

Transport for NSW

Epping to Chatswood Railway – Temporary Transport Plan

10 October 2014



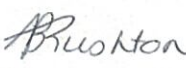


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Glossary and acronyms

Term	Definition
Average vehicle delay	Average vehicle delay is the difference between interrupted and uninterrupted travel times through the intersection and is measured in seconds per vehicle. At signalised intersections the average intersection delay is usually reported. At priority controlled intersections and roundabouts, the average delay for the most delayed movement is usually reported.
BTS	Bureau of Transport Statistics
CBD	Central business district
Degree of Saturation	Measures the ratio of demand flow to capacity. As Degree of Saturation approaches 1.0, extensive delays could be expected (refer to section 4.1.1).
Headway	A measurement of the distance or time between vehicles in a transit system. The precise definition varies depending on the application, but it is most commonly measured as the distance from the tip of one vehicle to the tip of the next one behind it, expressed as the time it will take for the trailing vehicle to cover that distance. A 'shorter' headway signifies a more frequent service.
km	kilometre
Level of Service	Basic performance parameter used to describe the operation of an intersection. Levels of service range from A (indicating good intersection operation) to F (indicating over-saturated conditions with long delays and queues) (refer to section 4.1.1).
m	metres
NWRL	North West Rail Link
PTIPS	Public Transport Information Priority System
PTPM	Public Transport Project Model
Queue length	Queue length is measured in metres reflecting the number of vehicles waiting at the stop line and is usually quoted as the 95th percentile back of queue, which is the value below which 95 per cent of all observed queue lengths fall. It reflects the number of vehicles per traffic lane at the start of the green period, when traffic starts moving again after a red signal. The intersection queue length is usually taken from the movement with the longest queue length.
RMS	Roads and Maritime Services
RTA	Roads and Traffic Authority
SCATS	Sydney Coordinated Adaptive Traffic System
SIDRA	Signalised and unsignalised Intersection Design and Research Aid
Transport for NSW	Transport for New South Wales
UAPs	Urban Activation Precincts
SRT	Sydney Rapid Transit

Executive summary

The North West Rail Link (NWRL) is a priority transport infrastructure project for the NSW Government and is the biggest transport infrastructure project in Sydney since the Harbour Bridge, opened in 1932. The NWRL will, for the first time, deliver a reliable heavy rail public transport service to the area with the highest car ownership levels per household in Australia. As an integral part of the NSW Government's Sydney's Rail Future plan, the project will feature next generation reliable, safe, state-of-the-art single deck, automated rapid transit trains.

The project includes:

- 23 kilometres (km) of new rapid transit line between Rouse Hill and Epping, including 15 km of tunnels and a 4 km skytrain viaduct.
- Eight new stations and parking for 4,000 cars.
- Conversion of the existing Epping to Chatswood railway to rapid transit standards including new platform safety screen doors and better customer amenities.

Customers will benefit from a train every 4 minutes in peak times, or 15 trains an hour. With rapid transit there will be no need for a timetable as customers can turn up and go.

The Epping to Chatswood railway forms a critical component of NWRL, as well as for NSW Government proposals to further extend rapid transit from Chatswood to North Sydney, the Sydney CBD and beyond to Bankstown. The NWRL, including converting the Epping to Chatswood railway to rapid transit, will provide significant benefits for customers through reliable and frequent train services and improved access to jobs and services. Delivery of the Epping to Chatswood railway Rapid Transit Conversion Program will initially commence with early works during weekends and with night-time possessions, to the extent that it is reasonably practical to install some equipment. These early works are expected to commence during 2015. However, the majority of works to be undertaken for the conversion program, including the commissioning of NWRL, will require an extended period of dedicated access to undertake the extensive scope of works. To provide this access, rail services between Epping and Chatswood will be temporarily removed for about 7 months (including weekdays and weekends) and is expected to commence during the second half of 2018. Additional weekend possessions of the Northern and North Shore lines will also be required during 2018 to provide access for works at the Epping and Chatswood junctions.

An interim rail service could potentially run between Epping and Chatswood for about 4 months while essential works begin to convert the Epping to Chatswood railway, subject to operational considerations closer to the start of major works.

During the temporary removal of rail services between Epping and Chatswood, replacement bus services will be required to continue the direct public transport connections between Epping, Chatswood and intermediate stations including Macquarie University, Macquarie Park and North Ryde.

This Epping to Chatswood Railway Temporary Transport Plan has been prepared to guide the development of a rail replacement bus service strategy that meets the needs of the customer during the temporary removal of rail services between Epping and Chatswood. It achieves this by:

- identifying customer experience and bus service objectives
- identifying the markets to be served by the rail replacement buses (along with the specific needs of these markets)
- outlining a service strategy (in terms of a rail replacement bus network) to meet the market needs.

The Temporary Transport Plan outlines the rail replacement bus services that will operate during the rail hours of operation. It includes the provision of additional services at interchange locations other than Epping and Chatswood to minimise the impact on customer journey times and minimise the increase in bus congestion at these locations. At the same time the Temporary Transport Plan seeks to provide efficient and customer friendly interchanges between modes and a customer friendly waiting environment.

The replacement of the Epping to Chatswood rail services with temporary bus services will result in:

- increased customer journey times
- an increase in the number of buses operating on the existing road network
- the relocations of some existing bus services at Epping and Chatswood to accommodate the additional rail replacement buses
- the temporary removal of some car parking at Epping, Chatswood and St Leonards in order to accommodate the operational requirements of the rail replacement buses.

These issues are examined throughout this Plan, giving consideration to the results from a demand assessment into forecast patronage and from traffic modelling of key intersections to be used by the rail replacement bus services.

Temporary Transport Plan

The Epping to Chatswood Railway Temporary Transport Plan is guided by customer experience and bus operational objectives as well as demand forecasts prepared by Transport for NSW's Bureau of Transport Statistics (BTS) using the Public Transport Project Model (PTPM).

The PTPM was developed as a project-specific demand model to provide patronage forecasts for the NWRL. PTPM is currently the best available source of patronage information for the NWRL and has been used to forecast, estimate and inform demand for the rail replacement bus services as part of the Temporary Transport Plan.

A five route bus strategy has been developed in response to customer objectives, bus operational objectives and demand forecasts. The foundations of this strategy are:

- Route 1: A base rail replacement bus service that will operate during the rail hours of operation every day (Route 1). This base service will replicate the rail service stopping all stations between Epping and Chatswood. This service is proposed to form the accessible service and would need to be provided with accessible buses.
- Route 2: An additional rail replacement bus route during peak hours to provide a faster connection between Epping and Chatswood by operating as a limited-stops route (Route 2).
- Routes 3, 4 and 5: Additional rail replacement bus routes that operate to/from stations other than Epping and Chatswood during peak hours (Routes 3, 4 and 5). The provision of services to interchange locations other than Epping and Chatswood provides a more competitive journey time (compared to the Route 1 all stations service) for some customers and will minimise the increase in bus congestion at Epping and Chatswood.

These routes along with their proposed operations are outlined in Table ES.1.

Table ES.1 Epping to Chatswood rail replacement bus routes and proposed operations

Route	Stations served	Times of operation ¹	Proposed operations
1	Epping Macquarie University Macquarie Park North Ryde Chatswood	Full time (hours of rail operations)	<ul style="list-style-type: none"> All stations service in both directions.
2	Epping North Ryde Chatswood	Peak periods only	<ul style="list-style-type: none"> Morning peak period buses operate from Epping to Chatswood via North Ryde. Evening peak period buses operate from Chatswood to Epping via North Ryde.
3	Beecroft Macquarie University Macquarie Park St Leonards	Peak periods only	<ul style="list-style-type: none"> Morning peak period buses operate from Beecroft to St Leonards via Macquarie University and Macquarie Park. Evening peak period buses operate from St Leonards to Beecroft via Macquarie Park and Macquarie University.
	Macquarie University Macquarie Park St Leonards	Peak periods only	<ul style="list-style-type: none"> Morning peak period buses operate from St Leonards to Macquarie University via Macquarie Park. Evening peak period buses operate from Macquarie University to St Leonards via Macquarie Park.
4	Eastwood Macquarie University Macquarie Park	Peak periods only	<ul style="list-style-type: none"> Morning peak period buses operate from Eastwood to Macquarie Park via Macquarie University. Evening peak period buses operate from Macquarie Park to Eastwood via Macquarie University.
5	Gordon Macquarie Park Macquarie University	Peak periods only	<ul style="list-style-type: none"> Morning peak period buses operate from Gordon to Macquarie University via Macquarie Park. Evening peak period buses operate from Macquarie University to Gordon via Macquarie Park.

These routes are shown in Figure ES.1.

¹ Morning peak: Approximately 6.00 am to 10.00 am. Evening peak: Approximately 3.00 pm to 7.00 pm

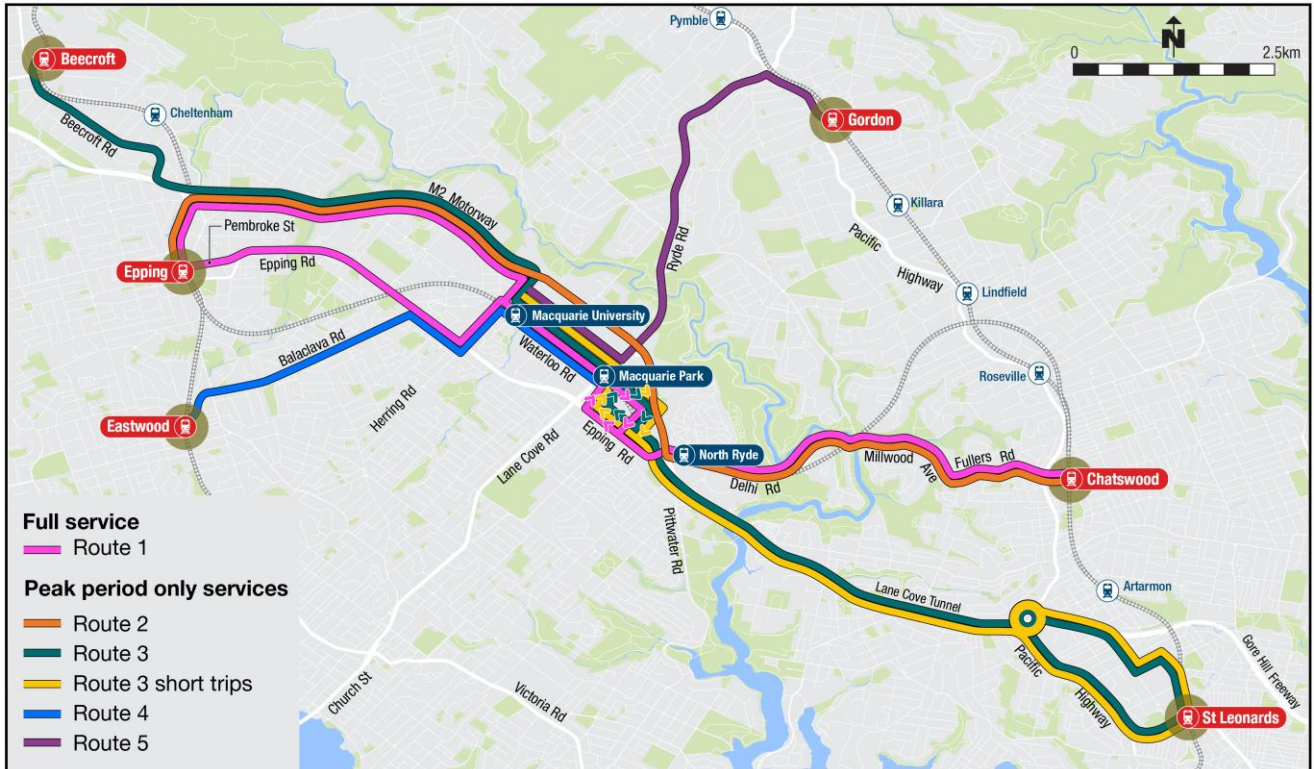


Figure ES.1 Epping to Chatswood rail replacement bus network

Benefits of the proposed five route rail replacement bus network are that it:

- minimises the numbers of customers required to interchange between bus and rail at Epping and Chatswood during the morning and evening peak periods
- supports a more manageable interchange at Epping and Chatswood, minimising the impact on local amenity
- provides customers with bus routes from other stations, which minimise travel time impacts for some customers compared to the alternative of interchanging at either Epping or Chatswood.

Traffic modelling

Traffic intersection modelling has been used to test the impacts the rail replacement buses would have on general traffic, and to identify potential traffic congestion points for the replacement bus routes. This involved:

- modelling key intersections
- testing alternative operational arrangements for rail replacement buses.

Traffic modelling was undertaken through the use of software that models intersections as a network rather than in isolation, allowing the interaction of queues between intersections to be modelled. Due to the large number of intersections used by the proposed rail replacement bus routes, key intersections were modelled to focus efforts on addressing the main issues and investigate the locations where the greatest benefit could be realised. Based on the proposed bus routes, their combined frequencies and an assessment of the traffic conditions along the route, 24 intersections were identified for assessment.

Results of the intersection modelling have been summarised based on their:

- Level of Service – basic performance parameter used to describe the operation of an intersection
- Degree of Saturation – the ratio of demand flow to capacity
- Average Vehicle Delay
- Queue Length.

The results for the 2013 existing situation (base case) intersection modelling confirms on-site observations that parts of the road network currently experience heavy congestion. In particular:

- Delhi Road, Epping Road, Lane Cove Road, Beecroft Road and the Pacific Highway experience a high traffic demand
- signal coordination is given (where possible) to these roads at the signalised intersections, however there are still high levels of congestion in both the morning and evening peak periods
- at many locations, queues were observed to extend from one intersection through to the next, impacting on intersection throughput
- a number of the assessed intersections are operating at near to capacity or at capacity (with a Level of Service D, E or F) in either or both peaks.

Background traffic growth from 2013 to 2019 is forecast to increase congestion and delays by less than 10 seconds per intersection. The addition of the rail replacement buses results in a marginal increase in average delays in addition to the background growth impact. Overall, the addition of the rail replacement buses has little impact on intersection performance; however some movements/approaches are affected more than others. The largest increase in average intersection delay is 25 seconds per vehicle at the intersection of Waterloo Road/Khartoum Road in the evening peak.

In general, results from the traffic modelling indicated that the road network can accommodate the rail replacement buses without modification, excepting the intersection of Epping Road, Langston Place and Blaxland Road, which requires a buses only signal phasing (B-signal).

Key findings

The key findings of the Temporary Transport Plan include:

- Providing a five route bus strategy during weekday morning and evening peak periods best meets the broad customer and bus operational objectives of minimising the impact to customers during the temporary removal of rail services between Epping and Chatswood, and of using bus resources efficiently. On the weekends and off peak periods, Route 1 will continue to provide services between Epping and Chatswood.
- Over a 24 hour period on a typical weekday, approximately 14,000 customers (28,000 trips) are forecast to use the rail replacement bus service during temporary removal of rail services between Epping and Chatswood.
- Delivery of the five route bus service strategy on a weekday will require a bus fleet of approximately 64 buses during the morning peak period and 75 buses during the evening peak period.

- The proposed scope of works for temporary facilities to support the Temporary Transport Plan includes the following items:
 - ▶ additional bus spaces, shelters and seats at selected locations
 - ▶ static signage at all locations
 - ▶ buses only signal phasing (B Signal) at Epping (Langston Place and Beecroft Road)
 - ▶ temporary removal of time restricted on-street car parking at Epping, Chatswood and St Leonards
 - ▶ temporary relocation of selected bus stops at Epping and Chatswood.
- Effective and targeted customer communication will be critical given the different routes and hours of operation for the Temporary Transport Plan, for example some routes only operate in morning and evening peak periods in the peak travel direction. While common pick-up stops for all rail replacement bus routes have been provided where possible to minimise customer confusion, there are some locations where the morning and evening peak period set-down bus stops are different (e.g. Chatswood Station). Bus marshals will be provided at all rail replacement bus service Route 1 locations at all times as well as at all departure locations for other peak period services to provide a customer service function and to support the efficient departure of buses from these stops. A detailed communications program will be implemented prior to the commencement of the temporary rail replacement bus services.

Changes to customer journey time are dependent on the customer's origin and destination, road network conditions as well as the time of day of travel. Bus travel times have been minimised where practical through the:

- provision of a limited-stops service during peak periods
- services to/from non-Epping to Chatswood railway stations which operate direct to Macquarie Park and Macquarie University during peak periods.

Bus journey times are however longer than train travel times due to the varying day to day road network conditions and the absence of a dedicated corridor. Customers interchanging between buses and trains will need to allow extra travel time for these interchanges. Customers travelling between the T1 Northern and North Shore lines who do not require access to Epping to Chatswood railway stations are encouraged to use the rail alternative via Strathfield or via Hornsby due to better journey time certainty for train travel.

Conclusions

The Epping to Chatswood Railway Temporary Transport Plan provides a balance between minimising customer impacts and minimising impacts on surrounding areas.

The Temporary Transport Plan responds to market needs, customer experience objectives and bus service objectives. The Plan responds to customer needs by:

- responding to identified customer markets and forecast levels of demand
- providing a limited-stops service in peak periods and connections to/from non-Epping to Chatswood railway stations
- minimising the congestion impacts at Epping and Chatswood transport interchanges in the peak periods
- minimising transfer times between rail and bus for Epping to Chatswood railway customers by providing rail replacement bus stops close to the rail stations
- identifying bus stop and supporting temporary facilities to provide a customer friendly environment.

Operational needs are met by:

- minimising the impacts on regular route buses by providing separate pick-up and set-down areas for rail replacement buses at locations where practical
- identifying bus stop and supporting temporary facilities to provide an efficient environment for buses to operate
- providing common pick-up stops for all rail replacement bus routes, where possible, minimising customer confusion
- responding to the specific functional requirements at each station served by rail replacement bus routes.

Impacts on surrounding areas and other customers have been minimised by:

- having bus routes operate across many locations to minimise congestion impacts at Epping and Chatswood transport interchanges
- providing bus stops which are separate to existing bus services where possible
- providing only temporary facilities to support bus operations which will be removed following opening of NWRL when the temporary bus services cease to operate
- continuing the operation of existing bus services and minimising the impact to these by relocating only selected existing bus services at Epping and Chatswood that are of a lower frequency compared to the rail replacement bus services.

Next steps

The Epping to Chatswood Railway Temporary Transport Plan provides a framework for the development of a rail replacement bus service strategy whilst minimising associated customer impacts during the temporary removal of rail services between Epping and Chatswood.

Further demand refinement will continue as part of the next steps in the development of the Temporary Transport Plan in order to determine the appropriate scenario for implementation during the temporary removal of rail services between Epping and Chatswood, taking into account changes to demand (including new information made available through the introduction of Opal) and traffic conditions.

The Temporary Transport Plan will be refined over time in the lead up to implementation. In the early weeks of the temporary rail replacement bus operations, performance of the Temporary Transport Plan will be monitored and changes made where practical and appropriate.

1. Introduction

1.1 Background

The North West Rail Link (NWRL) The North West Rail Link (NWRL) is a priority transport infrastructure project for the NSW Government and is the biggest transport infrastructure project in Sydney since the Harbour Bridge, opened in 1932. The NWRL will, for the first time, deliver a reliable heavy rail public transport service to the area with the highest car ownership levels per household in Australia. As an integral part of the NSW Government’s Sydney’s Rail Future plan, the project will feature next generation reliable, safe, state-of-the-art single deck, automated rapid transit trains.

The project includes:

- 23 kilometres (km) of new rapid transit line between Rouse Hill and Epping, including 15 km of tunnels and a 4 km skytrain viaduct.
- Eight new stations and parking for 4,000 cars
- Conversion of the existing Epping to Chatswood railway to rapid transit standards including new platform safety screen doors and better customer amenities.

Customers will benefit from a train every four minutes in peak times, or 15 trains an hour. With rapid transit there will be no need for a timetable as customers can turn up and go.

An overview of the NWRL and Epping to Chatswood railway is shown in Figure 1.1.

The first 15.5 km of the NWRL, between Epping Station and Bella Vista will be new underground twin tunnels, while a 4.2 km Skytrain viaduct will link Bella Vista and Rouse Hill. A further 4 km of viaduct, bridge and earthworks will be constructed between Rouse Hill and Cudgegong Road. The NWRL will also incorporate eight new stations at Cherrybrook, Castle Hill, Showground, Norwest, Bella Vista, Kellyville, Rouse Hill and Cudgegong Road.

Conversion of the Epping to Chatswood railway to rapid transit operations will require the temporary removal of rail services between Epping and Chatswood for the duration of about 7 months to provide dedicated access for the conversion works. During the temporary removal of rail services between Epping and Chatswood replacement buses will be required to maintain the direct public transport connections between Epping, Chatswood and intermediate stations including Macquarie University, Macquarie Park and North Ryde.

This Epping to Chatswood Railway Temporary Transport Plan has been prepared to guide the development of a rail replacement bus strategy that meets the needs of the customer during the temporary removal of rail services between Epping and Chatswood.



Source: Transport for NSW, 2013

Figure 1.1 Overview of the North West Rail Link and Epping to Chatswood railway

1.2 Project benefits

The NWRL, including conversion of the Epping to Chatswood railway to rapid transit operations, is a key priority passenger rail transport infrastructure project for the NSW Government and will operate as the first rapid transit rail system in NSW. The NWRL will bring a number of benefits to customers, including:

- a train at least every 4 minutes in peak times – rapid transit trains will mean there is no need for a timetable – customers will be able to just turn up and go
- next generation of fast, safe and reliable single deck trains
- high levels of customer safety including CCTV monitoring and platform screen doors on the station
- more train services between Epping and Chatswood including Macquarie University and Macquarie Park
- travel time savings from many areas of the north-west district to the central business district (CBD) and Macquarie Park
- travel time savings within the region, including to the Rouse Hill Town Centre, Norwest and Castle Hill
- new train services to existing suburbs in the Hills District as well as new areas that are planned for residential and commercial development
- bicycle, bus, taxi and car parking at stations.

Together with other rail infrastructure identified in *Sydney's Rail Future Modernising Sydney's Trains* (NSW Government 2012), key customer benefits include the ability to carry an additional 90,000 to 100,000 people per hour via rail in the peak hours and the reduction in the time trains dwell at stations and improved platform efficiency, resulting in faster, more reliable rail services.

The NWRL is Stage Three of Sydney's Rail Future.

Stage Four of Sydney's Rail Future is SRT – Sydney Rapid Transit. This proposed project will extend the NWRL beyond Chatswood to North Sydney, Sydney Harbour and the CBD. A western extension will take rapid transit to Bankstown.

Under SRT and a Western Sydney Rail Infrastructure Upgrade Program, capacity will be improved across the network with a 60 per cent increase in the number of trains. SRT will feature up to 30 trains in each direction an hour through the CBD.

1.3 Epping to Chatswood railway Rapid Transit Conversion Program

Delivery of the NWRL is planned to occur during the following stages:

- construction of the new section Cudgegong Road to Epping (currently underway)
- conversion of the Epping to Chatswood railway to rapid transit operations and full line systems commissioning and integration.

The NWRL (including the converted Epping to Chatswood railway) is anticipated to be operational during the first half of 2019.

Activities required to convert the Epping to Chatswood railway to rapid transit operations include:

- Segregation of the Epping to Chatswood railway operations from the Sydney Trains network, including removal of the existing track connections at Epping and Chatswood.
- Removal and reconfiguration of the overhead lines and changes to the signalling between the Epping to Chatswood railway and the Sydney Trains network. The Epping to Chatswood railway will remain physically connected through platforms, stairs, lifts and escalators at these stations for customer interchange.
- Changes to the existing track network to the south of Chatswood Station to enable connection to a proposed future second harbour crossing as part of the SRT.
- Changes to each station such as reconfiguration of platform seating, signage and other infrastructure and installation of platform screen doors, new signage, chiller units and customer information displays and modifications to station rooms.
- Removal of equipment no longer needed in the Epping to Chatswood railway tunnel.
- New cable routes to accommodate the NWRL and Sydney Trains services.
- Modifications to electrical, signalling, communications, fire and safety and mechanical systems.
- Segregation of the existing Chatswood North substation from the Sydney Trains network for use in the future operation of the NWRL.

Indicative illustrations of the modified Macquarie Park Station platform are provided in Figure 1.2 and Figure 1.3.



Figure 1.2 Indicative illustration of the proposed Macquarie Park Station showing new platform configuration



Figure 1.3 Indicative illustration of the proposed Macquarie Park Station showing new platform configuration (upper)

Delivery of the Epping to Chatswood railway Rapid Transit Conversion Program will initially commence with early works being undertaken during weekends and with night-time possessions to the extent that is reasonably practical to install some equipment. These early works are expected to commence during 2015. However, the majority of works associated with the conversion program, including the commissioning of NWRL, will require an extended period of dedicated access to undertake the extensive scope of works. To provide this access, rail services between Epping and Chatswood will be temporarily removed for a period of about 7 months (weekdays and weekends), expected to commence during the second half of 2018. Additional weekend possessions of the Northern and North Shore lines will also be required during 2018 to provide access for works at the Epping and Chatswood junctions.

An interim rail service could potentially run between Epping and Chatswood for about 4 months while essential works begin to convert the Epping to Chatswood railway, subject to operational considerations closer to the start of major works.

Table 1.1 shows the anticipated stages for the Epping to Chatswood railway Rapid Transit Conversion Program and commissioning of NWRL.

Table 1.1 Epping to Chatswood railway Rapid Transit Conversion Program anticipated stages

Stage	Northern Line services	Customer changes
Current timetable	<ul style="list-style-type: none"> ■ Northern Line services operate as current: <ul style="list-style-type: none"> ▶ Hornsby to the CBD via Macquarie Park ▶ Epping to the CBD via Strathfield. 	<ul style="list-style-type: none"> ■ Nil
Proposed interim rail service between Epping and Chatswood	<ul style="list-style-type: none"> ■ Northern Line services from Hornsby are diverted to the CBD via Strathfield. ■ Epping to the CBD via Strathfield services continue to operate as current. ■ An interim rail service is proposed to operate between Epping and Chatswood. ■ During any weekend possessions of the Epping to Chatswood railway, customers would be required to use a rail replacement bus service. 	<ul style="list-style-type: none"> ■ Customers between Normanhurst and Cheltenham travelling to the CBD now travel via Strathfield. ■ Customers accessing Epping to Chatswood railway stations interchange to a rail service at either Epping or Chatswood.
Temporary removal of rail services on the Epping to Chatswood railway	<ul style="list-style-type: none"> ■ Rail replacement bus services operate to serve the Epping to Chatswood railway stations during the temporary removal of rail services. ■ Northern Line services continue to operate to/from the CBD via Strathfield. 	<ul style="list-style-type: none"> ■ Customers accessing Epping to Chatswood railway stations, or travelling between Epping and Chatswood, interchange at Epping or Chatswood to a rail replacement bus service. ■ Supplementary bus services are provided in morning and evening peak periods to and from selected non-Epping to Chatswood railway stations.
Opening of NWRL	<ul style="list-style-type: none"> ■ Northern Line services continue to operate to/from the CBD via Strathfield. ■ Rail replacement buses will cease to operate. 	<ul style="list-style-type: none"> ■ Customers interchange at Epping and Chatswood to access NWRL services operating between Cudgegong Road and Chatswood.

1.4 Purpose of the Temporary Transport Plan

The purpose of this Temporary Transport Plan is to guide the planning for the Epping to Chatswood railway Rapid Transit Conversion Program. Essentially it identifies the requirements necessary for ensuring that the rail replacement bus services continue to provide direct public transport connections during the proposed temporary removal of rail services whilst minimising customer inconvenience.

The replacement of the rail services between Epping and Chatswood with temporary bus services will result in:

- increased customer journey times
- an increase in the number of buses operating on the existing road network
- the relocations of some existing bus services at Epping and Chatswood to accommodate the additional rail replacement buses
- the temporary removal of some car parking at Epping, Chatswood and St Leonards in order to accommodate the operational requirements of the rail replacement buses.

These issues are examined throughout this report, giving consideration to the results from a demand assessment into forecast patronage and from traffic modelling of key intersections to be used by the rail replacement bus services.

Following the Epping to Chatswood railway Rapid Transit Conversion Program, the NWRL will open and the rail replacement buses will cease to operate.

1.5 Methodology used to develop the Temporary Transport Plan

Table 1.2 summarises the approach adopted for the development of the Temporary Transport Plan. Further details are provided in the relevant chapters of this report.

Table 1.2 Project methodology

Step	Task	How the task is delivered
1	Summarise operating concept for the Temporary Transport Plan (Chapter 2)	<ul style="list-style-type: none"> ■ Customer experience objectives are identified. ■ Bus service objectives are identified. ■ The markets to be served by the rail replacement buses are identified. ■ A service strategy to meet the objectives for customer experience, bus services and the market needs is developed. ■ The specific route requirements for the rail replacement bus services are identified.
2	Demand assessment (Chapter 3)	<ul style="list-style-type: none"> ■ Public Transport Project Model (PTPM) outputs are used to quantify the peak numbers of passengers for each rail replacement bus route. ■ Forecast passenger demand is determined for each bus route based on the preferred demand scenario. ■ Indicative peak hour frequencies for buses are determined based on the forecast passenger demand associated with the preferred demand scenario. ■ Bus service requirements across the rest of the day and other periods of lower demand such as school holidays are developed based on existing information on the distribution of passengers to Epping to Chatswood railway stations.

Step	Task	How the task is delivered
3	Undertake traffic intersection modelling (Chapter 4 and Appendix C).	<ul style="list-style-type: none"> ■ Traffic intersection modelling has been undertaken to test the impacts of the rail replacement buses would have on general traffic. ■ Potential traffic congestion points for the replacement bus routes are identified.
4	Confirm the operational requirements for the Temporary Transport Plan (Chapter 4).	<ul style="list-style-type: none"> ■ The functional requirements for rail replacement bus routes at each railway station are identified. ■ The pick-up and set-down arrangements for buses at each station are developed in response to the functional requirements and in response to the outcomes of traffic modelling. ■ Recommendations are developed for how rail replacement buses interact with regular route buses at railway stations. ■ Identification of the scope of works for temporary facilities at each station, to support the Temporary Transport Plan.
5	Estimate travel times and average speeds for the rail replacement bus services (Chapter 5).	<ul style="list-style-type: none"> ■ Bus travel times (morning peak, evening peak, off peak and weekends) for customers accessing the rail replacement bus routes are estimated.
6	Determine the operating and indicative fleet requirements for the Temporary Transport Plan (Chapter 6)	<ul style="list-style-type: none"> ■ Operating requirements for the rail replacement bus services are identified. ■ Bus fleet requirements are calculated using the travel time assumptions and demand levels associated with each rail replacement bus route.
7	Assess the Temporary Transport Plan against objectives (Chapter 7).	<ul style="list-style-type: none"> ■ The Temporary Transport Plan is assessed against the customer experience and bus service objectives identified from step 1 (Chapter 2).

1.5.1 Engagement

The development and evaluation of this Temporary Transport Plan, has been undertaken in collaboration with the following representatives within Transport for NSW:

- Service Planning and Improvement Branch, Transport Services division
- Sydney Trains Trackwork Transport
- Roads and Maritime Services (RMS)
- Bureau of Transport Statistics (BTS), Planning and Programs
- members of the NWRL project team.

An extensive stakeholder and community engagement program will be undertaken as part of the Review of Environmental Factors (REF) for the conversion program. This will include major business associations, education facilities, councils and peak groups which have a direct relationship to the Epping to Chatswood railway.

Community and stakeholder input will be carefully considered as part of the Transport for NSW decision-making process.

An extensive community and stakeholder communications and awareness program will be developed and undertaken prior to implementation of the Temporary Transport Plan.

2. Development of the Temporary Transport Plan

This chapter provides an overview of how the Temporary Transport Plan for replacing train services between Epping and Chatswood with weekday and weekend bus services over an extended period has been developed. Development of the Plan has involved:

- identification of customer experience and bus service objectives
- identification of the markets to be served by the rail replacement buses (along with the specific needs of these markets)
- development of a service strategy (in terms of a replacement bus network) to meet the market needs.

Each of these is discussed in the following sections.

2.1 Temporary Transport Plan objectives

The overall objectives of the Temporary Transport Plan relate to customer experience and to the operation of the rail replacement bus services.

The primary customer experience objective is:

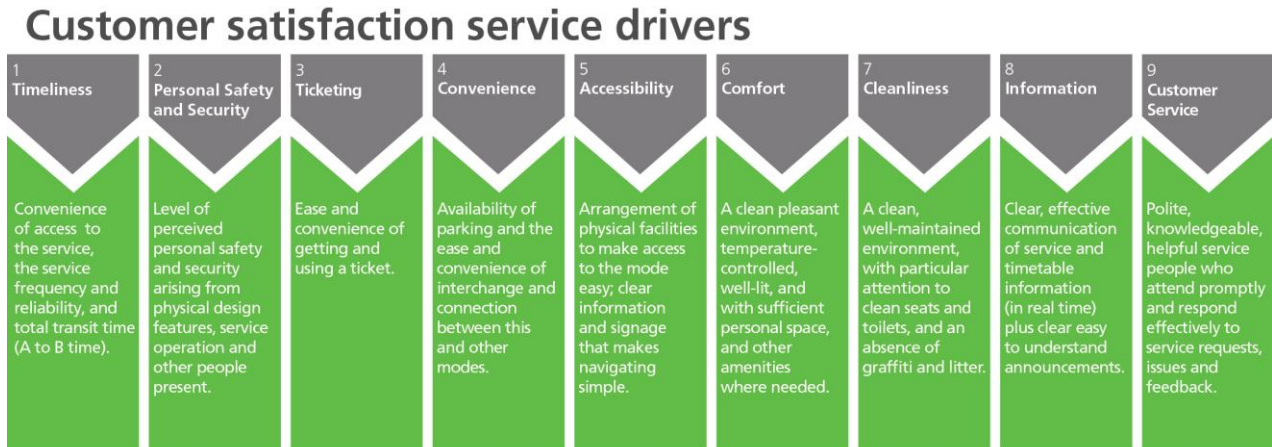
To minimise the impact for customers of temporarily replacing rail services on the Epping to Chatswood railway with a replacement bus service.

The primary bus services objective is:

To provide a balance between minimising customer impacts and efficient use of bus resources.

2.1.1 Customer experience

Transport for NSW has identified nine customer satisfaction service drivers which combine to deliver a positive customer experience. These drivers, and the areas they cover, are outlined in Figure 2.1.



Source: Transport for NSW

Figure 2.1 Customer satisfaction service drivers

To achieve its overall objectives the Temporary Transport Plan must also address these customer satisfaction service drivers.

Table 2.1 shows the specific requirements to deliver the Temporary Transport Plan objectives, and how they relate to the Transport for NSW customer satisfaction service drivers. The Temporary Transport Plan objectives listed in Table 2.1 were developed in collaboration with selected Transport for NSW representatives. The requirements listed in Table 2.1 have been used to develop the Temporary Transport Plan outlined in section 2.3. An assessment as to whether the Temporary Transport Plan and associated operational arrangements meets these customer experience and bus service objectives is provided in Chapter 7: *Meeting the Temporary Transport Plan objectives*.

