Construction vehicle - 20 cubic metre capacity, maximum length 19 metres

1. Introduction

1.1 Project background

Sydney Metro is a new standalone rail network identified in Sydney's Rail Future. The Sydney Metro network consists of Sydney Metro City & Southwest and Sydney Metro Northwest.

The proposed Sydney Metro City & Southwest comprises two core components:

- The Chatswood to Sydenham project (the project), the subject of this technical paper, would involve construction and operation of an underground rail line between Chatswood and Sydenham
- The Sydenham to Bankstown upgrade would involve the conversion of the 13.5 kilometer Bankstown line to metro standards and upgrade of existing stations between Sydenham and Bankstown.

Both components are subject to assessment by the Department of Planning and Environment and approval by the Minister for Planning under Part 5.1 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act). The Sydenham to Bankstown upgrade would be subject to a separate environmental impact assessment.

Sydney Metro Northwest (formerly the North West Rail Link) is currently under construction, services will start in the first half of 2019. This includes a new metro rail line between Rouse Hill and Epping and conversion of the existing rail line between Epping and Chatswood to metro standards.

Investigations have started on the possible extension of Sydney Metro from Bankstown to Liverpool. The potential extension would support growth in Sydney's south west by connecting communities, businesses, jobs and services as well as improving access between the south west and Sydney's CBD. It would also reduce growth pressure on road infrastructure and the rail network, including the potential to relieve crowding on the T1 Western Line, T2 South Line and T2 Airport Line.

The Sydney Metro Delivery Office has been established as part of Transport for NSW to manage the planning, procurement and delivery of the Sydney Metro network.

The Sydney Metro rail network is shown in **Figure 1.1**.

1.2 The Sydney Metro network

The customer experience underpins how Sydney Metro is being planned and designed. The customer experience incorporates all aspects of travel associated with the transport network, service and project including:

- The decision on how to travel
- The travel information available
- The speed and comfort of the journey
- The range and quantity of services available at stations, interchanges and within station precincts.

A high quality 'door to door' transport product is critical to attract and retain customers and also to meet broader transport and land use objectives. This includes providing a system that is inherently safe for customers on trains, at stations and at the interface with the public domain; providing direct, comfortable, legible and safe routes for customers between transport modes; and provide a clean, pleasant and comfortable environment for customers at stations and on trains.

Key features of the metro product include:

- Comfortable carriages with space for customers to sit or stand
- A ‘turn-up-and-go’ service, with high frequency trains, reduced journey times with faster trains, and new underground routes through the Sydney CBD
- Increased capacity to safely and reliably carry more customers per hour due to the increased frequency of trains
- Reduced dwell times at stations as each carriage would be single-deck with three doors, allowing customers to board and alight more quickly than they can with double-deck carriages.

The Chatswood to Sydenham project would have the capacity to run up to 30 trains per hour through the Sydney CBD in each direction, which would provide the foundation for delivering a 60 per cent increase in the number of trains operating in peak periods, and cater for an extra 100,000 customers per hour.

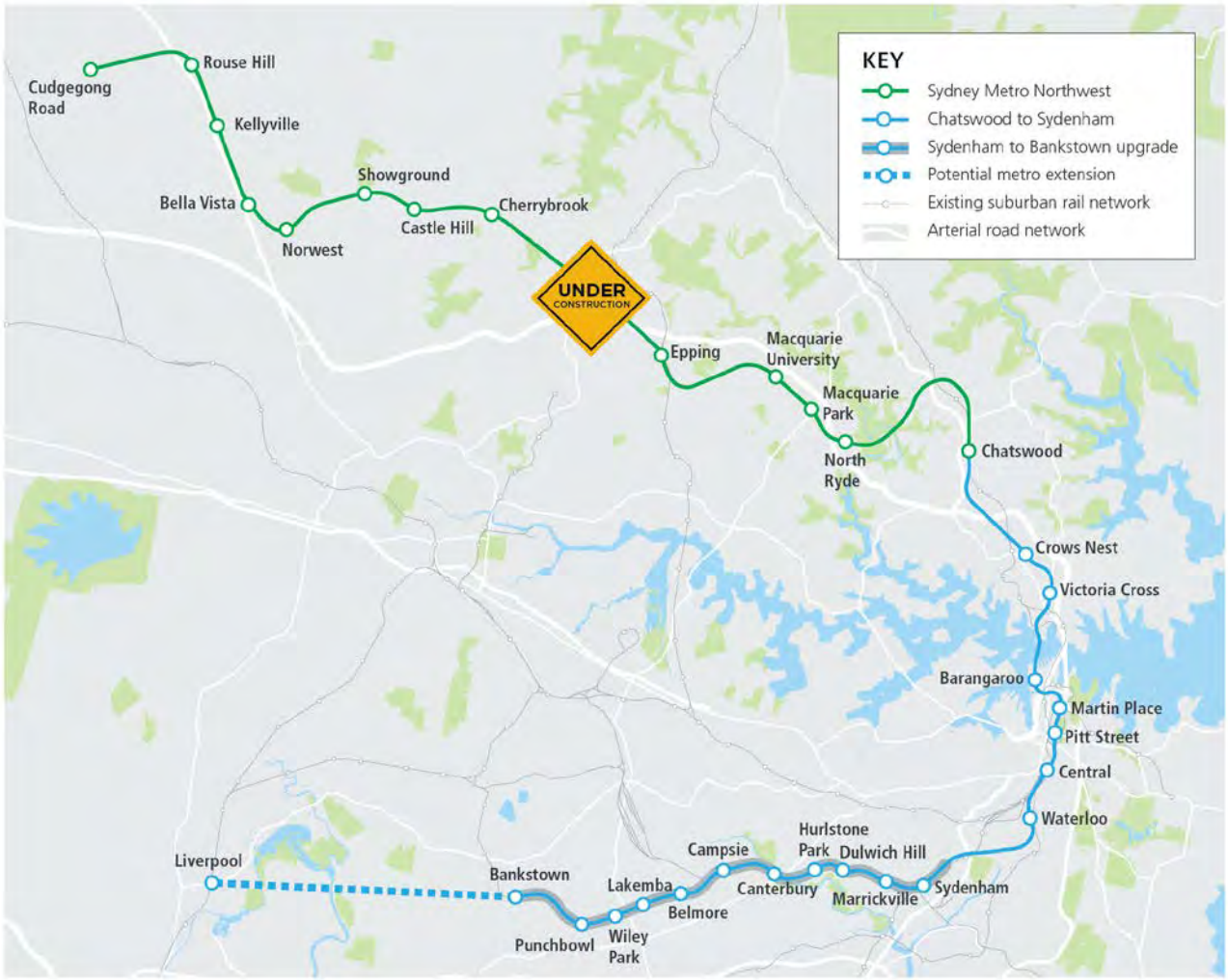


Figure 1.1 The Sydney Metro network

1.3 Overview of the project

1.3.1 Location

The Sydney Metro Chatswood to Sydenham project (the project) involves the construction and operation of a metro rail line. The project would be mainly located underground in twin tunnels extending from Chatswood on Sydney's north shore, crossing under Sydney Harbour, and continue to Sydenham.

1.3.2 Key features

The proposed alignment and key operational features of the project are shown in **Figure 1.2** and would include:

- Realignment of the T1 North Shore Line surface track within the existing rail corridor between Chatswood Station and Brand Street, Artarmon, including a new bridge for a section of the 'down' (northbound) track to pass over the proposed northern dive structure
- About 250 metres of aboveground metro tracks between Chatswood Station and the Chatswood dive structure
- A dive structure (about 400 metres long) and tunnel portal south of Chatswood Station and north of Mowbray Road, Chatswood (the Chatswood dive structure)
- About 15.5 kilometres of twin rail tunnels (that is, two tunnels located side-by-side) between Mowbray Road, Chatswood and Bedwin Road, Marrickville. The tunnel corridor would extend about 30 metres either side of each tunnel centre line and around all stations
- A substation (for traction power supply) in Artarmon, next to the Gore Hill Freeway, between the proposed Crows Nest Station and the Chatswood tunnel portal
- Metro stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street and Waterloo; and new underground platforms at Central Station
- A dive structure (about 400 metres long) and tunnel portal between Sydenham Station and Bedwin Road, Marrickville (the Marrickville dive structure)
- A services facility beside the Marrickville dive structure and tunnel portal, including a tunnel water treatment plant and a substation (for traction power supply).

The project would also include:

- Permanent closure of the road bridge at Nelson Street, Chatswood, and provision of an all vehicle right-turn movement from the Pacific Highway (southbound) into Mowbray Road (westbound)
- Permanent changes to arrangements for maintenance access from Hopetoun Avenue, Drake Street and Albert Avenue, Chatswood as well as a new access point from Brand Street, Artarmon
- Underground pedestrian links at some stations and connections to other modes of transport (such as the existing suburban rail network) and surrounding land uses
- Alterations to pedestrian and traffic arrangements and public transport infrastructure (where required) around the new stations and surrounding Central Station
- Installation and modification of existing Sydney Trains rail systems, including overhead wiring, signalling, rail corridor fencing and noise walls, within surface sections at the northern end of the project
- Noise barriers (where required) and other environmental protection measures.

The proposed construction activities for the project broadly include:

- Demolishing buildings and structures at the station sites and other construction sites
- Constructing tunnels, dive structures and tunnel portals
- Carrying out surface works between Chatswood Station and Brand Street, Artarmon
- Excavating, constructing and fitting out metro stations
- Fitting out tunnel rail systems and testing and commissioning of stations, tunnels, ancillary infrastructure, rail systems and trains
- Excavating shafts, carrying out structural work and fitting out ancillary infrastructure at Artarmon
- Carrying out structural work and fitting out ancillary infrastructure at Marrickville.

A number of construction sites would be required to construct the project. These include locations for tunnel equipment and tunnel boring machine support at Chatswood, Barangaroo and Marrickville as well as at station sites; a casting yard and segment storage facility at Marrickville and a temporary tunnel boring machine retrieval site at Blues Point.

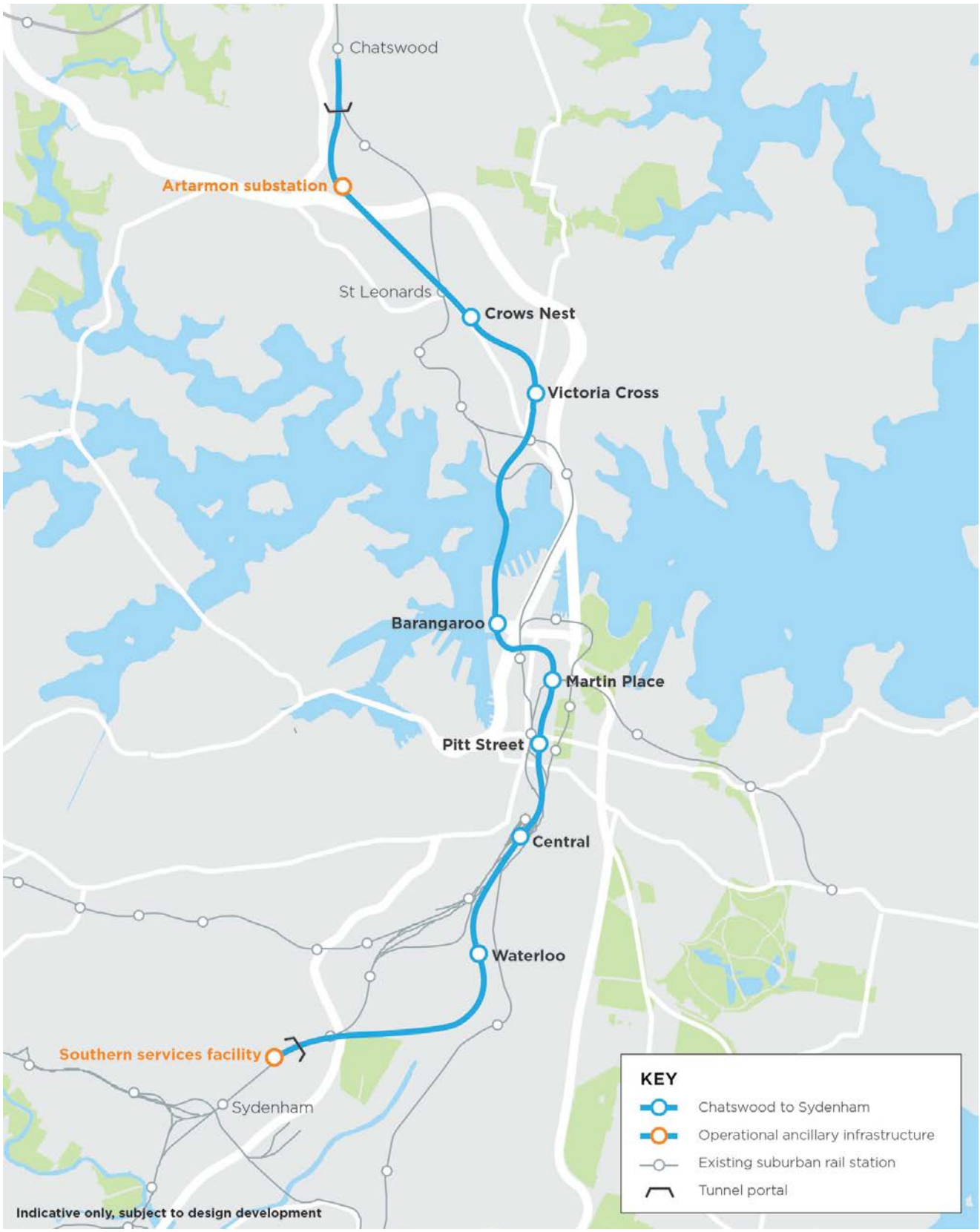


Figure 1.2 The project

1.4 Purpose and scope of this report

The project has been declared State significant infrastructure and critical State significant infrastructure and therefore is subject to assessment by the Department of Planning and Environment and approval by the Minister for Planning under Part 5.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

This technical paper, *Technical Paper 1: Traffic and Transport*, is one of a number of technical documents that forms part of the EIS. The purpose of this technical paper is to identify and assess the traffic and transport impacts of the project during both construction and operation. In doing so it responds directly to the Secretary's environmental assessment requirements.

This technical paper considers the construction and operational traffic and transport impacts on the local and regional traffic and transport network, including public transport, cyclists and pedestrians and includes:

- Identification of haulage routes, site access and egress points
- Daily and peak traffic movements likely to be generated by each component of the project and the impacts of this traffic on the local and regional traffic network including nearby intersections
- Impacts on the overall efficiency, ease, comfort, reliability and convenience of the public transport system (rail and bus), and interchange opportunities
- Impacts on vehicular, pedestrian, cyclist and public transport access
- Impacts on emergency services
- Impacts on parking supply
- Impacts on Sydney Harbour maritime traffic
- Operation of and modifications to intersections, and any changes to travel times for public transport services and private motorists
- Opportunities for the integration of rail and bus services including modal interchange facilities, local bus services, strategic corridors and external network connections, access and mobility considerations
- Measures to minimise or mitigate impacts, including an assessment of available options and the expected effect of the measures proposed, in accordance with relevant best practice guidelines.

1.5 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to traffic and transport, and where these requirements are addressed in this technical paper, are outlined in Table 1.1.

Table 1.1 : Secretary's environmental assessment requirements – traffic and transport

Secretary's environmental assessment requirements	Where addressed
1. The Proponent must assess construction transport and traffic (vehicle, pedestrian and cyclist) impacts, including, but not necessarily limited to:	
a) A considered approach to route identification and scheduling of transport movements	Chapter 3
b) The number, frequency and size of construction related vehicles (passenger, commercial and heavy vehicles, including spoil management movements)	Chapter 3
c) The capacity of or need to upgrade roads proposed as construction vehicle routes including Bedwin Road	Chapter 3
d) Changes to existing local and regional road networks including access to and around the proposed Chatswood tunnelling site	Chapter 3

Secretary's environmental assessment requirements	Where addressed
e) Construction worker parking	Chapter 3
f) The nature of existing traffic (types and number of movements) on construction access routes (including consideration of peak traffic times and sensitive road users and parking arrangements), including access to the Overseas Passenger Terminal for deliveries and passenger coaches	Chapter 2
g) Details of how construction and scheduling or works are to be coordinated in regard to public events; cumulative traffic impacts resulting from concurrent work on WestConnex, Barangaroo, Sydney Light Rail and other key construction projects in the Sydney CBD	Chapter 3
h) Alternatives to road transport or construction spoil	Chapter 3
i) Access constraints and impacts on public transport, pedestrian access and cyclists	Chapter 3
j) The need to close, divert or otherwise reconfigure elements of the road and cycle network associated with construction of the project	Chapter 3
k) Assess the likely risks of the project to public safety, paring particular attention to pedestrian safety and users of Sydney Harbour	Chapter 3
l) Impacts to water based traffic and shipping channels on users of Sydney harbour with particular reference to the channel between Blues Point and Millers Point for passage to and from White Bay, Glebe Island and Gore Cove	Chapter 3
2. The Proponent must assess the operational transport impacts of the project, including:	
m) Forecast travel demand and traffic volumes for the project and the surrounding road, cycle and public transport network	Chapter 4
n) Travel time analysis	Chapter 4
o) Performance of interchanges and intersections by undertaking a coordinated level of service analysis at locations affected by stations	Chapter 4
p) Wider transport interactions (local and regional roads, permanent loss of parking, the need for kiss and ride facilities, cycling, public and freight transport)	Chapter 4
q) Induced traffic and operational implications for public transport connected to station sites (particularly with respect to strategic bus corridors and bus routes) and consideration of opportunities to improve public transport linkages	Chapter 4
r) Impacts on pedestrian access in and around stations and connecting streets, capacity of streets at peak pedestrian times, including phasing of traffic lights, intersection crossing times and connectivity between stations	Chapter 4
s) Assess the benefits to each station and the general vicinity of walking and cycling catchments and the provision of infrastructure to support sustainable transport options	Chapter 4
t) Impacts on cyclists, pedestrian access and safety	Chapter 4
u) Opportunities to integrate cycling and pedestrian elements with surrounding networks and in the project.	Chapter 4

2. Existing traffic and transport environment

2.1 Regional traffic and transport environment

2.1.1 Regional active transport network

Pedestrians are generally catered for locally through footpaths and dedicated road crossings. The areas surrounding the project generally have a high volume of pedestrians, especially within the North Sydney, Crows Nest and Sydney CBD areas.

There is a relatively well defined cycle network across the lower North Shore which avoids the most heavily trafficked roads with marked and unmarked on-road cycle routes and off-road paths. Any changes to the cycle routes are a result of the implementation of Sydney's Cycling Future (Transport for NSW, December 2013).

Two key links in the cycle network are:

- The Sydney Harbour Bridge crossing, which is accessed from Alfred Street in Milsons Point (on the north) and Kent Street (in the south)
- The dedicated off-road Gore Hill Freeway cycleway, which provides a key regional link between Cammeray, Chatswood, Lane Cove, Macquarie Park and Epping.

Changes to cycle routes within the Sydney CBD are occurring as a result of the CBD and South East Light Rail project and the implementation of the Sydney City Centre Access Strategy (TfNSW, 2013). The implementation of these cycle routes is likely to be ongoing during construction of Sydney Metro.

South of the Sydney CBD, the major cycle routes operate through Waterloo and Alexandria, particularly along Bourke Street.

The Roads and Maritime Service's Cycleway Finder has been used to identify existing cycle networks and major routes.

2.1.2 Regional public transport network

2.1.2.1 Suburban rail

North of Sydney Harbour, the Sydney Trains rail network consists of the T1 North Shore Line. This line forms a key transport corridor connecting major and specialised centres both within Sydney's northern suburbs and south of Sydney Harbour. The T1 North Shore Line is currently constrained by the maximum number of services able to cross the Sydney Harbour Bridge. To the south of Sydney Harbour, the T1 North Shore Line continues through the Sydney CBD before connecting to the T1 Western and T1 Northern Lines.

South of the Sydney CBD, services operating on the T3 Bankstown Line merge with either the T2 Inner West and South Line or the T2 Airport Line. These lines continue through the Sydney CBD using the City Circle. This merging of rail lines to the south of Central Station creates a bottleneck, forcing trains to queue and causing backlogs in the west and southwest.

The T4 Eastern Suburbs and Illawarra Line also operates through the Sydney CBD from Bondi Junction to Cronulla and Waterfall.

Sydney Metro Northwest is currently being built and is due to open in 2019, providing metro services between Chatswood Station and Cudgegong Road Station in Rouse Hill. When it is completed, customers will be able to interchange at either Chatswood (to the T1 North Shore Line) or Epping (to the T1 Northern Line and the Newcastle & Central Coast Line) between metro services and suburban rail services.

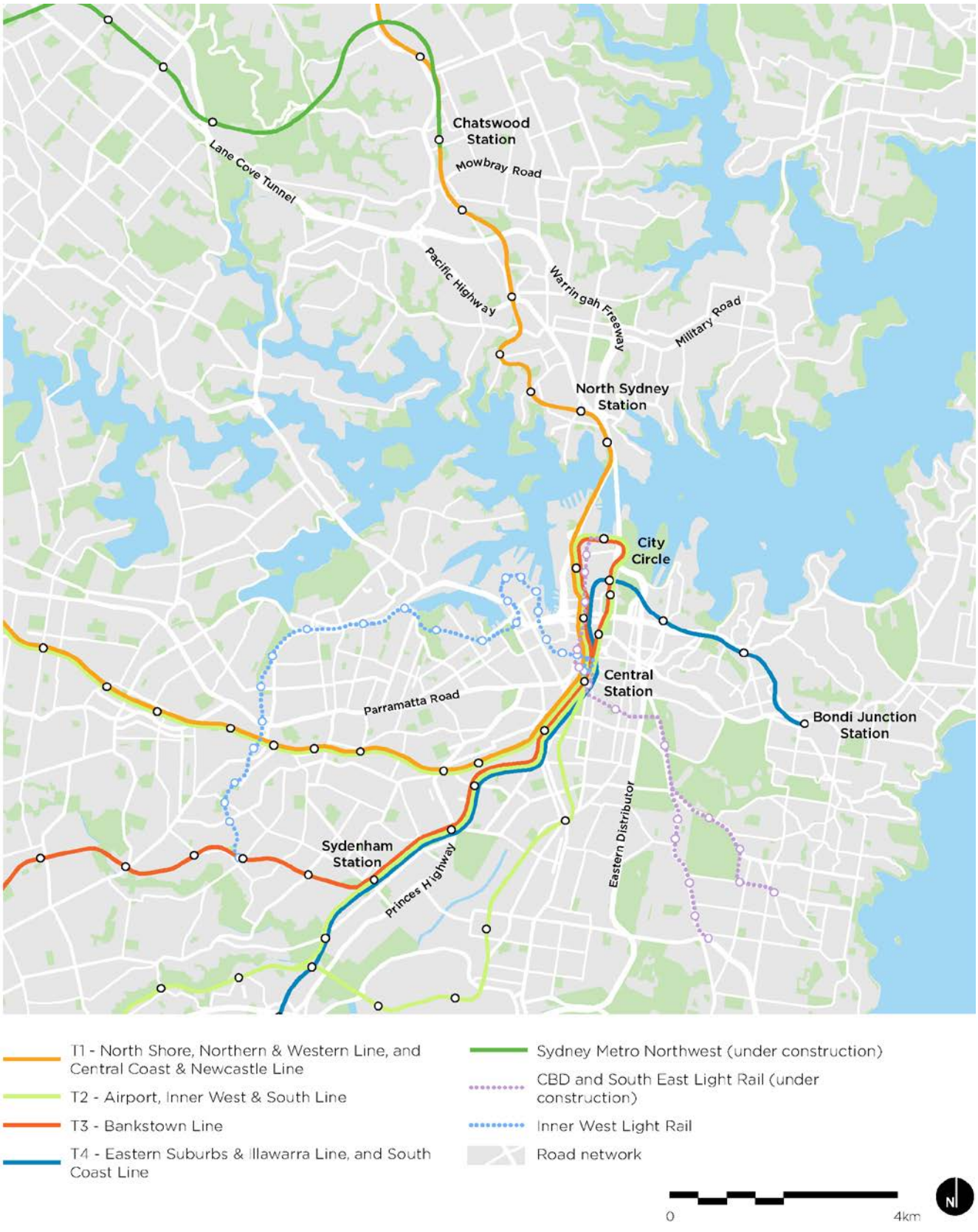


Figure 2.1 Overview of the existing and planned future rail and light rail network in the vicinity of the project

2.1.2.2 Bus network

Buses generally perform two main roles, being cross-regional public transport and local services connecting residential areas to key transport interchanges.

North of Sydney Harbour, major bus routes operate along the Hills M2 Motorway providing express services to the Sydney CBD and North Sydney. The Pacific Highway and Military Road / Spit Road also provide key bus corridors. The Pacific Highway connects areas to the north with key centres including Chatswood, St Leonards, North Sydney and the Sydney CBD. The Military Road / Spit Road corridor provides services from the Northern Beaches to the Sydney CBD via the Warringah Freeway and to the North Sydney CBD and providing links to St Leonards and Chatswood.

There are also a number of local services. These generally connect to rail stations, especially the key transport interchanges at Chatswood, St Leonards and North Sydney. These routes have frequent services both on and off peak.

Changes to the bus network that currently services the Hills District are anticipated following the opening of Sydney Metro Northwest in 2019. This is expected to result in a reduction in the number of buses crossing the Harbour Bridge.

Within the Sydney CBD, buses transport passengers from across Sydney into the CBD with many services running through the Sydney CBD in a north-south direction on Kent, Clarence, York, Castlereagh and Elizabeth streets, and in an east-west direction on Park and Druitt streets. Many bus services have also been redirected away from the core of the Sydney CBD to minimise congestion. Key bus interchanges within the Sydney CBD are provided at Wynyard Station, Town Hall Station and Central Station.

South of the Sydney CBD, key bus routes operate along the Princes Highway and King Street. There are also cross-regional services between Marrickville and Bondi Junction, and a number of local and feeder services that generally connect to rail stations to provide interchange opportunities. These routes have services both on and off peak.

2.1.2.3 Light rail

The light rail network consists of one line between Dulwich Hill and Central via Lilyfield and Pyrmont (the Inner West Light Rail). It has frequent services over extended periods. Whilst its share of passengers to the Sydney CBD is limited, it plays an important role in connecting the areas it serves to the Sydney CBD.

Light rail's role and function will be significantly increased following the introduction of the CBD and South East Light Rail (anticipated to commence operations in 2019). This will establish a new light rail network between Circular Quay and Randwick / Kingsford. The route will traverse along George Street, Eddy Avenue and Chalmers Street to Central Station, through Surry Hills to Moore Park, then to Kensington and Kingsford via Anzac Parade, and Randwick via Alison Road and High Street. Construction of the CBD and South East Light Rail is expected to occur concurrently with the construction of Sydney Metro, between the years of 2017 and 2019.

2.1.2.4 Ferry

Ferry services within Sydney perform two core functions – serving commuters and serving tourists / leisure customers. Most services connect to the Sydney CBD at Circular Quay. This includes services from the east (such as Watsons Bay), northeast (such as Manly), north (such as McMahons Point) and west (such as Parramatta River and Balmain). King Street Wharf on the western edge of the Sydney CBD is also served by Parramatta River services.

The Barangaroo Ferry Hub (expected to be open in 2016) will provide for new ferry services operating to and from the Barangaroo South area, and customers will have connections to Wynyard Station via Wynyard Walk.

2.1.3 Regional road network

North of Sydney Harbour, the road network is dominated by the key motorways – the Warringah Freeway / Gore Hill Freeway, the Lane Cove Tunnel and the Hills M2 Motorway. The Warringah Freeway / Gore Hill Freeway, connects to the Sydney Harbour Bridge and the Sydney Harbour Tunnel. As the main route to and from the Sydney CBD from the north, it carries large volumes of traffic that progressively increase to the south and on the approaches to the crossing of Sydney Harbour.

The main arterials roads relevant to the project north of Sydney Harbour are:

- The Pacific Highway, which is the key arterial road to the north. It passes through North Sydney, Crows Nest, St Leonards and Chatswood. Traffic volumes on the Pacific Highway generally increase to the north, especially between North Sydney and the connection to the Warringah Freeway around Artarmon
- Mowbray Road, which provides an important east–west connection between Lane Cove, Chatswood and Willoughby. It intersects with Epping Road, the Pacific Highway, Penshurst Street and Willoughby Road.

Numerous arterial and sub-arterial roads provide connections from the surrounding areas to the Pacific Highway and Military Road. North–south arterial roads such as Eastern Valley Way and Willoughby Road are also used as alternative routes to the Pacific Highway. The majority of the arterial and sub-arterial road network experiences significant traffic volumes and congestion, especially during the peak traffic periods.

South of Sydney Harbour, the motorway network provides regional through routes primarily located on the periphery of the Sydney CBD or within tunnels beneath the Sydney CBD providing access for motorists whose origin or destination is not within the Sydney CBD. These roads include the Western Distributor, Eastern Distributor, Cahill Expressway and Cross City Tunnel.

The arterial road network within the Sydney CBD generally forms a grid pattern. Key north–south roads include Elizabeth, York and Clarence streets. Key east–west roads include Park, Market, King, Bathurst, Liverpool and Goulburn streets. Many roads within the Sydney CBD are one-way and experience high traffic volumes and congestion, especially during the peak periods. Pressure on key north–south roads is expected to increase following the closure and subsequent pedestrianisation of George Street between Hunter and Bathurst streets as part of the CBD and South East Light Rail project.

South of the Sydney CBD, the road network is dominated by the Eastern Distributor (providing a connection to the M5 Motorway) and the key arterial roads of King Street, the Princes Highway and Regent Street.

2.1.4 Changing CBD traffic and transport environment

The Sydney CBD traffic and transport environment is complex and characterised by generally high volumes of traffic, high levels of congestion, numerous one-way streets and significant pedestrian volumes especially at peak travel times. This environment is currently undergoing changes through the implementation of the Sydney City Centre Access Strategy (TfNSW, 2013) including major transport projects such as the CBD and South East Light Rail, the pedestrianisation of George Street between Hunter Street and Bathurst Street, the new CBD Bus Strategy and the cycleway program. Construction of these projects, and other changes to the traffic and transport environment within the Sydney CBD would be occurring concurrently with the construction of Sydney Metro.

The CBD and South East Light Rail will run along George Street from Circular Quay to Central Station. *Sydney's Light Rail Future* (Transport for NSW, December 2012) states that it expects that once the CBD and South East Light Rail is operational in 2020, it would remove 180 buses from the Sydney CBD while additional bus network changes would bring this to a total of about 220 fewer buses entering the city centre in the morning peak.

The CBD Coordination Office has been established as a central point of leadership and authority on all traffic and transport in the Sydney CBD including:

- Ensuring urgent and coordinated responses by the Transport Management Centre and Roads and Maritime Services to traffic incidents
- Oversight of approvals for traffic management plans, and the allocation of areas and times for parking, loading zones and taxi ranks
- Coordination of permits to hold major events
- Sydney CBD related customer information and communications.

Sydney Metro would liaise closely with the CBD Coordination Office during detailed construction planning and throughout the construction phase to minimise the potential construction traffic impacts within the Sydney CBD, including potential cumulative impacts with other projects or special events.

2.2 Study area

The study area adopted for the traffic and transport assessment covers the central area of the wider Sydney Metro project, generally from Chatswood to Sydenham. The project covers approximately 15.5 kilometres of twin tunnels, including tunnels beneath Sydney Harbour, new underground stations on the north shore at Crows Nest and Victoria Cross; new underground stations within the Sydney CBD at Barangaroo, Martin Place and Pitt Street, new underground platforms at Central Station and a new station at Waterloo.

As the project is primarily underground, this assessment focuses on the local road and transport network in the vicinity of each of the proposed stations, as well as the Chatswood dive site, the Marrickville dive site, Artarmon substation and a temporary site at Blues Point.

From 4 October 2015, buses in the Sydney CBD operate predominantly along new priority routes on Elizabeth Street, Castlereagh Street, Park Street, Druitt Street, Clarence Street and York Street, and no longer operate along George Street ahead of Sydney CBD and South East Light Rail major construction.

New cross-city routes connect destinations on opposite sides of the city, and services have been expanded to Walsh Bay and Barangaroo. There are fewer buses in the core of the city centre, with some buses terminating on the edge of the CBD, close to transport interchanges such as Central, Town Hall and Wynyard.

These changes to bus operations have been incorporated into this traffic and transport assessment.

2.3 Chatswood dive site (northern) and surface works

The Chatswood dive site (northern) would commence approximately 120 metres south of Chatswood Station with the tunnel portal located immediately to the north of Mowbray Road, Chatswood. The main construction area would be bounded by Nelson Street to the north, the Pacific Highway to the west, Mowbray Road to the south and the railway line to the east. From this area the construction zone would also extend along the existing rail corridor to the north and south. The site location can be seen below in **Figure 2.2**.

Figure 2.2 : Chatswood dive site (northern) location

2.3.1 Active transport network

Footpaths are located on all frontages of the Pacific Highway, Nelson Street and Mowbray Road. Signalised crossing facilities are located on all arms of the intersection of the Pacific Highway and Mowbray Road. However, there are few crossing opportunities along the Pacific Highway; the next nearest signalised crossings are located 600 metres north at Pacific Highway / Albert Avenue and 680 metres south at the Pacific Highway / Gore Hill Freeway ramps.

Nelson Street is part of a key active transport link that provides a link between the Pacific Highway and the Frank Channon Walk, a shared path running to the Chatswood commercial centre. Nelson Street is also the only link to the eastern side of the rail line between Mowbray Road to the south and Albert Avenue at Chatswood Station. Pedestrian surveys undertaken in December 2015 showed that during the morning peak hour, a total of 16 pedestrians and five cyclists were observed crossing the Nelson Street overbridge in both directions and in the PM peak 22 pedestrians and five cyclists were observed.

2.3.2 Public transport services

Frequent bus services currently operate along the Pacific Highway with a bus stop located between Bryson Street and Mowbray Road in the southbound direction. There are eight unique bus routes in this area operating between Chatswood and destinations such as Manly, the Sydney CBD and Ryde. These services operate every five minutes during peak periods and every 10 minutes at other times.

The location of the nearest bus stops and bus routes can be seen in **Figure 2.3**.

The Epping to Chatswood Rail Conversion Temporary Transport Project will be providing rail replacement bus services for six to seven months from the end of 2018. An additional 30 bus services would arrive and depart Chatswood in the AM and PM peak hours. Buses would travel from North Ryde, via Fullers Road and use Victoria Avenue, Help Street, Brown Street and Railway Street in Chatswood. The replacement bus services would operate to the north of the Chatswood dive site and be temporary in nature.

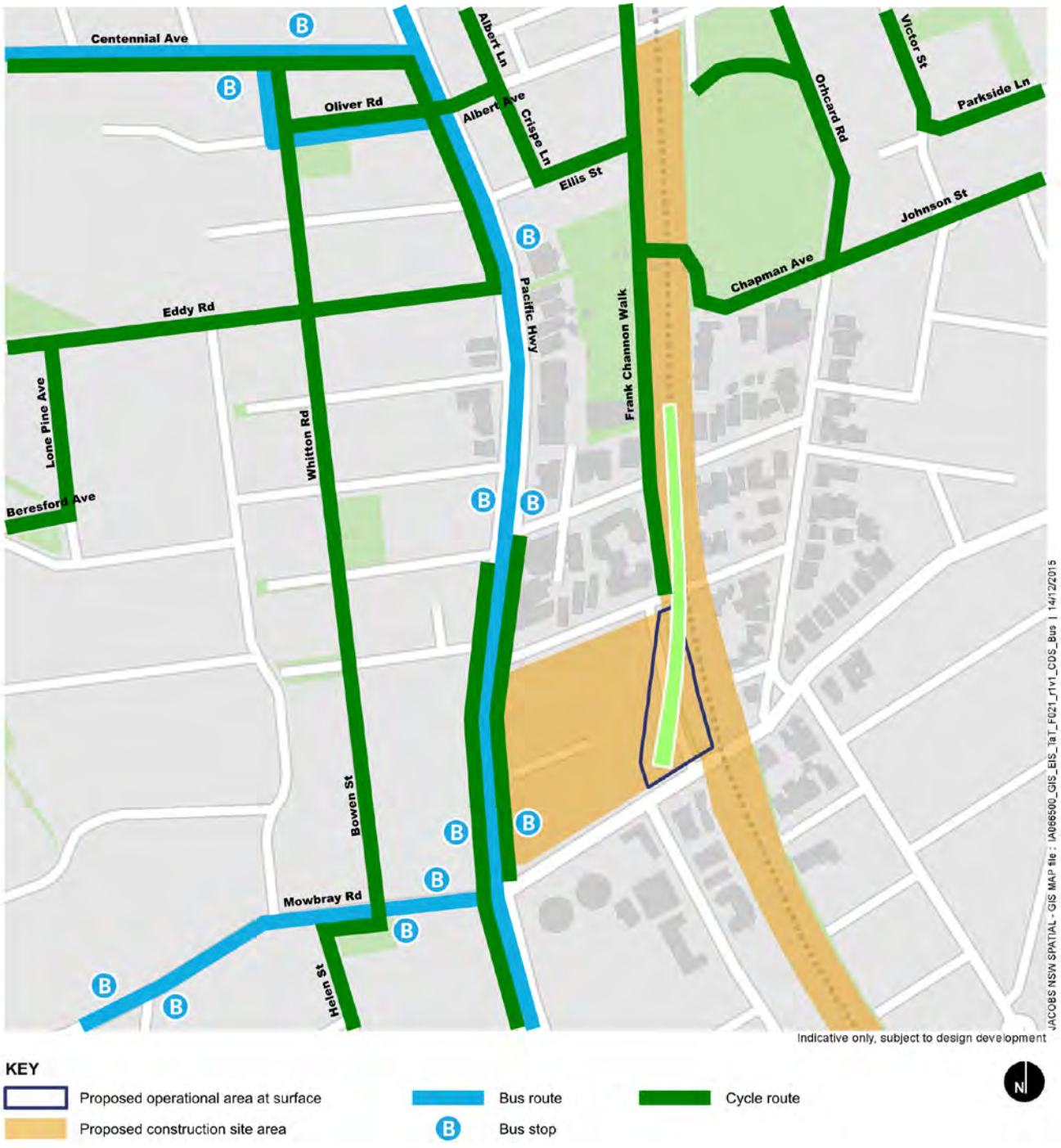


Figure 2.3 : Chatswood public transport and cycle routes

2.3.3 Existing traffic volumes and patterns

In the morning peak hour, the Pacific Highway currently experiences heavier flows in the southbound direction; between Albert Avenue and Nelson Street. There are approximately 2,020 vehicles per hour southbound and 1,880 vehicles per hour northbound. Traffic volumes are higher south of Mowbray Road, with approximately 2,180 vehicles per hour travelling southbound and 1,920 vehicles per hour northbound. On Mowbray Road, there are approximately 1,340 vehicles per hour travelling eastbound and 1,050 vehicles per hour travelling westbound. In contrast, traffic volumes on Nelson Street are light, with fewer than 30 vehicles per hour at the intersection with the Pacific Highway.

Traffic flows during the evening peak hour are generally higher in the northbound direction than in the morning peak. South of Mowbray Road there are approximately 2,570 vehicles per hour northbound and 1,920 vehicles per hour southbound. Between Nelson Street and Albert Avenue this reduces to 2,430 vehicles per hour northbound and 1,760 vehicles per hour southbound.

At the intersection of Pacific Highway and Mowbray Road, there is a heavy right turn movement into Mowbray Road westbound from the Pacific Highway (northbound). On Mowbray Road, there are approximately 1,470 vehicles per hour travelling westbound and 1,200 vehicles per hour eastbound. Similar to the morning peak, there are less than 100 vehicles per hour travelling on Nelson Street during the evening peak hour.

Approximate peak hour link volumes on key access roads are shown below in **Table 2.1**.

Table 2.1 : Chatswood dive site (northern) existing peak hour traffic volumes by direction (2015)

Road	Location	AM peak volume (vehicles per hour)	PM peak volume (vehicles per hour)
Pacific Highway	Between Fullers Road and Victoria Avenue (southbound)	2,320	1,710
	Between Fullers Road and Victoria Avenue (northbound)	1,550	2,470
Pacific Highway	Between Albert Avenue and Nelson Street (southbound)	2,020	1,760
	Between Albert Avenue and Nelson Street (northbound)	1,880	2,430
Pacific Highway	Between Mowbray Road and Howarth Road (southbound)	2,180	2,020
	Between Mowbray Road and Howarth Road (northbound)	1,920	2,570
Mowbray Road	Between Pacific Highway and Orchard Road (eastbound)	1,340	1,130
	Between Pacific Highway and Orchard Road (westbound)	1,050	1,420
Nelson Street	East of the Pacific Highway (eastbound)	60	95
	East of the Pacific Highway (westbound)	25	85

The southbound right turn movement from the Pacific Highway into Mowbray Road is prohibited for all vehicles with the exception of buses. Vehicles wishing to undertake this movement are required to turn left into Nelson Street and then right into Mowbray Road before proceeding straight through its intersection with the Pacific Highway.

2.4 Artarmon substation

The Artarmon substation is proposed to be located adjacent to the Gore Hill Freeway and to be bounded by Butchers Lane and Barton Road, with vehicular access via Barton Road. The location of the facility is shown below in **Figure 2.4**.

The site will be occupied by Artarmon Public School for the 2016 and 2017 academic years. The school however will vacate the site prior to construction commencing.

Figure 2.4 : Artarmon substation location

2.4.1 Active transport network

Footpaths are located along Reserve Road, Barton Road and Milner Road. Pedestrian facilities are not provided on Butchers Lane which is primarily used for residential parking and access to the driveways of properties fronting Milner Road. Marked pedestrian crossings are located on Reserve Road adjacent to Thomson Park and along Barton Road towards recreational facilities and schools in the area. A number of signalised pedestrian crossings exist near Artarmon Station, particularly on Jersey Road and Hampden Road. South of the Gore Hill Freeway towards the commercial area of Artarmon, footpaths exist along all frontages with signalised pedestrian crossings at key intersections on Reserve Road.

A dedicated cycle lane currently runs along Hampden Road linking St Leonards and the Royal North Shore Hospital with Artarmon Station. Bicycle parking facilities are available at Artarmon Station. There is also a short dedicated cycle lane marked on Francis Road between Hampden Road and Buller Road. Recommended on-road cycle routes for those wishing to cycle between Artarmon Station and Pacific Highway include Hampden Road, Jersey Road, Francis Street, Buller Road, Broughton Road and Rimmington Street.

2.4.2 Public transport services

Public transport services do not operate within close proximity to the site. The nearest rail service is accessible from Artarmon Station, approximately 700 metres from the site. This station is part of the T1 North Shore, Northern and Western Line and has frequent services particularly during peak periods. Bus services are at least 800m from the site and operate along the Pacific Highway and Campbell Street towards destinations such as Chatswood, Manly and the Sydney CBD.

In addition to the above, the Artarmon Loop is a free shuttle service operated by Willoughby City Council. Route B operates along Reserve Road in the vicinity of the site and serves Artarmon Station and St Leonards Station. Route B operates every 30 minutes between 10:00 am and 2:30 pm.

The location of bus stops and bus routes in the vicinity of the site can be seen in **Figure 2.5**.

Figure 2.5 : Artarmon public transport and cycle routes

2.4.3 Existing traffic volumes and patterns

Given that residential properties are primarily situated north of the Gore Hill Freeway and commercial businesses lie south of the Gore Hill Freeway, peak hour traffic volumes on Reserve Road reflect the current land use of the area. Between Butchers Lane and Barton Road, Reserve Road experiences northbound volumes of approximately 300 vehicles per hour during the morning peak hour and 520 vehicles per hour during the evening peak hour. In the southbound direction, volumes are approximately 430 vehicles per hour and 280 vehicles per hour during the morning and evening peak hours respectively.

In contrast, Reserve Road south of the Gore Hill Freeway recorded higher traffic volumes; northbound traffic of approximately 530 vehicles per hour during the morning peak hour and 1,170 vehicles per hour during the evening peak hour, and southbound volumes of approximately 1,270 vehicles per hour and 520 vehicles per hour during the morning and evening peak hours respectively. Butcher's Lane and Barton Road west of Reserve Road are 'no through' roads, consequently, low volumes of up to six vehicles per hour were recorded during the morning and evening peak periods. It was observed that the left turn from Barton Road east of Reserve Road at the roundabout was a major movement, accounting for 80 per cent to 90 per cent of total approach movements.

Approximate peak hour link volumes on key access roads are shown below in **Table 2.2**.

Table 2.2 : Artarmon substation existing peak hour traffic volumes by direction (2015)

Road	Location	AM peak volume (vehicles per hour)	PM peak volume (vehicles per hour)
Reserve Road	Between Butchers Lane and Barton Road (southbound)	430	280
	Between Butchers Lane and Barton Road (northbound)	300	520
Reserve Road	Between Barton Road and Gore Hill Freeway (southbound)	530	320
	Between Barton Road and Gore Hill Freeway (northbound)	450	610
Reserve Road	South of Gore Hill Freeway (southbound)	1,270	520
	South of Gore Hill Freeway (northbound)	530	1,170

2.5 Crows Nest Station

The area surrounding the proposed Crows Nest Station is currently defined as a mixed use centre with commercial and mixed use precincts to the north west (St Leonards); food, drink and retail districts along Willoughby Road, and residential areas to the northeast beyond Willoughby Road. To the south west of the proposed station, the land-use is characterised by education and medical facilities as well as residential. The station location can be seen below in **Figure 2.6**.

The proposed station would be approximately 530 metres southeast of St Leonards Station and 980 metres northeast of Wollstonecraft Station.

Currently there is minimal unrestricted on-street parking available in the Crows Nest area, reflecting the role of the precinct as a commercial and retail centre.

Figure 2.6 : Crows Nest Station location

2.5.1 Modes of travel

The 2011 Census Journey to Work data (AM data) indicates that there are approximately 19,730 workers in the area, with workers mainly travelling from local areas and districts to the north and west including Chatswood / Lane Cove (14 per cent), North Sydney / Mosman (13 per cent), Ku-ring-gai (seven per cent), Warringah (seven per cent) and the Sydney CBD (six per cent). The most common modes of travel identified were car and train, with smaller portions travelling via bus and walk (see **Figure 2.7**).

The data also indicates that there are approximately 9,350 residents in the catchment and that these residents primarily travel to work in; the Sydney CBD (36 per cent), local areas in North Sydney / Mosman (23 per cent) and Chatswood / Lane Cove (18 per cent). The most common modes of travel were identified as car and train, with reasonable portions also walking and travelling by bus.

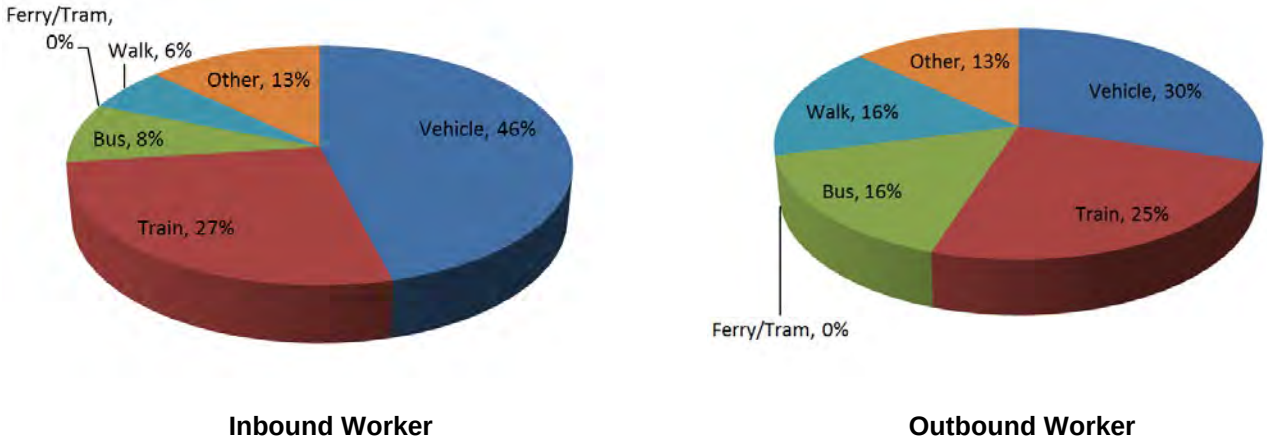


Figure 2.7 : Crows Nest Journey to Work Mode of Travel

The Journey to Work data suggests that a majority of the private vehicle users arriving in the area are travelling from the adjacent local areas of Chatswood, Lane Cove, North Sydney and Mosman, whilst the majority of train users to the area are travelling from areas further afield such as Ku-ring-gai, Hornsby and also inner city areas.

2.5.2 Active transport network

The pedestrian network in the precinct immediately surrounding the proposed station is well served by an existing network of footpaths. Connections can be made to surrounding land uses including residential, commercial and retail. Away from the Pacific Highway pedestrian crossing facilities are currently limited with no formal facilities provided on Hume Street, Clarke Street, Clarke Lane or Oxley Street in the vicinity of the site.

A Walking Assessment carried out for Transport for NSW identified primary north-south pedestrian desire lines along the Pacific Highway as pedestrians travel to and from the key node of St Leonards Station and the commercial core in St Leonards and Crows Nest. Further north, the Royal North Shore Hospital site is a major generator of pedestrian trips. Other key origins / destinations include Atchison Street, the Hume Street car park and the retail facilities on the Pacific Highway in Crows Nest.

Restaurants and cafes located on Willoughby Road and Ernest Place at Crows Nest are also major generators of pedestrian activity. A desire line exists from Oxley Street, across Clarke Street and through Hume Street Park to Willoughby Road.

Due to its proximity to major business centres, Crows Nest is often used as a thoroughfare for cyclists commuting to and from work. On-road marked bicycle routes within the vicinity of the proposed station run parallel to the eastern side of Pacific Highway along Alexander Street, Burlington Street, Willoughby Road, Clarke Street and Oxley Street, as well as Nicholson Street, Sinclair Street and Sinclair Road on the western side of the Pacific Highway. Willoughby Council has also identified marked on-road cycle routes on Shirley Road and Nicholson Street on the southern side of the Pacific Highway.

There are currently no bicycle parking facilities in the vicinity of the proposed station. The closest facilities to the station are a set of bicycle parking rails and O-rings located on Willoughby Road between Falcon Street and Albany Street.

2.5.3 Public transport services

Crows Nest is currently served by a number of buses operated by Sydney Buses and Hillsbus, with 21 bus routes passing through the area. Major bus stops in the vicinity of the proposed station are located along the Pacific Highway, Willoughby Road and Falcon Street. On Clarke Street private buses service the sports centre, with a layover area provided for bus parking. **Figure 2.8** shows the location of all routes and bus stops within the study area.

Figure 2.8: Crows Nest public transport and cycle routes

During the morning peak period the majority of routes passing through Crows Nest along the Pacific Highway are generally bound for North Sydney or the Sydney CBD. Routes servicing the Crows Nest town centre tend to travel along Willoughby Road, Alexander Street, Burlington Street and Falcon Street. Bus service frequencies in Crows Nest run regularly throughout the day, with approximately 300 services during the weekday morning peak (6 am to 10 am) and 360 services during the evening peak (3 pm to 7 pm).

2.5.4 Existing traffic volumes and patterns

Crows Nest currently experiences low to moderate levels of traffic congestion during peak periods. The intersection of Pacific Highway, Falcon Street, Willoughby Road and Shirley Street has been observed to operate at capacity during peak periods, with subsequent queuing along Falcon Street and the Pacific Highway.

In Crows Nest, traffic on the Pacific Highway does not exhibit strong tidal characteristics. 2015 traffic counts indicate that during the morning peak there are approximately 1,340 vehicles per hour southbound and 1,480 vehicles per hour northbound. Volumes are similar during the evening peak, with 1,360 vehicles per hour southbound and 1,410 vehicles per hour northbound. This section of the Pacific Highway has at least two trafficable lanes available to traffic in each direction at all times. There is an additional T3 lane, and associated clearway restrictions, in the southbound direction during the morning peak and in the northbound direction during the evening peak.

Approximate peak hour link volumes on key access roads are shown below in **Table 2.3**.

Table 2.3 : Crows Nest existing peak hour traffic volumes by direction (2015)

Road	Location	AM peak volume (vehicles per hour)	PM peak volume (vehicles per hour)
Pacific Highway	Between Oxley Street and Hume Street (southbound)	1,340	1,360
	Between Oxley Street and Hume Street (northbound)	1,480	1,410
Pacific Highway	Between Hume Street and Falcon Street (southbound)	1,290	1,290
	Between Hume Street and Falcon Street (northbound)	1,480	1,400
Hume Street	East of Pacific Highway (westbound)	150	190
	East of Pacific Highway (eastbound)	140	140
Oxley Street	East of Pacific Highway (westbound)	225	145
	East of Pacific Highway (eastbound)	145	150

2.6 Victoria Cross Station

Victoria Cross Station is proposed to be located on Miller Street in North Sydney between the Pacific Highway and McLaren Street. The station location can be seen below in **Figure 2.9**.

The precinct surrounding the station includes the commercial centre of North Sydney, a number of educational facilities, retail stores at Berry Square and Greenwood Plaza and a small proportion of residential properties.

Within 400 metres of the proposed station, there is no available unrestricted on-street parking. This reflects the constrained parking environment associated with the densely populated mix of commercial, educational, retail and residential land uses in the precinct.

The proposed metro station would be approximately 400 metres from the existing North Sydney Station, which is Sydney's 5th busiest with approximately 52,000 daily patrons (Transport for NSW).

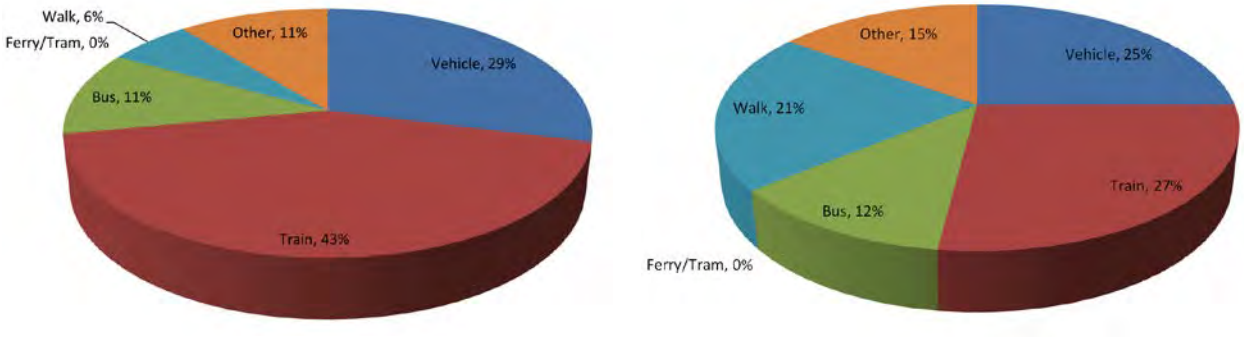
Figure 2.9 : Victoria Cross Station location

2.6.1 Modes of travel

The 2011 Journey to Work Census data (AM data) indicates that there are approximately 39,500 inbound workers to the area. These inbound journeys are identified as primarily travelling from within the North Sydney / Mosman area (11 per cent), the Sydney CBD (7 per cent), Chatswood / Lane Cove (7 per cent), and Warringah (five per cent). The dominant mode choices are identified as train and car, with smaller proportions via bus and walking.

The data indicates approximately 2,200 people reside in the catchment and that the majority of these travel to the Sydney CBD and within North Sydney / Mosman (local) for work. The main travel mode is via train, car and by foot, with a smaller proportion of journeys taken by bus.

The inbound and outbound mode share data are shown below in **Figure 2.10**.



Inbound Worker **Outbound Worker**

Figure 2.10 : Victoria Cross Journey to Work Data (Census 2011, Journey to Work data)

Overall a significant portion of travel to and from North Sydney (70 per cent) is currently undertaken by non-car modes. This is predominantly due to the role of heavy rail servicing the area with trains scheduled to run every three minutes in each direction during peak periods. Most locations within the North Sydney CBD are easily accessible from the train station. Areas south of Mount Street are within five minutes' walk of the station, and locations south of McLaren Street are within 10 minutes' walk.

2.6.2 Active transport network

North Sydney's high density of both dwellings and places of work also allows a high portion of internal trips to be made on foot. With a strong public transport network of bus and rail, the centre's work, residential and education uses generate a high volume of localised pedestrian trips.

The centre generates high pedestrian volumes, particularly during the commuter peak hours. At busy times, crossings within the North Sydney CBD become congested with pedestrians due to the lack of footpath space provided at some intersections.

Locally there are key pedestrian desire lines crossing the Pacific Highway at both Walker Street and Miller Street as pedestrians move from North Sydney Station to the commercial land uses of the North Sydney CBD. There are a number of subsurface pedestrian connections in the North Sydney centre from North Sydney Station, through the Greenwood Plaza and connecting to the local footpath network. A pedestrian over bridge provides connectivity across the Pacific Highway between Greenwood Plaza and Hill Street.

The educational precincts to the west of the Pacific Highway and north along Miller Street act as major generators of pedestrian trips. The education precinct contributes to the diversity of users in the North Sydney CBD.

The Berry Street / Miller Street intersection provides signalised crossing facilities on all arms and the Pacific Highway / Miller Street / Mount Street intersection also has signalised crossing facilities on all arms except for Mount Street which has a marked crossing. Pedestrian islands are also located between the Pacific Highway and Miller Street to the north and south of the intersection. These islands currently experience high levels of pedestrian use.

There are a number of facilities provided for cyclists including enclosed bicycle lockers, O-rings, bicycle rails and marked cycle paths. Marked on-road bicycle routes run along Miller Street, Pacific Highway, Blues Point Road and Mount Street. Secure bicycle lockers are available on Mount Street however cyclists must apply and seek approval from North Sydney Council to use these lockers. There is currently a waiting list, indicating the need for more parking facilities to be provided.

2.6.3 Public transport services

Victoria Cross in North Sydney is a major thoroughfare for buses with 44 unique bus routes passing through the area. Bus services are currently provided by Sydney Buses, Hillsbus and Forest Coach Lines. Major bus stops are located on Miller Street, Pacific Highway and Blue Street, with services intended to transport passengers away from the T1 North Shore rail line. **Figure 2.11** shows the locations of these stops and the bus routes in the study area.

The majority of routes operating within the area terminate in North Sydney, Milsons Point or the Sydney CBD. Most routes run regularly throughout the day, with approximately 420 services during the weekday morning peak (6 am to 10 am) and 450 services during the evening peak (3 pm to 7 pm).

North Sydney and its commercial core is also served by the existing T1 North Shore Rail Station, located on Blue Street, providing connections towards Hornsby, Chatswood and Macquarie Park in the north, the Sydney CBD to the south, and Parramatta, Blacktown and Penrith to the west.

A taxi rank is located on Berry Street, west of Miller Street however North Sydney Council has a desire to relocate the taxi rank in the future.

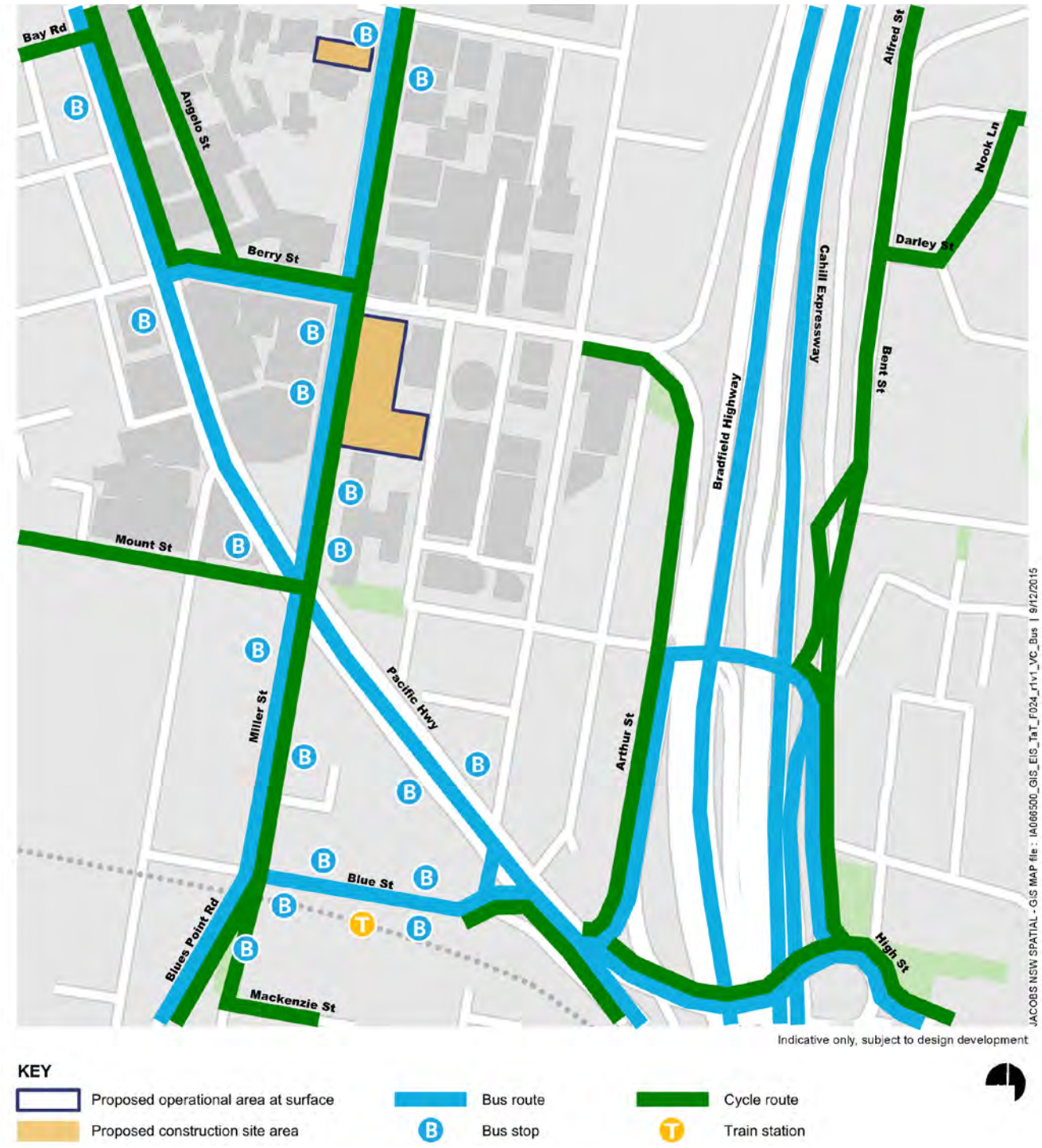


Figure 2.11 : Victoria Cross public transport and cycle routes

2.6.4 Existing traffic volumes and patterns

Analysis of 2015 traffic data revealed that during the morning peak hour, the Pacific Highway carries approximately 1,390 vehicles per hour travelling southbound between McLaren Street and Berry Street; at the intersection of the Pacific Highway / Miller Street this drops to approximately 520 vehicles per hour due to the large left turn movement into Berry Street. In the northbound direction on the Pacific Highway there are approximately 1,210 vehicles per hour north of Miller Street, dropping to 1,000 vehicles per hour north of Berry Street.

Berry Street also experiences high traffic volumes of approximately 1,220 vehicles per hour, two thirds of which is made up of vehicles accessing Berry Street from the Pacific Highway southbound. Vehicles travelling on Berry Street are predominantly heading towards the Sydney Harbour Bridge and Warringah Freeway interchanges on the eastern side of the North Sydney CBD.

Miller Street carries approximately 470 vehicles per hour northbound and 630 vehicles per hour southbound. In contrast, Walker Street exhibits strong tidal flow, with approximately 1,170 vehicles per hour travelling northbound and 160 passenger car units southbound in the morning peak.

Traffic volumes are generally lower during the evening peak hour. On the Pacific Highway north of Berry Street there are approximately 1,060 vehicles per hour southbound and 790 vehicles per hour northbound. As in the morning peak, southbound volumes on the Pacific Highway north of Miller Street are lower, with approximately 620 vehicles per hour.

Approximate peak hour link volumes on key access roads are shown below in **Table 2.4**.

Table 2.4 : Victoria Cross existing peak hour traffic volumes by direction (2015)

Road	Location	AM peak volume (vehicles per hour)	PM peak volume (vehicles per hour)
Pacific Highway	Between McLaren Street and Berry Street (southbound)	1,390	1,060
	Between McLaren Street and Berry Street (northbound)	1,000	790
Pacific Highway	Between Berry Street and Miller Street (southbound)	520	620
	Between Berry Street and Miller Street (northbound)	1,210	1,160
Miller Street	Between McLaren Street and Berry Street (southbound)	630	530
	Between McLaren Street and Berry Street (northbound)	470	500
Miller Street	Between Berry Street and Pacific Highway (southbound)	540	370
	Between Berry Street and Pacific Highway (northbound)	550	640
McLaren Street	Between Pacific Highway and Miller Street (eastbound)	240	190
	Between Pacific Highway and Miller Street (westbound)	290	250
Berry Street	Between Pacific Highway and Miller Street (eastbound)	1,220	940
	Between Miller Street and Walker Street (eastbound)	1,280	1,700
Walker Street	Between Arthur Street and Mount Street (southbound)	160	100
	Between Arthur Street and Mount Street (northbound)	1,170	940

2.7 Blues Point temporary site

The Blues Point temporary site would be located within Blues Point Reserve at the Blues Point Road / Henry Lawson Avenue intersection. Vehicular access to the site would be via Blues Point Road and Henry Lawson Avenue. The site location can be seen in **Figure 2.12**.

Figure 2.12 : Blues Point temporary site location

2.7.1 Active travel network

Henry Lawson Avenue acts as a pedestrian and cyclist desire line between McMahons Point Wharf and the foreshore reserve, parking at Blues Point Reserve and residential areas surrounding Blues Point Road. There is a footpath on the southern frontage of Henry Lawson Avenue and on both frontages of Blues Point Road. There is a marked on-road cycle route on Blues Point Road south of Lavender Street and on Henry Lawson Avenue.

Informal pedestrian paths also exist through Blues Point Reserve, providing Sydney Harbour foreshore access.

2.7.2 Public transport services

Bus services currently operate along Blues Point Road and Henry Lawson Avenue, performing a U-turn at the roundabout at the eastern end of Henry Lawson Avenue. There is a bus stop located in the westbound direction on Henry Lawson Avenue and buses currently operate at this bus stop on average every 30 minutes. A bus layover area that is important to bus operations is also provided immediately east of the bus stop. The bus routes and bus stop locations in the vicinity of the site can be seen below in **Figure 2.13**.

McMahons Point Wharf is located at the eastern end of Henry Lawson Avenue; the wharf is used by ferries on the F3 Parramatta River and F4 Darling Harbour routes, with six services in peak periods, services every 30 minutes during weekdays and every 20 minutes during weekends.

Figure 2.13 : Blues Point temporary site public transport and cycle routes

2.7.3 Existing traffic volumes and patterns

Utilising 2015 traffic data, in the morning peak hour there are approximately 360 vehicles per hour travelling northbound on Blues Point Road south of Union Street and approximately 320 vehicles per hour southbound.

In the evening, peak hour volumes are similar with approximately 300 vehicles per hour travelling northbound on Blues Point Road south of Union Street and approximately 300 vehicles per hour southbound.

Approximate peak hour link volumes on key access roads are shown below in **Table 2.5**.

Table 2.5 : Blues Point existing peak hour traffic volumes by direction (2015)

Road	Location	AM peak volume (vehicles per hour)	PM peak volume (vehicles per hour)
Blues Point Road	Between Blue Street and Union Street (southbound)	440	440
	Between Blue Street and Union Street (northbound)	400	460
Blues Point Road	South of Union Street (southbound)	320	300
	South of Union Street (northbound)	360	360

2.8 Barangaroo Station

The Barangaroo Station is proposed to be located adjacent to the Central Barangaroo precinct within the Barangaroo development, with a station entry planned at the southern and northern ends of the station. The station is proposed to serve the 23,000 new commercial jobs in the Central Barangaroo and Barangaroo South Precincts, as well as some employment areas in the north-western Sydney CBD. Barangaroo workers / visitors would continue to also access Wynyard Station depending on their origin / destination. The station would also provide access for visitors to Barangaroo Reserve and Walsh Bay. In addition, approximately 2,000 new residential apartments will be constructed as part of this development. The station location can be seen below in **Figure 2.14**.

The predominant access modes for the Barangaroo precinct are currently anticipated to be rail (via Wynyard Station) and bus, with an increased role of ferry anticipated with the proposed Barangaroo Ferry Hub at the southern end of the precinct. The new Wynyard Walk will provide grade separated pedestrian access from Central Barangaroo to Wynyard Station.

Wynyard Station would be approximately 850 metres from the proposed Barangaroo Station and is one of Sydney's busiest, accommodating approximately 23,600 patrons in the morning peak hour.

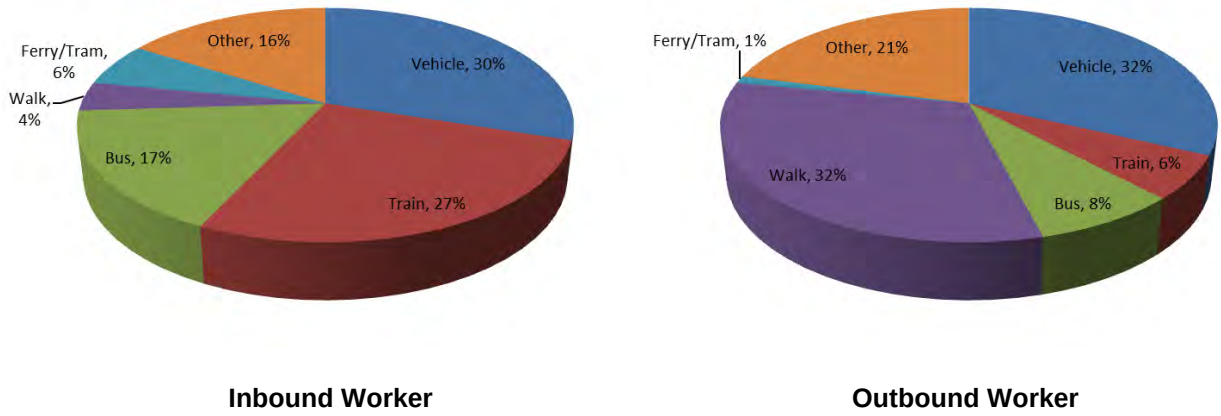
Figure 2.14 : Barangaroo Station location

2.8.1 Modes of travel

A review of the 2011 census Journey to Work data (AM data) in the vicinity of the site showed that approximately 2,850 workers entered the precinct to work, with 12 per cent of workers travelling from the Sydney CBD, six per cent from North Sydney, six per cent from the Eastern Suburbs, four per cent from Chatswood and the remaining 78 per cent from 'other' destinations.

Approximately 670 residents exited the precinct for work, with residents predominantly travelling to work in the Sydney CBD (61 per cent).

The existing mode share of inbound and outbound workers is presented below in **Figure 2.15**. However, the completion of the Barangaroo development will alter the transport mode share, with a significant shift away from private vehicles likely given the numerous public transport alternatives that are being introduced into the area.



Inbound Worker **Outbound Worker**

Figure 2.15 : Barangaroo Journey to Work Data (Census 2011, Journey to Work data)

2.8.2 Active travel network

Hickson Road currently has a pedestrian footway on both its eastern and western frontages, except for the 300m section at the northern end of Hickson Road, where there is a footpath on the western frontage only.

As part of the Barangaroo development, walking and cycling facilities in the area will be improved. Once complete, Barangaroo is anticipated to have more than 24,000 people living and working in the precinct and another 33,000 people visiting per day.

In addition to Wynyard Walk, pedestrian connections to Martin Place and Town Hall are planned to be enhanced as well as improvements to the foreshore connectivity linking Darling Harbour and Circular Quay. Improvements include footpath upgrades and widening. 'Sydney Steps', linking Millers Point at High Street with the waterfront promenade of Barangaroo as well as existing pedestrian links to Jenkins Lane would also provide convenient pedestrian options to / from the station.

The Barangaroo precinct currently has an on-road bicycle path running along Hickson Road. This path offers connections to the Sydney Harbour Bridge and the dedicated cycle path along Kent Street. Bicycle O-rings are located frequently throughout the Sydney CBD including the Barangaroo precinct. As part of the Barangaroo development, the City Walk Bridge will provide a second option for bicycle access to the area and a separate cycleway in Napoleon Street would give regional access via the Kent Street cycleway.

2.8.3 Public transport services

Bus services currently operate to/from Barangaroo along Hickson Road, with three routes servicing the area, the 311, 324 and 325. These routes are regular, with 60 services operating during the morning peak period (6am to 10am), and 70 services operating during the evening peak period (3 pm to 7 pm). **Figure 2.16** shows the location of bus stops and the roads traversed by these services.

Figure 2.16 : Barangaroo public transport and cycle routes

Wynyard Station is located approximately 850 metres southeast of the proposed metro station and serves the T1 North Shore, Northern and Western Line, T2 Airport, Inner West and South Line and T3 Bankstown Line. Wynyard Station will connect to Barangaroo via Wynyard Walk which is expected to open in 2016. The station currently sees high levels of patronage.

The new ferry hub at Barangaroo is planned to be open to customers in 2016. It would provide interchange opportunities to ferry services from Parramatta River and Inner Harbour, as well as direct access to and from the eastern suburbs at Double Bay, Rose Bay and Watsons Bay.

2.8.4 Existing traffic volumes and patterns

During the morning peak hour there are currently approximately 380 vehicles per hour travelling northbound on Sussex Street between King Street and Erskine Street, increasing to 570 vehicles per hour between Erskine Street and Napoleon Street. In the southbound direction, there are 400 vehicles per hour travelling between Napoleon Street and Erskine Street, approximately doubling to 810 vehicles per hour between Erskine Street and King Street.

Evening peak volumes show similar patterns to the morning peak hour; there are approximately 320 vehicles per hour travelling northbound between King Street and Erskine Street, increasing to 480 vehicles per hour between Erskine Street and Napoleon Street. In the southbound direction, there are 500 vehicles per hour travelling between Napoleon Street and Erskine Street, doubling to 1,020 vehicles per hour south of Erskine Street.

In both peak periods, there is a strong northbound movement along Sussex Street to Kent Street northbound via Napoleon Street.

Hickson Road currently experiences a high proportion of construction vehicles due to the Barangaroo construction works. 90 degree parking is provided along Hickson Road which is currently heavily used by construction workers from the Barangaroo development.

The Overseas Passenger Terminal (OPT) receives passenger coaches and delivery trucks to the terminal on days that a ship is in dock. The access route for coaches and trucks includes Hickson Road with only a short window of time to access the passenger terminal. Vehicles arrive over a short duration when the ship is either arriving or departing, which is typically around 6 am to 7 am or 6.30pm.

Approximate peak hour link volumes on key access roads are shown below in **Table 2.6**.

Table 2.6: Barangaroo existing peak hour traffic volumes by direction (2015)

Road	Location	AM peak volume (vehicles per hour)	PM peak volume (vehicles per hour)
Hickson Road	North of Napoleon Street (southbound)	190	430
	North of Napoleon Street (northbound)	420	410
Kent Street	Between Clarence Street and Margaret Street (southbound)	230	270
	Between Clarence Street and Margaret Street (northbound)	610	820
Sussex Street	Between Napoleon Street and Erskine Street (southbound)	400	500
	Between Napoleon Street and Erskine Street (northbound)	570	480
Sussex Street	Between Eskine Street and King Street (southbound)	810	1,020
	Between Eskine Street and King Street (northbound)	380	320
Sussex Street	Between King Street and Market Street (southbound)	840	1,200

2.9 Martin Place Station

The proposed Martin Place Station would be a new metro station close to the existing Martin Place Station. One entry would be to the north of Martin Place and one entry would be to the south of Martin place, bounded by Castlereagh Street to the west and Elizabeth Street to the east. The proposed station would be located in the Sydney CBD's financial precinct. The station location can be seen in **Figure 2.17**.

A Walking Assessment undertaken by Transport for NSW indicates that during the morning and evening peak periods, the station would serve a significant catchment of Sydney CBD, extending as north far as Circular Quay. Strong connections with the retail core surrounding Pitt Street Mall were also identified. The station would also be in close proximity to The Domain and would therefore service demand to / from major events held at that venue.

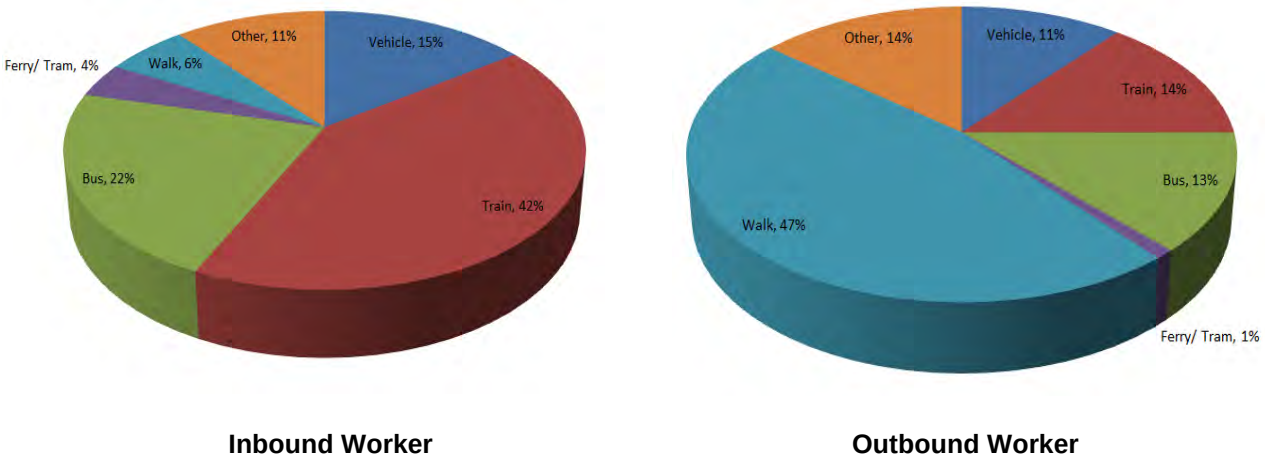
Figure 2.17 : Martin Place Station location

2.9.1 Modes of travel

The 2011 Journey to Work Census data (AM data) in the vicinity of Martin Place station indicates that approximately 48,200 inbound workers to the area are travelling mainly from within Sydney Inner City (12 per cent), Northern Beaches (nine per cent), North Sydney / Mosman (six per cent), Southern Beaches (five per cent) and 'other' accounting for 65 per cent. The mode share data indicates people currently mainly arrive via train (42 per cent), bus (22 per cent), Ferry (four per cent) and walking (six per cent).

With regard to the residents within the catchment, the data indicates that approximately 380 residents exited the precinct to work and their primary modes were walk (47 per cent), train (14 per cent) and bus (13 per cent). 77 per cent of residents were identified as travelling to work within the Sydney CBD.

The inbound and outbound mode share data can be seen below in **Figure 2.18**.



Inbound Worker **Outbound Worker**

Figure 2.18 : Martin Place Journey to Work Data (Census 2011, Journey to Work data)

2.9.2 Active transport network

Martin Place is pedestrian-only between George Street and Macquarie Street and as part of the CBD and South East Light Rail project, George Street, in the vicinity of Martin Place, will also be pedestrianised enhancing the pedestrian environment from what is currently available.

An assessment of the existing pedestrian activity was carried out by Transport for NSW which found that there are high numbers of pedestrians moving through Martin Place, with substantial levels of 'jaywalking' observed. Issues with pedestrian storage space were identified further north at Hunter Street, resulting from the high north-south movements with long waiting times crossing Hunter Street.

Pedestrian surveys of the Martin Place / Castlereagh Street and Martin Place / Elizabeth Street pedestrian crossings were undertaken on Tuesday 1 December 2015 between 6 am and 8 pm.

Approximately 44,300 pedestrians crossed Castlereagh Street during the survey period, with approximately 20,950 travelling eastbound and approximately 23,350 travelling westbound. In the morning period, the majority of pedestrians were observed travelling westbound in the direction of commercial buildings and George Street. In the evening, the majority of pedestrians were observed travelling eastbound, in the direction of Martin Place station.

Approximately 33,900 pedestrians crossed Elizabeth Street at Martin Place during the survey period, with approximately 13,700 travelling eastbound and approximately 17,200 travelling westbound. As with Castlereagh Street, the majority of pedestrians in the morning travel westbound and eastbound in the evening.

The City of Sydney is currently implementing a variety of strategies to improve the cycle network in the Sydney CBD. Within the immediate vicinity of Martin Place, a number of bicycle parking facilities are currently available, however, there is no provision of on- road separated or shared bicycle paths. Cyclists wishing to use this type of facility were previously required to travel along Kent Street and College Street for north-south journeys and Park Street for east-west journeys. However, the dedicated cycle lane along College Street has been removed as part of the new CBD access strategy developed to support the implementation of CBD and South East Light Rail along George Street. Dedicated cycle paths are also located throughout Hyde Park and the Domain.

As of October 2015, a new cycleway is operational on Castlereagh Street between Hay Street in the south and Liverpool Street in the north. This includes a two-way separated cycleway along Castlereagh Street in the north-south direction with connections to the Liverpool Street cycleway, which in turn connects to Sussex Street to the west.

2.9.3 Public transport services

The Martin Place precinct experiences high volumes of bus traffic during peak and off-peak times, particularly along Elizabeth Street and Castlereagh Street which, since the closure of George Street, are the main north-south bus corridors through the CBD. The bus routes and stop locations within the study area are shown in **Figure 2.19**.

Buses from all over Sydney converge and diverge near the proposed station with 62 unique bus routes servicing the area including night buses. In particular, direct access to buses traversing Castlereagh Street or Elizabeth Street is available. Buses along this spine generally serve customers from the south and eastern suburbs, with connectivity to bus routes servicing other areas of Sydney within walking distance.

Elizabeth Street is classified as a priority bus corridor and Castlereagh Street is a major southbound bus route. These roads form a 'couplet', with northbound bus services along Elizabeth Street matching southbound bus services along Castlereagh Street.

Martin Place Station on the T4 Eastern Suburbs and Illawarra Line and the South Coast Line provides a key Sydney CBD access point for customers travelling from the eastern suburbs and southern regions of Sydney.

The CBD and South East Light Rail will run along George Street from Circular Quay to Central Station. *Sydney's Light Rail Future* (Transport for NSW, December 2012) states that it expects that once the CBD and South East Light Rail is operational, it would remove 180 buses from the Sydney CBD while additional bus network changes would bring this to a total of about 220 fewer buses entering the city centre in the morning peak.

Figure 2.19 : Martin Place public transport and cycle routes

2.9.4 Existing traffic volumes and patterns

Traffic data collected in 2015 indicates that Elizabeth Street (northbound) experiences heavy traffic volumes greater than 1,100 vehicles per hour during both the morning and evening peak hours. In the southbound direction, Castlereagh Street carries less traffic than Elizabeth Street. There appears to be a strong movement from Macquarie Street (southbound) in the east to Castlereagh Street (southbound) via Hunter Street. These vehicles contribute to relatively heavy westbound flows on Hunter Street.

Approximate peak hour link volumes on key access roads are shown below in **Table 2.7**.

Table 2.7: Martin Place existing peak hour traffic volumes by direction (2015)

Road	Location	AM peak volume (vehicles per hour)	PM peak volume (vehicles per hour)
Castlereagh Street	Between King Street and Hunter Street (southbound)	380	510
Elizabeth Street	Between King Street and Hunter Street (northbound)	1,130	1,110
	Between King Street and Hunter Street (southbound)	410	590
Hunter Street	Between Castlereagh Street and Elizabeth Street (eastbound)	190	190
	Between Castlereagh Street and Elizabeth Street (westbound)	790	630

2.10 Pitt Street Station

The proposed Pitt Street Station would be located between the existing Town Hall Station and Museum Station, between Park Street to the north and Bathurst Street to the south. The station location can be seen in **Figure 2.20**.

In this location, Pitt Street is a one-way road for northbound movements. Park Street operates as a two-way road for buses and general traffic. West of Pitt Street, Park Street is restricted to one-way westbound for general traffic and bus only for eastbound movements.

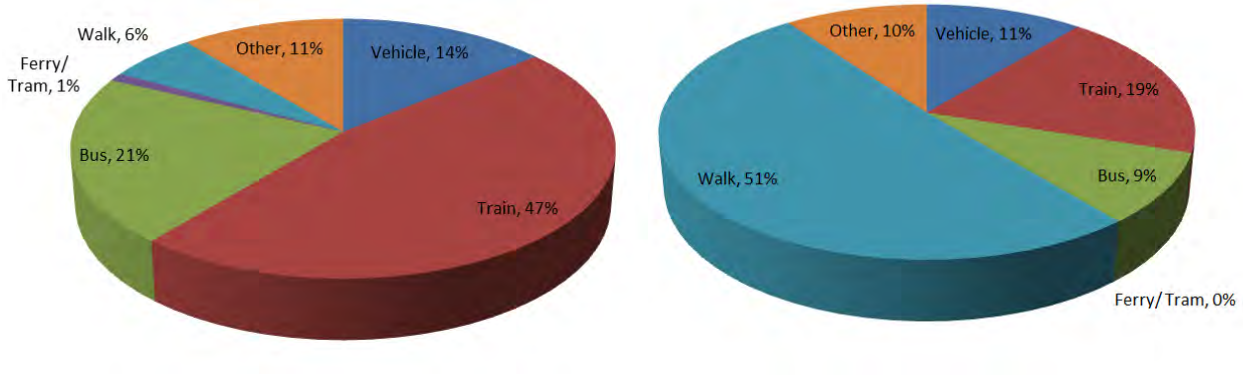
The large commercial buildings in the local catchment generate a dense employment base of approximately 81,680 workers with a relatively low residential population of approximately 10,600 (Transport for NSW).

Figure 2.20 : Pitt Street Station location

2.10.1 Modes of travel

The 2011 Journey to Work census data (AM data) for the travel zones in the vicinity of the Pitt Street Station show that approximately 27,770 workers entered the precinct to work who primarily travelled from Sydney Inner City (12 per cent), Eastern Suburbs (10 per cent), Strathfield (five per cent) and North Sydney / Mosman (five per cent), with 'other' accounting for 68 per cent. Less than 500 residents were identified in the precinct.

The primary modes of travel for inbound and outbound workers are presented below in **Figure 2.21**.



Inbound Workers **Outbound Workers**

Figure 2.21 : Pitt Street Journey to Work Data (Census 2011, Journey to Work data)

2.10.2 Active transport network

High volumes of pedestrian traffic are currently experienced in the vicinity of the Pitt Street Station in the AM and PM peak periods. Most of the pedestrian demand is in the east – west direction along Park Street and Bathurst Street. The pedestrian demand in this direction is driven by bus stop facilities with some additional movements from Town Hall and Museum stations and general circulation.

Pedestrian surveys were carried out in late 2015. **Figure 2.22** and **Figure 2.23** present the AM and PM peak period pedestrian counts at key intersections and mid-bocks near the proposed station accesses.

The Pitt Street Station would be situated within close proximity to separate dedicated cycle paths throughout Hyde Park. A dedicated on-road cycle lane also runs east-west on Park Street east of Elizabeth Street.

As of October 2015, a new cycleway is operational on Castlereagh Street between Hay Street in the south and Liverpool Street in the north. This includes a two-way separated cycleway along Castlereagh Street in the north-south direction with connections to the Liverpool Street cycleway, which in turn connects to Sussex Street to the west.

Similar to other CBD Metro stations, bicycle parking O-rings are located throughout the Sydney CBD. The City of Sydney provides free bicycle parking at its Goulburn Street carpark and bicycle pumps for public use at the southern end of Hyde Park, and select stores along Kent Street and Clarence Street.

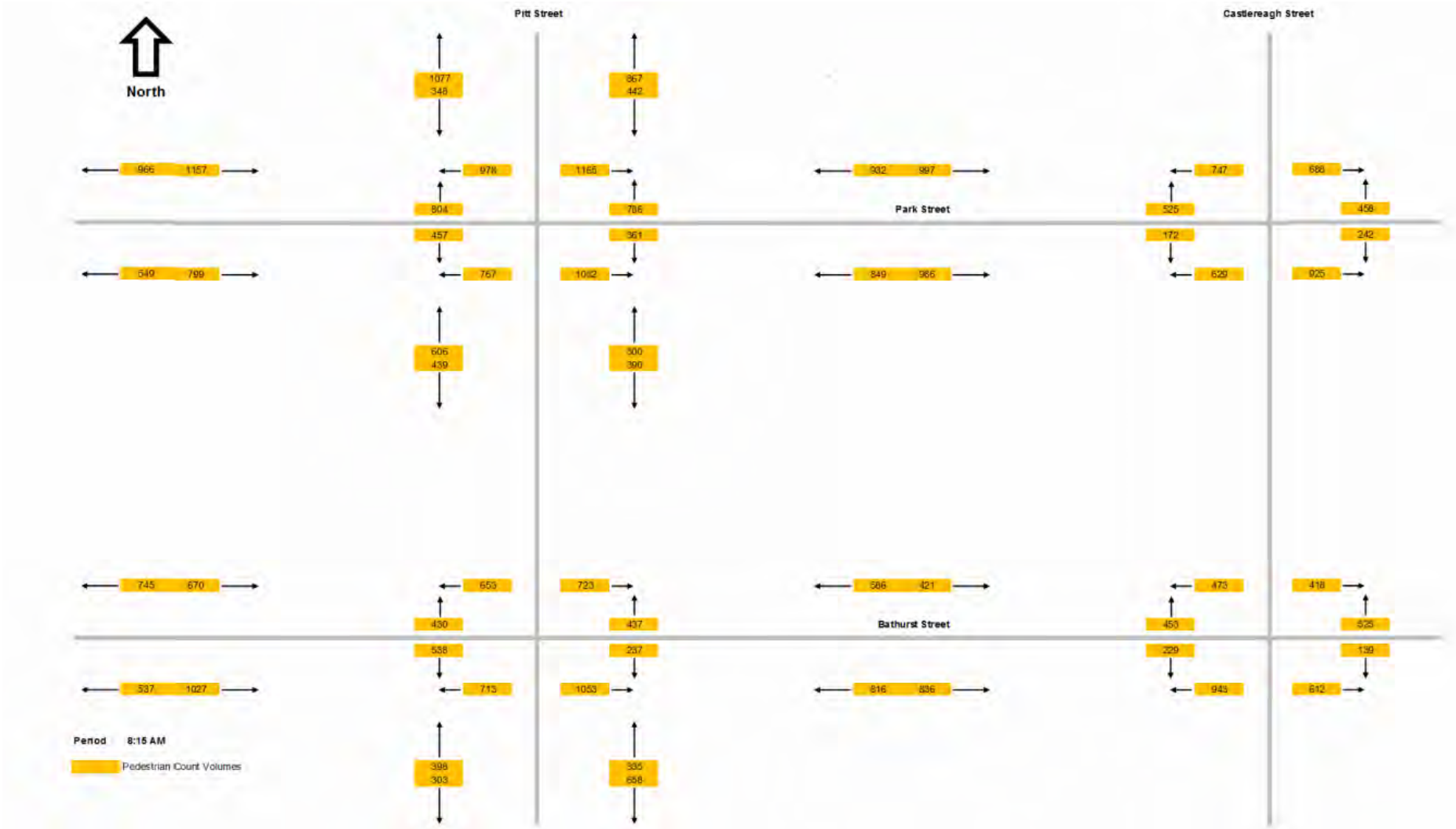


Figure 2.22: Pitt Street Station – AM peak hour existing pedestrian counts

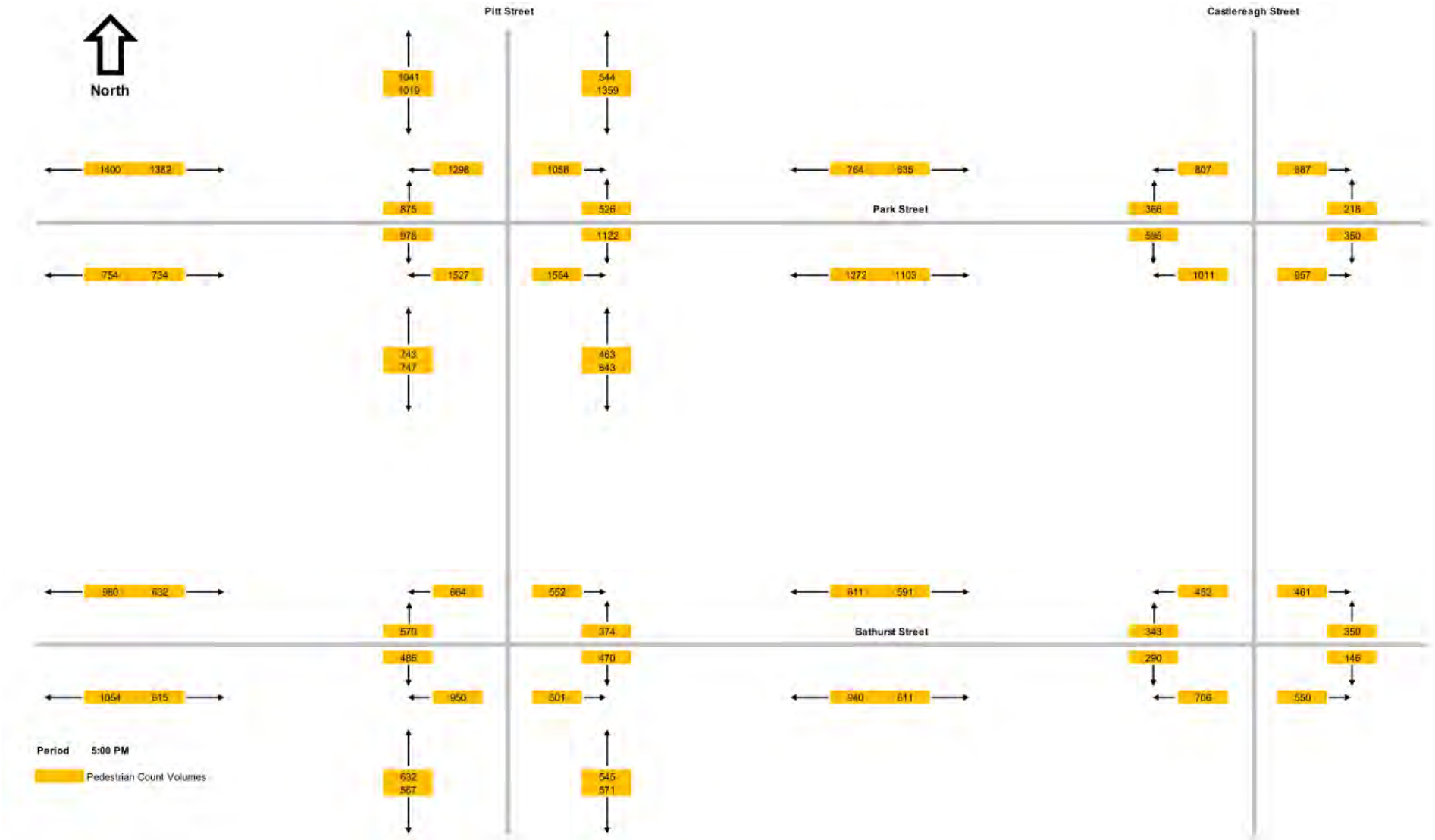


Figure 2.23 : Pitt Street Station – PM peak hour existing pedestrian counts

2.10.3 Public transport services

A number of bus routes operate within the vicinity of the proposed Pitt Street Station, particularly those that run north-south along Elizabeth Street and Castlereagh Street and services running east-west along Park Street. **Figure 2.24** shows the locations of bus stops and bus routes within the vicinity of the proposed station.

Figure 2.24 : Pitt Street public transport and cycle routes

Many of the north-south bus routes that pass through Martin Place along Castlereagh Street and Elizabeth Street fall within the catchment of the proposed Pitt Street Station. These routes primarily serve the east, south-east continuing towards Oxford Street or Central Station, services which pass through Broadway, and also the Metrobus Network. Park Street through the Sydney CBD is another major bus corridor with routes servicing the inner west towards Victoria Road, Pyrmont and Balmain. Also, a number of Metro buses which pass through the city centre operate along Park Street.

Town Hall Station located near the proposed Sydney Metro Pitt Street Station is currently the second-busiest railway station in the Sydney Trains network during the morning peak (behind Central Station). Town Hall also serves as a significant interchange station that is traversed by all train lines through the Sydney CBD.

Museum Station is located at the Elizabeth Street / Liverpool Street intersection. Trains on the T2 Airport, Inner West and South Line, T3 Bankstown Line and the Southern Highlands Line operate through Museum Station.

2.10.4 Existing traffic volumes and patterns

Traffic data collected in 2015 indicates that Bathurst Street carries traffic volumes greater than 1,100 vehicles per hour in both the morning and evening peak hours, with higher volumes observed in the evening peak. Park Street (westbound) also experiences relatively high volumes, particularly during the morning peak hour.

In contrast, north-south links on Castlereagh Street and Pitt Street generally carried less than 700 vehicles per hour in peak hours.

Approximate peak hour link volumes on key access roads are shown below in **Table 2.8**.

Table 2.8: Pitt Street existing peak hour traffic volumes by direction (2015)

Road	Location	AM peak volume (vehicles per hour)	PM peak volume (vehicles per hour)
Castlereagh Street	Between Park Street and Bathurst Street (southbound)	300	490
Pitt Street	Between Bathurst Street and Park Street (northbound)	530	480
Park Street	Between Castlereagh Street and Pitt Street (eastbound)	170	270
	Between Castlereagh Street and Pitt Street (westbound)	610	530
Bathurst Street	Between Castlereagh Street and Pitt Street (eastbound)	1,110	1,120

2.11 Central Station

Central Station is located at the southern end of the Sydney CBD, and is the busiest station in NSW. The station is supported by a network of footpaths providing linkages to key centres in the Sydney CBD, including Haymarket, Darling Harbour and Surry Hills. The Devonshire Street tunnel provides an important link between Surry Hills to the east and Railway Square to the west. Broadway and Eddy Avenue typically experience pedestrian congestion during peak hours resulting from interchange between bus and rail. The addition of a light rail stop at Chalmers Street will further increase pressure on the footpath network.

The location of the metro platforms at Central Station can be seen below in **Figure 2.25**.

Figure 2.25 : Metro at Central Station location

2.11.1 Active transport network

Pedestrian access to Central Station via Eddy Avenue has wide footways on both frontages. Signalised crossing facilities are available at the intersection with Pitt Street and a mid-block signalised crossing facility provides a link to Belmore Park providing connections along a key pedestrian desire line to the north of the station. Pedestrian access is also available from Lee Street to the southwest and Devonshire Street to the southeast, which are connected by the Devonshire Street Tunnel providing subsurface access to the station from its southern approaches.

Pedestrian surveys at Central Station were undertaken between 6 am and 8 pm on Tuesday 17 November 2015. The surveys showed that during the AM peak hour, approximately 1,400 pedestrians travelled eastbound through the Devonshire Street tunnel and approximately 4,500 pedestrians travelled westbound. The total number of pedestrian movements through the tunnel across the whole survey period was approximately 25,440 in the eastbound direction and approximately 22,330 in the westbound direction.

The survey also showed the direction customers travel to / from the station gates at the southern end of Central Station near Devonshire Street. **Table 2.9** presents the directions customers currently travel.

Table 2.9 : Devonshire Street Tunnel gate entries and exits

	To / from Devonshire Street (east)	To / from George St / Lee St (west)
Entries	35%	65%
Exits	32%	68%

The majority of customers entering and exiting platforms at the southern end of Central Station currently use the Devonshire Street Tunnel. Just over 6,000 pedestrians were also observed using the Devonshire Street Tunnel throughout the day without accessing the station.

The station has a good level of existing pedestrian facilities offering access to the north, southeast and northwest of the station.

The Central Station precinct currently has a shared off-road cycle path along Chalmers Street and throughout Prince Alfred Park and Belmore Park. Cycling is prohibited in the Devonshire Street Tunnel.

Cycle racks are provided at various locations around the station on Chalmers Street, Eddy Avenue and the Western Forecourt. Free bicycle parking is also available at the Goulburn Street car park operated by the City of Sydney. Public bicycle pumps provided by Council are also available for cyclists at Prince Alfred Park and at select cafes / stores in Surry Hills.

As of October 2015, a new cycleway is operational on Castlereagh Street between Hay Street in the south and Liverpool Street in the north. This includes a two-way separated cycleway along Castlereagh Street in the north-south direction with connections to the Liverpool Street cycleway, which in turn connects to Sussex Street to the west.

2.11.2 Public transport services

The Central Station precinct is a major interchange hub between rail, light rail and bus services. Eddy Avenue, Chalmers Street/ Elizabeth Street, and Railway Square experience high volumes of bus traffic throughout the day. Approximately 1,520 bus services run during the weekday morning peak period (6 am to 10 am) and 1,610 services during the evening peak period (3 pm to 7 pm). **Figure 2.26** shows the bus routes and stop locations within the study area.

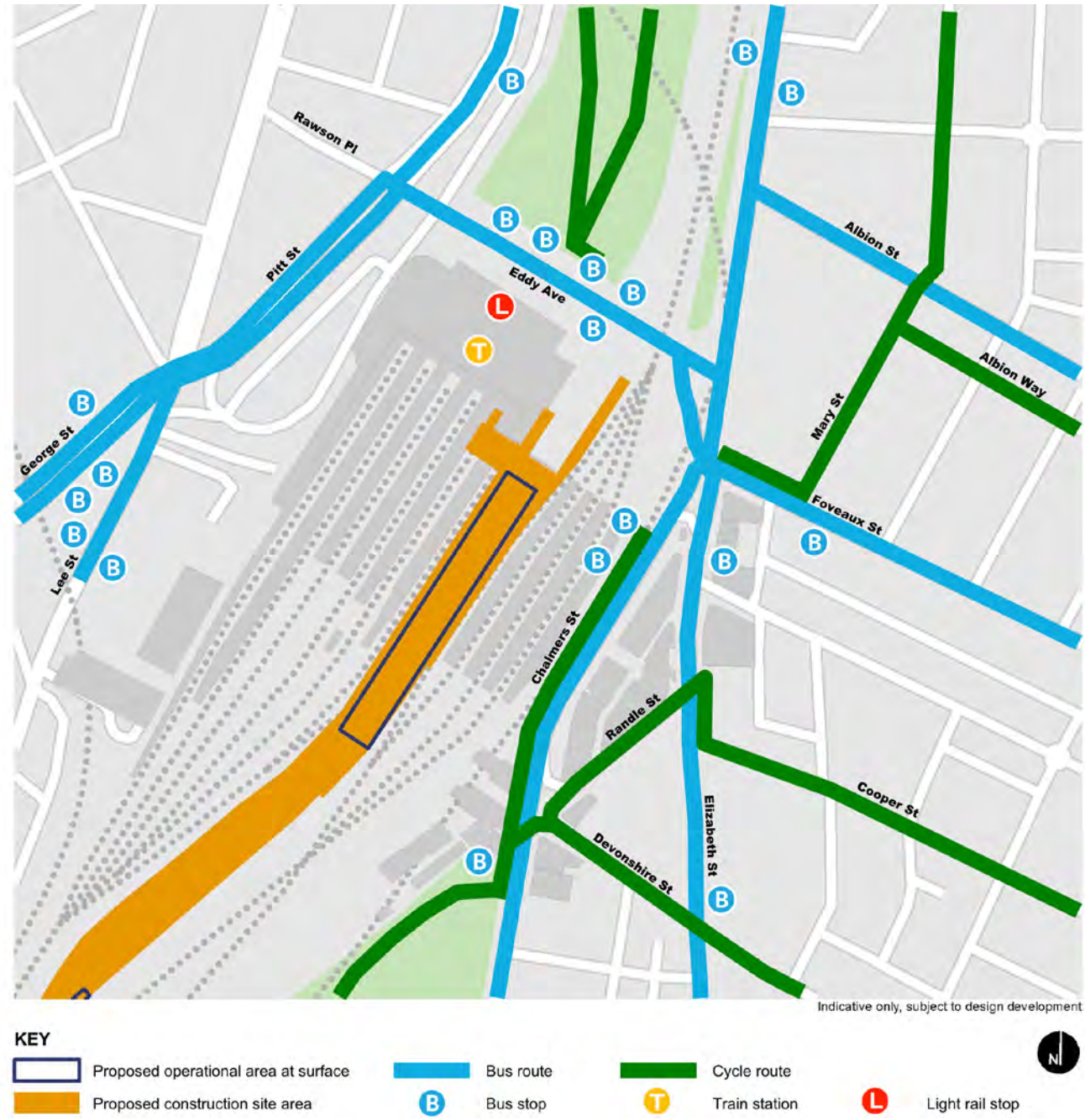


Figure 2.26 : Central station public transport and cycle routes

A total of 75 unique bus services operate in the vicinity of the proposed metro station with north-south services provided on Lee Street, Chalmers Street and Elizabeth Street. East-west services are provided on Eddy Avenue, Albion Street and Foveaux Street. Connectivity to late night bus services is provided at the Railway Square interchange.

In the future, as part of the CBD and South East Light Rail project, bus services would be diverted from the northern end of Chalmers Street (due to the location of the 'Central' light rail stop) and operate via Randle Street and Elizabeth Street. A new bus / light rail stop is also planned at Rawson Place.

Central Station is located at the southern end of the Sydney CBD, and is the busiest station in NSW. Central Station is the primary destination for intercity services with the majority of these services terminating at Central Station.

Central Station currently provides a number of underground pedestrian connections, running mainly east-west, providing interchange connectivity between platforms. These underground pedestrian connections currently experience high pedestrian volumes.

2.11.3 Existing traffic volumes and patterns

Currently there are very high volumes on all nearby major roads, on George Street and Regent Street in the western area of the network. On George Street in particular, congestion is exacerbated by large numbers of buses however it should be noted that traffic patterns in this area will change substantially following the partial closure of George Street and construction of the Sydney CBD and South East Light Rail. In the evening peak, Elizabeth Street (southbound) experiences similarly high volumes.

Cleveland Street is a major east-west arterial route that allows vehicles to by-pass George Street and the CBD; as such, a large number of vehicles were observed travelling from Cleveland Street (eastbound) to Elizabeth Street (northbound) via Chalmers Street. A corresponding movement is evident in the southbound direction as vehicles turn right from Elizabeth Street (southbound) into Cleveland Street.

Approximate peak hour link volumes on key access roads are shown below in **Table 2.10**.

Table 2.10: Central Station existing peak hour traffic volumes by direction (2015)

Road	Location	AM peak volume (vehicles per hour)	PM peak volume (vehicles per hour)
George Street	Between Pitt Street and Harris Street (northbound)	1,730	1,340
	Between Pitt Street and Harris Street (southbound)	890	1,480
Regent Street	Between Kensington Street and Lee Street (northbound)	780	550
	Between Kensington Street and Lee Street (southbound)	1,560	2,000
Cleveland Street	Between Regent Street and Chalmers Street (eastbound)	1,190	1,220
	Between Regent Street and Chalmers Street (westbound)	1,350	1,540
Chalmers Street	Between Devonshire Street and Foveaux Street (northbound)	1,160	1,100
Elizabeth Street	Between Devonshire Street and Foveaux Street (southbound)	1,040	1,520
Pitt Street	Between George Street and Eddy Avenue (northbound)	1,410	1,150

Central Station is the largest rail station and transport interchange in New South Wales, being the only station within the Sydney rail network that connects all InterCity and Suburban services.

Many pedestrian movements at the station occur within the station itself with interchange accounting for almost half of all peak station movements. The *Train Statistics 2014* report by Bureau of Transport Statistics indicates that Central is the busiest station on the Sydney Trains network in both ticket sales and barrier counts. In 2014, there were a total of 5.76 million ticket sales with 188,600 barrier movements per day. The percentage split of station entries and exits within the morning peak period were approximately 21 per cent entries and 79 per cent exits. Of the passengers exiting the station in the morning peak hour, the highest proportion of passengers travel towards Pitt Street and George Street.

2.12 Waterloo

The Waterloo Station would be located on Cope Street between Raglan and Wellington Streets, Waterloo. The station location can be seen below in **Figure 2.27**.

Figure 2.27 : Waterloo Station location

2.12.1 Active transport network

Footpaths are located on all streets in the vicinity of the station location, pedestrian refuges are located on all arms of the roundabouts at Cope Street / Ragland Street and Cope Street / Wellington Street and signalised crossing facilities are located at the intersections of Botany Road / Raglan Street and Botany Road / Wellington Street. Pedestrian attractors include Redfern Station and the Australian Technology Park, located approximately 400m and 700m north of the site respectively. Other attractors include the commercial strip along Botany Road to the north and south.

There is a short dedicated cycleway on Buckland Street between Botany Road and Wyndham Street in the westbound direction. 100m to the east of the proposed station site, there is also a two-way dedicated cycleway on George Street – cyclists may link to these sections via Wellington Street on the southern boundary of the site.

2.12.2 Public transport services

Bus services currently operate along Cope Street, Wellington Street and Botany Road serving the Sydney CBD, Marrickville, Bondi Junction, Mascot, Matraville and Eastgardens. The services that operate here include 305, 309, 310 and 355.

There are bus stops located nearby on Botany Road, Cope Street, Raglan Street and Wellington Street.

Bus stops and the bus routes in the vicinity of the site can be seen in **Figure 2.29**.

Figure 2.28 : Waterloo public transport and cycle routes

2.12.3 Existing traffic volumes and patterns

Traffic data collected in 2015 indicate traffic volumes greater than 1,000 vehicles per hour during the peak hour on Botany Road, Henderson Road and McEvoy Street. Botany Road and Wyndham Street operate as a north-south one-way pair between Cleveland Street and Henderson Road providing a key link between Sydney Airport and its surrounding suburbs to the Sydney CBD and inner west.

McEvoy Street and Henderson Road both run east-west, providing a major link between the inner west and the Sydney CBD or eastern suburbs.

Approximate peak hour link volumes on key access roads are shown below in **Table 2.11**.

Table 2.11: Waterloo existing peak hour traffic volumes by direction (2015)

Road	Location	AM peak volume (vehicles per hour)	PM peak volume (vehicles per hour)
Botany Road	Between Mandible Street and McEvoy Street (northbound)	870	840
	Between Mandible Street and McEvoy Street (southbound)	1,030	1,070
Botany Road	Between McEvoy Street and Wellington Street (northbound)	810	780
	Between McEvoy Street and Wellington Street (southbound)	1,140	1,210
Botany Road	Between Wellington Street and Raglan Street (northbound)	670	640
	Between Wellington Street and Raglan Street (southbound)	1,140	1,080
Wyndham Street	Between Henderson Road and Buckland Street (northbound)	470	420
	Between Henderson Road and Buckland Street (southbound)	190	190
Henderson Road	Between Wyndham Street and Botany Road (eastbound)	230	180
	Between Wyndham Street and Botany Road (westbound)	1,520	1,760
Henderson Road	West of Wyndham Street (eastbound)	680	650
	West of Wyndham Street (westbound)	610	830
Buckland Street	Between Wyndham Street and Botany Road (eastbound)	140	110
McEvoy Street	Between Wyndham Street and Botany Road (eastbound)	790	730
	Between Wyndham Street and Botany Road (westbound)	960	1,200
Bourke Road	Between Wyndham Street and Botany Road (eastbound)	360	410
	Between Wyndham Street and Botany Road (westbound)	400	390

2.13 Marrickville dive site (southern)

The Marrickville dive site (southern) would be located to the north of the T3 Bankstown Line between St Peters and Sydenham stations, adjacent to Murray Street and Edinburgh Road. Vehicular access to the site would be from Murray Street via Edinburgh Road, Bedwin Road, May Street and Princes Highway. The site location can be seen below in **Figure 2.29**.

Figure 2.29 : Marrickville dive site (southern) location

2.13.1 Active transport network

The construction site is located close to Marrickville Metro Shopping Centre and has well developed pedestrian connections. Edinburgh Road, Murray Road and Bedwin Road have paved footpaths on both sides of the street and kerb and guttering throughout. Nearby Smidmore Street is a pedestrian access route to Marrickville Metro, while Lord Street provides pedestrian access to St Peters Station. There are pedestrian refuge islands on all intersection arms at Edinburgh Road / Edgeware Road; at Edinburgh Road / Edgeware Road there is a pedestrian refuge island for crossing Edinburgh Road only, and at the roundabout at Edinburgh Road / Murray Street, there are pedestrian refuge islands for crossing Murray Street only. The nearest signalised pedestrian crossing is at Edinburgh Road / Smidmore Street to the west.

Edinburgh Road is also used as a cycle route to access St Peters Station from residential areas in Marrickville or access Marrickville Metro Shopping Centre from St Peters, however heavy traffic, on-street parking and a large number of driveways to vehicle workshops make it less suitable than less direct routes on nearby Llewellyn Street and Leicester Street.

2.13.2 Public transport services

Bus routes operating within the immediate vicinity of the site are the 308, 352 and 355. These buses travel along Edinburgh Road and Edgeware Road, servicing Marrickville Metro Shopping Centre and terminating at Bondi Junction or the Sydney CBD. Services run every 20 to 30 minutes throughout the day on weekdays and weekends. Bus routes in the vicinity of the site are shown in **Figure 2.30**.

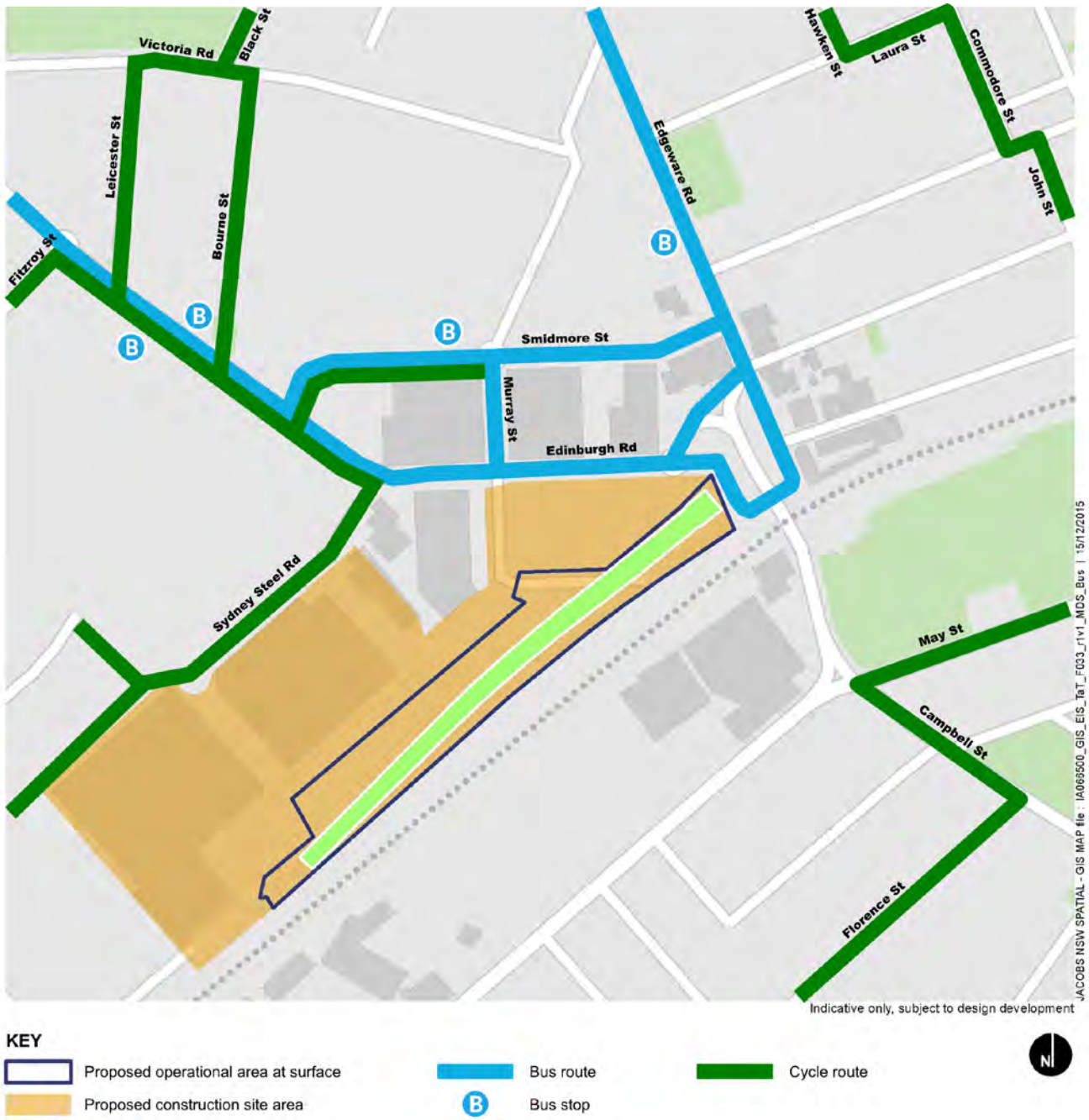


Figure 2.30 : Marrickville public transport and cycle routes

2.13.3 Existing traffic volumes and patterns

Traffic counts from 2015 revealed that the Princes Highway between May Street and Campbell Street experiences heavy traffic volumes southbound during the morning peak period of approximately 1,520 vehicles per hour and during the evening peak period of approximately 1,840 vehicles per hour. At the intersection of May Street and the Princes Highway, it was observed that the left turn from May Street was a dominant movement during both peak periods, accounting for approximately 90 per cent of total eastbound movements. Bedwin Road also experiences high traffic volumes ranging between 830 and 1,060 vehicles per hour in both directions during the morning and evening peak hour, respectively.

Low traffic volumes were recorded on Campbell Street between Princes Highway and May Street with a single lane provided in each direction. Similarly, low traffic counts were observed on Edinburgh Road between Edgeware Road and Murray Street.

Approximate peak hour link volumes on key access roads are shown below in **Table 2.12**.

Table 2.12: Marrickville dive site (southern) existing peak hour traffic volumes by direction (2015)

Road	Location	AM peak volume (vehicles per hour)	PM peak volume (vehicles per hour)
Pacific Highway	Between May Street and Campbell Street (southbound)	570	1,840
	Between May Street and Campbell Street (northbound)	1,520	940
Campbell Street	Between Princes Highway and May Street (eastbound)	390	390
	Between Princes Highway and May Street (westbound)	170	270
May Street	Between Princes Highway and Campbell Street (eastbound)	730	510
	Between Princes Highway and Campbell Street (westbound)	420	990
Bedwin Road	Between May Street and Edinburgh Road (southbound)	830	870
	Between May Street and Edinburgh Road (northbound)	890	1,060
Edinburgh Road	Between Murray Street and Edgeware Road (eastbound)	330	380
	Between Murray Street and Edgeware Road (westbound)	400	570

3. Construction Impacts

Construction of the Chatswood to Sydenham project would generate an increase in heavy vehicle movements travelling through the lower North Shore, Sydney CBD and inner west. In addition to these trips, adjustments to the transport network may be necessary to facilitate construction including the temporary closure of roads, removal of parking, cycle paths and footpaths, and the relocation of bus stops. This chapter identifies the potential traffic impacts associated with the construction activities of the project and identifies mitigation measures to minimise these impacts.

Proposed construction activities that would be undertaken include, but not limited to:

- Demolition of existing buildings and structures.
- Tunnel construction and precast concrete segment lining manufacture.
- Station excavation, ancillary facilities and structural works.
- Tunnel rail systems fit out.
- Station construction and fit out.
- Ancillary facility construction and fit out.

Key agency bodies that would be consulted during the construction phase include:

- The CBD Coordination Office – established to coordinate all traffic and transport in the Sydney CBD including decisions, directions and approvals affecting all road and traffic arrangements in the Sydney CBD. The Coordination office has and would continue to be consulted with regard to all Sydney CBD construction works.
- Roads and Maritime Services – a multi-modal transport agency within the broader Transport Cluster, known as Transport for NSW. They are responsible for the management of state roads, traffic signals and pedestrian crossings. Roads and Maritime Services have and would continue to be consulted where construction works impact state roads.
- State Transit (Sydney Buses and Sydney Trains) – state government bodies responsible for the operation of state buses and trains in Sydney. State Transit would be consulted where train or bus (services or stops) would be impacted by construction works.
- Barangaroo Delivery Authority – the Barangaroo Delivery Authority's role is to manage the city waterfront development at Barangaroo and to deliver development, public domain and sustainability in the area. The Barangaroo Delivery Authority is also responsible for Hickson Road in the vicinity of the Barangaroo development. They would be consulted primarily with regard to construction at the Barangaroo Station.
- Port Authority of NSW – a State Owned Corporation with responsibility for Sydney Harbour. They would be consulted primarily with regard to the Sydney Harbour crossing works as well as the potential access impacts to the Overseas Passenger Terminal due to construction works along Hickson Road.

3.1 Key assumptions

The key assumptions included within the analysis of the construction impacts are outlined below.

3.1.1 Construction vehicle types

The anticipated construction vehicle numbers described are based on the following assumed truck types at each construction site:

- Truck and Dog Combinations (20 cubic metre capacity, maximum length 19 metres): at the Chatswood and Marrickville dive sites
- Semi-trailers (maximum length 19 metres): at the Chatswood and Marrickville dive sites
- Single Unit Truck (10 cubic metre capacity, maximum length 12.5 metres or 8.8 metres): at all other construction sites

Under the Heavy Vehicle National Law (NSW) a heavy vehicle is defined has having a gross vehicle mass of more than 4.5 tonnes. Within this report, a light vehicle is classified as any vehicle equal to or less than 4.5 tonnes.

3.1.2 Construction Hours

Proposed construction hours are shown in **Table 3.1**. These hours have been developed based on a balanced consideration of achieving completion of work at the earliest opportunity and the need to minimise noise and traffic related impacts. As the tunnel boring machines would operate continuously, the tunnelling and associated support activities (including the removal of spoil from the construction sites) would need to be carried out up to 24 hours per day and seven days per week.

The majority of the station fit-out and other aboveground construction activities would be carried out during the following hours:

- 7 am to 6 pm Monday to Friday
- 8 am to 1 pm Saturdays
- No works on Sundays or Public Holidays.

However, other substantial activities (as identified in **Table 3.1**) would need to be carried out outside these hours.

Table 3.1 Construction working hours

Activity	Construction hours	Comments or exceptions
Underground construction activities		
Tunnelling	24 hours per day, seven days per week	Activities that support tunnelling may need to occur 24 hours per day, up to seven days per week. Rock hammering in the tunnel between 10 pm and 7 am would be precluded except where there would be no impact on sensitive receivers. Drill and blast, if required, would be carried out during periods anticipated to have the least impact on receivers.
Underground excavation at station and ancillary sites	24 hours per day, seven days per week	May need to occur outside standard daytime construction hours provided appropriate noise mitigation is in place. Drill and blast, if required, would be carried out during periods anticipated to have the least impact on receivers.
Tunnel and station fit-out (underground	24 hours per day, seven days per week	Activities that support tunnel and station fit-out may need to occur 24 hours per day, up to seven days per week.
Aboveground construction activities		
Demolition Station and ancillary facility fit-out and construction (aboveground)	7 am to 6 pm Monday to Friday 8 am to 1 pm Saturdays No works on Sundays and Public Holidays	Aboveground work supporting underground construction activities (eg concrete pumping, truck loading) are expected to be required 24 hours per day, up to seven days per-week where noise mitigation is in place. Non-disruptive preparatory work, repairs or maintenance may be carried out on Saturday afternoons between 1 pm and 5 pm or Sundays between 8 am and 5 pm. Activities requiring the temporary possession of roads or to accommodate road network requirements may need to be carried out outside the standard daytime construction hours during periods of low demand to minimise safety impacts and inconvenience to commuters. Activities requiring rail possessions may need to be carried out outside the standard construction hours up to 24 hours per day, seven days per week.
Construction traffic for material supply to, and spoil removal from, tunnelling and underground excavation (station and ancillary facility sites)	24 hours per day, seven days per week	Restrictions would be in place during peak hours and special events. At locations where night-time sensitive noise receivers are close to construction sites, significant construction vehicle movements are likely to be restricted during evening and night-time periods.

3.1.3 Spoil transport options

There are a number of transport options available for removing spoil from the station excavation and dive sites. Spoil haulage options that have been considered for the project are outlined in **Table 3.2**.

Table 3.2 : Spoil haulage options

Haulage option	Discussion
Road	Considered feasible for all sites due to their location directly adjacent to the existing road network and, in particular the proximity to the motorway / main arterial road network.
Rail	Rail transport options were investigated for the Chatswood dive site, Central Station and the Marrickville dive site due to their proximity to the rail network. **Chatswood dive site** The T1 North Shore Line is not currently rated for freight transport and includes steep grades and tight curves. The addition of spoil transport on this line would more than likely impact passenger rail operations. As such, rail transport is not considered feasible at this site. **Central Station construction site** Some rail siding space is available on the former Darling Harbour freight line, located on the western side of Central Station. The length of the siding is currently insufficient to accommodate a spoil train and additional infrastructure would be required to transport the spoil from the main construction site to the siding location. Train paths for spoil trains would also need to be secured which may impact passenger rail operations at Central Station. As such, rail transport is not considered feasible at this site. **Marrickville dive site** Track that could be used for a siding is potentially available on the southern side of the rail corridor. This track also provides ready access the Metropolitan Freight Network. The use of this track would require the transport of spoil material across the suburban rail lines which may result in safety risks and impact passenger rail operations. Rail transport of spoil may be feasible at this site subject to further investigations regarding rail safety risks and the identification of a suitable destination for unloading spoil in proximity to a re-use or disposal site.
Barge	Barge transport options were investigated for the Blues Point temporary site and the Barangaroo Station construction site due to their proximity to Sydney Harbour. **Blues Point temporary site** The site has ready access to a potential barge loading facilities via the existing wharf at the end of Blues Point Road. The use of a barge from this location may require strengthening works to the wharf and potentially dredging of the harbour bed to ensure sufficient depth Additionally, the volume of spoil proposed to be transported from this site is relatively minor and the establishment of barging facilities at this site is not considered to be a feasible solution. Barge transport of spoil may be feasible at this site subject to further investigations. **Barangaroo Station construction site** Barging of spoil at this site could potentially be achieved by utilising existing wharf areas at Barangaroo (to the south of the newly created 'Northern Cove') or to the north at Moore's Wharf (a Port Authority of NSW facility to the east of Barangaroo Reserve). The use of wharf space at Barangaroo could result in disruption to the construction of the adjacent Barangaroo development. However, barge transport of spoil from this location may be feasible subject to further investigation and agreement with Barangaroo Delivery Authority. The use of Moore's Wharf would require the transport of spoil from the Barangaroo Station construction site to the wharf through the use of a conveyor system or by road. Moore's Wharf is currently used by the Port Authority of NSW for various functions including emergency response. Barge transport of spoil may be feasible at this site subject to further investigations, agreement of the Port Authority of NSW and the development of a solution which ensured the existing functions supported by Moore's Wharf are not impacted.

The investigations found that, subject to further feasibility analysis, rail transport may be possible from the Marrickville dive site and barge transport may be possible from the Barangaroo Station construction site and from the Blues Point temporary site. However, as there are substantial constraints to these options that would need to be overcome, this traffic and transport assessment has assumed that all spoil would be transported by road.

Further consideration of rail and barge options would be carried out during the detailed design phase of the project. In the event that either or both of these options are adopted this is likely to result in a reduction to the road based construction traffic impacts described in this assessment.

3.1.4 Spoil haulage routes

Haul routes to and from the construction site have been developed in consultation with Roads and Maritime Services and the CBD Coordination Office, and with the following aims:

- Minimise the use of local or residential streets and maximise the use of arterial roads
- Minimise potential safety implications for pedestrians, cyclists and other road users
- Avoid the need to pass through or under the Sydney CBD for the construction sites external to the Sydney CBD
- Exit the Sydney CBD as efficiently as possible for the Sydney CBD construction sites
- Minimise the cumulative use of roads by trucks accessing different Sydney CBD construction sites.

The proposed haul routes for all construction sites are provided in the respective sections of this technical paper.

3.1.5 Construction worker parking

Due to the generally constrained nature of the construction sites, car parking for construction workers would not be provided at the majority of the sites. With the exception of the Chatswood and Marrickville dive sites, each construction site would typically provide between four to ten parking spaces intended to be used by engineers and other management staff.

The majority of the construction sites are located in close proximity to public transport services and construction workers would be encouraged to use these services. This may include incentive schemes. The Chatswood dive site and the Marrickville dive site would each provide about 300 car parking spaces. These facilities may be used to provide worker parking in association with shuttle bus transfers (park and ride) to other nearby construction sites.

In addition, consideration would be given to remote car parking in existing under-utilised car parks in association with shuttle bus transfers to the construction sites. For the Sydney CBD construction sites these car parks could include The Domain, Goulburn Street and Darling Harbour.

3.2 Assessment methodology

3.2.1 Outline of methodology

The construction impact assessment is based on the analysis of existing traffic movements on the local road network at each construction site to determine the current operational performance. Construction traffic is then added to the networks and analysed to identify potential impacts to road network performance. The approach to traffic modelling undertaken for this assessment aligns with the Roads and Maritime *Traffic Modelling Guidelines* (version 1.0, February 2013) and includes the following broad steps:

- Development of calibrated and validated existing base models to align with existing operational conditions at each intersection. The following data sources were used in the calibration and validation process:
  - Surveyed and SCATS traffic counts
  - SCATS traffic signal data
  - Site observations of pedestrian delays, posted speed limits, intersection configurations, lane usage, location of parking, bus stop locations, bottlenecks and pinch points.
- Application of anticipated construction traffic demands to the calibrated and validated base models to develop construction phase models to allow the identification of potential impacts.

The assessment of intersection performance was undertaken using LinSig (version 3.2). LinSig is a macro-simulation model capable of modelling isolated or coordinated networks of road intersections. It is able to assess performance at individual intersections and at a network level for existing or future year design options. To limit the level of complexity and to allow faster calculation of results, it uses a traffic flow model that considers platoons of vehicles rather than individual units. Provided that all signalised intersections in a network operate on the same cycle time, the pattern of traffic arrivals, departures and queues at an intersection stop line will be very similar during each cycle. LinSig is able to propagate these platoons of traffic through a road network to enable calculation of network performance statistics. LinSig is then able to optimise traffic signal timings for the network so that the level of delay is minimised or traffic capacity is maximised. This optimisation of the traffic signal timings is applied by the LinSig model to both the without and with project scenarios.

Corridor assignment in LinSig uses origin-destination assignment via origin-destination demand matrices formulated within the software. These are based on the creation of a balanced network diagram referenced to surveyed traffic conditions. Vehicles enter and exit the road network via a series of zones which represent key locations or strategic roads within the study area. Light vehicles and heavy vehicles are inserted into the model in a format known as passenger car units (PCU). These are based on the acknowledgement of the amount of road space different types of vehicles use. For example, a car is nominated as being 5.5 metres in length and represents one PCU; however the actual value of one PCU is equivalent to 6.25 metres of road space to take into consideration the impact of the space left between queuing vehicles.

The traffic modelling results obtained should not be interpreted in absolute terms, rather the purposes of traffic modelling is to enable a comparison to be made between the ‘with’ and ‘without’ construction traffic scenarios. Traffic signal operations have been modelled as fixed time operation whereas in reality the traffic signal control system used throughout Sydney is the Sydney Coordinated Adaptive Traffic System (SCATS). Under adaptive SCATS control the actual operational performance achieved is likely to be better than the modelled results. Furthermore, the adaptive nature of the traffic signal control available in Sydney means that intersections are able to modify phase times in response to variability in traffic demand. Therefore, it is important when reviewing the traffic modelling results that the scenarios be viewed relative to each other in order to determine any potential change in operational performance due to the project.

The traffic modelling undertaken was of the AM and PM peak periods only consistent with the standard approach for this of type assessment. The peak traffic periods represent a 'worst case scenario' as during these periods the road network experiences the maximum background traffic demand and the available spare capacity of the road network is at its most limited. Construction vehicle volumes are anticipated to be higher outside the AM and PM weekday peak periods; however, the number movements would remain relatively low and be within the range of daily variations in traffic volumes on the road network when compared to background traffic.

Construction activity within the Sydney CBD from other developments, such as Barangaroo, has been an on-going activity for a number of years. Consequently, the background traffic data collected in 2015, implicitly includes existing construction traffic associated with those on-going activity. Therefore, the use of traffic survey data from 2015 in the traffic assessment of this project takes into account the impact of construction vehicles from other construction activity within the Sydney CBD.

A qualitative assessment of the impacts of the construction activity on the walking, cycling and public transport networks has also been undertaken at each construction site.

3.2.2 Performance indicators

A fundamental measure of the success of the project would be the minimisation of disruption caused by construction activities. This would be achieved through effective traffic management techniques. Existing conditions and constraints have been identified and assessed with respect to the proposed construction site access arrangements, heavy vehicle routes and construction traffic volumes.

To assess the impact of the construction activities on the road network performance, intersections along the proposed construction routes between construction sites and the arterial road network have been assessed using LinSig. The main performance indicators for LinSig 3.2 include:

- Degree of Saturation (DoS) – the ratio between traffic volumes and capacity (v/c) of the intersection used to measure how close to capacity an intersection is operating. The DoS is a direct measure of the congestion level at the intersection. As DoS approaches 1.0, both queue length and delays increase rapidly. Satisfactory operations usually occur with a DoS range between 0.8-0.9 or below;
- Average Delay – duration, in seconds, of the average vehicle waiting time at an intersection; and
- Level of Service (LoS) – a measure of the overall performance of the intersection. For this purpose, average delay from Roads and Maritime Services LoS calculations has been used.

Criteria for these performance indicators are provided in **Table 3.3**.

Table 3.3 : Intersection Level of Service Criteria1

Level of Service	Average Delay (sec/veh)	Traffic signals and roundabouts
A	Less than 14	Good operation
B	15 to 28	Good with acceptable delays and spare capacity
C	29 to 42	Satisfactory
D	43 to 56	Operating near capacity
E	57 to 70	At capacity; at signals incidents will cause excessive delays
F	>70	Exceeds capacity; roundabouts require other control mode

[1] Guide to Traffic Generating Developments (RMS, 2002)

At the time of writing, the Sydney CBD is undergoing major changes in travel patterns and traffic behaviour, primarily associated with the closure and pedestrianisation of George Street. The traffic survey data used to develop the traffic models used in this assessment was collected at a point in time when George Street was open to all traffic. Therefore, in order to replicate the road network arrangements that are now in place and that would be in place during construction, the traffic data collected has been redistributed within the Sydney CBD in line with the preferred Sydney CBD driving routes, shown below in **Figure 3.1**. It is anticipated that the closure of George Street would be completed and the preferred driving routes fully in operation at the time the project commences construction.