Table 2.1 Requirements for delivering the Temporary Transport Plan objectives

Temporary Transport Plan objectives		Relevant Transport for NSW customer satisfaction service drivers
Customer service objective	Bus services objective	
Provide a rail replacement bus service that serves identified customer markets.	Minimise disruption to existing rail and bus customers.	<ul style="list-style-type: none"> ■ Timeliness ■ Convenience
Provide an efficient and customer friendly interchange between modes.	Not adversely impact the movement of pedestrians, nor the efficiency of regular bus services.	<ul style="list-style-type: none"> ■ Accessibility ■ Timeliness
Provide a customer friendly waiting environment.	Be operationally effective and efficient.	<ul style="list-style-type: none"> ■ Comfort ■ Cleanliness
Provide clear communication to customers regarding all aspects of the Temporary Transport Plan.	Bus and rail staff communicate with the customers to ensure that the travel options and changes are clearly understood.	<ul style="list-style-type: none"> ■ Customer service ■ Information ■ Ticketing
Maintain functionality for those not directly affected by the Temporary Transport Plan.	Provide sufficient capacity for passengers.	<ul style="list-style-type: none"> ■ Convenience ■ Accessibility ■ Customer service

2.2 Identification of customer markets

Identifying the specific customer markets to be served by the rail replacement bus services is an important factor in developing the Temporary Transport Plan. The markets demonstrate the different ways in which Epping to Chatswood railway services are used, and how the Epping to Chatswood railway interacts with the wider rail network. The markets are not derived from specific origin-destination data, but are derived from the different functions the Epping to Chatswood railway serves.

Five customer markets were identified, namely:

1. Northern Line customers boarding between Hornsby and Cheltenham who currently have a direct rail service to the CBD and lower North Shore via the Epping to Chatswood railway.
2. Epping to Chatswood railway customers boarding between Epping and Chatswood who currently have a direct rail service to stations south of Chatswood, to the CBD via the Epping to Chatswood railway and to upper Northern Line stations between Epping and Hornsby.
3. Customers from the Northern Line (south of Epping) who currently interchange to Epping to Chatswood railway trains at Epping.
4. Customers who interchange to Epping to Chatswood railway services at points south of Chatswood if they do not join a direct service from the CBD to the Epping to Chatswood railway stations.
5. Customers from the North Shore Line (north of Chatswood) who currently interchange to Epping to Chatswood railway services at Chatswood.

These five customer markets are shown in Figure 2.2.

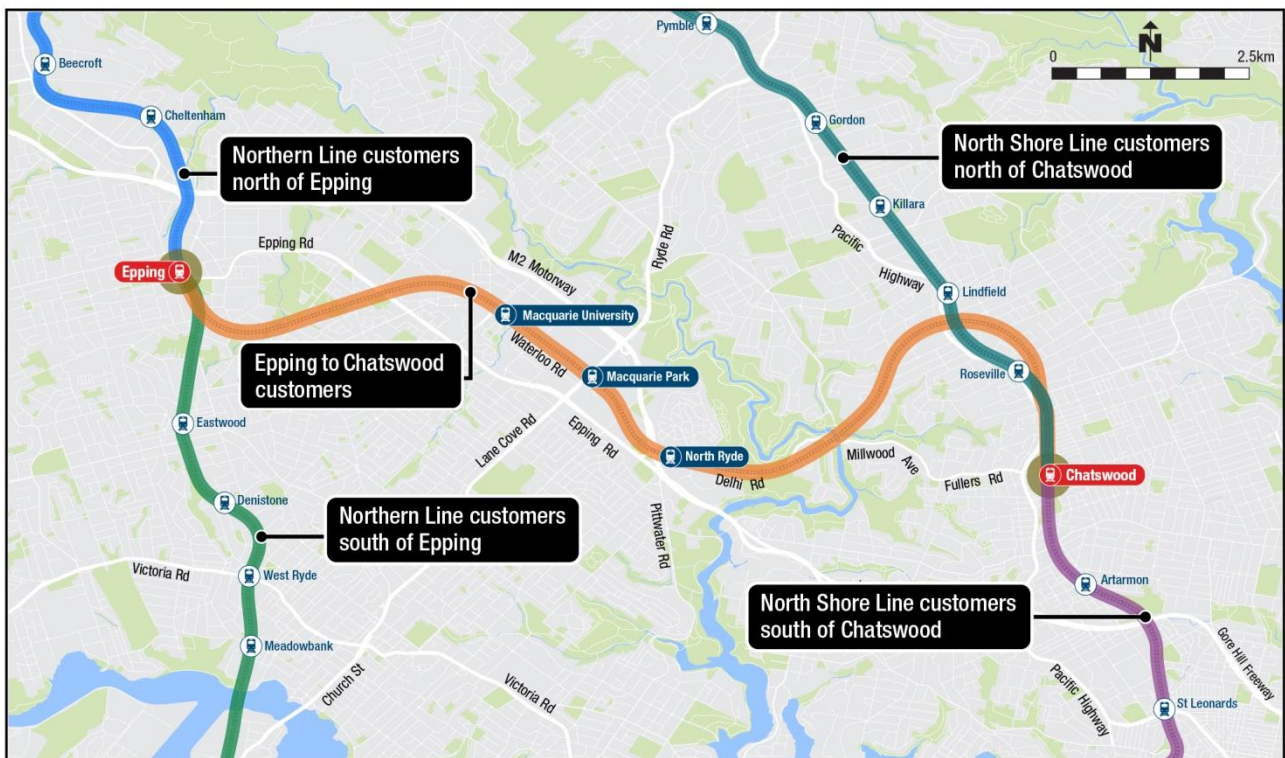


Figure 2.2 Epping to Chatswood railway customer markets

2.3 Rail replacement bus routes

A five route bus strategy has been developed to respond to the customer experience objectives, bus service objectives and the identified customer markets. The foundations of this strategy are:

- A base rail replacement bus service will operate during the rail hours of operation every day (Route 1). This base service will replicate the rail service stopping all stations between Epping and Chatswood. This service is proposed to form the accessible service and would need to be provided with accessible buses.
- An additional rail replacement bus route during peak hours to provide a faster connection between Epping and Chatswood by operating as a limited-stops route (Route 2).
- Additional rail replacement bus routes that operate to/from stations other than Epping and Chatswood during peak hours (Routes 3, 4 and 5). The provision of services to interchange locations other than Epping and Chatswood provide a more competitive journey time (compared to the Route 1 all stations service) for some customers and will minimise the increase in bus congestion at Epping and Chatswood.

Further details on these routes are outlined in the following sections.

2.3.1 Route 1

Route 1 provides a base rail replacement bus service, which replicates the rail service stopping all stations between Epping and Chatswood during all hours of rail operation. Route 1:

- serves the market for Epping to Chatswood railway customers boarding between Epping and Chatswood
- serves all other customer markets during the off peak and weekends, by providing rail to bus interchange at Epping and Chatswood
- provides consistency between the existing rail service and the temporary rail replacement bus service
- ensures that customers who are unaware of the temporary removal of rail services, and who arrive at an Epping to Chatswood railway station expecting to use a train, will be provided with a like for like replacement bus service across all times of the day and days of the week (during the hours of rail operations).

Route 1 is shown in Figure 2.3.

2.3.2 Route 2

Route 2 provides a limited-stops variant of the Route 1 service during peak hours only. Route 2:

- provides faster travel times than the Route 1 service between Epping, North Ryde and Chatswood
- operates from Epping to Chatswood in the morning peak period and from Chatswood to Epping in the evening peak period.

Route 2 is shown in Figure 2.4.

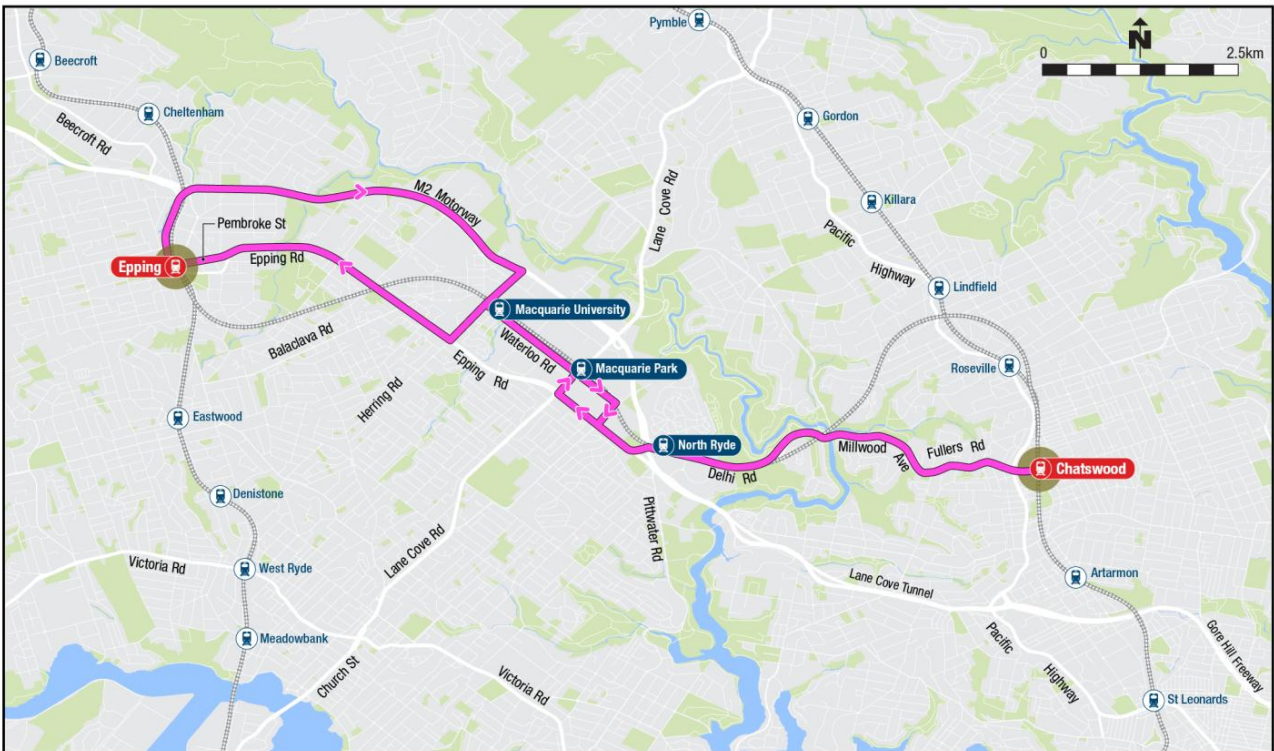


Figure 2.3 Rail replacement bus service - Route 1

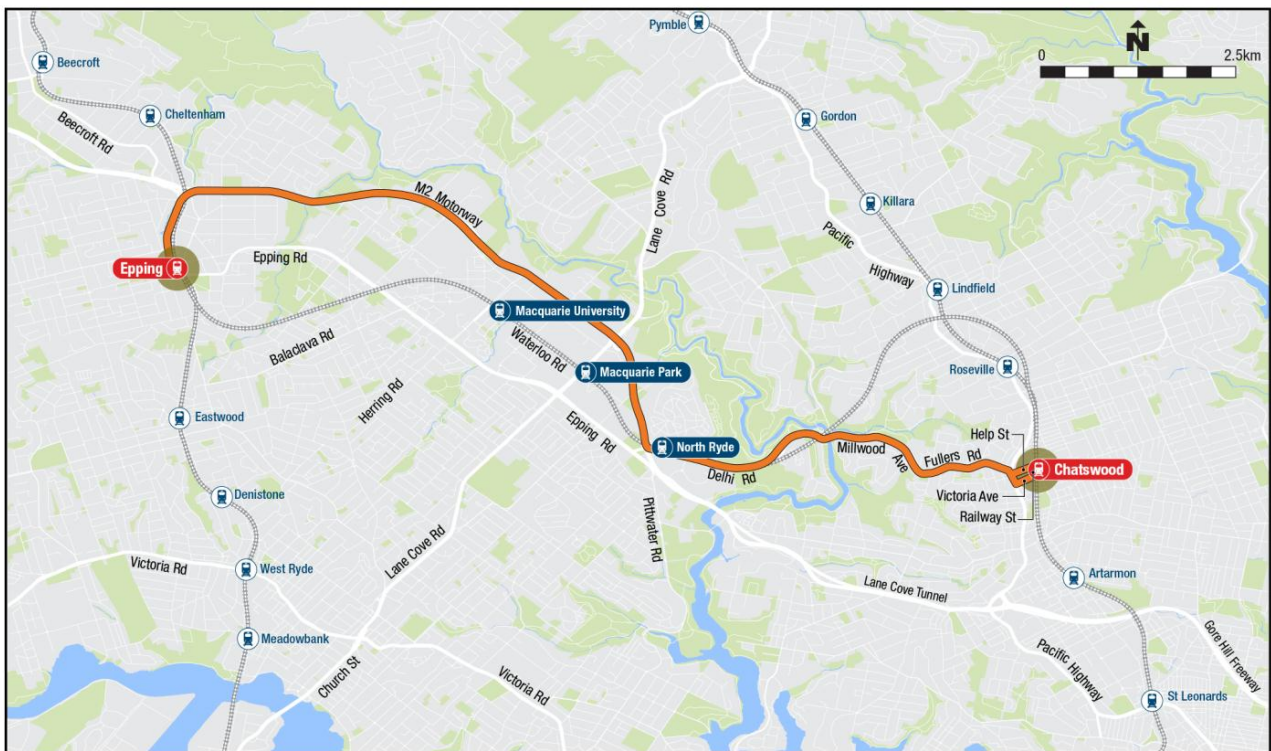


Figure 2.4 Rail replacement bus service - Route 2

2.3.3 Routes 3, 4 and 5

Routes 3, 4 and 5 provide direct peak period services from non-Epping to Chatswood railway stations to Macquarie Park and Macquarie University in the morning peak and from Macquarie Park and Macquarie University to non-Epping to Chatswood railway stations in the evening peak.

These additional peak period bus routes intercept rail customers at points on the Northern Line before Epping Station (at Eastwood and Beecroft) and on the North Shore Line before Chatswood Station (at Gordon and St Leonards). The following factors were taken into consideration when determining these passenger transfer locations:

- Eastwood Station is the closest station to Epping to the south. It has existing infrastructure to support bus/rail interchange, and has a direct route between Eastwood and Macquarie University via Balaclava Road, Epping Road and Herring Road.
- Although Cheltenham Station is closer to Epping, Beecroft Station is preferred as the location for passengers to transfer between bus and rail north of Epping. This is because it has existing infrastructure to support bus/rail interchange, and because Cheltenham Station is not currently served by bus.
- Although Artarmon Station is closer to Chatswood, St Leonards Station is preferred as the location for passengers to transfer between bus and rail south of Chatswood. This is because it has existing infrastructure to support bus/rail interchange, and it provides direct access for buses to/from the Lane Cove Tunnel and Epping Road. In addition Artarmon Station is not currently served by bus.
- Although Killara, Lindfield and Roseville stations are closer to Chatswood, Gordon Station is preferred as the location for passengers to transfer between bus and rail north of Chatswood. This is because it has existing infrastructure to support bus/rail interchange, and because it provides a direct route to Macquarie Park and Macquarie University via the Pacific Highway and Ryde Road.

These locations minimise the numbers of customers required to interchange between bus and rail at Epping and Chatswood stations thereby supporting a more manageable interchange and minimising the impact on local amenity. The numbers of buses required to facilitate interchange at Epping and Chatswood stations is also minimised by spreading fleet numbers across a number of other locations. The indicative rail catchments for Routes 3, 4 and 5 of the rail replacement bus service are shown in Figure 2.5.

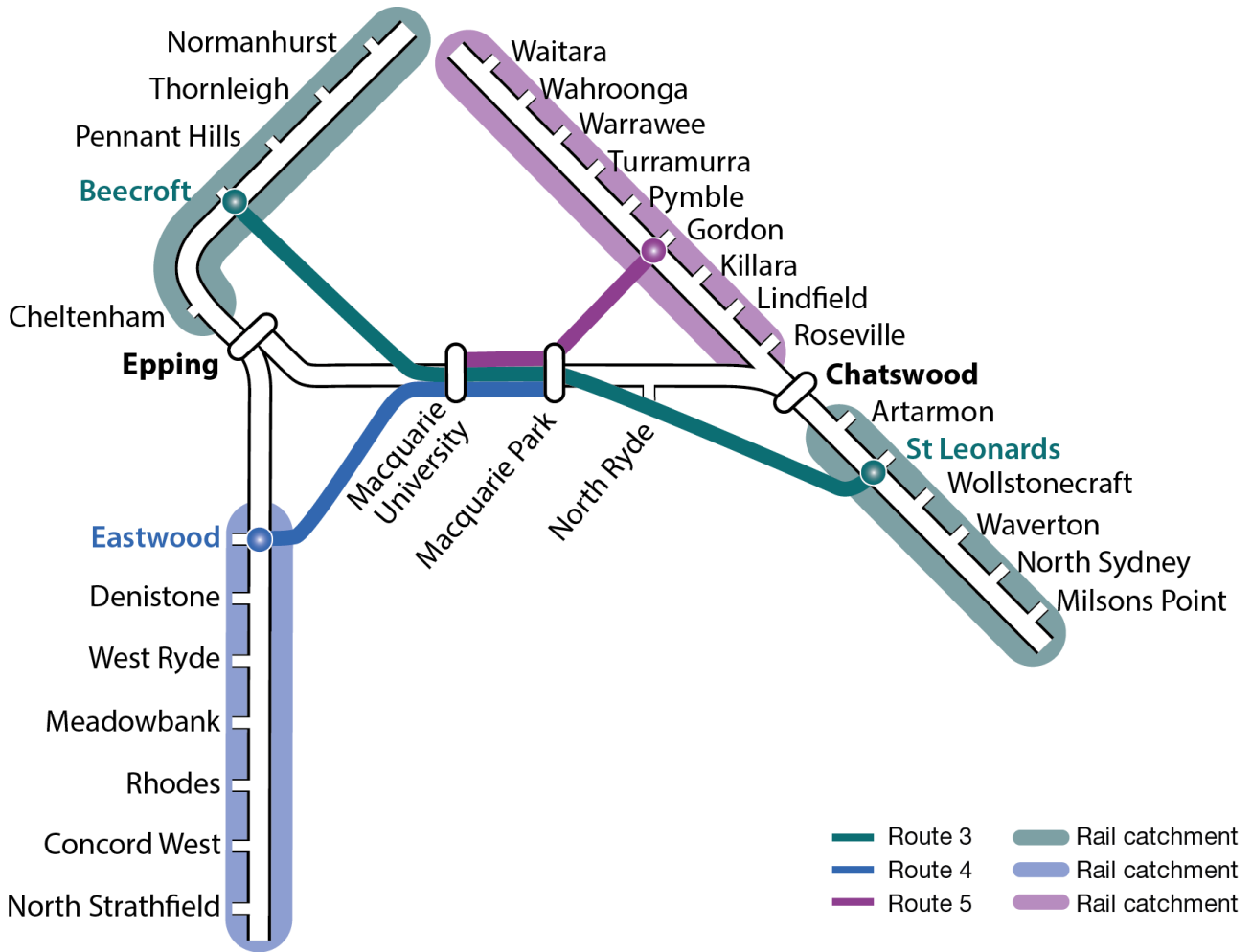


Figure 2.5 Rail catchments for the allocation of demand to rail replacement bus service Routes 3, 4 and 5

Buses operating from the new transfer locations (Beecroft, Eastwood, Gordon and St Leonards) can minimise travel times impacts for some customers compared to the alternative of interchanging at either Epping or Chatswood stations. They also minimise the increase in congestion at the busy Epping and Chatswood interchanges. The specific direct peak period services (Routes 3, 4 and 5) are shown in Figure 2.6.

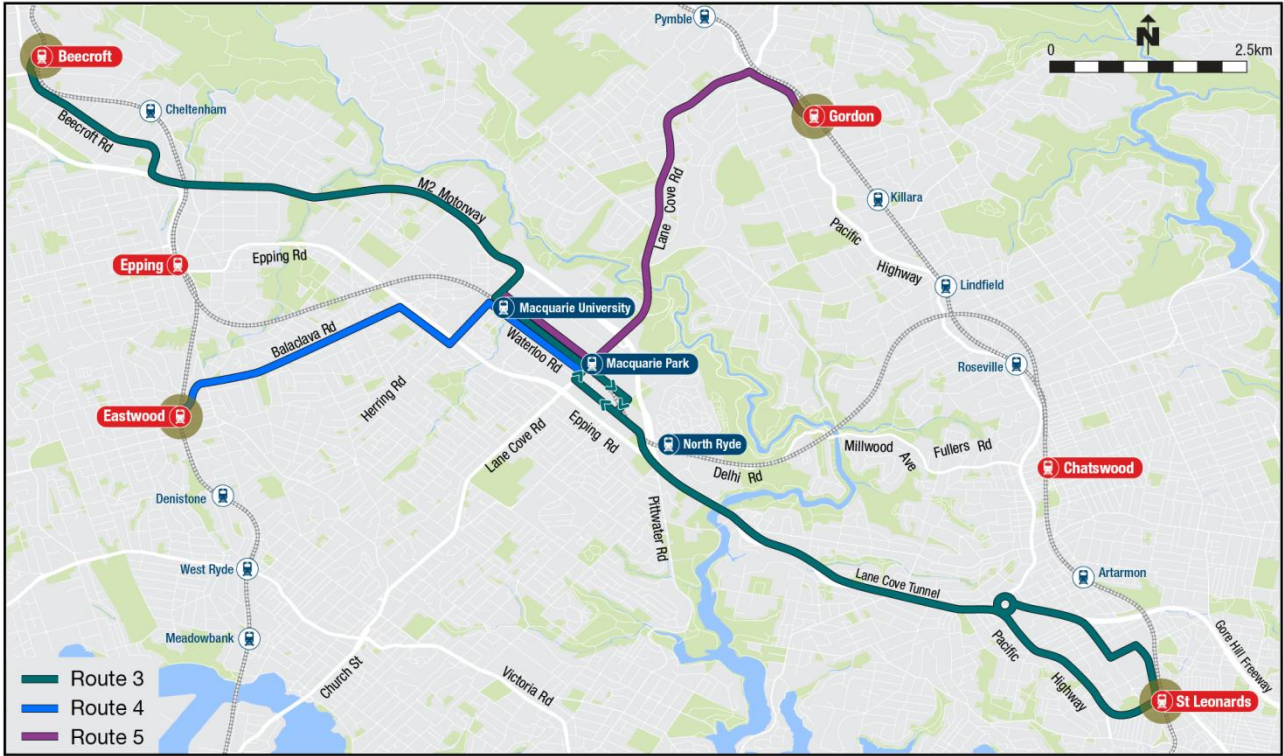


Figure 2.6 Rail replacement bus service - Routes 3, 4 and 5

2.3.4 Route summary

The rail replacement bus routes and associated operating assumptions are summarised in Table 2.2.

Table 2.2 Summary of rail replacement bus routes and proposed operations

Route	Stations served	Times of operation ²	Proposed operations
1	Epping Macquarie University Macquarie Park North Ryde Chatswood	Full time (hours of rail operations)	<ul style="list-style-type: none"> All stations service in both directions.
2	Epping North Ryde Chatswood	Peak periods only	<ul style="list-style-type: none"> Morning peak period buses operate from Epping to Chatswood via North Ryde. Evening peak period buses operate from Chatswood to Epping via North Ryde.

² Morning peak: Approximately 6.00 am to 10.00 am. Evening peak: Approximately 3.00 pm to 7.00 pm

Route	Stations served	Times of operation ²	Proposed operations
3	Beecroft Macquarie University Macquarie Park St Leonards	Peak periods only	<ul style="list-style-type: none"> ■ Morning peak period buses operate from Beecroft to St Leonards via Macquarie University and Macquarie Park. ■ Evening peak period buses operate from St Leonards to Beecroft via Macquarie Park and Macquarie University.
	Macquarie University Macquarie Park St Leonards	Peak periods only	<ul style="list-style-type: none"> ■ Morning peak period buses operate from St Leonards to Macquarie University via Macquarie Park. ■ Evening peak period buses operate from Macquarie University to St Leonards via Macquarie Park.
4	Eastwood Macquarie University Macquarie Park	Peak periods only	<ul style="list-style-type: none"> ■ Morning peak period buses operate from Eastwood to Macquarie Park via Macquarie University. ■ Evening peak period buses operate from Macquarie Park to Eastwood via Macquarie University.
5	Gordon Macquarie Park Macquarie University	Peak periods only	<ul style="list-style-type: none"> ■ Morning peak period buses operate from Gordon to Macquarie University via Macquarie Park. ■ Evening peak period buses operate from Macquarie University to Gordon via Macquarie Park.

Table 2.2 shows that the eastern section of Route 3 (Macquarie University to St Leonards) is proposed to operate in both directions during peak periods, whereas the other peak period only routes (Routes 2, 4 and 5) operate in only one direction. This is because during both morning and evening peak periods Route 3 buses will provide:

- a service to/from Macquarie University and Macquarie Park for Northern Line customers (north of Beecroft)
- a service which connects the Northern and North Shore Lines during peak hours, avoiding the busy interchanges at Epping and Chatswood stations
- a service to/from Macquarie Park and Macquarie University for North Shore Line customers between the CBD and St Leonards.

The full rail replacement bus network is shown in Figures 2.7 and 2.8 for the morning and evening peak periods respectively.

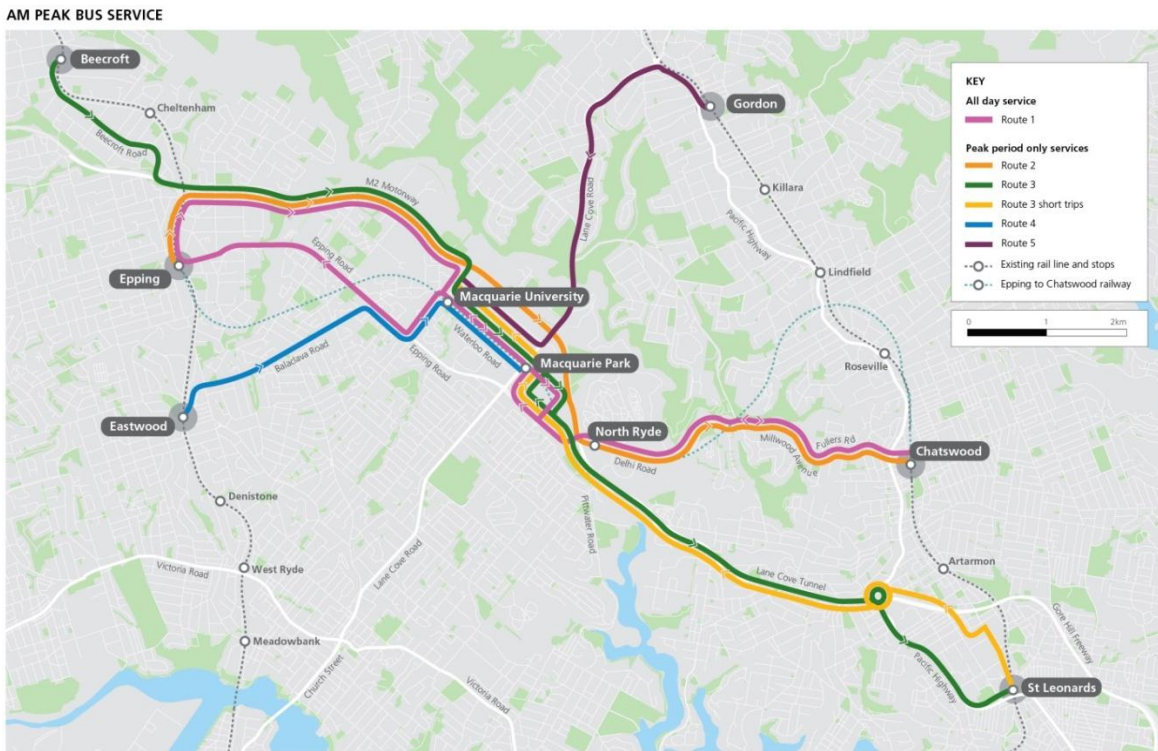


Figure 2.7 Rail replacement bus network during the morning peak period³

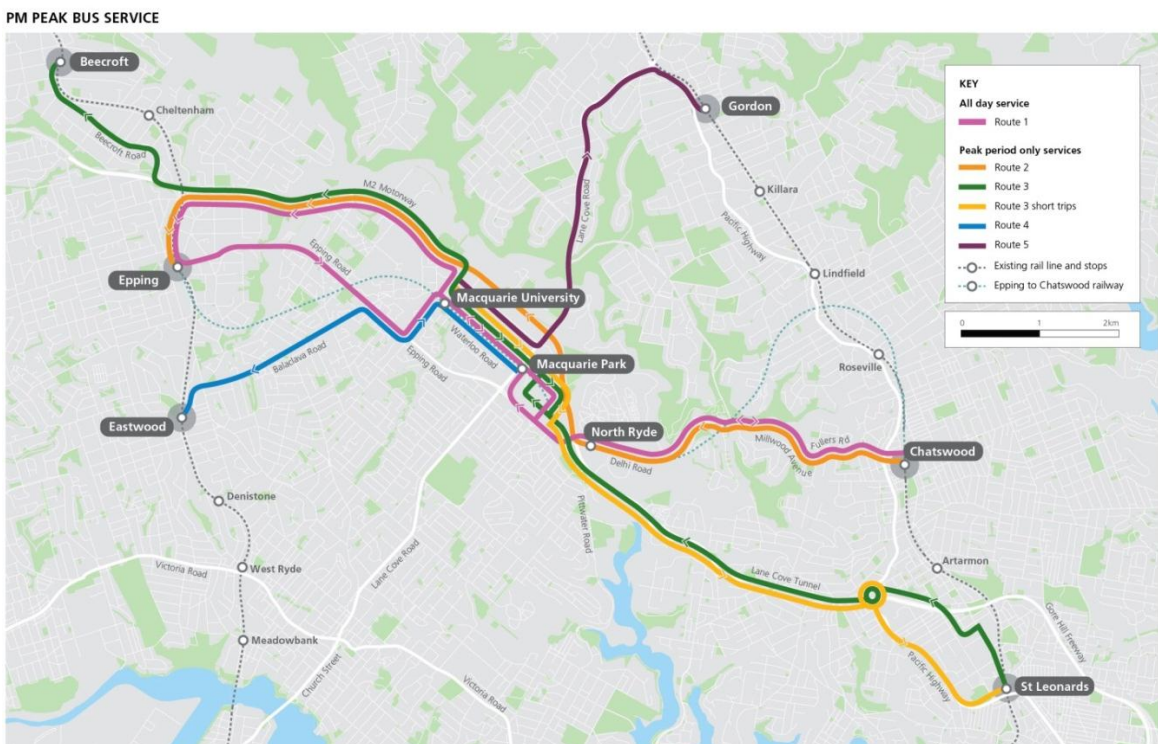


Figure 2.8 Rail replacement bus network during the evening peak period⁴

³ Route 3 short trips are trips during the morning peak period which operate between St Leonards and Macquarie University

⁴ Route 3 short trips are trips during the evening peak period which operate between Macquarie University and St Leonards

2.4 Sensitivity testing

As part of the options strategies considered, a two route rail replacement bus service was developed to assess how much extra bus activity would occur at the bus interchanges of Epping and Chatswood compared to the five route rail replacement bus service. Under this simplified two route rail replacement bus service, the same level of demand was catered for, but using fewer bus routes.

A summary of the routes and operating assumptions associated with the two route rail replacement bus service is provided in Table 2.3.

Table 2.3 Summary of the routes and proposed operations for the two route rail replacement bus service

Route	Stations served	Times of operation ⁵	Proposed operations
1	Epping Macquarie University Macquarie Park North Ryde Chatswood	Full time	<ul style="list-style-type: none"> All stations service in both directions.
2	Epping North Ryde Chatswood	Peak periods only	<ul style="list-style-type: none"> Morning peak period buses operate from Epping to Chatswood via North Ryde. Evening peak period buses operate from Chatswood to Epping via North Ryde.

Routes 1 and 2 under the two route rail replacement bus service are shown in Figure 2.9 for the morning and evening peak periods.

⁵ Morning peak: Approximately 6.00 am to 10.00 am. Evening peak: Approximately 3.00 pm to 7.00 pm

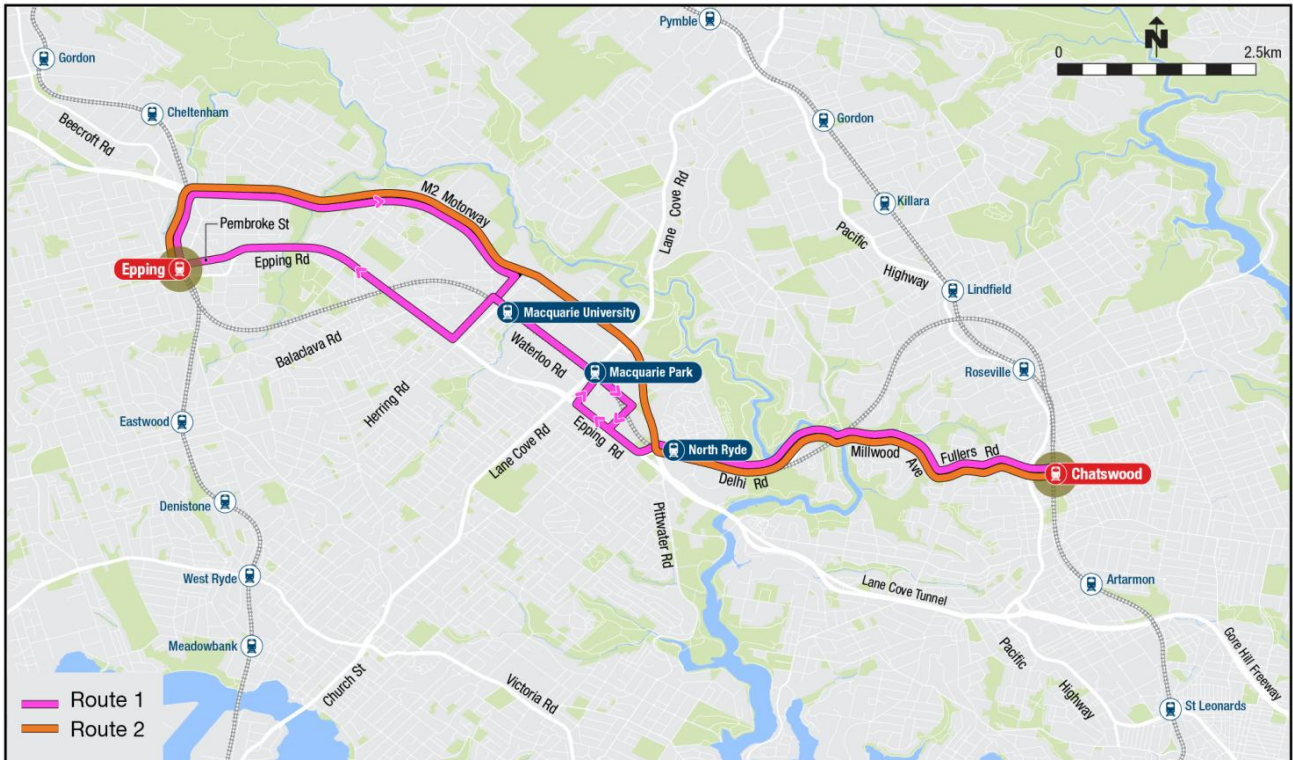


Figure 2.9 Peak period bus routes for the two route rail replacement bus service

Based on this assessment, the five route rail replacement bus service scenario is preferred for meeting passenger demand because it:

- minimises the numbers of customers required to interchange between bus and rail at Epping and Chatswood during morning and evening peak periods
- supports a more manageable interchange at Epping and Chatswood, minimising the impact on local amenity
- provides customers with bus routes from other stations, which can minimise travel time impacts for some customers compared to the alternative of interchanging at either Epping or Chatswood.

The detailed analysis for the two route rail replacement bus service scenario is included in Appendix A.