Figure 3.1 : Preferred CBD driving routes (**http://mysydney.nsw.gov.au/guides/driving**)

3.3 Chatswood dive site (northern) and northern surface works

3.3.1 Worksite location, parking and access

The Chatswood dive site would be located to the west of the existing T1 North Shore rail line. The construction site is bounded by Nelson Street to the north, the Pacific Highway to the west, Mowbray Road to the south and the rail corridor to the east. The northern surface works would extend along the existing rail line, south of Chatswood Station to Brand Street, Artarmon. The site location is shown in **Figure 3.2**.

Figure 3.2: Chatswood dive site and northern surface works

As part of the constructions work, and to facilitate the operation of the metro, the Nelson Street road bridge would be permanently closed and demolished as part of the project. The permanent closure is required to enable the construction of the dive structure and there is no option to reinstate the bridge once the permanent infrastructure is in place. As Nelson Street is currently used as a 'G-turn' facility for southbound vehicles on the Pacific Highway wishing to turn right onto Mowbray Road, it is proposed to realign the Pacific Highway and provide an all vehicle right turn movement from the Pacific Highway southbound to Mowbray Road westbound. For the purposes of the traffic assessment, two right turn lanes have been assumed, however the exact nature of this right turn provision would be determined during detailed construction planning. The Pacific Highway / Mowbray Road intersection upgrade works would be completed prior to the closure of Nelson Street.

Roads and Maritime are also investigating additional works to improve performance of this intersection as part of the Pinch Point Program. Sydney Metro would continue to consult with Roads and Maritime to ensure coordination of the works at this intersection. An indicative concept design for the Sydney Metro works at this intersection is shown in **Figure 3.3**.

Figure 3.3 : Pacific Highway / Mowbray Road intersection concept design

The modifications would include the provision of a southbound right turn facility, and associated traffic signal phase, from the Pacific Highway into Mowbray Road. This would also require the localised widening of the Pacific Highway to the north of Mowbray Road. New signals are also required at the Hampden Road / Mowbray Road intersection (currently an unsignalised intersection) to access and egress the construction site. The proposed concept design for these intersection upgrades is included below in Figure 3.4**.**

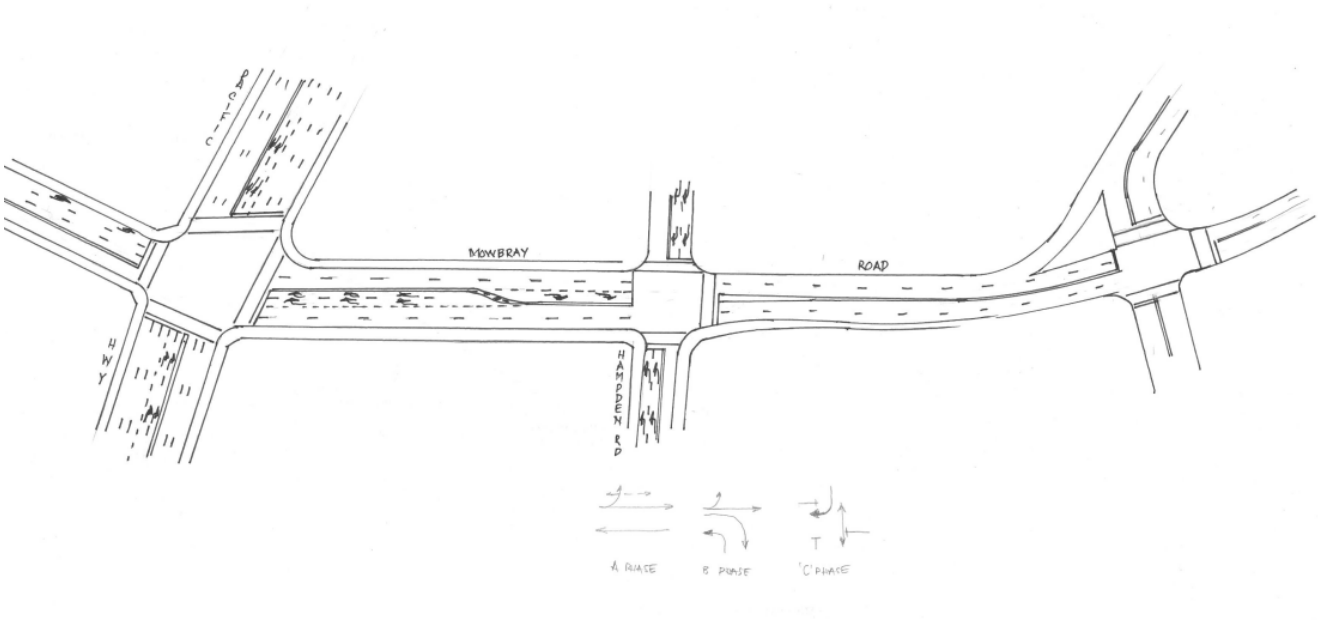


Figure 3.4: Concept design of the Mowbray Road intersection upgrades

Haulage routes to the construction site (shown in **Figure 3.5**) would be via the Pacific Highway, Nelson Street and Mowbray Road.

The primary vehicular access to the site would be southbound along the Pacific Highway, left into Nelson Street and right into the site from Nelson Street, alternatively, from the Pacific Highway left onto Mowbray Road and left into the site. The primary exit would be right out onto Mowbray Road and right onto the Pacific Highway. The vehicular access on Mowbray Road would form the fourth arm of a new signalised intersection with Hampden Road.

In addition, access to the northern surface track works site (metro tracks and the adjustments to the T1 North Shore Line) would be provided by existing access points on Hopetoun Avenue, Chatswood and Drake Street, Artarmon as well as a proposed new access point at Brand Street, Artarmon. It is anticipated that there would be about six vehicles per hour using these access and egress points on an occasional basis to carry out construction of the northern surface works. This volume is relatively minor and would not result in impacts to the performance of the surrounding road network.

About 1,000 square metres would be allocated to car parking, which would provide about 300 on-site parking spaces and the potential for a park and shuttle service to other construction sites.

A total workforce of about 480 is anticipated at the site, working various shifts. Shift times at the site are anticipated to be 7 am to 3 pm, 3 pm to 11 pm and 11 pm to 7 am.

No on-street parking spaces would be lost as part of the construction works.

Figure 3.5 : Chatswood dive site haulage routes

3.3.2 Construction activities

Major construction activities to take place at the Chatswood dive site include:

- Support surface metro track works and adjustment to the T1 North Shore Line between Chatswood Station and Brand Street, Artarmon including track slewing and construction of the T1 North Shore Line 'Down' (northbound) track bridge, within the rail corridor
- Excavate and construct the dive structure and tunnel portal
- Launch and support two tunnel boring machines for the major tunnelling works between Chatswood and Blues Point temporary site
- Support tunnel rail systems fit out works.

3.3.3 Construction vehicle movements

Construction vehicles (light vehicles and heavy vehicles) would access and egress the site 24 hours a day, with the peak construction period occurring between 10 am and 4 pm. The arrival and departure pattern of construction vehicles aims to minimise the impact of construction activity during the network peak periods, as well as keeping night time heavy vehicle movements to a low level. The largest construction vehicles anticipated at the site are truck and dog construction vehicles and semi-trailers.

The numbers of vehicles arriving at the site per hour during the various stages of construction are shown below in **Figure 3.6** and **Figure 3.7**. The same numbers of vehicles entering the site per hour are anticipated to exit the site per hour.

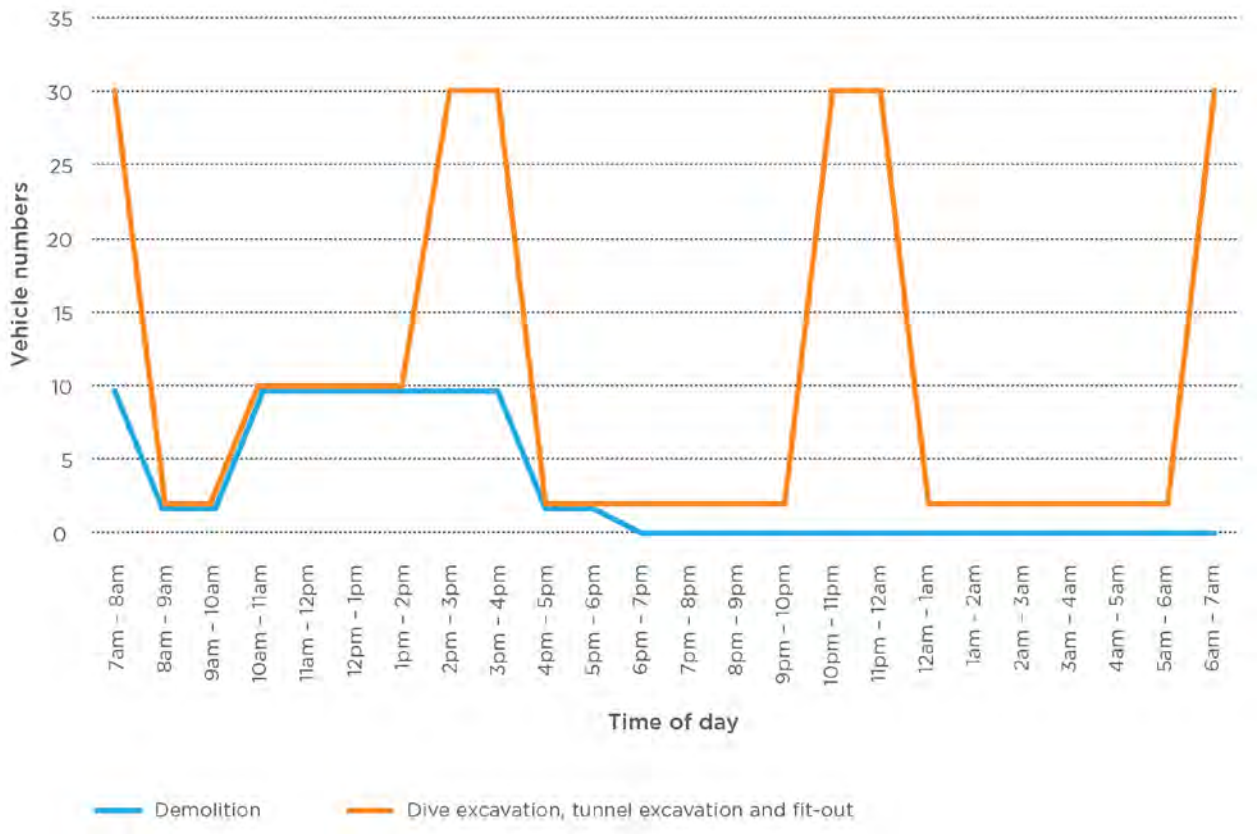


Figure 3.6 : Hourly light vehicle numbers (arrival only) at the Chatswood dive site

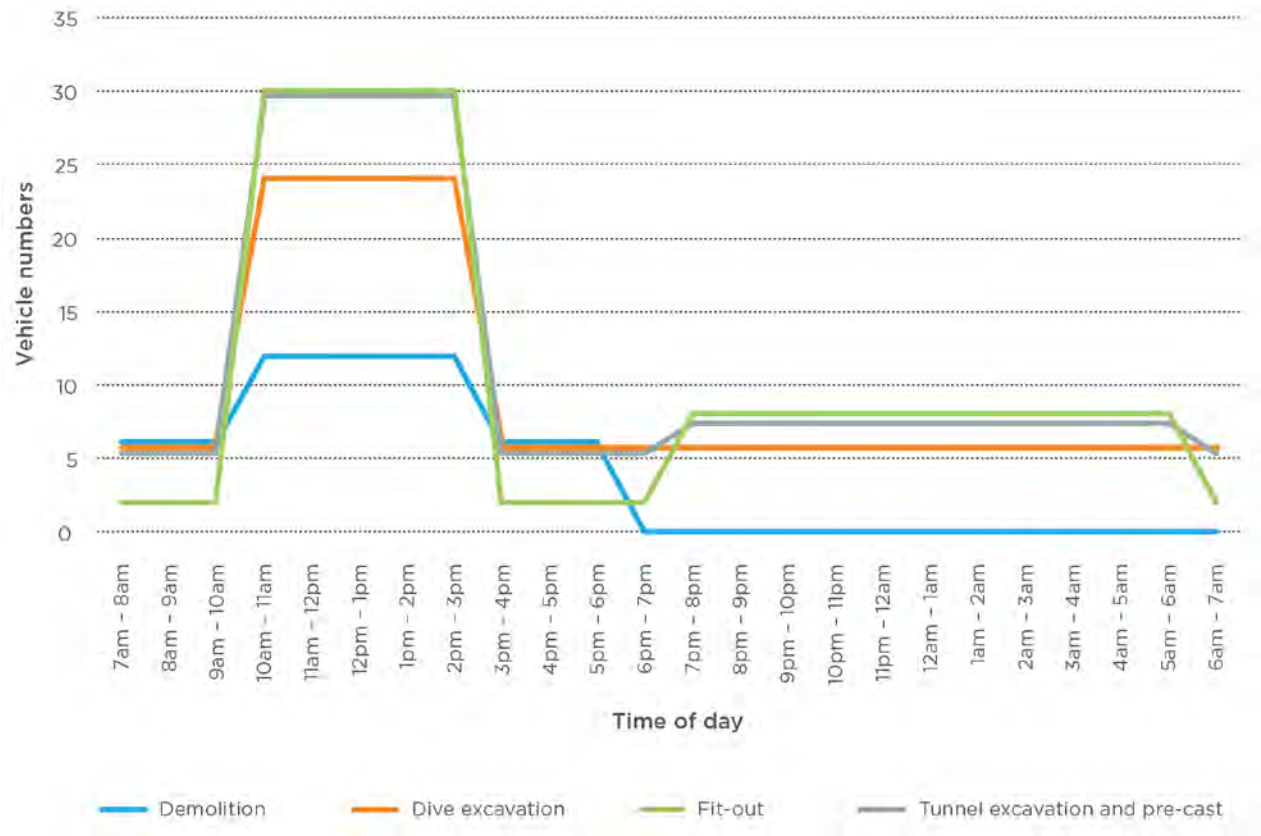


Figure 3.7 : Hourly heavy vehicle numbers (arrival only) at the Chatswood dive site

3.3.4 Road network performance

Figure 3.8 provides an overview of intersection locations surrounding the Chatswood dive site included within the assessment. The base scenario uses existing traffic data that has been redistributed to take into account the closure of Nelson Street and the introduction of the southbound right turn movement from the Pacific Highway to Mowbray Road. The base scenario has then been compared to the anticipated construction phase of the project during the network peak hour.

Table 3.4 summarises the average delay per vehicle, level of service and degree of saturation at each intersection for both the base and construction scenarios.

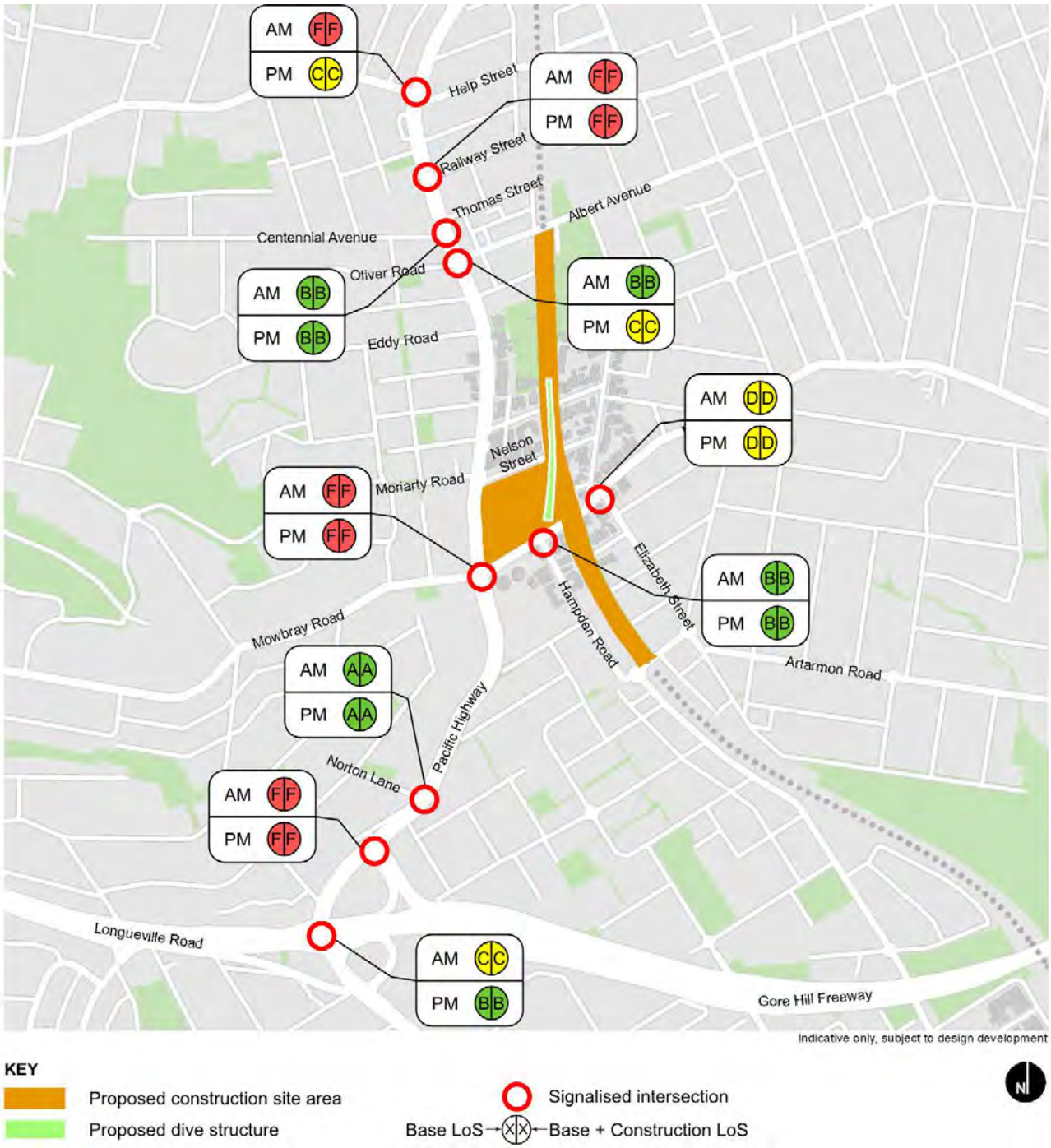


Figure 3.8 : Chatswood dive site assessed intersection locations

Table 3.4: Modelled intersection performance at the Chatswood dive site (AM and PM peak hour)

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Pacific Highway / Fullers Road / Help Street (signalised)								
AM peak	5,797	83	F	1.14	5,887	83	F	1.14
PM peak	5.655	39	C	0.93	5,690	41	C	0.95
Pacific Highway / Victoria Avenue (signalised)								
AM peak	4,525	101	F	0.90	4,615	101	F	0.90
PM peak	4,521	87	F	0.77	4,556	83	F	0.78
Pacific Highway / Centennial Avenue (signalised)								
AM peak	4,455	17	B	0.89	4,545	18	B	0.89
PM peak	4,784	23	B	0.89	4,819	21	B	0.89
Pacific Highway / Albert Avenue / Oliver Road (signalised)								
AM peak	4,663	24	B	0.75	4,753	23	B	0.74
PM peak	4,833	29	C	0.94	4,868	29	C	0.94
Pacific Highway / Mowbray Road (signalised)								
AM peak	6,672	72	F	1.06	6,740	81	F	1.07
PM peak	7,460	119	F	1.14	7,487	142	F	1.18
Pacific Highway / Howarth Road / Norton Lane (signalised)								
AM peak	4,582	5	A	0.59	4,582	6	A	0.62
PM peak	5,111	8	A	0.75	5,111	8	A	0.75
Pacific Highway / Gore Hill Freeway ramps (signalised)								
AM peak	5,107	77	F	1.12	5,107	76	F	1.12
PM peak	5,385	74	F	1.13	5,385	75	F	1.13
Pacific Highway / Longueville Road (signalised)								
AM peak	3,860	31	C	0.83	3,860	32	C	0.80
PM peak	3,748	27	B	0.77	3,748	27	B	0.75
Mowbray Road / Orchard Road / Elizabeth Street (signalised)								
AM peak	3,149	49	D	1.02	3,149	49	D	1.02
PM peak	3,129	45	D	0.84	3,129	44	D	0.84
Mowbray Road / Hampden Road (signalised)								
AM peak	2,792	25	B	0.80	2,861	25	B	0.79
PM peak	2,961	25	B	0.71	2,988	25	B	0.69

Note: Outputs from LinSig Version 3.2

Base

Under existing conditions, the base network experiences significant congestion along the Pacific Highway and Mowbray Road in the morning and evening peak periods. While signal coordination, particularly along the Pacific Highway, may reduce delays in the peak direction, there is competition for green time between the high through volumes in both directions along the Pacific Highway and side-street turning movements. In addition, a number of intersections are operating at, near or over capacity during peak periods.

Intersections on the Pacific Highway and Mowbray Road experience long delays due to high volumes of through traffic and conflicting right-turn movements. The following intersections currently perform at LOS E or F:

- Pacific Highway / Fullers Road / Help Street (AM peak).
- Pacific Highway / Victoria Avenue (AM and PM peaks).
- Pacific Highway / Mowbray Road (AM and PM peaks).
- Pacific Highway / Gore Hill Freeway ramps (AM peak).

In particular, the intersection at the Pacific Highway / Mowbray Road has an average delay greater than 100 seconds in the PM peak and the Pacific Highway / Victoria Avenue intersection has similar average delay in the AM peak.

Construction

The results in **Table 3.4** indicate that the addition of construction traffic would not have any major impacts on the operational performance of the intersections assessed. The number of additional construction vehicles is within the range of normal variation in traffic volumes.

At Pacific Highway / Fullers Road / Help Street, additional traffic would cause the degree of saturation to rise from 0.93 to 0.95 in the evening peak. However, this is reflective of the current over-saturation and sensitivity of this intersection.

Traffic signal operations have been modelled as fixed time operation and under adaptive SCATS control the actual operational performance achieved is likely to be better than the modelled results. Furthermore, the adaptive nature of the traffic signal control available in Sydney means that intersections are able to modify phase times in response to variability in traffic demand.

3.3.5 Public transport services

The southbound bus stop located between Bryson Street and Mowbray Road on the Pacific Highway may need to be relocated during the construction phase. The relocation of this bus stop would be carried out by Transport for NSW in consultation with the bus operators, Roads and Maritime Services and Willoughby Council. This would however not impact the operation of any of the bus services that use this stop; however, the relocation may result in some passengers having to walk slightly further distances to / from the bus stop.

The surface track works (adjustment to the T1 North Shore Line and the metro tracks) would require some works to be carried out during rail track possessions. These works would be coordinated with the Sydney Trains rail track possession schedule and possessions required for the conversion of the Epping to Chatswood Rail Line to reduce impacts to customers and alternative bus services would be provided during these possession works.

3.3.6 Active transport network

The closure of the Nelson Street bridge would remove the east-west cyclist and pedestrian connections across the T1 North Shore Rail Line. Pedestrians and cyclists would be able to use Mowbray Road to cross the rail line or Frank Channon Walk (a shared path connecting Chatswood Station and Nelson Street) and the underpass adjacent to Chatswood Oval. For a pedestrian or cyclist travelling between Chatswood Station and residential areas to the south, this would result in an additional travel distance of around 50 to 100 metres. Given the limited number of pedestrians and cyclists currently using the bridge, and with alternate routes available, the impact of its closure would be minor.

Short-term temporary closures of Frank Channon Walk would be required to safely carry out construction of the northern surface track works. These closures would typically occur over several weekends associated with work carried out during track possessions. During these periods, pedestrians and cyclists would need to use either the Pacific Highway or Orchard Road to access Chatswood Station from areas to the south.

3.3.7 Combined impacts with other Sydney Metro works

The Epping to Chatswood Rail Line Conversion would temporarily close the Epping to Chatswood Railway for six to seven months from late 2018. During this period replacement bus services would be operating, including 22 bus trips arriving at Chatswood and eight trips departing Chatswood in the AM peak hour. Buses would travel along Fullers Road and use the Pacific Highway between Fullers Road and Victoria Avenue. During the AM peak hour, the Chatswood dive site would generate a maximum of eight vehicles arriving and eight vehicles departing the site along the Pacific Highway. The cumulative impact of the replacement bus services and the construction vehicles is therefore considered to be negligible.

Additionally, due to the relatively low number of construction vehicles, the project is anticipated to have a minimal impact on the Epping to Chatswood Rail Conversion Temporary Transport Project.

3.4 Artarmon substation

3.4.1 Worksite location, parking and access

The Artarmon substation construction site would be located between Butchers Lane, Barton Road and the Gore Hill Freeway, with vehicular access proposed via Barton Road.

The site would receive single unit construction trucks. The site is expected to provide approximately four to 10 car parking spaces.

No on-street car parking spaces would be lost in the vicinity of the site.

Haulage routes to the construction site (shown below in **Figure 3.9**) would be via Barton Road, Reserve Road and the Gore Hill Freeway.

The site is anticipated to have a workforce of 60 working a variety of shifts.

Figure 3.9 : Artarmon substation haulage routes

3.4.2 Construction activities

The site would be used to construct the Artarmon traction substation. This would involve the excavation of a shaft to reticulate electrical cables to the tunnel below and the construction of an above ground building which would be fitted out with electrical equipment.

3.4.3 Construction vehicle movements

Construction vehicles (light vehicles and heavy vehicles) would generally access and egress the site during standard daytime construction hours only, with the peak construction period occurring between 10 am and 4 pm. The same numbers of vehicles entering the site are anticipated to exit the site per hour. The arrival and departure pattern of construction vehicles aims to minimise the impact of construction activity during the network peak periods.

The number of vehicles arriving per hour during the various stages of construction is shown below in **Figure 3.10** and **Figure 3.11**.

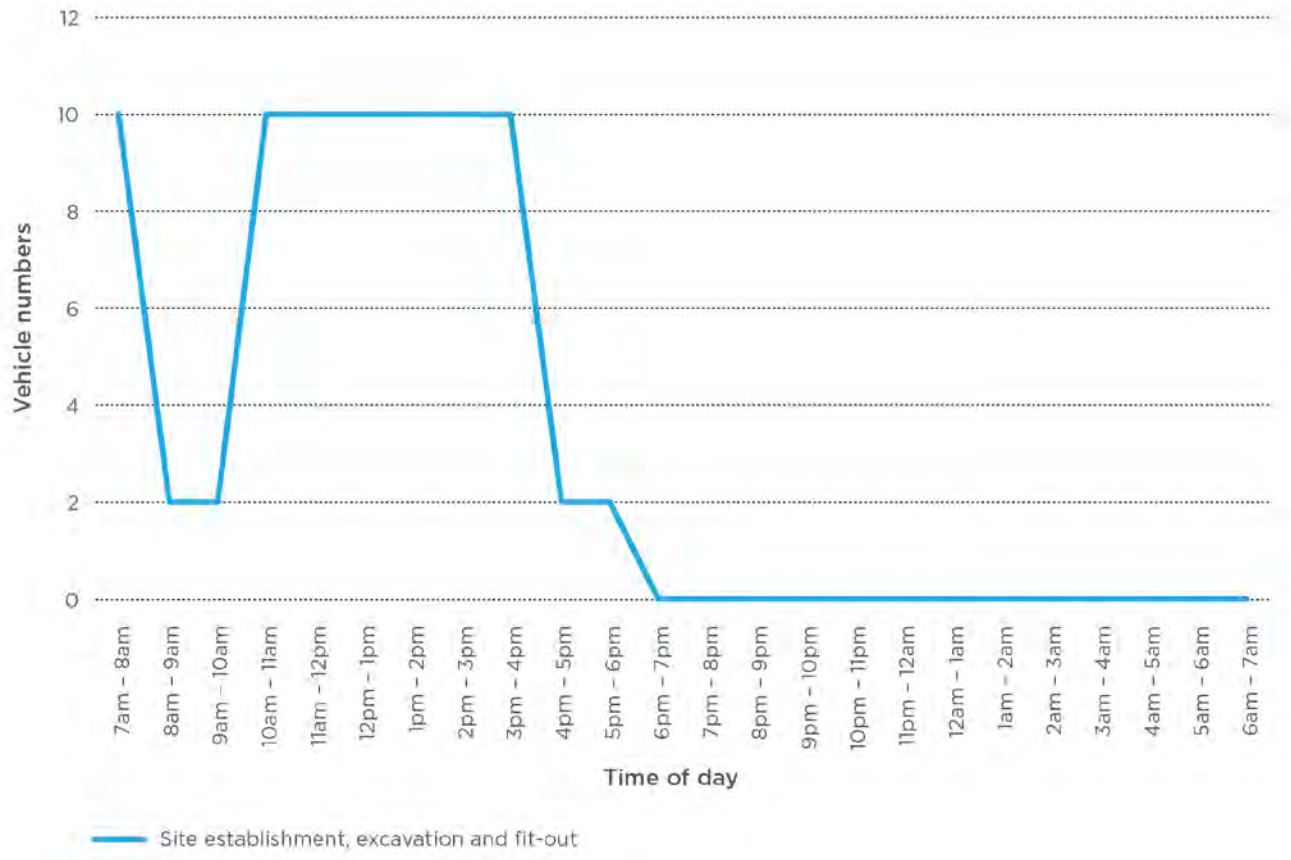


Figure 3.10 : Hourly light construction vehicle numbers (arrival only) at the Artarmon substation construction site

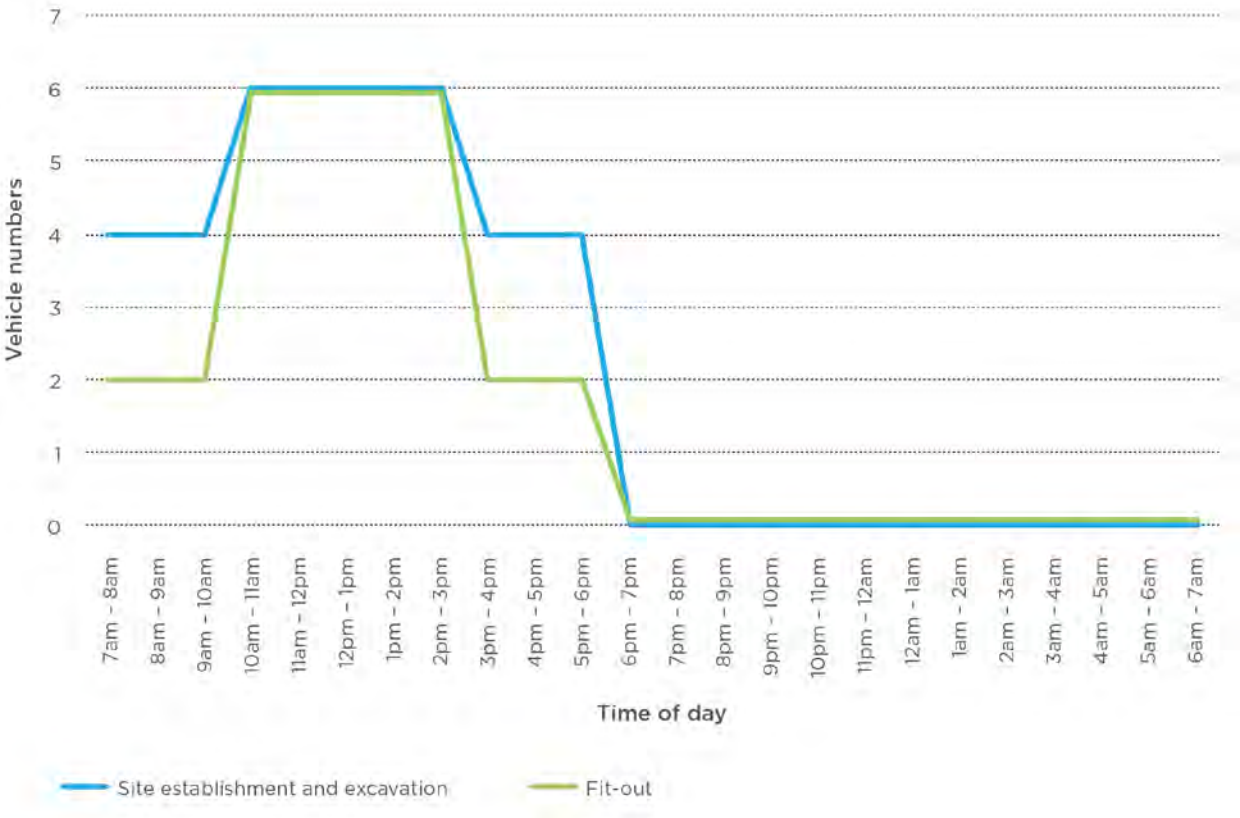


Figure 3.11 : Hourly heavy construction vehicle numbers (arrival only) at the Artarmon substation construction site

3.4.4 Road network performance

Figure 3.12 provides an overview of intersection locations surrounding the Artarmon substation included within the assessment.

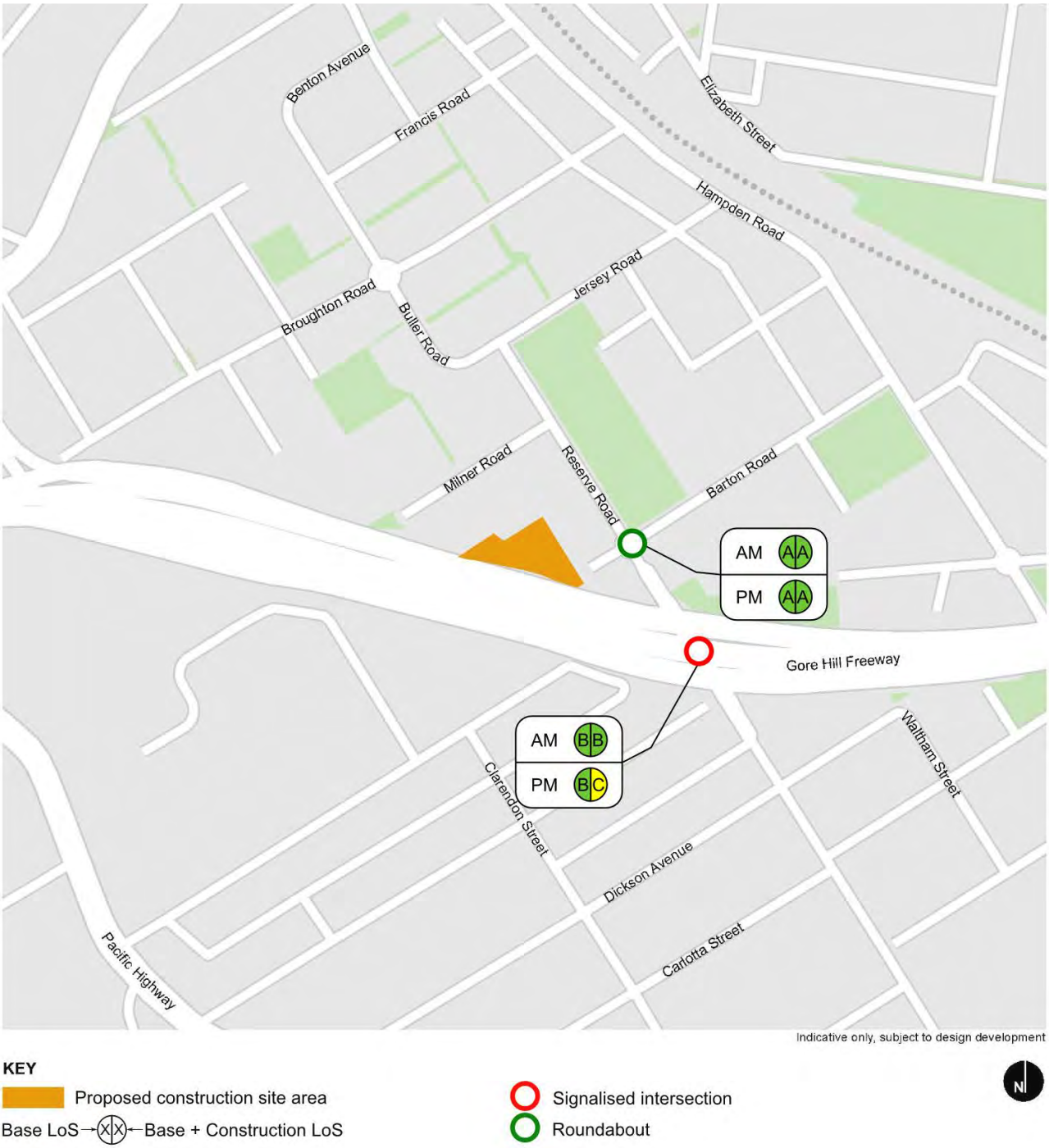


Figure 3.12 : Artarmon substation assessed intersection locations

Table 3.5 summarises the average delay per vehicle, level of service and degree of saturation at each intersection for the base and construction scenarios.

Table 3.5: Modelled intersection performance at Artarmon substation (AM and PM peak hour)

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Reserve Road / Gore Hill Freeway (signalised)								
AM peak	4,183	25	B	0.93	4,219	25	B	0.93
PM peak	3,661	28	B	0.93	3,697	31	C	0.98
Reserve Road / Barton Road (roundabout)								
AM peak	1,071	4	A	0.51	1,095	4	A	0.51
PM peak	1,059	6	A	0.63	1,083	6	A	0.65
Reserve Road / Butchers Lane (priority controlled)								
AM peak	483	3	A	0.01	483	3	A	0.01
PM peak	268	4	A	0.01	268	4	A	0.01

Note: Outputs from LinSig Version 3.2

Base

Currently, all intersections in the vicinity of Artarmon substation operate at LOS B or better in both the AM and PM peaks.

Construction

When construction vehicles were added to the network, the intersection of Reserve Road / Gore Hill Freeway is expected to deteriorate from LOS B to LOS C in the PM peak period however the deterioration in the average delay and degree of saturation would be minimal therefore no significant impact is expected at this or other locations.

3.4.5 Public transport services

As the Artarmon Loop only provides services every 30 minutes and the impact of construction vehicles at Artarmon substation is anticipated to be minor, any impacts to this service would be negligible.

3.4.6 Active transport network

The construction vehicles are not anticipated to impact on existing active transport networks in the vicinity of the site.

3.5 Crows Nest Station

3.5.1 Worksite location, parking and access

The Crows Nest Station construction site would be located between Oxley Street and Hume Lane, Crows Nest, bounded by the Pacific Highway and Clarke Lane. It is anticipated that between approximately four to 10 car parking spaces would be provided on site. Access to private property parking would be maintained.

Excavation of the station would involve the temporary closure of Hume Street (for approximately six months) to carry out the cut-and-cover works. During this period, vehicle access to Clarke Street and the remaining portions of Hume Street would be possible via Oxley Street. To maintain the movements available at the Hume Street intersection, an additional signal phase would be added to the Pacific Highway / Oxley Street intersection to allow a right turn movement from Oxley Street to the Pacific Highway northbound.

Construction works at this station would also require the closure of Clarke Lane in the area immediately to the north of its intersection with Hume Street. The remaining section of Clarke Lane would remain open and be converted to two way flow to retain access to the remaining properties on Clarke Street.

The site is anticipated to have a workforce of 240 working a variety of shifts.

Public transport would be promoted as the primary mode of transport for construction workers to minimise impacts on the local road network and parking availability. Off-site parking alternatives and associated shuttle arrangements to transport workers to and from the site would also be investigated.

The primary haulage routes (shown in **Figure 3.13**) would be via the Pacific Highway, Oxley Street, Clarke Street and Hume Street. Alternatively, construction vehicles could use the Pacific Highway / Albany Street intersection to access / exit the site. The intersection however currently experiences queuing along Albany Street and is therefore not considered the primary option.

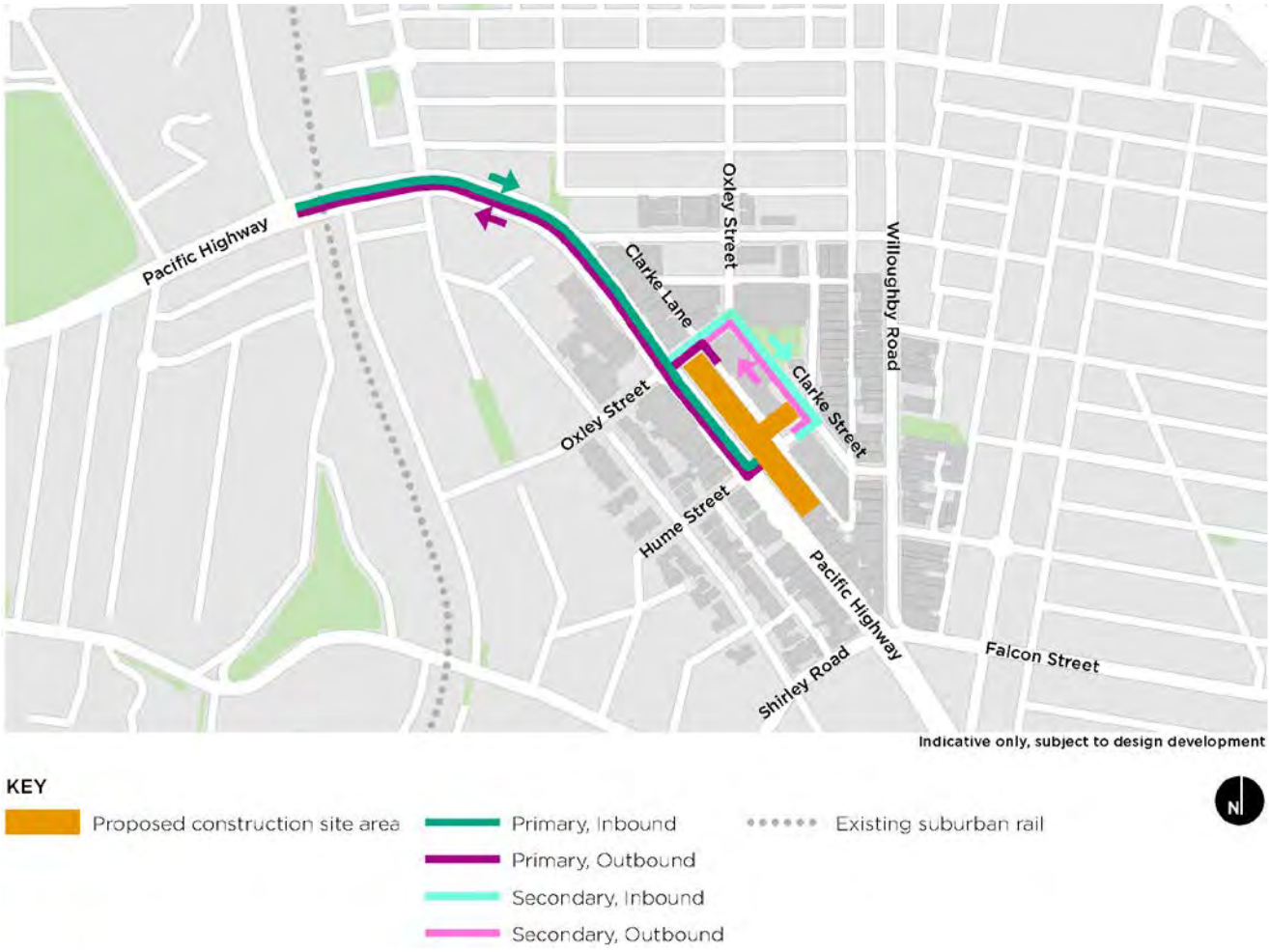


Figure 3.13: Crows Nest haulage Routes

Two to four on street car parking spaces would be lost on Hume Street. The parking spaces are currently metered with a ¼ P restriction between 8:30 am and 6 pm Monday to Friday and 8:30 am to 12 pm on Saturday. Consultation with North Sydney Council would be undertaken with regard to the loss of these parking spaces, however given the low number of parking spaces that would be lost the impact on parking would be minor.

3.5.2 Construction activities

The major construction activities planned for Crows Nest would involve:

- Enabling works such as building demolition, services relocation and provision of power supplies for station construction.
- Station excavation
- Station construction

3.5.3 Construction vehicle movements

Single unit trucks are proposed at the Crows Nest construction sites, with movements anticipated to be split evenly between the two sites. Light construction vehicles would also access the sites.

Construction vehicles would access and egress the site 24 hours a day, with the peak construction period occurring between 10 am and 4 pm. The same number of vehicles entering the site is anticipated to exit the site per hour. The arrival and departure pattern of construction vehicles aims to minimise the impact of construction activity during the network peak periods, as well as keeping night time heavy vehicle movements to a low level.

The total number of vehicles arriving at the construction sites is shown below in **Figure 3.14** and **Figure 3.15**.

Figure 3.14 : Hourly **light** construction vehicle numbers (arrival only) at the Crows Nest construction site

Figure 3.15 : Hourly heavy construction vehicle numbers (arrival only) at the Crows Nest construction site

3.5.4 Road network performance

Figure 3.16 and **Figure 3.17** provide an overview of intersection locations surrounding the Crows Nest Station included within the assessment with Hume Street open and with Hume Street closed respectively.

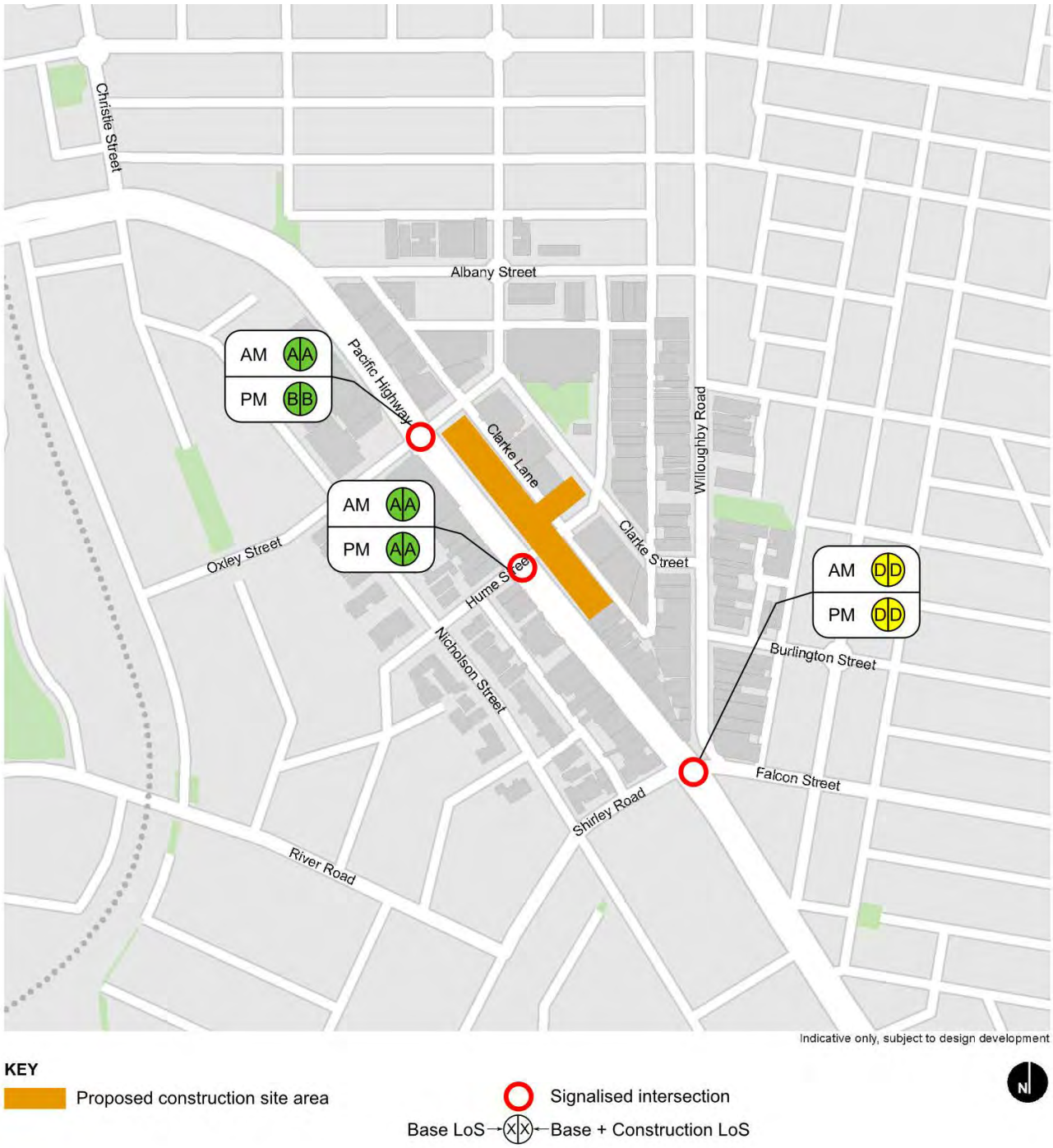


Figure 3.16 : Crows Nest Station assessed intersection locations, Hume Street open

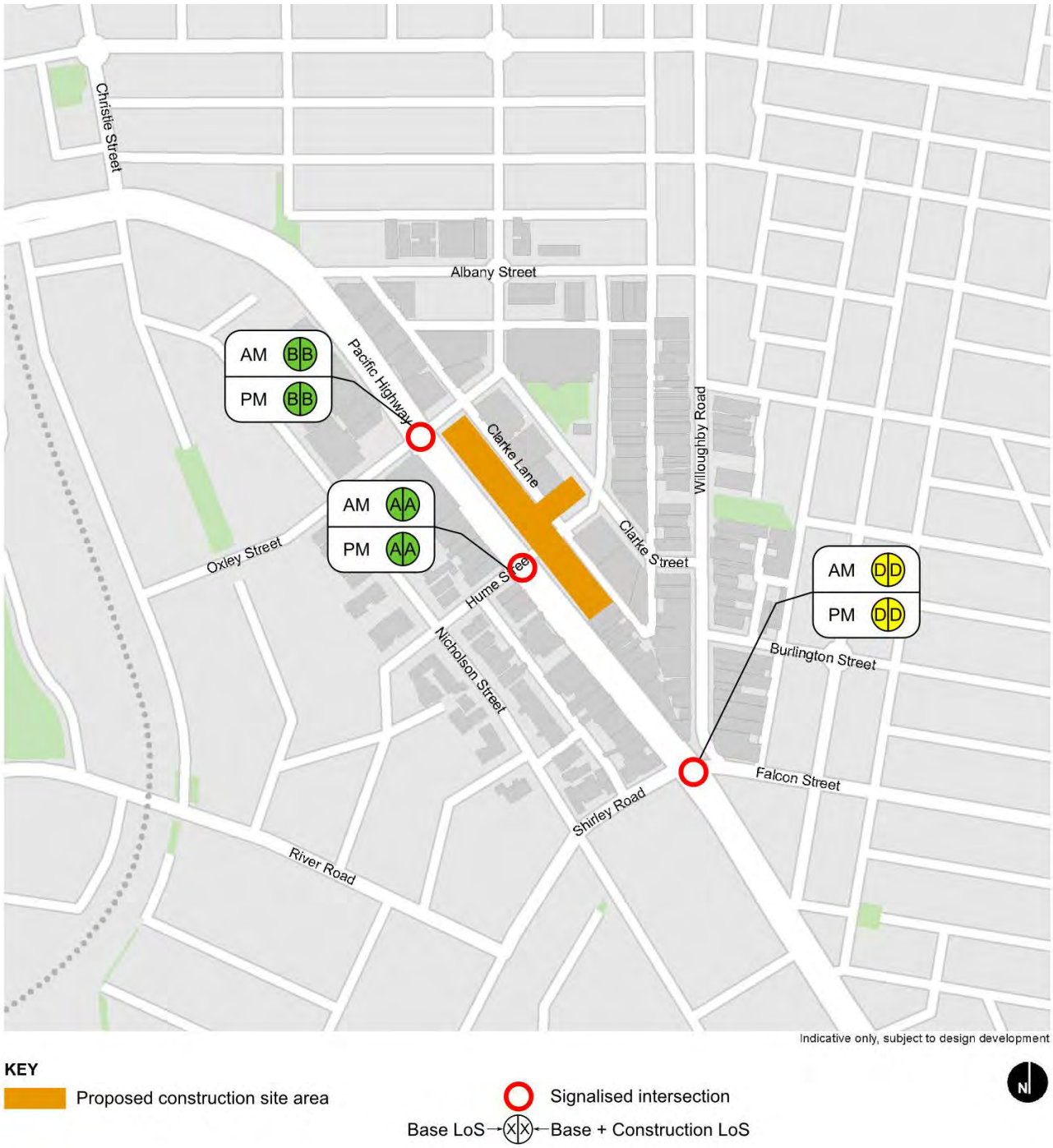


Figure 3.17 : Crows Nest Station assessed intersection locations, Hume Street closed

Table 3.6 and **Table 3.7** summarise the intersection performance under the base scenario and different stages of construction. **Table 3.6** provides the intersection performance when Hume Street is open to vehicular traffic and **Table 3.7** the performance when Hume Street is closed to vehicular traffic.

To provide a robust assessment of the closure of Hume Street, all vehicles currently entering and exiting Hume Street (on the north-eastern side of the Pacific Highway) have been redistributed to use the Oxley Street / Pacific Highway intersection. This redistribution includes:

- In the AM peak hour:
  - 150 vehicles from Hume Street westbound redistributed to Oxley Street westbound
  - 18 vehicles from Hume Street eastbound redistributed to Oxley Street eastbound
  - 134 vehicles on Pacific Highway southbound now turning left into Oxley Street
- In the PM peak hour:
  - 193 vehicles from Hume Street westbound redistributed to Oxley Street westbound
  - 14 vehicles from Hume Street eastbound redistributed to Oxley Street eastbound
  - 136 vehicles on Pacific Highway southbound now turning left into Oxley Street.

At each intersection, the tables below summarise the average delay per vehicle, level of service and degree of saturation obtained from LinSig for the base and construction scenarios.

Table 3.6: Modelled intersection performance at Crows Nest- Base and Construction (with Hume Street open) (AM and PM peak hour)

Intersection / peak period	Base				With Construction Stage 1,3			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Pacific Highway / Oxley Street (signalised)								
AM peak	3,403	13	A	0.63	3,453	13	A	0.63
PM peak	3,530	15	B	0.73	3,564	15	B	0.70
Pacific Highway / Hume Street (signalised)								
AM peak	3,244	13	A	0.59	3,294	13	A	0.61
PM peak	3,298	12	A	0.61	3,332	13	A	0.64
Pacific Highway / Falcon Street / Shirley Road (signalised)								
AM peak	3,958	50	D	0.86	3,958	50	D	0.86
PM peak	4,022	52	D	0.91	4,022	51	D	0.91

Note: Outputs from LinSig Version 3.2

Base

Currently, the intersections at Pacific Highway / Oxley Street and Pacific Highway / Hume Street operate at LOS B or better, and the intersection at Pacific Highway / Falcon Street / Shirley Road operates at LOS D during both peak periods. This intersection also experiences longer average delays. These delays are primarily experienced by vehicles on side streets (Falcon Street and Shirley Road) due to traffic signal coordination along the Pacific Highway. This intersection currently operates with a degree of saturation greater than 0.85 in both peaks.

Construction

During construction, the operational performance of the network does not deteriorate as a result of the construction traffic.

Therefore it can be seen that the impact on the local road network would be negligible.

Table 3.7: Modelled intersection performance at Crows Nest- Base and Construction (with Hume Street closed) (AM and PM peak hour)

Intersection / peak period	Base				With Construction Stage 2			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Pacific Highway / Oxley Street (signalised)								
AM peak	3,713	17	B	0.74	3,747	18	B	0.71
PM peak	3,883	21	B	0.74	3,917	22	B	0.77
Pacific Highway / Hume Street (signalised)								
AM peak	2,941	8	A	0.55	2,941	9	A	0.56
PM peak	2,955	8	A	0.48	2,955	8	A	0.52
Pacific Highway / Falcon Street / Shirley Road (signalised)								
AM peak	3,958	51	D	0.86	3,958	51	D	0.86
PM peak	4,022	51	D	0.92	4,022	50	D	0.92

Note: Outputs from LinSig Version 3.2

Construction

During the period of construction when Hume Street is closed to general traffic, an additional signal phase would be added to the Oxley Street / Pacific Highway intersection to permit a right turn movement out of Oxley Street. The additional construction traffic, redistributed Hume Street traffic and traffic signal modification would however not result in a change to the operational performance of the intersection in either the AM or PM peak. The intersection would continue to operate with a degree of saturation below 0.8 and at LOS B in the AM and PM peak hours.

Given the reasonably low number of vehicles that would be redistributed onto Clarke Street between Hume Street and Oxley Street during the closure of Hume Street, they are not anticipated to result in a material impact on the operation of Clarke Street. The impact would also be temporary and only apply whilst Hume Street is closed (anticipated to be for a period of around six months).

All other intersections maintain their existing LOS throughout the construction phase.

It can therefore be seen that construction activity does not have a significant impact on the operational performance of the road network in the vicinity of the Crows Nest Station construction site.

3.5.5 Public transport services

A bus stop on the eastern frontage of the Pacific Highway would need to be relocated during the construction works. The relocation of this bus stop would be carried out by Transport for NSW in consultation with the bus operators, Roads and Maritime Services and North Sydney Council. This would not impact the operation of any of the bus services that currently use this stop; however, the relocation may result in some passenger having to walk slightly further distances to / from the bus stop.

The only potential disruption to bus operations would be potential delays to the 265 service that operates along Oxley Street and continues on to Willoughby Road. However, as the 265 service operates on an hourly basis for most of the weekday, and every 30 minutes between 2:30 pm and 4:30 pm, the construction traffic impact on this service would be negligible due to the limited frequency of the service.

3.5.6 Active transport network

In order to carry out cut-and-cover works, Hume Street would be closed to vehicular traffic for a period of around six months. During this period, alternative pedestrian and cyclist access would be provided to the south (through the previously demolished building site).

During other stages of construction, the footpath on the southern side of Hume Street would be closed to pedestrians and therefore all pedestrians would be directed to use the footpath on the northern side. Footpaths surrounding the site would also be narrowed by about 600 millimetres. The existing footpath width is greater than three metres (building frontage to kerb), however, the footpath includes street furniture such as lighting poles and parking metres. A 2.4 metre footpath would be able to be maintained, in line with Austroads guidelines[2] however some street furniture may need to be relocated.

Pedestrian activity immediately surrounding the area is relatively low, therefore, it is expected that impacts on pedestrian activity would be minimal.

3.6 Victoria Cross Station

3.6.1 Worksite location, parking and access

The Victoria Cross Station construction would occur over two sites with a total footprint of approximately 5,400 square metres. The southern site would be located on the eastern side of Miller Street between the Pacific Highway and Berry Street. The northern site would be located on the western side of Miller Street about 30 metres south of its intersection with McLaren Street.

Four to 10 parking spaces would be provided within the site.

The site is anticipated to have a workforce of approximately 240 staff, working a variety of shifts.

Public transport would be promoted as the primary mode of transport for construction workers to minimise impacts on the local road network and parking availability. Off-site parking alternatives and associated shuttle arrangements to transport workers to and from the site would also be investigated.

Two to four on-street car parking spaces would be lost on Miller Street as part of the construction works. Parking spaces on Miller Street are currently metered and subject to either ½ P, 1P or 2P parking restrictions.

Haulage routes to the sites (shown in **Figure 3.18**) would be via the Pacific Highway, Berry Street and Miller Street. From the sites, haul routes would use Berry Street, Miller Street and Falcon Street to access the M1 motorway.

[2] Austroads Guide to Road Design Part 6A: Pedestrians and Cyclists Paths

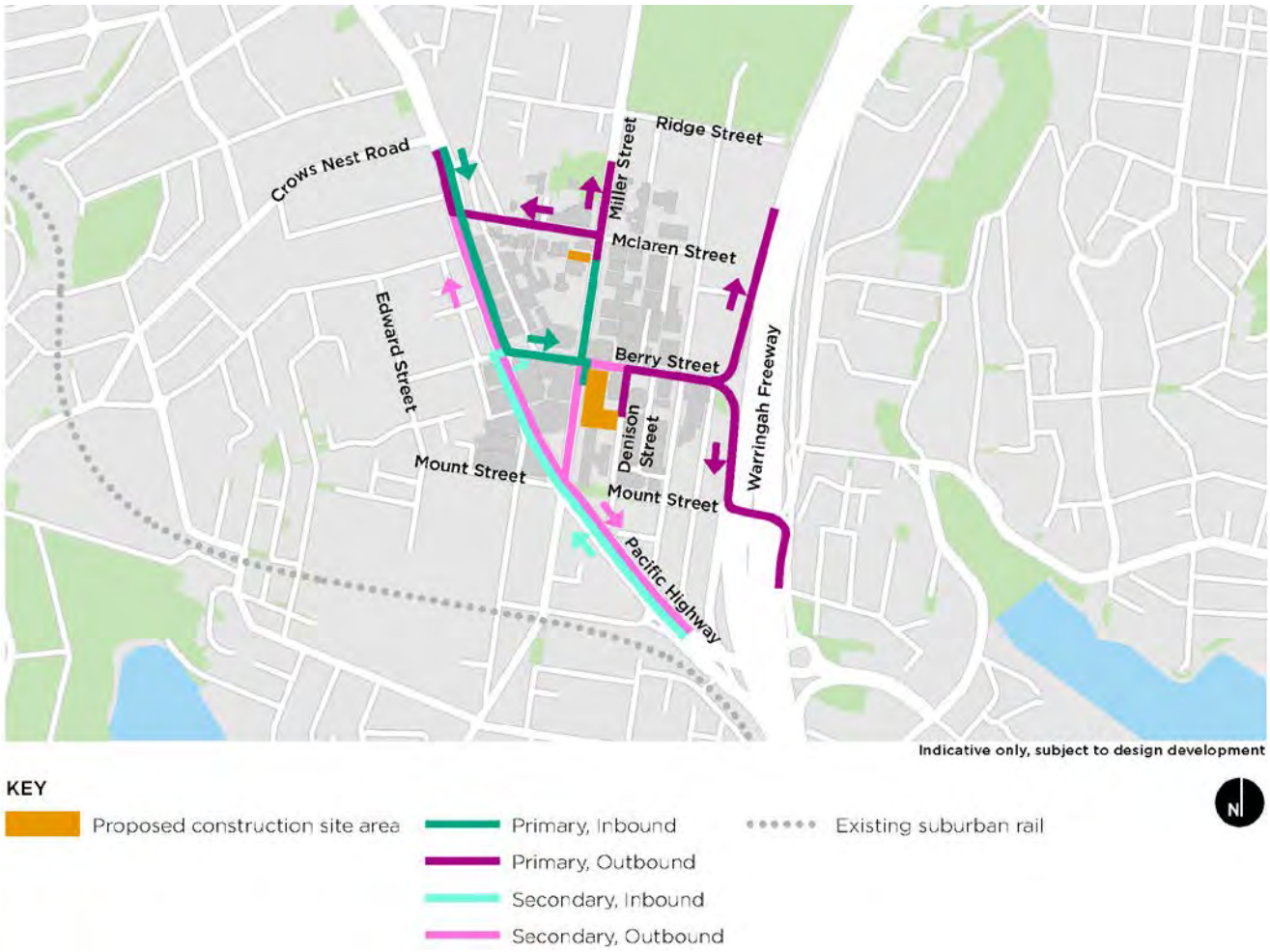


Figure 3.18 : Victoria Cross haulage routes

3.6.2 Construction activities

The major construction activities planned at Victoria Cross involve:

- Enabling works such as demolition of buildings on Miller Street, services relocation and provision of power supplies for tunnel construction.
- Excavation of cavern and shafts for the station.
- Station construction.

3.6.3 Construction vehicle movements

The construction vehicles proposed at the Victoria Cross Station sites include single unit trucks.

Construction vehicles would access and egress the site 24 hours a day, with the peak construction period occurring between 10 am and 4 pm. The arrival and departure pattern of construction vehicles aims to minimise the impact of construction activity during the network peak periods, as well as keeping night time heavy vehicle movements to a low level.

The total number of vehicles arriving at the Victoria Cross Station construction sites is shown below in **Figure 3.19** and **Figure 3.20**. Of the total number of construction vehicles generated by the Victoria Cross Station site, it is anticipated that 15 per cent of the vehicles would arrive at the northern construction site and 85 per cent of the vehicles would arrive at the southern site. The same number of vehicles accessing each site per hour is anticipated to exit each site.

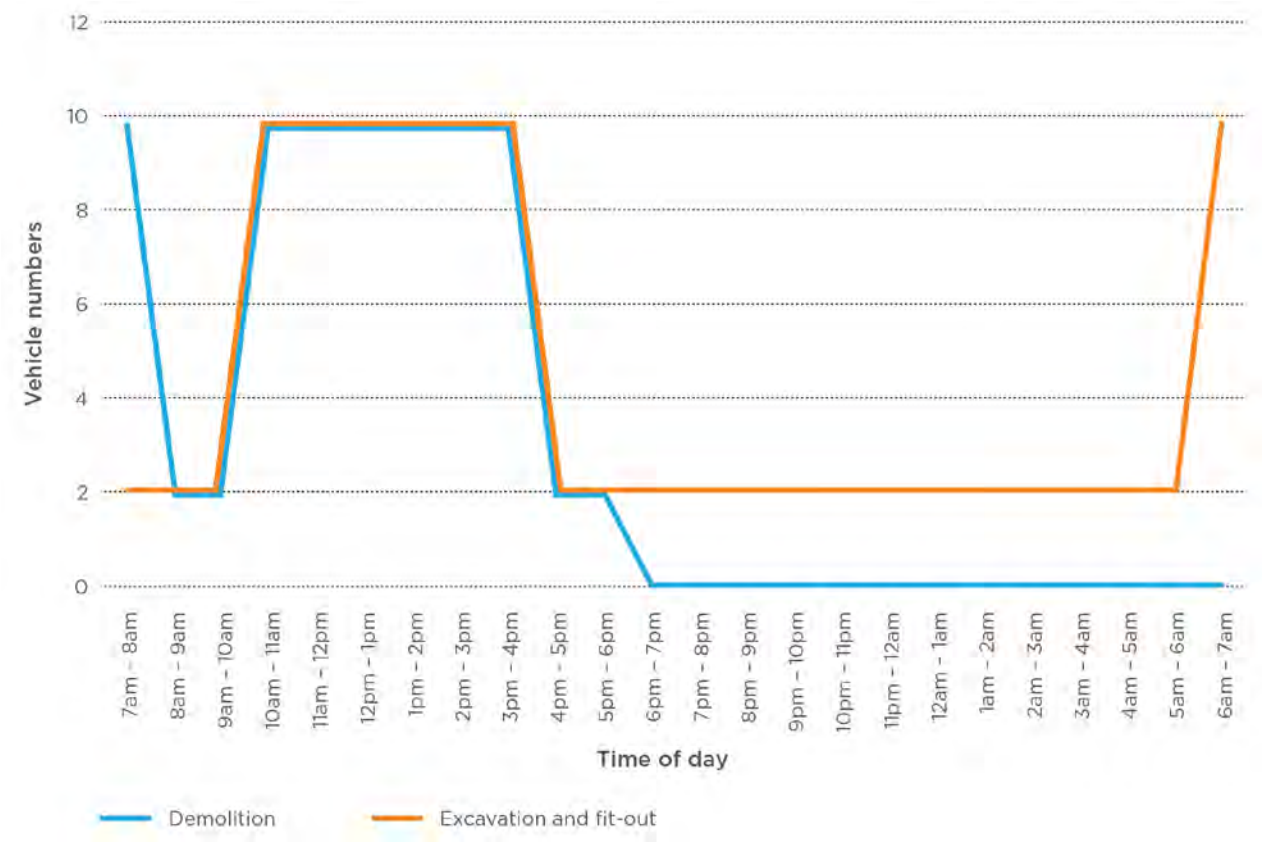


Figure 3.19 : Hourly light construction vehicle numbers (arrival only) at the Victoria Cross Station construction site

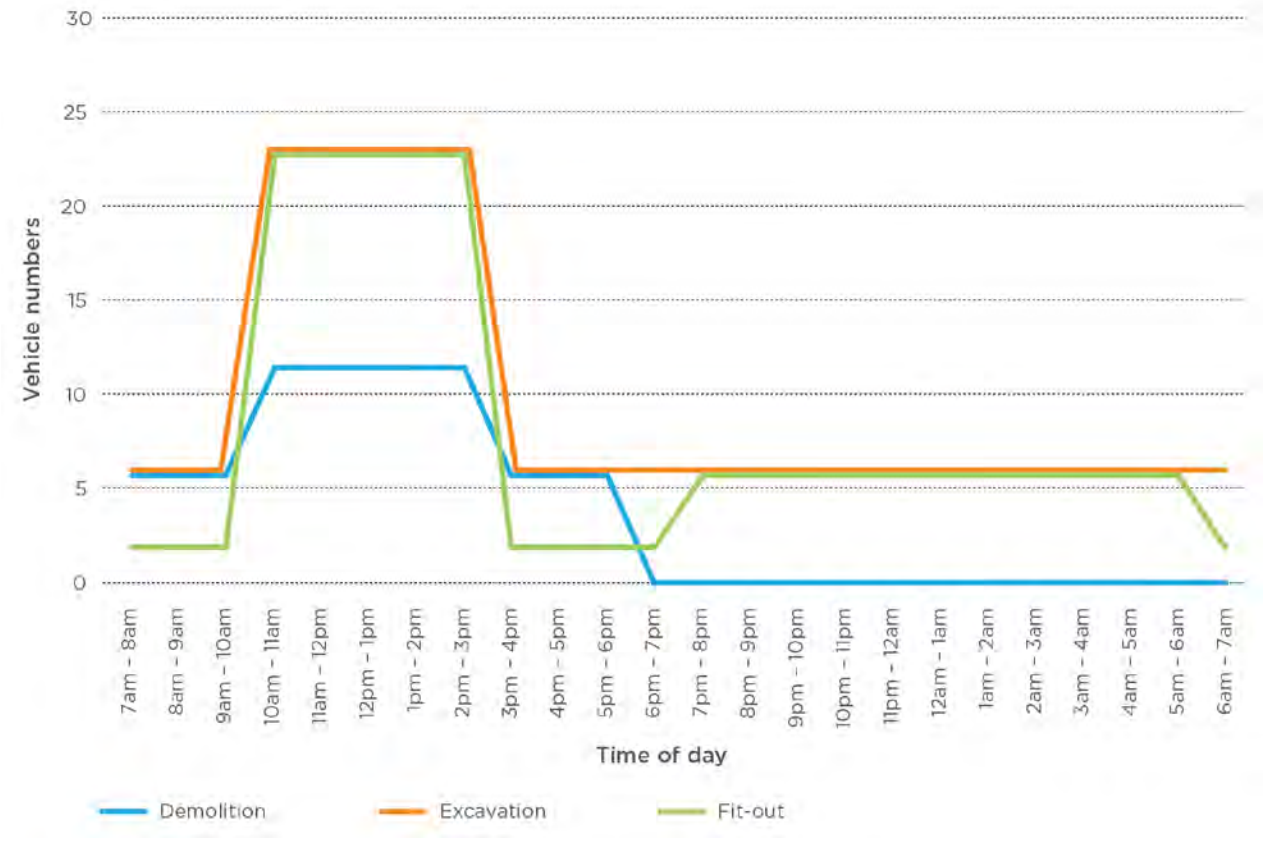


Figure 3.20 : Hourly heavy construction vehicle numbers (arrival only) at the Victoria Cross Station construction site

3.6.4 Road network performance

Figure 3.21 provides an overview of intersection locations surrounding the Victoria Cross Station included within the assessment.

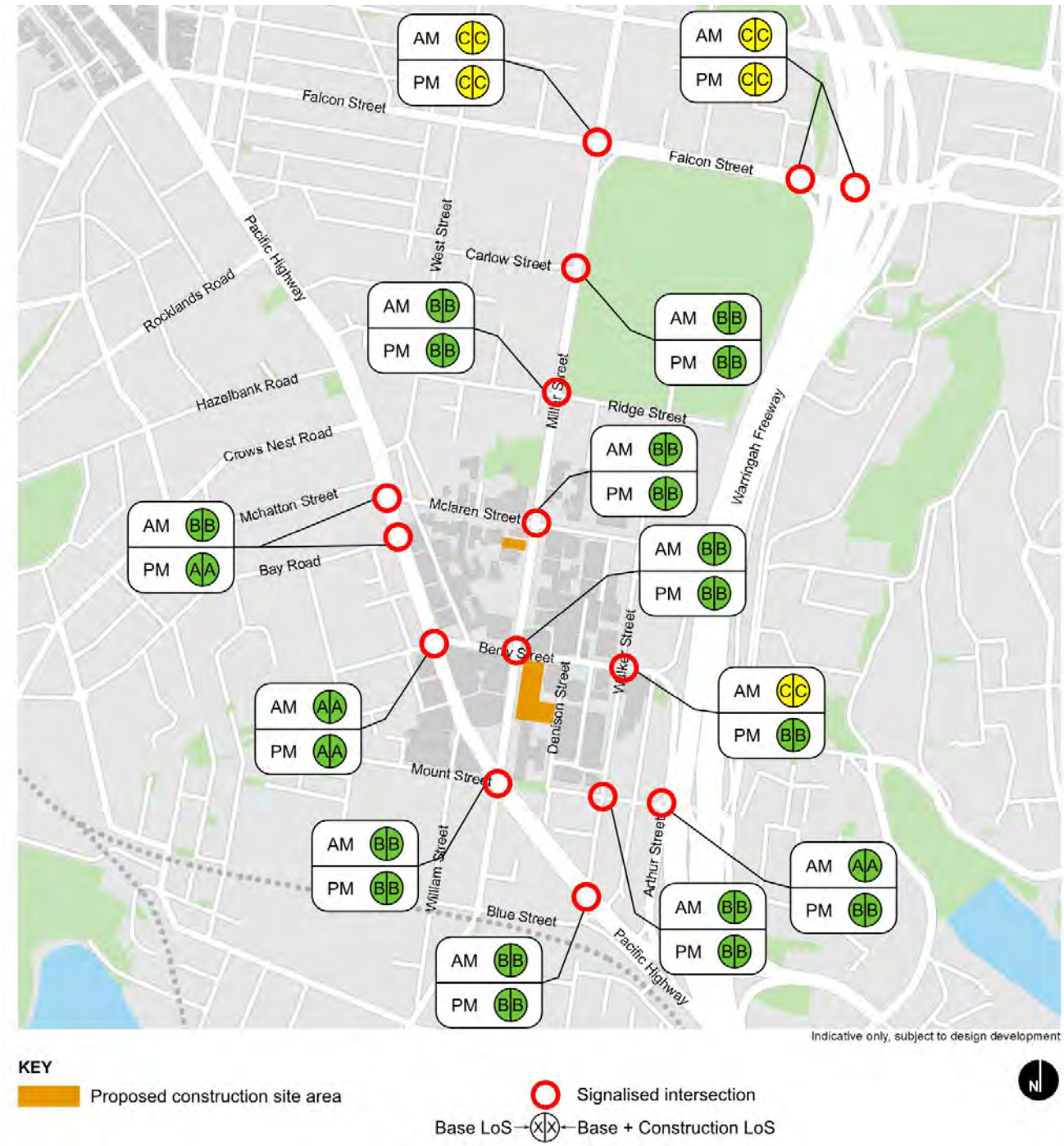


Figure 3.21 : Victoria Cross Station assessed intersection locations

At each intersection, **Table 3.8** summarises the average delay per vehicle, level of service and degree of saturation obtained from LinSig for the base and construction scenarios.

Table 3.8: Modelled intersection performance at Victoria Cross Station (AM and PM peak hour)

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Pacific Highway / McLaren Street (signalised)								
AM peak	3,495	17	B	0.85	3,536	16	B	0.85
PM peak	2,917	13	A	0.77	2,958	13	A	0.77
McLaren Street / Miller Street (signalised)								
AM peak	2,114	25	B	0.75	2,118	25	B	0.78
PM peak	1,672	26	B	0.84	1,675	26	B	0.84
Pacific Highway / Berry Street (signalised)								
AM peak	3,628	7	A	0.71	3,669	14	A	0.74
PM peak	2,913	11	A	0.80	2,954	11	A	0.79
Berry Street / Miller Street (signalised)								
AM peak	2,818	27	B	0.81	2,836	24	B	0.78
PM peak	1,938	23	B	0.57	1,955	23	B	0.56
Pacific Highway / Miller Street (signalised)								
AM peak	3,417	25	B	0.74	3,441	26	B	0.77
PM peak	3,211	27	B	0.78	3,235	27	B	0.78
Berry Street / Walker Street (signalised)								
AM peak	3,119	31	C	0.84	3,133	31	C	0.85
PM peak	2,373	27	B	0.75	2,387	27	B	0.75
Pacific Highway / Walker Street (signalised)								
AM peak	3,795	22	B	0.74	3,795	23	B	0.74
PM peak	3,242	21	B	0.65	3,242	21	B	0.65
Mount Street / Walker Street (signalised)								
AM peak	1,855	19	B	0.64	1,855	19	B	0.65
PM peak	1,644	26	B	0.60	1,644	26	B	0.56
Arthur Street / Mount Street (signalised)								
AM peak	1,353	10	A	0.68	1,353	10	A	0.66
PM peak	2,277	25	B	0.78	2,277	25	B	0.78
Miller Street / Ridge Street (signalised)								
AM peak	1,958	15	B	0.44	1,962	16	B	0.50
PM peak	1,338	19	B	0.45	1,341	19	B	0.45

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Miller Street / Carlow Street (signalised)								
AM peak	2,036	27	B	0.79	2,040	26	B	0.79
PM peak	1,425	28	B	0.72	1,428	28	B	0.72
Falcon Street / Miller Street (signalised)								
AM peak	4,629	30	C	0.93	4,633	31	C	0.82
PM peak	3,770	32	C	0.95	3,773	32	C	0.95
Falcon Street / Warringah Freeway ramps (signalised)								
AM peak	8,742	32	C	0.90	8,750	32	C	0.90
PM peak	7,439	31	C	0.92	7,446	31	C	0.92

Note: Outputs from LinSig Version 3.2

Base

All intersections operate at a LOS C or better. However, at some intersections, vehicles performing minor conflicting movements experience delays. These intersections are:

- Berry Street / Walker Street (AM peak)
- Falcon Street / Miller Street (AM and PM peaks)
- Falcon Street / Warringah Freeway ramps (AM and PM peaks)

Construction

The LOS at each intersection modelled does not deteriorate with the addition of the construction vehicles. Minor improvements in the average delay or degree of saturation are evident for some intersections which is likely to be the result of the model optimising the operation of the intersection with the additional construction traffic on certain movements. Furthermore, these minor operational improvements are within the normal variability of the modelling software and are not statistically significant.

The resulting impact of the construction vehicles is therefore considered insignificant.

3.6.5 Public transport services

The Victoria Cross Station precinct is currently served by a variety of public transport services. The bus stop at 194 Miller Street would need to be relocated during the construction works. The relocation of this bus stop would be carried out in consultation with the bus operators, Roads and Maritime Services and North Sydney Council. This would however not impact the operation of any of the bus services that currently use this stop however the relocation may result in some passenger having to walk slightly further distances to / from the bus stop.

Train services would not be affected by the construction activities as North Sydney Station is located further south of the proposed construction sites.

3.6.6 Active transport network

The on-road amenity for cyclists along Miller Street and Berry Street would be reduced during the construction phase due to the introduction of heavy vehicle movements, although cyclists currently using this route share the road with vehicles and buses. Cyclists who currently use this route could use Mount and Edward Streets on the western side of the Pacific Highway and therefore avoid the haul routes.

Footpaths on Miller Street in the vicinity of each of the construction sites would be reduced in width by approximately 600 millimetres during the construction works. Miller Street, between the Pacific Highway and Berry Street, has a footpath width greater than three metres (building frontage to kerb), however, the footpath includes street furniture such as lighting poles and parking metres. A 2.4 metre footpath would be able to be maintained, in line with Austroads guidelines[3] however some street furniture may need to be relocated. In the vicinity of the northern construction site, the existing footpath is approximately 3.6 metres wide and includes trees and street furniture such as a bus stop. With the relocation of the bus stop, a footpath of 2.4 metres would be maintained.

Monte Sant' Angelo Mercy College is located close to the proposed construction sites on Miller Street. School children currently use footpaths around the sites to travel between public transport services and the school. School drop off area are also located close to the sites on Berry and Miller streets. Sydney Metro would consult with Monte Sant' Angelo Mercy College to ensure safe pedestrian and drop off arrangements are provided for school children during construction. In addition, haulage of materials to and from the construction site would be scheduled to minimise movements during school pick up and drop off times.

3.7 Blues Point temporary site

3.7.1 Worksite location, parking and access

The Blues Point temporary site would be located within Blues Point Reserve at the southern end of Blues Point Road. Single unit trucks are proposed at the site, as well as tunnel boring machine transport vehicles.

Vehicular access and egress to and from the site would be left in from Blues Point Road and left out to Henry Lawson Avenue (shown in **Figure 3.22**). The removal of the tunnel boring machine components is likely to be via Blues Point Road however the option of transporting these large components by barge using the existing wharf facilities at the end of Blues Point Road would be further investigated during detailed construction planning. The removal of the tunnel boring machine components via Blues Point Road would require the temporary short-term closure of the road (most likely overnight) and the temporary removal of street furniture, such as signage, pedestrian islands and bollards. During these closures, access to properties would be maintained, however delays may be experienced.

Approximately four on street car parking spaces on Blues Point Road would be removed during the site establishment and shaft excavation stage. During each tunnel boring machine retrieval activity, all on street car parking spaces (around 23 spaces in total) on the eastern side of Blues Point Road adjacent to the site would also need to be removed. This loss of parking would be for a period of approximately four weeks and on four separate occasions. It is recognised that this temporary loss of parking would impact the ability for some visitors to access this area. Alternative on-street parking (approximately eight spaces) is available on the opposite side of Blues Point Road and approximately 50 metres further north along Blues Point Road. Options to retain some car parking at the end of Blues Point Road, including a disabled parking space, would be investigation during detailed design.

It is anticipated that there would be a workforce of 60 at the site, working a variety of shifts.

Public transport would be promoted as the primary mode of transport for construction workers to minimise impacts on the local road network and parking availability. Off-site parking alternatives and associated shuttle arrangements to transport workers to and from the site would also be investigated.

Four to 10 parking spaces would be provided within the site.

[3] Austroads Guide to Road Design Part 6A: Pedestrians and Cyclists Paths

Figure 3.22 : Blues Point temporary site haulage route

3.7.2 Construction activities

Construction works at the site would involve the excavation of a shaft to the tunnels below resulting in approximately 8,000 cubic meters of spoil being removed from the site. The cutter heads and shields of the tunnel boring machines from the Chatswood portal and from the Barangaroo Station construction site would be retrieved through this shaft. During the retrieval of the tunnel boring machine components, this site would expand to encompass the current car parking on Blues Point Road adjacent to the reserve and, potentially, the end of Blues Point Road.

3.7.3 Construction vehicle movements

This site would not be in use throughout the whole project construction period. Site establishment and shaft excavation works would occur over a period of about 12 months and then the site would remain inactive until retrieval is required. Each tunnel boring machine retrieval phase would take approximately four weeks.

During the majority of construction, construction vehicles would access and egress the site between 7 am and 6 pm, with the peak construction period occurring between 10 am and 4 pm. During the tunnel boring machine retrieval phase, construction vehicles would access and egress the site over a 24 hour per day period, with a peak construction period occurring between 10 am and 4 pm.

The number of vehicles arriving at the construction site is shown below in **Figure 3.23** and **Figure 3.24**. During the tunnel boring machine retrieval, oversized vehicle movements would mostly occur overnight.

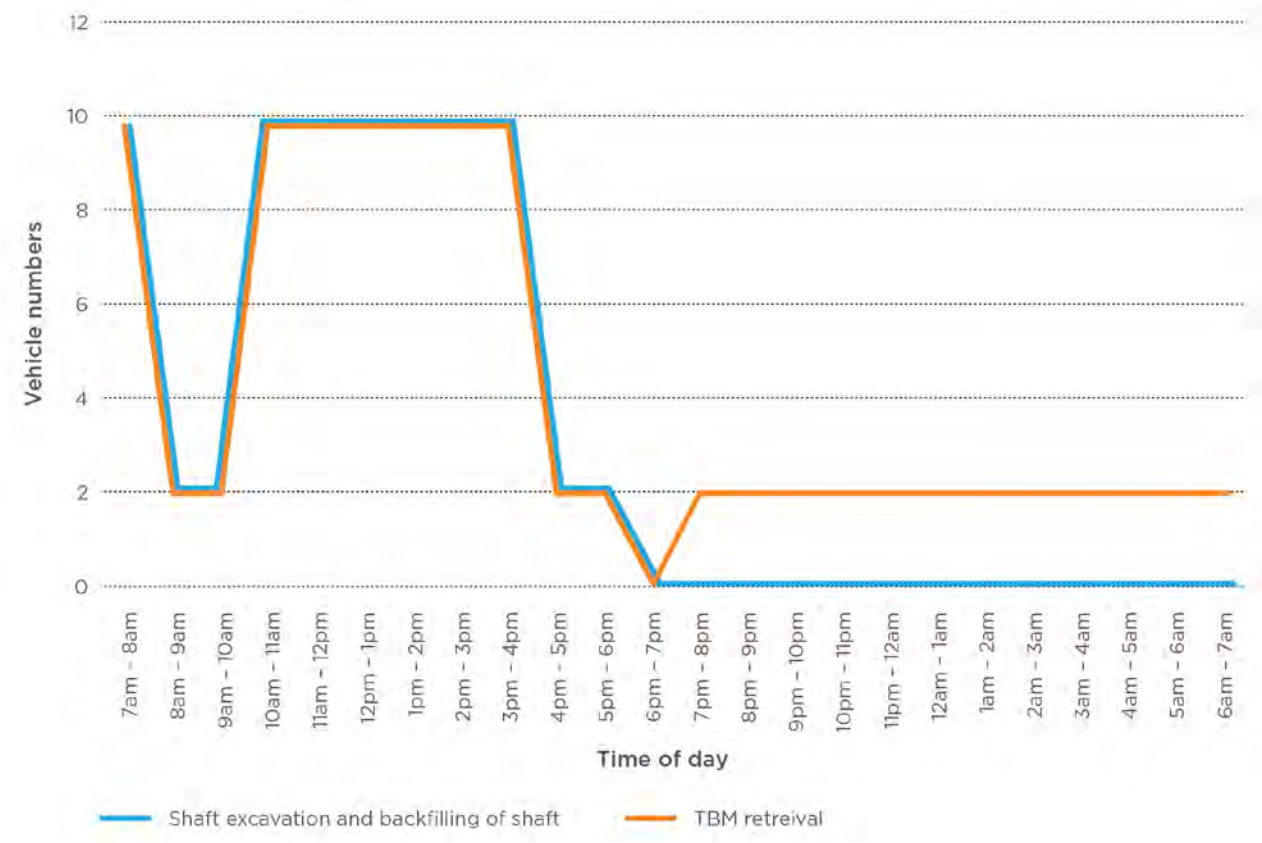


Figure 3.23 : Hourly light construction vehicle numbers (arrival only) at the Blues Point temporary site

Figure 3.24 : Hourly heavy construction vehicle numbers (arrival only) at the Blues Point temporary site

No construction works would take place at the site during the New Years' Eve celebrations. Options to provide additional park space for public use during this period would be investigated during detailed construction planning.

3.7.4 Road network performance

Figure 3.25 provides an overview of intersection locations surrounding the Blues Point temporary site included within the assessment.

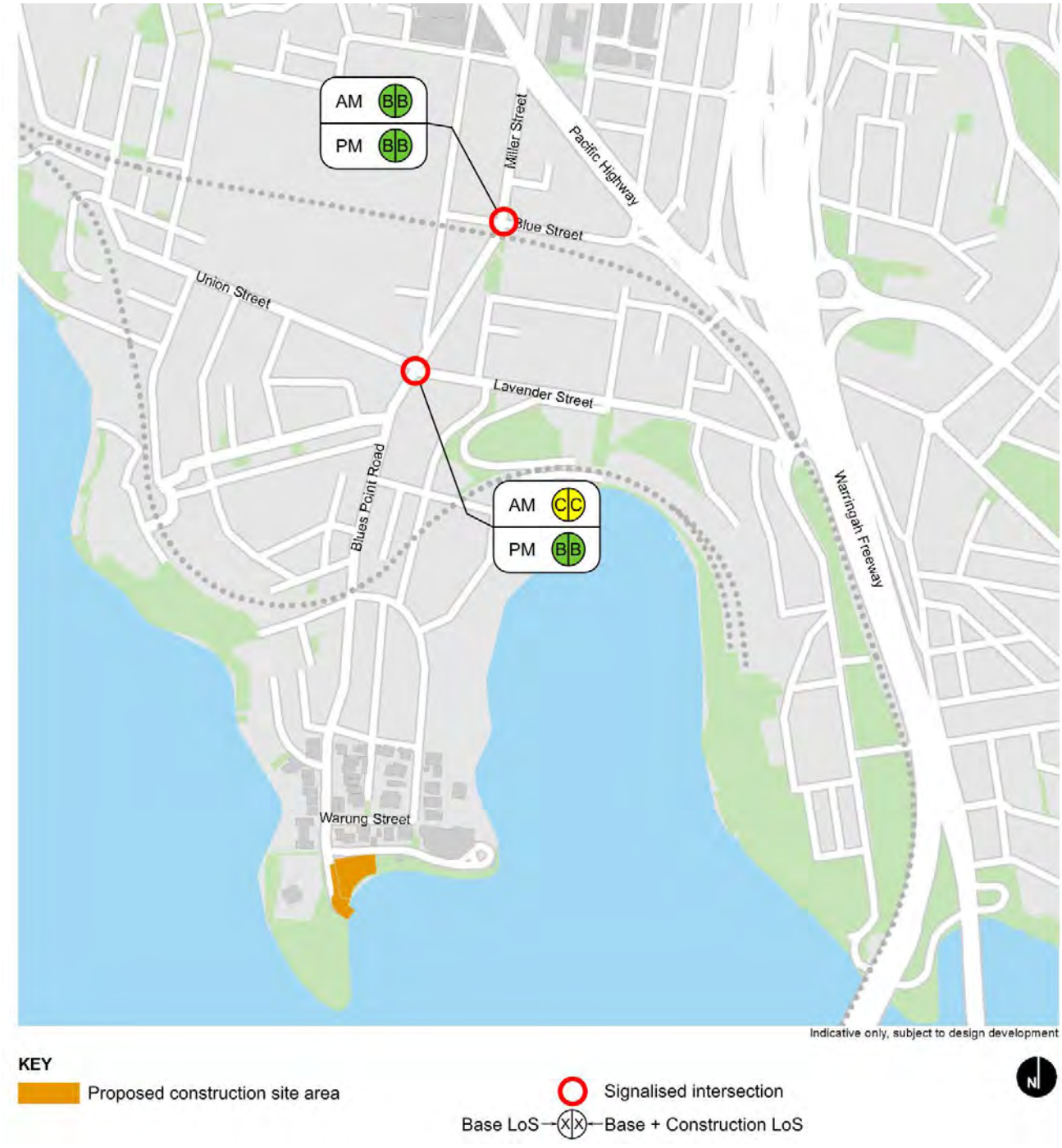


Figure 3.25 : Blues Point temporary site assessed intersection locations

At each intersection, **Table 3.9** summarises the average delay per vehicle, level of service and degree of saturation obtained from LinSig for the base and construction scenarios.

Table 3.9: Modelled intersection performance at Blues Point temporary site (AM and PM peak hour)

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Blues Point Road / Union Street / Lavender Street (signalised)								
AM peak	1,526	33	C	0.70	1,550	33	C	0.68
PM peak	1,375	24	B	0.67	1,399	24	B	0.67
Blues Point Road / Blue Street / Miller Street (signalised)								
AM peak	1,644	19	B	0.67	1,668	18	B	0.64
PM peak	1,610	15	B	0.59	1,634	15	B	0.59

Note: Outputs from LinSig Version 3.2

Base

In the base scenario all intersections are seen to be operating at LOS B except for the Blues Point Road / Union Street / Lavender Street intersection during the AM peak which operates at LOS C.

Construction

The operational performance observed at each intersection in the base scenario is maintained once the construction traffic is included on the network.

Any minor improvements in the average delay or degree of saturation are likely to be the result of the model optimising the operation of the intersection with the additional construction traffic on certain movements. Furthermore, these minor operational improvements are within the normal variability of the modelling software and are not statistically significant.

The construction traffic impact is therefore considered to be insignificant.

3.7.5 Public transport services

The bus stop located on the southern frontage of Henry Lawson Avenue would need to be relocated during the construction works. The temporary relocation of this bus stop would be carried out by Transport for NSW in consultation with the bus operators, Roads and Maritime Services and North Sydney Council. The relocation of the bus stop would not impact the operation of any of the bus services that currently utilise the stop, however, may result in some passenger having to walk slightly further distances to / from the bus stop.

3.7.6 Active transport network

The footpaths around the site would generally be maintained during construction. During the tunnel boring machine retrieval, the footpath along Blues Point Road adjacent to the site would be temporarily closed.

A five metre wide zone would be maintained along the foreshore for pedestrian and cyclist access and, therefore, there would be minimal disruption to the active transport network.

3.8 Sydney Harbour ground improvement works

Ground improvement works are likely to be required across Sydney Harbour prior to excavation of the tunnels. The works would require the establishment of solid blocks (each approximately 35 metres wide by 20 metres long by 16 metres deep) at two points where the tunnel alignment passes through a rock-sediment transition zone.

The locations of the ground improvement works are shown in **Figure 3.26**. The location of the ground improvement works is located in one the narrowest sections of the harbour. Important maritime movements occur through this section of the harbour including cruise ship access to the White Bay Cruise Passenger Terminal, tanker access to the Viva Energy facilities at Gore Bay and Clyde, Sydney Ferries services and recreational boating activities.

The current preferred method of ground improvement works is a jet grouting approach. The grout would be delivered to the barges from an on-shore facility and would be injected from the barge via a crane and drilling lead. This would be achieved through the use of three barges on the harbour. One barge would be used to carry out the grout works which would generally remain in the harbour for the duration of the works. The other two barges would be used to transport grout to and spoil from the works area to an on-shore facility (likely to occur once per day). In addition, tug boats would be required to move the barges and small boats would transport construction workers as required. The anticipated boat movements associated with the harbour ground improvement work include:

- Jet grouting barge would travel back to the on-shore facility once per week
- Grout delivery and spoil barges would travel to and from the on-shore facility once per day
- Small boats would transfer workers between the on-shore facility and the jet grout barge multiple times per day

This relatively small number of boat movements, compared to existing movements within the operational harbour, are not anticipated to result in any impacts to recreational, commercial or transport related maritime movements.

The physical presence of the barges within the harbour could result in impacts to shipping channels, especially large tankers accessing Viva Energy's facilities at Gore Bay and Clyde, or pose a navigational safety hazard. The proposed method for the ground improvement work has been subject to ongoing discussions with the Harbour Master. This consultation has determined that the two grout blocks would be carried out at separate times in order to keep shipping channels open. At this stage it is expected that the southern grout block would be carried out first, followed by the northern grout block. This would allow sufficient navigational space around the barges to permit safe passage of these tankers.

In relation to potential navigational safety impacts, appropriate warning signals and demarcation would be provided for all harbour activity. The nature of these warning signals would be determined in consultation with the Harbour Master to ensure harbour safety is not affected.

Consultation prior to and during the ground improvement work would continue to be carried out with the Port Authority of NSW (Harbour Master), Roads and Maritime Services and Sydney Ferries in relation to maintaining open shipping channels and ensuring the proposed work does not impact the safety of other harbour users.

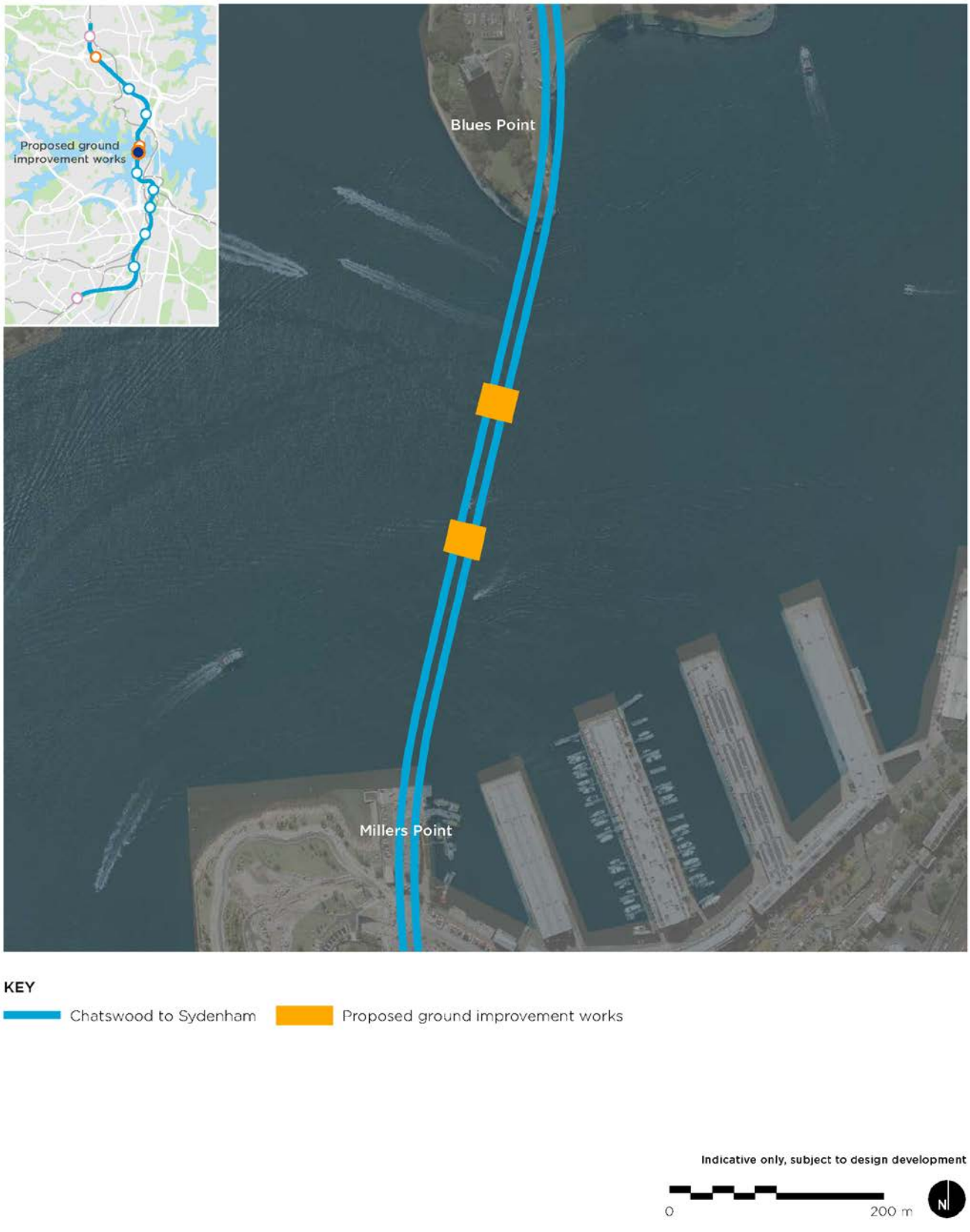


Figure 3.26 : Indicative locations of ground improvement works

3.9 Sydney CBD overview

The project would include four construction sites within the Sydney CBD. The combined haul routes for these sites are shown on **Figure 3.27**. These haul routes have been defined with the aim of exiting the Sydney CBD as efficiently as possible and minimising the combined use of roads by trucks accessing each construction site. The potential traffic impacts of construction at each of these sites are described in the following sections.

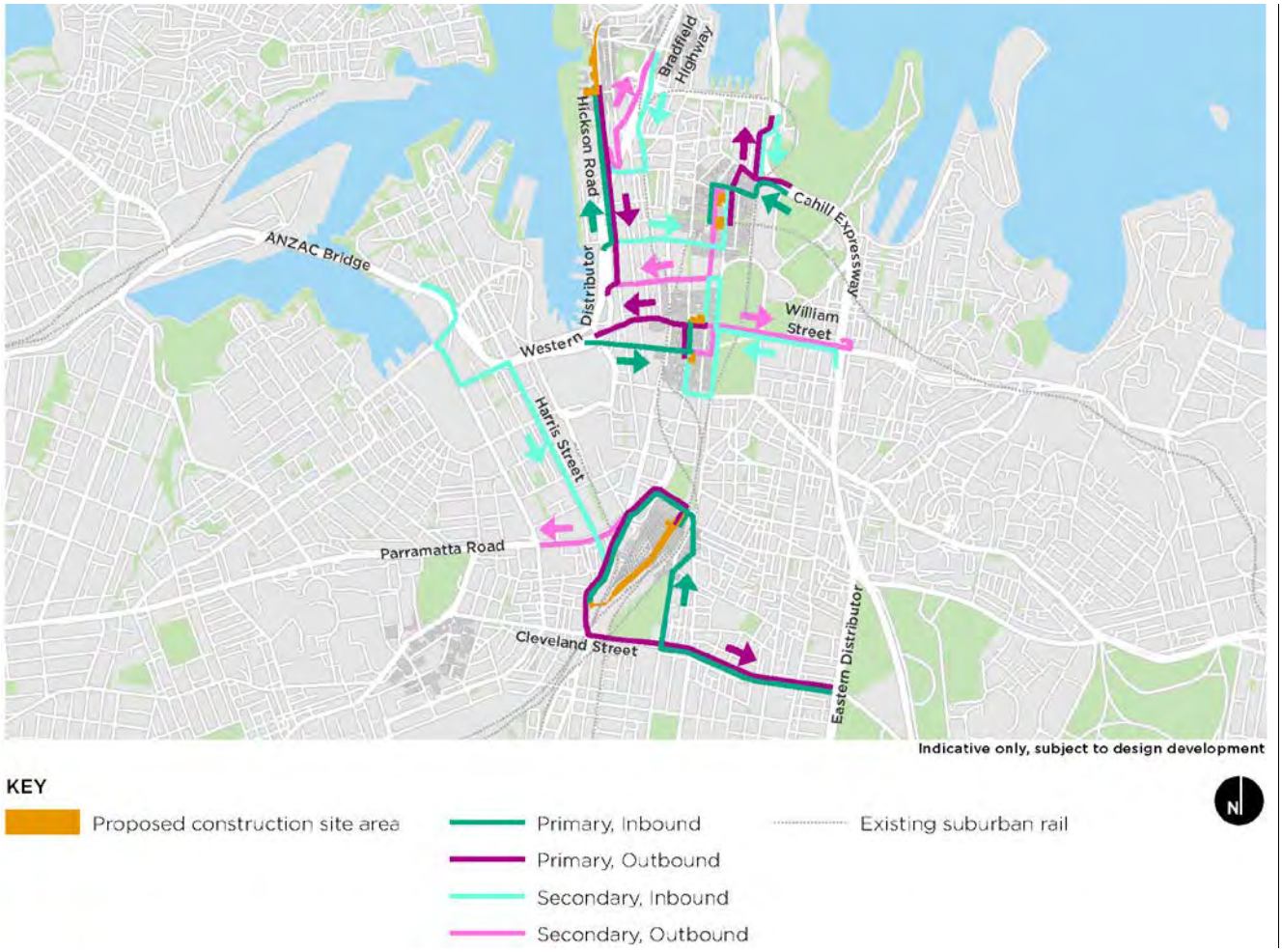


Figure 3.27 : Sydney CBD combined haul routes

3.10 Barangaroo Station

3.10.1 Worksite location, parking and access

The Barangaroo Station construction site would be located to the west of Hickson Road, south of the Munn Street overpass. The site is proposed to receive single unit trucks as well as tunnel boring machine transport vehicles. The site is anticipated to have a workforce of 300 staff, working a variety of shifts.

Vehicular access to and egress from the Barangaroo Station construction site (shown in **Figure 3.28**) would be via Hickson Road.

Figure 3.28 : Barangaroo Station haulage routes

Construction works would require the partial closure of Hickson Road however two-way traffic would generally be maintained. Traffic arrangements in this location would be coordinated with works being carried out by Barangaroo Delivery Authority. There is the potential for short term, temporary full closures of Hickson Road during launch and retrieval of the tunnel boring machines. This would be coordinated with the CBD Coordination Office and Barangaroo Delivery Authority and is likely to occur at night when traffic volumes are expected to be very low.

Approximately 125 on-street parking spaces on Hickson Road would be removed as part of the construction works. The main users of these car parking spaces are currently construction workers at the adjacent Barangaroo development, although some spaces may be used by local residents and visitors. Sydney Metro would consult with the Barangaroo Delivery Authority to identify locations for alternative car parking spaces, or to implement alternative strategies to reduce the demand for parking by construction workers across the two projects.

Approximately four to 10 parking spaces would be provided on site.

Public transport would be promoted as the primary mode of transport for construction workers to minimise impacts on the local road network and parking availability. Off-site parking alternatives and associated shuttle arrangements to transport workers to and from the site would also be investigated.

3.10.2 Construction activities

The major construction activities planned at Barangaroo involve:

- Launch and support for the tunnel boring machine for the Sydney Harbour crossing drive to Blues Point temporary site
- Retrieval of the cutter heads and shields of the two tunnel boring machines driven from the Marrickville dive site
- Excavation and construction of Barangaroo Station.

3.10.3 Construction vehicle movements

It is proposed that single unit trucks would access the site.

Construction vehicles would access and egress the site 24 hours a day, with the peak construction period occurring between 10 am and 3 pm. The arrival and departure pattern of construction vehicles aims to minimise the impact of construction activity during the network peak periods, as well as keeping night time heavy vehicle movements to a low level.

The number of vehicles arriving at the construction site is shown below in **Figure 3.29** and **Figure 3.30.** The same number of vehicles entering the site per hour is anticipated to exit the site per hour.

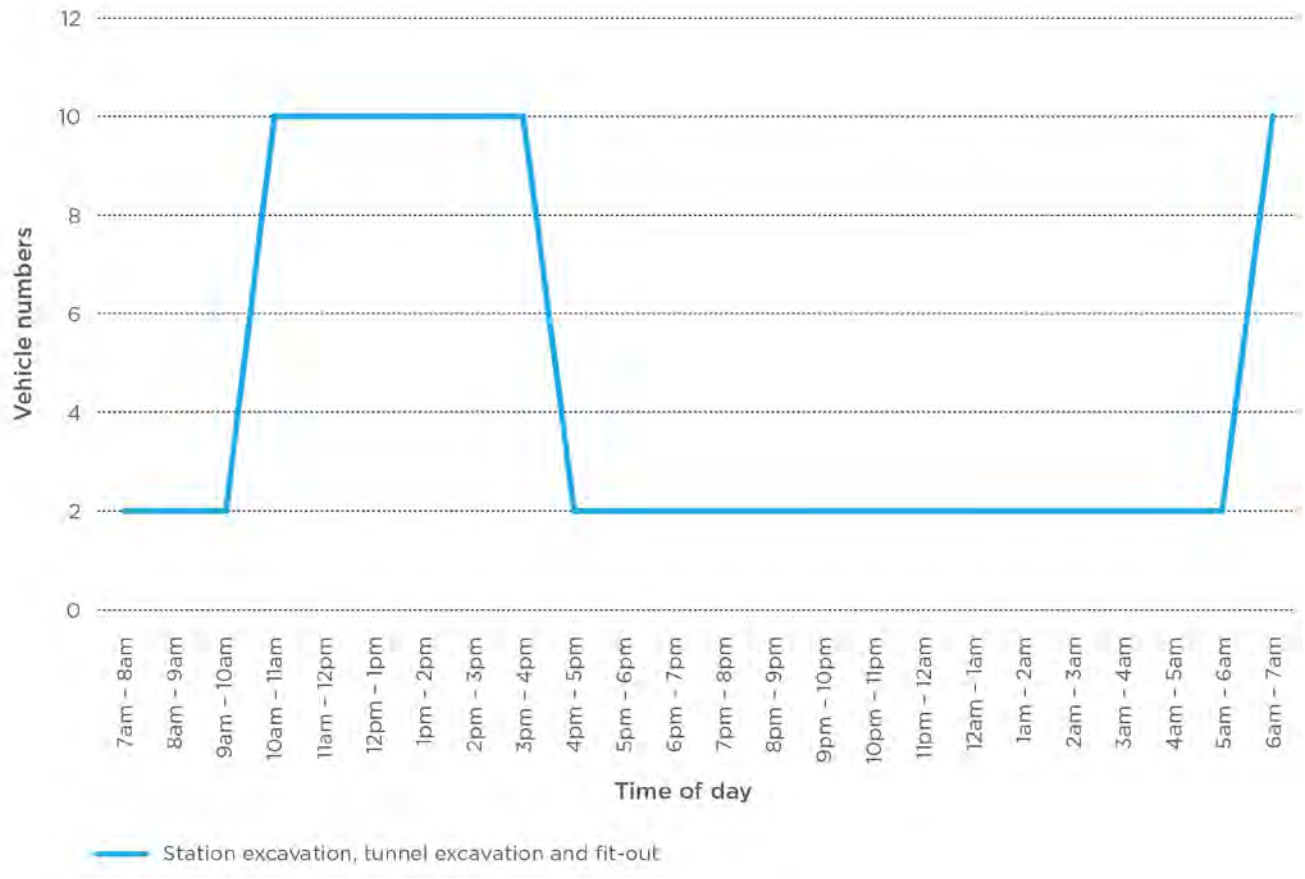


Figure 3.29 : Hourly light construction vehicle numbers (arrival only) at the Barangaroo Station construction site

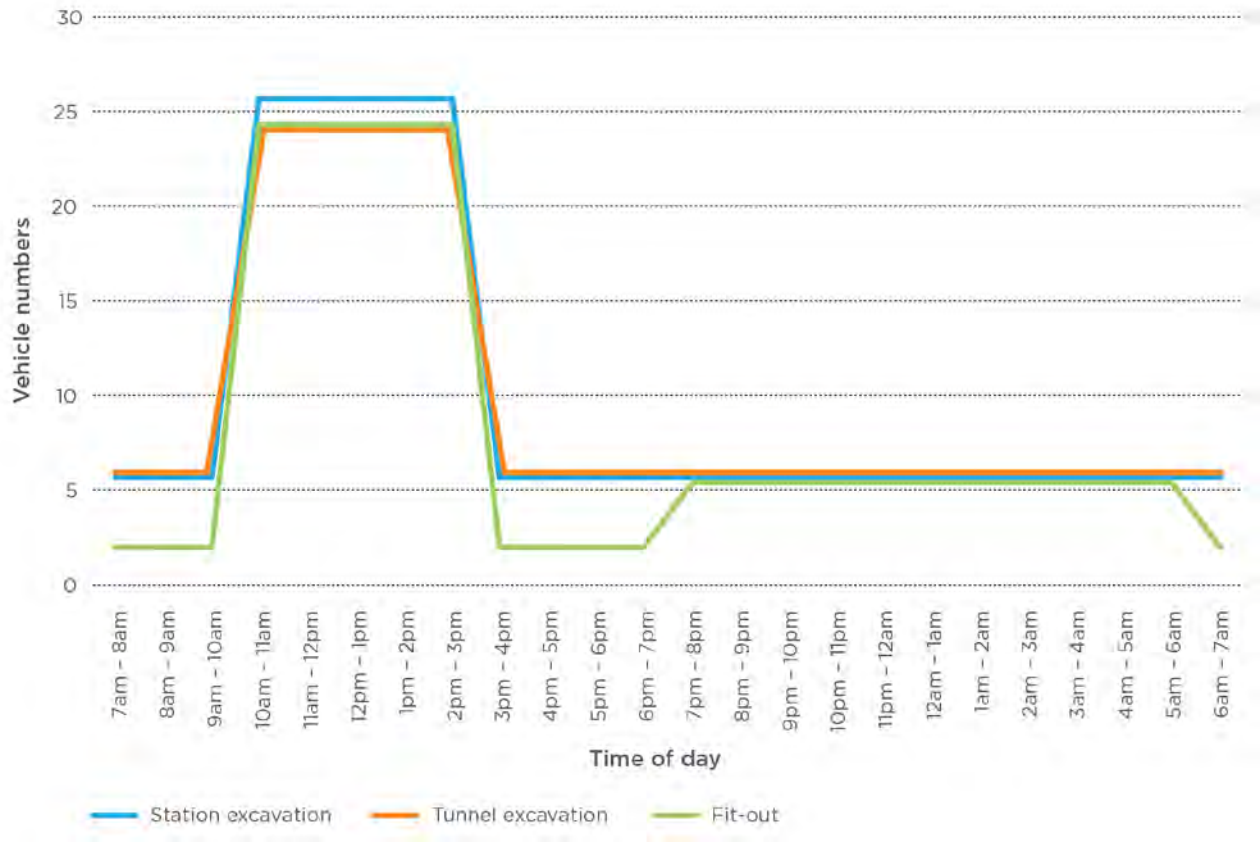


Figure 3.30 : Hourly heavy construction vehicle numbers (arrival only) at the Barangaroo Station construction site

3.10.4 Public transport services

Bus services would continue to operate along Hickson Road during the construction period. State Transit would be advised of any temporary road closures, which would aim to be scheduled outside of bus operating periods such as at night.

The relocation of any bus stops, if required, would be carried out by Transport for NSW in consultation with the bus operators, Roads and Maritime Services, the CBD Coordination Office and the Barangaroo Delivery Authority. Any relocation of bus stops would not impact the operation of bus services however it may result in some passenger having to walk marginally further to access bus stops.

The construction traffic is therefore anticipated to result in minimal impacts on public transport services.

3.10.5 Active transport network

The construction works would result in temporary closures of footpaths along Hickson Road. Impacts would potentially be to both frontages however closures would be staged to ensure one footpath is always provided. Full overnight closures may be required during tunnel boring machine launch and retrieval works. In the event that closure of both footpaths is required, alternative pedestrian facilities or detours would be provided.

Hickson Road currently experiences high proportions of construction vehicles as a result of the Barangaroo development works. The construction would be staged to generally maintain one lane in each direction, providing access for cyclists. Any full closures are anticipated to occur at night when cycle numbers are expected to be negligible. The impact of the Metro construction works on cyclists using Hickson Road would, therefore, not be significantly worse than the current environment.

3.10.6 Road network performance

Figure 3.31 provides an overview of existing intersection locations surrounding the Barangaroo Station included within the assessment.

Figure 3.31 : Barangaroo Station assessed intersection locations

At each intersection, **Table 3.10** summarises the average delay per vehicle, level of service and degree of saturation obtained from LinSig during the base and construction scenarios.

Table 3.10: Modelled intersection performance at Barangaroo Station (AM and PM peak hour)

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Shelley Street / Sussex Street (signalised)								
AM peak	1,295	14	A	0.61	1,329	14	A	0.63
PM peak	1,008	12	A	0.35	1,042	12	A	0.37
Sussex Street / Napoleon Street (signalised)								
AM peak	1,464	22	B	0.70	1,498	22	B	0.68
PM peak	1,177	18	B	0.55	1,211	18	B	0.55
Kent Street / Napoleon Street / Margaret Street (signalised)								
AM peak	1,660	20	B	0.52	1,660	20	B	0.52
PM peak	1,135	15	B	0.37	1,135	15	B	0.37
Kent Street / Clarence Street / Harbour Bridge on-ramp (signalised)								
AM peak	2,027	63	E	1.00	2,027	63	E	1.00
PM peak	1,758	47	D	0.93	1,758	47	D	0.93
Sussex Street / Erskine Street (signalised)								
AM peak	2,347	34	C	0.80	2,381	34	C	0.77
PM peak	1,901	28	B	0.59	1,935	28	B	0.59
Sussex Street / King Street (signalised)								
AM peak	3,137	35	C	0.90	3,171	36	C	0.92
PM peak	2,224	25	B	0.72	2,258	25	B	0.73
Sussex Street / Market Street (signalised)								
AM peak	2,308	23	B	0.82	2,325	23	B	0.83
PM peak	2,337	20	B	0.76	2,354	20	B	0.77

Note: Outputs from LinSig Version 3.2

Base

Within the Barangaroo road network all intersections operate at LOS of C or better except for the Kent Street / Clarence Street / Sydney Harbour Bridge entry ramp intersection which is operating at capacity.

At the intersection at Kent Street / Clarence Street / Sydney Harbour Bridge entry ramp, the majority of vehicles perform right-turn movements from either Kent Street (northbound) or Clarence Street (westbound). Conflict between these major movements causes delays, particularly in the morning peak.

Construction

At all intersections the pre-construction LOS is maintained with the addition of the construction traffic. It can therefore be seen that the construction phase would result in insignificant impacts on the local road network.

Traffic signal operations have been modelled as fixed time operation and under adaptive SCATS control the actual operational performance in the field is likely to better than the modelled results. Furthermore, the adaptive nature of the traffic signal control available in Sydney means that intersections are able to modify phase times in response to variability in traffic demand.

With regard to the coaches and delivery vehicles using Hickson Road to access the Overseas Passenger Terminal, these vehicles arrive over a short duration when a ship is either arriving or departing, which is typically around 6 am to 7 am or 6.30pm. During these periods of the day the number of construction vehicles arriving and departing the Barangaroo Station construction site would be low, therefore, the cumulative impact is expected to be minimal. The Port Authority of NSW would be consulted throughout the construction phase, particularly with regard to the launch / retrieval of the tunnel boring machines to ensure any impacts are managed in advance.

3.11 Martin Place Station

3.11.1 Worksite location, parking and access

The Martin Place Station construction sites would be between Elizabeth Street and Castlereagh Street, over two sites. The northern site would be approximately 2,500 square metres and would occupy part of the block bound by Elizabeth, Hunter and Castlereagh streets. The southern site would be approximately 2,000 square metres and would front Martin Place between Elizabeth and Castlereagh streets. The sites would receive single unit trucks.

No on-street car parking spaces would be lost as a result of the construction works.

Approximately four to 10 parking spaces would be provided on site.

Public transport would be promoted as the primary mode of transport for construction workers to minimise impacts on the local road network and parking availability. Off-site parking alternatives and associated shuttle arrangements to transport workers to and from the site would also be investigated.

A workforce of 240 construction staff would be at the site, working a variety of shifts.

Vehicular access to both sites would be left in from Castlereagh Street and vehicles would exit left out onto Elizabeth Street. **Figure 3.32** shows the proposed routes for construction vehicles.

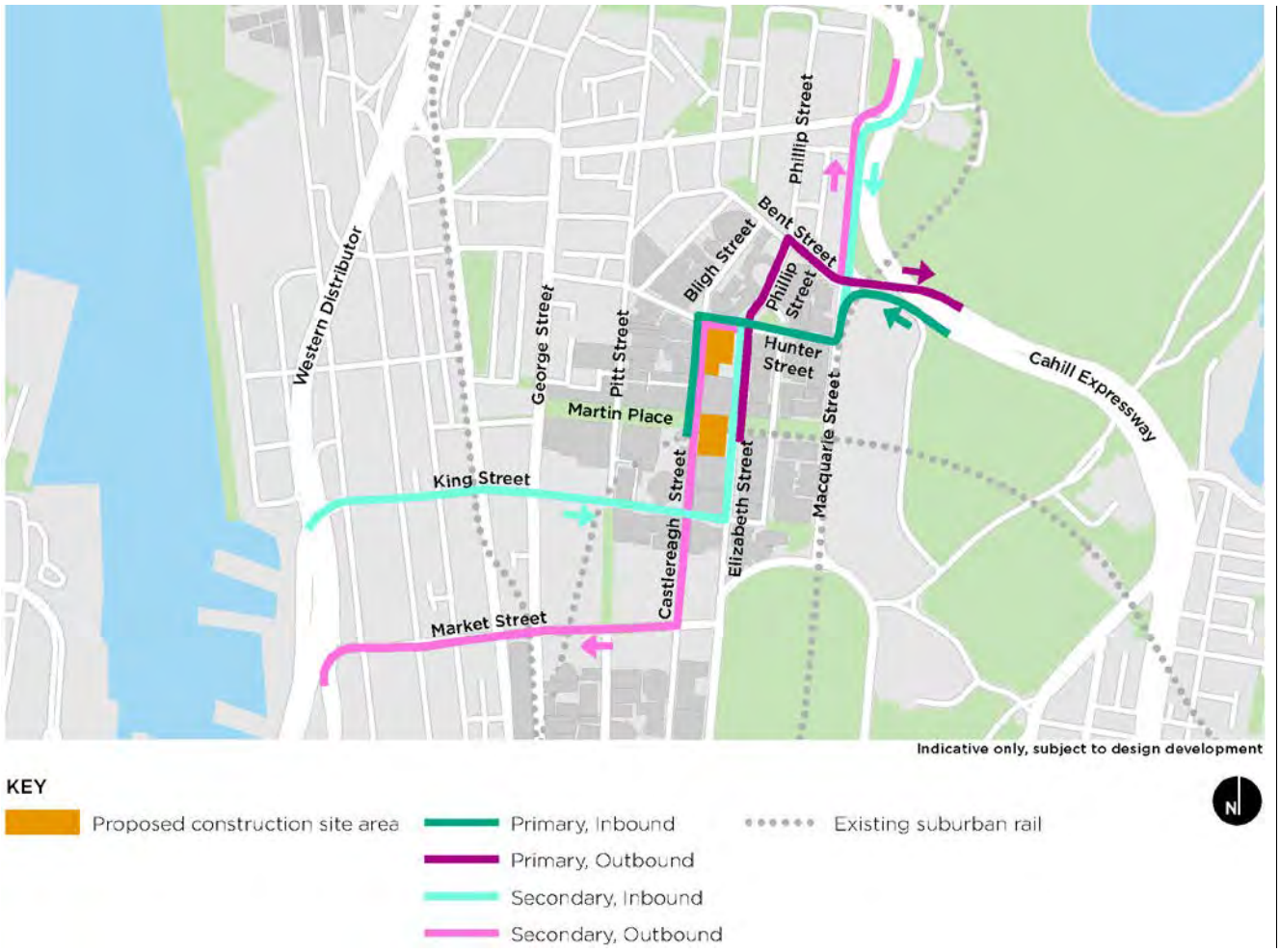


Figure 3.32 : Martin Place Station haulage routes

3.11.2 Construction activities

The major construction activities planned at Martin Place would involve:

- Enabling works such as site acquisition, demolition of buildings at both sites, services relocation and provision of power supplies for construction.
- Demolition of existing subway beneath Martin Place
- Installation of working platforms at street level
- Excavation of shafts and caverns for the station
- Station construction

3.11.3 Construction vehicle movements

Construction vehicles would access and egress the site 24 hours a day, with the peak construction period occurring between 10 am and 3 pm. The arrival and departure pattern of construction vehicles aims to minimise the impact of construction activity during the network peak periods, as well as keeping night time heavy vehicle movements to a low level.

The total number of vehicles arriving at the construction sites is shown below in **Figure 3.33** and **Figure 3.34**. The vehicle numbers presented below would be split evenly between the two construction sites and the same number of vehicles accessing each site per hour is anticipated to exit each site.

Figure 3.33 : Hourly light construction vehicle numbers (arrival only) at the Martin Place Station construction site

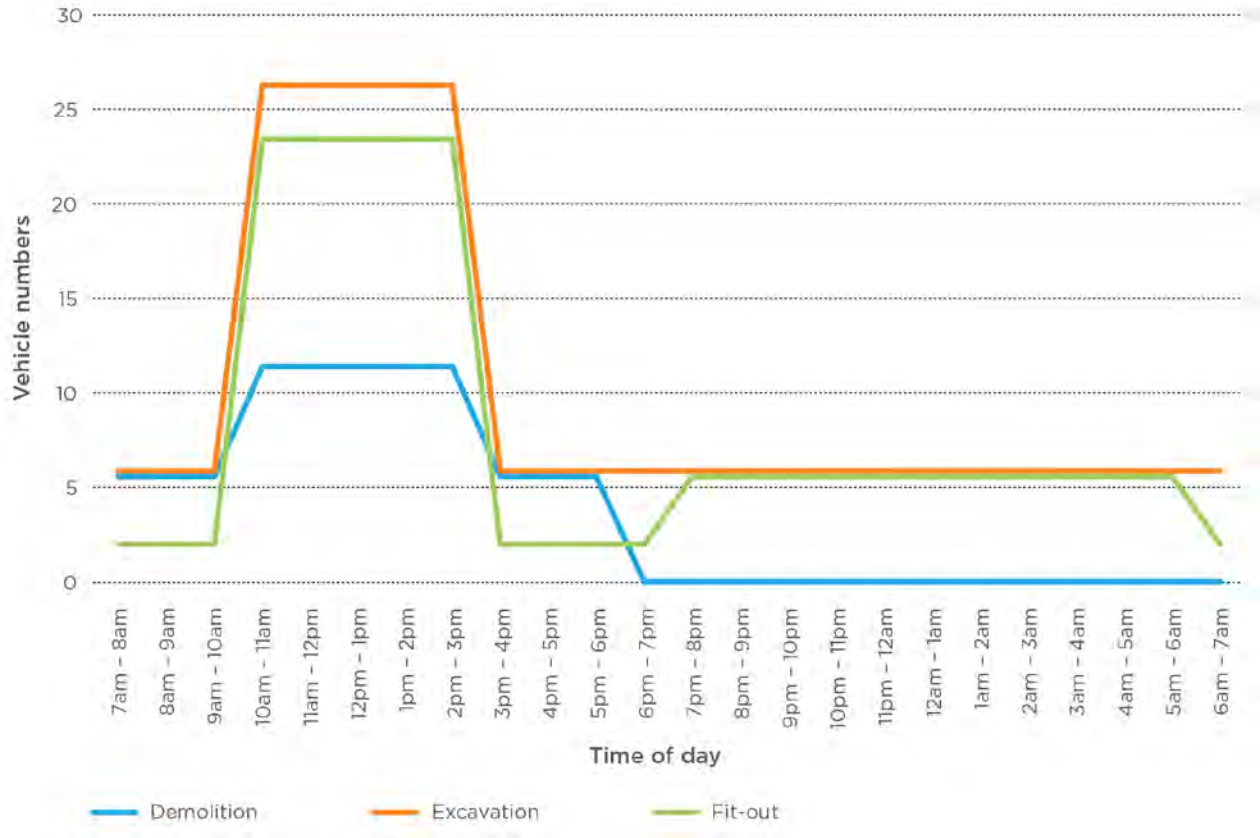


Figure 3.34 : Hourly heavy construction vehicle numbers (arrival only) at the Martin Place Station construction site

3.11.4 Road network performance

Figure 3.35 provides an overview of existing intersection locations surrounding the Martin Place Metro Station included within the assessment. A base scenario has been determined using traffic data from before the closure of George Street which was redistributed in accordance with the preferred Sydney CBD driving routes. The base scenario has then been assessed with the anticipated construction traffic.

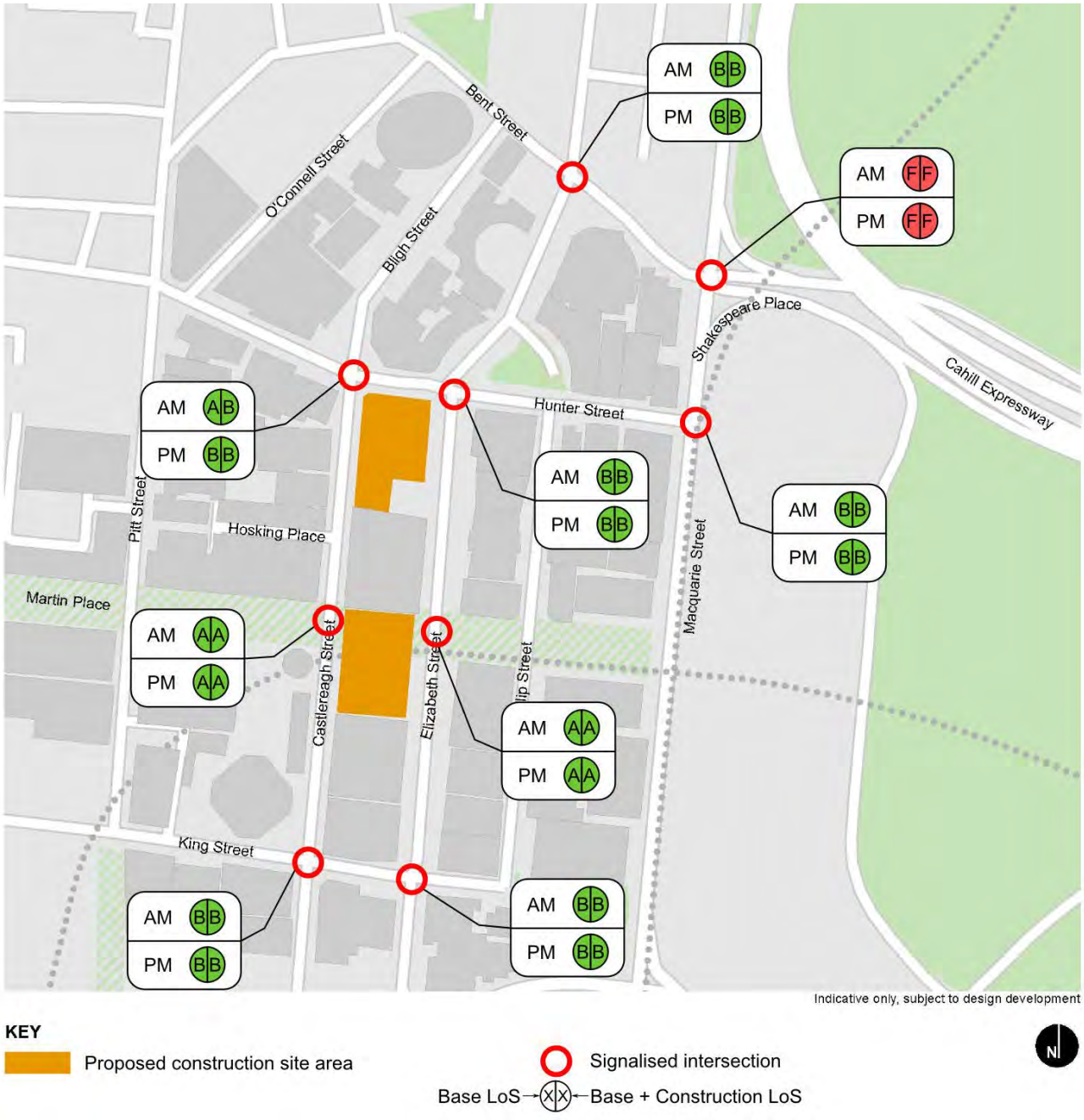


Figure 3.35 : Martin Place Station assessed intersection locations

At each intersection, **Table 3.11** summarises the average delay per vehicle, level of service and degree of saturation obtained from LinSig.

Table 3.11: Modelled intersection performance at proposed Martin Place Station construction site (AM and PM peak hour)

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Elizabeth Street / Phillip Street / Hunter Street (signalised)								
AM peak	2,620	23	B	0.84	2,656	23	B	0.83
PM peak	2,653	26	B	0.79	2,689	23	B	0.81
Elizabeth Street / Martin Place (signalised)								
AM peak	1,825	5	A	0.42	1,834	7	A	0.42
PM peak	1,804	4	A	0.40	1,813	7	A	0.41
Elizabeth Street / King Street (signalised)								
AM peak	2,676	26	B	0.73	2,676	26	B	0.73
PM peak	2,842	24	B	0.73	2,842	25	B	0.71
Hunter Street / Macquarie Street (signalised)								
AM peak	2,912	20	B	0.83	2,930	21	B	0.86
PM peak	3,404	20	B	0.82	3,422	20	B	0.83
Macquarie Street / Bent Street / Eastern Distributor ramps (signalised)								
AM peak	4,576	155	F	1.27	4,612	156	F	1.27
PM peak	4,432	161	F	1.19	4,468	167	F	1.29
Castlereagh Street / Hunter Street / Bligh Street (signalised)								
AM peak	1,210	15	A	0.45	1,228	15	B	0.45
PM peak	1,245	16	B	0.52	1,263	16	B	0.50
Castlereagh Street / Martin Place (signalised)								
AM peak	497	6	A	0.23	506	6	A	0.24
PM peak	481	6	A	0.28	490	6	A	0.28
Castlereagh Street / King Street (signalised)								
AM peak	2,021	21	B	0.50	2,021	21	B	0.50
PM peak	2,165	22	B	0.61	2,165	21	B	0.64
Bent Street / Phillip Street (signalised)								
AM peak	2,443	17	B	0.74	2,461	17	B	0.74
PM peak	2,396	18	B	0.63	2,414	25	B	0.71

Note: Outputs from LinSig Version 3.2

Base

The intersection at Macquarie Street / Bent Street / Eastern Distributor ramps is extremely congested during the morning and evening peak periods. Long delays are caused by conflict between high volumes of traffic on the eastern distributor ramps (westbound) and Macquarie Street (southbound). In the morning and evening peak, the intersection operates above its theoretical capacity at a LOS F.

All other intersections operate at LOS B or better. However, at the intersection of Elizabeth Street / Phillip Street / Hunter Street, signal coordination along Elizabeth Street causes long delays (greater than 23 seconds) for conflicting right turn movements and vehicles on side-streets.

Construction

The performance of the intersection of Castlereagh Street / Hunter Street / Bligh Street deteriorates during construction from LOS A to LOS B in the morning peak. However, the average delay and degree of saturation at the intersection is not impacted by the addition of the construction traffic, therefore, the overall impact on the operation of the intersection would be negligible.

Traffic signal operations have been modelled as fixed time operation and under adaptive SCATS control the actual operational performance in the field is likely to better than the modelled results. Furthermore, the adaptive nature of the traffic signal control available in Sydney means that intersections are able to modify phase times in response to variability in traffic demand.

The remaining intersections maintain their base LOS during the construction of the project and therefore the impact of the construction traffic on these intersections is considered insignificant.