3. Demand assessment

This chapter outlines the methodology and results from an assessment into the forecast patronage demand for the rail replacement bus services proposed as part of the Temporary Transport Plan. The demand assessment uses outputs from the Public Transport Project Model (PTPM) along with some out of model analysis to develop a preferred demand scenario for the Project. The preferred demand scenario was applied to the five rail replacement bus routes as outlined in Chapter 2: *Development of the Temporary Transport Plan* to determine the service frequency required to meet demand.

3.1 Methodology

The PTPM model outputs, along with some out of model analysis, were used to determine and assess the following three forecast demand scenarios:

- Scenario A (maximum potential demand)
- Scenario B (minimum demand for a rail replacement bus service)
- Scenario C (considers demand results from both scenarios A and B to form a conservative estimate for planning purposes).

The PTPM was developed within Transport for NSW by the Bureau of Transport Statistics (BTS) as a project-specific demand model to provide patronage forecasts for the NWRL. The PTPM is the best available source of patronage information for the NWRL and has been used to forecast, estimate and inform demand for the rail replacement bus services as part of the Temporary Transport Plan.

The PTPM is a sophisticated mathematical incremental mode choice model for the whole of Sydney, representing the morning peak 3.5-hours of a typical rail 'busy day' (i.e. Tuesday/Wednesday/Thursday during the school term). The model relies on complex interactions between numerous variables and assumptions many years into the future to forecast patronage.

Figure 3.1 illustrates the process for determining forecast demand for rail replacement bus services.

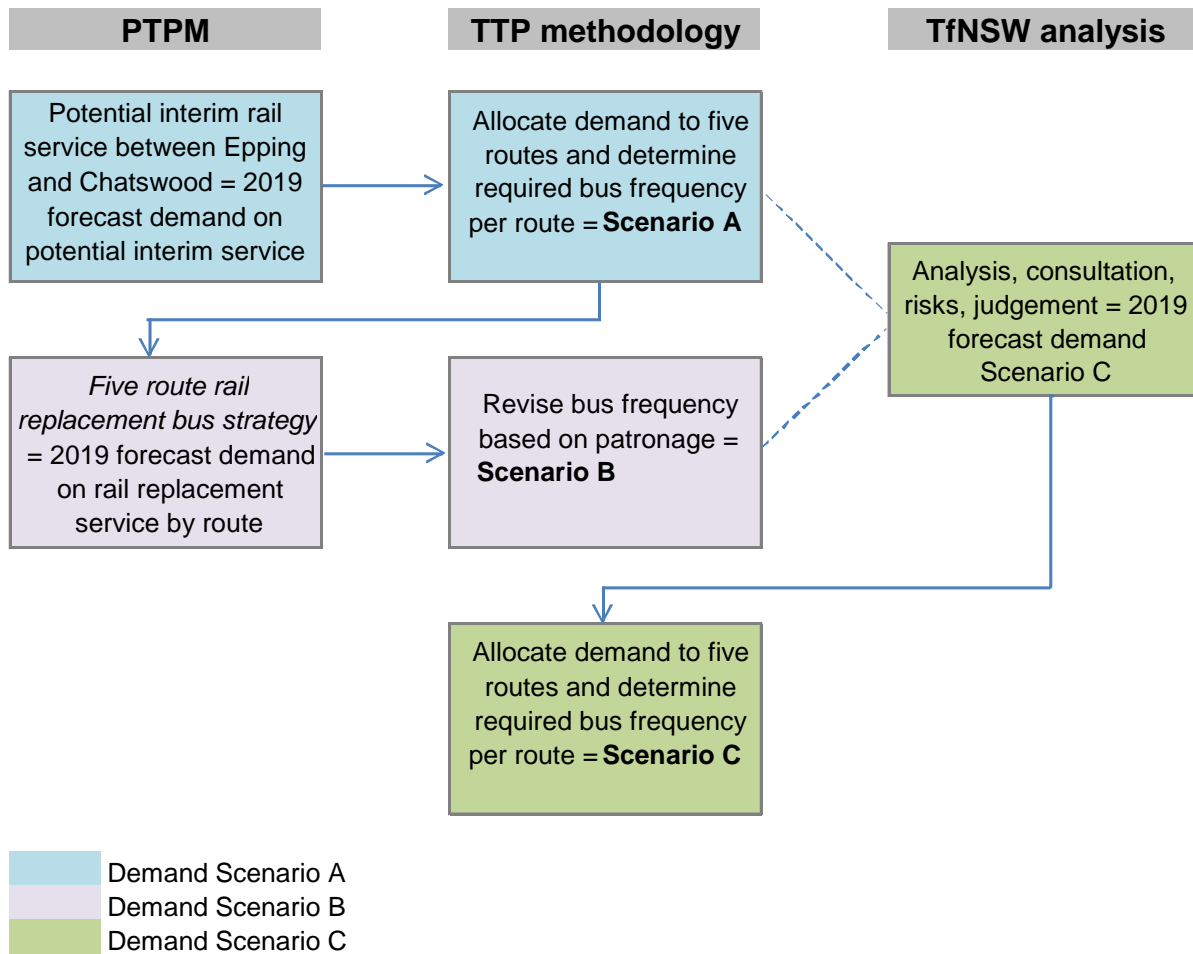


Figure 3.1 Developing forecast patronage for rail replacement bus services

The morning peak hour represents the busiest hour of the day and has therefore been the focus of the demand assessment. A factoring process has been undertaken to determine demand for other time periods, including weekday estimates of the evening peak, off peak, early morning and late evening, as well as weekend and school holiday demand estimates. The methodology for factoring is explained throughout this chapter, where relevant. All demand data presented in this chapter is for the year 2019.

3.2 Demand scenarios

This section provides an overview of the three demand scenarios developed and assessed for the rail replacement bus services. Further details are provided in Appendix B. It should be noted that whilst the Epping to Chatswood railway serves the customer markets identified in section 2.2, there are two primary types of trips which utilise the Epping to Chatswood railway corridor:

- customers accessing Epping to Chatswood railway stations
- customers travelling through the Epping to Chatswood railway corridor on the train but not accessing the stations (i.e. customers travelling between the Northern and North Shore Lines).

Scenario A

Scenario A is assumed to represent the maximum potential demand for a rail replacement bus service, whereby the rail replacement bus demand is assumed to be that a potential interim rail service operating between Epping and Chatswood. Some customers would choose an alternative journey on the rail network if a potential interim rail service were to operate between Epping and Chatswood. Table 3.1 summarises the eastbound and westbound demand under Scenario A.

Table 3.1 Scenario A, eastbound and westbound demand

One hour morning peak	Eastbound	Westbound
Modelled through trips	1,400	150
Modelled Epping to Chatswood railway destination trips	1,300	1,450
Total	2,700	1,600

Over a 24 hour period on a typical weekday, approximately 21,000 customers (42,000 trips) are forecast to use the rail replacement bus service under Scenario A, which is based on the demand for a potential interim rail service between Epping and Chatswood.

Scenario B

Scenario B demand is determined by using PTPM to model demand for the five route replacement bus service when no rail services operate between Epping and Chatswood. The commencement of a rail replacement bus service between Epping and Chatswood would lead to further customers choosing alternative transport arrangements, including on the rail network, because the journey time for a rail replacement bus service, particularly in the peak, would be longer than the potential interim rail service (Scenario A).

In terms of eastbound demand (from Epping) analysis of the model results indicate that over half (56 per cent) of customers from Scenario A would not use the rail replacement bus services under Scenario B either seeking alternative journeys on the rail network, or using existing bus services or private vehicles. The westbound demand from Chatswood showed only a minor change from Scenario A (a reduction of 6.5 per cent). Based on experience from weekend or short school holiday possessions, around 10 to 20 per cent of rail customers find an alternative transport option, or choose not to travel, when rail replacement bus services operate. The decreased eastbound patronage in Scenario B was considered to be low, which could be partially attributed to the fact that some customers would have a viable rail network alternative to the rail replacement bus service (which is often not the case for weekend or short school holiday possessions).

Table 3.2 summarises the eastbound and westbound demand under Scenario B.

Table 3.2 Scenario B, eastbound and westbound demand

One hour morning peak	Eastbound	Westbound
Modelled through trips	350	25
Modelled Epping to Chatswood railway destination trips	850	1,475
Total	1,200	1,500

Over a 24 hour period on a typical weekday, approximately 9,250 customers (18,500 trips) are forecast to use the rail replacement bus service under Scenario B. An analysis of customer transport choice in the model and consultation within Transport for NSW determined that for the purposes of the Temporary Transport Plan, the forecast patronage under Scenario B should be considered the minimum potential demand for the replacement bus services.

Scenario C (preferred demand scenario)

A third demand scenario was determined by analysing PTPM outputs for scenarios A and B to determine a demand scenario appropriate to inform planning – Scenario C. The analysis undertaken to develop Scenario C included:

- Understanding the destination of the customer and the travel alternatives available to them. Generally, it was considered that customers with an Epping to Chatswood railway station as a destination had limited viable transport alternatives to the rail replacement bus service. Conversely, those customers travelling through the Epping to Chatswood railway corridor had viable (and potentially faster) options on the rail network.
- Analysis of the alternative modes of transport used by customers not using the rail replacement buses services in Scenario B. It was considered that customers who (in the model) changed to private vehicle or an existing bus service could potentially be expected to use the rail replacement bus service. It is considered reasonable to assume that the 7 month duration of the Epping to Chatswood railway Rapid Transit Conversion Program would mean it is unlikely that customers would opt to use a private vehicle (due to cost and limited availability of parking).

Based on the above analysis, 50 per cent of Scenario A ‘through trips’ and 100 per cent of ‘Epping to Chatswood railway destination trips’ were included to form Scenario C.

Table 3.3 summarises the eastbound and westbound forecast patronage under Scenario C for the morning peak hour.

Table 3.3 Scenario C, eastbound and westbound forecast patronage – morning peak hour

One hour morning peak	Eastbound	Westbound
Through trips (50% of Scenario A)	700	75
Epping to Chatswood railway destination trips (100% of Scenario A)	1,300	1,450
Total	2,000	1,525

Over a 24 hour period on a typical weekday, approximately 14,000 customers (28,000 trips) are forecast to use the rail replacement bus service.

Scenario C is the preferred scenario for planning purposes and represents a conservative demand scenario taking into account the modelled Scenario A and Scenario B results. Under Scenario C, it is assumed that 74 per cent of eastbound and 95 per cent of westbound customers who would use Scenario A would use the rail replacement bus services when they commence.

3.3 Application of forecast demand

3.3.1 Key assumptions

Application of forecast demand to the five rail replacement bus routes has been undertaken based on the following key assumptions:

- An average of 50 passengers per bus (seated plus standing).
- A minimum demand of 200 customers per hour is required to operate the route. Where demand for a route is less than 200 people, the route does not operate and the demand is reassigned to another route.
- Where the demand is a minimum of 200 people per hour, but less than 300 people per hour on any route, a minimum of 6 buses per hour are provided for customer convenience.
- The development of the evening peak period bus frequencies has been determined based on a factoring process used to develop an all-day service profile (as described in section 3.4).

The distribution of evening peak period demand across each of the bus routes is assumed to be the reverse of the morning peak period, however the actual volume of demand and the corresponding bus frequencies are different to the morning peak (as described in section 3.4).

3.3.2 Rail replacement bus trips based on forecast demand

Eastbound and westbound patronage for Scenario C was allocated to the five rail replacement bus routes as shown in Table 3.4. This table presents the demand and the number of bus trips, assuming an average of 50 customers per bus (seated plus standing), required during the morning peak one hour to cater for each route.

Table 3.4 Distribution of morning peak (1 hour) demand – Scenario C

		Eastbound customers	Eastbound bus trips	Westbound customers	Westbound bus trips
Route 1	Epping to Chatswood	200	6		
	Chatswood to Epping			400	8
Route 2	Epping to Chatswood	800	16		
Route 3	Beecroft to St Leonards	400	8		
	St Leonards to Macquarie University			900	18
Route 4	Eastwood to Macquarie Park	600	12		
Route 5	Gordon to Macquarie Park/University			225	6
	Total	2,000	42	1,525	32

The number of bus trips in the morning peak hour is shown schematically in Figure 3.2.

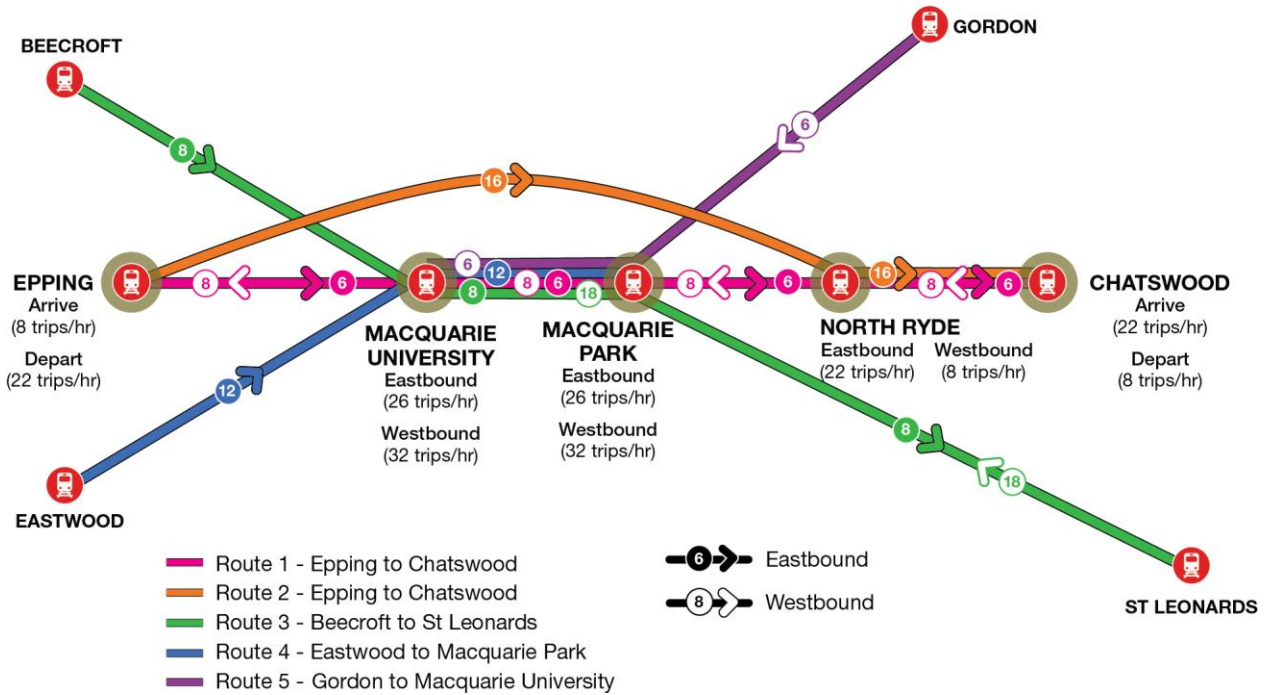


Figure 3.2 Morning peak (1 hour) bus trips - Scenario C

The distribution of demand during the evening peak is assumed to be the reverse of that in the morning peak, but the level of demand is different. Further discussion on the assumptions for the evening peak is in section 3.4 (All day service profile).

The number of bus trips in the evening peak hour for Scenario C is shown schematically in Figure 3.3.

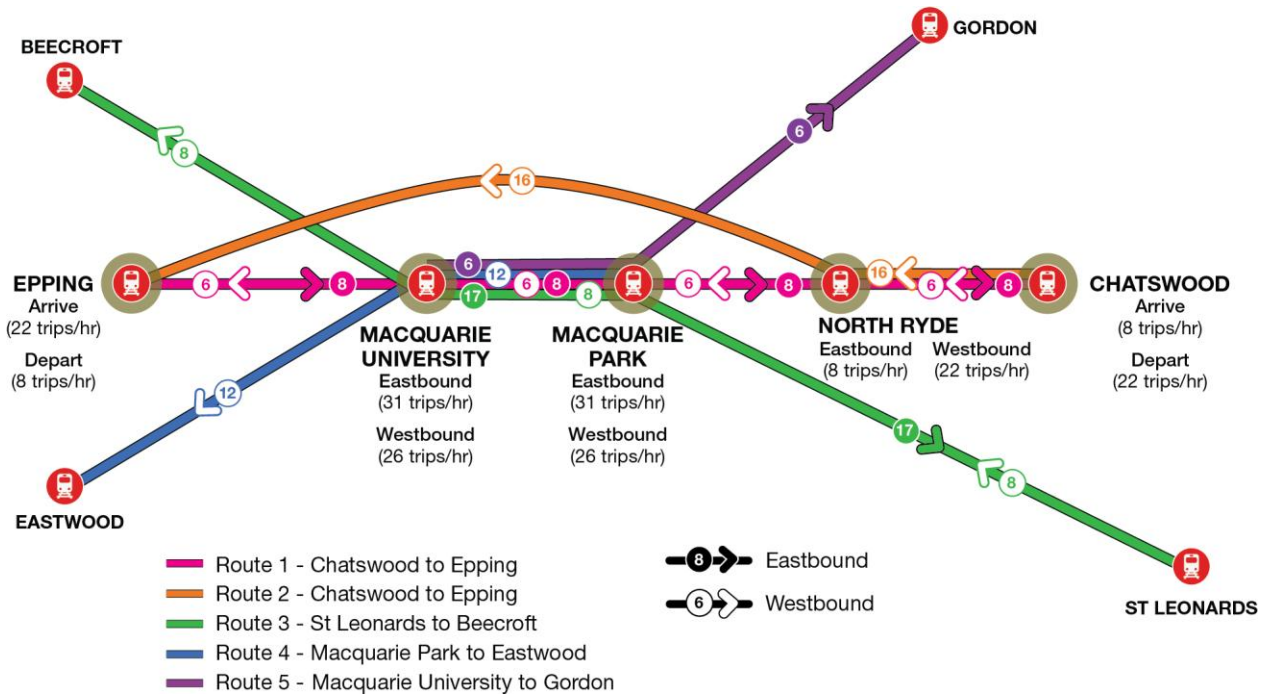


Figure 3.3 Evening peak (1 hour) bus trips - Scenario C

3.4 All day service profile

This section presents an estimation of demand for the rail replacement bus services across the remainder of the weekday (i.e. outside of the morning peak period).

3.4.1 Methodology

Data from the Transport for NSW Compendium of Rail Travel Statistics (the Rail Compendium) and ticket barrier counts for the Epping to Chatswood railway stations was analysed to determine a profile of demand for the rest of the day.

Rail Compendium data

Station entries and exits from the Rail Compendium for the three exclusive Epping to Chatswood railway stations (Macquarie University, Macquarie Park and North Ryde) were used to estimate the relative demand for early morning, off peak, evening peak and evening services compared to the demand for services during the morning peak.

An extract of the relevant Rail Compendium data is shown in Table 3.5. Given these Epping to Chatswood railway stations are predominantly destination stations, the number of early morning and off peak exits and evening peak and late evening entries are considered against morning peak exits.

Table 3.5 Rail Compendium data (station entries and exits) for Epping to Chatswood railway exclusive stations

Rail Station	Before 6.00 am		6.00 am–9.30 am (Morning peak)		9.30 am–3.00 pm		3.00 pm–6.30 pm (Afternoon peak)		6.30 pm–2.00 am	
	Entries	Exits	Entries	Exits	Entries	Exits	Entries	Exits	Entries	Exits
Macquarie University	80	80	860	2,690	2,310	3,430	3,830	1,620	1,430	700
Macquarie Park	30	30	340	2,290	430	560	2,240	440	470	200
North Ryde			190	820	300	240	830	260	130	140
Total	110	110	1,390	5,800	3,040	4,230	6,900	2,320	2,030	1,040
As a % of morning peak exits		2%				73%	120%		35%	

The all-day demand profile has been developed based on Table 3.5 for each demand scenario to inform the development of bus frequencies across the same period.

This data for station entries and exits shows that on weekdays:

- early morning (before 6.00 am) exits at Epping to Chatswood railway stations are approximately 2 per cent of the Epping to Chatswood railway station exits during the 3.5 hour morning peak
- off peak exits (i.e. between the morning and the evening peak periods) at Epping to Chatswood railway stations are approximately 73 per cent of the Epping to Chatswood railway station exits during the 3.5 hour morning peak
- evening peak entries at Epping to Chatswood railway stations are approximately 120 per cent of the Epping to Chatswood railway station exits during the 3.5 hour morning peak

- night time (after 6.30 pm) entries at Epping to Chatswood railway stations are approximately 35 per cent of the Epping to Chatswood railway station exits during the 3.5 hour morning peak.

Ticket barrier counts

Ticket barrier counts for Epping to Chatswood railway stations were used to develop a demand profile within the morning peak, off peak, and evening peak. The ticket barrier counts are based on 15 minute intervals, from approximately 6.00 am to 11.00 pm, and the totals for the main time periods are consistent with the figures reported in the Rail Compendium. The ticket barrier counts were aggregated into hourly bands in order to account for any variation in the number of trains that arrive in each 15 minute period, and to provide an indicative demand profile across the day.

Morning peak and shoulder peak

The ticket barrier counts data show that for the morning peak and shoulder peak:

- The peak hour of the morning peak period (based on Epping to Chatswood railway station exit barrier counts) is 8.00 am to 9.00 am, and represents 56 per cent of the morning 3.5 hour peak demand.
- Distribution of the remaining morning peak period demand (based on Epping to Chatswood railway station exits, and on the definition of the morning peak hour within the Rail Compendium as 6.00 am to 9.30 am) is spread as follows:
 - ▶ 6.00 am to 7.00 am: 13 per cent of the remaining 2.5 hour demand
 - ▶ 7.00 am to 8.00 am: 51 per cent of the remaining 2.5 hour demand
 - ▶ 9.00 am to 9.30 am: 36 per cent of the remaining 2.5 hour demand.
- Epping to Chatswood railway station exits between 9.00 am and 10.00 am are significantly greater than in the remaining off peak hours (10.00 am to 3.00 pm). As this hour falls partially within the morning peak and partially within the off peak as defined within the Rail Compendium, an additional time period (shoulder peak) has been adopted for the demand profile of Epping to Chatswood railway demand across the day, to more accurately reflect the transition in demand between peak and off peak periods.

Evening peak

The ticket barrier counts data show that for the evening peak:

- The peak hour of the evening peak period (based on Epping to Chatswood railway station exits) is 5.00 pm to 6.00 pm, and represents 44 per cent of the evening 3.5 hour peak demand.
- Distribution of the remaining evening peak period demand is spread as follows:
 - ▶ 3.00 pm to 4.00 pm: 29 per cent of the remaining 2.5 hour demand
 - ▶ 4.00 pm to 5.00 pm: 50 per cent of the remaining 2.5 hour demand
 - ▶ 6.00 pm to 6.30 pm: 21 per cent of the remaining 2.5 hour demand.

Demand profile

Table 3.6 shows the time categories which are used in the allocation of demand across the day based on the demand profiles from the Rail Compendium and the ticket barrier count data.

Table 3.6 Time categories across the day

Pre morning peak	Morning peak			Shoulder morning peak	Off peak	Evening peak			Shoulder evening peak	Evening
Before 6.00 am	6.00 am to 7.00 am	7.00 am to 8.00 am	8.00 am to 9.00 am	9.00 am to 10.00 am	10.00 am to 3.00 pm	3.00 pm to 4.00 pm	4.00 pm to 5.00 pm	5.00 pm to 6.00 pm	6.00 pm to 7.00 pm	After 7.00 pm
1%	2%	7%	17%	9%	18%	6%	10%	16%	5%	9%

In applying the demand profile to the Temporary Transport Plan, the following assumptions about how the rail replacement bus services will operate have been made:

- Route 1 (Epping to Chatswood via all stations) operates at all times during the hours of rail operations.
- Off peak trips on Route 1 are equally spread between the eastbound and westbound directions.
- In the evening peak the distribution of trips across the five rail replacement bus routes is the reverse of that for the morning peak. However the actual volume of demand is different to the morning peak (as shown in Table 3.4). This difference in demand, together with how the demand is distributed across the evening peak period, results in some differences in bus frequencies between the morning and evening peak periods.
- Where demand levels indicate a level of service below the minimum frequency currently provided by weekend rail replacement buses (6 buses per hour), the level of service is increased to this minimum level.

For the purposes of this study there is no expectation of a material shift in the profile of the Epping to Chatswood railway stations between now and 2019. Table 3.7 shows the number of bus trips per hour across a regular (school term) weekday for the preferred demand scenario (Scenario C). Corresponding tables for scenarios A and B can be found in Appendix B along with the associated demand levels across the day. The shaded columns represent the morning and evening peak hours.

Table 3.7 Bus trips per hour across a regular weekday (preferred demand scenario)

		Bus trips per hour										
		Pre morning peak	Morning peak			Shoulder peak	Off peak	Evening peak			Shoulder evening peak	Evening
		Before 6.00 am	6.00 am to 7.00 am	7.00 am to 8.00 am	8.00 am to 9.00 am	9.00 am to 10.00 am	10.00 am to 3.00 pm	3.00 pm to 4.00 pm	4.00 pm to 5.00 pm	5.00 pm to 6.00 pm	6.00 pm to 7.00 pm	After 7.00 pm
Route 1	Epping to Chatswood	6	6	6	6	6	8	8	8	8	6	6
	Chatswood to Epping	6	6	6	8	6	8	6	6	6	6	6
Route 2	Epping to Chatswood		6	7	16	9						
	Chatswood to Epping							6	10	16	6	
Route 3	Beecroft to St Leonards		6	6	8	6						
	St Leonards to Beecroft							6	6	8	6	
	Macquarie University to St Leonards							7	11	17	6	
	St Leonards to Macquarie University		6	8	18	10						
Route 4	Eastwood to Macquarie Park		6	6	12	7						
	Macquarie Park to Eastwood							6	8	12	6	
Route 5	Gordon to Macquarie University		6	6	6	6						
	Macquarie University to Gordon							6	6	6	6	
	Total trips per hour	12	42	45	74	50	16	45	55	73	42	12
	Morning peak bus trips		161									
	Evening peak bus trips							173				

3.4.2 Weekend services

Weekend rail replacement bus services are proposed to replicate the off peak service pattern, whereby only Route 1 operates. This reflects the current service provided during Epping to Chatswood railway weekend possessions, where an all stations bus service operates all day. The frequency of the weekend service is proposed to be the same as currently provided during weekend track work (i.e. a minimum 10 minute frequency across the day). Appendix B shows the PTPM demand forecasts for weekends, based on the potential interim rail service between Epping and Chatswood (Scenario A), which confirms a 10 minute frequency is sufficient for Saturday and Sunday. The weekend demand profile is expected to be fairly even across the day and will be reviewed as part of future demand refinement for the Temporary Transport Plan.

3.5 School holiday demand profile

The patronage forecasts presented in the above section are for non-school holiday periods. The BTS at Transport for NSW provided Epping to Chatswood railway specific expansion factors for school holiday periods. Table 3.8 shows the estimated proportion of non-school holiday period demand during school holiday periods for Epping to Chatswood railway stations.

Table 3.8 School holiday demand profile

School holiday period	Proportion of non-school holiday period demand
Christmas	65%
Easter	75%
July	65%
October	80%

The reduced demand during school holidays may result in minor refinement of the scheduled number of trips on the rail replacement bus routes.

4. Implementation of the Temporary Transport Plan

4.1 Overview and methodology

This chapter uses the demand outputs from Chapter 3: *Demand Assessment* to determine the operational requirements for providing the Epping to Chatswood rail replacement bus routes (Routes 1 to 5). A summary of the other operational arrangements considered for the rail replacement buses but not taken forward are shown in Appendix E for reference.

The bus operational requirements are divided into the following categories for each station:

- bus stops at each station served by the rail replacement bus routes including:
 - ▶ functional requirements based on the preferred demand scenario (Scenario C)
 - ▶ pick-up and set-down arrangements
 - ▶ interactions with other bus services, including testing the capacity of bus stops to accommodate increased numbers of buses, where the operational arrangements include sharing bus stop space with existing routes
 - ▶ impacts to the provision of parking and taxi services
- traffic impacts based on the results of traffic modelling (refer to section 4.1.1)
- temporary facilities required to support the rail replacement bus services.

It is acknowledged that in the early weeks of the temporary rail replacement bus operations, performance will be monitored and changes made where practical and appropriate. The following section provides an overview of the traffic modelling methodology used to determine traffic impacts.

4.1.1 Traffic modelling

A key component of the assessment was to undertake traffic modelling to test the impacts that the rail replacement buses would have on general traffic and on the operation of the replacement bus routes. This involved:

- modelling key intersections
- testing alternative operational arrangements for rail replacement buses.

Methodology

The methodology used to assess the traffic impacts of the rail replacement bus services is presented in Figure 4.1. A brief description of the steps in the process follows. A full description of the traffic modelling process and results is provided in Appendix C.

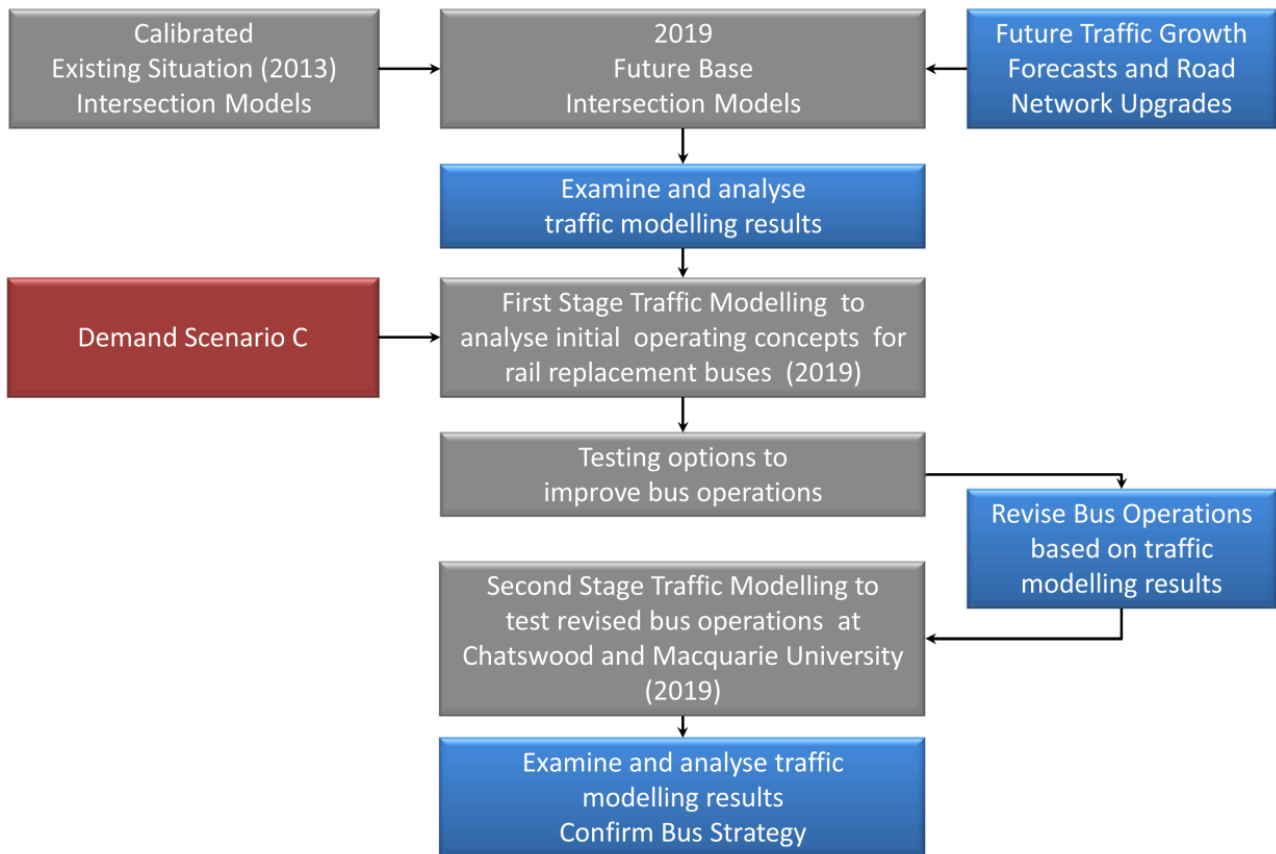


Figure 4.1 Traffic modelling methodology

Software

Traffic modelling was undertaken using the SIDRA (Signalised and Un-signalised Intersection Design and Research Aid) Version 6 software. This software models intersections as a network rather than in isolation, allowing the interaction of queues between intersections to be modelled. Results of the intersection modelling have been summarised based on their:

- Level of Service
- Degree of Saturation
- Average Vehicle Delay
- Queue Length.

Level of Service

Level of Service is a basic performance parameter used to describe the operation of an intersection. Levels of service range from A (indicating good intersection operation) to F (indicating over-saturated conditions with long delays and queues). At signalised intersections, the Level of Service criteria are related to average intersection delay (seconds per vehicle). At priority controlled (give-way and stop controlled) and roundabout intersections, the Level of Service is based on the modelled delay (seconds per vehicle) for the most delayed movement (refer to Table 4.1). The green, yellow and red coloured shading indicate good, satisfactory and poor performance respectively.

Table 4.1 Level of Service criteria for intersections

Level of Service	Average delay (seconds per vehicle)	Traffic signals, roundabout	Give Way and stop signs
A	Less than 14	Good operation.	Good operation.
B	15 to 28	Good with acceptable delays and spare capacity.	Acceptable delays and spare capacity.
C	29 to 42	Satisfactory.	Satisfactory, but accident study required.
D	43 to 56	Operating near capacity.	Near capacity and accident study required.
E	57 to 70	At capacity. At signals, incidents would cause excessive delays. Roundabouts require other control mode.	At capacity; requires other control mode.
F	Greater than 71	Unsatisfactory with excessive queuing.	Unsatisfactory with excessive queuing; requires other control mode.

Source: RTA (now RMS) Guide to Traffic Generating Developments, 2002

Diagrams that depict intersection performance in terms of Level of Service for the future base case (2019) and the future base case with rail replacement buses are provided throughout this chapter. In each case these diagrams show the Level of Service in the morning peak (left hand side of circle) and evening peak (right hand side of circle) as illustrated in Figure 4.2.

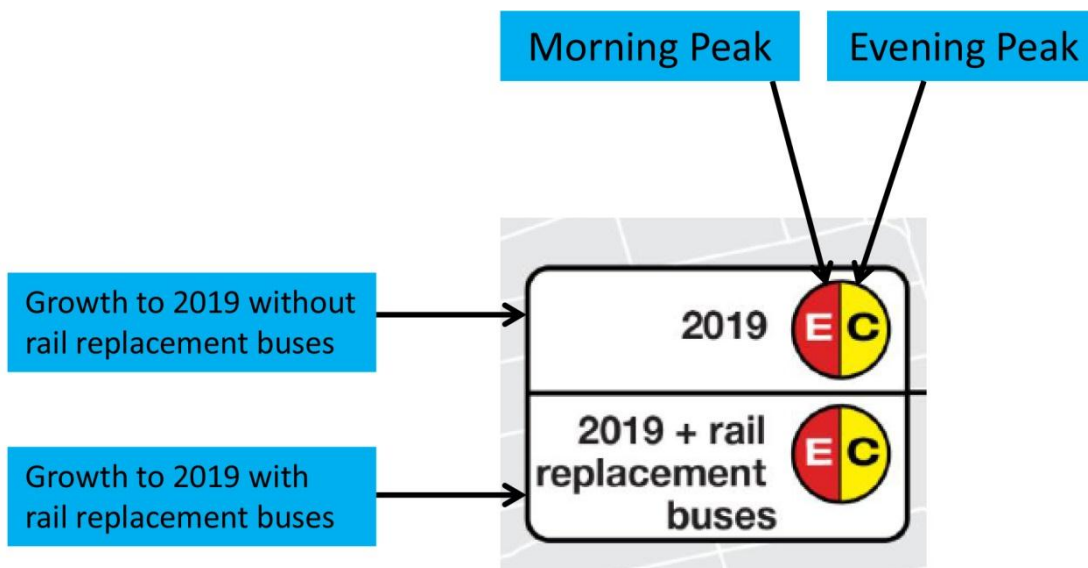


Figure 4.2 Level of Service example diagram

Degree of saturation

The Degree of Saturation is the ratio of demand flow to capacity, and therefore has no unit. As it approaches 1.0, extensive queues and delays could be expected. For a satisfactory situation, the Degree of Saturation should be less than the nominated practical degree of saturation, usually 0.9. The intersection Degree of Saturation is based on the movement with the highest value.