3.11.5 Public transport services

Impacts to bus services are expected during construction works particularly as Elizabeth Street and Castlereagh Street form part of the main north-south spine for buses travelling through the city for routes predominately serving the southern, inner west and eastern suburbs of Sydney. The addition of construction vehicles and site access points on these streets may result in impacts to bus services including minor delays to travel times. To minimise these potential impacts, the Martin Place construction sites would be arranged to ensure construction vehicles are loaded and unloaded off the street.

In the event that any bus stops on Castlereagh or Elizabeth streets are required to be temporarily relocated during the construction works, this would be carried out by Transport for NSW in consultation with the bus operators and the CBD Coordination Office. The temporary relocation of any bus stops would not impact the operation of bus services; however, it may result in some passenger having to walk slightly further to access bus stops.

The construction of the underground platform to platform connection between the existing Martin Place Station and the Sydney Metro Martin Place Station would require the occupation of some space on the Sydney Trains and NSW Trains platforms. These works would be carried out without impacting on any suburban and intercity rail services.

3.11.6 Active transport network

Martin Place, between Castlereagh and Elizabeth streets, would be closed to pedestrians and cyclists for a period of around six months. Alternative surface pedestrian and cyclist access would be provided to the south through the site of the previously demolished building. The width of this access would be sufficient to cater for the anticipated peak pedestrian and cyclist movements through Martin Place.

The existing underground pedestrian concourse between Castlereagh and Elizabeth streets, and the associated connections to Martin Place would also be closed during these cut-and-cover works. The primary function of the underground concourse is to provide access to the existing Martin Place Station. During this period, suburban rail customers would be able to use the existing Martin Place Station entry points to the east of Elizabeth Street and the east of Philip Street. This would result in additional pedestrians using the pedestrian crossing facilities at Castlereagh and Elizabeth Streets. There is sufficient pedestrian storage space within Martin Place to accommodate these additional peak pedestrian movements.

During the construction period, 60 Martin Place will also be undergoing redevelopment resulting in the Martin Place Station staircase adjacent to 60 Martin Place (east of Phillip Street) also being closed for a three year period.

Using pedestrian survey data collected in November 2015, the level of service (LOS) for pedestrians at each remaining access point has been calculated for the construction period. All of the existing customers using the staircase adjacent to 60 Martin Place have been redistributed to use the westbound facing staircase adjacent to the Reserve Bank of Australia.

Given that the majority of customers currently using the access points that would close during construction would be travelling to / from the west of Martin Place Station, it has been assumed that 70 per cent would be redistributed to use the staircase between Elizabeth Street and Phillip Street to access and egress Martin Place Station during this stage of construction. It has also been assumed that 15 per cent would use the Colonial Centre passageway and 15 per cent would use the staircase to the east of Phillip Street (adjacent to the Reserve Bank of Australia building). No customers have been assumed to use the eastbound facing staircase adjacent to the Reserve Bank of Australia building.

The peak minute (representing a worst case scenario) pedestrian LOS during construction at the station entrance locations is presented in **Table 3.12.**

Table 3.12 : Martin Place construction pedestrian Level of Service

	AM peak minute		PM peak minute	
	Base	Construction	Base	Construction
Staircase adjacent to the Reserve Bank of Australia building	C	F	A	D
Colonial Centre passageway	A	B	A	B
Staircase between Elizabeth and Phillip Streets	D	F	A	F

During construction work, guidance recommends maintaining a LOS D or better for staircases and passageways. It can be seen that one access point maintains a LOS D or better and therefore operates within an acceptable level of service during construction. However the staircase in Martin Place between Elizabeth and Phillip Streets would operate at a LOS F in the AM and PM peak minute and the staircase adjacent to the Reserve Bank of Australia would also operate at a LOS F in the AM peak minute. A LOS F represents a breakdown in pedestrian flow with many stoppages. This result represents the peak minute and the average minute during the AM and PM peak period is predicted to have a better performance. This impact would also only be temporary, for approximately six months, whilst the four western access points are closed.

Providing pedestrian marshalls at Martin Place Station during the AM and PM peak periods directing customers to available, alternate access locations would mitigate the impact on the staircase between Elizabeth and Phillip streets.

The closure of these access and egress points to and from Martin Place Station may also necessitate changes to the emergency evacuation procedures for Martin Place Station. Transport for NSW would work with Sydney Trains in the planning of emergency evacuation procedures for Martin Place Station.

Martin Place provides an important function during certain major events in the Sydney CBD. As outlined in Section 3.17, liaison would occur with the CBD Coordination Office, Roads and Maritime Services and the event organisers regarding appropriate management of pedestrians in and around Martin Place Station during these events.

Footpaths surrounding the site on Elizabeth Street and Castlereagh Street would be reduced in width by approximately 600 millimetres during the construction works. The affected footpaths are greater than three metres wide; therefore, a 2.4 metre wide footpath would be maintained. Street furniture such as post boxes, parking metres and street signs may need to be relocated.

Pedestrian crossings on Castlereagh Street and Elizabeth Street are currently 30 metres wide and may be reduced to allow construction vehicle access to the sites whilst maintaining bidirectional pedestrian and cyclist paths. As the area generates high pedestrian activity, traffic controllers may be required to manage any conflicts between pedestrians, cyclists and construction vehicles.

3.12 Pitt Street Station

3.12.1 Worksite location, parking and access

Two construction sites for the Pitt Street Station are proposed between Castlereagh Street and Pitt Street. The northern site would be adjacent to Park Street and would be accessed by via a right turn in from Pitt Street and a right turn out onto Castlereagh Street. The southern site would be adjacent to Bathurst Street and vehicular access to the site would be via a right turn in from Bathurst Street and exit would be a right turn out onto Pitt Street. Haulage vehicles are anticipated to access and exit towards the west of the site. The proposed haulage routes are shown below in **Figure 3.36**.

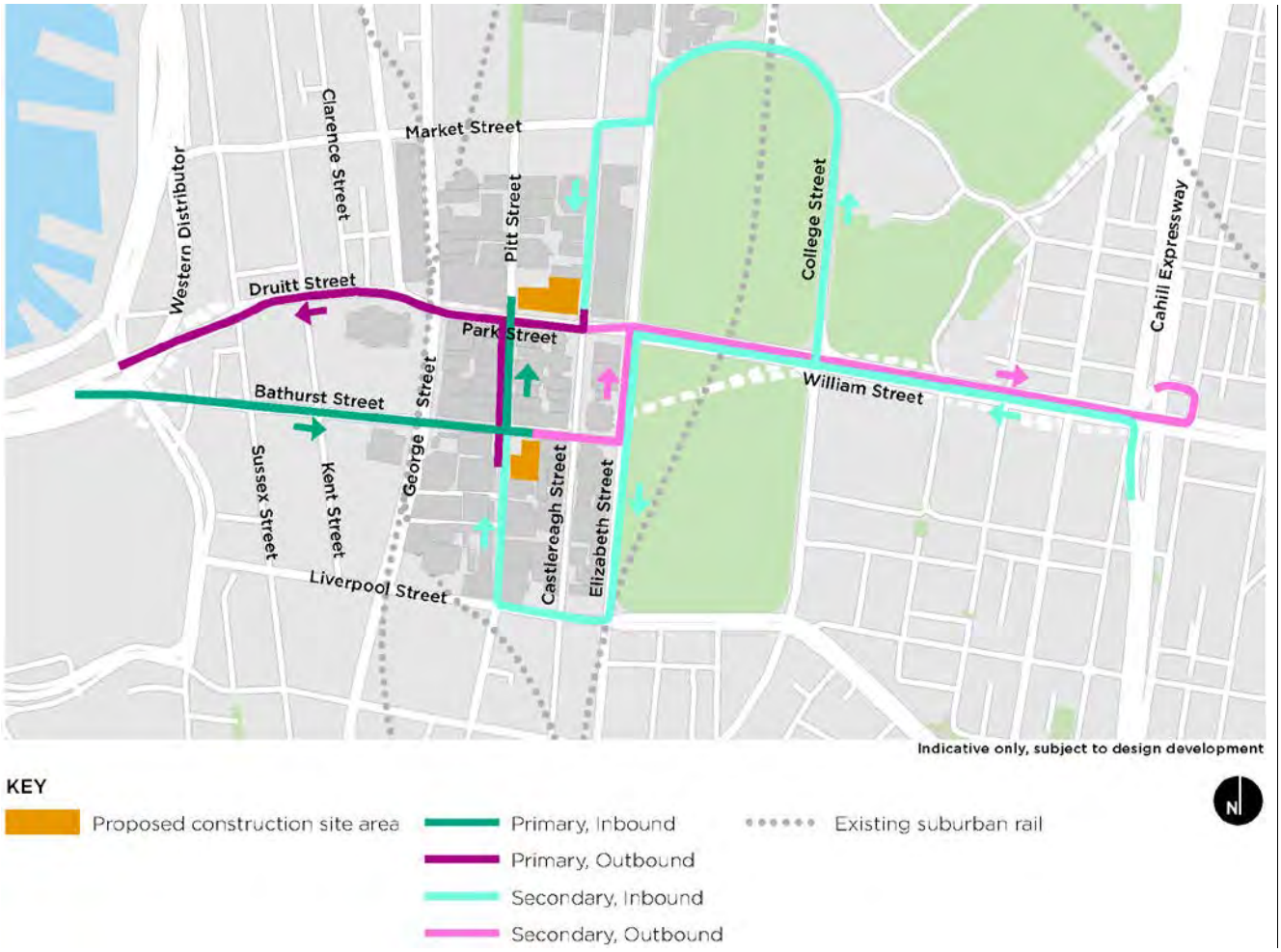


Figure 3.36 : Pitt Street Station haulage routes

A workforce of 240 staff would be anticipated at the site, working a variety of shifts.

Approximately four to 10 parking spaces would be provided on site.

Public transport would be promoted as the primary mode of transport for construction workers to minimise impacts on the local road network and parking availability. Off-site parking alternatives and associated shuttle arrangements to transport workers to and from the site would also be investigated.

No on-street car parking spaces, taxi facilities or loading zones in the vicinity of the site are anticipated to be impacted.

3.12.2 Construction activities

The major construction activities planned at Pitt Street involve:

- Enabling works such as demolition of buildings at both sites, services relocation and provision of power supplies for construction
- Excavation of shafts and caverns for the station
- Station construction

3.12.3 Construction vehicle movements

It is proposed that both the northern and southern sites would receive single unit trucks.

Construction vehicles would access and egress the site 24 hours a day, with the peak construction period occurring between 10 am and 3 pm. The arrival and departure pattern of construction vehicles aims to minimise the impact of construction activity during the network peak periods, as well as keeping night time heavy vehicle movements to a low level.

The total number of vehicles arriving at the construction sites is shown below in **Figure 3.37** and **Figure 3.38**. The vehicle numbers presented below would be split evenly between the two Pitt Street construction sites and the same number of vehicles that access each site per hour are anticipated to exit each site.

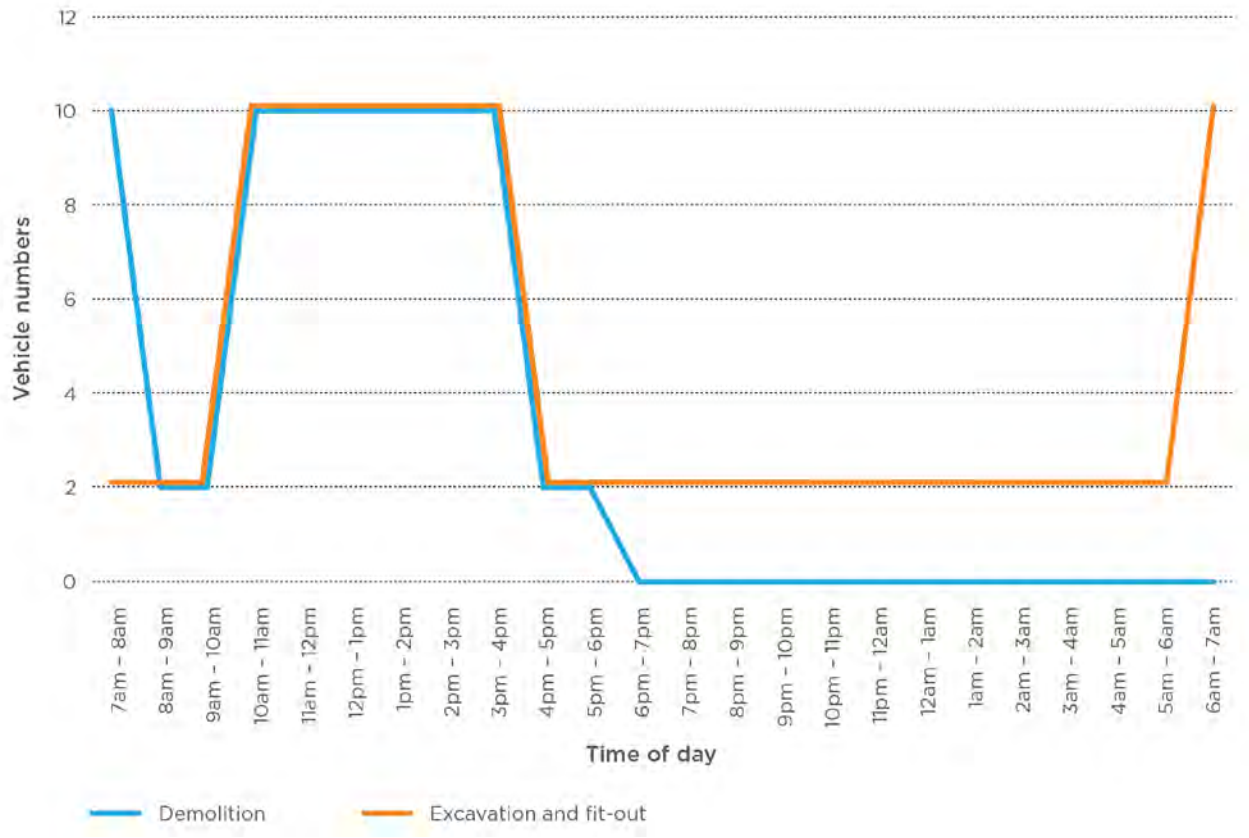


Figure 3.37 : Hourly light construction vehicle numbers (arrival only) at the Pitt Street Station construction site

Figure 3.38 : Hourly heavy construction vehicle numbers (arrival only) at the Pitt Street Station construction site

3.12.4 Road network performance

Figure 3.39 provides an overview of existing intersection locations surrounding the Pitt Street Station included within the assessment. A base scenario has been determined using traffic data from before the closure of George Street which has been redistributed in accordance with the preferred Sydney CBD driving routes. The base scenario has then been assessed with the anticipated construction traffic.

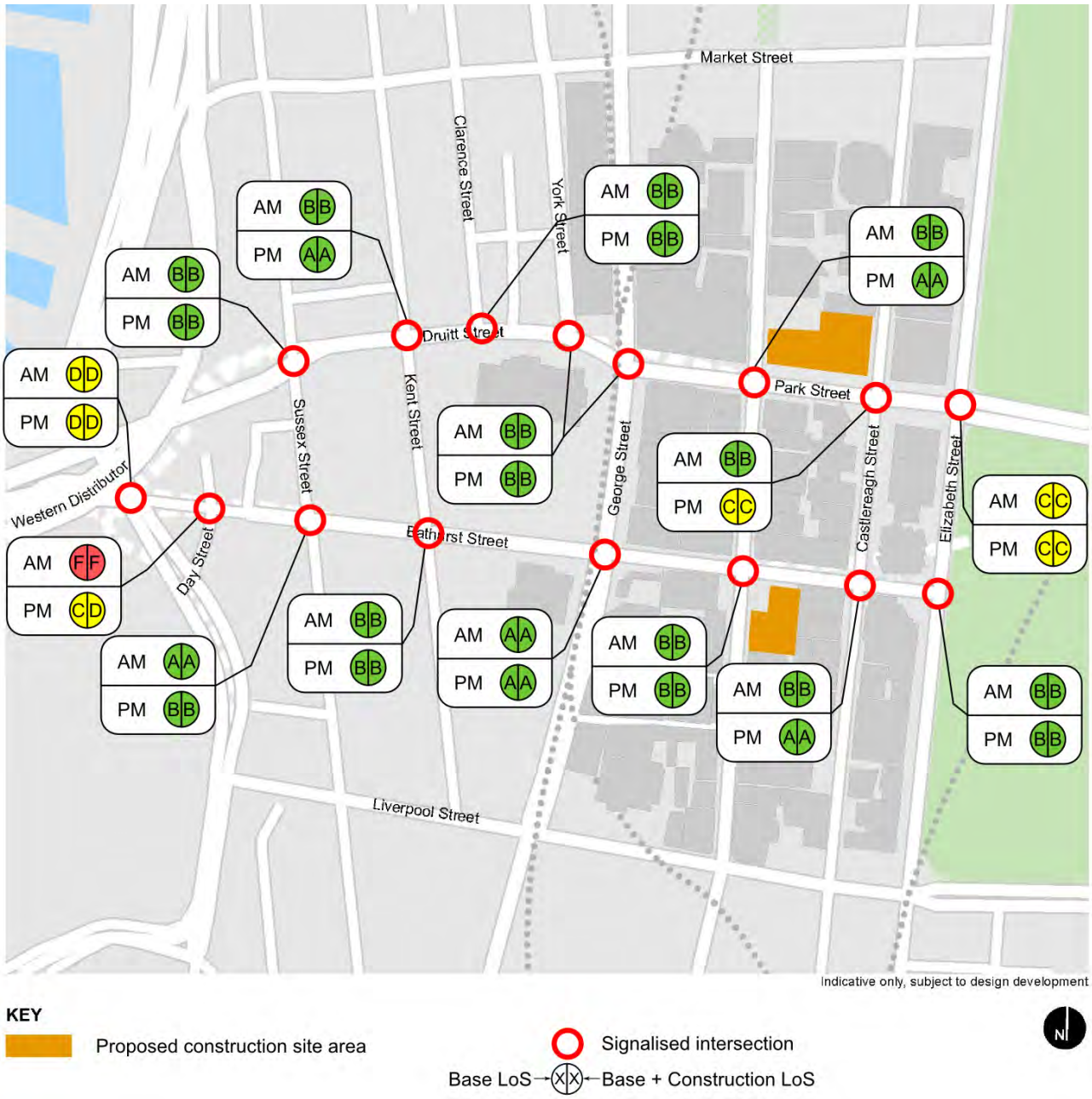


Figure 3.39 : Pitt Street Station assessed intersection locations

At each intersection, **Table 3.13** summarises the average delay per vehicle, level of service and degree of saturation obtained from LinSig.

Table 3.13: Modelled intersection performance at Pitt Street Station (AM and PM peak hour)

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Druitt Street / Sussex Street (signalised)								
AM peak	1,236	22	B	0.51	1,261	22	B	0.52
PM peak	1,559	26	B	0.70	1,576	26	B	0.69
Druitt Street / Kent Street (signalised)								
AM peak	1,607	17	B	0.67	1,632	17	B	0.65
PM peak	1,478	14	A	0.65	1,495	14	A	0.65
Druitt Street / Clarence Street (signalised)								
AM peak	1,120	20	B	0.87	1,145	18	B	0.87
PM peak	1,071	15	B	0.77	1,088	15	B	0.77
Druitt Street / Park Street / George Street / York Street (signalised)								
AM peak	1,335	18	B	0.80	1,360	18	B	0.79
PM peak	1,230	15	B	0.67	1,246	15	B	0.67
Park Street / Pitt Street (signalised)								
AM peak	1,700	18	B	0.63	1,737	18	B	0.63
PM peak	1,538	15	A	0.50	1,563	15	A	0.51
Park Street / Castlereagh Street (signalised)								
AM peak	1,666	23	B	0.67	1,679	23	B	0.67
PM peak	1,617	30	C	0.72	1,625	30	C	0.72
Park Street / Elizabeth Street (signalised)								
AM peak	3,781	35	C	0.72	3,781	35	C	0.72
PM peak	3,923	38	C	0.82	3,923	38	C	0.82
Bathurst Street / Harbour Street (signalised)								
AM peak	4,325	49	D	0.93	4,350	50	D	0.93
PM peak	3,536	43	D	0.93	3,553	44	D	0.93
Bathurst Street / Day Street (signalised)								
AM peak	1,718	307	F	1.19	1,743	324	F	1.20
PM peak	1,325	41	C	0.93	1,342	46	D	0.95
Bathurst Street / Sussex Street (signalised)								
AM peak	2,181	14	A	0.75	2,206	14	A	0.61
PM peak	1,953	16	B	0.76	1,970	16	B	0.74

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Bathurst Street / Kent Street (signalised)								
AM peak	2,188	21	B	0.78	2,213	20	B	0.79
PM peak	1,818	22	B	0.72	1,835	22	B	0.71
Bathurst Street / George Street (signalised)								
AM peak	1,137	10	A	0.45	1,162	10	A	0.45
PM peak	985	10	A	0.47	1,002	10	A	0.49
Bathurst Street / Pitt Street (signalised)								
AM peak	1,593	20	B	0.54	1,632	20	B	0.54
PM peak	1,415	26	B	0.55	1,440	27	B	0.57
Bathurst Street / Castlereagh Street (signalised)								
AM peak	1,416	22	B	0.55	1,416	22	B	0.55
PM peak	1,458	10	A	0.54	1,458	10	A	0.54
Bathurst Street / Elizabeth Street (signalised)								
AM peak	2,927	27	B	0.73	2,927	27	B	0.73
PM peak	3,205	18	B	0.64	3,205	17	B	0.66

Note: Outputs from LinSig Version 3.2

Base

All intersections were recorded as operating at a LOS C or better except for the following:

- Bathurst Street / Harbour Street (LOS D in both the AM and PM peaks)
- Bathurst Street / Day Street (LOS F in the AM peak)

The Bathurst Street / Day Street intersection operates with a degree of saturation of greater than 1.0, therefore, in the base scenario this intersection is operating above its theoretical capacity.

Construction

The intersection performance is maintained at all intersections during the construction phase of the project except for the Bathurst Street / Day Street intersection in the PM peak where the LOS deteriorates from LOS C to LOS D. This is likely due to the fact that the intersection is currently operating close to its theoretical capacity (degree of saturation 0.93). The average delay deteriorates from 41 to 46 seconds per vehicle and the degree of saturation deteriorates from 0.93 to 0.95. It is therefore considered that the impact of the construction traffic on the operational performance of this intersection would be relatively minor when compared to its current operation.

Therefore, it can be concluded that the impact from the additional construction traffic generated by the Pitt Street construction sites would be minimal.

3.12.5 Public transport services

Buses (excluding coaches) do not operate on Pitt Street between Hunter Street and Goulburn Street. However, Elizabeth, Castlereagh and Park streets are main thoroughfares for buses travelling through the Sydney CBD. The addition of construction vehicle routes on these streets may result in impacts to these bus services such as minor delays to travel times. In order to minimise these potential impacts, the Pitt Street construction sites would be arranged to ensure construction vehicles are loaded and unloaded off the street. Additionally, the Pitt Street Station north site has been arranged to avoid an access or egress point via Park Street to reduce the potential for impacts to bus services.

In the event that any bus stops around the Pitt Street Station construction sites are required to be temporarily relocated during the construction works, this would be carried out by Transport for NSW in consultation with the bus operators and the CBD Coordination Office. The temporary relocation of any bus stops would not impact the operation of bus services, however, it may result in some passenger having to walk slightly further to access bus stops.

It is anticipated that the existing rail network (including Town Hall and Museum stations) would not be impacted by the Pitt Street Station construction works.

3.12.6 Active transport network

The City Centre Access Strategy (Transport for NSW, 2013) identifies Castlereagh Street as a future strategic cycle route. Depending on the timing of the implementation of this cycle facility, Sydney Metro would liaise with the CBD Coordination Office and the City of Sydney Council to manage the potential impacts to cyclists on this section of the cycle route, and the provision of any alternative facilities should they be necessary.

Footpaths surrounding the sites on Pitt, Bathurst and Castlereagh Streets would be reduced in width by around 600 millimetres during the construction works. All footpaths are currently greater than three metres wide, therefore, a 2.4 metres wide footpath would be maintained, in line with the width requirements for footpaths set out in the Austroads guidelines[4].

3.12.7 Combined impacts

The Pitt Street and Barangaroo sites would both use the Western Distributor as their primary haulage route. However, given the low volumes of anticipated hourly heavy and light vehicles generated by each site, the cumulative impact of vehicles travelling to and from both sites is not considered to cause a material impact on the operational performance of the Western Distributor.

3.13 Central Station construction sites

3.13.1 Worksite location, parking and access

Construction of the new metro platforms at Central Station would occur within the Central Station Sydney Yard site which would be about 16,500 m^2 and located in the area of existing Platforms 13, 14 and 15 and the area between the suburban and country lines to the south. This incorporates the footprint of the future underground platforms. The site is currently part of the Central Station operational area. Access would be via a new left-in / left-out intersection on Regent Street located between the petrol station and the masonic temple.

The site would receive single unit trucks.

No on-street parking spaces would be lost as a result of the construction works.

The haulage routes to access the Central Station construction sites are shown in **Figure 3.40**.

[4] Austroads Guide to Road Design Part 6A: Pedestrian and Cyclists Paths.

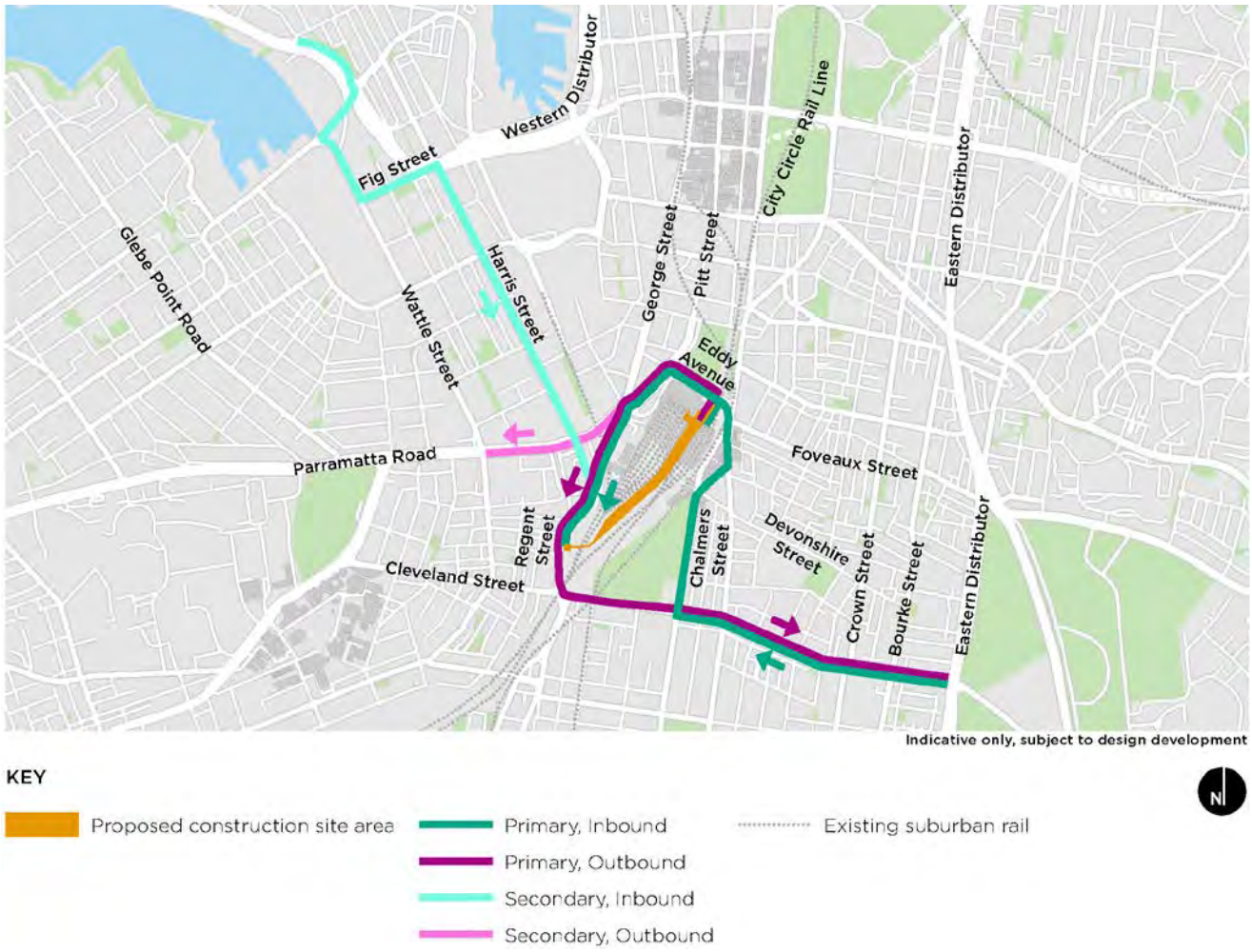


Figure 3.40 : Central Station haulage routes

A workforce of 320 construction staff is anticipated at the site, working a variety of shifts.

Four to 10 car parking spaces would be provided within each construction site.

Public transport would be promoted as the primary mode of transport for construction workers to minimise impacts on the local road network and parking availability. Off-site parking alternatives and associated shuttle arrangements to transport workers to and from the site would also be investigated.

3.13.2 Construction activities

Construction of the cut-and-cover station would impact the existing underground pedestrian connections between station platforms at Central Station. Opportunities would be investigated to retain some underground connectivity through staging of the construction works. In addition, a temporary pedestrian bridge would be provided from Platform 4 to Platform 23 to maintain interchange connectivity between the platforms.

The temporary pedestrian bridge would require a number of rail possessions to enable its construction.

Following construction works, the temporary bridge would be dismantled and removed, and the platform canopy sections re-instated.

3.13.3 Construction vehicle movements

Construction vehicles would access and egress the Central Station construction sites 24 hours a day. The peak construction arrivals and departures would occur between 10 am and 3 pm. Throughout the 24 hour period, on average the total construction vehicles that would access the Central Station construction site per hour are shown below in **Figure 3.41** and **Figure 3.42**. It is anticipated that the same number of vehicles would exit the site per hour.

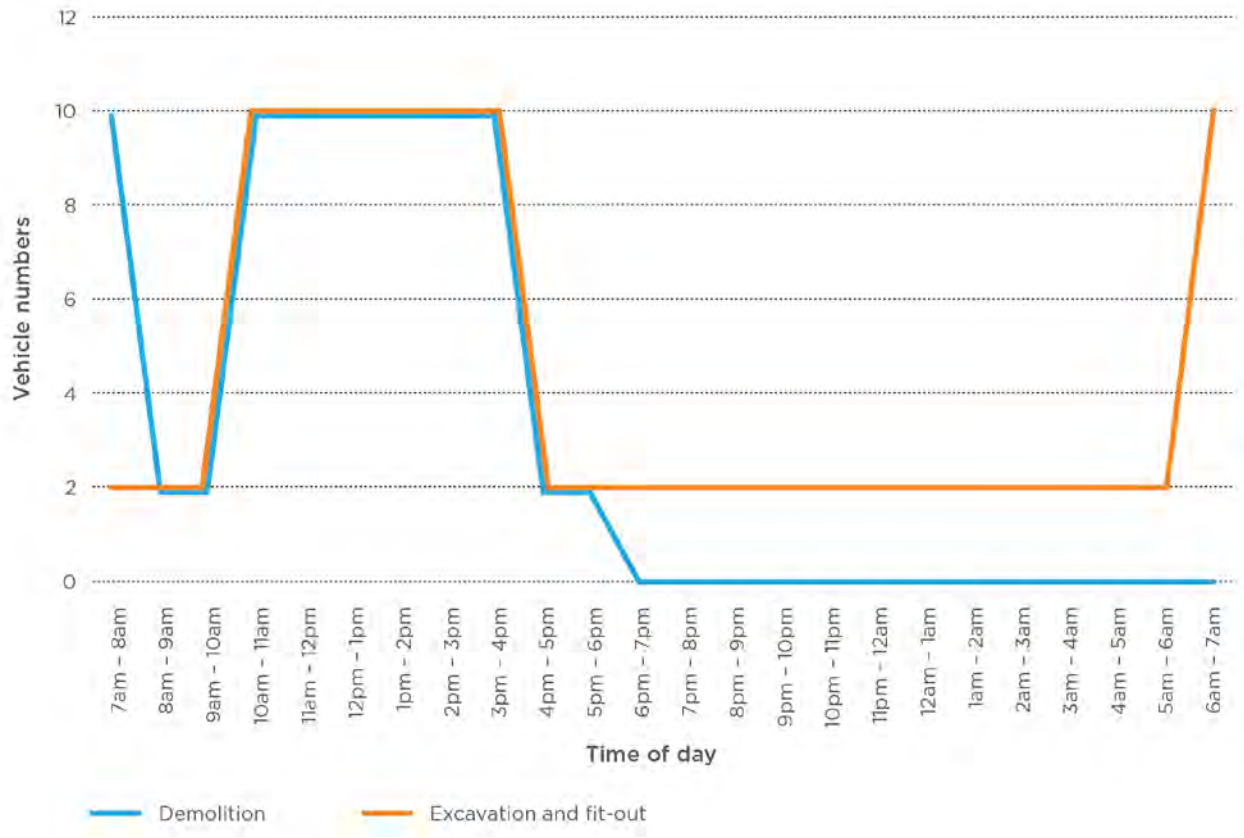


Figure 3.41 : Hourly light construction vehicle numbers (arrival only) at the Central Station construction site

Figure 3.42 : Hourly heavy construction vehicle numbers (arrival only) at the Central Station construction site

3.13.4 Road network performance

Figure 3.43 provides an overview of the intersection locations surrounding Central station included within the assessment.

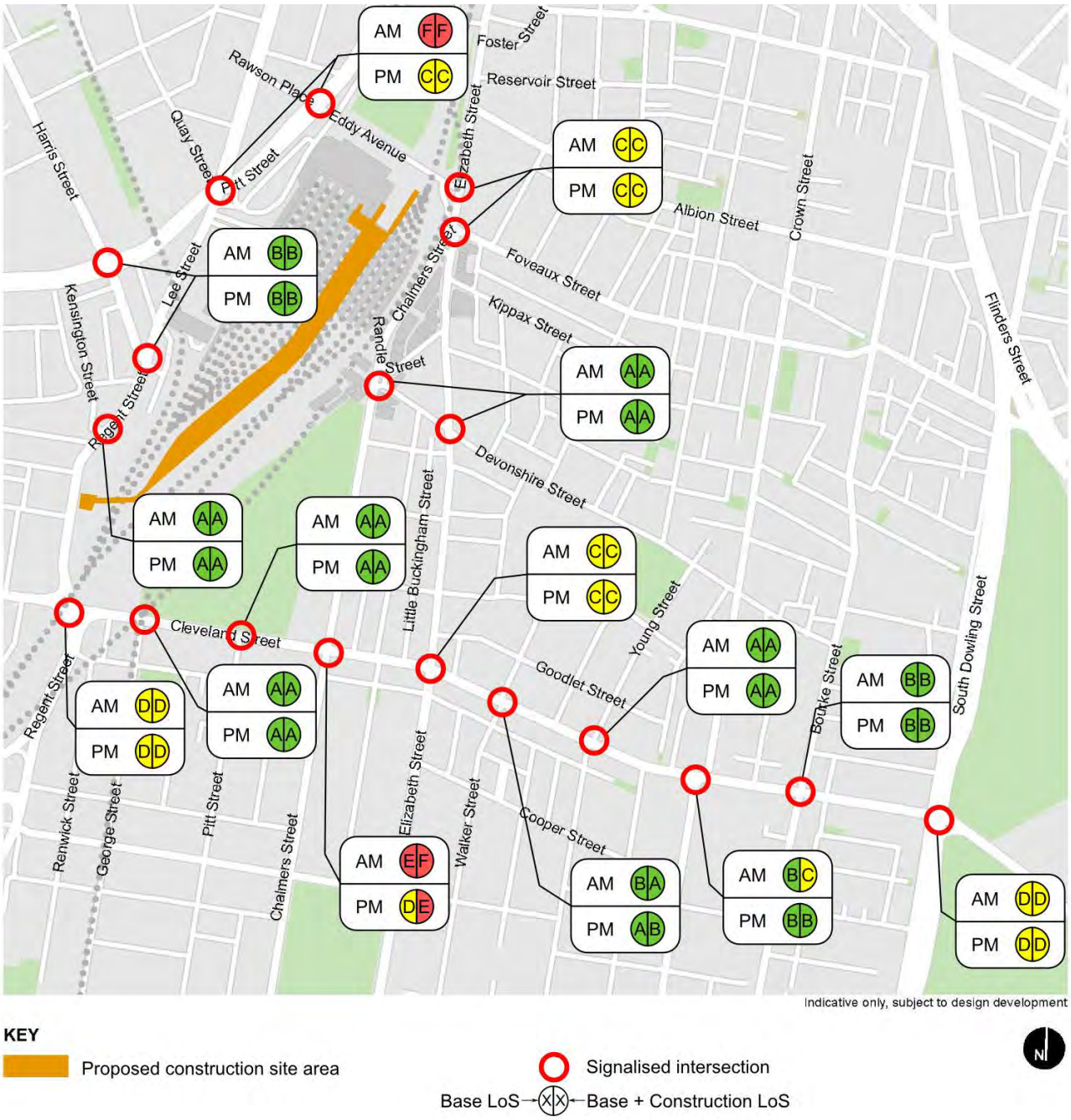


Figure 3.43 : Central Station assessed intersection locations

At each intersection, **Table 3.14** summarises the average delay per vehicle, level of service and degree of saturation obtained from LinSig during the base and construction scenarios.

Table 3.14: Modelled intersection performance at Central Station construction site (AM and PM peak hour)

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Regent Street / Harris Street / Broadway / George Street (signalised)								
AM peak	4,996	26	B	0.79	4,996	26	B	0.79
PM peak	5,401	24	B	0.85	5,401	24	B	0.85
Regent Street / Lee Street (signalised)								
AM peak	3,174	17	B	0.76	3,191	17	B	0.75
PM peak	3,109	16	B	0.78	3,126	17	B	0.75
George Street / Pitt Street / Lee Street / Quay Street (signalised)								
AM peak	4,929	122	F	1.20	4,946	122	F	1.20
PM peak	4,824	29	C	0.89	4,841	37	C	0.97
Pitt Street / Eddy Avenue / Rawson Parade (signalised)								
AM peak	5,053	89	F	1.13	5,070	88	F	1.13
PM peak	5,099	31	C	0.82	5,116	33	C	0.87
Eddy Avenue / Elizabeth Street / Foveaux Street (signalised)								
AM peak	4,216	31	C	0.87	4,233	30	C	0.88
PM peak	4,283	37	C	0.96	4,300	39	C	0.96
Elizabeth Street / Devonshire Street (signalised)								
AM peak	1,514	7	A	0.50	1,514	7	A	0.50
PM peak	2,015	8	A	0.77	2,015	9	A	0.77
Elizabeth Street / Cleveland Street (signalised)								
AM peak	3,580	31	C	0.83	3,614	32	C	0.81
PM peak	3,860	33	C	0.82	3,895	34	C	0.82
Chalmers Street / Cleveland Street (signalised)								
AM peak	4,058	62	E	1.11	4,092	75	F	1.22
PM peak	3,859	51	D	0.99	3,893	59	E	1.04
Chalmers Street / Devonshire Street (signalised)								
AM peak	1,533	13	A	0.78	1,550	13	A	0.79
PM peak	1,425	9	A	0.51	1,442	9	A	0.49
Regent Street / Cleveland Street (signalised)								
AM peak	6,680	53	D	1.00	6,714	52	D	1.00
PM peak	6,341	48	D	0.98	6,375	49	D	0.98

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Regent Street / Kensington Street (signalised)								
AM peak	2,954	6	A	0.44	2,971	6	A	0.44
PM peak	2,863	5	A	0.48	2,880	5	A	0.48
Cleveland Street / George Street (signalised)								
AM peak	2,784	8	A	0.57	2,801	8	A	0.57
PM peak	2,643	9	A	0.57	2,660	8	A	0.57
Cleveland Street / Pitt Street (signalised)								
AM peak	2,873	10	A	0.64	2,890	8	A	0.61
PM peak	2,740	10	A	0.62	2,757	10	A	0.62
Cleveland Street / Wilton Street / Walker Street (signalised)								
AM peak	2,529	15	B	0.61	2,563	9	A	0.49
PM peak	2,338	7	A	0.45	2,372	16	B	0.62
Cleveland Street / Marlborough Street / Young Street (signalised)								
AM peak	2,374	9	A	0.51	2,408	7	A	0.45
PM peak	2,329	9	A	0.51	2,363	8	A	0.47
Cleveland Street / Crown Street / Baptist Street (signalised)								
AM peak	3,072	27	B	0.88	3,106	32	C	0.88
PM peak	2,935	24	B	0.71	2,969	27	B	0.83
Cleveland Street / Bourke Street (signalised)								
AM peak	2,783	19	B	0.75	2,817	18	B	0.71
PM peak	2,746	20	B	0.63	2,780	17	B	0.67
Cleveland Street / South Dowling Street (signalised)								
AM peak	4,000	46	D	0.97	4,034	47	D	0.97
PM peak	4,093	44	D	0.95	4,127	48	D	0.95

Note: Outputs from LinSig Version 3.2

Base

A number of intersections along the Central Station haulage routes currently operate near, at or over capacity. These include:

- George Street / Pitt Street / Lee Street / Quay Street (AM peak)
- Pitt Street / Eddy Avenue / Rawson Parade (AM peak)
- Chalmers Street / Cleveland Street (AM peak and PM peak)
- Regent Street / Cleveland Street (AM peak and PM peak)
- Cleveland Street / South Dowling Street (AM peak and PM peak)

The remaining intersections all operate at LOS C or better.

It can be seen that a number of intersections along the haulage route are already operating at capacity, particularly in the AM peak period and therefore the network currently experiences delays and queuing.

Construction

With the construction traffic included on the network, all intersection maintain their base LOS except for Chalmers Street / Cleveland Street which deteriorates from LOS E to LOS F in the AM peak and from LOS D to LOS E in the PM peak. This intersection is already operating at or over capacity and therefore is sensitive to the minor addition of the construction traffic. The Cleveland Street / Crown Street / Baptist Street intersection also deteriorates from LOS B to LOS C in the AM peak. The degree of saturation at the intersection however remains unchanged and, therefore this impact would be minimal.

The Cleveland Street / Wilton Street / Walker Street intersection was seen to improve its LOS from B to A in the AM peak. This is likely due to the model being able to optimise this intersection to improve its operation.

Therefore, it can be seen that the proposed Central Station haulage route includes a number of intersections that are operating at or over capacity. The addition of construction traffic to the network results in a marginal deterioration in the performance of those intersections currently experiencing some congestion during the AM and PM peak periods.

3.13.5 Public transport services

As the Central Station precinct is a major interchange between bus and rail services, some construction impacts to the public transport network may be experienced.

The construction of the platforms at Central Station is likely to result in alterations to the Sydney Trains and NSW Trains timetable due to the closure of platforms 13, 14 and 15. Transport for NSW would liaise with Sydney Trains and NSW Trains in relation to the necessary timetable alterations.

A number of rail track possessions would be required to carry out the works at Central Station, including for:

- Construction of the access bridge from Regent Street to Sydney Yard and associated adjustments to existing rail systems
- Construction of the temporary pedestrian overbridge
- Adjustments to rail systems around platforms 13, 14 and 15 to facilitate cut-and-cover construction of the metro station
- Adjustments to rail systems around platforms, the paid underground pedestrian connections and Devonshire Street tunnel

Wherever possible, these works would be carried out within the standard Sydney Trains track possession schedule. However additional possessions, potentially including some extended track possessions, are likely to be required to facilitate these works. Alternative bus services would be provided during these possession works.

Bus services may experience some short term delays due to the additional heavy vehicles on the road network; however this impact is anticipated to be minimal.

The additional heavy vehicles on the road network are not anticipated to impact the operation of the Sydney Light Rail when it becomes operational.

3.13.6 Active transport network

Construction of the platforms at Central Station would require the closure of the Devonshire Street pedestrian tunnel for a period of approximately two weeks. During this closure, east-west pedestrian connectivity would be provided via Eddy Avenue, the northern station concourse or Cleveland Street. Pedestrians using the Devonshire Street tunnel would be required to walk an additional 320 metres approximately from Devonshire Street to the Pitt Street / George Street / Lee Street intersection, via Eddy Avenue, when compared to using the Devonshire Street tunnel. As the closure is only for two weeks, this impact would be temporary and therefore would not result in a significant impact.

The construction of the platforms would also result in the temporary closure of the existing underground pedestrian connections within Central Station. These underground pedestrian connections are used by customers to interchange at Central Station. To provide for this functionality, a temporary pedestrian overbridge would be provided between platforms 4 and 23 with stair connections to each platform. This provides the same level of access to those which would be removed during the construction phase. The current lift access to the platforms at the northern concourse would be maintained during construction. This is shown in **Figure 3.44**.

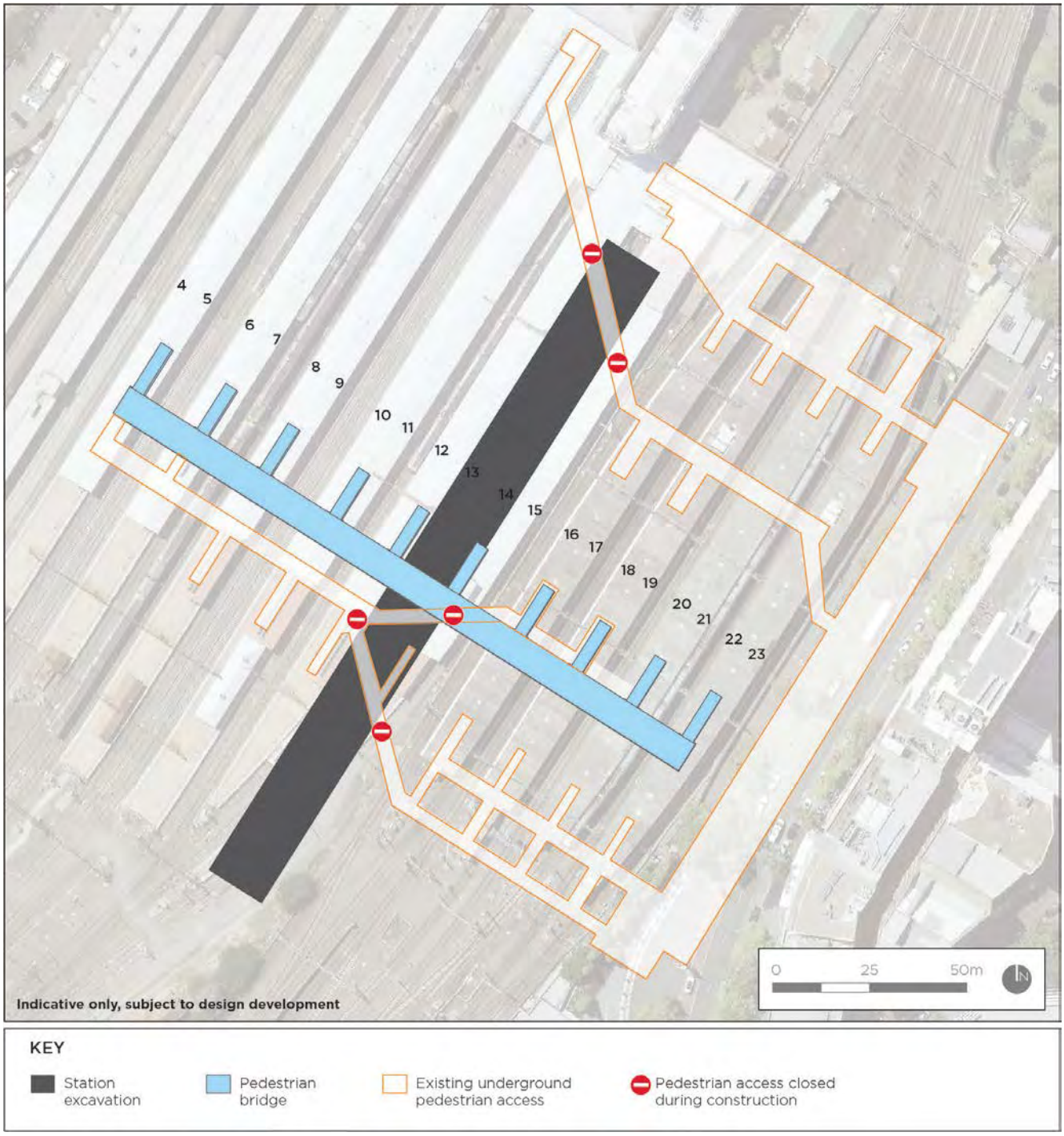


Figure 3.44 : Central Station construction pedestrian arrangement

3.14 Waterloo Station

3.14.1 Worksite location, parking and access

The site would be located within the block bounded by Raglan Street, Cope Street, Wellington Street and Botany Road in Waterloo. Single unit trucks are proposed to access the Waterloo Station construction site.

A workforce of 240 construction staff is anticipated at the site and would work a variety of shifts.

Public transport would be promoted as the primary mode of transport for construction workers to minimise impacts on the local road network and parking availability. Off-site parking alternatives and associated shuttle arrangements to transport workers to and from the site would also be investigated.

Four to 10 car parking spaces would be provided on-site.

Between two and four on-street parking spaces on Raglan Street would be lost during construction and on-street parking along Cope and Wellington Streets would be temporarily removed during demolition works.

Depending on the direction of potential disposal sites, haulage routes may be to the north or south along Botany Road and Gibbons Street. The proposed haulages routes can be seen in **Figure 3.45**. To provide flexibility, this assessment has included all construction vehicles using the northern haul route and all construction vehicles using the southern haul route. As such, the assessment is considered to be conservative.

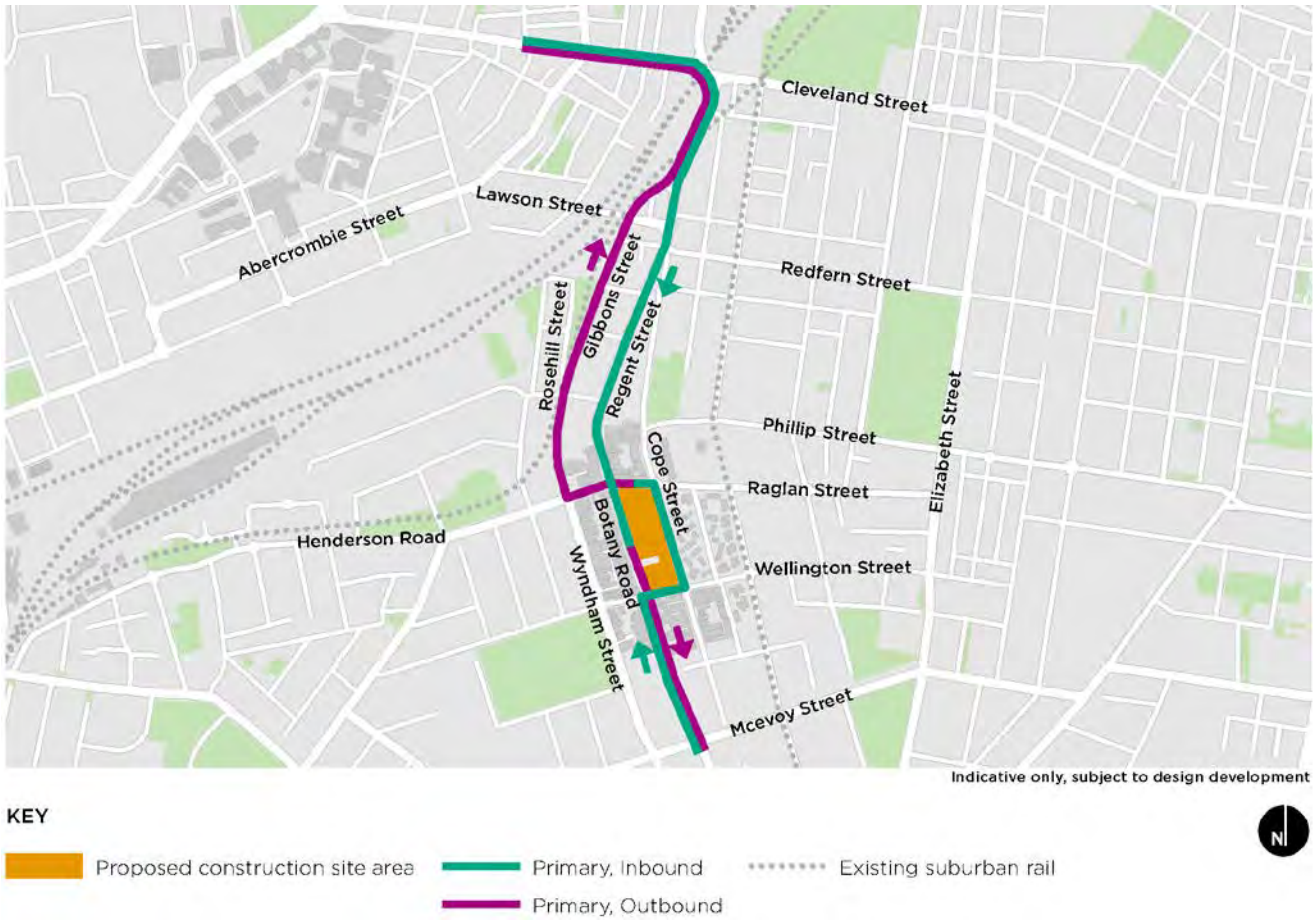


Figure 3.45 : Waterloo Station proposed haulage routes

3.14.2 Construction activities

The construction would include the demolition of buildings, cut-and-cover excavation in of the station followed by bottom-up construction of the permanent structures.

3.14.3 Construction vehicle movements

Construction vehicles would access and egress the site 24 hours a day, with the peak construction period occurring between 10 am and 3 pm. The arrival and departure pattern of construction vehicles aims to minimise the impact of construction activity during the network peak periods, as well as keeping night time heavy vehicle movements to a low level.

The number of vehicles arriving at the construction site is shown below in **Figure 3.46** and **Figure 3.47**. The same number of vehicles that access the site per hour are anticipated to exit the site in the same hour.

Figure 3.46 : Hourly light construction vehicle numbers (arrival only) at the Waterloo Station construction site

Figure 3.47 : Hourly heavy construction vehicle numbers (arrival only) at the Waterloo Station construction site

3.14.4 Road network performance

Figure 3.48 and **Figure 3.49** provide an overview of the intersection locations surrounding the station at Waterloo included within the assessment.

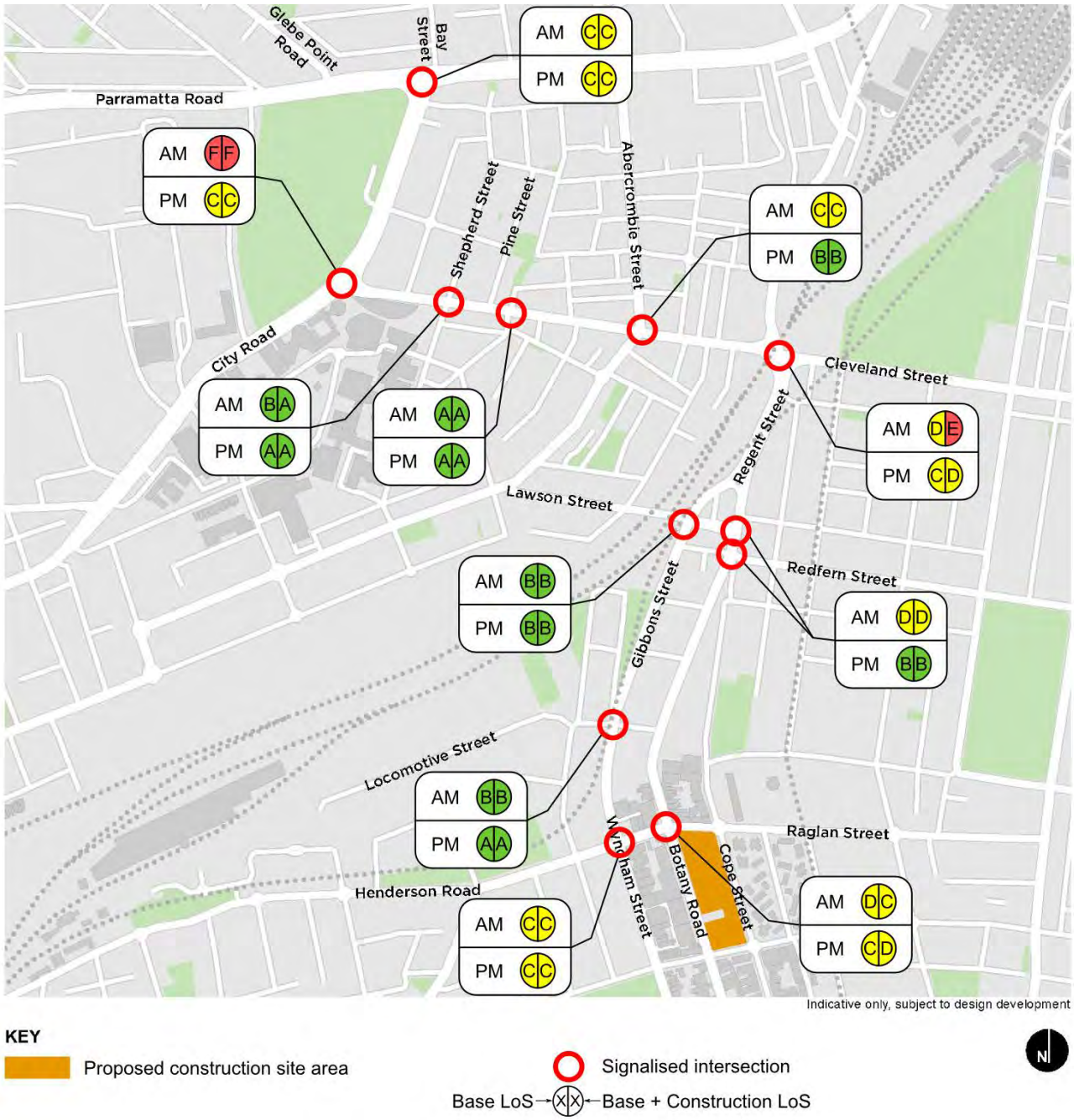


Figure 3.48 : Waterloo Station assessed intersection locations, northern route

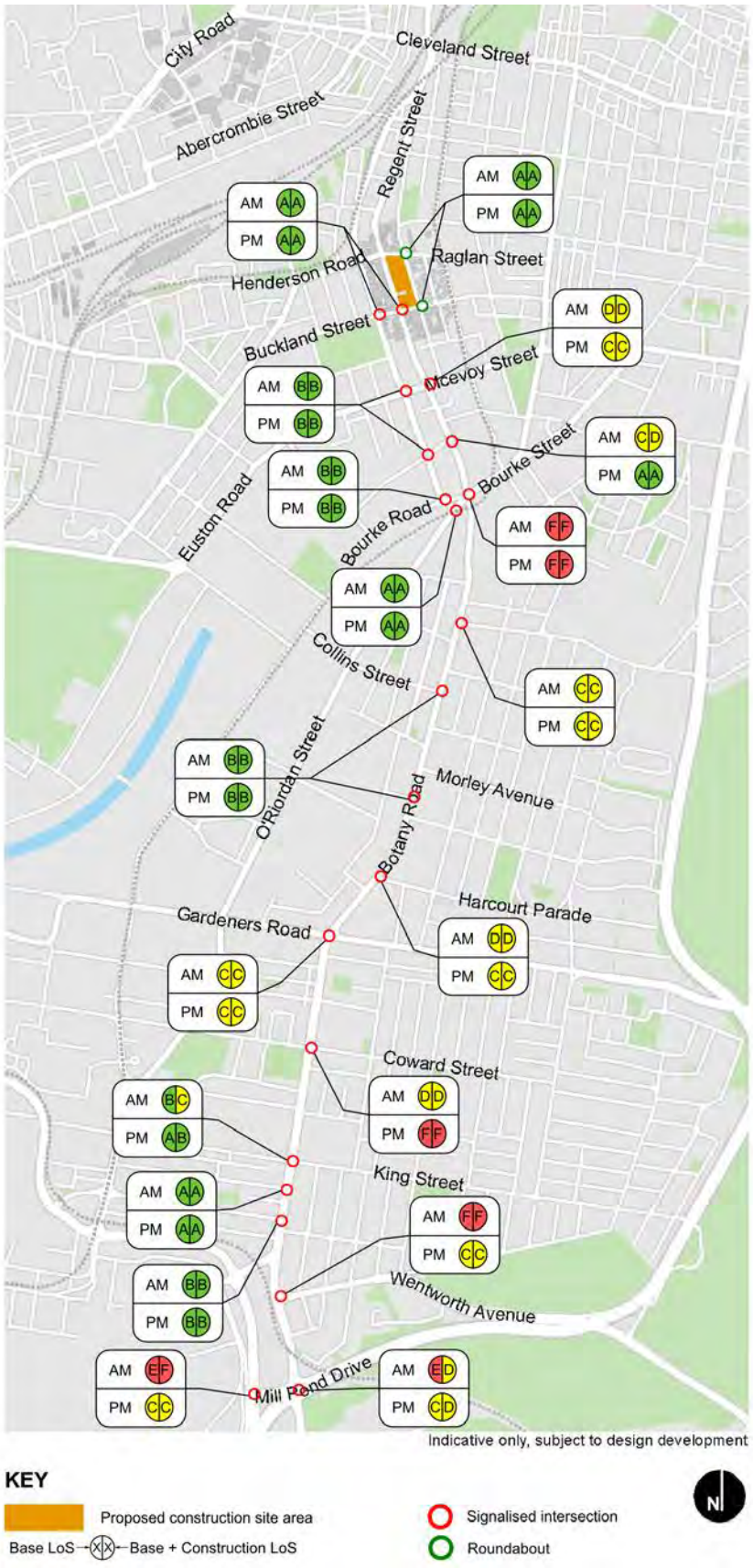


Figure 3.49 : Waterloo Station assessed intersection locations, southern route

At each intersection, **Table 3.15** and **Table 3.16** summarise the average delay per vehicle, level of service and degree of saturation obtained from LinSig during the base and construction scenarios for the northern and southern haul routes, respectively.

Table 3.15: Modelled intersection performance at Waterloo – Northern haul route (AM and PM peak hour)

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Wyndham Street / Gibbons Street / Boundary Street (signalised)								
AM peak	2,057	18	B	0.63	2,074	18	B	0.63
PM peak	1,512	6	A	0.48	1,529	5	A	0.48
Gibbons Street / Lawson Street (signalised)								
AM peak	2,731	20	B	0.87	2,748	20	B	0.87
PM peak	2,037	17	B	0.79	2,054	17	B	0.79
Wyndham Street / Henderson Road (signalised)								
AM peak	3,102	36	C	0.86	3,119	35	C	0.86
PM peak	2,929	30	C	0.81	2,946	30	C	0.81
Botany Road / Henderson Road / Raglan Street (signalised)								
AM peak	3,299	44	D	0.89	3,333	39	C	0.91
PM peak	3,178	42	C	0.92	3,212	43	D	0.92
Regent Street / Lawson Square / Redfern Street (signalised)								
AM peak	3,049	47	D	1.03	3,066	45	D	1.03
PM peak	2,936	25	B	0.98	2,953	28	B	0.99
Cleveland Street / Regent Street (signalised)								
AM peak	6,604	56	D	1.06	6,638	63	E	1.08
PM peak	6,146	42	C	0.94	6,180	44	D	0.96
Cleveland Street / Abercrombie Street (signalised)								
AM peak	3,636	33	C	0.85	3,670	32	C	0.85
PM peak	3,566	29	B	0.77	3,600	29	B	0.77
Cleveland Street / Boundary Street / Beaumont Street (signalised)								
AM peak	2,289	6	A	0.44	2,323	4	A	0.46
PM peak	2,379	3	A	0.43	2,413	4	A	0.44
Cleveland Street / Shepherd Street (signalised)								
AM peak	2,536	19	B	0.54	2,570	13	A	0.51
PM peak	2,544	14	A	0.54	2,578	14	A	0.57

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
City Road / Cleveland Street (signalised)								
AM peak	4,084	92	F	1.16	4,118	99	F	1.19
PM peak	4,111	31	C	0.91	4,145	33	C	0.93
City Road / Parramatta Road / Broadway / Bay Street (signalised)								
AM peak	5,064	34	C	0.92	5,098	34	C	0.92
PM peak	5,309	35	C	0.92	5,343	36	C	0.94

Note: Outputs from LinSig Version 3.2

Base

During the base scenario, all intersections operate at LOS C or better except for those listed below:

- Regent Street / Lawson Square / Redfern Street (LOS D in the AM peak)
- Cleveland Street / Regent Street (LOS D in the AM peak)
- City Road / Cleveland Street (LOS F in the AM peak)

It can be seen that the network has three intersections that currently operating in excess of their theoretical capacity in the AM peak period.

Construction

During construction the majority of intersections maintain their current LOS except for the Cleveland Street / Regent Street intersection which deteriorates from LOS D to LOS E in the AM peak and LOS C to LOS D in the PM peak. This intersection is already operating close to its theoretical capacity. However, the deterioration in the degree of saturation in both the AM and PM peaks is minor and, therefore, the overall operational impact on the network would be minimal.

The operational performance of the Cleveland Street / Shepherd Street intersection was seen to improve from LOS B to LOS A in the AM peak. Any minor improvements in the average delay or degree of saturation are likely to be the result of the model optimising the operation of the intersection with the additional construction traffic applied to certain movements. Furthermore, these minor operational improvements are within the normal variability of the modelling software and are not statistically significant.

It can therefore be seen that the construction traffic would have a minimal impact on the performance of the intersections along the haul route.