Input data

Existing situation models were developed and calibrated using on-site observations, the results of queue length and traffic volume surveys (undertaken in late July/early August 2013) and SCATS (Sydney Coordinated Adaptive Traffic System) signal data provided by RMS.

Key intersections

Due to the large number of intersections used by the proposed rail replacement buses, key intersections were modelled to focus efforts on addressing the main issues and investigate the locations where the greatest benefit could be realised. Based on the proposed bus routes, their combined frequencies and an assessment of the traffic conditions along the route, a list of 24 key intersections were identified. Intersections around Gordon Station and Beecroft Station were not included due to the smaller number of buses, and hence low relative impact. The intersections modelled are identified in Table 4.2 along with the rail replacement bus routes and shown in Figure 4.3. Additional figures showing details at a larger scale for each of the stations where traffic intersection modelling was undertaken are provided in Appendix C.

Table 4.2 Intersections assessed as part of the traffic modelling

Location	Intersection	Rail replacement bus route
Epping	1. Eastbound M2 Motorway off ramp and Beecroft Road	Routes 1, 2 and 3
	2. Beecroft Road and Carlingford Road	Routes 1 and 2
	3. Beecroft Road, High Street and Bridge Street	Routes 1 and 2
	4. Epping Road, Langston Place and Blaxland Road	Routes 1 and 2
	5. Pembroke Street, Oxford Street, Cambridge Street and Langston Place	Routes 1 and 2
Macquarie University	6. Epping Road and Balaclava Road	Routes 1 and 4
	7. Epping Road and Herring Road	Routes 1 and 4
	8. Waterloo Road, University Avenue and Herring Road	Routes 1, 3, 4 and 5
	9. Talavera Road and Herring Road	Routes 1 and 3
	10. M2 Motorway on/off ramps and Herring Road	Route 1
Macquarie Park	11. Waterloo Road and Khartoum Road	Routes 1, 3 and 5
	12. Lane Cove Road and Waterloo Road	Routes 1, 3 and 5
	13. Lane Cove Road and Epping Road	Routes 1 and 3
	14. Epping Road and Wicks Road	Routes 1 and 3
North Ryde	15. Epping Road and Delhi Road	Routes 1 and 3
	16. Delhi Road and M2 Motorway on/off ramps	Routes 1 and 2
Chatswood	17. Pacific Highway and Fullers Road	Routes 1 and 2
	18. Pacific Highway and Victoria Avenue	Routes 1 and 2
	19. Railway Street and Victoria Avenue	Routes 1 and 2
	20. Railway Street and Help Street	Routes 1 and 2

Location	Intersection	Rail replacement bus route
St Leonards	21. Pacific Highway and Herbert Street	Route 3
Eastwood	22. Blaxland Road and Balaclava Road	Route 4
	23. Blaxland Road and May Street	Route 4
	24. Blaxland Road and Ethel Street	Route 4

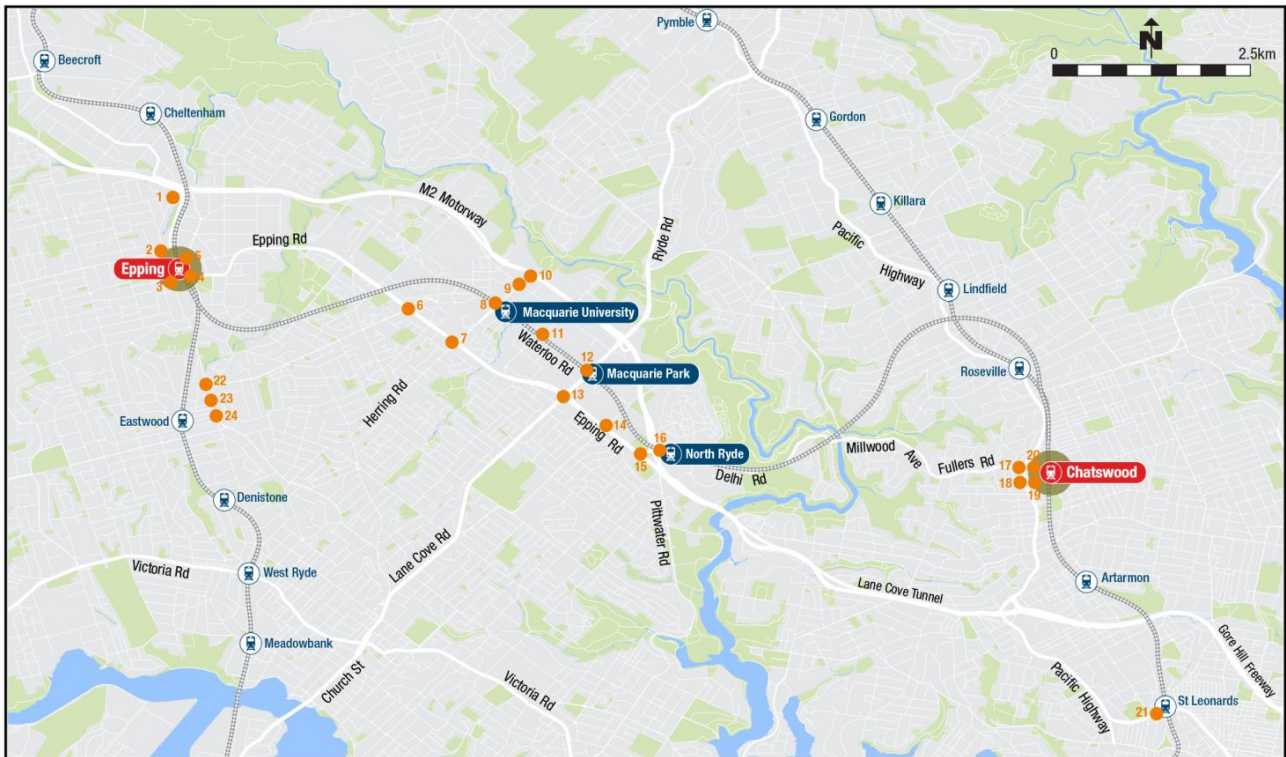


Figure 4.3 Intersections modelled for the traffic modelling of the rail replacement bus services

Future growth

Traffic conditions in 2019, the anticipated year when the Epping to Chatswood railway Rapid Transit Conversion Program would occur, were forecast using growth estimates from RMS’ strategic traffic model. Base conditions in 2019 were forecast without the rail replacement buses.

Rail replacement bus numbers

The replacement bus frequencies were modelled for demand Scenario C including the alternative methods of operation for Chatswood and Macquarie University as per Figure 4.1. Full details of the traffic modelling can be found in Appendix C.

Future road upgrades and potential bus priority projects

RMS, Transport for NSW and the NSW Department of Planning and Infrastructure (now Planning and Environment) were consulted about currently planned changes to the road network that should be included in the future year traffic models. A number of future projects were identified, but many were either due to be implemented after 2019 or are unfunded/ uncertain. The only projects that could be identified as being programmed and funded with reasonable certainty were associated with the Epping Town Centre Urban Activation Precinct (UAP). These are described in section 4.2.6.

Traffic-related options for bus operation improvement

A number of options for intersection upgrades and bus routing were tested to assist in refining the Temporary Transport Plan. These options are described in this chapter with full details provided in Appendix C.

Outline of the overall traffic modelling findings

Average traffic delays of less than 10 seconds per vehicle are regarded as having a minimal impact on the performance of the intersection. Delay increases greater than this are regarded as more significant. This terminology is used throughout this chapter when describing the traffic modelling results at each station.

The results of the 2013 existing situation intersection modelling confirms on-site observations that parts of the road network currently experience heavy congestion:

- Delhi Road, Epping Road, Lane Cove Road, Beecroft Road and the Pacific Highway experience a high traffic demand
- signal coordination is given (where possible) to these roads at the signalised intersections, however there are still high levels of congestion in both the morning and evening peak periods
- at many locations, queues were observed to extend from one intersection through to the next, impacting on intersection throughput
- a number of the assessed intersections are operating with a Level of Service D, E or F in either or both peaks, equating to an average vehicle delay of 43 seconds up to 83 seconds.

Background traffic growth from 2013 to 2019 is forecast to increase congestion and delays by less than 10 seconds per intersection. The addition of the rail replacement buses results in a marginal increase in average delays (3 seconds per intersection) in addition to the background growth impact. Overall, the addition of the rail replacement buses has little impact on intersection performance; however some movements/approaches are affected more than others. The largest increase in average intersection delay is 25 seconds per vehicle at the intersection of Waterloo Road/Khartoum Road in the evening peak.

4.2 Epping Station

4.2.1 Bus operations

The recommendations for enabling the efficient operation of rail replacement bus services at Epping Station, whilst minimising impacts on other bus routes and meeting customer experience objectives are summarised in Figures 4.4 and 4.5 for the morning and evening peak periods respectively. Further supporting details on these recommendations are provided in section 4.2.2 through to section 4.2.7.

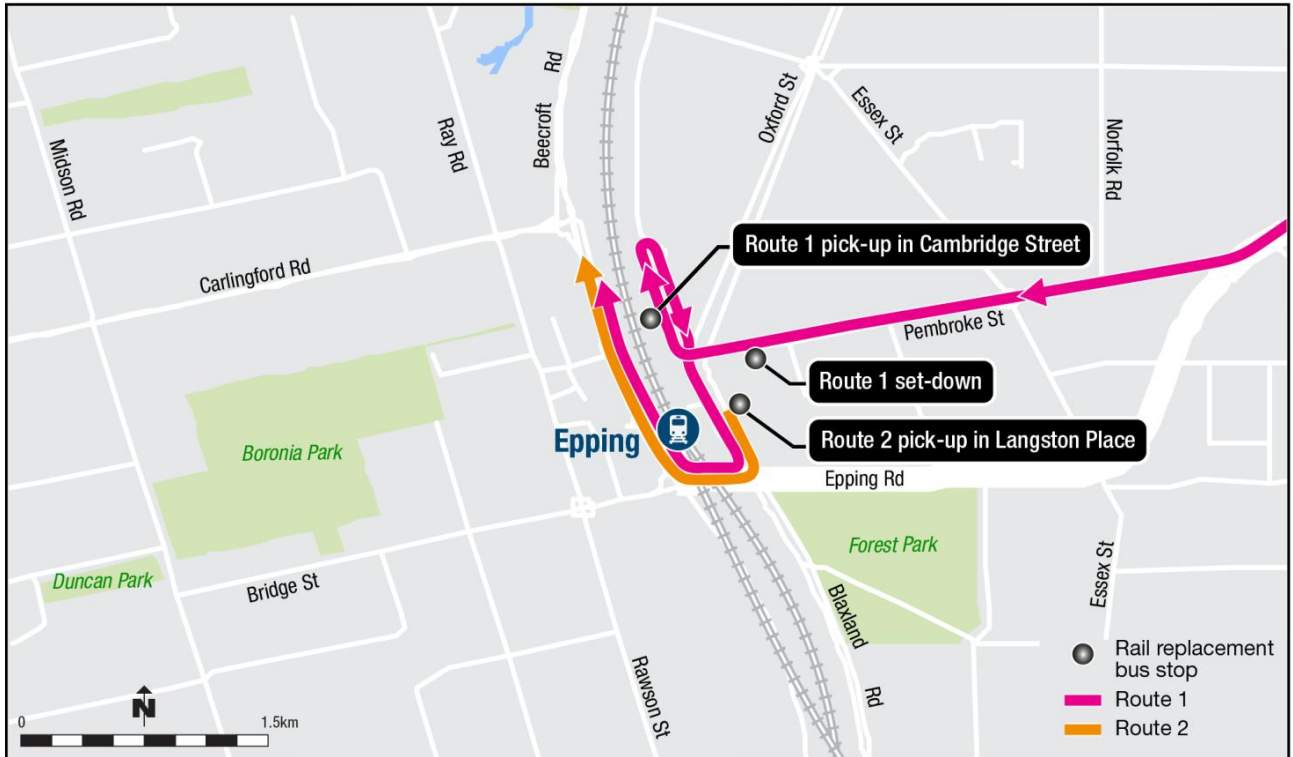


Figure 4.4 Morning peak rail replacement bus operations at Epping Station



Figure 4.5 Evening peak (Routes 1 and 2) and off peak (Route 1 only) rail replacement bus operations at Epping Station

4.2.2 Functional requirements

As a terminal point for rail replacement buses, and as an interchange point with Northern Line and intercity trains, Epping Station has a number of distinct functional requirements. These are summarised in Table 4.3.

Table 4.3 Functional requirements for rail replacement buses at Epping Station

Functional requirement	Notes
Sufficient kerb space for two buses at nominated pick-up stop(s).	<ul style="list-style-type: none"> 6 to 8 departures per hour on Route 1 to Macquarie University and Macquarie Park. 16 departures per hour on Route 2 to North Ryde and Chatswood. Allows concurrent boarding when required.
Separate pick-up stops for Routes 1 and 2.	<ul style="list-style-type: none"> Directs customers to the most appropriate service for their destination to avoid customer confusion.
Separate pick-up and set-down areas.	<ul style="list-style-type: none"> Delivers improved efficiency for the designated pick-up stops by separating boarding and alighting passenger flows.
Minimise disruption to other bus routes.	<ul style="list-style-type: none"> Epping Station serves as a terminus for other routes (288, 290, and 994) and as an interchange point for through route 295.
Maintain a common stop for the base service (Route 1) across all time periods.	<ul style="list-style-type: none"> Provides consistency across all time periods and days of the week.
Provide bus stops close to the railway station.	<ul style="list-style-type: none"> Minimises the impact on the customers interchanging between bus and train.

Functional requirement	Notes
Route 1 buses are able to operate to/from Macquarie University via the most efficient route, according to the time of the day.	<ul style="list-style-type: none"> ▪ Morning peak services operate from Epping via Beecroft Road and the M2. ▪ Morning peak services operate to Epping via Epping Road and Pembroke Street. ▪ Evening peak and off peak services operate from Epping via Pembroke Street and Epping Road. ▪ Evening peak and off peak services operate to Epping via the M2 and Beecroft Road.

4.2.3 Pick-up and set-down requirements

Based on the identified functional requirements the recommended pick-up and set-down requirements at Epping Station are:

- Cambridge Street (western side) – pick-up for the base service (Route 1)
- Langston Place (eastern side) – a separate (morning peak only) pick-up stop for Route 2
- set-down in Langston Place (western side) for buses arriving from the M2, or in Pembroke Street (shared with regular route services 288 and 290 setting down at Epping Station) for buses arriving from Epping Road.

These locations are shown in Figures 4.4 and 4.5. The justification for these pick-up and set-down locations is outlined in Table 4.4.

Table 4.4 Epping Station rail replacement bus pick-up and set-down requirements

Pick-up/set-down location	Justification
Cambridge Street (western side): <ul style="list-style-type: none"> ▪ Pick-up for the base service (Route 1). 	<ul style="list-style-type: none"> ▪ Provides level access from the station concourse. ▪ No roads to cross between the station and the bus stop. ▪ As used currently during track work on the Northern Line. ▪ Buses can depart Epping via either Pembroke Street or via Langston Place and Beecroft Road.
Langston Place (eastern side): <ul style="list-style-type: none"> ▪ Separate (morning peak only) pick-up stop for Route 2. 	<ul style="list-style-type: none"> ▪ Provides separate boarding areas for passengers to North Ryde/ Chatswood.
Set-down in Langston Place (western side) for buses arriving from the M2, or in Pembroke Street (shared with regular route services 288 and 290 setting down at Epping Station) for buses arriving from Epping Road.	<ul style="list-style-type: none"> ▪ Separates set-down and pick-up functions. ▪ Allows space for two buses on the pick-up stand. ▪ Buses can then be called onto the pick-up stands by bus service supervisors after setting down passengers. ▪ Although all bus stop dwell times at the set-down only stop in Pembroke Street will be low, if the stop is occupied by regular route buses, Route 1 buses arriving at Epping via Pembroke Street also have the option of setting down passengers in Cambridge Street, at the pick-up stop.

4.2.4 Interaction with other bus services

Based on the identified functional requirements, the operation of the rail replacement buses at Epping Station requires some amendments to other regular bus routes. These include:

- relocating Route 295 (to North Epping) and Route 994 (Optus Express) from Cambridge Street to Oxford Street
- relocating the set-down stop for buses terminating at Epping (Routes 288 and 290) from Cambridge Street to Pembroke Street.

The justification for these relocations is outlined in Table 4.5.

Table 4.5 Required amendments to other regular bus stops and justification – Epping Station

Bus stop relocation	Justification
<p>From Cambridge Street to Oxford Street:</p> <ul style="list-style-type: none"> ■ Route 295 (to North Epping); and ■ Route 994 (Optus Express). 	<ul style="list-style-type: none"> ■ Only rail replacement buses pick-up at Cambridge Street. ■ Provides a clear separation between rail replacement buses and other buses. ■ Relocated regular bus routes have lower frequencies and/or hours of operation compared to the rail replacement buses namely: <ul style="list-style-type: none"> ▶ Route 295 which operates: <ul style="list-style-type: none"> – 30 trips from Cambridge Street to North Epping on weekdays between approximately 6.00 am and 9.00 pm (includes a maximum frequency of 3 trips per hour during the morning peak period) – 12 trips (one trip per hour) from Cambridge Street to North Epping on Saturdays between approximately 8.30 am and 7.30 pm – 12 trips (one trip per hour) from Cambridge Street to North Epping on Sundays between approximately 9.00 am and 6.00 pm. ▶ Route 994 (Optus Express) only operates from Epping during the morning peak period (maximum of six trips per hour). ■ Oxford Street stop was used previously by these routes prior to the redevelopment of the Epping interchange. ■ The distance between Epping Station exit and the relocated bus stop is approximately 70 metres (m) and access is provided via a signalised crossing at Cambridge Street.
<p>From Cambridge Street to Pembroke Street:</p> <ul style="list-style-type: none"> ■ set-down for buses terminating at Epping (Routes 288 and 290). 	<ul style="list-style-type: none"> ■ Means that no buses are proposed to set-down passengers in Cambridge Street and a pick-up only stop is preserved at Cambridge Street. ■ The Pembroke Street stop was used previously by these routes prior to the redevelopment of the Epping interchange, and is approximately 50 m away from the current set-down stop. ■ Relocating these routes provides a clear separation between rail replacement and other buses. ■ The frequency of current regular routes is as follows: <ul style="list-style-type: none"> ▶ Route 288 – currently two trips per hour arriving at Epping during the morning peak on weekdays as well as Saturdays and Sundays ▶ Route 290 – currently two trips per hour arriving at Epping during the morning peak on weekdays and one trip per hour on Saturdays and Sundays. ■ Regular route buses will set-down only in Pembroke Street and then proceed to the layover location in Cambridge Street. ■ The distance between the relocated set-down stop at Pembroke Street and Epping Station entrance is approximately 80 m and access to/from the relocated set-down stop is maintained via the signalised crossing at Langston Place.

All relocated stops and services will revert to their existing locations once the Epping to Chatswood railway Rapid Transit Conversion Program is complete and NWRL is operational.

Layover and standby locations

No changes are proposed to layover or pick-up stops for Routes 288 and 290. The Beecroft Road southbound bus zone can be used for a standby bus. The front section of this bus zone is currently used by Metrobus Route M54 between Parramatta and Macquarie Park. There is a concept plan for introducing a bus only turn from Bridge Street to Epping Road, which would mean that Route M54 buses would no longer need to use the Beecroft Road stop, thereby creating additional space within the bus zone for rail replacement standby buses. The Transport for NSW Bus Priority Infrastructure Program has committed to bus priority improvements within Epping Town Centre, including providing bus only access from Bridge Street onto Beecroft Road.

The high frequency of rail replacement buses and the limited space available at Epping means that layover times need to be kept to a minimum. After dropping off passengers at Epping, those buses commencing another trip from Epping would be called onto the stop as soon as possible from the set-down stop.

Northern Line rail possessions

It is possible that weekend possessions on the Northern Line may also be scheduled during the period of the Epping to Chatswood railway Rapid Transit Conversion Program. Rail replacement buses for the Northern Line use the Beecroft Road stops at Epping Station and are therefore separate from the rail replacement buses using Cambridge Street (on the other side of the rail line). On weekends only Route 1 (all stations Epping to Chatswood) would operate. To avoid any conflict with Northern Line replacement buses, Route 1 services travelling between Macquarie University and Epping via the M2 and Beecroft Road would set-down passengers in Langston Place.

Bus stop capacity

Results from the bus stop capacity analysis indicate that:

- the bus stop in Cambridge Street could accommodate the target number of buses (eight) during the morning and evening peak periods
- the bus stop in Langston Place (western side) could accommodate the target number of buses (22) during the evening peak period
- the bus stop in Langston Place (eastern side) could experience capacity issues in accommodating the target number of buses (16) during the morning peak period
- the bus stop in Pembroke Street could accommodate the target number of buses (11) during the morning peak.

Bus loading at Langston Place (east side) will require supervision by bus marshals during the morning peak period, in order to minimise bus stop dwell times. Full detailed bus stop capacity analyses including risks and mitigation measures are provided in Appendix D.

4.2.5 Parking and taxis

Short term parking arrangements at Epping Station currently includes:

- Langston Place (western side) – (½P):
 - ▶ 8.30 am–6.00 pm Monday–Friday
 - ▶ 8.30 am–12.30 pm Saturday

- Langston Place (eastern side) – (½P):
 - ▶ 8.30 am–6.00 pm Monday–Friday
 - ▶ 8.30 am–12.30 pm Saturday
- Pembroke Street (southern side, east of Langston Place) – (1P):
 - ▶ 8.30 am–6.00 pm Monday–Friday
 - ▶ 8.30 am–12.30 pm Saturday.

Based on the identified functional requirements, and on the pick-up and set-down requirements, operation of the rail replacement buses at Epping Station requires some temporary changes to the provision of parking and taxis. These changes are outlined in Table 4.6.

Table 4.6 Epping Station – Temporary changes to provision of parking and taxis

Parking/taxis change	Justification
Langston Place (western side): <ul style="list-style-type: none"> ■ Temporary removal of kiss and ride parking (short term ½P) (approximately six spaces), so that all space is for buses and taxis. ■ Move the taxi rank to the south (replacing the kiss-and-ride). 	<ul style="list-style-type: none"> ■ Move the taxi rank to the south (replacing kiss and ride), so that the bus zone moves closer to the station (replacing taxi stand). ■ Use the Langston Place (western side) bus zone as a set-down and layover space for the rail replacement buses. ■ There is already an existing kiss and ride at the northern side of Pembroke Street which has signs stating that passenger set-down and pick-up are permitted during the nominated 'no parking' hours (6.30 am to 9.30 am, and 4.00 pm to 6.00 pm).
Langston Place (eastern side): <ul style="list-style-type: none"> ■ temporary extension of the existing weekday 'no parking' restriction from 8.30 am until peak hour operation of Route 2 ends (at approximately 10.00 am). 	<ul style="list-style-type: none"> ■ Provides a separate pick-up area for Route 2 services to North Ryde and Chatswood.
Pembroke Street (southern side): <ul style="list-style-type: none"> ■ temporary removal of short term parking (approximately four spaces). 	<ul style="list-style-type: none"> ■ Allows set-down for Routes 288 and 290.

4.2.6 Traffic impacts

Existing situation intersection performance (2013)

Table 4.7 provides a summary of the existing intersection performance around Epping Station.

Table 4.7 Summary of existing intersection performance - Epping Station

Site ID	Intersection	Peak period	Degree of Saturation	Average Delay (sec)	Level of Service	95 th percentile queue (m) ¹
1	Eastbound M2 Motorway off ramp and Beecroft Road	AM	0.58	6	A	88 (NW)
		PM	0.71	10	A	84 (SE)
2	Beecroft Road and Carlingford Road	AM	1.03	51	D	415 (W)
		PM	1.31	49	D	321 (N)
3	Beecroft Road, High Street and Bridge Street	AM	0.69	11 (W)	A	11 (W)
		PM	0.81	16 (W)	B	9 (W)

Site ID	Intersection	Peak period	Degree of Saturation	Average Delay (sec)	Level of Service	95 th percentile queue (m) ¹
4	Epping Road, Langston Place and Blaxland Road	AM	1.02	36	C	317 (W)
		PM	1.37	54	D	528 (E)
5	Pembroke Street, Oxford Street, Cambridge Street and Langston Place	AM	0.46	20	B	57 (NE)
		PM	0.32	20	B	41 (NE)

(1) Notes: Letter indicates approach with the longest queue, N = north, NE = north-east, E = east, SE = south-east, S = south, SW = south-west, W = west, NW = north-west

The modelling results matched on-site observations and indicated that:

- During the morning peak, parking is allowed in the kerbside lane of the northbound approach to the Beecroft Road/Carlingford Road intersection, reducing its capacity.
- High levels of traffic congestion were observed at the Beecroft Road/Carlingford Road intersection during morning and evening peak periods, especially along the Carlingford Road approach where the queue extended through the nearby Rawson Street intersection. The right turn pocket on Beecroft Road north approach frequently exceeded its capacity.
- Long queues were observed on the east and west approaches to the Beecroft Road/Epping Road/Langston Place/Blaxland Road intersection in both peaks.
- No issues were identified at the Beecroft Road/M2 off-ramps intersection or the Pembroke Street, Oxford Street, Cambridge Street and Langston Place intersection.

Future base intersection performance (2019)

Epping Town Centre Urban Activation Precinct (UAP)

The 2019 base scenario at Epping Station was modified to include the road changes planned for the Epping Town Centre Urban Activation Precinct (UAP). Three intersection upgrades are planned, with two affecting the key intersections modelled for this assessment. These are highlighted in Table 4.8.

Table 4.8 Epping Town Centre UAP planned intersection modifications

Intersection	Planned upgrade
Beecroft Road and Carlingford Road	Provide additional right-turn lanes from Beecroft Road (north) onto Carlingford Road (west).
Epping Road, Langston Place and Blaxland Road	Widening Epping Road between Essex Street and Blaxland Road, including intersection works and removal of the right hand turn from Langston Place onto Beecroft Road.
Epping Road and Essex Street	Additional right-turn lane from Essex Street into Epping Road.

Source: NSW Department of Planning and Infrastructure, March 2014

These intersection upgrades are expected to be completed by the end of 2015 (NSW Department of Planning and Infrastructure 2014).

The results from the intersection modelling for base conditions in 2019, taking into consideration these proposed road changes, showed that:

- As the Beecroft Road/Carlingford Road intersection is already operating at capacity in 2013, the additional traffic growth would result in a worsening of conditions for the main traffic movements. However, the addition of a second right turn lane on the Beecroft Road north approach to the Beecroft Road/Carlingford Road intersection would result in improved performance for this movement.

- The removal of the right turn from Langston Place onto Beecroft Road at the Beecroft Road/Epping Road/Langston Place/Blaxland Road intersection would result in an overall improvement in intersection performance, largely due to the reallocation of green time that was previously assigned to the right turn phase. However there would be a worsening in the performance of the Epping Road approach, due to the addition of the redirected right turn volume.

Traffic modelling results (2019) with rail replacement buses

The traffic modelling at Epping Station was based on the operation of rail replacement buses as shown in Figures 4.4 and 4.5. The Epping Town Centre planned upgrade for the intersection of Epping Road, Langston Place and Blaxland Road removed the existing right-turn from Langston Place to Beecroft Road. This proposed southbound right turn ban creates a detour for the rail replacement buses via Essex Street, potentially delaying these buses and increasing the length of their route. For the purposes of traffic modelling it has been assumed that the right turn at this intersection could be reintroduced temporarily for buses only. This is achieved through the conversion of the right lane on Langston Place (the current right turn lane) into a bus only lane and the modification of the traffic signal phasing to include a B-signal that runs in parallel with the southbound through movement. The morning peak hour bus operations were based on the assumption that Route 1 and Route 2 buses departing Epping can turn right into Beecroft Road. This was tested through the traffic modelling.

The traffic modelling for buses departing and arriving at Epping during the morning peak and evening peak periods was based on the preferred demand scenario and included the following bus movements:

- Route 1 to Epping: 8 morning peak (1 hour) trips and 6 evening peak (1 hour) trips
- Route 1 from Epping: 6 morning peak (1 hour) trips and 8 evening peak (1 hour) trips
- Route 2 to Epping: 16 evening peak (1 hour) trips
- Route 2 from Epping: 16 morning peak (1 hour) trips.

The results of the traffic modelling are shown in Figure 4.6. They indicate that:

- Eastbound M2 Motorway off ramp and Beecroft Road:
 - ▶ The addition of the rail replacement buses had minimal impact on average delays (less than a 10 second increase) in both peaks and as such minimal impact on the operation of this intersection.
- Beecroft Road and Carlingford Road:
 - ▶ In the morning peak the additional buses result in an increase in the queue length of approximately 45 m and minimal impact on average delays (less than 10 seconds) for the through traffic movement on the Beecroft Road north approach.
 - ▶ During the evening peak the additional buses result in an increase in the queue length of 40 m and minimal impact on average delays (less than 10 seconds) for the through traffic movement on the Beecroft Road south approach.
- Beecroft Road, High Street and Bridge Street:
 - ▶ The addition of the rail replacement buses had minimal impact on the operation of this intersection.
- Beecroft Road, Epping Road, Langston Place and Blaxland Road:
 - ▶ The removal of the right turn from Langston Place into Beecroft Road allowed some improvements to be gained in the 2019 base assessment (phasing improvements). The addition of the rail replacement bus services through this intersection has resulted in the need to reintroduce a right turn phase from Langston Place (a 'Bus Only' phase in this case). As a result of this there is an overall decrease in performance for the intersection as a whole when compared to the 2019 base results.

- ▶ Rail replacement buses cause an increase in delays and queues for Blaxland Road (additional one minute average delay per vehicle and additional 100 m queue length for through vehicles in the morning peak), due to the additional right turn for buses on Langston Place.
- ▶ Overall there is minimal impact on the intersection (less than 10 seconds increase in average delay), resulting in the performance during the morning peak changing from Level of Service B to C.
- ▶ Rail replacement buses experience approximately 80 to 90 seconds delay turning right from Langston Place into Beecroft Road, but this is less than the 2 minutes currently experienced.
- ▶ Queue lengths on Langston Place are unlikely to affect the intersection with Pembroke Street.
- Langston Place, Pembroke Street, Oxford Street and Cambridge Street:
 - ▶ The addition of the rail replacement buses had minimal impact on the operation of this intersection.

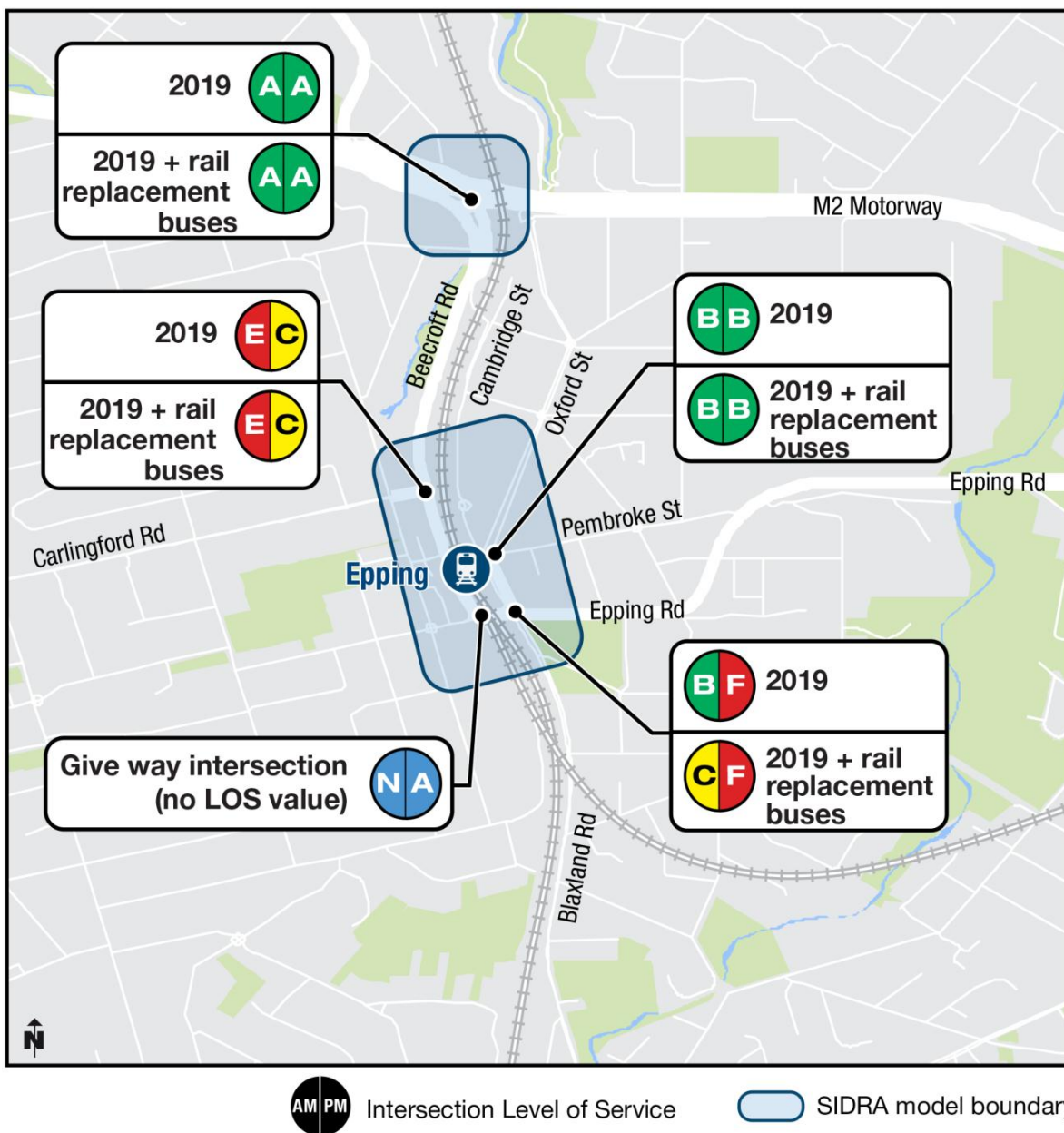


Figure 4.6 Traffic modelling results at Epping Station

4.2.7 Infrastructure and temporary facilities

Specific infrastructure needs around Epping Station which may support the requirements identified in the previous sections include the introduction of a B-signal at the intersection of Langston Place and Beecroft Road, to allow buses on Routes 1 and 2 to turn into Beecroft Road during the morning peak period. The introduction of the B signal is part of the bus priority program or part of the RMS traffic management. By 2019 the RMS plan is to remove the right hand turn for general traffic (buses excepted) from Langston Place into Beecroft Road. The B-signal is required due to the volume of rail replacement buses required to make this turn.

Figure 4.7 shows the proposed scope of works for temporary facilities associated with Epping Station.

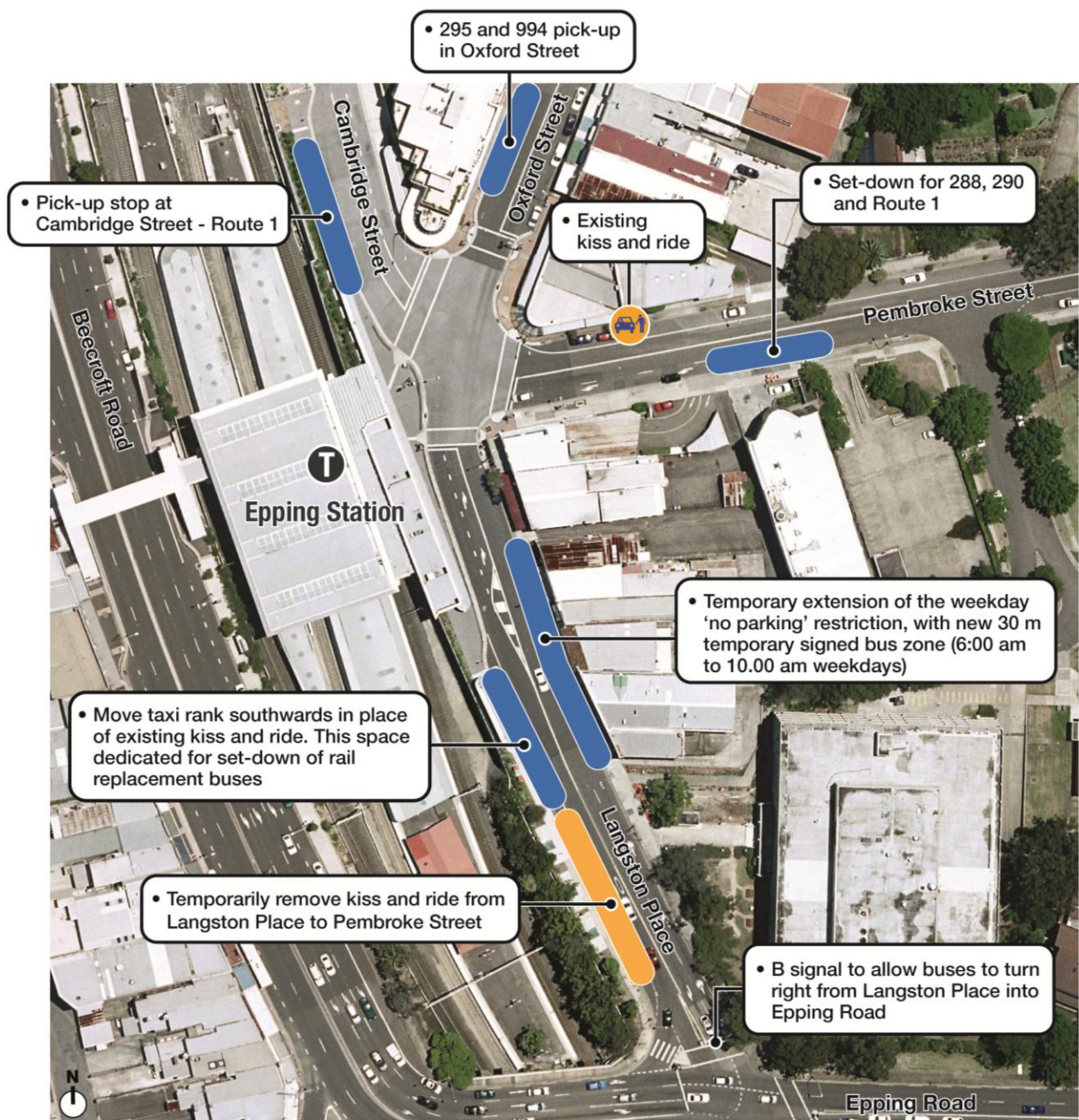


Figure 4.7 Proposed scope of works for temporary facilities - Epping Station

4.3 Macquarie University Station

4.3.1 Bus operations

The recommendations for enabling the efficient operation of rail replacement bus routes at Macquarie University Station, whilst minimising impacts on other bus routes and meeting customer experience objectives are summarised in Figures 4.8 and 4.9. Further details on the recommendations are provided in section 4.3.2 through to section 4.3.7.

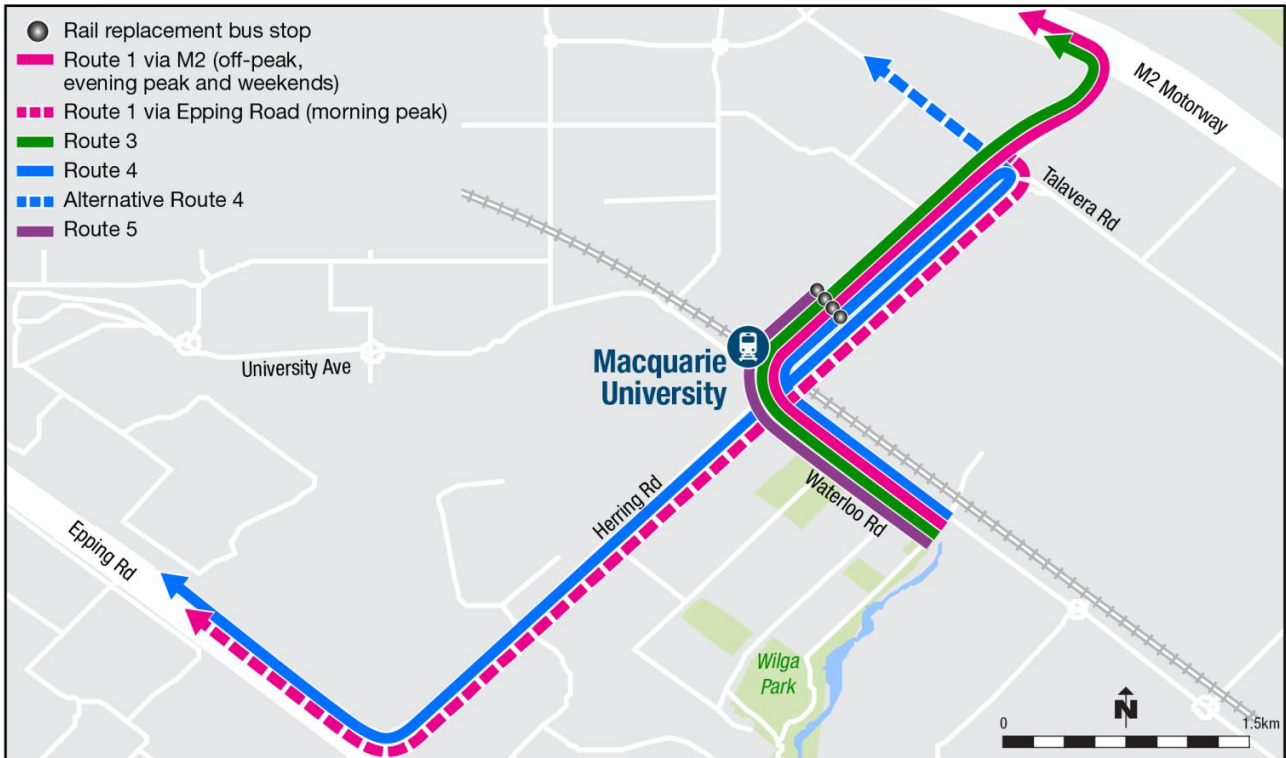


Figure 4.8 Westbound rail replacement bus operations at Macquarie University Station⁶

⁶ Figure 4.7 shows an alternative for Route 4 to Eastwood. This alternative route travels via Talavera Road, Culloden Road, Vimiera Road and Balaclava Road. This provides an alternative for Route 4 if there is significant congestion in the Macquarie Centre interchange.

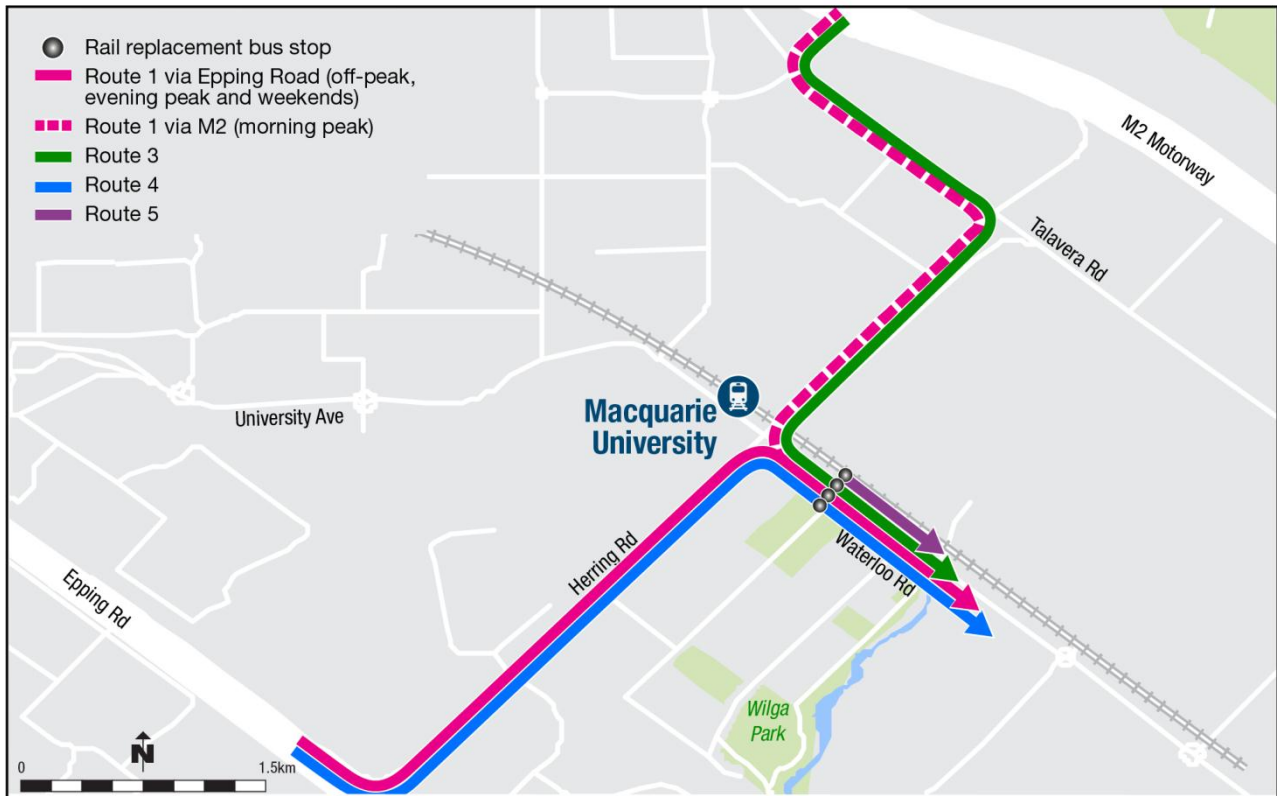


Figure 4.9 Eastbound rail replacement bus operations at Macquarie University Station

4.3.2 Functional requirements

The functional requirements for Macquarie University Station are summarised in Table 4.9.

Table 4.9 Functional requirements for rail replacement buses at Macquarie University Station

Functional requirement	Notes
Maintain a common stop in each direction for the base service (Route 1) across all time periods.	<ul style="list-style-type: none"> Provides consistency across all time periods and days of the week.
Common eastbound pick-up and set-down stop for all rail replacement bus routes.	<ul style="list-style-type: none"> Route 1 to Macquarie Park, North Ryde and Chatswood (full time). Route 4 to Macquarie Park (morning peak). Route 3 to St Leonards (morning and evening peak). Route 5 to Gordon (evening peak).
Common westbound pick-up and set-down stop for all rail replacement bus routes.	<ul style="list-style-type: none"> Route 1 to Epping (full time). Route 3 to Beecroft (evening peak). Route 3 terminating (morning peak). Route 4 to Eastwood (evening peak). Route 5 terminating (morning peak).
Minimise disruption to other bus routes.	<ul style="list-style-type: none"> Westbound bus stop (Herring Road) and the eastbound bus stop (Waterloo Road) are used by regular bus routes throughout the week.
Provide direct access between bus stops and the Macquarie Shopping Centre and University Campus.	<ul style="list-style-type: none"> Replicates the proximity of the train service to both these key destinations.

The number of rail replacement buses serving Macquarie University during peak hours is summarised in Table 4.10.

Table 4.10 Peak hour rail replacement bus numbers at Macquarie University Station

	Eastbound			Westbound		
	Route	To	Number of trips per hour	Route	To	Number of trips per hour
Morning peak	1	Chatswood	6	1	Epping	8
	3	St Leonards	8	3	Terminate	18
	4	Macquarie Park	12	5	Terminate	6
			26			32
Evening peak	1	Chatswood	8	1	Epping	6
	3	St Leonards	17	3	Beecroft	8
	5	Gordon	6	4	Eastwood	12
			31			26

4.3.3 Pick-up and set-down requirements

Based on the identified functional requirements, the preferred pick-up and set-down requirements at Macquarie University Station are:

- Waterloo Road (east of Herring Road) – eastbound pick-up and set-down
- Herring Road (opposite Macquarie Shopping Centre) – westbound pick-up and set-down.

These locations are shown in Figures 4.8 and 4.9. The justification for these locations is outlined in Table 4.11.

Table 4.11 Macquarie University Station rail replacement bus pick-up and set-down requirements

Pick-up/set-down location	Justification
Eastbound pick-up and set-down stop in Waterloo Road (east of Herring Road).	<ul style="list-style-type: none"> ■ Provides direct access to Macquarie Shopping Centre and Macquarie University. ■ Provides a common eastbound pick-up and set-down for all rail replacement bus routes.
Westbound pick-up and set-down stop in Herring Road, opposite Macquarie Shopping Centre.	<ul style="list-style-type: none"> ■ Provides direct access to/from Macquarie University. ■ Provides access to Macquarie Shopping Centre via pedestrian signals at the front of the bus stop. ■ On departure from the bus stop, buses can directly access the M2 or can access Epping Road via the Macquarie Shopping Centre U-turn allowing flexibility in operations.

4.3.4 Interaction with other bus services

Eastbound bus stop (Waterloo Road)

The existing eastbound bus stop in Waterloo Road would be extended in order to provide additional capacity for the rail replacement bus services. The eastbound stop would be shared with services setting down from the M2, and with Metrobus Route M41, as shown in Table 4.12.

Although for regular route buses set-down at this stop and therefore dwell times are low, there is a potential congestion as the rail replacement buses increase the number of peak hour buses using the stop from 21 to 53 during the morning peak (1 hour) and from 20 to 55 during the evening peak (1 hour).

Table 4.12 All services using the Macquarie University eastbound bus stop (Waterloo Road)

Routes	Buses per hour	
	7.30 am to 8.30 am	5.00 pm to 6.00 pm
611, 619, 621, 628, 630, 651, 740 from the M2	15	14
Route 4 from Eastwood	12	-
M41 to Hurstville	6	6
Route 3 to St Leonards	-	18
Route 5 to Gordon	-	6
Route 1 Epping to Chatswood	6	8
Route 3 Beecroft to St Leonards	8	-
Estimated future growth of services – 2019*	6	3
	21 (now) 27 (with future growth) 53 (with rail replacement buses + future growth)	20 (now) 23 (with future growth) 55 (with rail replacement buses + future growth)

*Source: Transport Services Division (Transport for NSW)

Westbound bus stop (Herring Road)

The westbound stop would be shared with services picking up and travelling via the M2, and with Metrobus Route M41, as shown in Table 4.13.

Dwell times for regular route buses at this stop are higher than at the eastbound stop, as buses are primarily picking up customers. There is potential congestion as the rail replacement buses plus the growth in regular route buses would increase the number of peak hour buses using the stop from 18 to 52 during the morning peak (1 hour) and from 22 to 54 during the evening peak (1 hour).

To support the effective operation of buses at this stop, it is recommended that only the regular route services shown in Table 4.13 share the stop with rail replacement buses. These are the routes for which this bus stop provides the only pick-up point at Macquarie University/Macquarie Shopping Centre. All other regular route buses which are not scheduled to use this stop but occasionally do so would be instructed to only use their scheduled bus stops at Macquarie University and Macquarie Shopping Centre.

Bus stop capacity analysis has been undertaken to test the feasibility of the Waterloo Road and Herring Road bus stops to accommodate the number of buses shown in Tables 4.12 and 4.13 respectively. Results indicate that the stops provide sufficient capacity. Full detailed bus stop capacity analyses including risks and mitigation measures are provided in Appendix D.

Table 4.13 All services using the Macquarie University westbound bus stop (Herring Road)

Routes	Buses per hour (exclusive to this stop)	
	7.30 am to 8.30 am	5.00 pm to 6.00 pm
M41 to Marsfield	6	6
Route 3 from St Leonards	18	-
Route 5 from Gordon	6	-
611, 619, 621, 628, 651, 740 to the M2	12	16
Route 4 to Eastwood	-	12
Route 1 Chatswood to Epping	8	6
Route 3 to Beecroft	-	8
Estimated future growth of services – 2019*	2	6
	18 (now) 20 (with future growth) 52 (with rail replacement buses + future growth)	22 (now) 28 (with future growth) 54 (with rail replacement buses + future growth)

*Source: Transport Services Division (Transport for NSW)

4.3.5 Parking and taxis

No changes to the provision of parking or the location of taxi ranks are required as a result of the rail replacement buses at Macquarie University Station.

4.3.6 Traffic impacts

Existing situation intersection performance (2013)

Table 4.14 provides a summary of the existing intersection performance around Macquarie University Station.

Table 4.14 Summary of existing intersection performance – Macquarie University Station

Site ID	Intersection	Peak period	Degree of Saturation	Average Delay (sec)	Level of Service	95 th percentile queue (m) ¹
6	Epping Road and Balaclava Road	AM	0.95	56	D	415 (NW)
		PM	0.96	56	D	366 (SE)
7	Epping Road and Herring Road	AM	1.19	78	F	439 (NW)
		PM	1.03	63	E	333 (SE)
8	Waterloo Road, University Avenue and Herring Road	AM	0.78	46	D	198 (SW)
		PM	0.94	57	E	236 (SE)
8a	Herring Road signalised pedestrian crossing	AM	0.51	12 veh, 19 ped	A, B	90 (SW)
		PM	0.64	13 veh, 18 ped	A, B	121 (SW)
9	Talavera Road and Herring Road	AM	0.85	34	C	159 (NW)
		PM	0.81	39	C	125 (SW)
10	M2 Motorway on/off Ramps and Herring Road – not modelled, see intersection 9, north approach for results					

(1) Notes: Letter indicates approach with the longest queue, N = north, NE = north-east, E = east, SE = south-east, S = south, SW = south-west, W = west, NW = north-west

These results match on-site observations and indicate that:

- On the Epping Road between its intersection with Balaclava Road and Herring Road, long queues were observed on Epping Road north-west approach in the morning peak and Epping Road south-east approach in the evening peak, respectively. However, queues were not extending back to the adjacent signalised intersection.
- No significant queuing issues were identified on Balaclava Road.
- Long queues were observed on Herring Road south-west approach to the intersection with Epping Road in the morning peak and Herring Road north-east approach in the evening peak, respectively.
- No issues were identified at the Herring Road/Talavera Road intersection in both peak periods.
- In the evening peak, the capacity of the left turn lane from Waterloo Road north-west approach into Khartoum Road was reduced due to downstream constraints (extended queue from the Talavera Road/Khartoum Road intersection), which results in queues on Waterloo Road north-west approach.

Future base intersection performance (2019)

The results from the intersection modelling for base conditions in 2019 around Macquarie University Station showed that:

- Along the Epping Road corridor, the greatest impact is seen on the Epping Road approaches to the Herring Road and Balaclava Road intersections, where in both peaks the degree of saturation operation of some movements increased to a degree of saturation rate of over 1.0.
- Along the Herring Road corridor, there has been a relatively small decrease in the operating conditions, with Level of Service indicators remaining the same as the 2013 values.

Traffic modelling results (2019) with rail replacement buses

Traffic modelling for westbound buses was based on the following bus movements:

- Route 1 to Epping: 8 morning peak (1 hour) trips and 6 evening peak (1 hour) trips
- Route 3 from St Leonards, terminating trips: 18 morning peak (1 hour) trips
- Route 3 to Beecroft: 8 evening peak (1 hour) trips
- Route 4 to Eastwood: 12 evening peak (1 hour) trips
- Route 5 from Gordon, terminating trips: 6 morning peak (1 hour) trips.

Traffic modelling for eastbound buses was based on the following bus movements:

- Route 1 to Chatswood: 6 morning peak (1 hour) trips and 8 evening peak (1 hour) trips
- Route 3 to St Leonards: 8 morning peak (1 hour) trips and 17 evening peak (1 hour) trips
- Route 4 to Macquarie Park: 12 morning peak (1 hour) trips
- Route 5 to Gordon: 6 evening peak (1 hour) trips.

The results of the traffic modelling for the year 2019 with and without rail replacement buses for the Macquarie University area is shown in Figure 4.10. The results indicate that:

- Epping Road and Herring Road:
 - ▶ the addition of the buses had minimal impact on the operation of this intersection in the morning peak
 - ▶ during the evening peak the rail replacement buses increase delays on Herring Road, north of Epping Road, by 13 seconds per vehicle, but have minimal impacts on other intersection approaches.
- Waterloo Road, University Avenue and Herring Road:
 - ▶ there was an increase to the right turn queue on the Waterloo Road south-east approach in both peaks (up to 60 m), as well as increased delays (up to 30 seconds additional wait time).
- Talavera Road, Herring Road and M2 Motorway on/off ramps:
 - ▶ in the morning peak there is an increase to the queue and delays on the Herring Road south-west approach reported for the right turn movement (approximately 70 m increase)
 - ▶ there are minimal impacts during the evening peak.
- The addition of rail replacement buses had minimal impact on the operation of the Epping Road and Balaclava Road intersection or the Herring Road pedestrian crossing.

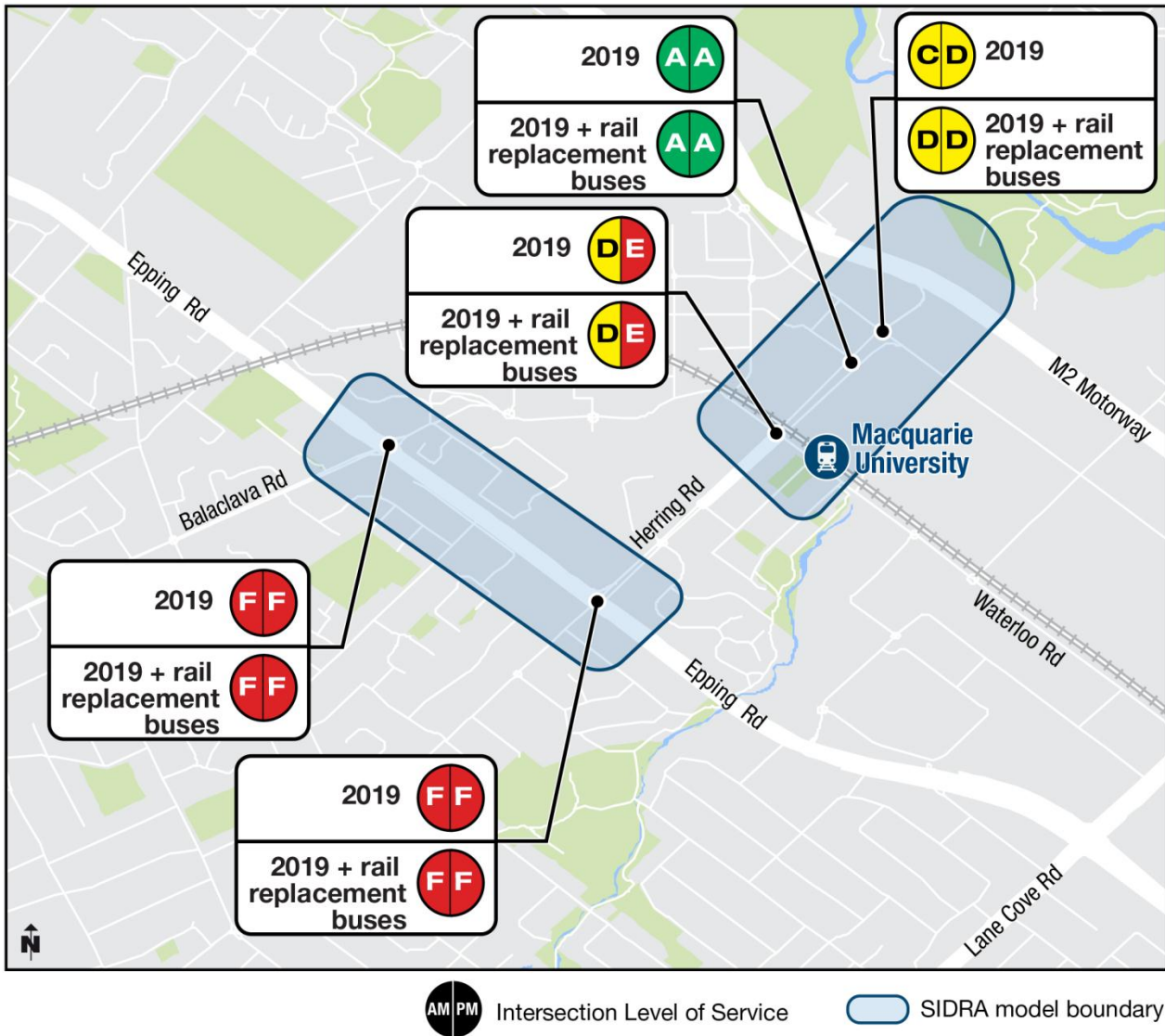


Figure 4.10 Traffic modelling results at Macquarie University Station

4.3.7 Temporary facilities

Specific temporary facilities around Macquarie University Station which will support the requirements identified in sections 4.3.2 to 4.3.6 include:

- extension of the existing eastbound stop closer to the car park entrance to provide additional space for rail replacement buses
- temporary weather protection, seating and information at the eastbound and westbound stops as while seating exists no shelter facilities are currently provided at the eastbound stop.

Figure 4.11 shows the proposed scope of works for temporary facilities associated with Macquarie University Station.

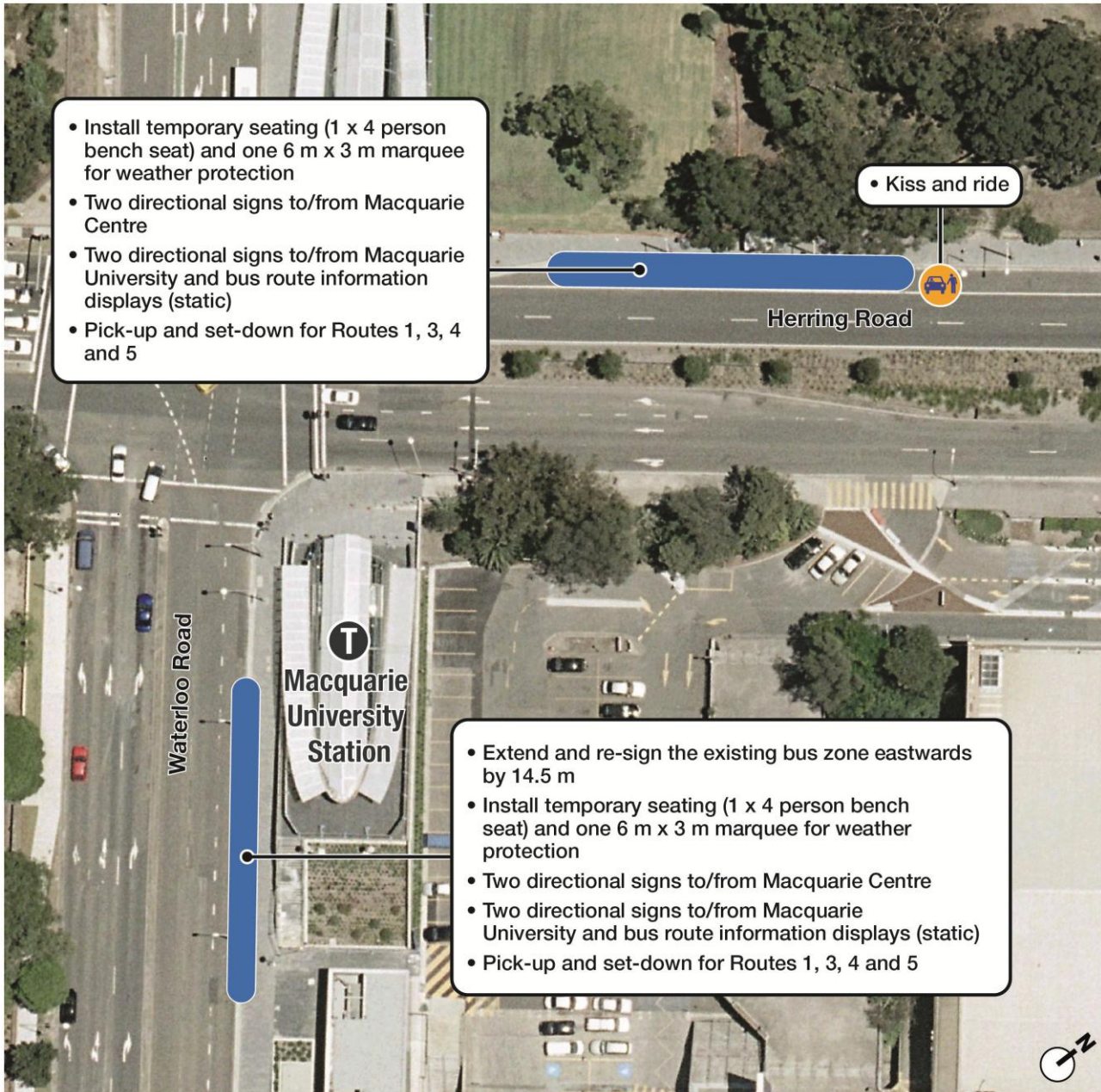


Figure 4.11 Proposed scope of works for temporary facilities - Macquarie University Station

Macquarie Shopping Centre redevelopment

The redevelopment of Macquarie Shopping Centre is due for completion in late 2014 and will add approximately 31,800 m² in floor space for additional major retail traders as well as an additional 130 speciality outlets and 1,050 additional car parking spaces. There is the potential for the recommendations outlined in this Temporary Transport Plan to be affected by changes to entry and exit points for traffic to/from the shopping centre, and by additional traffic generated by this redevelopment.

There are some other potential development sites that may also be considered in a review of the Temporary Transport Plan at a future date, which include:

- 120–128 Herring Road (MP09_0195)
- 110–114 Herring Road (MP10_112) Mixed Use Development of Stamford Hotel site

- Herring Road Urban Activation Precinct. This UAP has the potential to increase local housing supply and deliver up to 2,400 new homes by 2021 (NSW Planning and Environment 2014). The period available to provide submissions on this proposed development closed recently on 10 August 2014.

4.4 Macquarie Park Station

4.4.1 Bus operations

The recommendations for enabling the efficient operation of rail replacement bus routes at Macquarie Park Station, whilst minimising impacts on other bus routes and meeting customer experience objectives is summarised in Figures 4.12 and 4.13. Further details on the recommendations are provided in section 4.4.2 through to section 4.4.7.

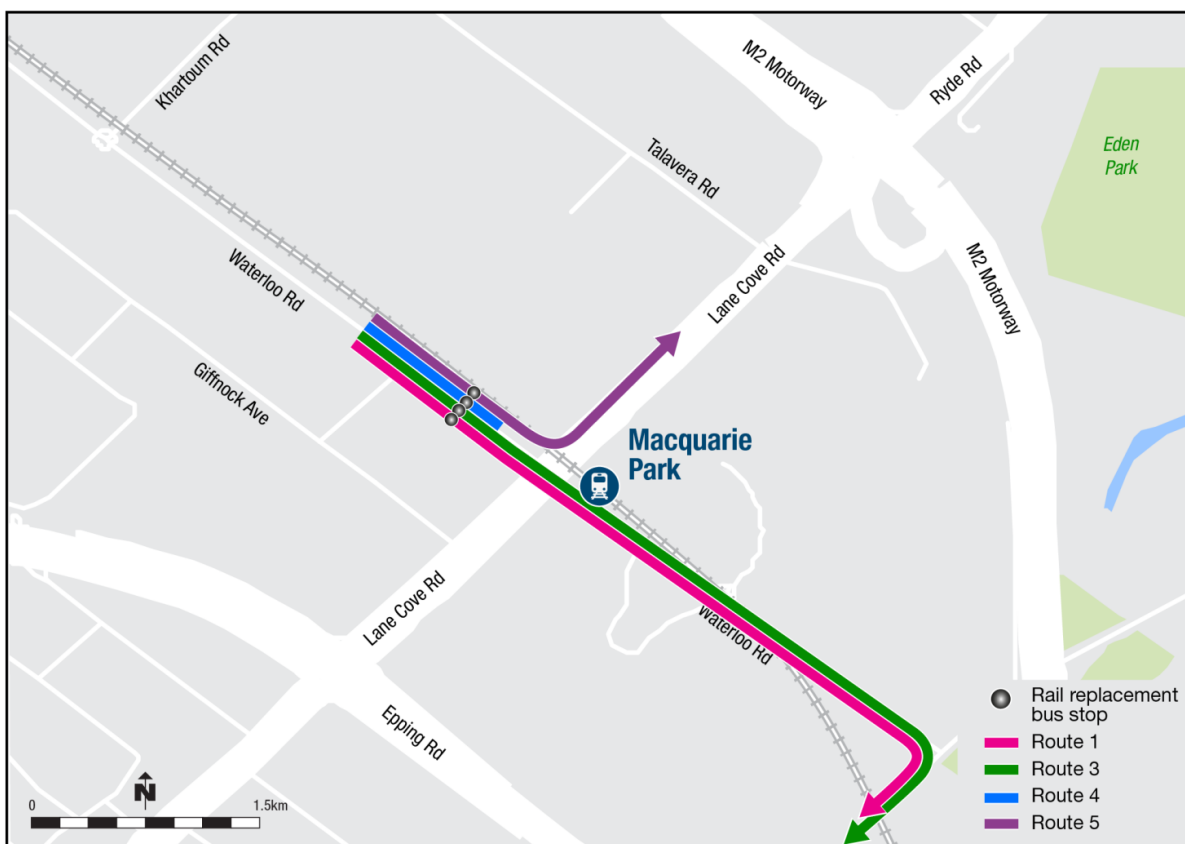


Figure 4.12 Eastbound rail replacement bus operations at Macquarie Park Station

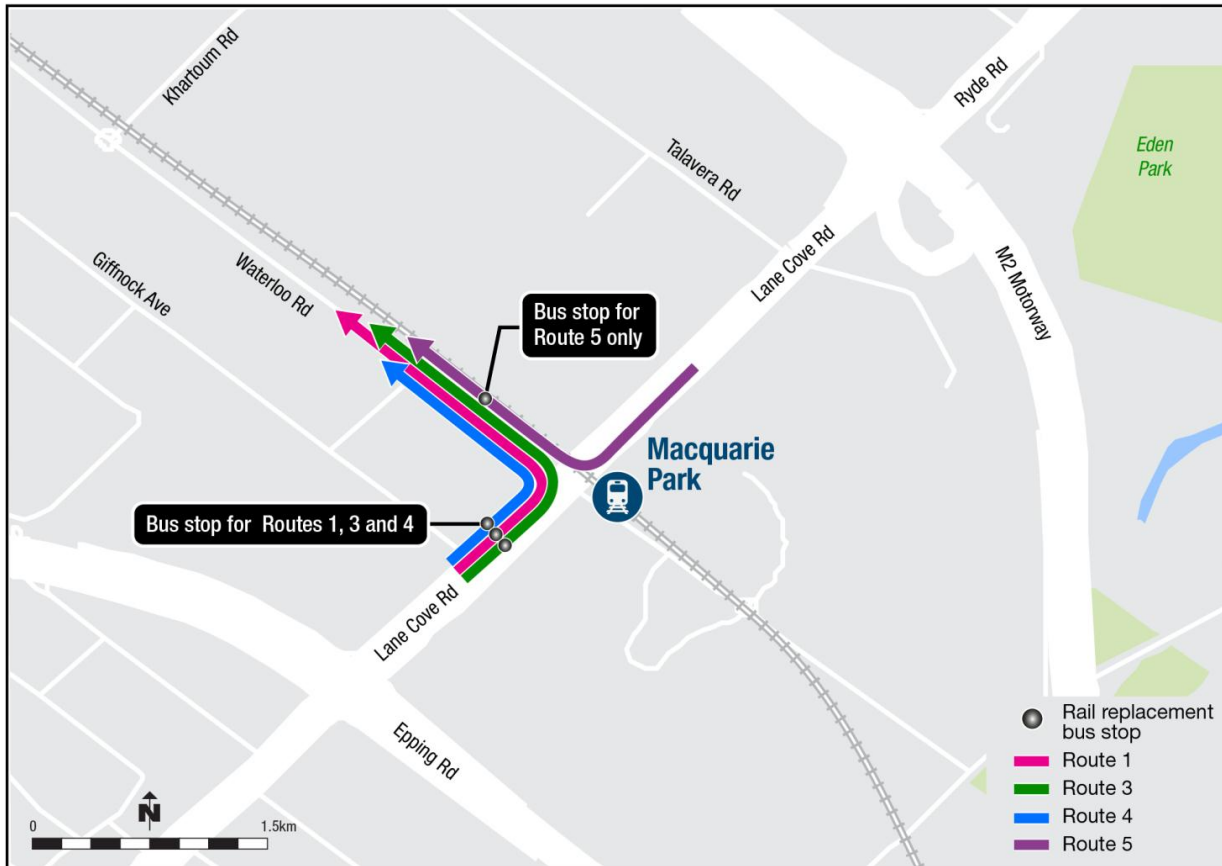


Figure 4.13 Westbound rail replacement bus operations at Macquarie Park Station

4.4.2 Functional requirements

The functional requirements for Macquarie Park Station are summarised in Table 4.15.