Table 3.16 : Modelled intersection performance at Waterloo – Southern haul route (AM and PM peak hour)

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Wyndham Street / Mandible Street (signalised)								
AM peak	962	21	B	0.42	962	20	B	0.42
PM peak	938	21	B	0.42	938	21	B	0.44
Botany Road / Mandible Street (signalised)								
AM peak	2,336	35	C	1.03	2,370	55	D	1.09
PM peak	2,102	6	A	0.56	2,136	6	A	0.58
Wyndham Street / McEvoy Street (signalised)								
AM peak	2,627	22	B	0.63	2,627	24	B	0.68
PM peak	2,617	25	B	0.77	2,617	24	B	0.77
Botany Road / McEvoy Street (signalised)								
AM peak	3,888	46	D	0.95	3,922	46	D	0.96
PM peak	3,688	38	C	0.92	3,722	39	C	0.94
Wyndham Street / Buckland Street (signalised)								
AM peak	867	13	A	0.46	867	13	A	0.46
PM peak	819	11	A	0.46	819	11	A	0.46
Botany Road / Buckland Street (signalised)								
AM peak	2,410	10	A	0.55	2,444	12	A	0.49
PM peak	2,247	13	A	0.53	2,281	13	A	0.55
Raglan Street / Cope Street (roundabout)								
AM peak	1,005	8	A	0.34	1,022	7	A	0.34
PM peak	1,082	4	A	0.38	1,099	4	A	0.38
Wellington Street / Cope Street (roundabout)								
AM peak	743	3	A	0.30	760	3	A	0.30
PM peak	839	3	A	0.31	856	3	A	0.31
Wyndham Street / O'Riordan Street (signalised)								
AM peak	1,992	8	A	0.42	1,992	8	A	0.42
PM peak	2,038	7	A	0.38	2,038	7	A	0.40
Wyndham Street / Bourke Road (signalised)								
AM peak	1,505	19	B	0.40	1,505	19	B	0.40
PM peak	1,503	19	B	0.40	1,503	19	B	0.42

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Botany Road / Bourke Street / Bourke Road / O'Riordan Street (signalised)								
AM peak	4,675	109	F	1.14	4,709	115	F	1.14
PM peak	4,454	130	F	1.11	4,488	130	F	1.11
Botany Road / Epsom Road (signalised)								
AM peak	2,678	30	C	0.87	2,712	30	C	0.89
PM peak	2,436	32	C	0.87	2,470	32	C	0.87
Botany Road / Collins Street (signalised)								
AM peak	2,614	16	B	0.76	2,648	16	B	0.79
PM peak	2,323	19	B	0.81	2,357	19	B	0.81
Botany Road / Shirley Street (signalised)								
AM peak	2,626	15	B	0.60	2,660	15	B	0.61
PM peak	2,327	19	B	0.82	2,361	19	B	0.82
Botany Road / Harcourt Parade (signalised)								
AM peak	3,007	47	D	0.96	3,041	53	D	0.98
PM peak	2,788	38	C	0.76	2,822	38	C	0.78
Botany Road / Gardeners Road (signalised)								
AM peak	4,847	37	C	0.97	4,881	38	C	0.97
PM peak	4,437	35	C	0.99	4,471	35	C	0.99
Botany Road / Coward Street (signalised)								
AM peak	3,146	57	D	0.96	3,180	54	D	0.97
PM peak	3,181	71	F	1.02	3,215	75	F	1.01
Botany Road / King Street (signalised)								
AM peak	3,428	25	B	0.82	3,462	33	C	0.90
PM peak	3,083	15	A	0.62	3,117	16	B	0.59
Botany Road / High Street (signalised)								
AM peak	3,157	11	A	0.75	3,191	11	A	0.78
PM peak	2,550	4	A	0.39	2,584	3	A	0.40
Botany Road / Robey Street (signalised)								
AM peak	3,300	17	B	0.69	3,334	14	A	0.82
PM peak	2,839	16	B	0.65	2,873	10	A	0.62

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Botany Road / General Holmes Drive (signalised)								
AM peak	3,332	19	B	0.77	3,366	18	B	0.67
PM peak	2,924	17	B	0.73	2,958	18	B	0.70
Botany Road / Wentworth Avenue (signalised)								
AM peak	4,339	112	F	1.18	4,373	110	F	1.16
PM peak	3,436	39	C	0.90	3,470	32	C	0.93
Botany Road / Mill Pond Road / Southern Cross Drive ramps								
AM peak	6,552	62	E	1.03	6,586	55	D	1.01
PM peak	5,628	43	C	0.97	5,662	44	D	0.98
General Holmes Drive / Mill Pond Road (signalised)								
AM peak	6,599	67	E	1.04	6,633	80	F	1.07
PM peak	5,799	41	C	0.93	5,833	42	C	0.95

Note: Outputs from LinSig Version 3.2

Base

Along the southern haul route three intersections currently operate at LOS F and are operating over capacity. These include:

- Botany Road / Bourke Street / Bourke Road / O'Riordan Street (AM and PM peak)
- Botany Road / Coward Street (PM peak)
- Botany Road / Wentworth Avenue (AM peak)

A number of other intersections along Botany Road, as well as the General Holmes Drive / Mill Pond Road intersection are also operating near or at capacity.

Construction

The addition of the construction traffic results in the LOS of five intersections deteriorating, namely:

- Botany Road / Mandible Street
- Botany Road / Henderson Road / Raglan Street
- Botany Road / King Street
- Botany Road / Mill Pond Road / Southern Cross Drive ramps
- General Holmes Drive / Mill Pond Road

Most of these intersections were operating at or near capacity and the increase in the degree of saturation was either zero or minimal and therefore the impact on the overall operation of the intersection would be minimal.

At two intersections, Botany Road / Henderson Road / Raglan Street and Botany Road / Mill Pond Road / Southern Cross Drive ramps, the operational performance was observed to improve in the AM peak.

Any minor improvements in the average delay or degree of saturation are likely to be the result of the model optimising the operation of the intersection with the additional construction traffic on certain movements. Furthermore, these minor operational improvements are within the normal variability of the modelling software and are not statistically significant.

It can therefore be seen that the southern haul route already has a number of intersections operating at or over capacity, however the impact of the additional construction traffic on the operational performance of the intersections would be minimal.

3.14.5 Public transport services

The bus stop currently located near 103 Botany Road may need to be temporarily relocated during the construction works. The relocation of this bus stop would be carried out by Transport for NSW in consultation with the bus operators, Roads and Maritime Services and City of Sydney Council. The temporary relocation of the bus stop would not impact the operation of any bus services however it may result in some passenger having to walk slightly further to access bus stops.

3.14.6 Active transport network

Existing footpaths long Botany Road, Cope Street, Raglan Street and Wellington Street (bounding the construction site) would be reduced by approximately 600 millimetres adjacent to the proposed hoarding. Footpaths along Botany Street, Raglan Street and Cope Street are currently greater than 3 metres wide, within which there are various items of street furniture such as trees, a rubbish bin and road signs. Therefore, a 2.4 metre wide footpath would be maintained, in line with Austroads guidelines[5], however may require the relocation of some items of street furniture. The footpath on Wellington Street is approximately 1.9 metres wide with a grass verge approximately 1.6 metres wide. With a combined width of approximately 3.5 metres, an appropriate footpath would be maintained along Wellington Street.

Existing cycle facilities on Botany Road (south of Wellington Street), Buckland Street and George Street in the vicinity of the site would not be impacted.

3.14.7 Combined impacts

If the northern haul route is adopted, construction vehicles from the Waterloo Station and Central Station construction sites would both use the Regent Street / Cleveland Street intersection. Given the low construction vehicles anticipated during the morning peak hour, this cumulative impact is not considered to have a material impact on the operation of the intersection.

No other works in the vicinity of the Waterloo Station construction site are known to be occurring consecutively, therefore, there would be no cumulative impacts in this area of the project

3.15 Marrickville dive site (southern)

3.15.1 Worksite location, parking and access

The Marrickville dive site would be required to provide sufficient area for materials storage, materials delivery, spoil removal and a pre-cast concrete plant.

The site is anticipated to have a workforce of 400 construction staff, working a variety of shifts.

The site would include 300 car parking spaces that could be used by construction staff, with the option to provide a park and shuttle service to other construction sites.

Two to four on-street parking spaces adjacent to the site would be lost as part of the construction. Given the low number of parking spaces that would be lost, the impact on parking would be minor.

[5] Austroads Guide to Road Design Part 6A: Pedestrian and Cyclist Paths

The Edinburgh Road / Edgeware Road intersection is proposed to be signalised as part of the project, to improve the safety of the intersection, and the upgrade would occur at the commencement of construction. The design would consider advance traffic signal warning lights on Edgeware Road to further improve safety. The proposed layout is shown in **Figure 3.50**. No other upgrades to surrounding roads, including Bedwin Road, are required.

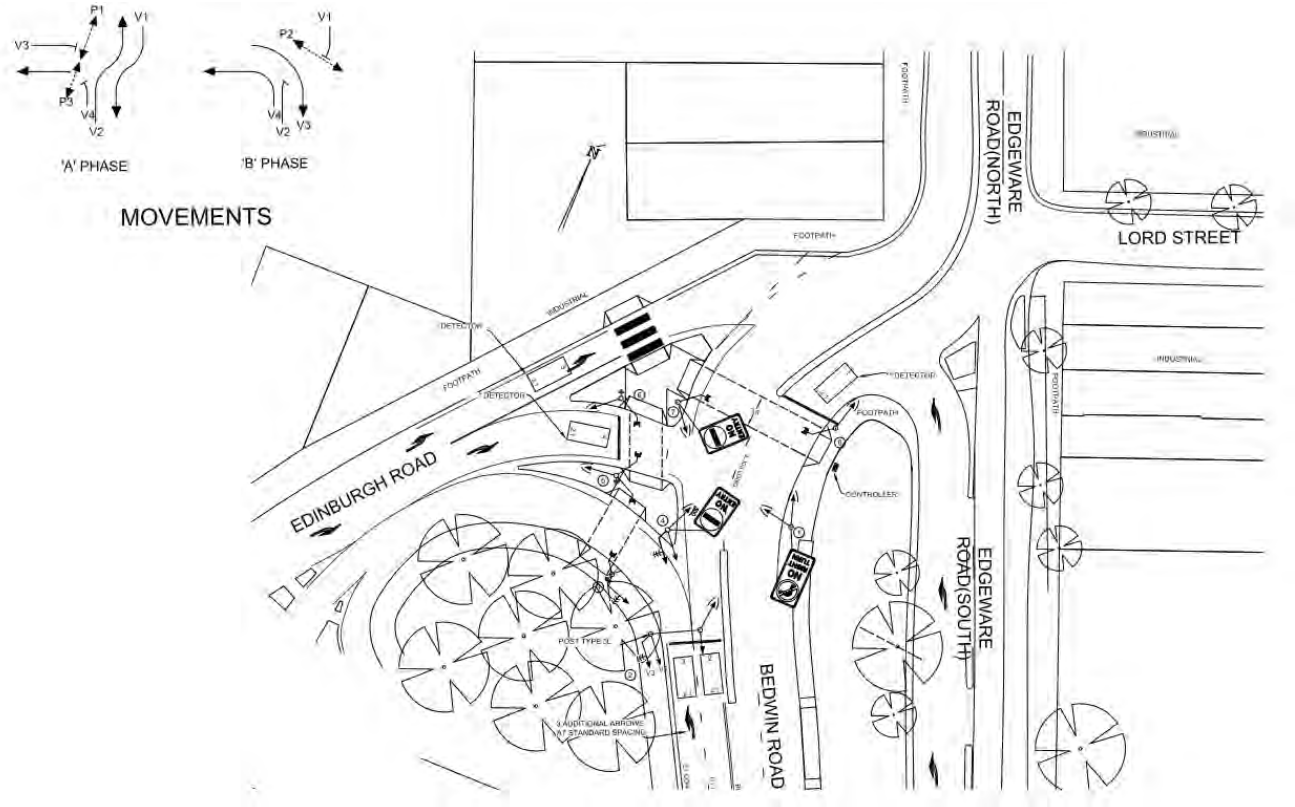


Figure 3.50 : Edinburgh Road / Edgeware Road proposed signals concept design

Vehicular access and egress to and from the site would be from Edinburgh Road and onto Bedwin Road, May Street and the Princes Highway. **Figure 3.51** illustrates the proposed haulage routes.

Figure 3.51 : Marrickville dive site haulage routes

3.15.2 Construction activities

The Marrickville dive site would be used to:

- Excavate and construct the dive structure and tunnel portal
- Launch and support two tunnel boring machines for the major tunnel works
- Support tunnel rail systems fit out works
- Support the construction of the southern services facility
- Facilitate a pre-cast concrete plant

3.15.3 Construction vehicle movements

Truck and dog construction vehicles and semi-trailers, with a maximum length of 19 metres are proposed to access the Marrickville dive site.

Construction vehicles would access and egress site 24 hours a day. The peak construction arrivals and departures would occur between 10 am and 3 pm. Throughout the 24 hour period, the construction vehicles arriving at the site are shown below in **Figure 3.52** and **Figure 3.53,** with the same number exiting the site in each hour.

The arrival and departure pattern of construction vehicles aims to minimise the impact of construction activity during the network peak periods, as well as keeping night time heavy vehicle movements to a low level.

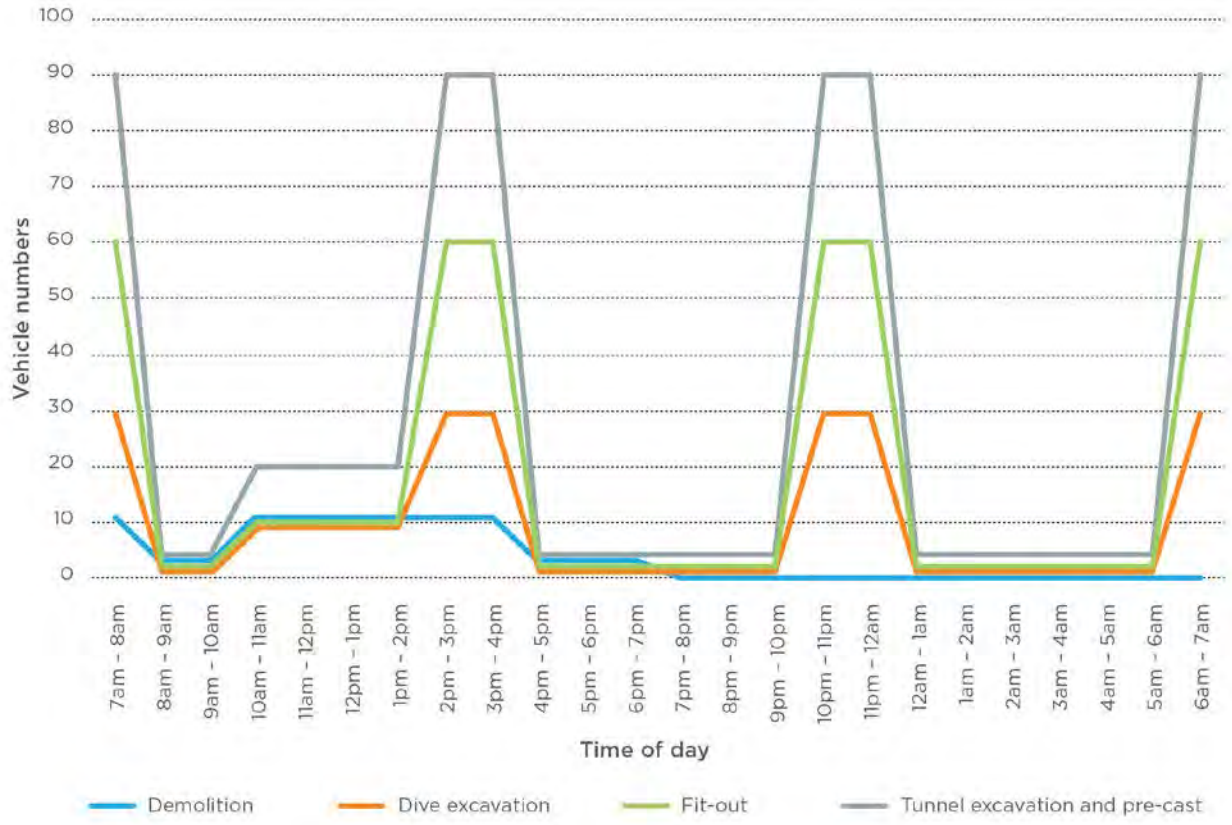


Figure 3.52 : Hourly light construction vehicle numbers (arrival only) at the Marrickville dive site (southern)

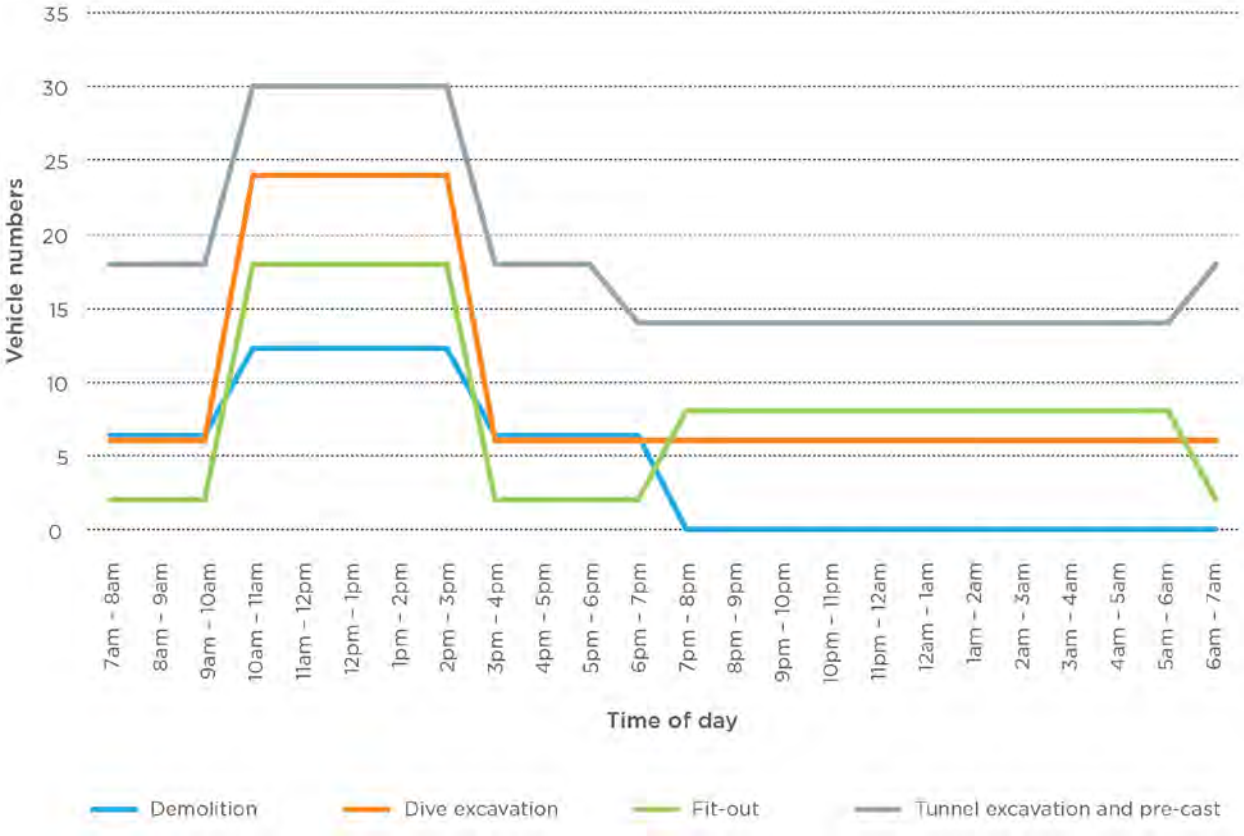


Figure 3.53 : Hourly light construction vehicle numbers (arrival only) at the Marrickville dive site (southern)

3.15.4 Road network performance

Figure 3.54 provides an overview of the intersection locations surrounding the station at the Marrickville dive site included within the assessment.

Figure 3.54 : Marrickville dive site assessed intersection locations

At each intersection, **Table 3.17** summarises the average delay per vehicle, level of service and degree of saturation obtained from LinSig during the base and construction scenarios.

Table 3.17: Modelled intersection performance at Marrickville dive site (AM and PM peak hour)

Intersection / peak period	Base				With Construction			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Edinburgh Road / Murray Street (roundabout)								
AM peak	979	4	A	0.48	1,077	4	A	0.52
PM peak	1,168	6	A	0.66	1,266	6	A	0.71
Edinburgh Road / Edgeware Road (roundabout)								
AM peak	886	3	A	0.38	984	4	A	0.43
PM peak	1,085	3	A	0.40	1,183	4	A	0.45
Edinburgh Road / Bedwin Road / Edgeware Road (signalised)								
AM peak	1,926	11	A	0.55	2,024	13	A	0.58
PM peak	1,940	11	A	0.66	2,038	13	A	0.69
Bedwin Road / Unwins Bridge Road / Campbell Street / May Street (signalised)								
AM peak	2,796	45	D	1.01	2,894	51	D	1.03
PM peak	2,993	42	C	1.01	3,091	47	D	1.03
Princes Highway / Campbell Street (signalised)								
AM peak	3,527	34	C	1.00	3,625	35	C	1.00
PM peak	3,862	30	C	0.86	3,960	30	C	0.86
Princess Highway / May Street (signalised)								
AM peak	3,756	33	C	0.83	3,854	35	C	0.80
PM peak	4,392	25	B	0.81	4,490	29	C	0.86

Note: Outputs from LinSig Version 3.2

Base

All intersections operate at LOS D or better and the unsignalised intersections operate at LOS A.

The worst performing intersections are:

- Bedwin Road / Unwins Bridge Road / Campbell Street / May Street (LOS D in the AM peak and LOS C in the PM peak);
- Princes Highway / Capbell Street (LOS C in both peaks); and
- Princes Highway / May Street (LOS C in the AM peak)

The signalised intersections of Princes Highway / Campbell Street and Bedwin Road / Unwins Bridge Road / Campbell Street / May Street currently operate at or over capacity.

Construction

All intersections maintain their existing LOS with the construction traffic added onto the network except for the Bedwin Road / Unwins Bridge Road / Campbell Street / May Street intersection which deteriorates from LOS C to LOS D in the PM peak. However, the increase in the average vehicle delay and degree of saturation is relatively minor. Therefore, the deterioration in the operational performance of the intersection is not considered to have a material impact on the overall operation of the road network.

Therefore, it is considered that impacts resulting from the construction traffic would be minimal.

3.15.5 Public transport services

Minimal disruption would be expected to bus services operating along Edinburgh Road due to the low number of heavy vehicles trips generated by the construction works. No major track works would occur at this site however there is the potential for rail possessions which would be negotiated with Sydney Trains.

3.15.6 Active transport network

The active transport network would be largely unaffected by construction works at the Marrickville dive site. Formal cycle paths currently do not exist within the vicinity of the work site and pedestrian footpaths are expected to remain open during construction activities. There would be potential for minor conflict between trucks and pedestrians at the Edinburgh Road site access point, however options to enhance pedestrian and cyclist safety in the vicinity of the construction site would be investigated during detailed construction planning.

3.16 Pedestrian, cyclist and motorist safety

The introduction of additional heavy vehicles to the network has the potential to result in safety impacts to pedestrians, cyclists and other motorists, especially where there is an increased likelihood for interaction with pedestrians and cyclists.

Key locations where pedestrian and cyclist safety issues may arise include:

- Construction site access and egress points where construction vehicles would interface with pedestrians using surrounding footpaths. This would be especially important in the Sydney CBD where high volumes of pedestrians are expected
- Construction sites where access and egress points, or haul routes would interface with marked cycle routes. This would occur at Chatswood dive site, Victoria Cross, Crows Nest, Blues Point, Barangaroo, Pitt Street, Central, Waterloo and Marrickville dive site
- Locations where footpath widths are reduced around the construction sites
- At Victoria Cross Station construction site where the haul route or haul routes would be located near the Mont Sant' Angelo Mercy College and could interface with school drop off and pick up points, or the route for school children from nearby bus stops. Further information on potential construction traffic issues around this school are provided in Section 3.6.

Access and egress arrangements at construction sites have been developed with consideration for pedestrian, cyclist and motorist safety. For example, the need for construction vehicles to turn right to or from arterial roads to access construction sites has been avoided where possible.

Appropriate controls would be established where vehicles are required to cross footpaths to access construction sites. This may include manual supervision, physical barriers or temporary traffic signals as required. Safety audits would be carried out at each of the construction site traffic access and egress points.

In addition, the Sydney Metro project is currently investigating options to further enhance pedestrian, cyclist and motorist safety in the vicinity of construction sites. This would include measures such as:

- Use of speed awareness signs in conjunction with variable message signs near construction sites to provide alerts to drivers
- Shared experience educational events that allow pedestrians, cyclists or motorists to sit in trucks and understand the visibility restrictions of truck drivers, and for truck drivers to understand the visibility from a bicycle
- Specific construction driver training to understand route constraints, expectations, safety issues and to limit the use of compression braking
- Safety devices on construction vehicles that warn drivers of the presence of a vulnerable road user located in the vehicles' blind spots and warn the vulnerable road user that a vehicle is about to turn.

3.17 Major special events

A high proportion of events occur within the Sydney CBD area where events are held at the Domain, the Rocks and the Royal Botanic Gardens. The operational phase of Sydney Metro would provide additional public transport options for attendees at special events and are unlikely to negatively impact the operational performance of the road network, therefore, special events have only been assessed with regard to the construction phase.

The Sydney CBD hosts a number of annual events, with The Domain being a key attractor. A list of annual major special events in the vicinity of the Sydney metro construction sites is included below in **Table 3.18**.

Table 3.18: Major special events in the Sydney CBD

Indicative Month	Event	Location
December/January	New Years' Eve Celebrations	Primarily Circular Quay, Blues Point and Barangaroo areas. Whole Sydney CBD would be affected.
January	Field Day	The Domain
January	Sydney Festival	Sydney CBD
January	Australia Day Celebrations	Primarily harbour foreshore area
February	Opera in the Domain	The Domain
February	Tropfest	The Domain
March	Mardi Gras Parade / Party	Oxford Street / Hyde Park area
April	Anzac Day Parade	Martin Place, Pitt Street, George Street, Bathurst Street, Elizabeth Street, Hyde Park
May	Mother's Day Classic	Martin Place, Hyde Park and The Domain
May / June	Vivid Festival	Sydney CBD and Chatswood
June	Sydney Film Festival	Sydney CBD
July	Reserve Forces Day	Macquarie Street
August	City 2 Surf	Hyde Park, Park Street, William Street

Indicative Month	Event	Location
September	Sydney Marathon	Milsons Point, Circular Quay, Sussex Street, Macquarie Street, Phillip Street, The Domain, Hyde Park, Oxford Street and Darling Harbour.
October	Sydney Spring Cycle	Milsons Point, Barangaroo, Cahill Expressway, Sussex Street
November	Sydney to Gong	Sydney Park
December	Carols in the Domain	The Domain

In addition, there are various events within the Moore Park Entertainment precinct throughout the year (such as sporting events and music concerts) with Central Station being a major transport focus for access to and from these events. Where there would be a forecast attendance of over 25,000 people within the Moore Park Entertainment precinct, these events would also be included within construction planning and management.

The Roads and Maritime Services special events management guidelines identify the following classes of special events:

- Class 1: an event that impacts major traffic and transport systems and there is significant disruption to the non-event community. For example, an event that affects a principal transport route in Sydney such as the Mardi Gras Parade and City 2 Surf.
- Class 2: is an event that impacts local traffic and transport systems and there is low scale disruption to the non-event community. For example, an event that blocks off the main town street or shopping centre but does not impact a principal transport route.
- Class 3: is an event with minimal impact on local roads and negligible impact on the non-event community.
- Class 4: is an event conducted entirely under Police control (but is not a protest or demonstration).

Liaison would occur with event organisers of Class 1 and 2 events, and (as relevant) the CBD Coordination Office and Roads and Maritime Services to provide appropriate management of construction vehicle movements to manage potential impacts to event goers, the general public and the construction works. This may involve measures such as temporary adjustment to haul routes, working hours or potentially stopping works for the duration of the event.

3.18 Emergency vehicles

As identified in the above sections, the introduction of construction traffic is anticipated to result in minor to negligible impacts to surrounding intersection performance. As such, there is not anticipated to be any significant change to emergency vehicle access. Further, construction sites would be arranged to ensure emergency vehicle access to nearby buildings and precincts is maintained. Construction sites may also be made available for emergency vehicle passage if required.

Ongoing consultation would be carried out with emergency service providers in relation to changed traffic conditions.

3.19 Power supply routes

The majority of the power supply routes would be constructed by trenching within the road reserve. Roads which are likely to be impacted by the construction of the power supply routes are identified in Chapter 7 (Project description – construction). Where major roads are crossed by the route (such as Mowbray Road for the Chatswood dive site power supply), alternative construction methods would be used such as under boring in order to avoid impacts to the road network.

This trenching work would result in temporary changes to traffic arrangements potentially including the occupation of traffic lanes, parking areas or the footpath.

For the majority of the construction period two-way traffic would be maintained, however there may be some periods when full road or lane closures are required. These are most likely to occur at night when traffic volumes are lower. Where pedestrian footpaths are impacted, a suitable alternative route around the work area would be provided and signposted.

In addition, the work may result in reduced access to some properties for short periods of time (typically less than one day). In this event, suitable alternative arrangements would be discussed with the land owner.

As the works would progress along the power supply route alignment, the potential impacts in a particular location would be short-lived, typically occurring for up to two weeks.

4. Operational impacts

The project is one component of the Sydney Metro City & Southwest, which would deliver around 30 kilometres of metro rail between Chatswood and Bankstown, including:

- A new crossing beneath Sydney Harbour
- New railway stations in the Sydney CBD and lower North Shore
- An upgrade and conversion to metro rail between Sydenham and Bankstown

The project would connect with the Sydney Metro Northwest at Chatswood.

Once complete, the Sydney Metro network would deliver 66 kilometres of metro rail line between Rouse Hill and Bankstown and up to 31 stations.

This chapter provides an operational traffic and transport assessment of the Chatswood to Sydenham project.

4.1 Strategic traffic and transport impacts

The design of the project would aim to avoid or reduce impacts associated with operational traffic and transport. It would improve road traffic conditions by providing a convenient and efficient travel alternative to the use of the private car.

Chapter 3 (Strategic need and justification) of the Environmental Impact Statement identifies the anticipated transport benefits following the implementation of the Sydney Metro network, as well as the specific benefits of the Chatswood to Sydenham project. The strategic traffic and transport related impacts and benefits of the operation of the project are outlined below.

4.1.1 Travel time savings

The project would improve travel times by:

- Providing more direct routes to key destinations
- Reducing crowding on trains and stations, which would improve the reliability of services
- Offering an alternative, faster and more reliable public transport trip to the Sydney CBD and North Sydney.

The largest travel time savings would be experienced in areas where new stations are provided (such as Crows Nest), where more direct routes are provided. Travel time savings would be experienced by existing rail customers (who would directly benefit from shorter travel times), new rail customers (who would transfer from road-based transport to rail). Specifically, travel time savings enabled by the project would be experienced by:

- Sydney Metro Northwest and T1 North Shore Line customers who would have access to more direct Sydney Metro services to key activity areas in the Global Economic Corridor
- Central Coast customers travelling to North Shore and Sydney CBD stations would have significant travel time savings, with these services being able to take advantage of the more direct routes made possible by the introduction of the project
- North Shore and North Sydney customers who would have direct rail access to key destinations in the Global Economic Corridor such as Martin Place and Norwest Business Park
- Eastern suburbs customers who would have more direct access to key destinations in the Global Economic Corridor, interchanging to direct services at Martin Place Station instead of the crowded Town Hall Station.

Travel time savings are also likely to be experienced by road and remaining bus users who would experience less congestion.

Some key forecast travel time savings associated with the Chatswood to Sydenham project are shown in **Table 4.1**.

Table 4.1: Indicative travel time savings

Origin	Destination	Journey (with and without project	Travel time savings (approx..)
Martin Place (station)	Chatswood (station)	**Without project**: 10 minute walk Martin Place to Wynyard Station 20 minute train Wynyard to Chatswood TOTAL: 30 minutes **With project**: 11 minute metro Martin Place to Chatswood	19 minutes
Norwest (station) (currently under construction)	Central (station)	**Without project**: 28 minute metro Norwest to Chatswood 3 minute interchange 26 minute train Chatswood to Central TOTAL: 57 minutes **With project**: 42 minute metro Norwest to Central	15 minutes
Martin Place (station)	North Sydney (corner Miller Street and Pacific Highway)	**Without project**: 10 minute walk Martin Place to Wynyard Station 7 minute train Wynyard to North Sydney Station 6 minute walk to Miller Street TOTAL: 23 minutes **With project**: 5 minute metro Martin Place to Victoria Cross 3 minute walk to Miller Street TOTAL: 8 minutes	15 minutes
Macquarie Park (station)	North Sydney (corner Miller Street and Pacific Highway)	**Without project**: 9 minute metro Macquarie Park to Chatswood 3 minute interchange 13 minute train Chatswood to North Sydney Station 6 minute walk to Miller Street TOTAL: 31 minutes **With project**: 15 minute metro Macquarie Park to Victoria Cross 3 minute walk to Miller Street TOTAL: 18 minutes	13 minutes

Origin	Destination	Journey (with and without project	Travel time savings (approx..)
Crows Nest (Hume Street)	Central (station)	**Without project**: 9 minute walk Hume Street to St Leonards Station 23 minute train St Leonards to Central TOTAL: 32 minutes **With project**: 11 minute metro Crows Nest to Central	21 minutes
Bondi Junction (station)	North Sydney (corner Miller Street and Pacific Highway)	**Without project**: 11 minute train Bondi Junction to Town Hall 3 minute interchange 10 minute train Town Hall to North Sydney Station 6 minute walk to Miller Street TOTAL: 30 minutes **With project**: 8 minute train Bondi Junction to Martin Place 3 minute interchange 5 minute metro Martin Place to Victoria Cross 3 minute walk to Miller Street TOTAL: 19 minutes	11 minutes
Bankstown (station)	Central (station)	**Without project**: 30 minute to 36 minute train Bankstown to Central **With project**: 26 minute metro Bankstown to Central	Up to 10 minutes

4.1.2 Decreased station crowding

The provision of new Sydney CBD stations and platforms at Barangaroo, Martin Place, Pitt Street and Central would spread station loading and decrease crowding at Wynyard and Town Hall stations, and at some platforms at Central Station. The project would also provide relief to North Sydney and St Leonards stations with alternative metro stations at nearby Victoria Cross and Crows Nest. The anticipated change in passenger demand at key platforms within the Sydney CBD and at North Sydney and St Leonards stations is shown in **Figure 4.1**.

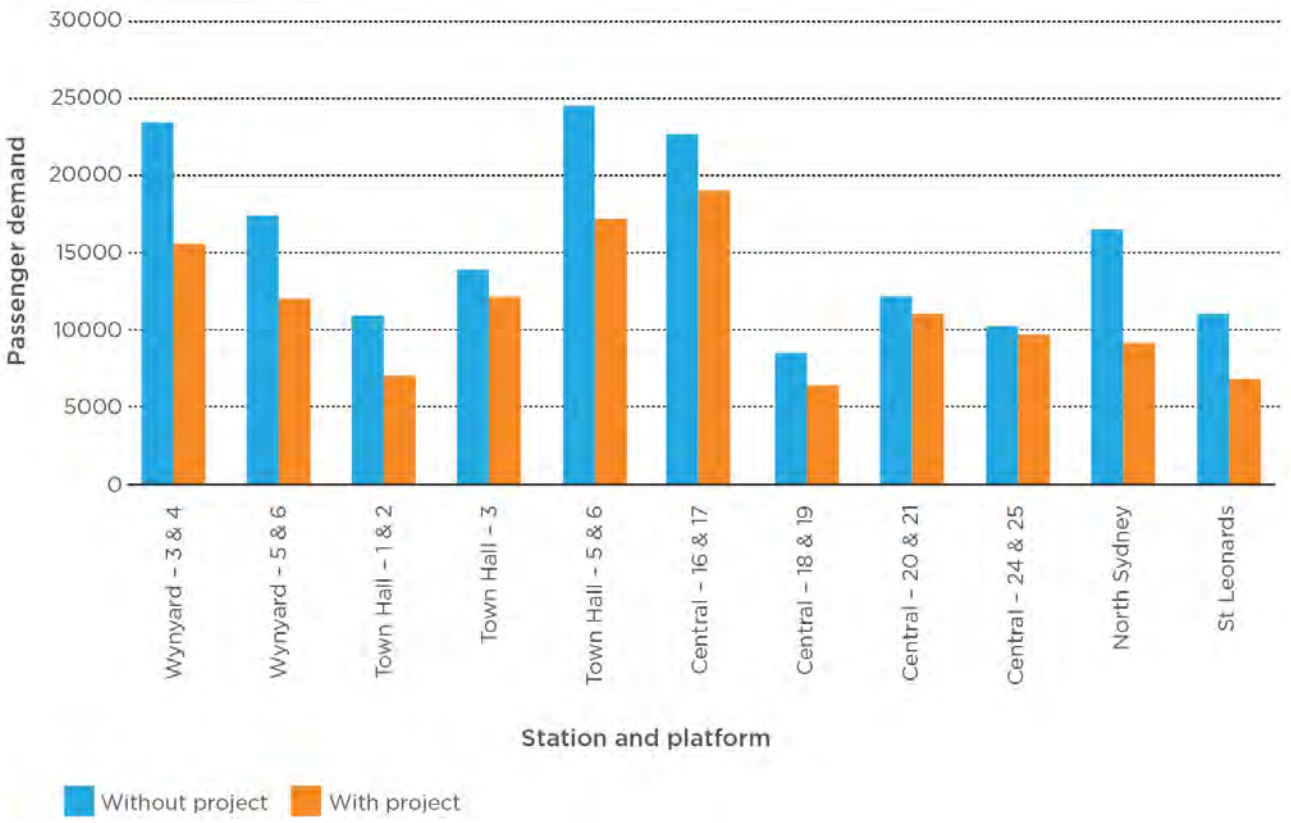


Figure 4.1 : Decreased station crowding (AM peak one hour)

4.1.3 Increased rail network reach and use

The project would increase the use and reach of the rail network by providing:

- New stations at Barangaroo, Crows Nest and Victoria Cross would directly increase rail catchment areas
- More direct connections to high-capacity Sydney CBD stations at Martin Place and Pitt Street would increase Sydney CBD rail catchment areas
- Additional interchange capability at Central Station, Martin Place and Pitt Street (to Town Hall Station).

The project would also provide a direct link for Sydney Metro Northwest customers to the Sydney CBD.

4.1.4 Improved network resilience

Heavy rail access through the Sydney CBD and across the harbour is currently limited to the T1 North Shore, Northern and Western Line. Shutdowns during unplanned and planned events currently impact on customer service provision. Closures of the Harbour Bridge for example can cease the provision of both bus and rail public transport services linking the Sydney CBD to key destinations on the lower North Shore and Northern Sydney. The T1 North Shore Line is also subject to periodic maintenance which reduces access for passengers to key stations such as North Sydney, St Leonards and Chatswood.

The project would provide an additional, high-capacity public transport link through the Sydney CBD and across Sydney Harbour. This would provide an alternative option for customers during these unplanned and planned events which may force closure of other Sydney CBD and harbour links.

4.1.5 Bus network benefits

The project would provide bus network benefits by:

- Freeing of bus services by bus customers transferring to rail, enabling the opportunity to redeploy bus services from the north and north west
- Reducing demand for Sydney Harbour Bridge bus services, freeing capacity over the Harbour Bridge.

The project would also provide the opportunity for bus-rail interchange at the new metro stations which could reduce reliance on cross-regional bus routes and potentially reducing congestion and improving travel times for remaining bus customers. Bus network improvements potentially enabled by the project would be considered by Transport for NSW as part of future reviews of the bus network and associated timetabling.

4.1.6 Improved conditions for road users

By encouraging more people to use the rail network, the project would reduce congestion on the road network, including on key road corridors such as the Sydney Harbour Bridge, Sydney Harbour Tunnel and Eastern Distributor.

4.1.7 Erskineville and St Peters rail services

Erskineville and St Peters stations are currently served by trains on the T3 Bankstown Line. After opening of the project, trains on the T3 Bankstown Line would be moved to other lines such as the T2 Inner West and South Line. Erskineville and St Peters stations would continue to be served by Sydney Trains services. Customer demand levels at these stations would be taken into account when new train timetables are being designed over the coming years.

4.2 Integration strategy

The operational impacts and assessment has been based on Transport for NSW's strategic planning documents including Sydney City Centre Access Strategy (TfNSW, December 2013), patronage modelling for the project, transport plans for all access modes and station and precinct design plans.

The objective of the hierarchy is to allow the most prominent locations within an interchange precinct to be allocated to the most efficient and sustainable modes. This approach has been adopted as the preferred modal hierarchy for the integration strategy for the project and is presented in **Figure 4.2**.

Figure 4.2 : Station access hierarchy

Walking and cycling: identified as the highest priority access modes to rail as they are the most sustainable, cost-effective, equitable and accessible modes. Pedestrians and cyclists have the lowest environmental impact and (typically) spatial requirements whilst they also contribute to personal safety, urban and commercial viability. As the stations are all located within established urban areas, walking and cycling access would be predominantly along existing paths and routes which are extensive around all stations. Given the importance of active transport access to the stations these modes have been expanded on further below.

Public transport: the second highest priority in station planning is typically focussed on facilitating interchange to other public transport modes. These services expand the effective catchment area of the suburban rail system, and seamless interchange is required in order to maximise the uptake of linked trips within the public transport network.

Taxis: are the highest ranked of all the car-based modes, supplementing the public transport system for access to destinations separated from the public transport network.

Kiss-and-ride: the preferred mode of those accessing the station by private vehicle, but a relatively low priority, kiss-and-ride supports the concept of car sharing and trip chaining, reducing the number of single-occupant trips and in some instances parking demand.

Park-and-ride: the lowest priority of all modes. Given the high accessibility to sustainable transport modes in Sydney, formal parking facilities are only suggested outside of major centres. All of the proposed stations within this project are within a 10 kilometre radius of the Sydney CBD, therefore park-and-ride facilities have not been considered for this project.

CBD stations have been designed with reference to the Sydney City Centre Access Strategy (Transport for NSW, December 2103).

As the stations are all located within established urban areas, walking and cycling access would be predominantly along existing paths and routes which are extensive around all stations. Given the importance of active transport access to the stations these modes have been expanded on below.

As no car parking is to be provided at any of the metro stations, the project would not induce traffic demand once operational.

4.2.1 Role of walking

Walking is recognised as the highest priority access mode to public transport nodes. It is available to the broadest range of customers, requires minimal spaces and facilities and is the most sustainable mode of travel compared to other modes. Successful walkable environments facilitate greater public transport use, contribute to healthy communities through the encouragement of physical activity and can enhance both the economic and social aspects of an area.

Sydney's Walking Future (Transport for NSW, 2013) identifies four major factors that would encourage customers to make the choice to walk more:

- Connectivity and reduced delays – pedestrian routes which provide direct connection to key land uses (e.g. public transport) with minimal delays at main roads
- Safety and security – an enhanced level of safety including at road crossings, slowing traffic in busy areas and provision of good lighting
- Health and wellbeing – promotion of health benefits of walking
- Supporting facilities – measures that enhance the journey for customers, including weather protection and more facilities at transport interchanges

The walking catchment for a rail station is generally taken to be up to 800 metres.

The walking objectives include improving the customer experience by providing safe, direct, continuous, high quality and clearly-signposted walking paths to stations, and between the stations and other transport modes.

Recent modelling forecasts show that an average of 66 per cent of customers would walk to stations outside the Sydney CBD in 2026 and at the Sydney CBD stations, most people would walk to their final destination.

Appropriate footpath widths and gradients would be provided outside of station exits and throughout the public domain altered at the metro station to link transport modes and provide safe and equitable pedestrian access. Vision and mobility impaired customers would be considered in the pavement designs, for example by keeping one side of the travel path clear of fittings and fixtures and providing Tactile Ground Surface Indicators on travel paths to warn of hazards and assist wayfinding where required.

4.2.2 Role of cycling

Cycling is becoming an increasingly popular mode of transport, with a 50 per cent increase in journey to work trips by bicycle recorded in metropolitan Sydney since 2006[6]. A well connected network of bicycle routes is an integral component of an integrated transport network.

Sydney's Cycling Future (Transport for NSW, 2013) identifies four major factors which influence the decision of cyclists in choosing to ride a bike to their destination:

- Connectivity and separation – direct bicycle routes which are ideally separated from moving vehicular traffic
- Safe behaviour – increased road user awareness and priority at main intersections
- Supporting facilities – end of trip facilities that support cycling, including bicycle parking at transport interchanges
- Health, wellbeing and confidence – promotion of the health benefits of riding a bike, education and confidence courses.

Planning for cyclists at metro stations provides an opportunity to improve traffic congestion, reduce greenhouse gas emissions and provide people with healthier lifestyles. The cycling catchment for a rail station is generally taken to be up to five kilometres, or approximately 20 minutes travel time.

Based on the above, the integration strategy for each proposed metro station focuses primarily on walking and cycling, followed by public transport and finally vehicular integration. The integration provided at each station, as well as the impact of each station and the interchange requirements is presented below.

The amount and type of bike parking provided at stations would be based on the Transport for NSW Bike and Ride initiative, identified in Sydney's Cycling Future. The facilities are likely to be similar to those being introduced at several Sydney Trains stations, including Blacktown and Campbelltown. At these stations, secure bike spaces are provided in sheds which are free to use by train customers and can be accessed by OPAL cards.

The bike parking would be located close to the station, connect with the local cycle network and be in secure sheds and shelters so customers can safely leave their bikes and catch a train. The amount of parking would reflect forecast passenger demand at each station which is likely to be around one to two per cent of station entries.

4.3 Key assumptions

The operational impacts are assessed using the patronage forecasting provided by Transport for NSW. Two models were configured and run to produce preliminary forecast passenger demand and their anticipated mode of arrival / departure from each station. The Public Transport Project Model (PTPM) is operated by the Bureau of Statistics and Analytics and is informed by a number of assumptions regarding future land and transport use and operations. The Enhanced Train Crowding Model (ETCM) is operated by AECOM and provides detailed rail modelling analysis for station entries and exits, line loading and platform crowding. Inputs to the ETCM are based on the outputs generated from the PTPM.

[6] Sydney's Cycling Future, December 2013

This assessment is based on patronage forecasts from the above models provided by Transport for NSW in November 2015.

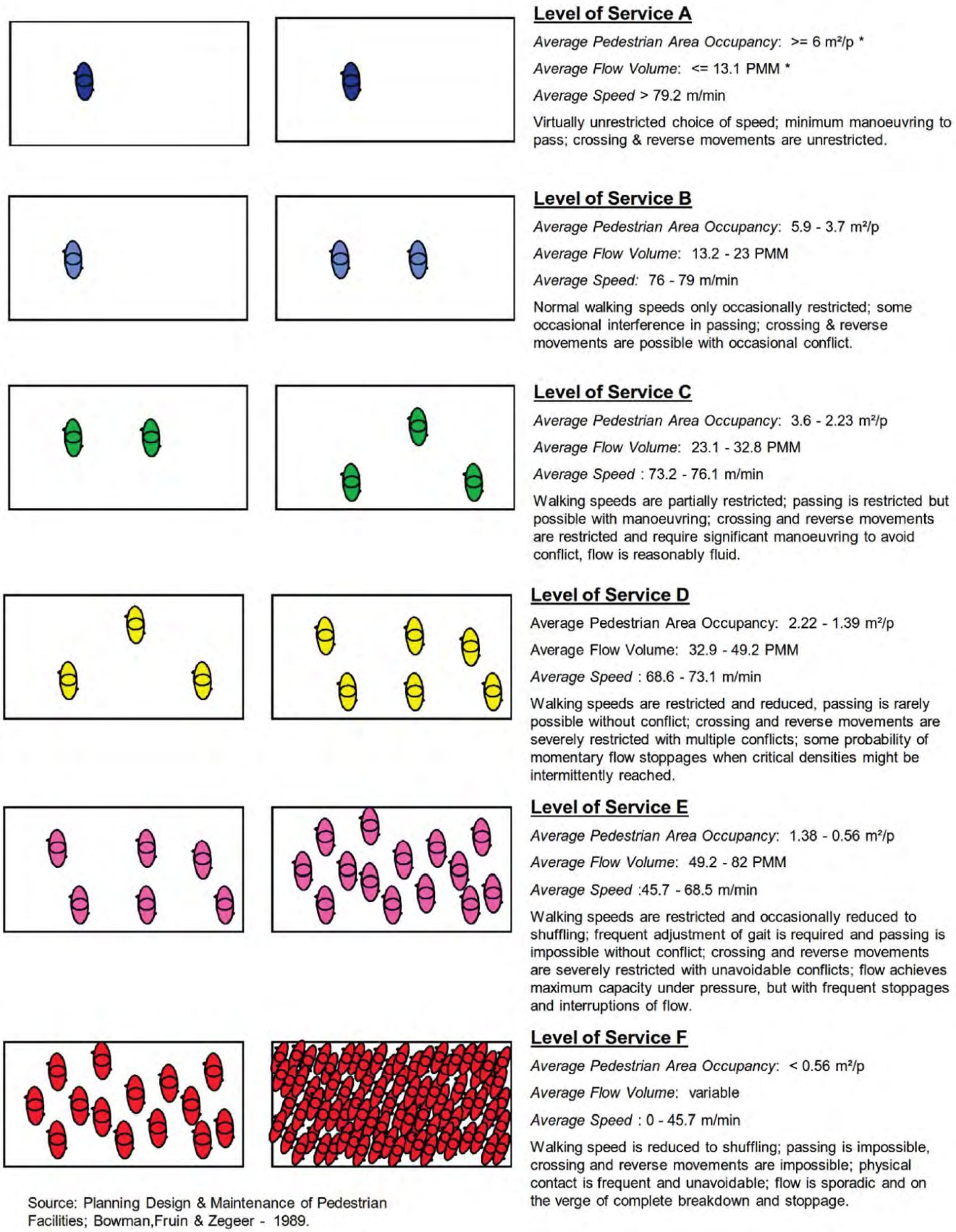
Cycling forecasts at each station were determined using the outputs of the patronage modelling and the Transport for NSW Bike and Ride initiative, identified in Sydney's Cycling Future (Transport for NSW, 2013).

Notwithstanding that the PTPM is the best available source of patronage information, the model outputs are forecasts based on assumed future land use and employment predictions. Should the land use and employment assumptions used not eventuate; actual passenger arrivals and departure from stations would differ from those predicted.

Preliminary pedestrian modelling has been carried out as part of the design of the metro stations to identify potential issues in the future pedestrian environment for the project. The assumptions used as part of the assessment include:

- At street level intersections, where pedestrians are travelling to a destination diagonally across from their current location, in reality would cross depending on the next available green phase and space, however for the purpose of the assessment it was assumed diagonal movements are split evenly between both route options.
- PM peak volume = 0.91 x AM peak volume.
- PM distribution = reverse of AM distribution.
- Interchange with buses not included within the assessment (except at Pitt Street Station).
- No growth rate has been applied to background pedestrian flows due to uncertainty regarding future bus plan, traffic growth, changes due to light rail and the pedestrianisation of George Street.

To quantify footpath capacity in the pedestrian analysis, the Fruin definitions for level of service (LOS), as shown in **Figure 4.3**, were adopted. The Fruin LOS analysis is based on hourly volumes, and as such, the resultant LOS is an average for the peak hour.



Level of Service A

Average Pedestrian Area Occupancy: >= 6 m²/p *

Average Flow Volume: <= 13.1 PMM *

Average Speed > 79.2 m/min

Virtually unrestricted choice of speed; minimum manoeuvring to pass; crossing & reverse movements are unrestricted.

Level of Service B

Average Pedestrian Area Occupancy: 5.9 - 3.7 m²/p

Average Flow Volume: 13.2 - 23 PMM

Average Speed: 76 - 79 m/min

Normal walking speeds only occasionally restricted; some occasional interference in passing; crossing & reverse movements are possible with occasional conflict.

Level of Service C

Average Pedestrian Area Occupancy: 3.6 - 2.23 m²/p

Average Flow Volume: 23.1 - 32.8 PMM

Average Speed : 73.2 - 76.1 m/min

Walking speeds are partially restricted; passing is restricted but possible with manoeuvring; crossing and reverse movements are restricted and require significant manoeuvring to avoid conflict, flow is reasonably fluid.

Level of Service D

Average Pedestrian Area Occupancy: 2.22 - 1.39 m²/p

Average Flow Volume: 32.9 - 49.2 PMM

Average Speed : 68.6 - 73.1 m/min

Walking speeds are restricted and reduced, passing is rarely possible without conflict; crossing and reverse movements are severely restricted with multiple conflicts; some probability of momentary flow stoppages when critical densities might be intermittently reached.

Level of Service E

Average Pedestrian Area Occupancy: 1.38 - 0.56 m²/p

Average Flow Volume: 49.2 - 82 PMM

Average Speed :45.7 - 68.5 m/min

Walking speeds are restricted and occasionally reduced to shuffling; frequent adjustment of gait is required and passing is impossible without conflict; crossing and reverse movements are severely restricted with unavoidable conflicts; flow achieves maximum capacity under pressure, but with frequent stoppages and interruptions of flow.

Level of Service F

Average Pedestrian Area Occupancy: < 0.56 m²/p

Average Flow Volume: variable

Average Speed : 0 - 45.7 m/min

Walking speed is reduced to shuffling; passing is impossible, crossing and reverse movements are impossible; physical contact is frequent and unavoidable; flow is sporadic and on the verge of complete breakdown and stoppage.

Source: Planning Design & Maintenance of Pedestrian Facilities; Bowman,Fruin & Zegeer - 1989.

Figure 4.3 : Fruin pedestrian level of service

Due to the location of each of the stations, particularly within the Sydney CBD area, metro customers are not anticipated to park-and-ride and would be discouraged to do so by the absence of car parking facilities. None of the metro stations include commuter car parking facilities, therefore, the metro stations are not considered to be a major vehicular traffic generator.

The Sydney CBD traffic and transport environment is currently undergoing changes as the Sydney City Centre Access Strategy is progressively implemented. This includes the expected operation of major transport projects such as the CBD and South East Light Rail, the associated pedestrianisation of George Street between Hunter Street and Bathurst Street, and the new CBD Bus Strategy. The implementation of these changes results in an altered baseline for the operational traffic and transport assessment. The assumptions regarding the status of these projects which were considered as part of the assessment are:

- CBD and South East Light Rail completed and operational
- George Street pedestrianised between Hunter Street and Bathurst Street
- Sydney CBD bus network consistent with the changes implemented on 4 October 2015
- Road network consistent with the changes required by CBD and South East Light Rail including:
  - conversion of Pitt Street to two-way operation between Bridge and Alfred Streets
  - conversion of Hunter Street to two-way operation between Pitt and George Streets
- Sydney CBD cycle routes implemented consistent with the Sydney City Centre Access Strategy (Transport for NSW, 2013)
- Central Barangaroo completed and open
- Barangaroo Ferry Hub completed and operational
- Wynyard Walk completed and open.

4.4 Assessment methodology

The operational assessment has been based on the following information:

- Sydney City Centre Access Strategy (Transport for NSW, December 2013)
- Sydney Metro Patronage Forecast Demand
- Sydney Metro station precinct plans
- Sydney Metro preliminary pedestrian analysis.

A qualitative assessment of the operation of the project has been carried out, including a description of the transport integration of each station and assessment of the potential traffic and transport impacts.

The assessment uses patronage forecasts provided by Transport for NSW and includes active travel, public transport and private vehicle access to and from each station.

The patronage forecasts were produced for 2036 based on land use planning projections available from the Department of Planning and Environment. However, the design year adopted for the project is 2056 to ensure the design of the stations would be able to accommodate future growth.

Where permanent intersection upgrades as part of the project would occur, a quantitative assessment has been undertaken to identify impacts to the local road network. The assessment compares the existing layout of the intersection and the ‘operational’ state using LinSig Version 3.2. The background traffic in the ‘operational’ state was assumed to be the same as the existing traffic demand.

4.5 Chatswood dive

4.5.1 Nelson Street Bridge

The Nelson Street Bridge would remain closed following the construction of the project. With regard to pedestrian impact, this would mean pedestrians would be required to either use Mowbray Road, approximately 130 metres to the south or an underpass adjacent to Chatswood Oval, approximately 320 metres to the north to cross the rail line.

Pedestrian surveys undertaken in December 2015 showed that during the morning peak hour, 16 pedestrians and five cyclists were observed crossing the Nelson Street bridge in both directions. Across the whole survey day, 6 am to 8pm, 176 pedestrians and 31 cyclists were observed crossing the bridge.

In the morning peak period, there is a reasonably even split of pedestrians and cyclists travelling east and west over the bridge. In the evening peak period, the majority of trips were observed travelling southbound along Channon Walk and turning east to cross the bridge, away from Chatswood Station and the main business / retail area.

It is likely that the majority of pedestrians and cyclists travelling across the Nelson Street bridge would be travelling between Chatswood Station or the main business / retail area of Chatswood and residential areas to the south.

As part of the project, Frank Channon Walk (a shared path currently connection Chatswood Station to Nelson Street) would be extended from Nelson Street to Mowbray Road on the western side of the rail line to provide an enhanced facility for pedestrians and cyclists and provide continued access between Chatswood Station and residential areas to the south. Those travelling from residential areas to the south-east of the rail line would need to use the underpass adjacent to Chatswood Oval to cross the rail line and access Frank Channon Walk. Orchard Road, running parallel to Frank Channon Walk on the eastern side of the rail line, could also be used as an alternative north-south route for journeys between the Chatswood retail areas and residential areas to the south.

For some pedestrians or cyclists travelling between Chatswood Station and residential areas to the south, this would result in an additional travel distance of around 50 to 100 metres; whilst for others it would result in a reduction in travel distances of around 50 to 100 metres.

Due to the extension of Frank Channon Walk and the availability of alternative facilities in the area the closure of Nelson Street bridge is not anticipated to result in significant impacts for pedestrians and cyclists.

The provision of new traffic signals at the Mowbray Road / Hampden Road intersections would provide additional pedestrian connectivity across Mowbray Road between the existing pedestrian crossings at the Pacific Highway and Orchard Road and a direct link to the extended Frank Channon Walk.

4.5.2 Operational impact

Due to the closure of the Nelson Street bridge, the project would provide an all vehicle right turn movement from the Pacific Highway southbound to Mowbray Road westbound. For the purposes of this traffic assessment it is assumed that two right turn lanes would be provided. The project would also provide new signals at the Mowbray Road / Hampden Road intersection.

Nelson Street also provides local access for properties located to the east of the T1 North Shore Rail Line. Following closure of the Nelson Street bridge, these residents would need to use alternative roads to cross the rail line such as Mowbray Road or Albert Avenue. This would result in a marginal increase to travel times.

The operational impacts of the revised layout of the Pacific Highway / Mowbray Road intersection and the signalising of Mowbray Road / Hampden Road have been assessed against the existing road layout. The outputs are shown below in **Table 4.2**.

Table 4.2 : Chatswood dive Operational Assessment (AM and PM peak)

Intersection / peak period	Existing				Operational			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Pacific Highway / Fullers Road / Help Street (signalised)								
AM peak	5,797	86	F	1.14	5,797	83	F	1.14
PM peak	5,655	41	C	0.94	5.655	39	C	0.93
Pacific Highway / Victoria Avenue (signalised)								
AM peak	4,525	101	F	0.89	4,525	101	F	0.90
PM peak	4,521	90	F	0.77	4,521	87	F	0.77
Pacific Highway / Centennial Avenue (signalised)								
AM peak	4,455	15	B	0.86	4,455	17	B	0.89
PM peak	4,784	26	B	0.91	4,784	23	B	0.89
Pacific Highway / Albert Avenue / Oliver Road (signalised)								
AM peak	4,663	23	B	0.73	4,663	24	B	0.75
PM peak	4,833	20	B	0.96	4,833	29	C	0.94
Pacific Highway / Mowbray Road (signalised)								
AM peak	6,605	57	E	1.02	6,672	72	F	1.06
PM peak	7,445	89	F	1.10	7,460	119	F	1.14
Pacific Highway / Howarth Road / Norton Lane (signalised)								
AM peak	4,582	5	A	0.59	4,582	5	A	0.59
PM peak	5,111	8	A	0.76	5,111	8	A	0.75
Pacific Highway / Gore Hill Freeway ramps (signalised)								
AM peak	5,107	74	F	1.09	5,107	77	F	1.12
PM peak	5,385	79	F	1.15	5,385	74	F	1.13
Pacific Highway / Longueville Road (signalised)								
AM peak	3,860	32	C	0.80	3,860	31	C	0.83
PM peak	3,748	27	B	0.74	3,748	27	B	0.77
Mowbray Road / Orchard Road / Elizabeth Street (signalised)								
AM peak	3,216	52	D	1.02	3,149	49	D	1.02
PM peak	3,230	76	F	1.15	3,129	45	D	0.84
Mowbray Road / Hampden Road (priority controlled)					**(signalised)**			
AM peak	2,859	292	F	1.12	2,792	25	B	0.80
PM peak	3,026	22	B	0.55	2,961	25	B	0.71

Note: Outputs from LinSig Version 3.2

It can be seen from the above that the Pacific Highway / Mowbray Road intersection is already operating over its theoretical capacity and that the revised layout, including dual southbound right turn lanes from the Pacific Highway into Mowbray Road would result in the overall operational performance of the intersection deteriorating from LOS E to LOS F. The operational performance in the PM peak would remain unchanged.

Introducing signals at the Mowbray Road / Hampden Road intersection would improve the operational performance in the AM peak from LOS F to LOS B, with the intersection improving from currently operating above its theoretical capacity, to be operating with a degree of saturation of 0.80.

The majority of the other intersections would remain unchanged as a result of these two intersections being upgraded.

4.6 Crows Nest Station

4.6.1 Location

The Crows Nest Station would be located within the block of Pacific Highway, Oxley Street, Clarke Lane, and Hume Street. One pedestrian access point would be located on the corner of Hume and Clarke Streets and one would be located to the north of the station on the corner of the Pacific Highway and Oxley Street. This station would facilitate the extension of the economic clustering and employment land uses to the south, link to the Chandos Street commercial corridor via Oxley Street, improve access to the village centre of Crows Nest and serve the extensive residential catchment to the south-west of the Pacific Highway. The location and integration of the station is shown below in **Figure 4.4**.

Customers to the station are anticipated to include existing residents within walking and cycling distance, visitors and patrons accessing the leisure and retail strip along Willoughby Road and the existing employment area extending along Willoughby Road, Atchison Street, Christie Street, Chandos Street and the Pacific Highway.

Figure 4.4 : Crows Nest Station location and transport integration

4.6.2 Passenger demand

Preliminary forecasts for the 2036 AM peak hour indicate approximately 4,600 customers entering and approximately 5,650 customers exiting the station, reflecting the mixed use nature of the area serving both residents and commercial workers.

The forecast mode arrival for the station is shown below in **Table 4.3**. The forecasts indicate more than half of the morning peak arrivals would be walking, with approximately 17 per cent interchanging from bus to the metro station. This demonstrates the need to provide appropriate pedestrian facilities in the vicinity of the site and efficient and seamless transfer between bus stops in the precinct and station entrances.

Table 4.3: 2036 Crows Nest Station - Forecast Mode of Arrival (AM busiest hour)

Walk	Cycle	Bus	Kiss-and-ride	Park-and-ride
75%	1%	17%	7%	0%

The forecast direction of walking (during the morning peak, the busiest period) has been derived based on the future residential and employment populations for travel zones within the walking catchment of the Crows Nest station and is presented below in **Figure 4.5** and **Figure 4.6**.

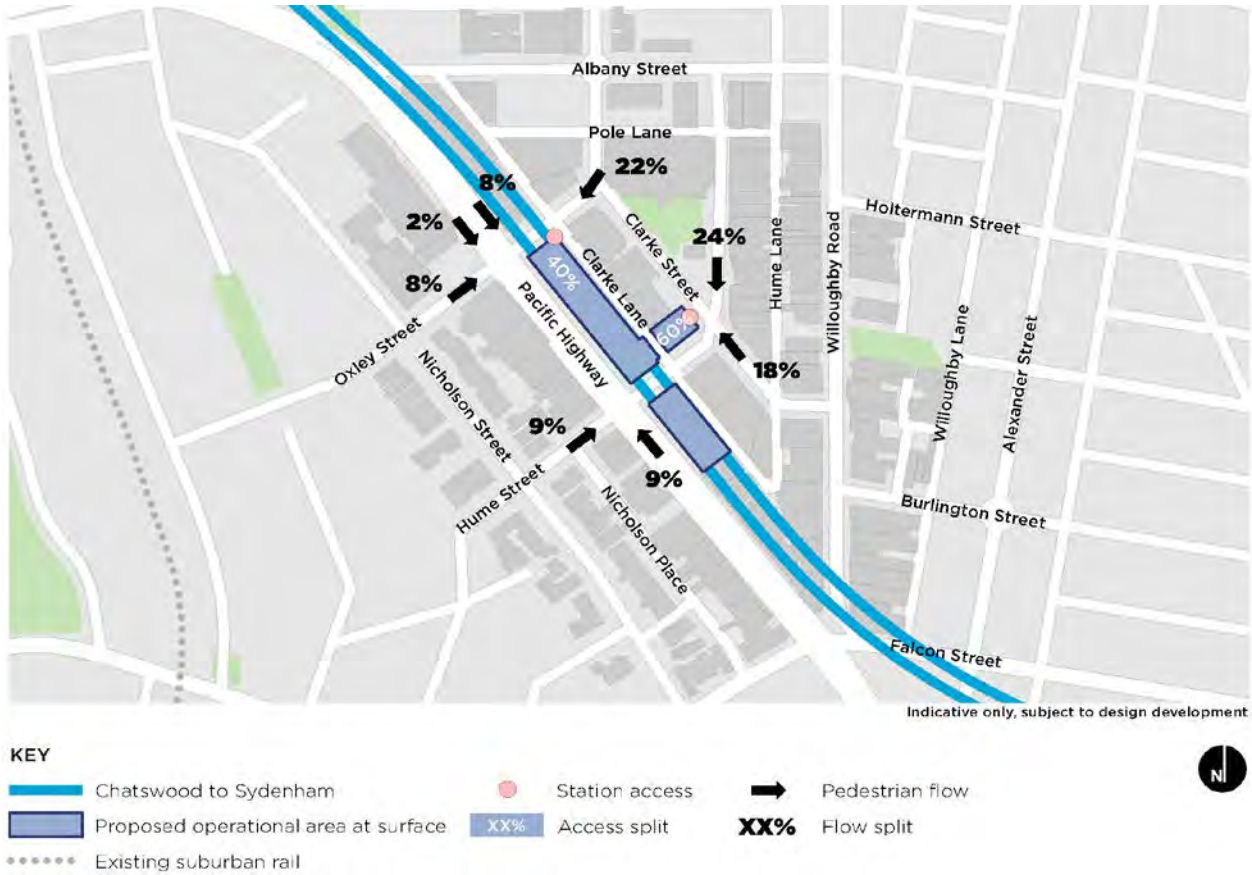


Figure 4.5: Crows Nest: AM peak boarding patronage distribution

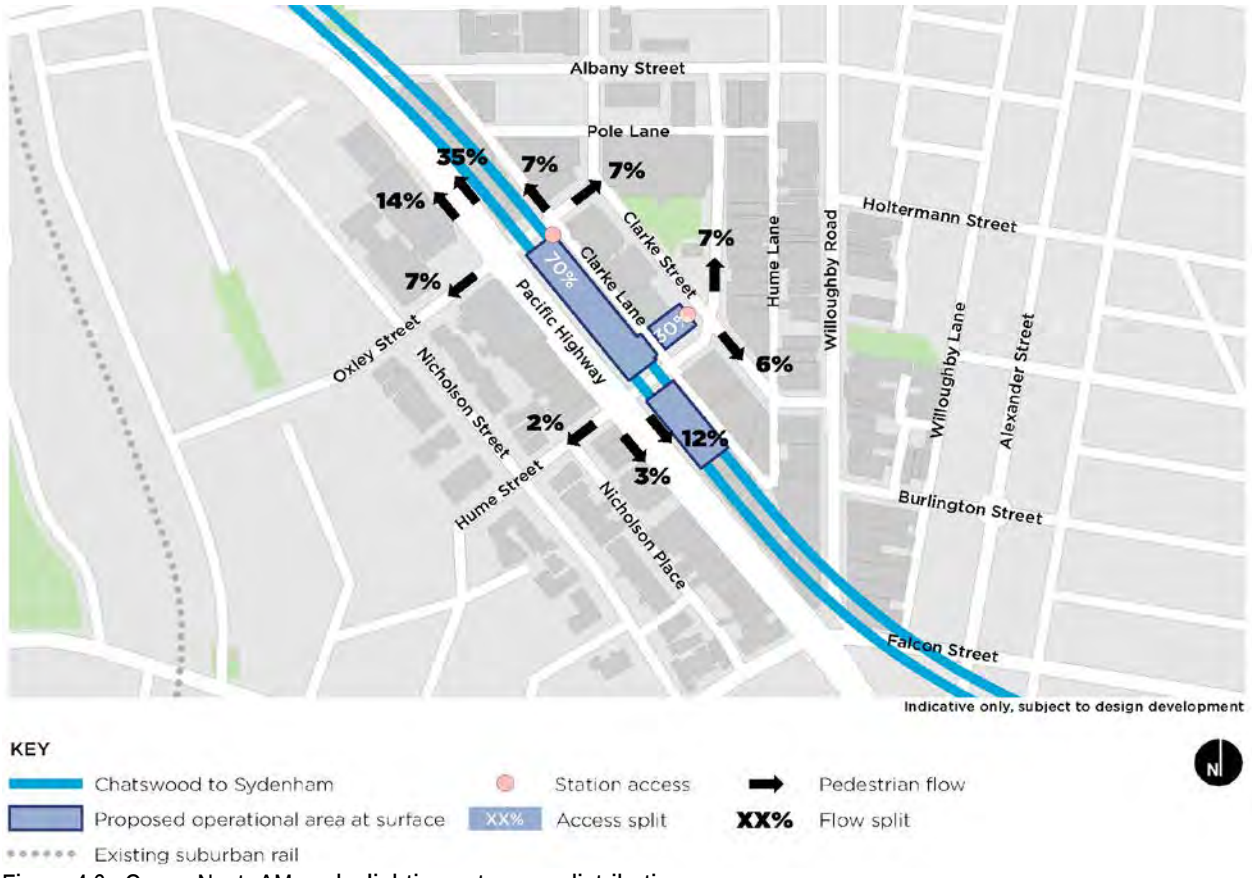


Figure 4.6 : Crows Nest: AM peak alighting patronage distribution

It is expected that a high number of pedestrians arriving at the station in the AM peak hour would arrive from the north and east from the Crows Nest residential area. Almost 50 per cent of customers departing the station in the AM peak hour would be expected to walk north along the Pacific Highway towards the commercial area at St Leonards. .