Table 4.15 Functional requirements for rail replacement buses at Macquarie Park Station

Functional requirement	Note
Maintain a common stop for the base service (Route 1) across all time periods.	<ul style="list-style-type: none"> Provides consistency across all time periods and days of the week.
Common eastbound pick-up and set-down stop for all rail replacement bus routes.	<ul style="list-style-type: none"> Route 1 to North Ryde and Chatswood (full time). Route 4 terminating (morning peak). Route 3 to St Leonards (morning and evening peak). Route 5 to Gordon (evening peak).
Westbound pick-up and set-down stops for all rail replacement bus routes.	<ul style="list-style-type: none"> Routes 1 to Epping (full time). Route 3 to Beecroft (evening peak). Route 3 to Macquarie University (morning peak). Route 4 to Eastwood (evening peak). Route 5 to Macquarie University (morning peak).
Minimise disruption to other bus routes.	<ul style="list-style-type: none"> Waterloo Road used by regular bus routes throughout the week.
Provide direct access between bus stops and surrounding businesses.	<ul style="list-style-type: none"> Replicates the proximity of the train service to destinations around Macquarie Park.

The number of rail replacement buses serving Macquarie Park during peak hours is summarised in Table 4.16.

Table 4.16 Peak (1 hour) rail replacement bus numbers at Macquarie Park Station

	Eastbound			Westbound		
	Route	To	Number of trips per hour	Route	To	Number of trips per hour
Morning peak	1	Chatswood	6	1	Epping	8
	3	St Leonards	8	3	Macquarie University	18
	4	Terminating	12	5	Macquarie University	6
			26			32
Evening peak	1	Chatswood	8	1	Epping	6
	3	St Leonards	17	3	Beecroft	8
	5	Gordon	6	4	Eastwood	12
			31			26

4.4.3 Pick-up and set-down requirements

Based on the identified functional requirements the preferred pick-up and set-down requirements at Macquarie Park Station are:

- Waterloo Road (west of Lane Cove Road) – eastbound pick-up and set-down (existing bus stop)
- Lane Cove Road – westbound pick-up and set-down (existing northbound bus stop).

These locations are shown in Figures 4.12 and 4.13. The justification for these locations is outlined in Table 4.17.

Table 4.17 Macquarie Park Station rail replacement bus pick-up and set-down requirements

Pick-up/set-down location	Justification
Eastbound pick-up and set-down at the existing stop in Waterloo Road (west of Lane Cove Road).	<ul style="list-style-type: none"> ■ Provides a common pick-up stop for all rail replacement buses. ■ Buses can rank behind each other at the stop if required.
Westbound pick-up and set-down at the existing northbound bus stop in Lane Cove Road.	<ul style="list-style-type: none"> ■ Provides a common stop for rail replacement bus Routes 1, 3 and 4. Route 5 from Gordon during the morning peak would set-down passengers at the existing bus stop in Waterloo Road. ■ Buses can rank behind each other at the Lane Cove Road stop if required. ■ The number of regular route buses at the Lane Cove Road stop is much less than at the existing westbound bus stop in Waterloo Road, and therefore the impact of rail replacement buses is minimised.

4.4.4 Interaction with other bus services

Based on the identified functional requirements, the operation of the rail replacement buses at Macquarie Park Station requires no relocation of other bus routes.

Eastbound bus stop (Waterloo Road)

The eastbound stop is shared with services terminating at Macquarie Park (from the M2 and from Parramatta), and with Route 197, as shown in Table 4.18.

Table 4.18 All services using the Macquarie Park eastbound bus stop (Waterloo Road)

Routes	Buses per hour	
	7.30 am to 8.30 am	5.00 pm to 6.00 pm
611, 619, 621, 628, 630, 651, 740 from the M2 M54 from Parramatta	23	18
Route 4 from Eastwood	12	-
197 to Gordon, M41 to Hurstville	10	12
Route 3 to St Leonards	-	17
Route 5 to Gordon	-	6
Route 1 Epping to Chatswood	6	8
Route 3 Beecroft to St Leonards	8	-
Estimated future growth in services – 2019*	6	3
	33 (now) 39 (with future growth) 65 (with rail replacement buses + future growth)	30 (now) 33 (with future growth) 64 (with rail replacement buses + future growth)

*Source: Transport Services Division (Transport for NSW)

Although most regular route buses set-down at this stop and therefore dwell times are low, there is potential bus stop congestion as the rail replacement buses increase the number of peak hour buses using the stop from 33 to 65 during the morning peak (1 hour) and from 30 to 64 during the evening peak (1 hour).

Westbound bus stop (Lane Cove Road)

The westbound stop in Lane Cove Road is shared with buses to Macquarie Shopping Centre/University and to Parramatta, as shown in Table 4.19.

Bus stop capacity analysis has been undertaken to test the feasibility of the Waterloo Road and Lane Cove Road bus stops to accommodate the number of buses shown in Tables 4.16 and 4.17 respectively. Results indicate that the Lane Cove Road bus stop has sufficient capacity. The analysis indicated however that when constrained (i.e. including green time ratio) the Waterloo Road bus stop may not be able to accommodate the target number of buses in both the morning and evening peak periods. Supervision of bus loading and unloading by bus marshals will be required during the morning and evening peak periods at this location to minimise bus stop dwell times. Full detailed bus stop capacity analyses including risks and mitigation measures are provided in Appendix D.

Table 4.19 All services using the Macquarie Park westbound bus stop (Lane Cove Road)

Routes	Buses per hour	
	7.30 am to 8.30 am	5.00 pm to 6.00 pm
292 to Marsfield 459, 506 to Macquarie University 545 to Parramatta M41 to Marsfield	18	19
Route 1 Chatswood to Epping	8	6
Route 3 St Leonards to Macquarie University /Beecroft	18	8
Route 4 to Eastwood	-	12
Estimated future growth in services – 2019*	3	3
	18 (now) 21 (with future growth) 47 (with rail replacement buses + future growth)	19 (now) 22 (with future growth) 48 (with rail replacement buses + future growth)

*Source: Transport Services Division (Transport for NSW)

Westbound bus stop (Waterloo Road)

The westbound stop in Waterloo Road is only required for rail replacement buses (Route 5 from Gordon) during the morning peak period. The bus stop is shared with buses to Macquarie Shopping Centre/University and to the north-west via the M2, as shown in Table 4.20.

Table 4.20 Macquarie Park Station westbound morning peak bus stop dwell times (Waterloo Road)

AM	Trips/hour	Function	Average dwell time by route group (seconds)	Total dwell time (seconds)	Average dwell time for the bus stop (seconds)
611, 619, 621, 628, 630, 651, M54	22	pick-up	10	220	
197, M41	10	set-down	60	600	
Route 5	6	set-down	60	360	
	38			1180	31

Bus stop capacity analysis has been undertaken to test the feasibility of the westbound Waterloo Road bus stop to accommodate the number of buses shown in Table 4.20 during the morning peak period. Results indicate that the bus stop has sufficient capacity.

4.4.5 Parking and taxis

No changes to the provision of parking or the location of taxi ranks are required as a result of the rail replacement buses at Macquarie University Station.

4.4.6 Traffic impacts

Existing situation intersection performance (2013)

Table 4.21 provides a summary of the existing intersection performance around Macquarie Park Station.

Table 4.21 Summary of existing intersection performance – Macquarie Park Station

Site ID	Intersection	Peak period	Degree of Saturation	Average Delay (sec)	Level of Service	95 th percentile queue (m) ¹
11	Waterloo Road and Khartoum Road	AM	0.74	41 (NE)	C	99 (SE)
		PM	0.86	60 (NW)	E	192 (NW)
12	Lane Cove Road and Waterloo Road	AM	1.05	36	C	248 (SW)
		PM	1.00	49	D	358 (NE)
13	Lane Cove Road and Epping Road	AM	1.04	56	D	381 (SW)
		PM	0.97	53	D	265 (SW)
14	Epping Road and Wicks Road	AM	1.10	83	F	686 (NW)
		PM	1.11	50	D	489 (NW)

(1) Notes: Letter indicates approach with the longest queue, N = north, NE = north-east, E = east, SE = south-east, S = south, SW = south-west, W = west, NW = north-west

These results match on-site observations and indicate that:

- High traffic volumes were observed along Lane Cove Road in both peak hours, with queues often extending back to adjacent signalised intersections.
- Due to the high proportion of green time that is allocated to Lane Cove Road approaches, long queues were observed on Epping Road approaches, especially in the evening peak hour.
- In the evening peak, the capacity of the left turn slip lane from Lane Cove Road north into Epping Road east was reduced due to downstream constraints (high main line flow on Epping Road, combined with merge requirements due to bus lane designation), which resulted in queues on Lane Cove Road.
- At the Epping Road/Wicks Road intersection extensive queuing was observed on both Epping Road approaches, as well as the Wicks Road south-west approach. Some non-compliance with the Bus Only designation for the kerbside lane on the Epping Road north-west approach was noted.

Future base intersection performance (2019)

The results from the intersection modelling for base conditions in 2019 around Macquarie Park Station showed that:

- The additional volumes at the Waterloo Road/Khartoum Road roundabout has resulted in an increase in the maximum queue lengths of approximately 50 m in the morning peak and 80 m in the evening peak, with the roundabout now shown to be operating above the practical capacity limits for this type of intersection.
- Along the Lane Cove Road corridor, there were large increases in the queue lengths in both directions at the Waterloo Road and Epping Road intersections. As a result of these increases, there were also significant increases to the queue lengths for those turn lanes at each intersection that provide access to Lane Cove Road (e.g. the Epping Road off ramps).
- At the Epping Road/Wicks Road intersection, there were increases in queues on the Wicks Road approaches. In the evening peak there was a significant increase in the queue and delay on the Epping Road north-west approach, due to this approach now operating at capacity (not the case in 2013).

Traffic modelling results (2019) with rail replacement buses

Traffic modelling for westbound buses was based on the following bus movements:

- Route 1 to Epping: 8 morning peak (1 hour) trips and 6 evening peak (1 hour) trips.
- Route 3 to Macquarie University: 18 morning peak (1 hour) trips.
- Route 3 to Beecroft: 8 evening peak (1 hour) trips.
- Route 4 to Eastwood: 12 evening peak (1 hour) trips.
- Route 5 to Macquarie University: 6 morning peak (1 hour) trips.

Traffic modelling for eastbound buses was based on the following bus movements:

- Route 1 to Chatswood: 6 morning peak (1 hour) trips and 8 evening peak (1 hour) trips.
- Route 3 to St Leonards: 8 morning peak (1 hour) trips and 18 evening peak (1 hour) trips.
- Route 4 to Macquarie Park: 12 morning peak (1 hour) trips.
- Route 5 to Gordon: 6 evening peak (1 hour) trips.

The traffic modelling results for Macquarie Park Station are shown in Figure 4.14 and include:

- Waterloo Road and Khartoum Road:
 - ▶ The additional delays at the intersection due to the rail replacement buses were less than 10 seconds in both peaks, resulting in one approach reducing from Level of Service D to E; however there was an increase in the evening peak queue of approximately 80 m on the Waterloo Road north-west approach.
- Lane Cove Road and Waterloo Road:
 - ▶ In the morning peak there was an approximate 50 m increase in queue length and 17 seconds in average delays for through traffic on the Waterloo Road north-west approach (degree of saturation has also increased to be above 1.0). There was minimal change in the evening peak.
- Lane Cove Road and Epping Road:
 - ▶ the addition of the rail replacement buses had minimal impact on the operation of this intersection.
- Epping Road and Wicks Road:
 - ▶ in the morning peak period there was a minimal increase in delay (less than 10 seconds) and queue length on Wicks Road, north of Epping Road
 - ▶ in the evening peak there was an increase in delay of approximately 45 seconds per vehicle and 60 m of queue length on Wicks Road north-east approach.

The traffic modelling also indicated that the sharing of the left hand turn lane by buses travelling straight ahead (across Lane Cove Road) would have no positive impact on bus travel times, and in fact could make travel times worse during the evening peak when the left hand turn lane is congested.

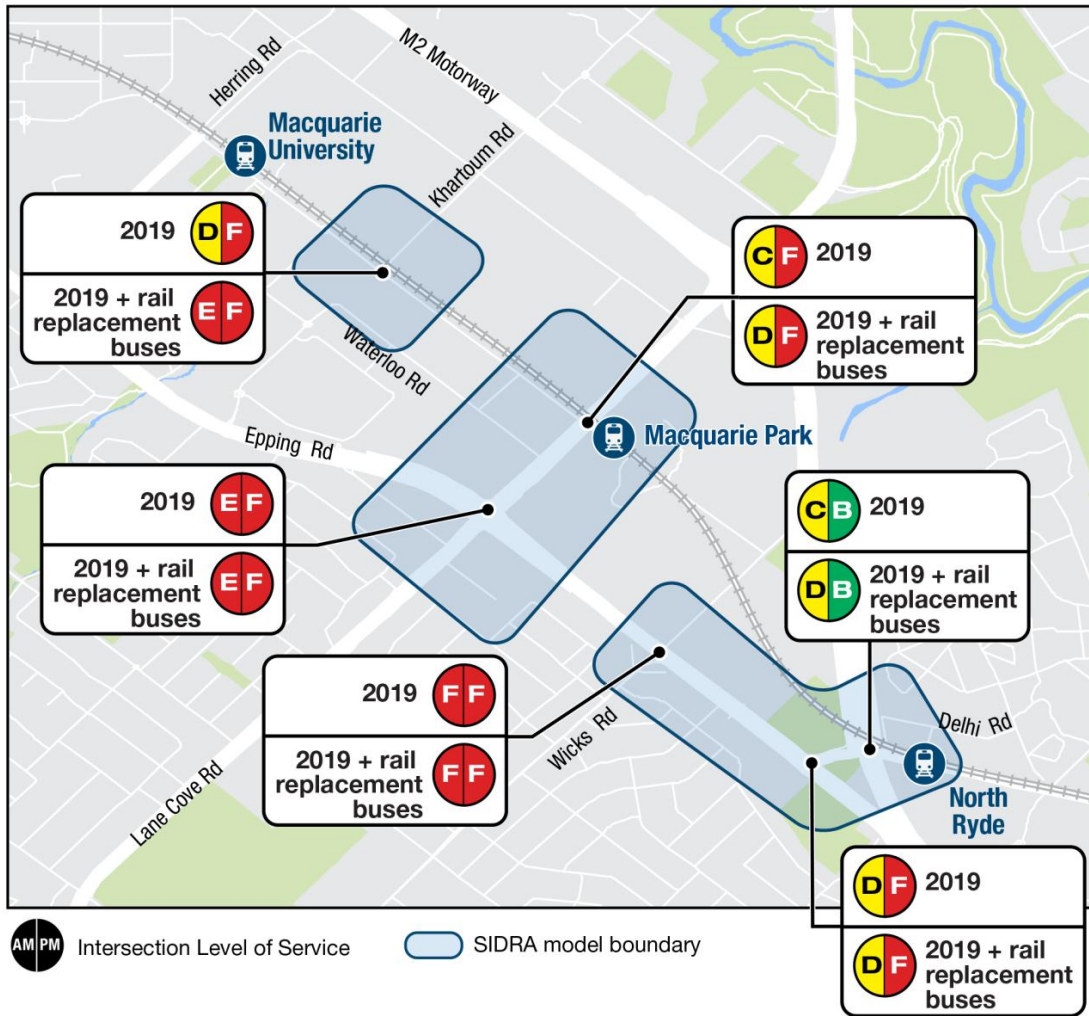


Figure 4.14 Traffic modelling results at Macquarie Park and North Ryde stations

Westbound bus lane on Epping Road

A potential bus priority measure identified by Transport for NSW Transport Services, as part of its regular planning for improvements to the bus network (currently unfunded), is the creation of a westbound bus lane on Epping Road between Wicks Road and the off-ramp to Lane Cove Road to assist regular service buses to bypass the queue of vehicles waiting at the intersection with Lane Cove Road. However, this project would also assist rail replacement buses if it were implemented in time. The proposed extended bus lane would increase the continuity of bus priority measures along Epping Road, linking the facility at the westbound bus stop on Epping Road, west of Wicks Road, to the newly constructed bus lanes on Lane Cove Road. While bus lane cannot be provided all the way to the stop line, buses would be given priority to enter this lane. Increased continuity of bus lane is likely to improve the reliability of bus services.

Under the proposal, the westbound bus lane would continue to the point where the left-turn slip lane into Lane Cove Road starts, a distance of approximately 500 m. This bus priority measure would require the widening of the southern side of Epping Road for approximately 150 m within the verge, and is unlikely to affect footpath width or require land acquisition. It would shorten the length of the second (kerbside) lane for traffic by approximately 250 m.

The extended bus lane would take away queuing space for the right turning movement into Lane Cove Road, especially during the evening peak period. The SIDRA results indicate that this would have an impact on the intersection performance, potentially resulting in an additional delay of approximately 40 seconds to general traffic using the westbound off-ramp. However, as SIDRA only looks at the impact on traffic conditions at the intersection, it cannot provide results for the impact on general traffic between the Wicks Road intersection and the start of the off-ramp, nor can it provide an estimate of the benefit to buses in the bus lane before they get to the intersection. This measure appears to have merit for rail replacement buses and regular buses however the impact on the general traffic would require further assessment.

4.4.7 Temporary facilities

The requirements for temporary facilities at Macquarie Park Station include the provision of temporary weather protection, seating and information at the eastbound stop, where no shelter facilities are currently provided (and noting that the eastbound stop is located on a shared pedestrian and bicycle path). Figure 4.15 shows the proposed scope of works for temporary facilities associated with Macquarie Park Station.

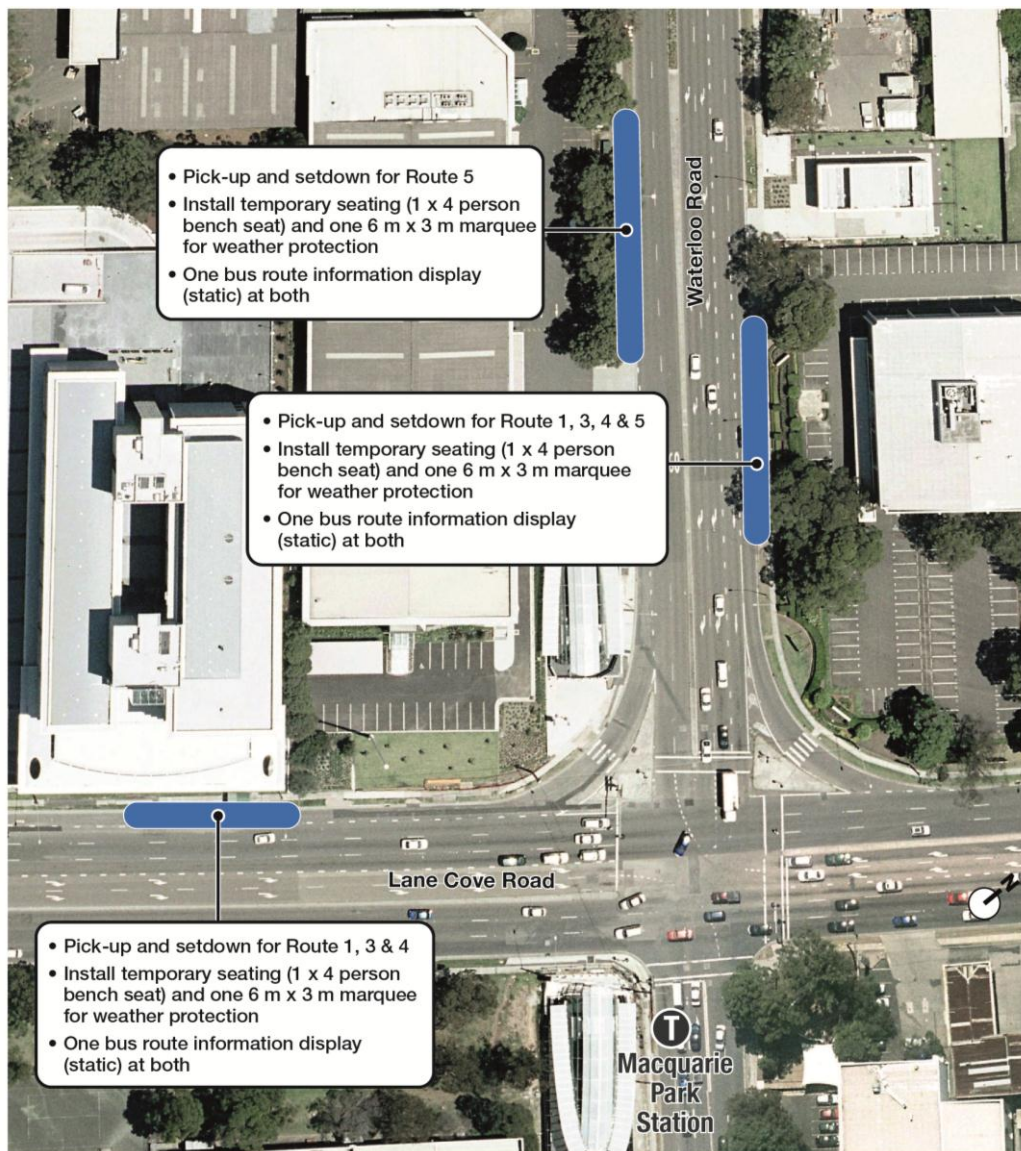


Figure 4.15 Proposed scope of works for temporary facilities - Macquarie Park Station

4.5 North Ryde Station

4.5.1 Bus operations

The recommendations for enabling the efficient operation of rail replacement bus routes at North Ryde Station, whilst minimising impacts on other bus routes and meeting customer experience objectives are summarised in Figure 4.16. Further details on the recommendations are provided in section 4.5.2 through to section 4.5.7.

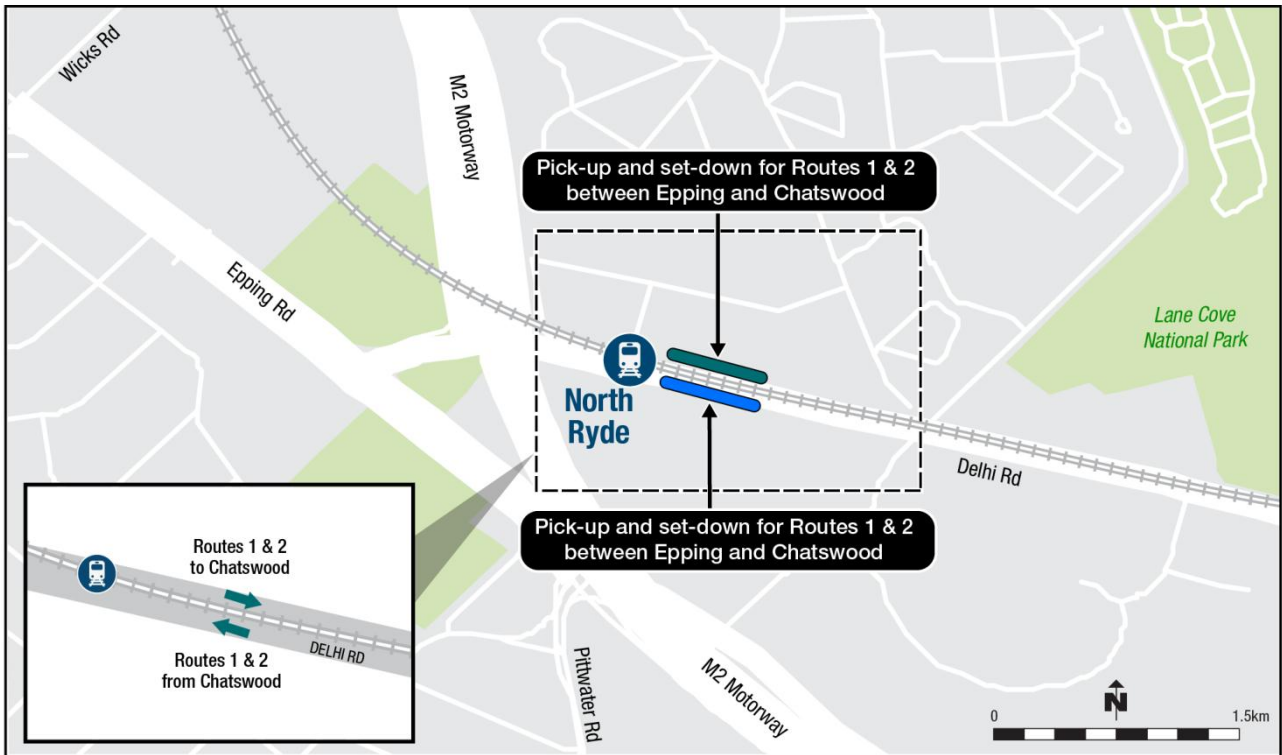


Figure 4.16 Rail replacement bus operations at North Ryde Station

4.5.2 Functional requirements

The functional requirements for North Ryde Station are summarised in Table 4.22.

Table 4.22 Functional requirements for rail replacement buses at North Ryde Station

Functional requirement	Note
Maintain a common stop for the Route 1 service across all time periods.	<ul style="list-style-type: none"> Provides consistency across all time periods and days of the week.
Common eastbound pick-up and set-down stop for all rail replacement bus routes.	<ul style="list-style-type: none"> Routes 1 and 2 to Chatswood.
Common westbound pick-up and set-down stop for all rail replacement bus routes.	<ul style="list-style-type: none"> Routes 1 and 2 to Epping.
Minimise disruption to other bus routes.	<ul style="list-style-type: none"> Delhi Road used by regular bus route 545 throughout the week.
Provide direct access between bus stops and surrounding land uses.	<ul style="list-style-type: none"> Replicates the proximity of the train service to destinations around North Ryde.

4.5.3 Pick-up and set-down requirements

Based on the identified functional requirements the pick-up and set-down requirements at North Ryde Station are to use the existing eastbound and westbound bus stops on Delhi Road. These locations are shown on Figure 4.16.

The number of rail replacement buses serving North Ryde during peak hours is summarised in Table 4.23.

Table 4.23 Peak hour rail replacement bus numbers at North Ryde Station

	Eastbound			Westbound		
	Route	To	Number of trips per hour	Route	To	Number of trips per hour
Morning peak	1	Chatswood	6	1	Epping	8
	2	Chatswood	16			
			22			8
Evening peak	1	Chatswood	8	1	Epping	6
				2	Epping	16
			8			22

4.5.4 Interaction with other bus services

Based on the identified functional requirements, the operation of the rail replacement buses at North Ryde Station requires no relocation of other bus routes.

The eastbound and westbound stops are shared with Route 545, as shown in Table 4.24.

Capacity analysis has been undertaken to test the feasibility for the stop to accommodate this number of buses. Results indicate that the stops provide sufficient capacity. The capacity analysis is included in Appendix D.

Table 4.24 All services using the North Ryde Station stop

Direction	Routes	Buses per hour	
		7.30 am to 8.30 am	5.00 pm to 6.00 pm
Eastbound	545 from Parramatta	6	6
	Route 1 from Epping	6	8
	Route 2 from Epping	16	-
	Future growth in services	0	0
	Total	6 (now) 28 (with rail replacement buses)	6 (now) 14 (with rail replacement buses)

Direction	Routes	Buses per hour	
		7.30 am to 8.30 am	5.00 pm to 6.00 pm
Westbound	545 from Chatswood	6	6
	Route 1 from Chatswood	8	6
	Route 2 from Chatswood	-	16
	Future growth in services	0	0
	Total	6 (now) 14 (with rail replacement buses)	6 (now) 28 (with rail replacement buses)

4.5.5 Parking and taxis

No changes to the provision of parking or the location of taxi ranks are required as a result of the rail replacement buses at North Ryde Station.

4.5.6 Traffic impacts

Existing situation intersection performance (2013)

Table 4.25 provides a summary of the existing intersection performance around North Ryde Station.

Table 4.25 Summary of existing intersection performance – North Ryde Station

Site ID	Intersection	Peak period	Degree of Saturation	Average Delay (sec)	Level of Service	95 th percentile queue (m) ¹
15	Epping Road and Delhi Road	AM	1.16	46	D	597 (NW)
		PM	1.10	74	F	670 (NW)
16	Delhi Road and M2 Motorway On/Off Ramps	AM	0.97	36	C	162 (N)
		PM	0.90	23	B	220 (E)

(1) Notes: Letter indicates approach with the longest queue, N = north, NE = north-east, E = east, SE = south-east, S = south, SW = south-west, W = west, NW = north-west

These results match on-site observations and indicate that:

- The queue on the Epping Road north-west approach to the Epping Road/Delhi Road intersection extended at times back to the Epping Road/Wicks Road intersection, in both peaks. Further west along Epping Road, the queue extended from Wicks Road over the Lane Cove Road overpass.
- There was a low level of compliance with the morning peak T3 lane on the Epping Road north-west approach to the Epping Road/Delhi Road intersection.
- The traffic flow between the Epping Road/Delhi Road Delhi Road/M2 intersections was at times restricted due to the extent of the queuing.
- Eastbound traffic flow from the Delhi Road/M2 intersection was also constrained by the downstream capacity constraint caused by the next set of signals.

Future base intersection performance (2019)

The results from the intersection modelling for base conditions in 2019 around North Ryde Station showed that as the applied traffic growth along the main Epping Road and Delhi Road corridors was minimal (due to 2013 conditions already being highly congested), there was only a small increase in the delays and queues at these intersections.

Traffic modelling results (2019) with rail replacement buses

Traffic modelling for westbound buses was based on the following bus movements:

- Route 1 to Epping: 8 morning peak (1 hour) trips and 6 evening peak (1 hour) trips.
- Route 2 to Epping: 16 evening peak (1 hour) trips.

Traffic modelling for eastbound buses was based on the following bus movements:

- Route 1 to Chatswood: 6 morning peak (1 hour) trips and 8 evening peak (1 hour) trips.
- Route 2 to Chatswood: 16 morning peak (1 hour) trips.

The intersections modelled at North Ryde are included in Figure 4.14. Traffic modelling results for North Ryde are:

- Delhi Road and M2 Motorway on/off ramps:
 - ▶ in the evening peak the right turn queue from Delhi Road to the M2 on-ramp increases by 45 m as a result of the rail replacement buses (as is the delay), with a corresponding increase in delay of approximately 20 seconds per vehicle
 - ▶ the impacts in the morning peak are minimal, with small (less than 10 seconds per vehicle) delays in the through movements on Delhi Road.
- The addition of the rail replacement buses had minimal impact on the operation of the Epping Road and Delhi Road intersection.

North Ryde Station Urban Activation Precinct (UAP)

Development within the vicinity of North Ryde Station at the Urban Activation Precinct (UAP) is expected to add traffic to the already congested area. The package of road upgrades shown in Figure 4.17, have been proposed by the developers to mitigate its impact, including:

- additional turn lanes/through lanes at several intersections
- new signals at Wicks Road/Waterloo Road
- widening of Delhi Road with second eastbound lane to Julius Avenue (east).

The upgrades would assist rail replacement buses by minimising delays and congestion.

An additional potential development in the vicinity of the North Ryde Station is the M2 redevelopment site, which is a 14 hectare precinct that would deliver more than 3,000 new dwellings and over 50,000 m² of retail/commercial floor space. Construction on this redevelopment project is expected to commence mid-2015. The potential exists for the recommendations in this Temporary Transport Plan to be affected by additional traffic generated by this redevelopment.

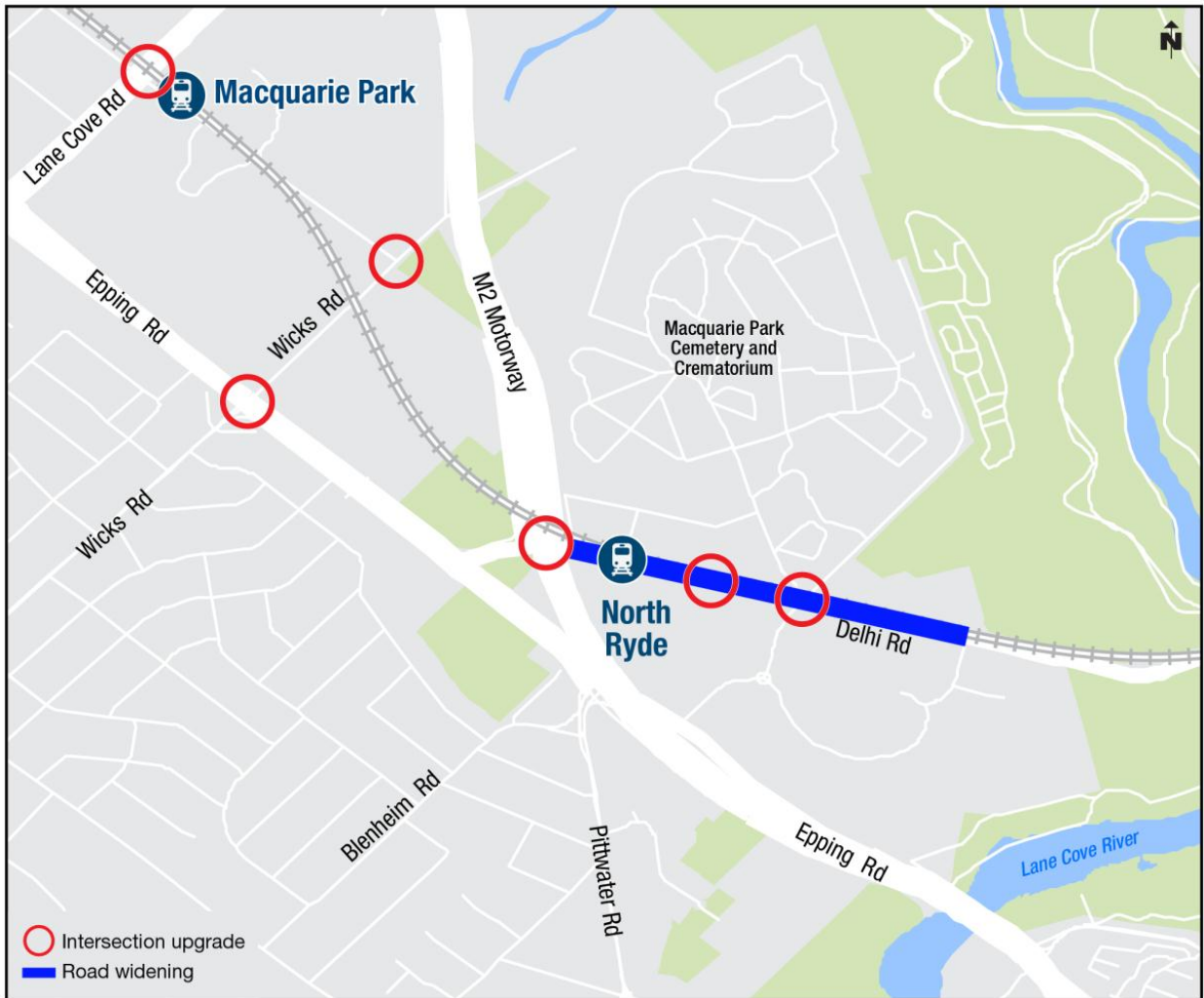


Figure 4.17 North Ryde Urban Activation Precinct – proposed works

4.5.7 Temporary facilities

Shelters and seating are currently provided at the eastbound and westbound stops at North Ryde Station. Figure 4.18 shows the proposed scope of works for temporary facilities associated with North Ryde Station.

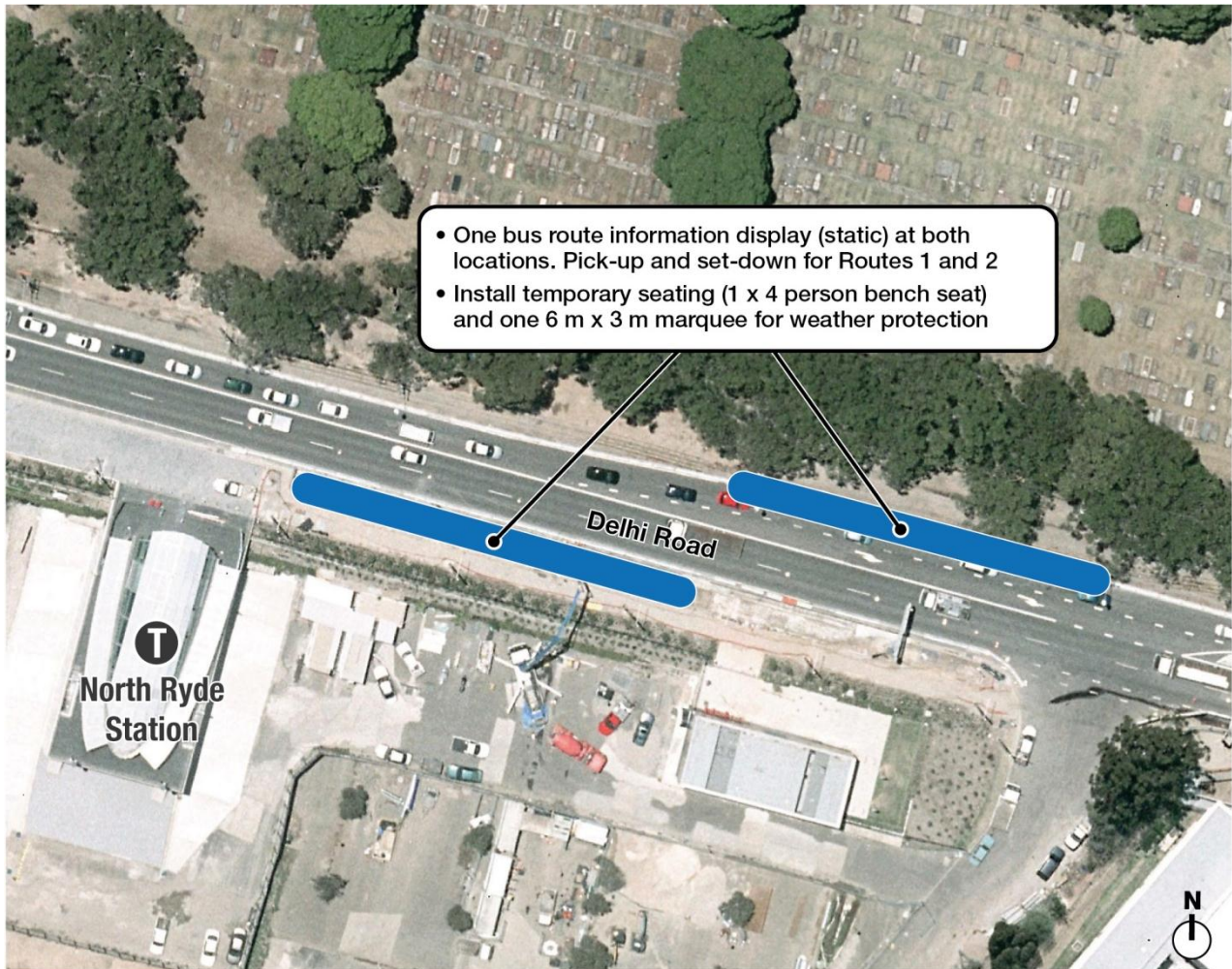


Figure 4.18 Proposed scope of works for temporary facilities - North Ryde Station

4.6 Chatswood Station

4.6.1 Bus operations

The recommendations for enabling the efficient operation of rail replacement bus routes at Chatswood Station, whilst minimising impacts on other bus routes and meeting customer experience objectives are summarised in Figures 4.19, 4.20 and 4.21 for the morning peak, off peak and evening peak respectively. Further details on these recommendations are provided in section 4.6.2 through to section 4.6.7.

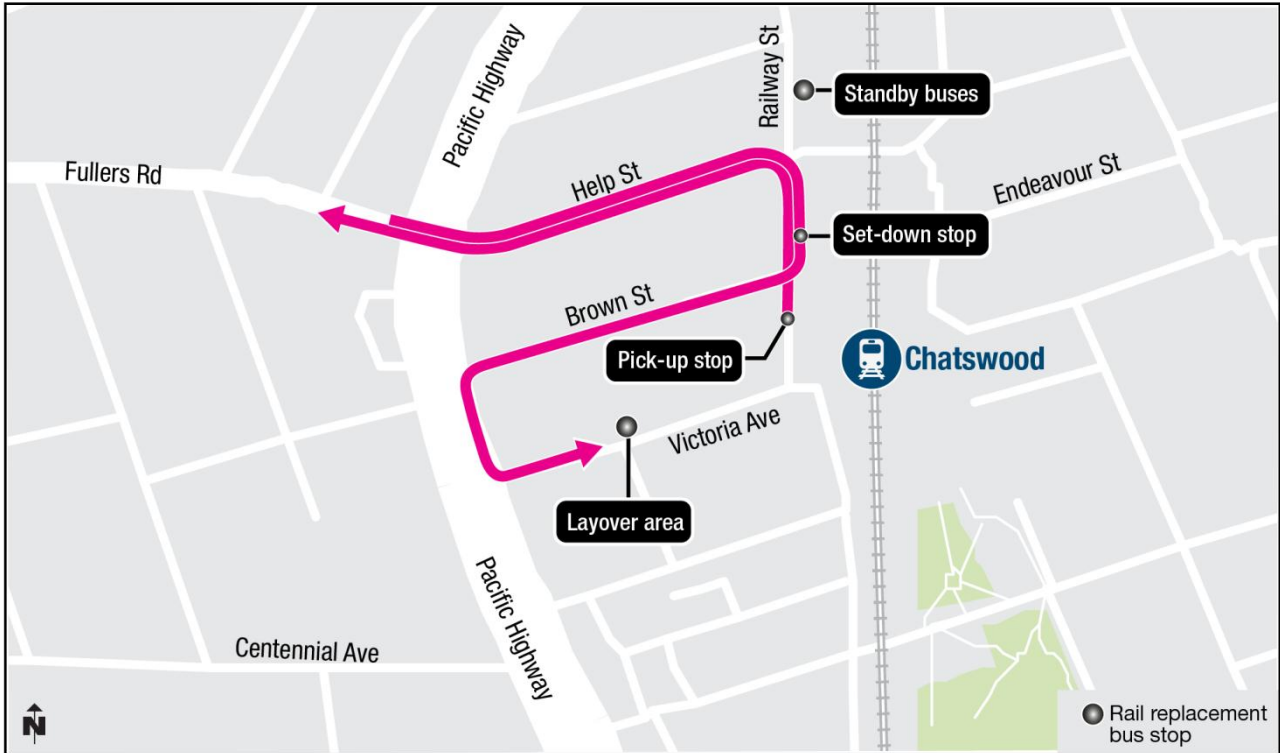


Figure 4.19 Morning peak rail replacement bus operations at Chatswood Station



Figure 4.20 Off peak rail replacement bus operations at Chatswood Station



Figure 4.21 Evening peak rail replacement bus operations at Chatswood Station

4.6.2 Functional requirements

As a terminal point for rail replacement buses, and as an interchange point with North Shore trains, Chatswood Station has a number of distinct functional requirements. These are summarised in Table 4.26.

Table 4.26 Functional requirements for rail replacement buses at Chatswood Station

Functional requirement	Notes
Pick-up space for two routes during the evening peak period.	<ul style="list-style-type: none"> 6 to 8 departures per hour on Route 1 to North Ryde, Macquarie Park and Macquarie University. 16 departures per hour on Route 2 to North Ryde and Epping.
Space for two buses at a time at the pick-up stop.	<ul style="list-style-type: none"> Allows concurrent boarding when required.
Separate pick-up and set-down areas.	<ul style="list-style-type: none"> Delivers improved efficiency for the designated pick-up stop. Separates boarding and alighting passenger flows.
Minimise disruption to other bus routes.	<ul style="list-style-type: none"> Chatswood Station (west of the railway line) serves as a terminus for multiple bus routes (Routes 143, 144, 200, 255, 256, 258, 261, 533, 534, 536, 545, 558, 565, and 627).
Maintain a common stop for the base service (Route 1) across all time periods.	<ul style="list-style-type: none"> Provides consistency across all time periods and days of the week.
Provide bus stops close to the railway station.	<ul style="list-style-type: none"> Minimises the customer impact of interchanging between bus and train.

4.6.3 Pick-up and set-down requirements

Based on the identified functional requirements the preferred pick-up and set-down requirements at Chatswood Station are:

- Railway Street (west side) – pick-up
- Railway Street (eastern side) – morning peak (approximately 6.00 am to 10.00 am) set-down
- Victoria Avenue (north side) – off peak (approximately 10.00 am to 2.00 pm) set-down
- Chatswood Interchange (Stand C) – evening peak (approximately 2.00 pm to 8.00 pm) set-down.

These locations are shown in Figures 4.19, 4.20 and 4.21. The justification for these pick-up and set-down locations are outlined in Table 4.27.

Table 4.27 Chatswood Station rail replacement bus pick-up and set-down locations

Pick-up/set-down location	Justification
Railway Street (west side) – pick-up.	<ul style="list-style-type: none"> Provides a dedicated pick-up stop across the road from the western exit of Chatswood Station. Provides space for two buses.
Railway Street (eastern side) - Morning peak set-down.	<ul style="list-style-type: none"> During the morning peak period, rail replacement buses set-down in Railway Street, avoiding the traffic delays associated with the turn from Fullers Road onto the Pacific Highway. Rail replacement buses with a scheduled return trip set-down north of Brown Street and operate to the pick-up stop via Brown Street, Pacific Highway and Victoria Avenue.

Pick-up/set-down location	Justification
Victoria Avenue (north side) - Off peak set-down.	<ul style="list-style-type: none"> ■ Separates the set-down and pick-up functions. ■ Buses can be called onto the pick-up stop the set-down stop by bus service supervisors.
Chatswood Interchange (Stand C) - Evening peak set-down:	<ul style="list-style-type: none"> ■ During the evening peak period, rail replacement buses set-down in the Chatswood Interchange rather than in Railway Street because the tidal flow arrangements on the Pacific Highway do not allow buses to make the same movements during the evening as they do in the morning peak period. ■ Buses arriving at Chatswood with a scheduled return trip are required to run empty between Chatswood Interchange and Railway Street via Help Street, Pacific Highway and Victoria Avenue. ■ Pick-up space within the Chatswood Interchange remains exclusively for regular route buses.

It should be noted that these arrangements result in three different set-down locations for rail replacement buses arriving at Chatswood, depending on the time of a weekday (Victoria Avenue, Railway Street and Chatswood Interchange). The pick-up location remains the same at all times of bus operation minimising confusion for customers.

4.6.4 Interaction with other bus services

Based on the identified functional requirements the operation of the rail replacement buses at Chatswood Station requires some temporary amendments to other bus routes. These are:

- temporary relocation of Route 558 (to East Lindfield), Route 565 (to West Lindfield) and Route 627 (to Castle Hill) from Railway Street to Victoria Avenue (north side behind the taxi rank)
- the set-down and layover area for the rail replacement buses in Victoria Avenue will be located behind the relocated stop for Routes 558, 565 and 627.

The justification for these relocations is outlined in Table 4.28.

Table 4.28 Required amendments to other regular bus stops and justification – Chatswood Station

Bus stop relocation	Justification
From Railway Street to Victoria Avenue (north side behind the taxi rank): <ul style="list-style-type: none"> ■ Route 558 (to East Lindfield) ■ Route 565 (to West Lindfield) ■ Route 627 (to Castle Hill). 	<ul style="list-style-type: none"> ■ Frees up the Railway Street bus stop for rail replacement bus routes. ■ Relocated regular bus routes have lower frequencies and/or hours of operation compared to the rail replacement buses, namely: <ul style="list-style-type: none"> ▶ Route 558 has only eight trips per weekday (up to one trip per hour) from Chatswood ▶ Route 565 has only 13 trips per weekday (up to 2 trips per hour during the peak) from Chatswood ▶ Route 627 operates from Chatswood only during the afternoon peak period, with a maximum of three trips per hour. ■ For customers of the abovementioned routes, access to/from Chatswood Station remains the same (i.e. via the pedestrian crossing on Railway Street) but the walking distance from the crossing to the bus stop increases slightly (by approximately 50 m).
The set-down and layover area for the rail replacement buses in Victoria Avenue will be located behind the re-located stop for Routes 558, 565 and 627.	<ul style="list-style-type: none"> ■ Replicates the existing arrangement for set-down and layover for these services.

All relocated stops and services will revert to their existing locations once the Epping to Chatswood railway Rapid Transit Conversion Program works are complete.

Layover and standby locations

The high frequency of rail replacement buses and the limited space available at Chatswood means that layover times need to be kept to a minimum. After dropping off passengers at Chatswood, those buses commencing another trip to Epping would be called onto the stop as soon as possible.

Standby buses at Chatswood would be held on the eastern side of Railway Street, north of Help Street, where they will not impede the operation of other buses at Chatswood. This would require:

- Turning the peak hour only bus zone north of Help Street into a full time bus zone (this zone currently operates as 2 hour parking between 9.30 am and 3.00 pm weekdays, and 8.00 am to 4.00 pm Saturday).
- Truncating the hours of the short term parking behind the existing bus zone, so that during peak hours there is sufficient space available for rail replacement stand by buses and for regular services which currently use the existing bus zone as a layover area. This would mean the existing 2 hour parking would change from 8.00 am to 6.00 pm on weekdays, to 10.00 am to 3.00 pm weekdays.

From this location buses would access the pick-up stop (if required) via Railway Street, Help Street, Pacific Highway and Victoria Avenue.

North Shore Line rail possessions

It is possible that weekend possessions on the North Shore Line may also be scheduled during the period of the Epping to Chatswood railway Rapid Transit Conversion Program. Rail replacement buses for the North Shore Line use both sides of Victoria Avenue. Southbound buses will have no impact on rail replacement bus routes. Northbound services however will use the same space allocated as set-down and layover for rail replacement buses. In this instance, because only Route 1 (Chatswood to Epping all stops) operates on weekends, the rail replacement buses will be able to set-down at the pick-up stop in Railway Street.

Bus stop capacity

Results from the bus stop capacity analysis indicate that:

- the bus stop in Railway Street (eastern side, south of Bowen Street) could experience capacity issues in accommodating the target number of buses (31) during the morning peak period
- the bus stop in Railway Street (eastern side, north of Bowen Street) could accommodate the target number of buses (22) during the morning peak period
- Chatswood Interchange bus stop could accommodate the target number of buses (43) during the evening peak period.

Bus loading and unloading at Railway Street (eastern side, south of Bowen Street) will require supervision by bus marshals during the morning peak period, in order to minimise bus stop dwell times. Full detailed bus stop capacity analyses including risks and mitigation measures are provided in Appendix D.

4.6.5 Parking and taxis

Short term parking arrangements at Chatswood Station currently includes:

- Victoria Avenue (northern side, Pacific Highway to Railway Street) – (½P):
 - ▶ 8.30 am–6.00 pm Monday–Friday
 - ▶ 8.30 am–4.00 pm Saturday

- Railway Street (eastern side, north of Help Street) – (2P):
 - ▶ 8.00 am–6.00 pm Monday–Friday
 - ▶ 8.30 am–4.30 pm Saturday
- Brown Street (south side, west of Railway Street) – (1P):
 - ▶ 8.30 am–6.00 pm Monday–Friday
 - ▶ 8.30 am–4.30 pm Saturday.

Based on the identified functional requirements, and on the pick-up and set-down requirements, operation of the rail replacement buses at Chatswood Station requires some temporary changes to the provision of parking. All temporary changes to parking will revert to their existing arrangements once the Epping to Chatswood railway Rapid Transit Conversion Program is complete and NWRL is operational. These changes are outlined in Table 4.29.

Table 4.29 Chatswood Station – Temporary changes to provision of parking and taxis

Parking/taxis change	Justification
Victoria Avenue: <ul style="list-style-type: none"> ■ temporary removal of all parking behind the taxi rank (approximately 14 spaces). 	<ul style="list-style-type: none"> ■ Creates space for the provision of a relocated bus stop for Routes 558, 565 and 627. ■ Creates space for a set-down and layover area for rail replacement buses.
Railway Street (eastern side, north of Help Street): <ul style="list-style-type: none"> ■ temporary removal of parking (approximately eight spaces). 	<ul style="list-style-type: none"> ■ Provides dedicated space for standby buses at Chatswood.
Brown Street (southern side), near the intersection with Railway Street (between the car park driveways): <ul style="list-style-type: none"> ■ temporary extension of the existing ‘no parking’ restriction from 8.30 am until 10.00 am on weekdays. 	<ul style="list-style-type: none"> ■ 1 hour parking at this location currently commences at 8.30 am on weekdays. ■ Temporary extension of the existing “no parking” restriction from 8.30 am to 10.00 am would provide some additional set-down space in Brown Street, for those buses that may be unable to set-down in Railway Street at the nominated set-down stop, and which are scheduled to depart from the pick- up stop for a return trip to Epping.

4.6.6 Traffic impacts

Existing situation intersection performance (2013)

Table 4.30 provides a summary of the existing intersection performance around Chatswood Station.

Table 4.30 Summary of existing intersection performance – Chatswood Station

Site ID	Intersection	Peak period	Degree of Saturation	Average Delay (sec)	Level of Service	95 th percentile queue (m) ¹
17	Pacific Highway and Fullers Road	AM	1.23	70	F	473 (N)
		PM	1.56	69	E	261 (S)
18	Pacific Highway and Victoria Avenue	AM	1.07	17	B	191 (S)
		PM	0.99	35	C	437 (S)
19	Railway Street and Victoria Avenue	AM	0.54	veh 16, ped 12	B, A	43 (W)
		PM	0.41	veh 14, ped 12	B, A	30 (W)

Site ID	Intersection	Peak period	Degree of Saturation	Average Delay (sec)	Level of Service	95 th percentile queue (m) ¹
20	Railway Street and Help Street	AM	0.46	18	B	58 (E)
		PM	0.75	27	B	105 (S)

(1) Notes: Letter indicates approach with the longest queue, N = north, NE = north-east, E = east, SE = south-east, S = south, SW = south-west, W = west, NW = north-west

These results match on-site observations and indicate that:

- High traffic volumes along Pacific Highway both peaks, queues often extending back to adjacent signalised intersections. High proportion of green time allocated to Pacific Highway approaches.
- Extensive queues were also observed on the Fullers Road and Help Street approaches to the Fullers Road/Pacific Highway/Help Street intersection.
- High pedestrian demand at the pedestrian crossing on Victoria Street, resulting in the crossing signal being activated regularly.

Future base intersection performance (2019)

The results from the intersection modelling for base conditions in 2019 around Chatswood Station showed an increase in queues and delays on all approaches to the Pacific Highway/Fullers Road intersection in both peaks. In particular, a decrease in the Level of Service during the evening peak period was noted at the following intersections:

- Pacific Highway and Fuller Road (from Level of Service E to F)
- Pacific Highway and Victoria Avenue (from Level of Service C to D)
- Railway Street and Help Street (Level of Service B to C).

The modelling results also showed a decrease in the Level of Service of pedestrian movements during both the morning and evening peak periods at the Railway Street and Victoria Avenue intersection (from Level of Service A to B).

Traffic modelling results (2019) with rail replacement buses

Traffic modelling was based on the following bus movements:

- Route 1:
 - 6 morning peak (1 hour) and 8 evening peak (1 hour) arrivals
 - 6 morning peak (1 hour) and 8 evening peak (1 hour) departures.
- Route 2:
 - 16 morning peak (1 hour) arrivals and 16 evening peak (1 hour) departures.

Traffic modelling results for Chatswood Station are shown in Figure 4.22. They indicate that:

- Pacific Highway and Fullers Road:
 - As the proposed bus routes which serve Chatswood Station operate on a loop through this network, this results in the buses passing through this intersection twice (on the approach and then departure from the station). The impact of the additional buses on this already heavily congested intersection is significant in both peaks, with:
 - 15 second increase in delays for the through movement from Fullers Road to Help Street during the morning peak

- 90 second increase in delays for the right turn from Fullers Road to Pacific Highway during the evening peak
- 70 second increase in delays and 90 m increase to queue length for the through movement from Help Street to Fullers Road in the evening peak.
- The addition of the rail replacement buses had minimal impact on the operation of the following intersections:
 - ▶ Pacific Highway and Victoria Avenue
 - ▶ Railway Street and Victoria Avenue pedestrian crossing
 - ▶ Railway Street and Help Street.

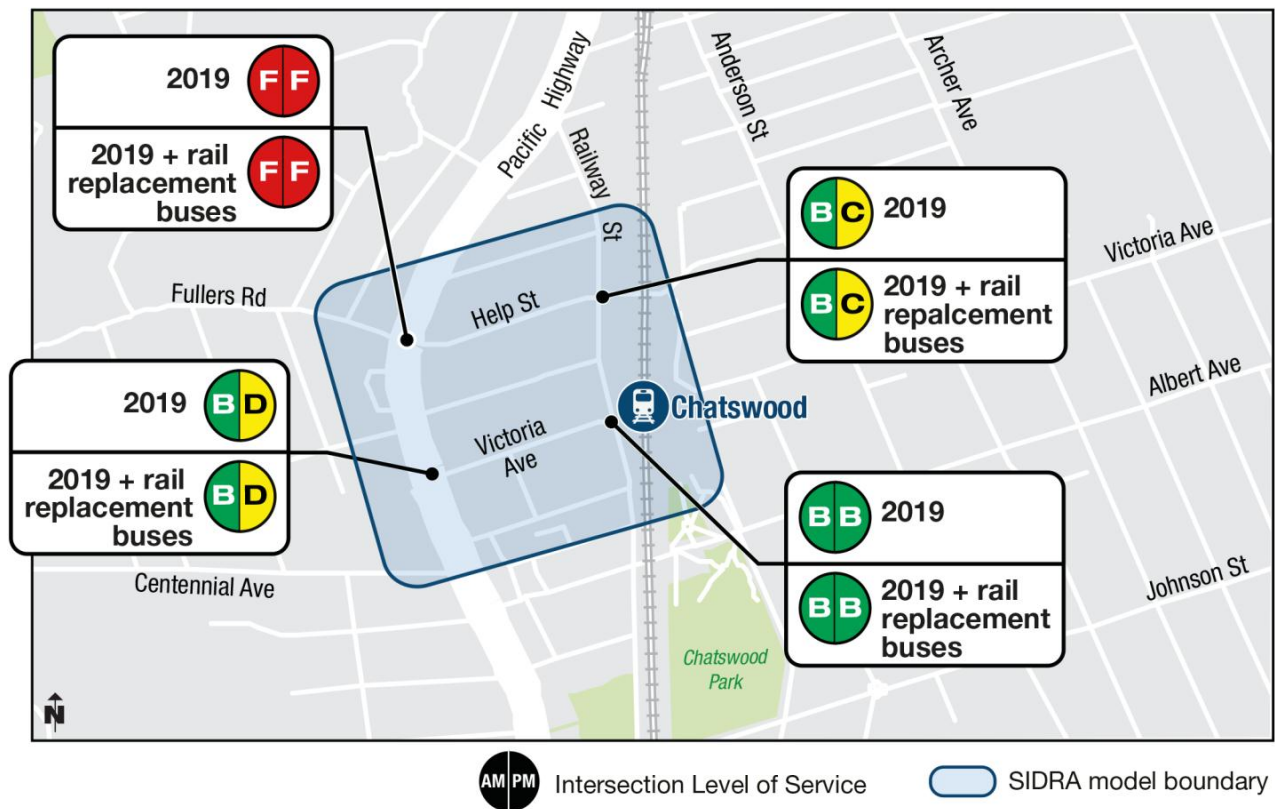


Figure 4.22 Traffic modelling results at Chatswood Station

The 2013 intersection performance results highlighted that the intersection of Pacific Highway, Fullers Road and Help Street is operating above capacity and at Level of Service F in the evening peak. There are multiple ways the Route 1 and Route 2 buses can travel to and from the potential terminus locations. These options have been tested to determine which one has the least amount of impact on intersection performance and bus travel times. These SIDRA intersection model results for these options indicate that:

- Travelling through from Fullers Road into Help Street leads to lesser delays compared to the right-turn onto the Pacific Highway.
- The number of additional rail replacement buses using Victoria Avenue to turn right onto the Pacific Highway exceeds the capacity of this movement at the intersection, resulting in long delays and queues. No adjustment to the traffic signals has been assumed.

As such an anti-clockwise option (similar to that proposed off-peak in Figure 4.20) could produce an advantage for buses in the morning peak over the preferred option, depending on the amount of delay experienced by buses turning from Brown Street into the Pacific Highway in the morning peak. It is recommended that further analysis and testing using buses in representative traffic conditions is undertaken during the morning and evening peaks to confirm the bus travel times on each path and the difficulty for buses to make the turn from Brown Street into the Pacific Highway during the morning peak.

Full results of this option analysis are presented in Appendix C7.

4.6.7 Temporary facilities

Shelters and seating are currently provided at the pick-up stop in Railway Street, but not in Victoria Avenue which has building awnings to provide weather protection. Figure 4.23 shows the proposed scope of works for temporary facilities associated with Chatswood Station.

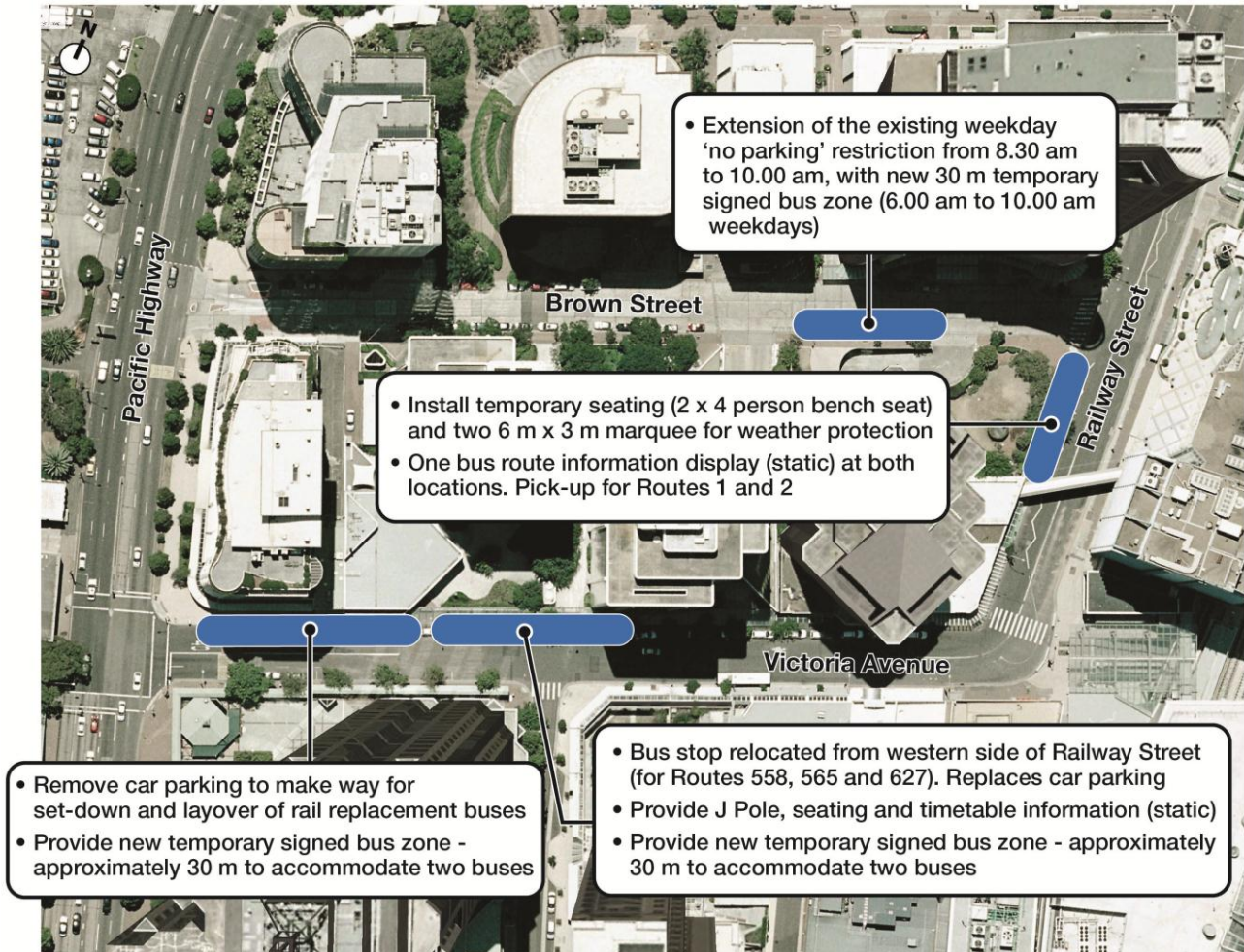


Figure 4.23 Proposed scope of works for temporary facilities - Chatswood Station

4.7 Eastwood Station

4.7.1 Bus operations

The recommendations for enabling the efficient operation of rail replacement bus routes at Eastwood Station, whilst minimising impacts on other bus routes and meeting customer experience objectives are summarised in Figure 4.24. Further details on these recommendations are provided in section 4.7.2 through to section 4.7.6.

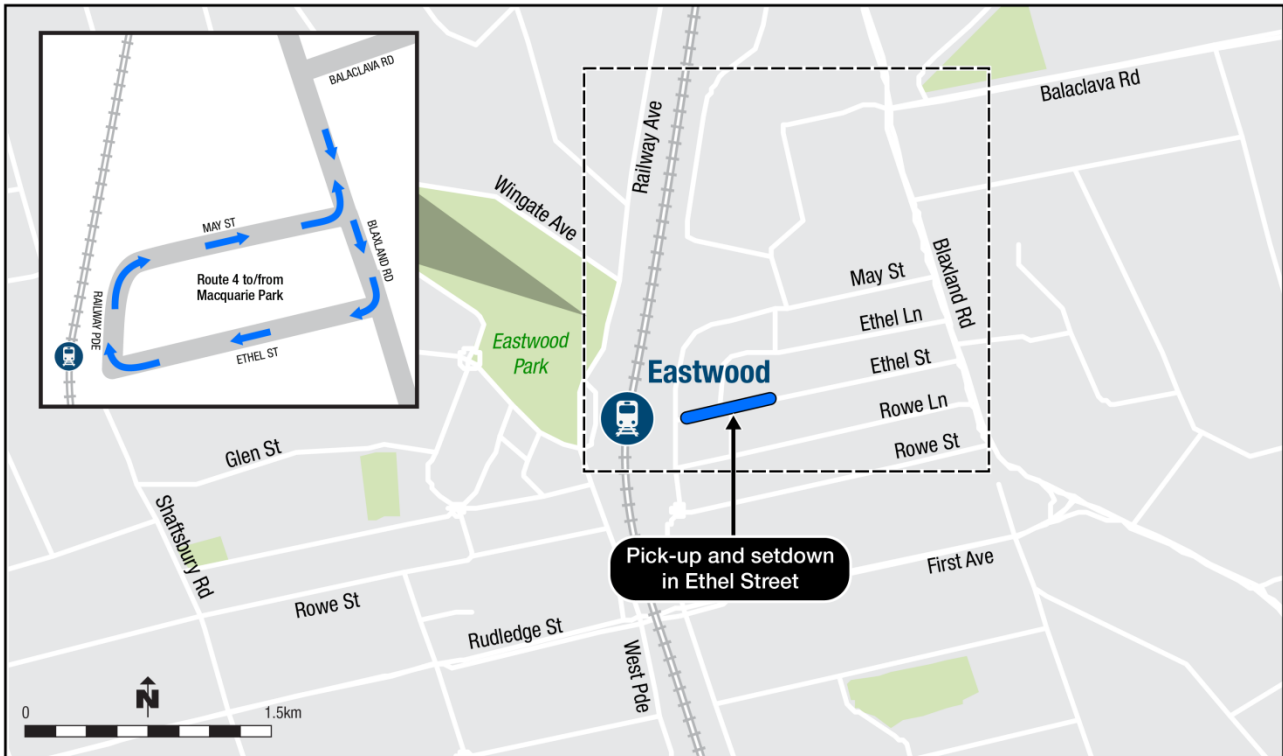


Figure 4.24 Rail replacement bus operations at Eastwood Station

4.7.2 Functional requirements

The functional requirements for Eastwood Station are summarised in Table 4.31.

Table 4.31 Functional requirements at Eastwood Station

Functional requirement	Notes
Pick-up during the morning peak only.	<ul style="list-style-type: none"> 12 departures per hour on Route 4 to Macquarie University and Macquarie Park.
Set-down during the evening peak only.	<ul style="list-style-type: none"> 12 arrivals per hour on Route 4 from Macquarie Park and Macquarie University.
Minimise disruption to other bus routes.	<ul style="list-style-type: none"> Route 551 has 3 trips per hour on weekdays during school term only at Ethel Street bus stop: <ul style="list-style-type: none"> Arriving during the morning peak (between approximately 7:30 am to 9:30 am) setting down. Departing during the evening peak (between approximately 3:30 pm to 4:30 pm) picking up. Route 545 uses the bus stop in West Parade.
Provide bus stops close to the railway station.	<ul style="list-style-type: none"> Minimises the customer impact of interchanging between bus and train.