4.6.3 Integration with pedestrian network

Patronage forecasts for the future indicate that the station would significantly increase pedestrian flows in the local precinct. Pedestrian modelling results for the year 2026 are presented in **Figure 4.7** (AM peak hour) and **Figure 4.8** (PM peak hour).

Patronage analysis of the station and streetscape indicates there would be limited impacts to pedestrians and road traffic due to the presence of the Metro station. As a suburban station, the patronage is significantly lower than most Sydney CBD stations, resulting in volumes being less than 10 people per minute along most footpaths and crossings.

With the exception of some locations, the majority of footpaths in the area would continue to operate at a level of service A. In both the AM and PM peak periods, the most heavily used footpaths and crossings to access the station would include:

- Oxley Street (southern side) between Clarke Street and Pacific Highway which would operate at a level of service D immediately around the station entry
- North-south pedestrian crossing at the intersection of the Pacific Highway and Oxley Street
- Pacific Highway (eastern side) north of Oxley Street which would operate at a level of service C.

Pedestrian arrivals and departures are expected to be the highest proportion of journeys to/from the station.

The following design features would be provided to accommodate the future pedestrian demand and ensure easy and safe interchange for pedestrians:

- Station entrance via plazas on the corner of Clarke and Hume streets, and the corner of the Pacific Highway and Oxley Street
- New crossing facilities around the Hume Street / Clarke Street intersection
- New crossing facility on Oxley Street near Clarke Street
- A mid-block pedestrian crossing facility on Clarke Street between Hume Street and Oxley Street
- A new signalised crossing facility on the northern arm of the Pacific Highway at the Pacific Highway / Oxley Street intersection providing improved pedestrian connections to and from the west of the station
- Installation of wayfinding signage and Sydney Metro information.

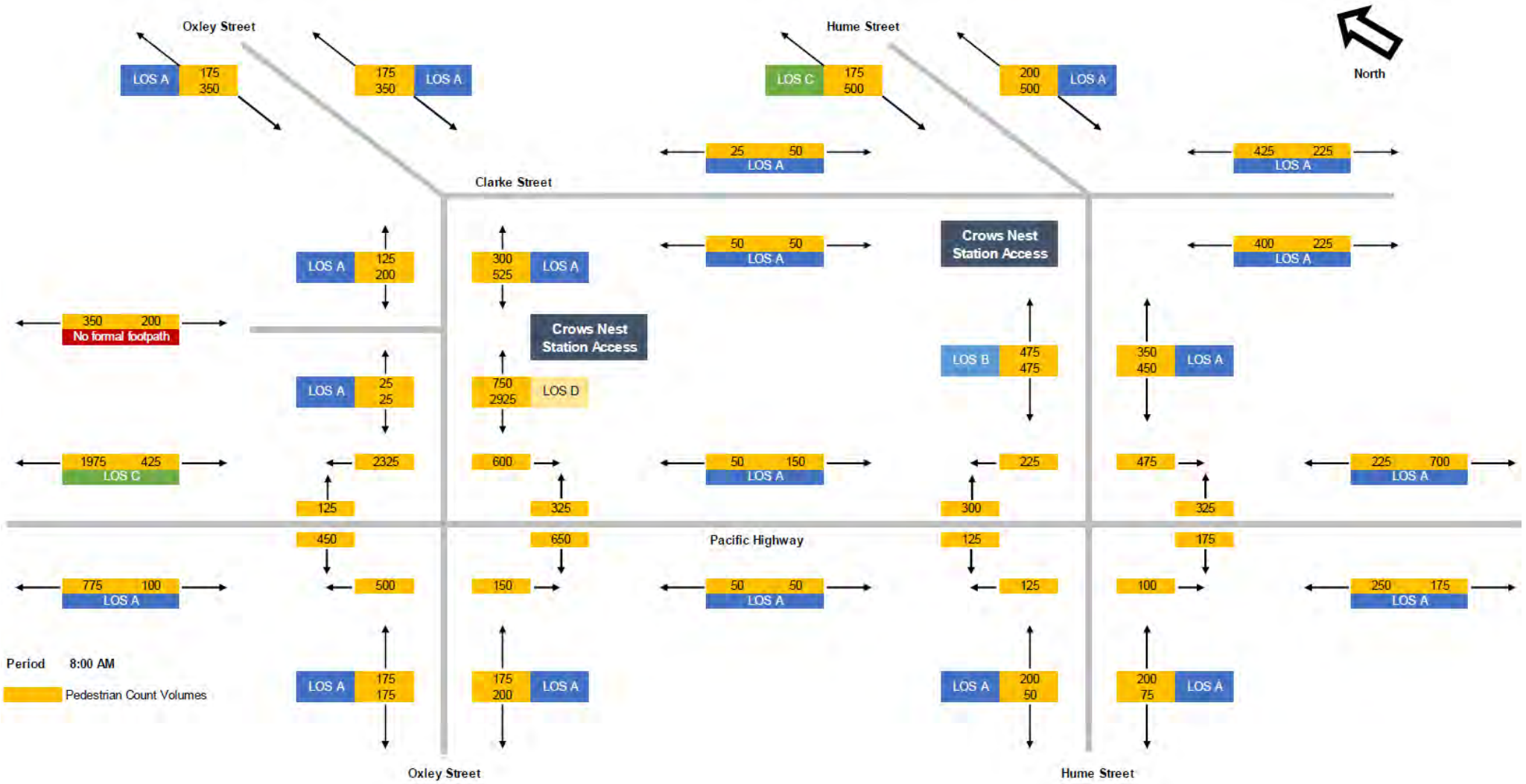


Figure 4.7 : Crows Nest Station: 2026 AM peak hour pedestrian modelling results

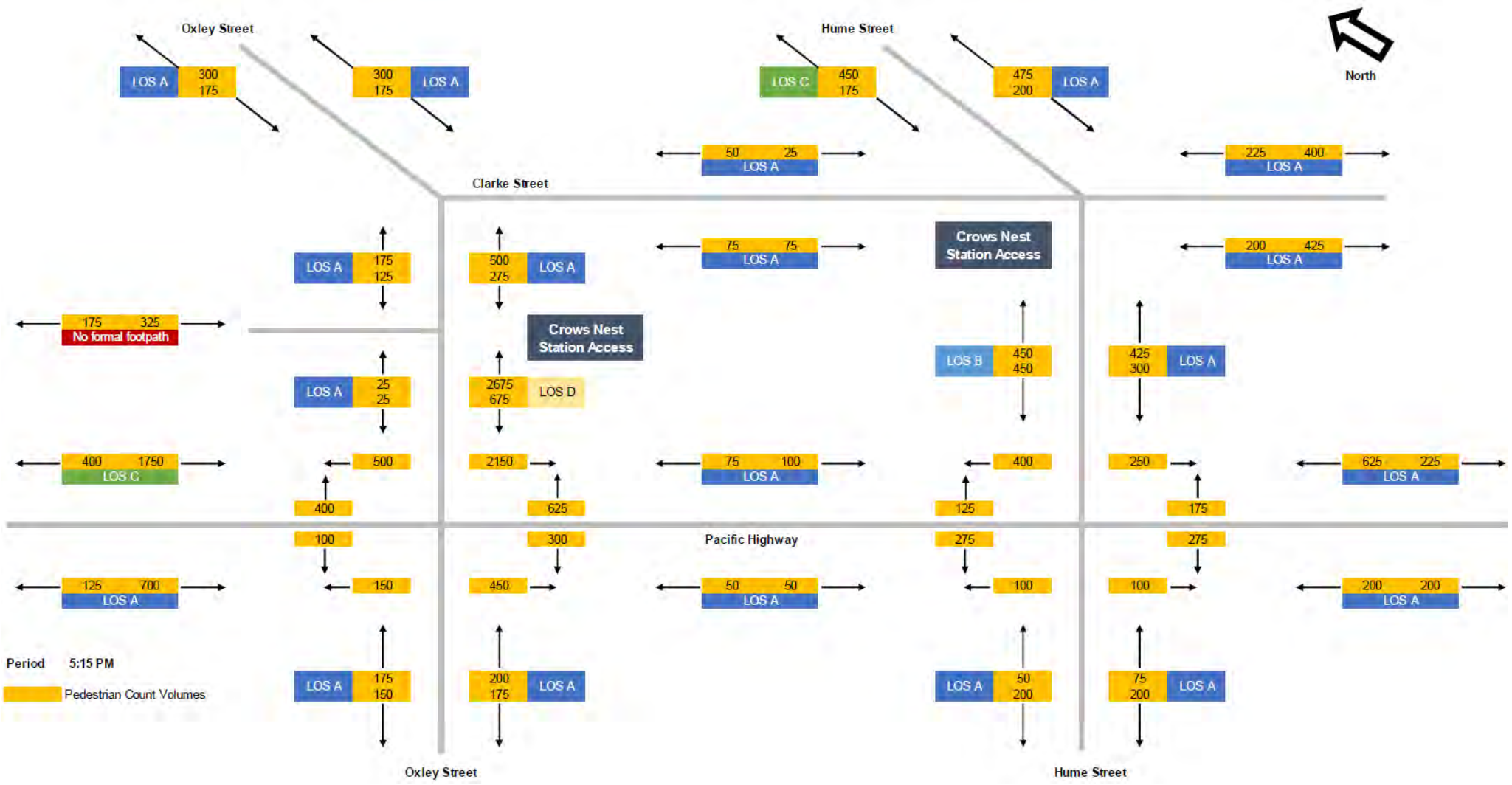


Figure 4.8 : Crows Nest Station: 2026 PM peak hour pedestrian modelling results

4.6.4 Integration with cycle network

An on-road marked bicycle route along Clarke Street, directly adjacent to the metro station would provide convenient connections to the cycle routes that are currently well used by cyclists. The new route would provide cycle connections between the existing facilities along Clarke Street and Nicholson Street and run along the station entrance frontage.

The following would be provided to enable efficient cyclist access to the station:

- A new on-road marked cycle route along Hume Street between Clarke Street and Nicholson Street connecting to existing on-road marked cycle routes
- Bicycle parking at the Hume Street / Clarke Street entrance and the Pacific Highway / Oxley Street entrance
- Installation of wayfinding signage and Sydney Metro information.

4.6.5 Integration with public transport network

The anticipated station entry demand by public transport at Crows Nest Station in the morning peak hour would be approximately 17 per cent. Bus interchange activity at the Crows Nest Station is expected to be the second highest method of arrival after pedestrians.

The existing bus network in the vicinity of the station currently has comprehensive coverage of the potential catchment for the proposed station. The existing bus network, with bus stops located on the Pacific Highway, within 100 metres of the station entrances would provide convenient access to Crows Nest Station. For this reason, short and convenient links between bus services and the station would be available via the existing bus facilities in the vicinity of the site.

4.6.6 Integration with road network

Crows Nest currently experiences low to moderate levels of traffic congestion during peak periods, particularly along the Pacific Highway. Traffic forecasts indicate moderate growth between now and 2036, with traffic demand estimated to grow by approximately 16 per cent by 2036.

No customers are anticipated to park-and-ride at the station and seven percent are anticipated to kiss-and-ride during the morning peak hour. Kiss-and-ride facilities would be provided on both frontages of Clarke Street. This volume of drop-off during the peak hour is not anticipated to have a material impact on the operation of the road network in the vicinity of the station.

To meet the likely increase in demand for taxi and kiss and ride, and to minimise walking distances for metro passengers, the following would be provided:

- A taxi rank on the south western side of Clarke Street
- Kiss-and-ride facilities on both sides of Clarke Street between Oxley Street and Hume Street.

The impact on the road network in the vicinity of the Crows Nest station as a result of the new signalised pedestrian crossing on the Pacific Highway has been assessed. The modelled outputs of the existing network and the network in the operational stage of the project including the proposed pedestrian crossing of the Pacific Highway are shown below in **Table 4.4.**

Table 4.4 : Crows Nest Operational Intersection Performance – AM and PM peak

Intersection / peak period	Existing				Operational			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Pacific Highway / Oxley Street (signalised)								
AM peak	3,403	13	A	0.63	3,712	17	B	0.74
PM peak	3,530	15	B	0.73	3,883	21	B	0.70
Pacific Highway / Hume Street (signalised)								
AM peak	3,244	13	A	0.59	2,941	8	A	0.55
PM peak	3,298	12	A	0.61	2,955	7	A	0.49
Pacific Highway / Falcon Street / Shirley Road (signalised)								
AM peak	3,958	50	D	0.86	3,958	51	D	0.86
PM peak	4,022	52	D	0.91	4,022	52	D	0.91

Note: Outputs from LinSig Version 3.2

It can be seen from the above that the operational performance of the Pacific Highway / Oxley Street intersection deteriorates marginally in the AM peak hour, however is unchanged in the PM peak hour. In both peak hours the intersection would operate at a LOS B with the new signalised pedestrian crossing.

Therefore, it can be concluded that the introduction of a pedestrian crossing across the northern arm of the Pacific Highway in the vicinity of the station would have a minimal impact on the local road network. Furthermore, the addition of a signalised pedestrian crossing on this arm of the intersection improves the level of access of pedestrians travelling to or from the north west corner of the intersection.

4.7 Victoria Cross Station

4.7.1 Location

The Victoria Cross Station would be located on Miller Street, between McLaren Street and the Pacific Highway. The station access would be located on Miller Street to the south of Berry Street. This station would activate the northern end of the North Sydney CBD, serve the educational establishments to the north of Berry Street and the west of the Pacific Highway, and provide relief to the existing North Sydney Station.

The station location and integration into the surrounding area is shown in **Figure 4.9**.

The anticipated customers using the station would be travelling to nearby employment, education and residential precincts.

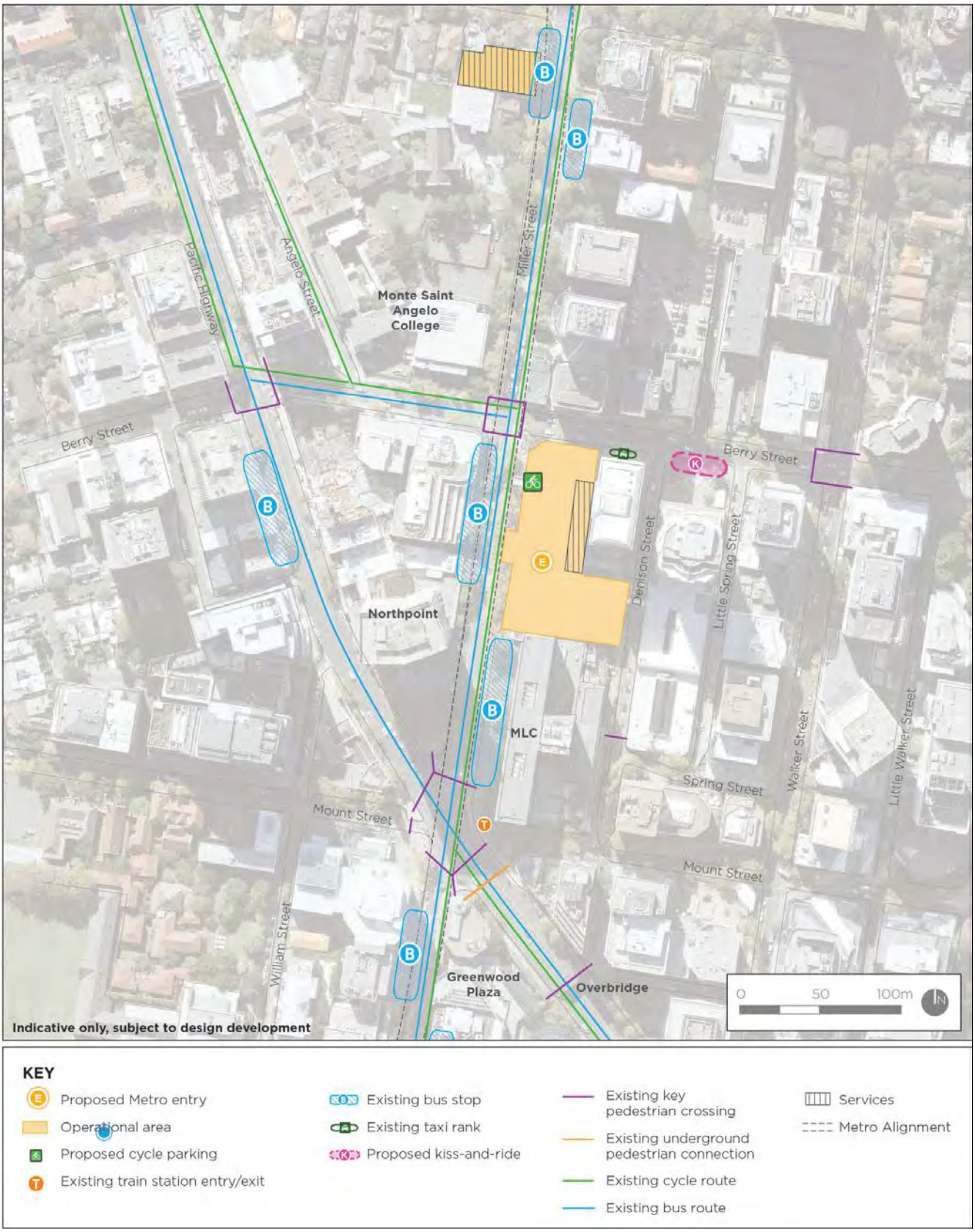


Figure 4.9 : Victoria Cross Station location and transport integration

4.7.2 Passenger demand

Preliminary forecasts for the 2036 AM peak hour indicate approximately 2,600 customers entering at the station and approximately 12,550 customers exiting.

The forecast mode of arrival at the station is shown below in **Table 4.5**. The forecasts indicate that for the relatively small portion of working residents accessing the station in the morning, the majority would do so via walking.

Table 4.5: 2036 Victoria Cross Station - Forecast Mode of Arrival (AM busiest hour)

Walk	Cycling	Bus	Kiss-and-ride	Park-and-ride
67%	1%	26%	6%	0%

The majority of morning exits from the station are expected to travel to the south towards the commercial core while 12 per cent are expected to exit the station to the north to commercial and educational land uses, 10 per cent to the east and 12 per cent to the west. **Figure 4.10** and **Figure 4.11** show the morning peak hour boarding and alighting passenger distribution patterns.

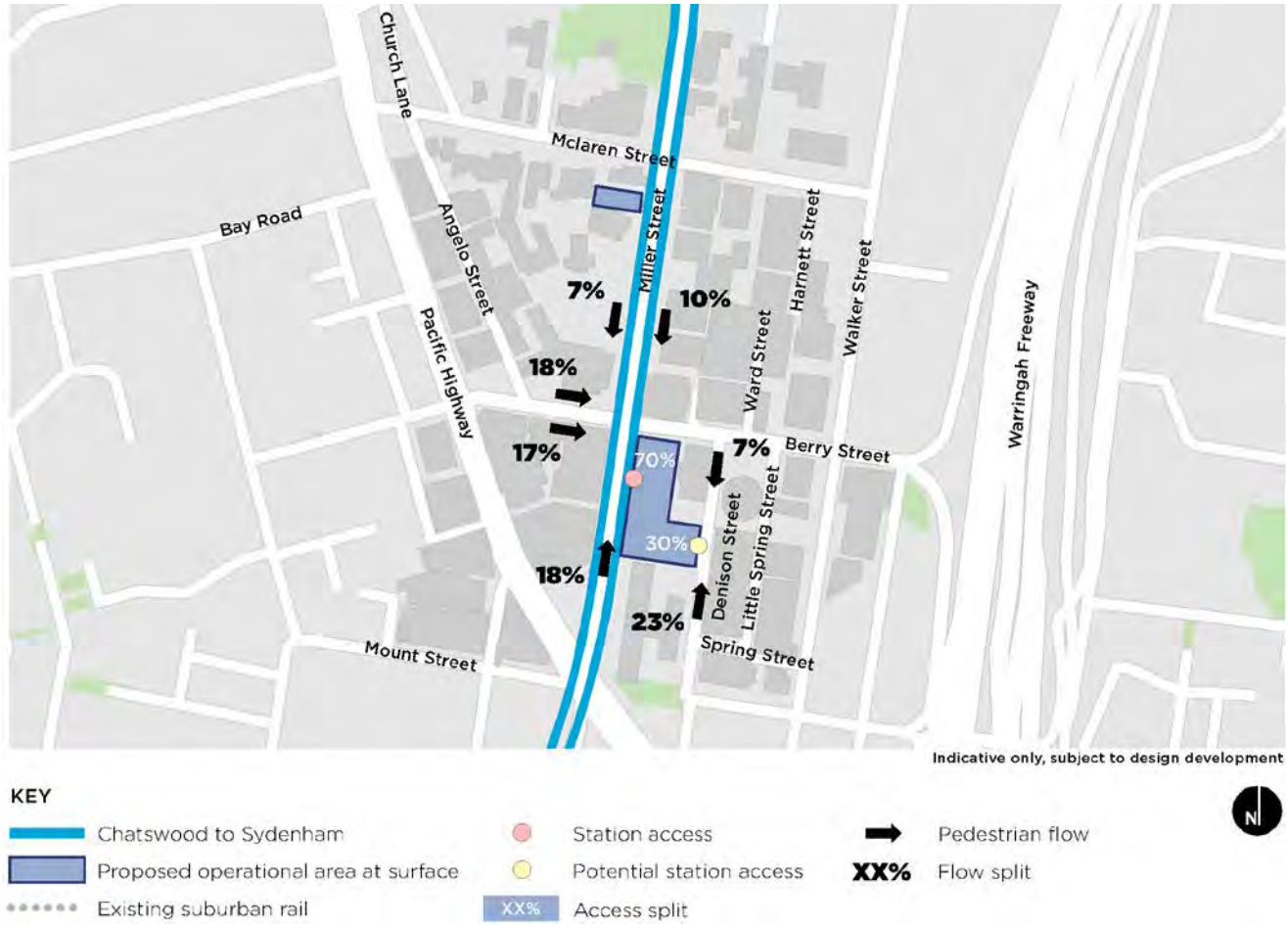


Figure 4.10 : Victoria Cross Station: AM peak boarding patronage distribution

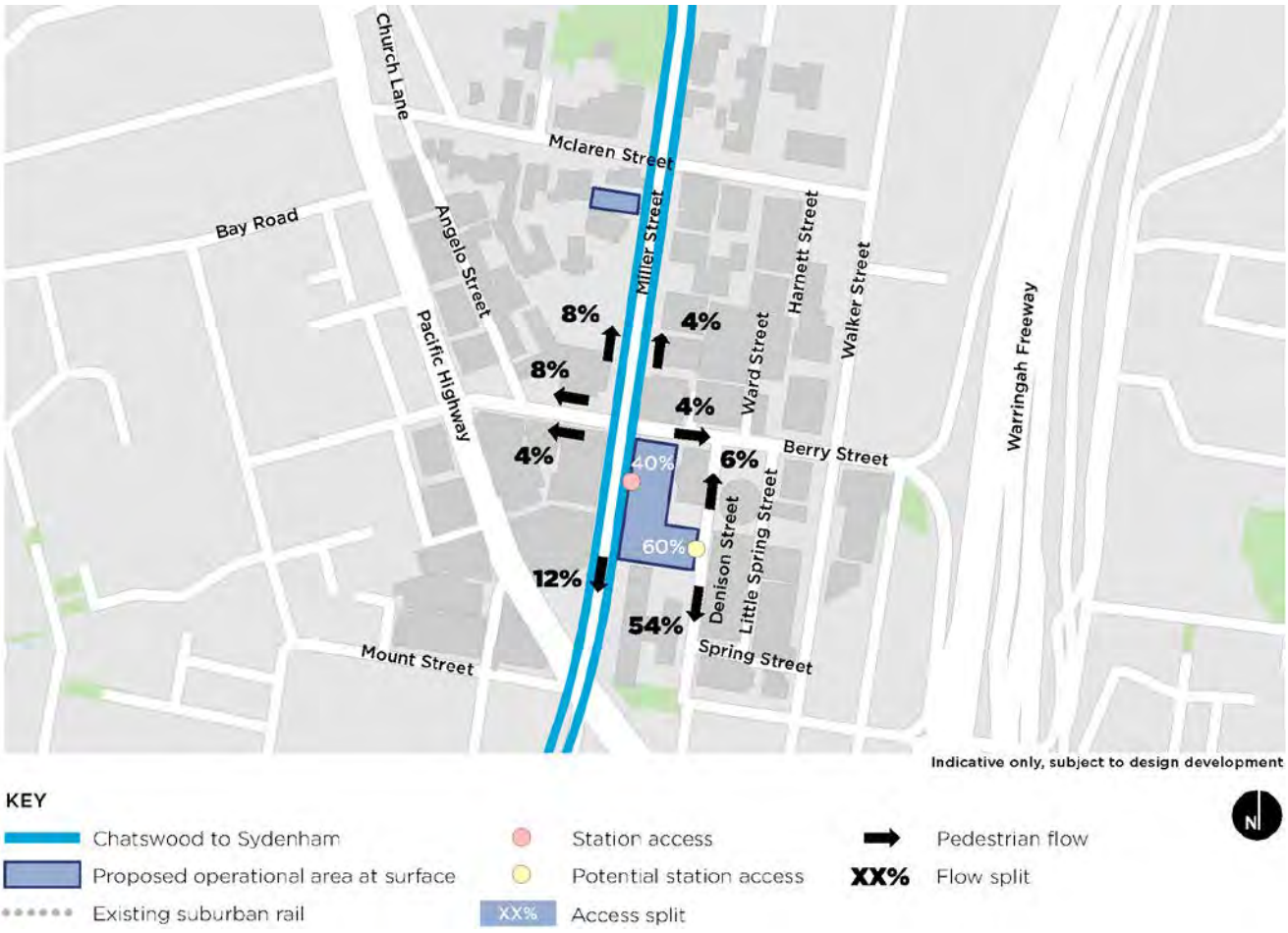


Figure 4.11 : Victoria Cross Station: AM peak alighting patronage distribution

4.7.3 Integration with pedestrian network

With a comprehensive existing public transport network of bus and rail, the areas employment, residential and educational land-uses generate a high volume of localised pedestrian trips accessing public transport modes.

Strong pedestrian desire lines have been identified from the cluster of bus stops along Miller Street, and the educational facilities to the west. Mount Street also acts as a key pedestrian route to provide east-west access to the commercial uses on either side of the Pacific Highway. Customers would use existing pedestrian crossing facilities in the vicinity of the station.

The high proportion of walking journeys expected at the Victoria Cross Station means the pedestrian movement and access to the site has been considered a priority as part of the station design. The following design features are proposed to ensure smooth interchange for pedestrians:

- A pedestrian plaza forming the access to the station from Miller Street and Berry Street
- Direct pedestrian links to Denison Street, providing access to and from the commercial area to the east of the station
- Wayfinding signage and Sydney Metro information within the North Sydney CBD.

Pedestrian modelling results for the year 2026 are presented in **Figure 4.12** (AM peak hour) and **Figure 4.13** (PM peak hour).

Pedestrian modelling of the station and streetscape identified that the majority of the footpaths in the area would operate at a level of service B or better. However, two locations have been identified where there would be potential for safety risks or impacts to pedestrians and / or traffic due to the presence of the Metro station. These locations include:

- Intersection of Miller Street and Berry Street
- Denison Street which would operate at a level of service E.

At the intersection of Miller Street and Berry Street, pedestrian movements are increased due to the proximity of the station access to the intersection. Although the intersection is in a comparatively low-speed environment, if the crossing capacity is not increased there may be an increase in informal crossing, which may lead to pedestrian safety issues and delays to traffic.

Options to mitigate the impact may include:

- Widening of the pedestrian crossing, which would increase the pedestrian throughput without effecting cycle-times
- Increase the pedestrian green-time, which would increase the pedestrian throughput by extending the proportion of green-time per cycle at the intersection. However, this would consequently reduce green-time available for vehicle movements
- Providing a mid-block crossing on Miller Street immediately outside of the station entrance.

At the eastern access to the station, a large proportion of the station demand is expected to traverse along Denison Street. Currently Denison Street is a Shared Zone south of Spring Street, however between the proposed station exit and Spring Street, Denison Street only has a narrow footpath with several driveways. Consequently, with the significant increase in pedestrian volumes, the road may no longer be suitable for both pedestrians and vehicles without significantly compromising pedestrian safety and/or traffic delays.

To mitigate this potential risk, an option would be the pedestrianisation of Denison Street between Berry and Spring Streets, and if vehicle access is required for loading, vehicle movements could be limited to off-peak periods.

Additionally, the existing pedestrian islands located between the Pacific Highway and Miller Street to the north and south of the intersection currently experience high levels of pedestrian use. Their capacity to accommodate the anticipated increased demand would be further investigated during detailed design.

The above mitigation options would be investigated further in consultation with Roads and Maritime Services and North Sydney Council.

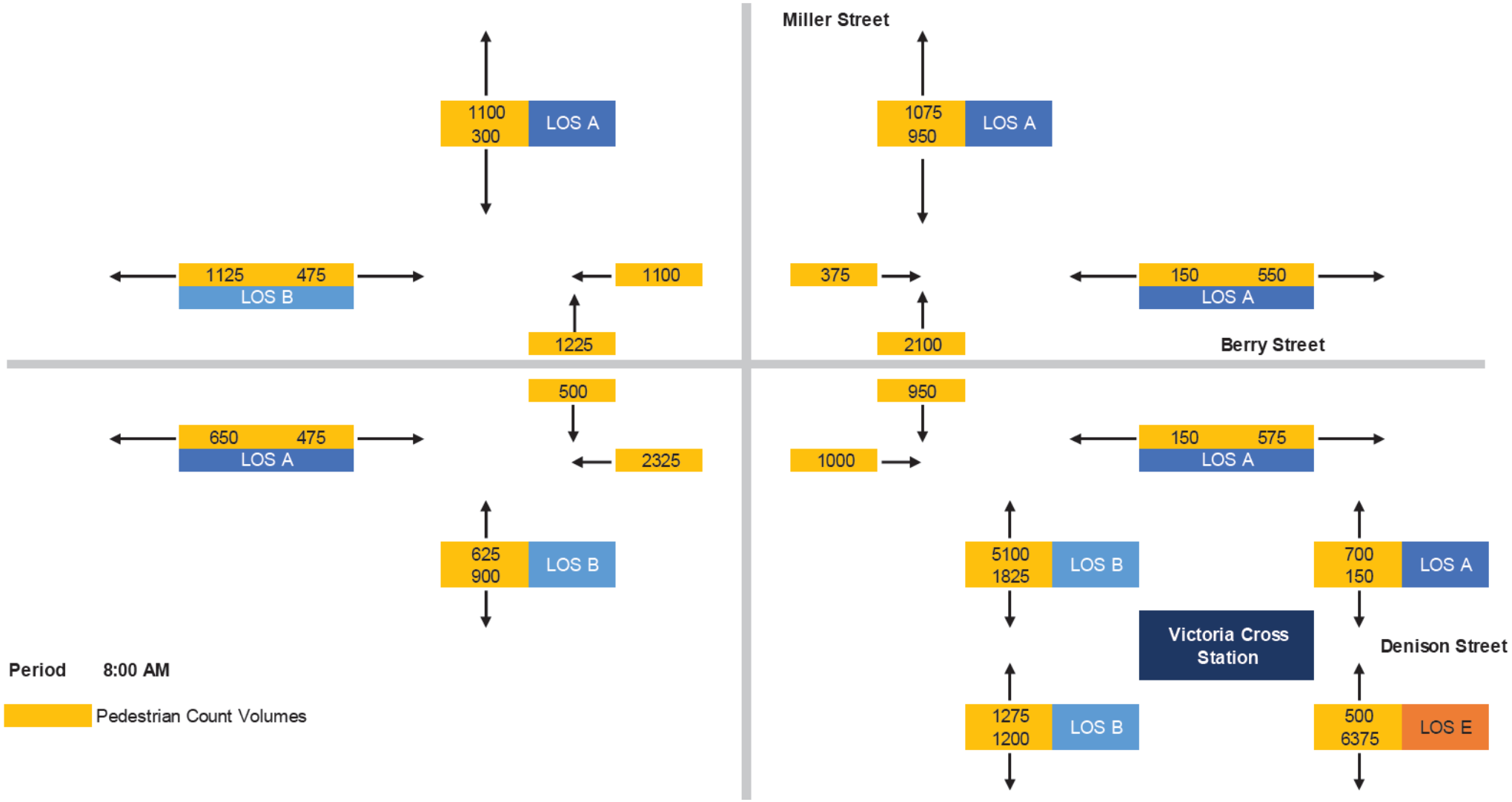


Figure 4.12 : Victoria Cross Station: 2026 AM peak hour pedestrian modelling results

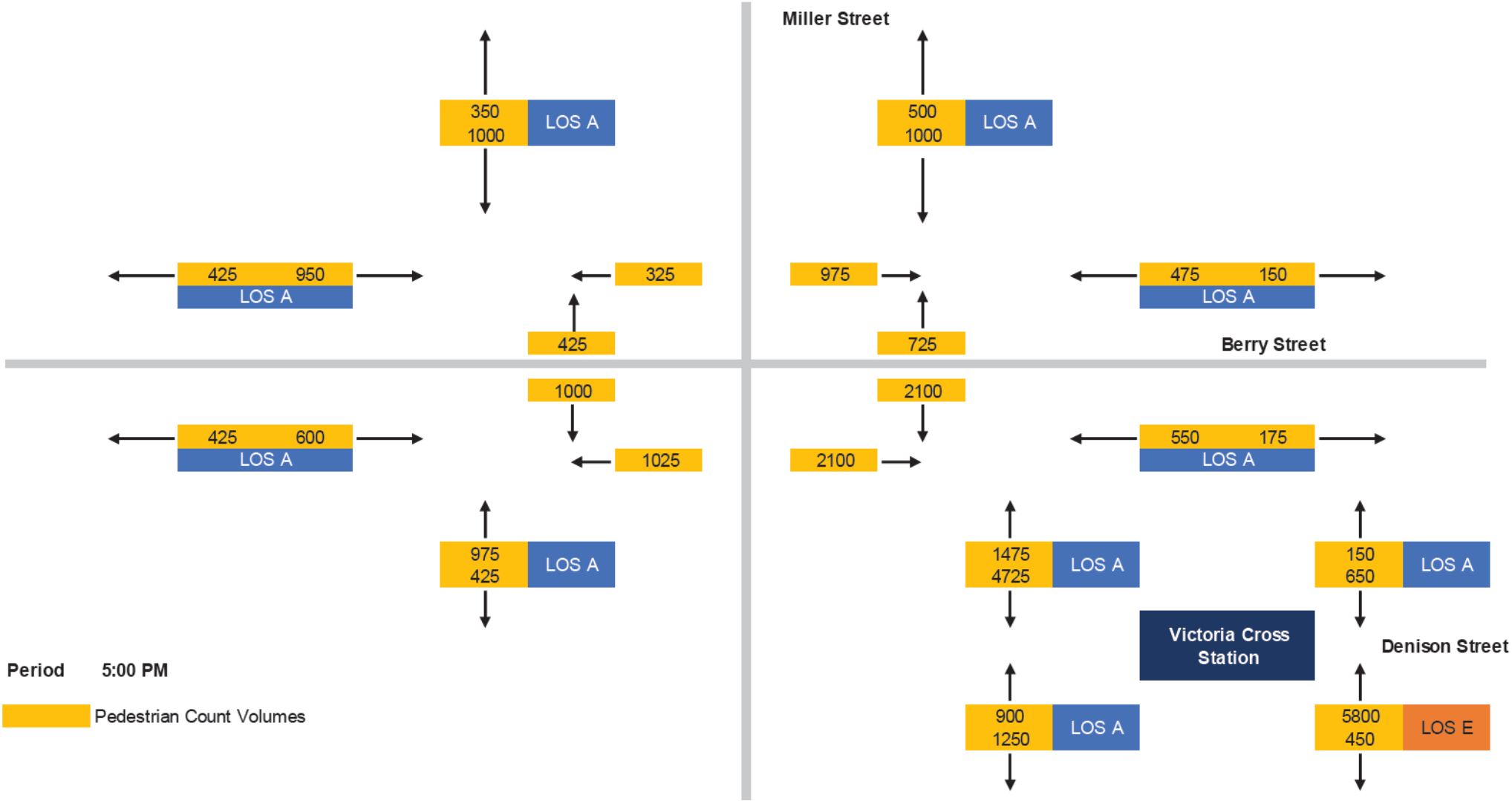


Figure 4.13 : Victoria Cross Station: 2026 PM peak hour pedestrian modelling results

4.7.4 Integration with cycle network

Existing on road bicycle routes along the Pacific Highway, Berry Street, Angelo Street and Miller Street would provide convenient cycle access to the station. Existing cycle parking facilities located on Mount Street (adjacent to the subsurface entrance to Greenwood Plaza) would also be available to metro customers.

These existing facilities would be complimented by additional cycle parking on Miller Street to the north of the station entrance.

4.7.5 Integration with public transport network

The North Sydney area is a major thoroughfare for buses with services connecting the area to the Northern Beaches and lower North Shore, including Mosman, Northbridge and Chatswood to the Sydney CBD. The majority of these bus services operate along either Miller Street or the Pacific Highway.

Bus stops serving many of the routes to North Sydney are currently located on Miller Street between the Pacific Highway and Berry Street, immediately opposite and to the south of the metro entrance plaza. Approximately 26 per cent of morning peak hour arrivals are anticipated to be via bus therefore these bus stops would provide convenient interchange.

Bus stops on the Pacific Highway are also located approximately 250 metres walking distance from the metro entrance on Miller Street and would also provide interchange potential.

4.7.6 Integration with road network

Given the location of the station and anticipated patronage, no customers would park-and-ride at the Victoria Cross Station. Approximately six percent of morning peak hour arrivals are anticipated to be dropped-off at the station. Given the low forecast vehicular arrivals, the metro station is not anticipated to have a material impact on the operational performance of the road network in the vicinity of the site during operation.

The existing taxi stands on Berry Street, to the west of Dennison Street, would be maintained and provide taxi facilities adjacent to the station plaza.

In addition to the existing facilities, kiss-and-ride facilities would be provided on the southern side of Berry Street to the east of Dennison Street.

4.8 Barangaroo Station

4.8.1 Location

Barangaroo Station would be beneath Hickson Road towards its northern end and designed to not only serve the increased population resulting from the Barangaroo development, but also act as an important alternative to and reduced reliance on both Wynyard and Martin Place stations. The station at Barangaroo would service a residential catchment at Millers Point, Walsh Bay and future residents at Barangaroo, as well as visitors to Barangaroo Reserve.

A station access to the south would be integrated with the future Barangaroo Central development and provide access for customers in the Barangaroo South development. A northern access from the station would provide direct access to Barangaroo Reserve and Walsh Bay beyond.

The location and integration of the Barangaroo Station is shown below in **Figure 4.14**.

Customers using the station are anticipated to be traveling to nearby employment, recreation and tourist precincts, as well as those travelling to and from nearby existing and future residential areas.

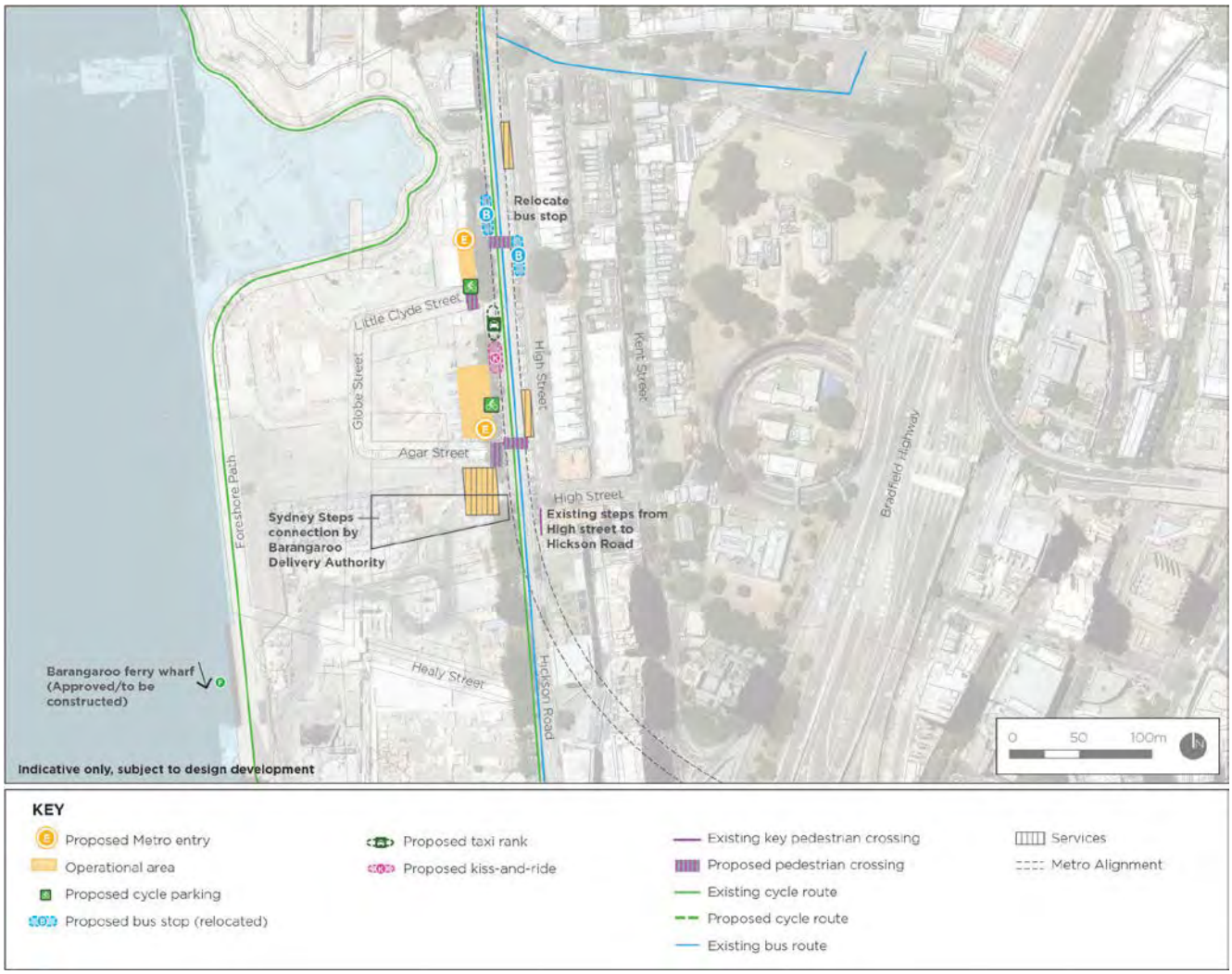


Figure 4.14 : Barangaroo Station location and transport integration

4.8.2 Passenger demand

Preliminary forecasts for the 2036 AM peak hour indicate that approximately 900 customers would enter the Barangaroo Station, while approximately 6,525 customers are forecast to exit the station, reflecting the predominant commuter use of the station to access employment centres within Barangaroo and in the Sydney CBD. It is anticipated that the majority of the pedestrian departures would be walking trips to local commercial buildings, with minimal transfer to bus or ferry and negligible volumes by private vehicle. The forecast mode of arrival at the station during the morning peak hour is presented in **Table 4.6**.

Table 4.6: 2036 Barangaroo Station - Forecast Mode of Arrival (AM busiest hour)

Walk	Cycle	Bus	Kiss-and-ride	Park-and-ride
57%	3%	39%	1%	0%

Figure 4.11 and **Figure 4.16** show the morning peak hour exiting passenger distribution patterns.

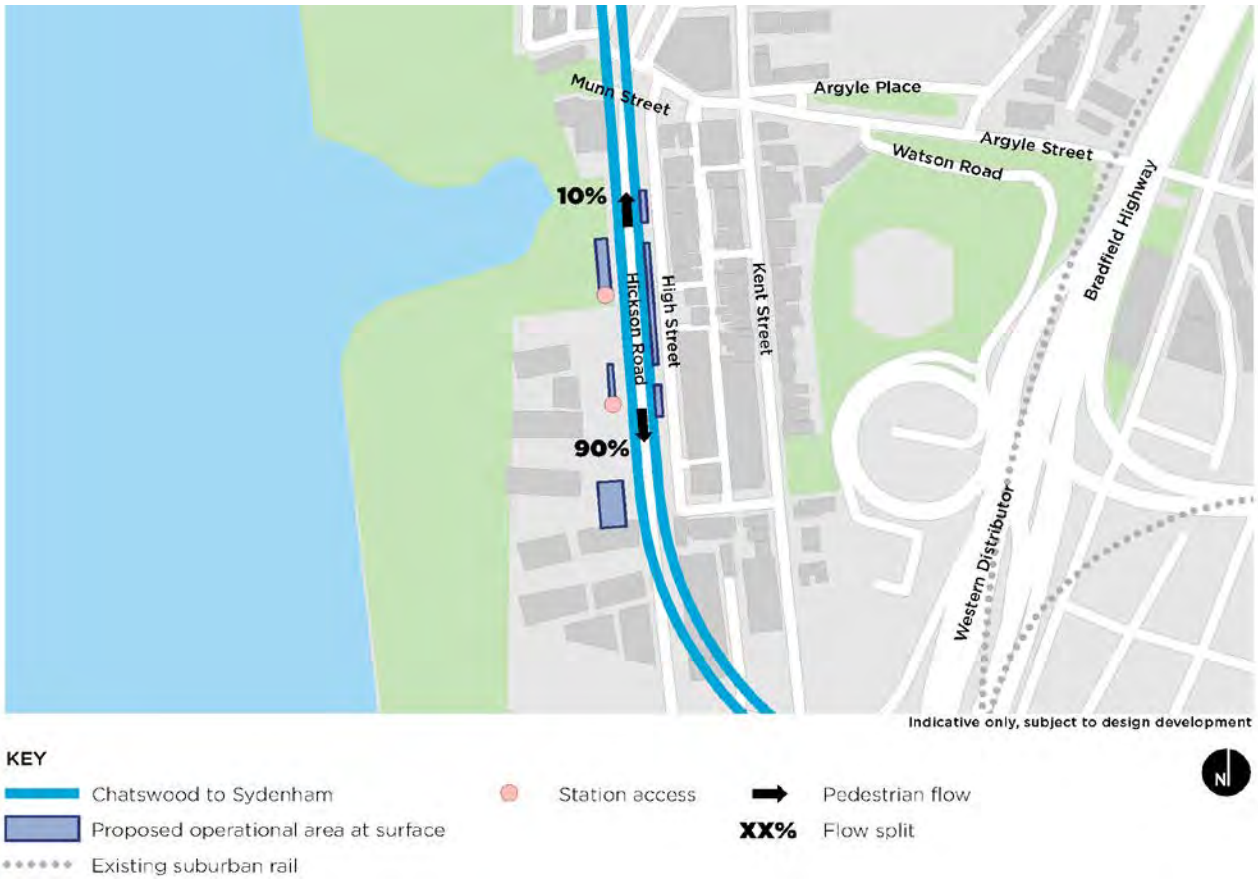


Figure 4.15 AM peak hour Barangaroo Station passenger alighting distribution

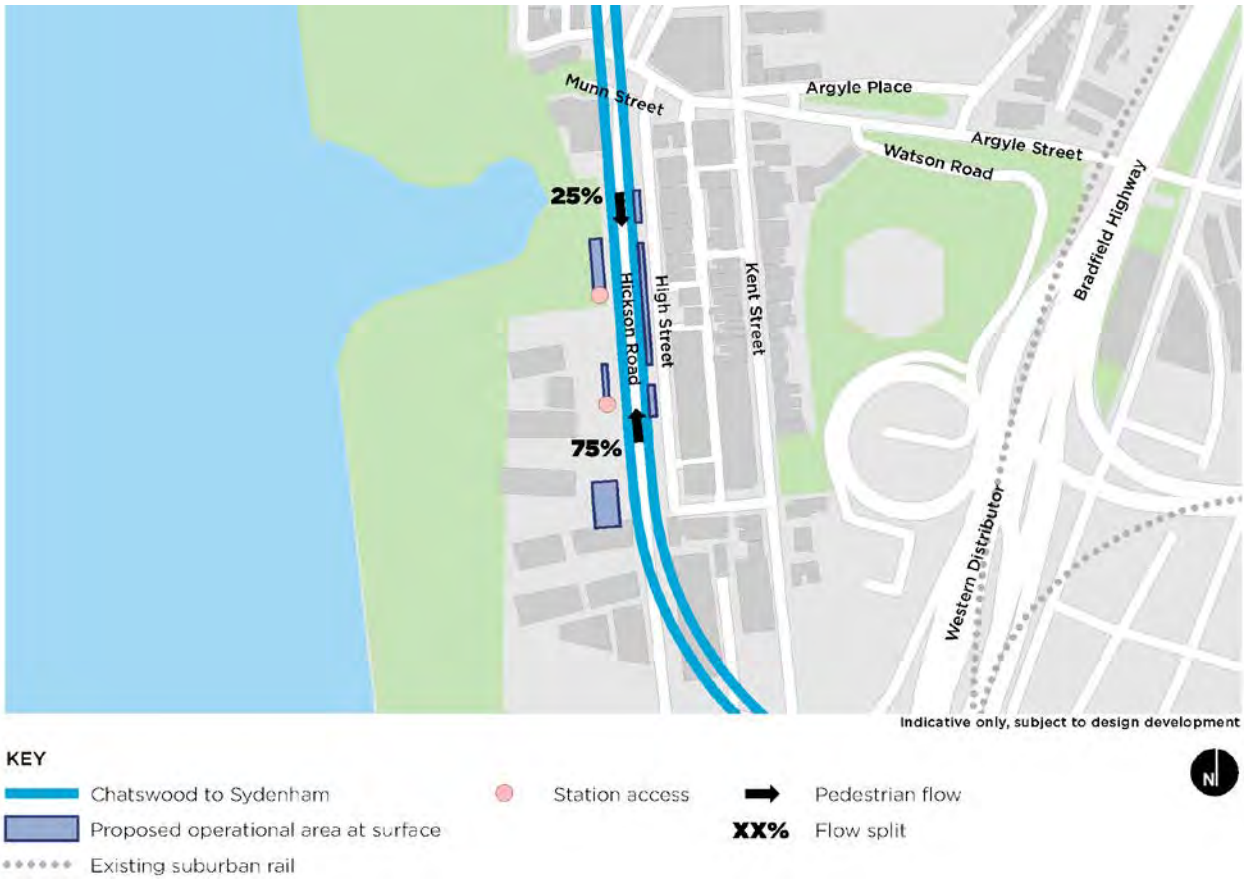


Figure 4.16 : AM peak hour Barangaroo Station passenger boarding distribution

4.8.3 Integration with pedestrian network

Based on the future residential and employment populations for travel zones within the walking catchment of the proposed station, the forecast direction of walk only arrivals and departures indicates that arrivals to the station would be primarily from the south from future residents of Central Barangaroo and Barangaroo South precincts. Ninety per cent of all station exits during the morning peak hour are anticipated to travel to the south towards the Barangaroo South commercial precinct.

Pedestrians would use the footpaths along Hickson Road, as well as the new network of footpaths through Central Barangaroo, Barangaroo South and Foreshore Walkway. As part of the Barangaroo development, enhanced east-west pedestrian connectivity would be provided through improvements to the Sydney Steps. This would also provide connectivity to the station from the east.

The high proportion of walking journeys expected at the Barangaroo Station means the pedestrian movement and access to the site has been considered a priority as part of the station design. Pedestrian crossing facilities in the vicinity of the station would be developed in consultation with the Barangaroo Delivery Authority. At this stage, these are anticipated to include:

- Pedestrian crossing facilities on Hickson Road to the north of Agar Street and near the northern station entry
- Pedestrian crossing facility on Little Clyde Street adjacent to Hickson Road
- Pedestrian crossing facility on Agar Street adjacent to Hickson Road
- Wayfinding signage and Sydney Metro information within the Barangaroo area

The northern station entry would also provide convenient access to special events at Barangaroo Reserve. During these events, pedestrian management would occur at street level to control the flow of pedestrians into the station environment.

As the streetscape surrounding the proposed Barangaroo Station is currently being redeveloped, pedestrian modelling concluded that the pedestrian infrastructure (including footpaths and crossings) designed as part of the redevelopment would provide a satisfactory pedestrian environment including flow, manoeuvrability and spacing between individuals.

4.8.4 Integration with cycle network

An existing on-road cycle path exists along Hickson road adjacent to the station. Cycle paths are also currently provided throughout Barangaroo Reserve and are planned to be integrated within the Barangaroo development along the foreshore to Pyrmont Bridge, which would provide additional cycle links to the station. To enable integration of these cycle paths with the station, cycle parking facilities would be provides adjacent to Hickson Road at both station entry points.

4.8.5 Integration with public transport network

A number of bus services operate along Hickson Road which would provide interchange potential with metro. The closest bus stops to the north of the station would be relocated closer to the northern station entry.

Customer interchange would also be possible with the new Barangaroo Ferry Hub via pedestrian footpaths within Central Barangaroo including Foreshore Walk.

4.8.6 Integration with road network

The mode split of customers entering and exiting the station by car is anticipated to be very low. As such, impacts on the road network are expected to be negligible.

To enable interchange with the road network, the following design features are proposed at the station:

- A taxi stand on the western side of Hickson Road between the two station entries
- A kiss-and-ride facility located on the western side of Hickson Road between the two station entries.

The provision of these design features would be developed further in consultation with Barangaroo Delivery Authority.

4.9 Martin Place Station

4.9.1 Location

The proposed metro Martin Place Station would be located between Castlereagh Street and Elizabeth Street.

The Martin Place Station would have the following pedestrian access points:

- A plaza with entry near the corner of Castlereagh and Hunter Street as well as near the corner of Elizabeth and Hunter streets
- A plaza entry on the south-western corner of Martin Place and Castlereagh Street

The station location and integration is included below as **Figure 4.17**.

The purpose of the station would be to serve the Sydney CBD financial core and retail areas, facilitate interchange between the Sydney Trains T4 Eastern Suburbs and Illawarra line, provide critical relief to Wynyard and Town Hall stations and to service events in Martin Place and the Domain.

The customers expected to use the station include those travelling to nearby employment, civic, commercial, retail and entertainment precincts, as well as customers interchanging to and from metro services and other modes of transport.

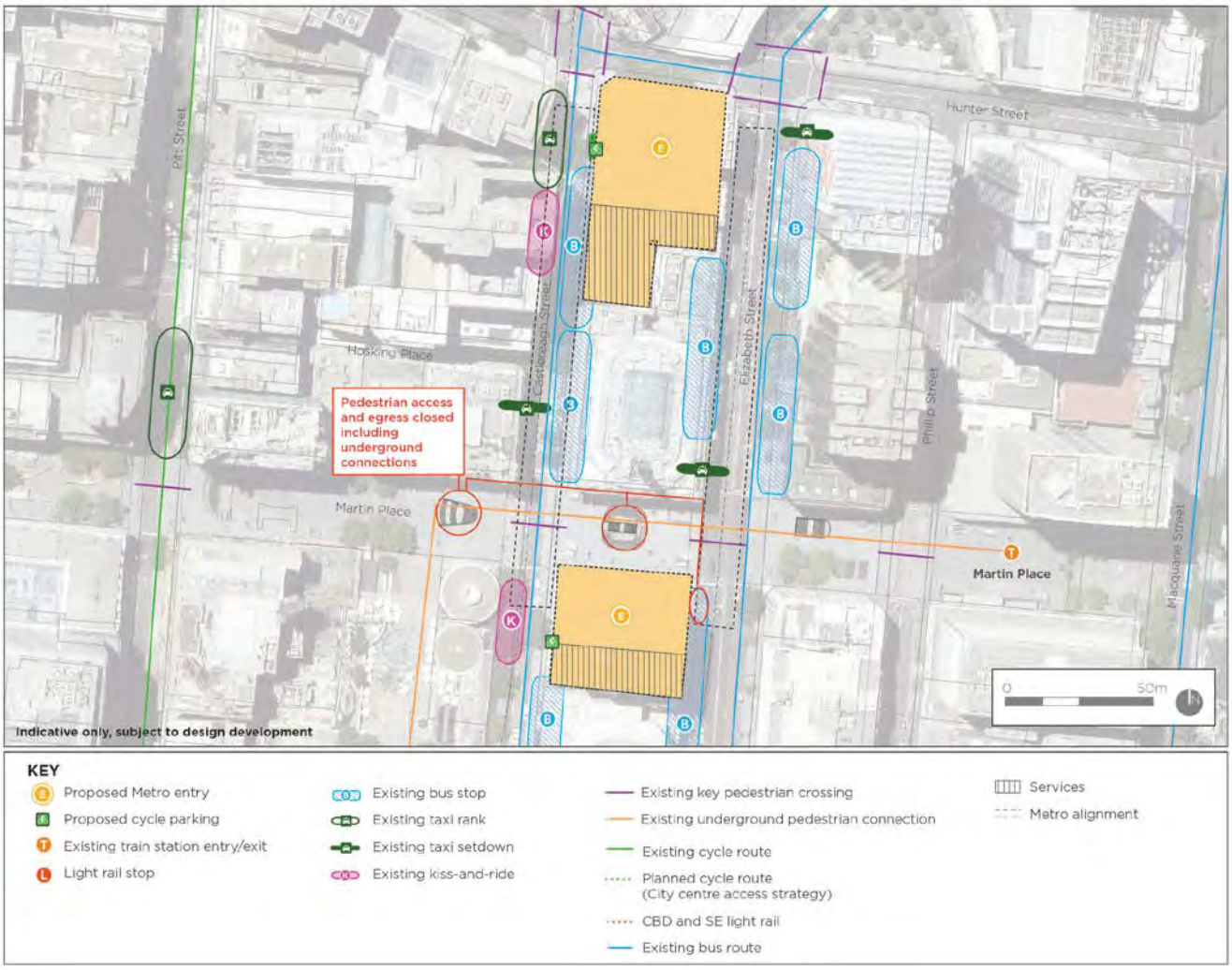


Figure 4.17 : Martin Place Station location and transport integration

4.9.2 Passenger demand

Preliminary forecasts for the 2036 AM peak hour indicate approximately 800 customers would enter the station and approximately 14,500 customers would exit the station, which reflects the heavy employment density within the precinct. The 2036 modal breakdown of arrival during the morning peak hour is presented in **Table 4.7**.

Table 4.7: 2036 Martin Place Station - Forecast Mode of Arrival (AM busiest hour)

Walk	Cycle	Bus	Kiss-and-ride	Park-and-ride
32%	2%	66%	0%	0%

It is anticipated that almost all exits would be walking trips to local commercial land uses, with some transfer to bus. In addition, it is expected that around 4,100 customers would interchange between Sydney Metro and other rail services.

The distribution of customers exiting and entering the station in the morning peak hour is shown below in **Figure 4.18** and **Figure 4.19**.

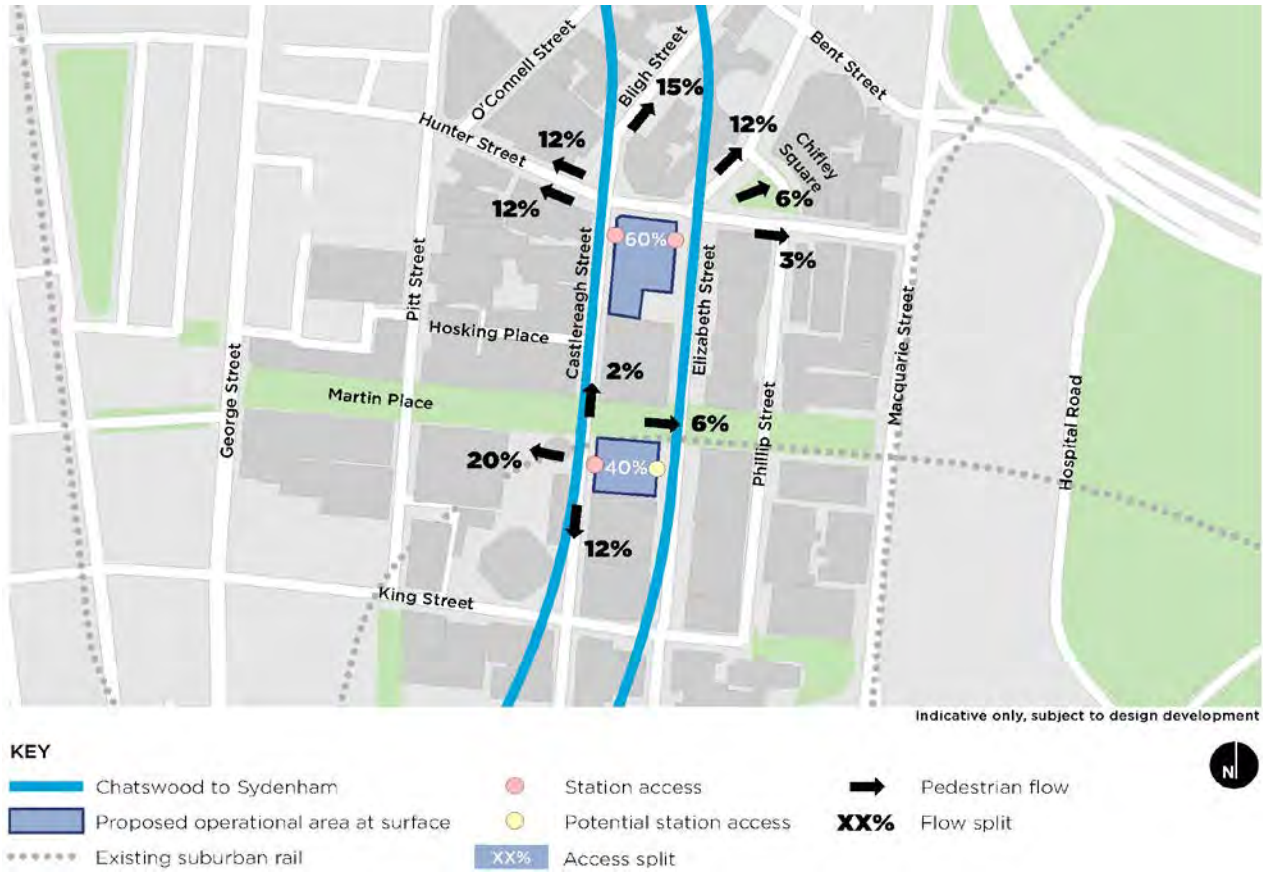


Figure 4.18 : AM peak hour Martin Place Station passenger alighting distribution

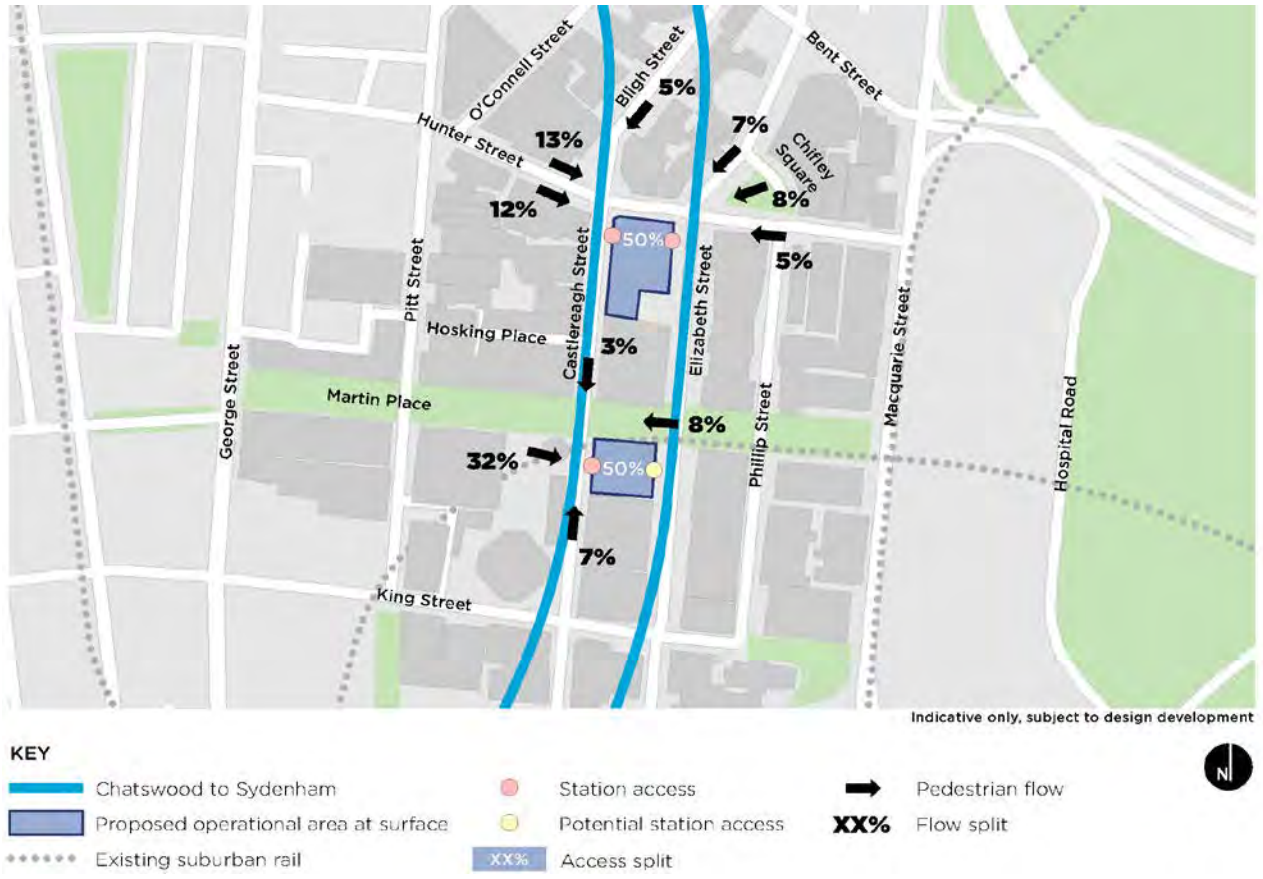


Figure 4.19 : AM peak hour Martin Place Station passenger boarding distribution

4.9.3 Integration with pedestrian network

Pedestrian entry and exit movements would be the primary mode of access to the Martin Place Station and therefore integration with the pedestrian network is a key consideration. Direct pedestrian access would be provided to Martin Place, which provides a pedestrianised east-west link, and footpaths on Castlereagh and Elizabeth streets form north-south connections. Signalised pedestrian crossing facilities are located at Martin Place on Elizabeth Street and Castlereagh Street, as well as at the Hunter Street intersections with Elizabeth and Castlereagh Streets. In the vicinity of Martin Place, George Street will also be pedestrianised as part of the CBD and South East light rail project which would provide an additional pedestrian friendly link for passengers.

A new underground pedestrian link between the existing suburban Martin Place Station platforms and the metro station platforms would be provided to facilitate train / metro interchange without the need for customers to travel to the surface.

The following design measures would be provided to accommodate the future pedestrian demand and ensure easy and safe interchange for pedestrians:

- Open plaza entrances to the station with ample footpath space within the site to accommodate the anticipated pedestrian demand
- A new underground pedestrian link between the suburban Martin Place Station platforms and the metro station platforms
- Installation of wayfinding signage and Sydney Metro information within the Sydney CBD

Additionally, the existing access and egress points to the west of Elizabeth Street from Martin Place to the underground concourse connection to the existing Martin Place Station would be closed. Customers travelling to and from the west wishing to access the existing Martin Place Station would be able to use the remaining access points to the east of Elizabeth Street and the new southern metro entrance.

Pedestrian modelling results for the year 2026 are presented in **Figure 4.20** (AM peak hour) and **Figure 4.21** (PM peak hour).

With the exception of some locations, the majority of footpaths in the area would continue to operate at a level of service B or better. However, based on site observations and pedestrian modelling of the station and streetscape around Martin Place, three locations were identified where there is potential for safety risks or impacts to pedestrian flow and / or traffic as a result of the metro station. These locations include:

- Intersection of Hunter Street, Castlereagh Street and Bligh Street
- Hunter Street (west of Castlereagh Street) which would operate at a level of service C in the AM and PM peak hours
- Martin Place mid-block crossing of Castlereagh Street

At the intersection of Hunter and Castlereagh Streets, actions may need to be taken to increase crossing capacity and, hence, reduce queue lengths, particularly on the southeast corner during the AM peak hour. Reducing queue lengths would assist in the deterrence of informal crossing. Thisincludes the provision of an underground pedestrian connection from the station platforms to O'Connell Street and / or Bligh Street. The location of this underground connection is identified in Chapter 6 of the Environmental Impact Statement. In addition, other treatments could include:

- Widening of the pedestrian crossing at Castlereagh Street, which would increase the pedestrian throughput without effecting cycle-times.
- Increase the pedestrian green-time, which would increase the pedestrian throughput by extending the proportion of green-time per cycle at the intersection. However, this consequently reduces green-time available for vehicle movements.
- Decrease overall cycle-time, which would increase the frequency of green-time for pedestrians over a given period of time. However, this could lead to losses in effective green-time for vehicles, as more time is lost in inter-green periods between movements.

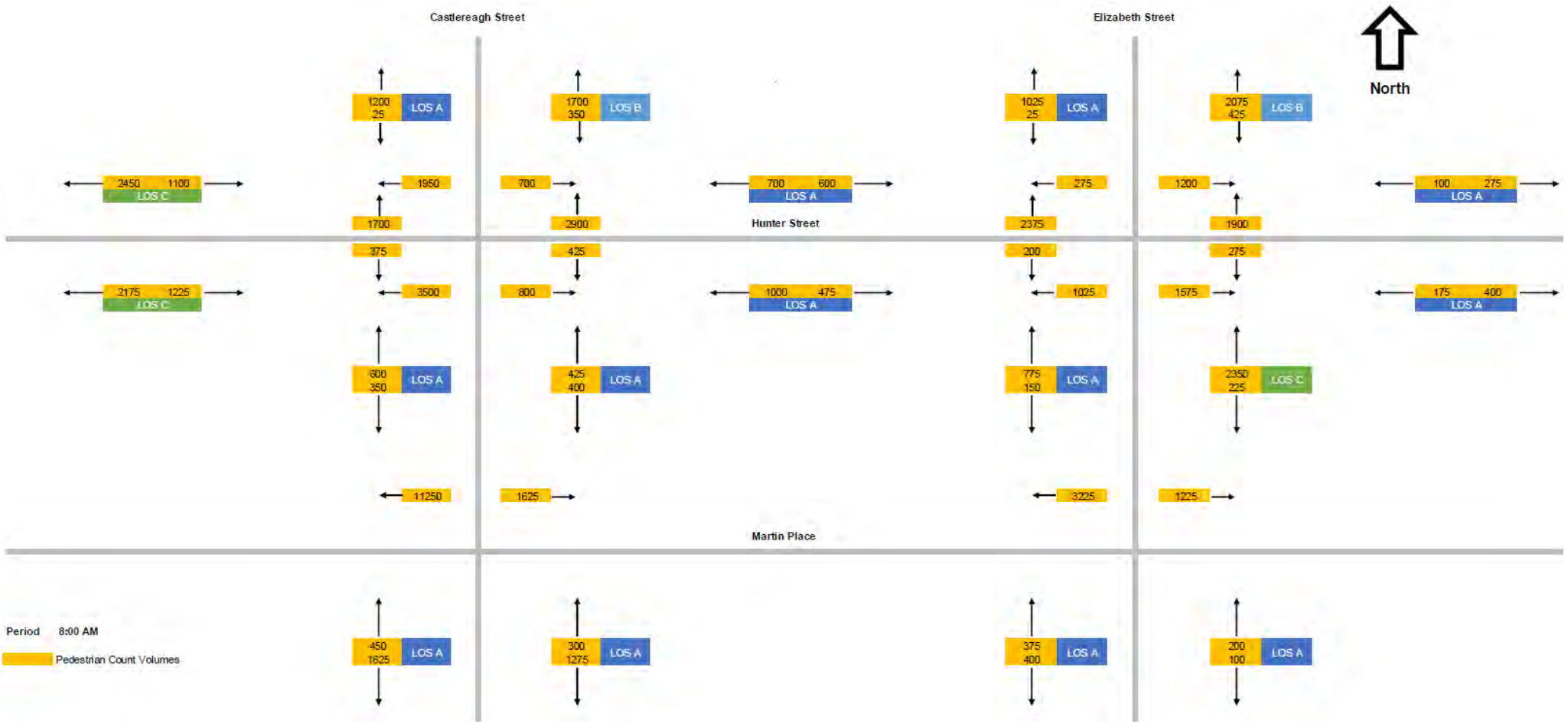


Figure 4.20 : Martin Place Station: 2026 AM peak hour pedestrian modelling results

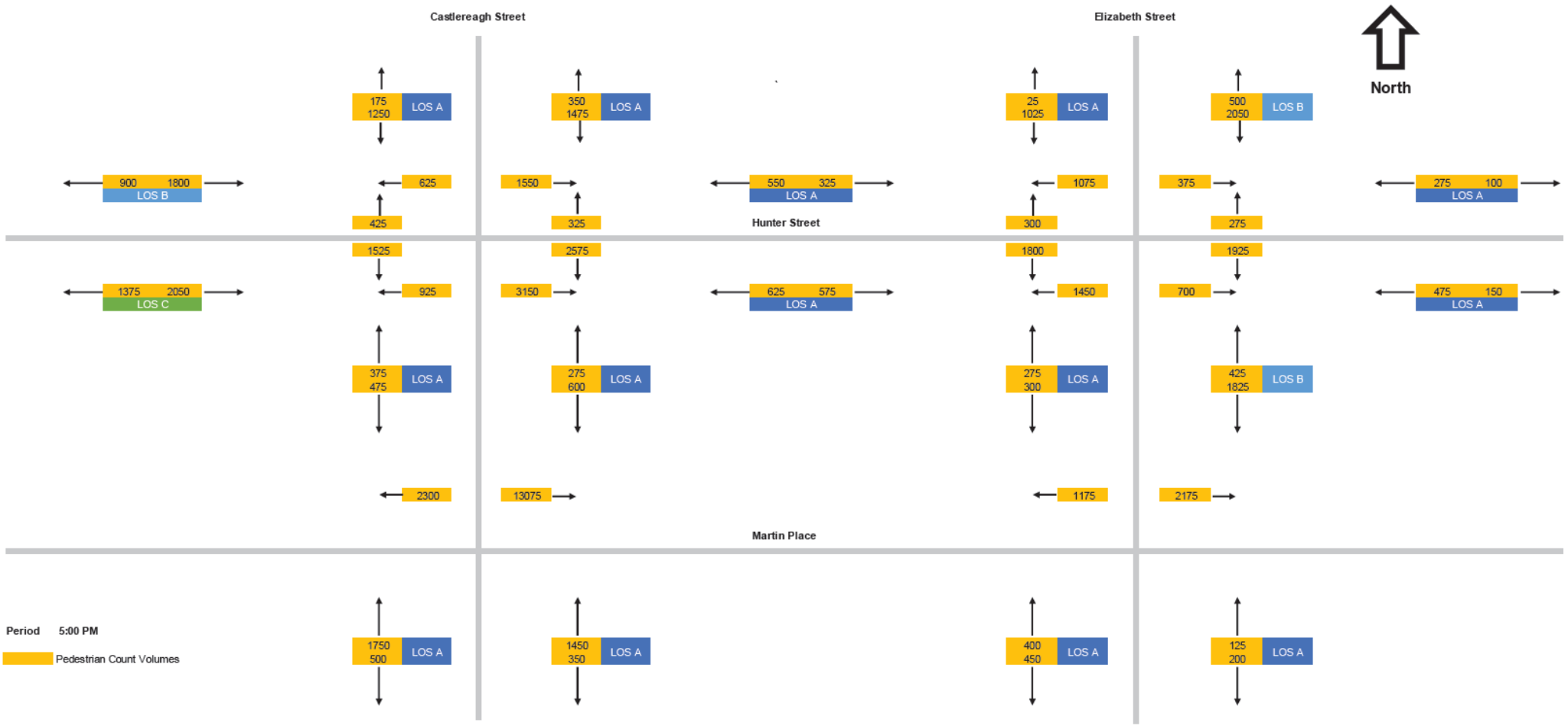


Figure 4.21 : Martin Place Station: 2026 PM peak hour pedestrian modelling results

With regard to the footpaths running along both frontages of Hunter Street west of Castlereagh Street, site observations and modelling indicate that pedestrian movements occur in platoons which are dependent on green-time at intersection crossings. This results in an uneven distribution over the hour, increased congestion and deterioration of the pedestrian environment.

To mitigate the impact to the footpath, an option may involve removing or reducing street furniture (such as trees) to increase the effective width of the footpath.

Towards the southern end of the station, the main impact from the project would be the Martin Place mid-block crossing with Castlereagh Street. The majority of existing Martin Place Station users use the pedestrian crossing to travel west in the AM peak, and the reverse in the PM peak. The metro station would result in a significant increase of these movements. Nevertheless, with 2026 and 2036 demands, the crossing was found to provide sufficient space for queuing without blocking background pedestrian flows, and the green-time allows the queue to clear each cycle.

The above mitigation options would be investigated further in consultation with the CBD Co-ordination Office, The City of Sydney Council and Roads and Maritime Services.

4.9.4 Integration with cycle network

As previously discussed, a number of cycle facilities are currently being installed in the Sydney CBD area which would improve safety and convenience for cyclists.

Some on-street cycle parking facilities are currently available at the intersection of Martin Place and Castlereagh Street, adjacent to the station entrance, providing some cycle parking in the vicinity of the station.

To enable cycle interchange with the station, new cycle parking facilities would be provided on Castlereagh Street at both station entrances.

4.9.5 Integration with public transport network

The project would provide a new underground pedestrian link between the existing Martin Place train station platforms and the Martin Place Metro station platforms, ensuring convenient integration between suburban rail and the metro.

Following implementation of the new CBD Bus Network in 2015, Elizabeth Street is now a key north-south bus route through the Sydney CBD. Castlereagh Street is also a designated north-south bus route. These bus routes, and associated bus stops would provide convenient interchange opportunities between bus and metro services.

The northern station entrance on Castlereagh Street provide a connection to the new light rail station that would be located on George Street, near its intersection with Hunter Street. Alternatively, connections could be made from the southern station entrance, along Martin Place and the pedestrianised George Street. This would provide an appropriate connection for the small proportion of passengers expected to interchange between the metro and light rail.

4.9.6 Integration with road network

High pedestrian and interchange activity is anticipated at the station. Existing taxi facilities on Castlereagh and Elizabeth Streets in the vicinity of the station entrances would be retained and could be used by metro customers.

It is therefore considered that the impact on operational performance of the road network in the vicinity of the site would be insignificant.

4.10 Pitt Street Station

4.10.1 Location

The Pitt Street Station would be located between Pitt and Castlereagh Streets, north of the Park Street intersection and south of the Bathurst Street intersection. The pedestrian access locations to the station would be:

- A northern entrance with access via Pitt and Park streets
- A southern entrance via Bathurst Street between Pitt and Castlereagh streets.

The station location and integration is included below in **Figure 4.22**.

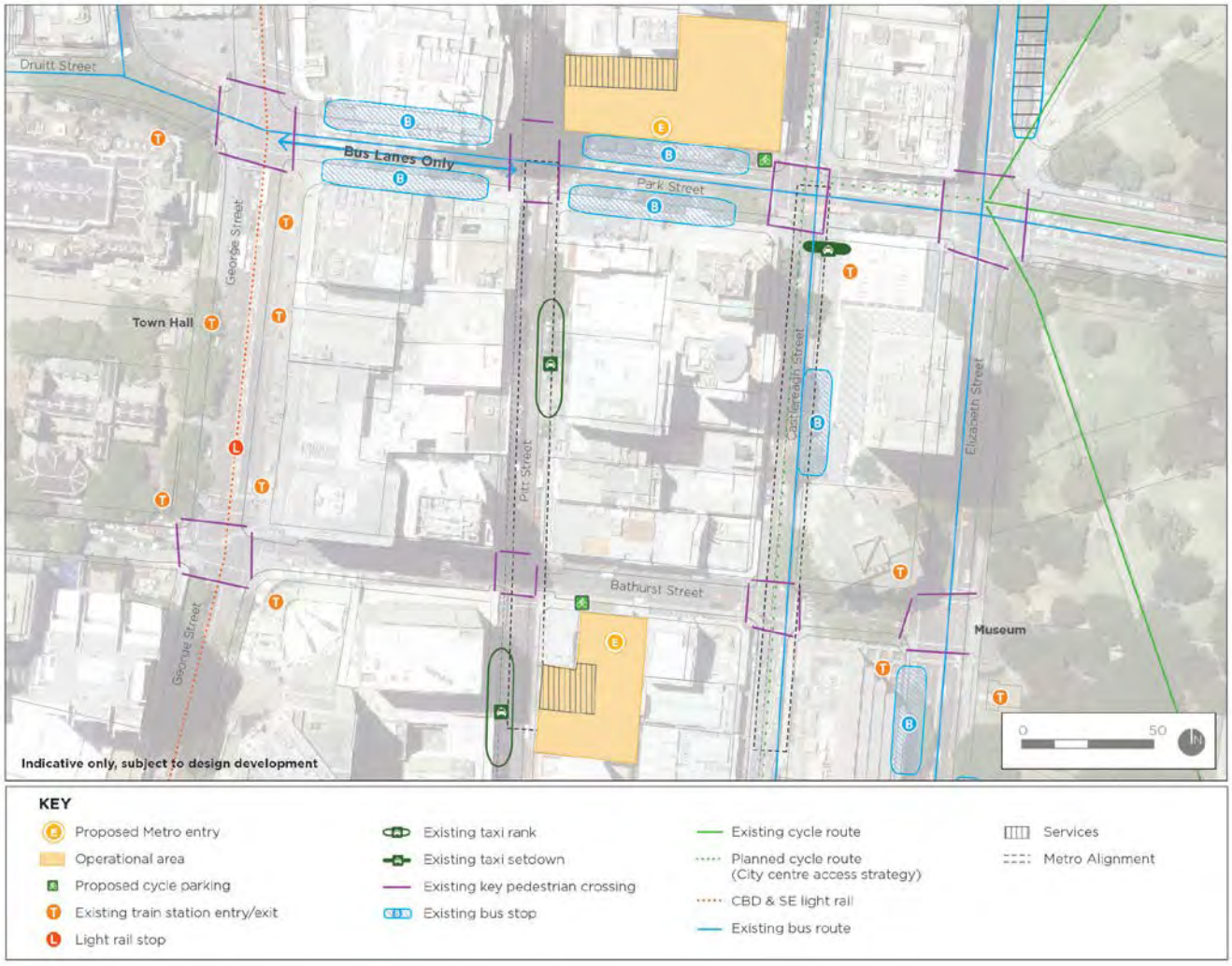


Figure 4.22 : Pitt Street Station location and transport integration

The customers using the station are anticipated to be travelling to and from the mid-town retail, employment and entertainment precincts.

4.10.2 Passenger demand

Preliminary forecasts for the 2036 AM peak hour indicate that around 1,500 customers would be entering the station and around 7,575 customers would be exiting the station. This correlates with the residential buildings in the vicinity of the station as well as the commercial and retail uses within the area.

The forecast 2036 mode of arrival during the morning peak hour is shown below in **Table 4.8**.

Table 4.8: 2036 Pitt Street Station - Forecast Mode of Arrival (AM busiest hour)

Walk	Cycle	Bus	Kiss-and-ride	Park-and-ride
45%	2%	52%	1%	0%

It is anticipated that almost all exits would be walking trips to local commercial uses, with some transfer to bus.

It would be expected that 23 per cent of people exiting the station would travel north along Pitt Street, 18per cent would head in a north western direction towards the Queen Victoria Building and beyond, 26per cent in a south-westerly direction towards George Street and Liverpool Street and five per cent would travel in an easterly direction. The alighting and boarding distribution at the station is shown in **Figure 4.23** and **Figure 4.24**.

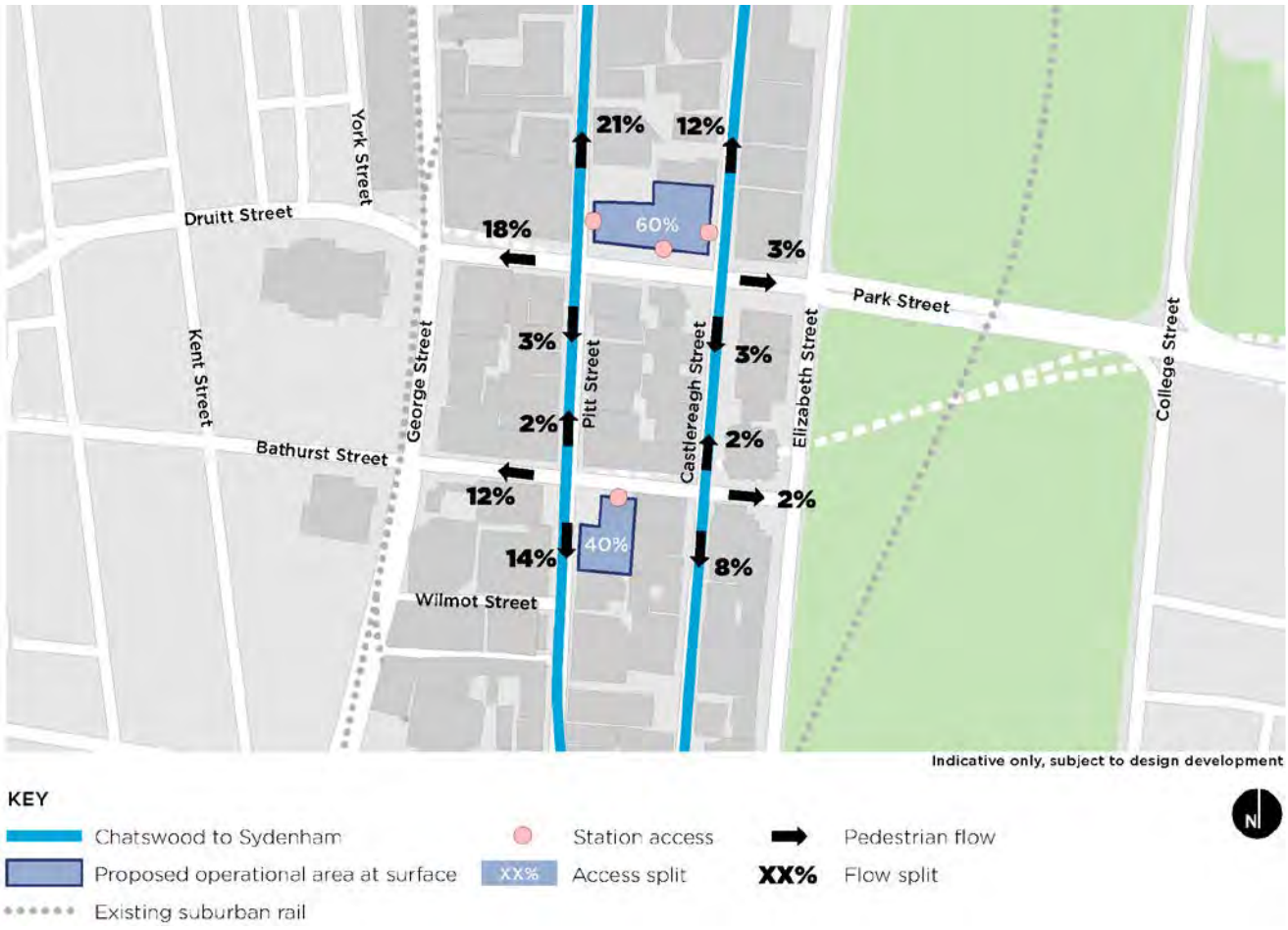


Figure 4.23 : AM peak hour Pitt Street Station alighting passenger distribution

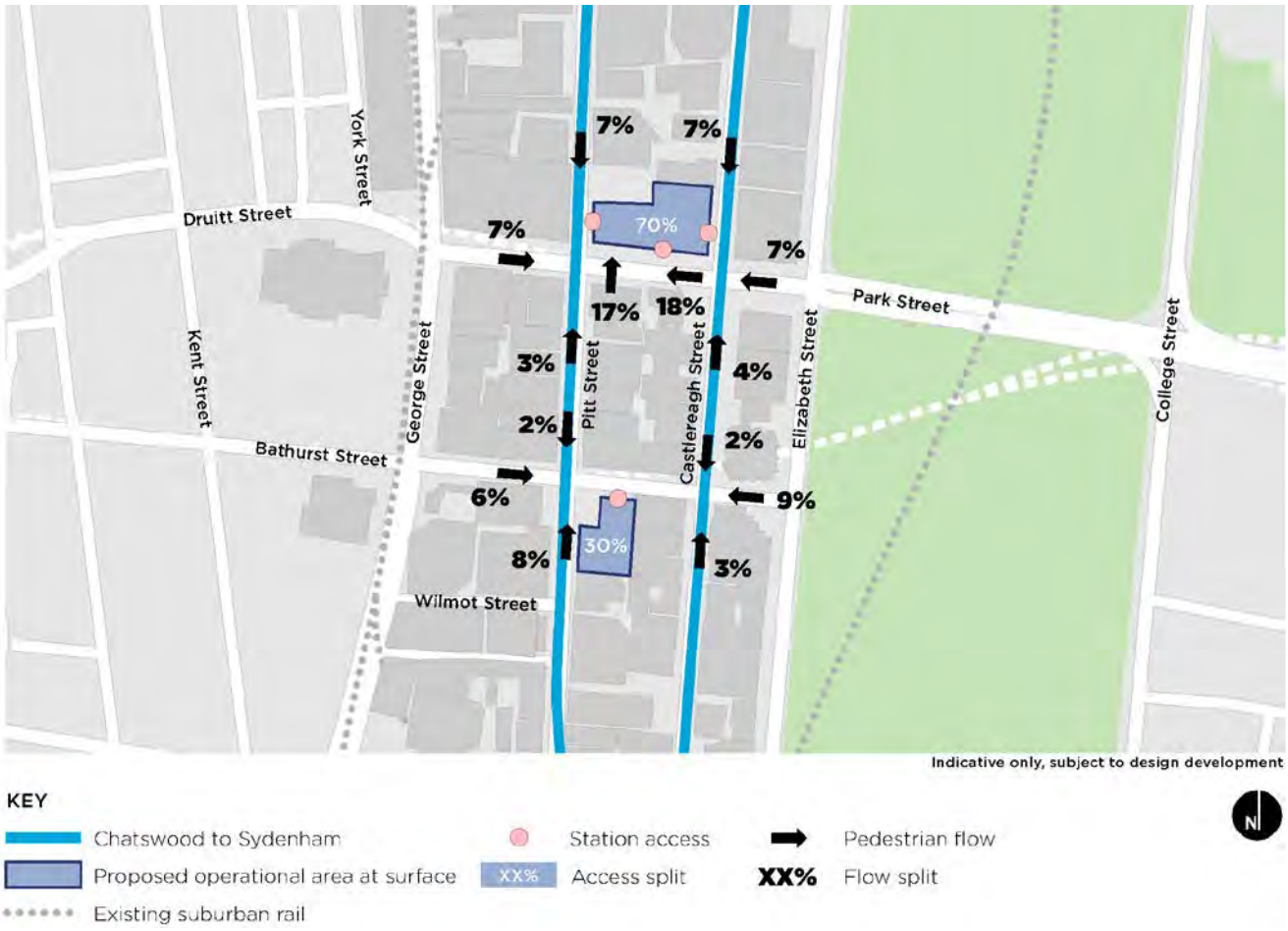


Figure 4.24 : AM peak hour Pitt Street Station boarding passenger distribution

4.10.3 Integration with pedestrian network

The northern station entrance would be a plaza entrance that would incorporate sufficient pedestrian space to accommodate the forecast number of entries and exits at the station. Similarly, the southern entrance off Bathurst Street would accommodate pedestrian space to accommodate the forecast customer numbers.

Pedestrian modelling results for the year 2026 are presented in **Figure 4.25** (AM peak hour) and **Figure 4.26** (PM peak hour).

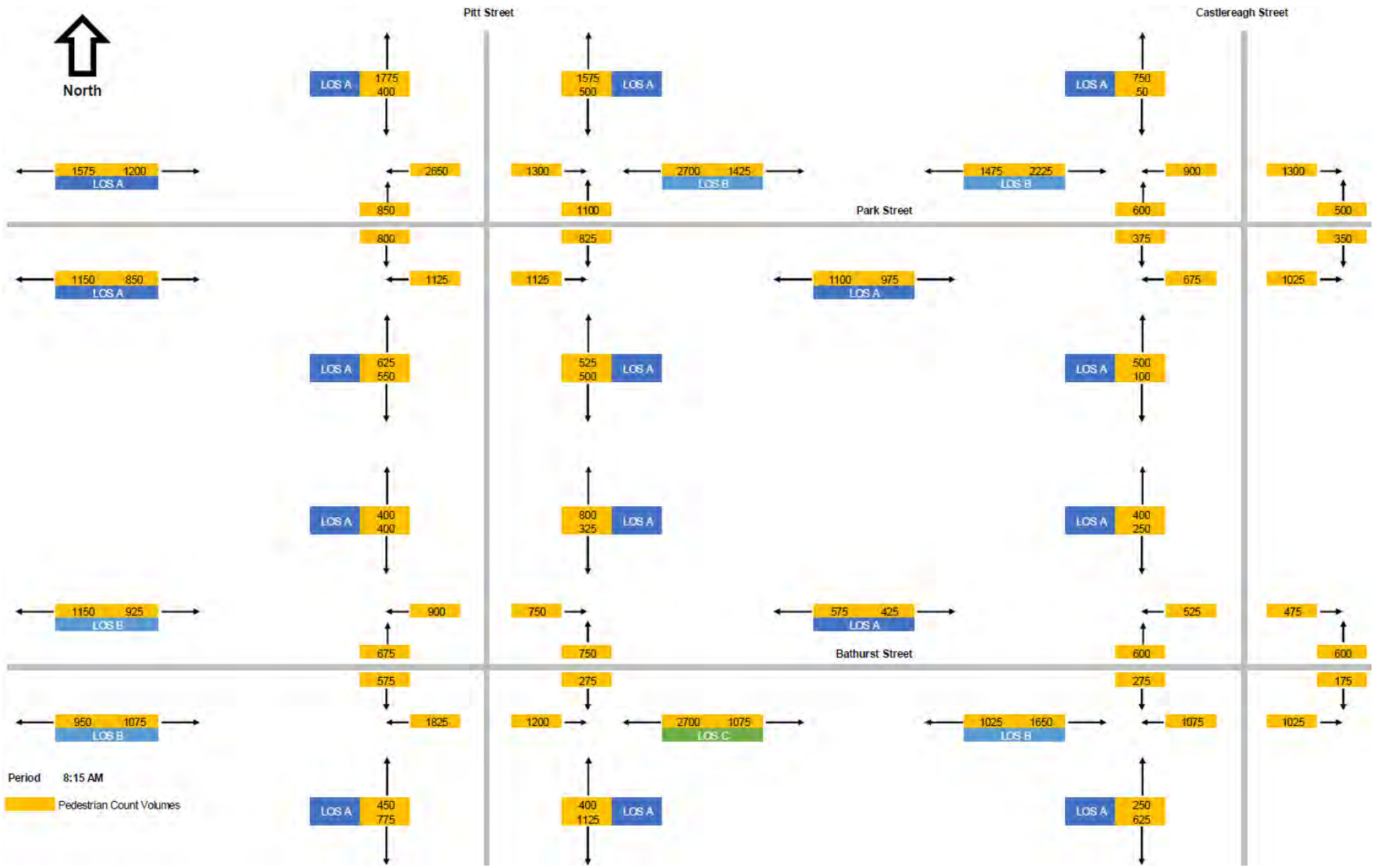


Figure 4.25 : Pitt Street: 2026 AM peak hour pedestrian modelling results

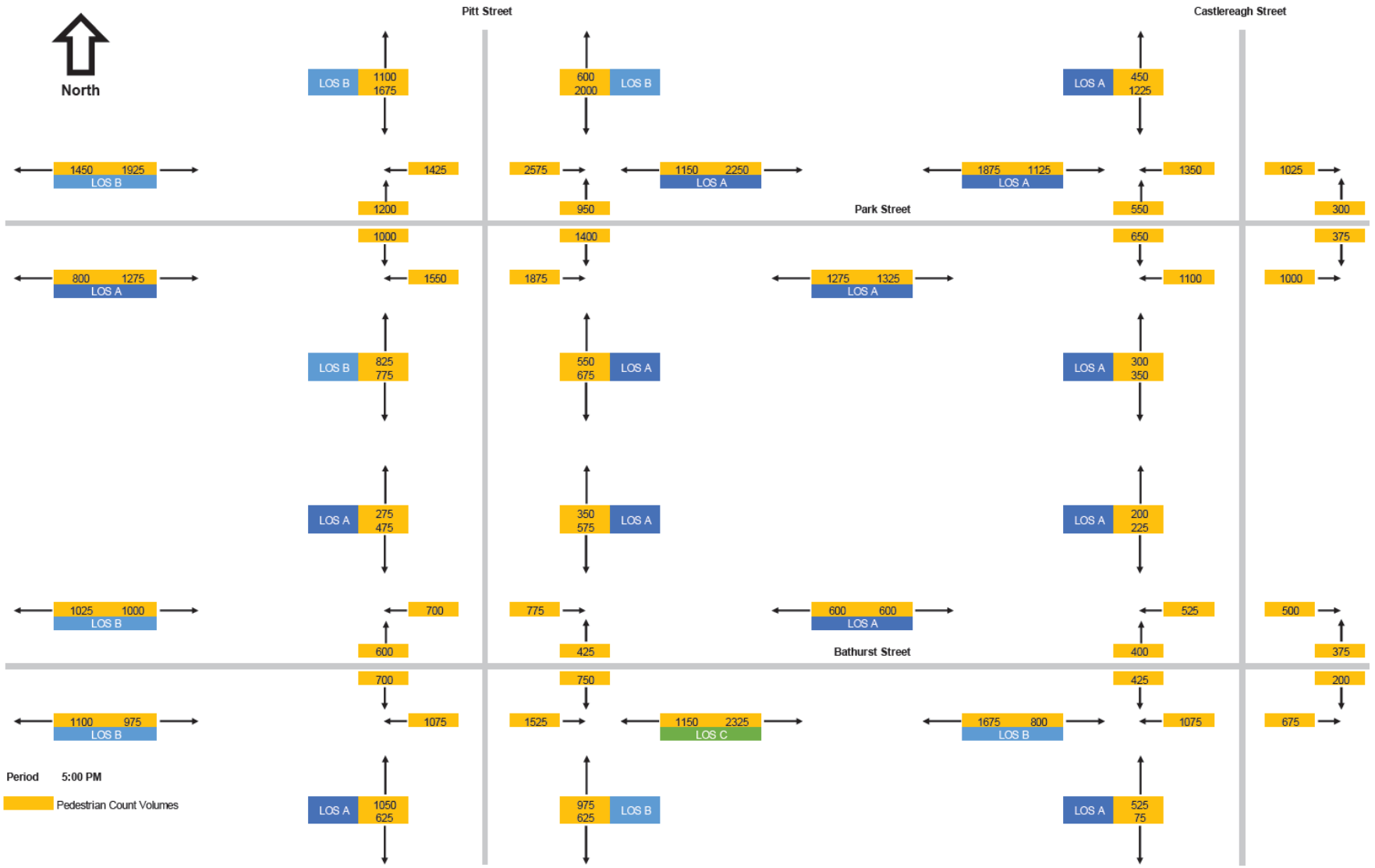


Figure 4.26 : Pitt Street: 2026 PM peak hour pedestrian modelling results

With the exception of some locations, the majority of footpaths in the area would continue to operate at a level of service B or better. However, patronage analysis and pedestrian modelling of the station and streetscape have identified three locations where there is potential for impacts to pedestrians and/or traffic due to the presence of the Metro station. Locations include:

- Park Street mid-block near the station access due to the presence of a major bus interchange
- Intersection of Pitt Street and Park Street
- Intersection of Pitt Street and Bathurst Street.

The highest pedestrian volumes occur along the footpaths connecting to both the northern and southern station entries, particularly west of the station access towards the Pitt Street intersections. These pedestrian volumes are however less than 100 people per minute in both directions, a flow rate to be expected within the Sydney CBD.

This could however be a potential issue at the mid-block on Park Street between Pitt and Castlereagh streets, which acts as a major interchange with bus services. In addition to queuing and alighting customers, the bus stop infrastructure significantly reduces the effective width of the footpath, further reducing the space available to pedestrians.

At the Pitt Street intersections with Park Street and Bathurst Street, the east-west pedestrian crossing volumes nearest to the station entries may double in both peak periods. This however is not anticipated to be a significant issue as the crossing operates in parallel with the primary vehicle movement of the intersection and therefore pedestrian green time could be extended to the length of the east-west vehicle green time (if required) without compromising the intersection performance.

Wayfinding signage and metro information would be provided in the Sydney CBD to enable pedestrian interchange.

4.10.4 Integration with cycle network

Easy cycle access to and from the station along the existing Park Street cycle lane would provide good connections to the east of the site.

To enable cycle interchange with the station, cycle parking would be provided:

- At the northern station entrance near the Park Street / Castlereagh Street intersection
- At the southern station entrance near the Bathurst Street entrance.

4.10.5 Integration with public transport network

Patronage forecasts shows approximately 52 per cent of passenger arriving in the morning peak hour would interchange from bus services, while approximately 45 per cent would walk to the station.

Existing bus stops are located outside the northern station entrance on Park Street, which is identified as a key bus corridor within the Sydney City Centre Access Strategy. Bus stops are also located on Castlereagh and Elizabeth Streets north and south of the station.

Direct connections would be possible to the new light rail station on George Street. The distance between this southern station entry and the light rail station would be less than 200 metres, providing an efficient interchange.

4.10.6 Integration with road network

A minor number of customers are anticipated to access the Pitt Street station via car and therefore the impact of the station on the operational performance of the road network in the vicinity of the site would be insignificant.

Existing taxi facilities are available near the station which would provide easy and convenient taxi connections to both the northern and southern station entrances.

Due to the low level of residential population in the precinct, no kiss-and-ride facilities are proposed near the Pitt Street Station.

4.11 Central Station metro platforms

4.11.1 Location

Central Station is located to the south of the Sydney CBD area and the proposed metro platforms would be located below existing platforms 13, 14 and 15.

Customers would access the metro station via the existing northern station entry from Eddy Avenue, the main northern concourse, or via the existing underground pedestrian connections.

The location of the two new underground metro platforms would facilitate a critical interchange with intercity and suburban rail services, light rail and bus services.

To provide access for Sydney Metro and Sydney Trains to undertake maintenance once the project is operational, a vehicular access bridge would be provided from Regent Street to ‘Sydney Yard’, located between the suburban and intercity rail lines.

The location and integration of the station is shown in **Figure 4.27**.

Customers to the station are anticipated to be those travelling to nearby employment, education and entertainment precincts or those interchanging to and from metro services and other modes of transport.

Figure 4.27 : Central Metro Station location and transport integration

4.11.2 Passenger demand

Preliminary forecasts for Central Station anticipate approximately 2,100 metro customers would enter the station during the morning peak hour in 2036 and approximately 9,650 metro customers would exit the station during the same period. In addition, there is anticipated to be approximately 9,600 customers interchanging between Sydney Metro and other rail services at Central Station.

Table 4.9: 2036 Central Station - Forecast Mode of Arrival (AM busiest hour)

Walk	Cycle	Bus	Kiss-and-ride	Park-and-ride
46%	1%	52%	1%	0%

The expected direction the exiting and entering trips would take during the morning peak period is shown below in **Figure 4.28** and **Figure 4.29**.

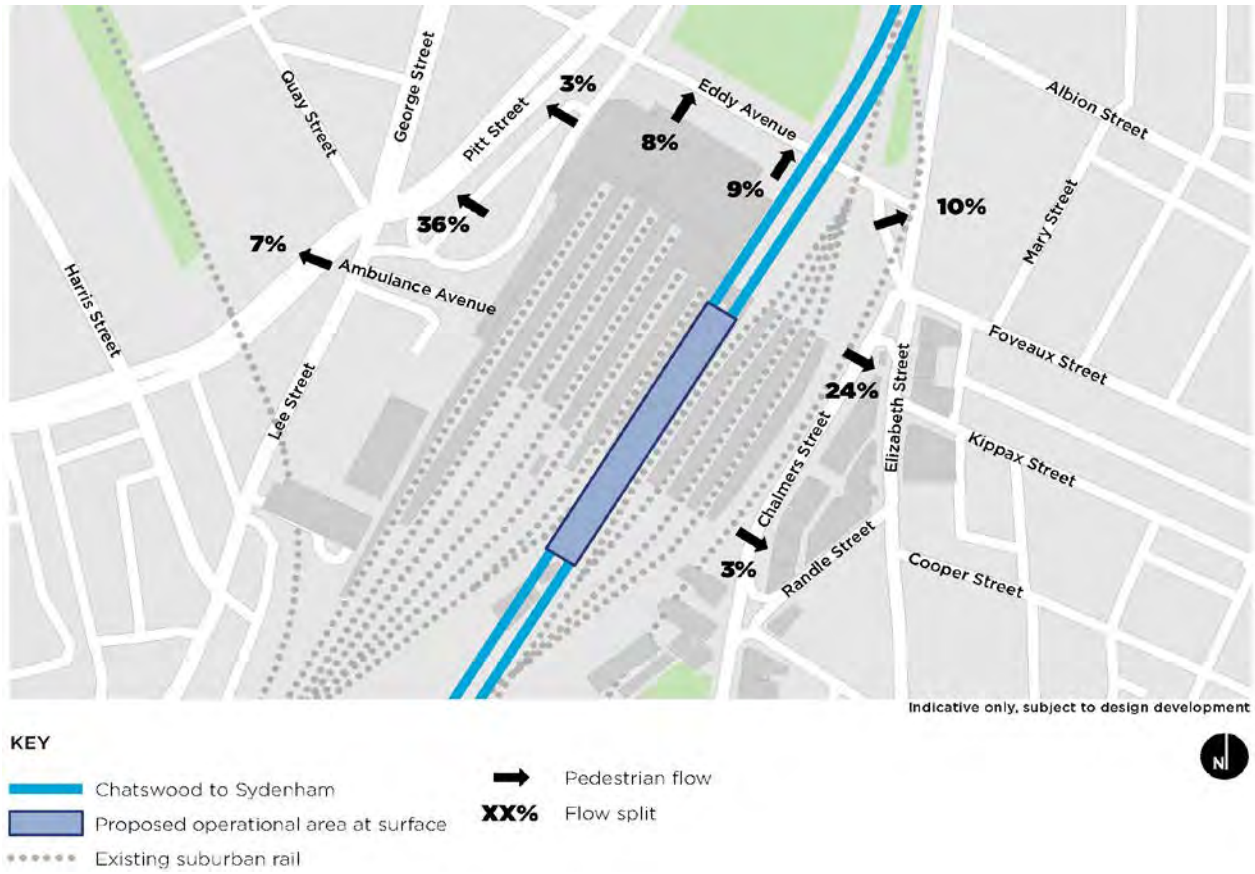


Figure 4.28 : AM peak hour Central Station Metro platforms passenger alighting distribution

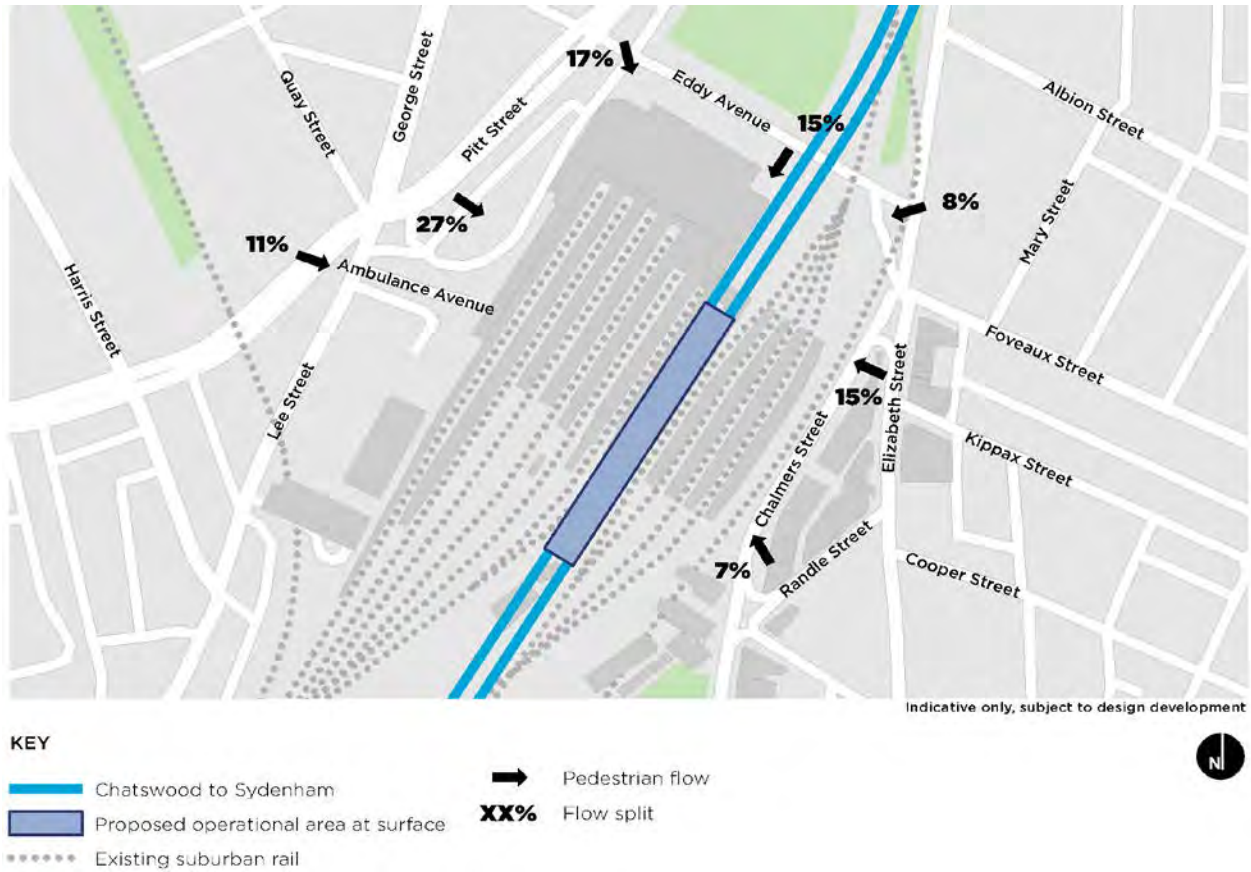


Figure 4.29 : AM peak hour Central Station Metro platforms passenger boarding distribution

4.11.3 Integration with pedestrian network

Integration with the pedestrian network is a priority at Central Station.

Pedestrians would be able to interchange between metro and suburban train lines via the existing northern concourse and the existing paid underground pedestrian connections at Central Station which would be connected to the metro concourse. The station and platforms have been designed using forecast patronage data, therefore would accommodate the anticipated pedestrian movements within Central station.

Pedestrian analysis at Central concluded that a maximum of eight people per minute would be added to any exit during the AM peak hour and subsequent street level footpaths. Therefore, based on this relatively insignificant increase, it is unlikely that any issues related to pedestrian capacity on the local pedestrian network would arise as a result of the project.

4.11.4 Integration with cycle network

A new cycle path is currently being built along Castlereagh Street between Belmore Park and Liverpool Street, as well as along Liverpool Street from Castlereagh Street to Sussex Street. This would improve the existing and any future north-south and east-west connections to and from the Central Station. Metro customers would be able to use the existing cycle parking facilities at Central Station.

4.11.5 Integration with public transport

A high proportion of public transport interchange is expected at Central Station. Customers would be able to interchange with suburban and intercity train lines via the existing northern concourse and the existing underground pedestrian connections at Central Station which would be connected to the metro concourse.

Within Central Station, metro customers would be able to use existing access options to interchange with bus services in the vicinity of Central Station as well as with light rail services and coach services providing regional connections.

4.11.6 Integration with road network

The metro platforms at Central Station are not anticipated to have any impact on the operational performance of the local road network.

Customers would use existing drop-off facilities such as the drop-off area within the western forecourt of Central Station.

4.12 Waterloo Station

4.12.1 Location

Waterloo Station would be located on Cope Street between Raglan and Wellington Streets. Pedestrian access to the station would be via the northern end of the station on the corner of Raglan and Cope Streets.

The location and integration of the station is shown below in **Figure 4.30**.

The anticipated customers that would use the station include those travelling to and from the nearby existing and future residential developments as well as to and from commercial precincts.

Figure 4.30 : Waterloo Station location and integration

4.12.2 Passenger Demand

The preliminary 2036 forecast is for approximately 3,700 customers to enter the station in the morning peak hour and for approximately 2,350 customers to exit the station during the same period. This reflects the residential and commercial uses in the vicinity of the station.

The forecast mode of arrival during the 2036 morning peak hour is presented below in **Table 4.10**.

Table 4.10: 2036 Waterloo Station (option) - Forecast Mode of Arrival (AM busiest hour)

Walk	Cycle	Bus	Kiss-and-ride	Park-and-ride
76%	1%	19%	4%	0%

It can be seen that the majority of customers accessing the station are anticipated to walk, and it would be expected that the majority of customers exiting the site during this period would also walk, primarily to local commercial uses.

The forecast entry and exit distribution during the AM peak hour can be seen below in **Figure 4.31** and **Figure 4.32**.

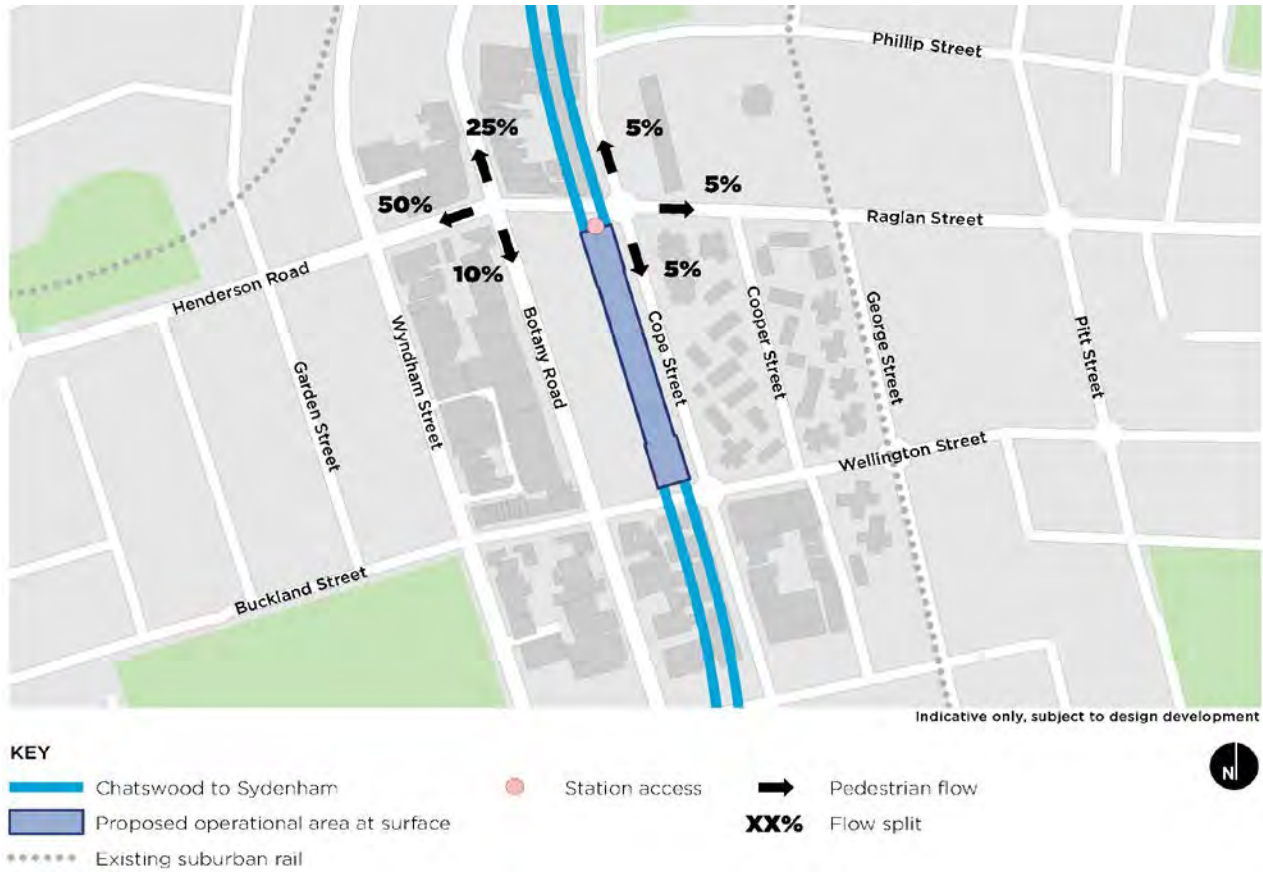


Figure 4.31 : AM peak hour Waterloo passenger alighting distribution

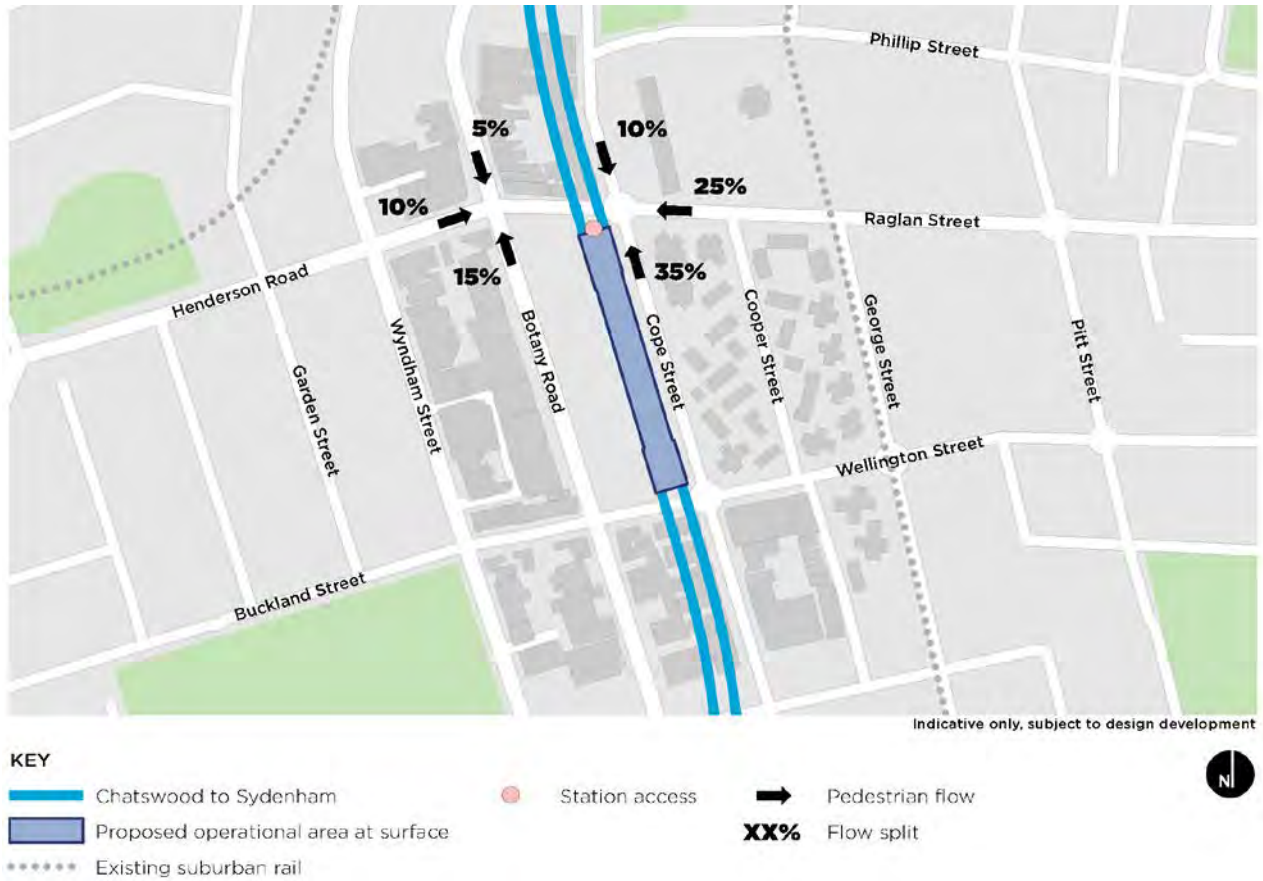


Figure 4.32 : AM peak hour Waterloo passenger boarding distribution

4.12.3 Integration with pedestrian network

The station entrance would be a plaza entrance that would incorporate sufficient pedestrian space to accommodate the forecast number of entries and exits at the station. Adjacent to the station entrance marked pedestrian crossing facilities would be provided across Raglan Street to provide a safe north – south pedestrian connection to the entrance as well as across Cope Street to provide a safe east – west pedestrian connection. The highest pedestrian volumes are anticipated to occur along the southern Raglan Street footpath where the station access would be located. Currently the footpath and the retail frontage provide sufficient width to accommodate the Metro patronage demand.

4.12.4 Integration with cycle network

A new on-road cycle route would be provided along Raglan Street and Henderson Street, between George Street to the east and the shared path through the Vice Chancellors Oval to the west. This would provide direct access past the station entrance, connecting existing cycle route facilities to the east and west of the station. To the east of the station, George Street has a segregated cycle route providing safe and convenient north - south connections and the shared path via the Vice Chancellors Oval provides cycle connections to the west of the station.

To enable easy cycle interchange, bicycle parking would be provided near the station entrance at Raglan Street.

4.12.5 Integration with public transport network

Existing bus stops on Botany Road between Raglan Street and Wellington Street are generally located within an easy walking distance of the station entrance. To enable better integration with the metro station entry, the southbound bus stop on Botany Road would be relocated further north and the bus stops on Cope Street would be relocated to Botany Road. The northbound and southbound bus stops provide convenient interchange to and from the Sydney CBD to the north and Mascot, Matraville and East Gardens to the south.

4.12.6 Integration with road network

To accommodate the small number (four per cent in the AM peak hour) of customers anticipated to access the station by road, kiss-and-ride facilities and a taxi rank would be provided on Cope Street, just south of its intersection with Raglan Street, providing convenient access to the station entry.

This volume of drop-off during the peak hour is not anticipated to have a material impact on the operation of the road network in the vicinity of the station.

4.13 Marrickville dive

4.13.1 Operational Impact

An assessment of the operational impacts of signalising the Edinburgh Road / Bedwin Road / Edgeware Road intersection, which is currently priority controlled, has been undertaken and the results are included in **Table 4.11**.

Table 4.11 : Marrickville dive Operational Assessment (AM and PM peak)

Intersection / peak period	Existing				Operational			
	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation	Demand flow (PCUs per hour)	Average delay (seconds per vehicle)	Level of Service	Degree of saturation
Edinburgh Road / Murray Street (roundabout)								
AM peak	979	4	A	0.48	979	4	A	0.48
PM peak	1,168	6	A	0.66	1,168	6	A	0.66
Edinburgh Road / Edgeware Road (roundabout)								
AM peak	886	3	A	0.38	886	3	A	0.38
PM peak	1,085	3	A	0.40	1,085	3	A	0.40
Edinburgh Road / Bedwin Road / Edgeware Road (priority controlled)					**(signalised)**			
AM peak	1,926	4	A	0.12	1,926	11	A	0.55
PM peak	1,940	12	A	0.49	1,940	11	A	0.66
Bedwin Road / Unwins Bridge Road / Campbell Street / May Street (signalised)								
AM peak	2,796	47	D	1.01	2,796	45	D	1.01
PM peak	2,993	43	C	1.01	2,993	42	C	1.01
Princes Highway / Campbell Street (signalised)								
AM peak	3,527	34	C	1.00	3,527	34	C	1.00
PM peak	3,862	30	C	0.86	3,862	30	C	0.86
Princess Highway / May Street (signalised)								
AM peak	3,756	33	C	0.81	3,756	33	C	0.83
PM peak	4,392	25	B	0.81	4,392	25	B	0.81

Note: Outputs from LinSig Version 3.2

It can be seen from the above that with the signalisation of the Edinburgh Road / Bedwin Road / Edgeware Road intersection, all intersections in the vicinity maintain their existing level of operation.

4.14 Maintenance access requirements

Vehicles would be required to access operational ancillary infrastructure, stations and tunnel portals to undertake periodic maintenance activities. The expected maintenance access frequency is outlined in **Table 4.12**. Due to the anticipated number of vehicles and the expected frequency of access, maintenance access is not expected to result in any impacts to the surrounding network.

Table 4.12 : Maintenance access requirements

Location	Access requirement	Vehicle type	Frequency
Stations and service buildings	Delivery of consumables and minor waste removal	Light and utility vehicles	Daily
	Maintenance inspections	Light and utility vehicles	Weekly to fortnightly
	Significant deliveries and waste removal	Tipper trucks	Weekly
	Major maintenance and replacement of large plant items	Heavy rigid trucks and cranes	Occasional
Substation (Artarmon substation, Victoria Cross Station, Barangaroo Station, Pitt Street Station and southern services facility)	Visual inspection	Light vehicles	Fortnightly
	Replacement of consumables	Light and utility vehicles	Quarterly
	Major maintenance and replacement of large plant items	Heavy rigid trucks and cranes	Yearly
Water treatment plant (southern services facility)	Delivery of consumables and waste removal	Light vehicles and heavy rigid trucks	Weekly
Tunnel portals	Inspections and testing of track and in-tunnel equipment	Light vehicles	Weekly
	Track and equipment maintenance	Light and utility vehicles	Occasional

5. Mitigation measures

5.1 Construction

The planning for the projects, and the arrangements of the construction sites have been developed to avoid and minimise traffic and transport related impacts where possible. This has included:

- Haulage routes have been developed in consultation with Roads and Maritime Services and the CBD Coordination Office and have aimed to:
  - Minimise the use of local roads and use the most efficient route to the arterial road network
  - Carry out the bulk of the spoil haulage task outside of the critical Sydney CBD area
  - Avoid the use of common routes for Sydney CBD construction sites
  - Avoid routes which cross the Sydney CBD where possible.
- Selection of truck sizes at each construction site has considered a balance between reducing overall truck movements and manoeuvrability to and within the sites

The approach to traffic and transport management during the construction phase, including the process for all Traffic Management Plans, is outlined in the Construction Environmental Management Framework (Appendix D to the environmental impact statement).

The CBD Coordination Office has been established to coordinate all traffic and transport in the Sydney CBD including decisions, directions and approvals affecting all road and traffic arrangements in the Sydney CBD. Sydney Metro would liaise closely with the CBD Coordination Office during detailed construction planning and throughout construction phase to minimise the potential construction traffic impacts within the Sydney CBD, including potential cumulative impacts with other projects or special events.

A traffic and transport liaison group would also be established to liaise with relevant stakeholders during the detailed construction planning and throughout the construction of the project.

In addition to the above measures which have already been applied to the project, mitigation measures to avoid, reduce and manage the potential impacts are identified in **Table 5.1**.

Table 5.1 : Construction traffic and transport mitigation measures

Ref	Mitigation measure	Applicable locations(s)[1]
T1	Ongoing consultation would be carried out with (as relevant to the location) the CBD Coordination Office, Roads and Maritime Services, Sydney Trains, NSW Trains, local councils, emergency services and bus operators in order to minimise traffic and transport impacts during construction.	All except metro rail tunnels
T2	Road Safety Audits would be carried out at each construction site. Audits would address vehicular access and egress, and pedestrian, cyclist and public transport safety.	All except metro rail tunnels
T3	Directional signage and line marking would be used to direct and guide drivers and pedestrians past construction sites and on the surrounding network. This would be supplemented by Variable Message Signs to advise drivers of potential delays, traffic diversions, speed restrictions, or alternate routes.	All except metro rail tunnels
T4	In the event of a traffic related incident, co-ordination would be carried out with the CBD Coordination Office and / or the Transport Management Centre's Operations Manager.	All except metro rail tunnels

Ref	Mitigation measure	Applicable locations(s)[1]
T5	The community would be notified in advance of proposed road and pedestrian network changes through media channels and other appropriate forms of community liaison.	All except metro rail tunnels
T6	Vehicle access to and from construction sites would be managed to ensure pedestrian, cyclist and motorist safety. Depending on the location, this may require manual supervision, physical barriers, temporary traffic signals and modifications to existing signals or, on occasions, police presence.	All except metro rail tunnels
T7	Additional enhancements for pedestrian, cyclist and motorist safety in the vicinity of the construction sites would be implemented during construction. This would include measures such as: • Use of speed awareness signs in conjunction with variable message signs near construction sites to provide alerts to drivers • Shared experience educational events that allow pedestrians, cyclists or motorists to sit in trucks and understand the visibility restrictions of truck drivers, and for truck drivers to understand the visibility from a bicycle • Specific construction driver training to understand route constraints, expectations, safety issues and to limit the use of compression braking • Safety devices on construction vehicles that warn drivers of the presence of a vulnerable road user located in the vehicles' blind spots and warn the vulnerable road user that a vehicle is about to turn.	All except metro rail tunnels
T8	Access to existing properties and buildings would be maintained in consultation with property owners.	All except metro rail tunnels
T9	All trucks would enter and exit construction sites in a forward gear, where feasible and reasonable.	All except metro rail tunnels
T10	Any relocation of bus stops would be carried out by Transport for NSW in consultation with Roads and Maritime Services, the CBD Coordination Office (for relevant locations), the relevant local council and bus operators. Wayfinding and customer information would be provided to notify customers of relocated bus stops.	All except metro rail tunnels
T11	For special events that require specific traffic measures, those measures would be developed in consultation the CBD Coordination Office (for relevant locations), Roads and Maritime Services, and the organisers of the event.	BN, MP, PS, CS
T12	Construction sites would be managed to minimise construction staff parking on surrounding streets. The following measures would be implemented: • Encouraging staff to use public or active transport • Encouraging ride sharing • Provision of alternative parking locations and shuttle bus transfers where feasible and reasonable.	All except metro rail tunnels
T13	Construction site traffic would be managed to minimise movements in the AM and PM peak periods.	All except metro rail tunnels
T14	Construction site traffic immediately around construction sites would be managed to minimise movements through school zones during pick up and drop off times.	All except metro rail tunnels
T15	Pedestrian and cyclist access would be maintained at Crows Nest during the temporary closure of Hume Street, and at Martin Place during the temporary partial closure of Martin Place. Wayfinding and customer information would be provided to guide pedestrians and cyclists to alternative routes.	CN, MP

Ref	Mitigation measure	Applicable locations(s)[1]
T16	Timing for the temporary closure of the Devonshire Street tunnel would avoid periods of peak pedestrian demand. Wayfinding and customer information would be provided to guide pedestrians to alternative routes.	CS
T17	Consultation would occur with the Harbour Master, Roads and Maritime Services and Sydney Ferries to ensure shipping channels are maintained during the Sydney Harbour ground improvement works.	GI
T18	During the closure of existing entrances to Martin Place Station, marshalls would be provided during the AM and PM peak periods to direct customers to available access and egress points.	MP
T19	Where existing parking is removed to facilitate construction activities, alternative parking facilities would be provided where feasible and reasonable.	All except metro rail tunnels
T20	Alternative pedestrian routes and property access would be provided where these are affected during the construction of the power supply routes.	PSR

[1] STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.

5.2 Operation

As identified in Chapter 4, the metro stations have been designed to integrate with other transport modes following the integrations hierarchy of:

- Walking and cycling
- Light rail, rail and bus
- Taxis
- Kiss-and-ride
- Park-and-ride.

In addition to the measures which have already been applied to the project, mitigation measures to avoid, reduce and manage the potential operational traffic and transport impacts are identified in **Table 5.2**.

Table 5.2 : Operational traffic and transport mitigation measures

Ref	Mitigation measure	Applicable location(s)[1]
OpT1	Enhancement of pedestrian infrastructure in the vicinity of Victoria Cross and Martin Place stations would be investigated further in consultation with (as relevant to the location) the CBD Coordination Office, Roads and Maritime Services and the relevant local council.	VC, MP
OpT2	Access would be maintained to neighbouring properties.	All except metro rail tunnels

1 STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.