4.7.3 Pick-up and set-down requirements and interaction with other bus services

Based on the identified functional requirements the pick-up and set-down requirements at Eastwood Station involve all buses arriving and departing from Ethel Street. The Ethel Street bus zone will be shared with a regular bus route. The stop is only used as a pick-up stop on weekdays during school term between approximately 3.30 pm and 4.30 pm (three trips departing on Route 551 to Marsfield), and as a set-down stop on weekdays between approximately 7:30 am and 9:30 am (three trips arriving on Route 551 from Marsfield).

Capacity analysis has been undertaken to test the feasibility for the bus stop to accommodate this number of buses. Results indicate that the stops provide sufficient capacity. The capacity analysis is included in Appendix D.

4.7.4 Parking and taxis

No changes to the provision of parking or the location of taxi ranks are required as a result of the rail replacement buses at Eastwood Station.

4.7.5 Traffic impacts

Existing situation intersection performance (2013)

Table 4.32 provides a summary of the existing intersection performance around Eastwood Station.

Table 4.32 Summary of existing intersection performance – Eastwood Station

Site ID	Intersection	Peak period	Degree of Saturation	Average Delay (sec)	Level of Service	95 th percentile queue (m) ¹
22	Blaxland Road and Balaclava Road	AM	1.07	53	D	473 (S)
		PM	0.83	28	B	189 (E)
23	Blaxland Road and May Street	AM	0.85	18	B	194 (S)
		PM	0.87	13	A	142 (S)
24	Blaxland Road and Ethel Street	AM	0.51	22 (W)	B	32 (N)
		PM	0.43	20 (N)	B	41 (N)

(1) Notes: Letter indicates approach with the longest queue, N = north, NE = north-east, E = east, SE = south-east, S = south, SW = south-west, W = west, NW = north-west

These results match on-site observations and indicate that:

- extensive queues were observed on right turning lane from Blaxland Road into Balaclava Road during both morning and evening peak hours, where the queue often extended up to the Blaxland Road/Ethel Street intersection
- no issues were identified at the Blaxland Road/May Street and Blaxland Road/Ethel Street intersection in both peak hours.

Future base intersection performance (2019)

The results from the intersection modelling for base conditions in 2019 around Eastwood Station showed that:

- During the morning peak queue increases are seen at the Balaclava Road/Blaxland Road intersection and the Blaxland Road/May Street intersection, for the critical turn movements. The morning peak remains the critical peak for this network.
- In the evening peak all three intersections within the assessed network continue to operate satisfactorily with an overall Level of Service of C or better.

Traffic modelling results (2019) with rail replacement buses

Traffic modelling for Eastwood Station was based on the operation of rail replacement buses as shown in Figure 4.24. The traffic modelling results for Eastwood Station are summarised as:

- Blaxland Road and Balaclava Road:
 - ▶ the addition of the rail replacement buses resulted in an additional 20 second delay for the right-turn movement from Blaxland Road into Balaclava Road (it is an already highly congested movement) during the morning peak
 - ▶ there was minimal impact during the evening peak at this intersection.
- The addition of the rail replacement buses had minimal impact on the operation of either the Blaxland Road and May Street intersection or the Blaxland Road and Ethel Street intersection.

The results of the traffic modelling are shown in Figure 4.25. Changes to traffic signal phasing at the Blaxland Road and Balaclava Road intersection were tested, but the yield in overall improvement to intersection performance was small.

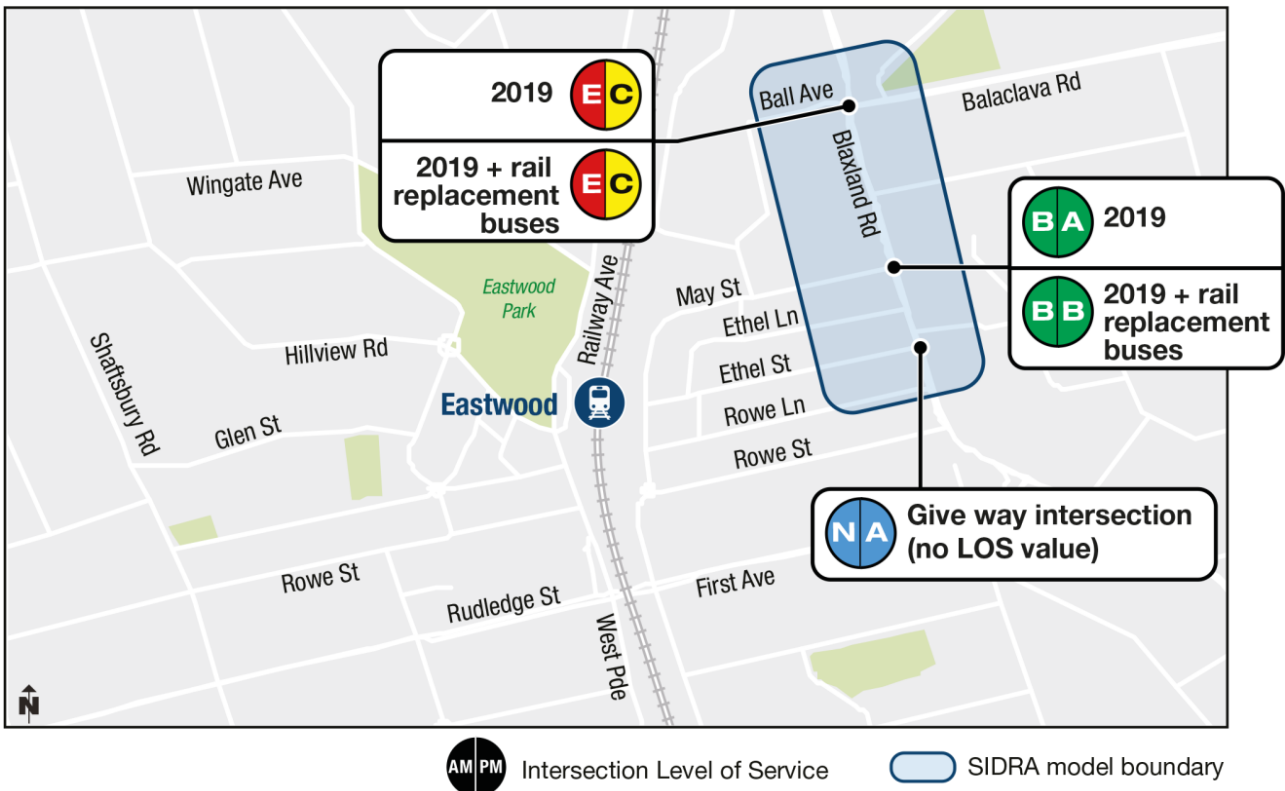


Figure 4.25 Traffic modelling results at Eastwood Station

4.7.6 Temporary facilities

Shelters and seating are currently provided at the stop in Ethel Street. Figure 4.26 shows the proposed scope of works for temporary facilities associated with Eastwood Station.

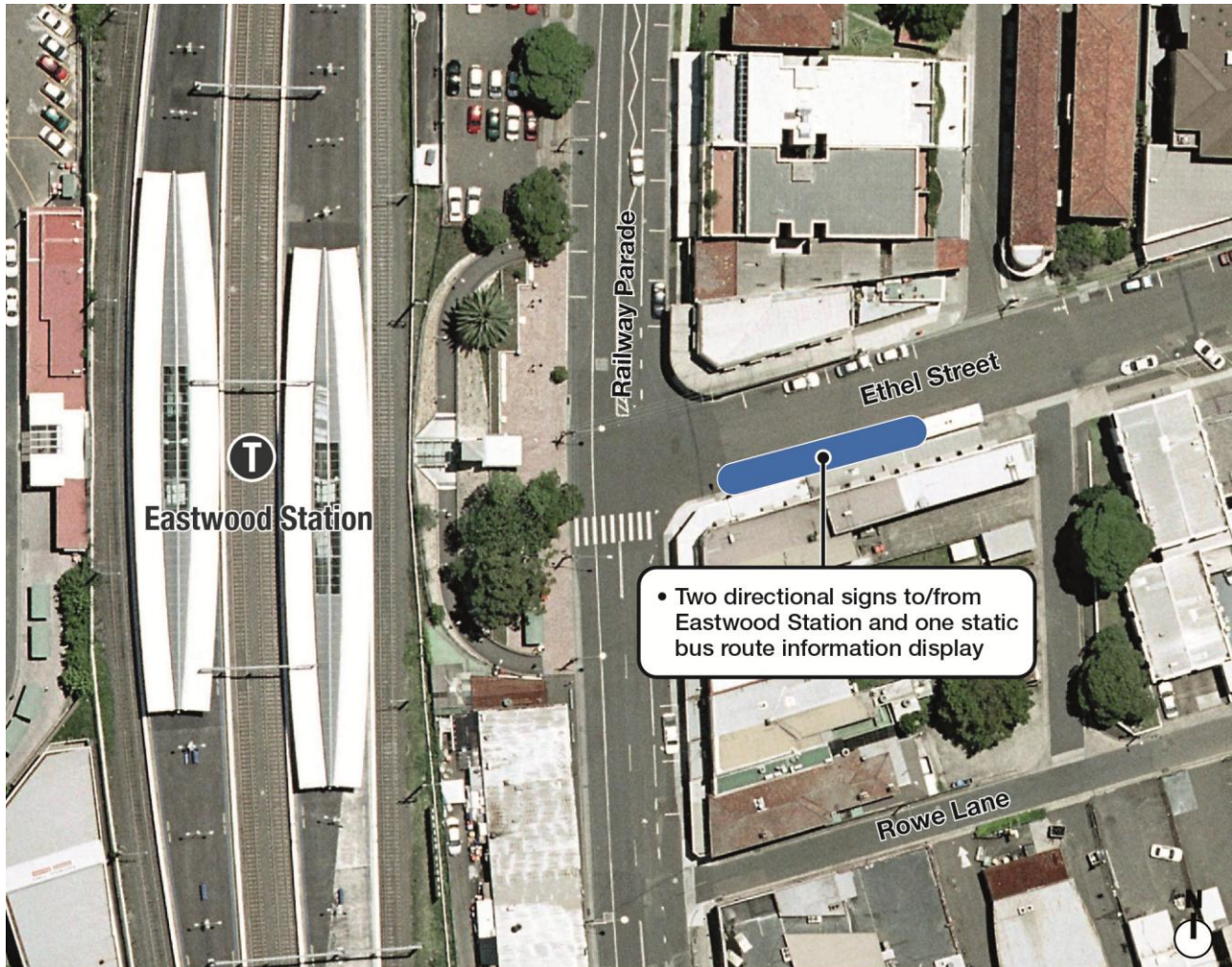


Figure 4.26 Proposed scope of works for temporary facilities - Eastwood Station

4.8 Beecroft Station

4.8.1 Bus operations

The recommendations for enabling the efficient operation of rail replacement bus routes at Beecroft Station, whilst minimising impacts on other bus routes and meeting customer experience objectives are summarised in Figure 4.27. Further details on these recommendations are provided in section 4.8.2 through to section 4.8.5.

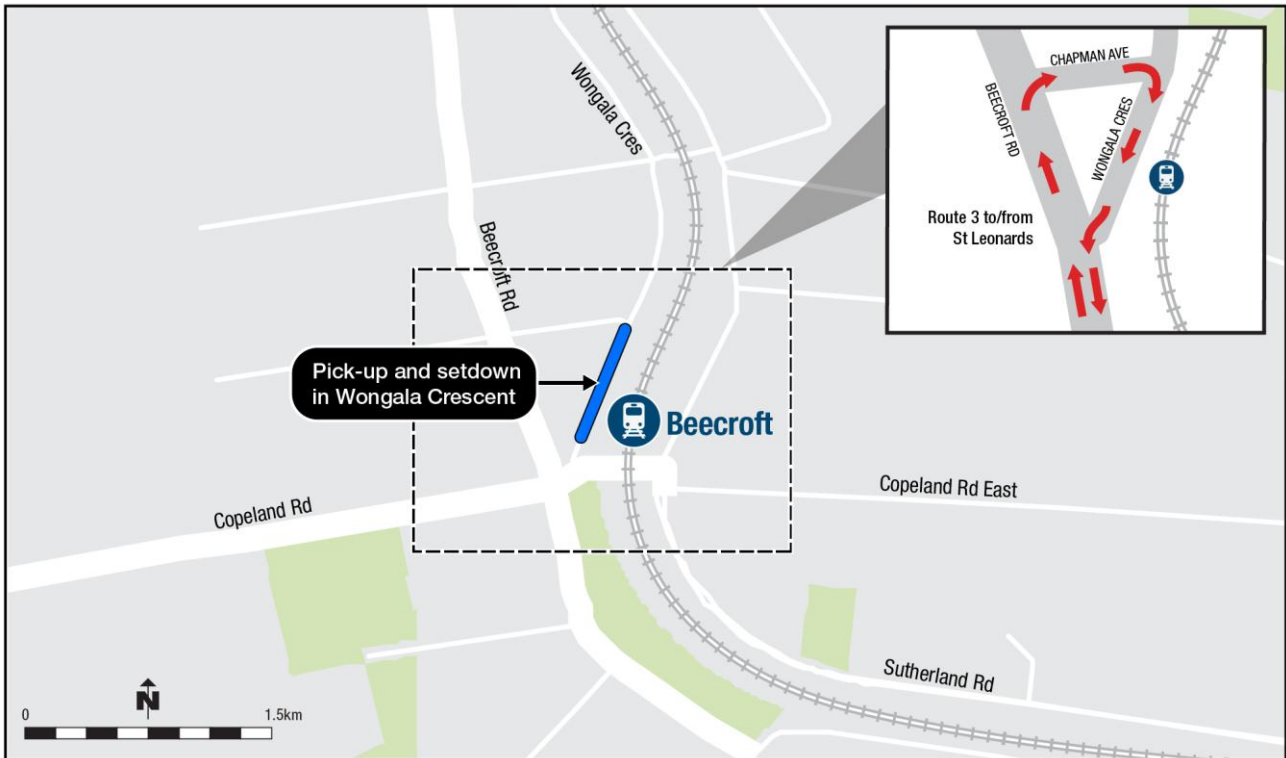


Figure 4.27 Rail replacement bus operations at Beecroft Station

4.8.2 Functional requirements

The functional requirements for Beecroft Station are summarised in Table 4.33.

Table 4.33 Functional requirements at Beecroft Station

Functional requirement	Notes
Pick-up during the morning peak only.	<ul style="list-style-type: none"> Eight trips per hour on Route 3 to Macquarie University and St Leonards via Macquarie Park.
Set-down during the evening peak only.	<ul style="list-style-type: none"> Eight trips per hour on Route 3 from St Leonards, Macquarie Park and Macquarie University.
Minimise disruption to other bus routes.	<ul style="list-style-type: none"> Two terminating routes and one through route also operate to Beecroft Station (Routes 553, 635 and 651).
Provide bus stops close to the railway station.	<ul style="list-style-type: none"> Minimises the customer impact of interchanging between bus and train.

4.8.3 Pick-up and set-down requirements and interaction with other bus services

Based on the identified functional requirements the pick-up and set-down requirements at Beecroft Station are to have buses depart from the existing bus stop on Wongala Crescent. This location provides space for three buses and provides at grade access between the bus stop and the railway station entrance. The bus stop would be shared with:

- Route 553 to West Pennant Hills (one morning peak hour departure)
- Route 635 to Castle Hill (one morning peak hour departure)
- Route 651 to Castle Hill (one morning peak hour departure)
- Route 651 to Macquarie Park (three morning peak hour departures).

Capacity analysis has been undertaken to test the feasibility for the bus stop to accommodate this number of buses. Results indicate that the stops provide sufficient capacity. The capacity analysis is included in Appendix D.

4.8.4 Parking and taxis

No changes to the provision of parking or the location of taxi ranks are required as a result of the rail replacement buses at Beecroft Station.

4.8.5 Temporary facilities

Shelters and seating are currently provided at the stop in Wongala Crescent. Figure 4.28 shows the proposed scope of works for temporary facilities associated with Beecroft Station.

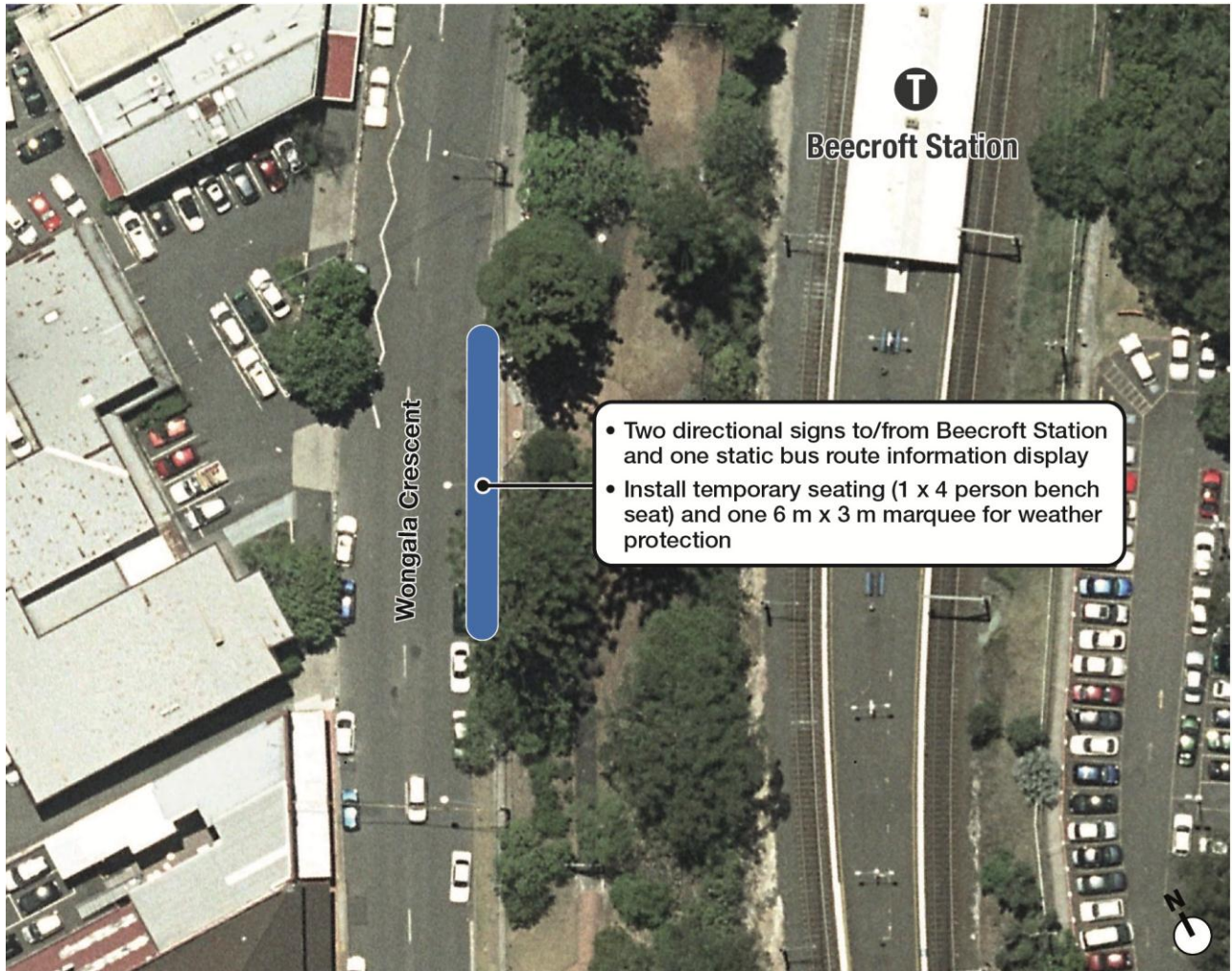


Figure 4.28 Proposed scope of works for temporary facilities - Beecroft Station

4.9 Gordon Station

4.9.1 Bus operations

The recommendations for enabling the efficient operation of rail replacement bus routes at Gordon Station, whilst minimising impacts on other bus routes and meeting customer experience objectives are summarised in Figure 4.29. Further details on these recommendations are provided in section 4.9.2 through to section 4.9.5.

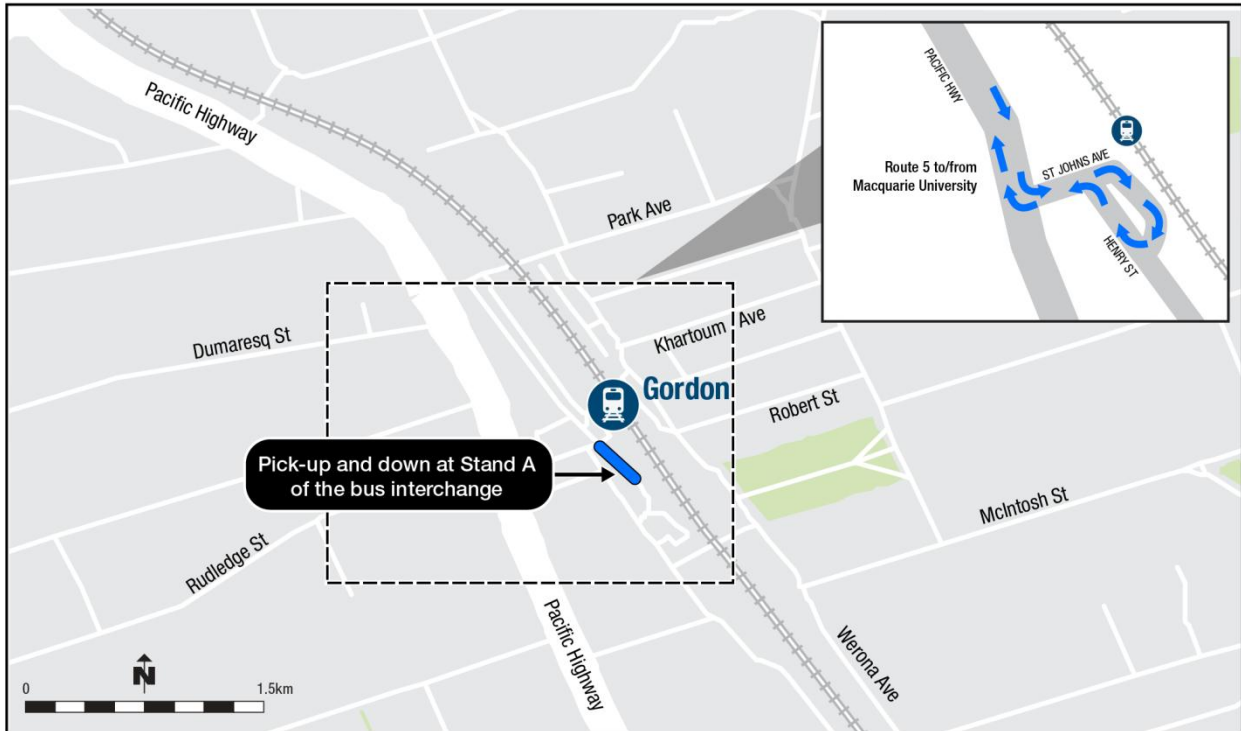


Figure 4.29 Rail replacement bus operations at Gordon Station

4.9.2 Functional requirements

The functional requirements for Gordon Station are summarised in Table 4.34.

Table 4.34 Functional requirements at Gordon Station

Functional requirement	Notes
Pick-up during the morning peak only.	<ul style="list-style-type: none"> Six trips per hour on Route 5 to Macquarie Park and Macquarie University.
Set-down during the evening peak only.	<ul style="list-style-type: none"> Six trips per hour on Route 5 from Macquarie University and Macquarie Park.
Minimise disruption to other bus routes.	<ul style="list-style-type: none"> Six other bus routes also operate to or through Gordon Station (Routes 195, 196, 197, 560, 562, 582).
Provide bus stops close to the railway station.	<ul style="list-style-type: none"> Minimises the customer impact of the interchanging between bus and train.

4.9.3 Pick-up and set-down requirements and interaction with other bus services

Based on the identified functional requirements the pick-up and set-down requirements at Gordon Station are for buses to depart from Stand A at the Gordon Station interchange. This:

- provides space for two buses
- bus stop is shared with Route 197 to Macquarie University (four morning peak hour departures).

Capacity analysis has been undertaken to test the feasibility for the bus stop to accommodate this number of buses. Results indicate that the stops provide sufficient capacity. The capacity analysis is included in Appendix D.

4.9.4 Parking and taxis

No changes to the provision of parking or the location of taxi ranks are required as a result of the rail replacement buses at Gordon Station.

4.9.5 Temporary facilities

Shelters are currently provided at the Gordon interchange. Work on the upgrade of the interchange at Gordon is also currently underway. This work will improve the operation of the interchange for buses (including rail replacement buses) by providing a looped bus roadway with separate pick-up and set-down areas. Figure 4.30 shows the proposed scope of works for temporary facilities associated with Gordon Station.

There are longer term plans being made for the existing Gordon Town Centre including traffic changes. These will be reviewed for impacts on the Temporary Transport Plan at a future date.

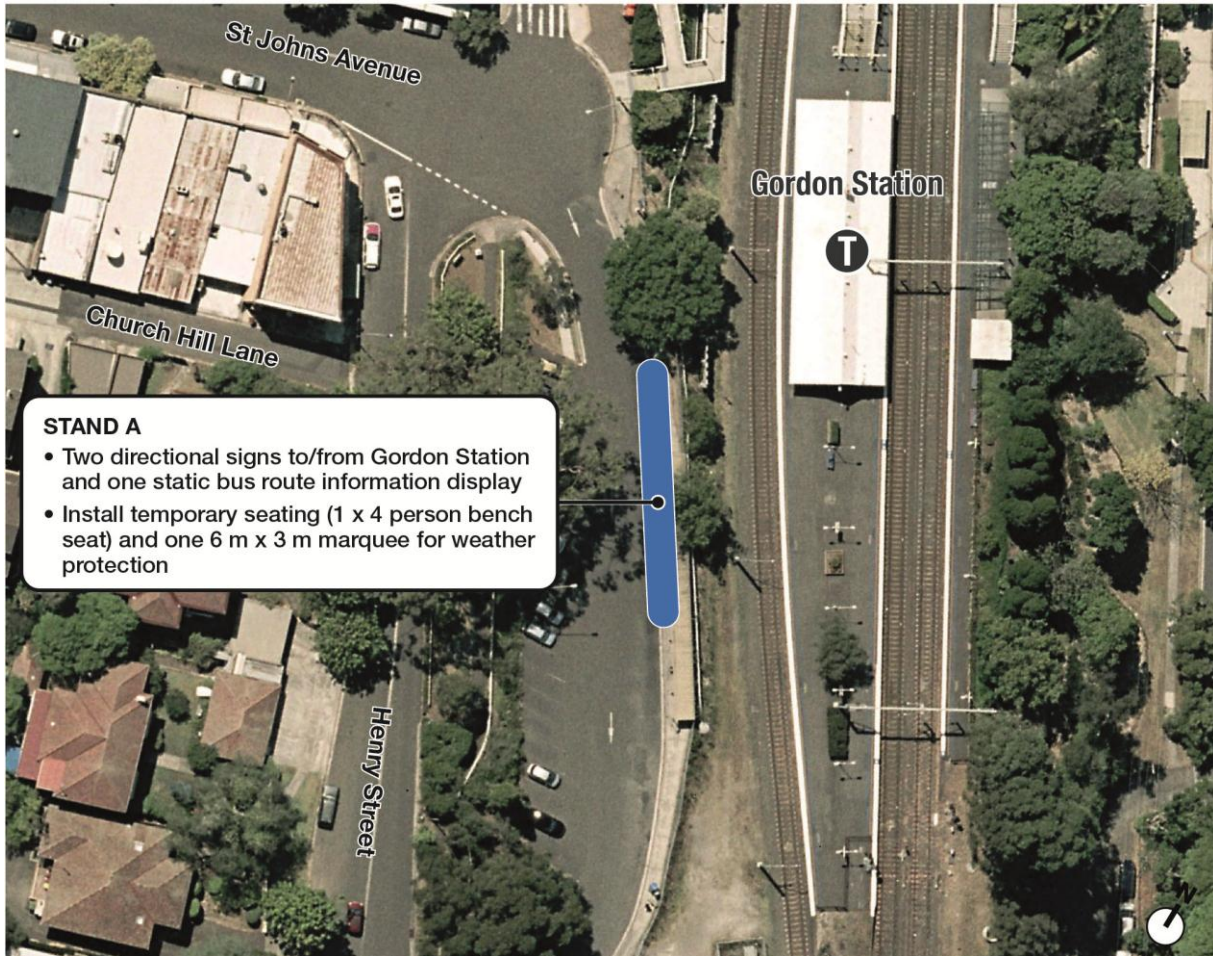


Figure 4.30 Proposed scope of works for temporary facilities - Gordon Station

4.10 St Leonards Station

4.10.1 Bus operations

The recommendations for enabling the efficient operation of rail replacement bus routes at St Leonards Station, whilst minimising impacts on other bus routes and meeting customer experience objectives is summarised in Figure 4.31. Further details on these recommendations are provided in section 4.10.2 through to section 4.10.5.

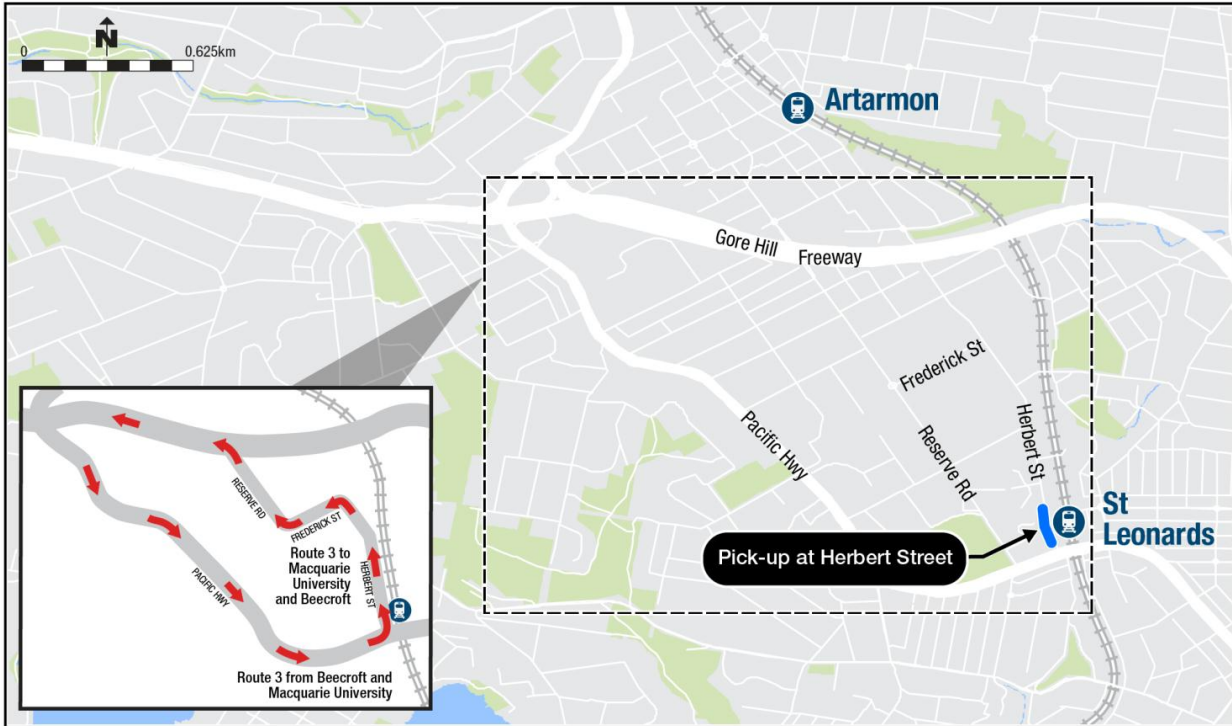


Figure 4.31 Rail replacement bus operations at St Leonards Station

Buses would use the existing stop on Herbert Street, north of the Pacific Highway. Passengers crossing Herbert Street to get into St Leonards Station have two options:

- walk 80 m to the signalised pedestrian crossing at the Pacific Highway
- walk 30 m to the pedestrian overbridge over Herbert Street.

4.10.2 Functional requirements

The functional requirements for St Leonards Station are summarised in Table 4.35.

Table 4.35 Functional requirements at St Leonards Station

Functional requirement	Notes
Pick-up and set-down during the morning peak.	<ul style="list-style-type: none"> ■ 18 trips per hour on Route 3 from St Leonards to Macquarie Park and Macquarie University. ■ Eight trips per hour arriving on Route 3 from Beecroft, Macquarie University and Macquarie Park.
Pick-up and set-down during the evening peak.	<ul style="list-style-type: none"> ■ 17 trips per hour arriving on Route 3 from Macquarie University and Macquarie Park. ■ Eight trips per hour on Route 3 to Macquarie Park, Macquarie University and Beecroft.

Functional requirement	Notes
Minimise disruption to other bus routes.	<ul style="list-style-type: none"> 15 other bus routes also operate to or through St Leonards Station along the Pacific Highway (Routes 140, 143, 144, 200, 252, 254, 265, 286, 287, 290, 602, 612, 622, 653, M20). The Artarmon Loop and Gore Hill shuttle bus routes pick-up in Herbert Street.
Provide bus stops close to the railway station.	<ul style="list-style-type: none"> Minimises the customer impact of interchanging between bus and train.

4.10.3 Pick-up and set-down requirements and interaction with other bus services

Based on the identified functional requirements the pick-up and set-down requirements at St Leonards Station are for buses to depart from Herbert Street. Justification for this location is that it:

- the bus stop is separate from the 15 other bus routes that serve St Leonards
- provides space for two buses
- the bus stop is located behind the stop used by the Artarmon Loop service (peak hour frequency of every 7–8 minutes) and Gore Hill shuttle bus and away from the other bus services listed in Table 4.35
- access to/from St Leonards Station is via the pedestrian overbridge (with stair or lift access) or via the pedestrian crossing at the intersection of Herbert Street and the Pacific Highway.

Capacity analysis has been undertaken to test the feasibility for the stop to accommodate this number of buses. Results indicate that the stops provide sufficient capacity. The capacity analysis is included in Appendix D.

4.10.4 Traffic impacts

Existing situation intersection performance (2013)

Table 4.36 provides a summary of the existing intersection performance around St Leonards Station.

Table 4.36 Summary of existing intersection performance – St Leonards Station

Site ID	Intersection	Peak period	Degree of Saturation	Average Delay (sec)	Level of Service	95 th percentile queue (m) ¹
21	Pacific Highway and Herbert Street	AM	0.90	21	B	224 (N)
		PM	0.82	23	B	244 (N)

(1) Notes: Letter indicates approach with the longest queue, N = north, NE = north-east, E = east, SE = south-east, S = south, SW = south-west, W = west, NW = north-west

These results match on-site observations and indicate that the Pacific Highway/Herbert Street intersection appeared to operate well during both peak hours.

Future base intersection performance (2019)

The results from the intersection modelling for base conditions in 2019 around St Leonards Station showed that the greatest impact occurred in the evening peak with larger increase in queue lengths, however the average delay values were still less than one minute for most movements (overall Level of Service B in both peaks).

Traffic modelling results (2019) with rail replacement buses

Traffic modelling was based on the operation of rail replacement buses as shown in Figure 4.30. The traffic modelling results for the intersection of Pacific Highway and Herbert Street in St Leonards indicate that the rail replacement buses have minimal impact (Level of Service B remains, no change to average delays).

The results of the traffic modelling are shown in Figure 4.32.

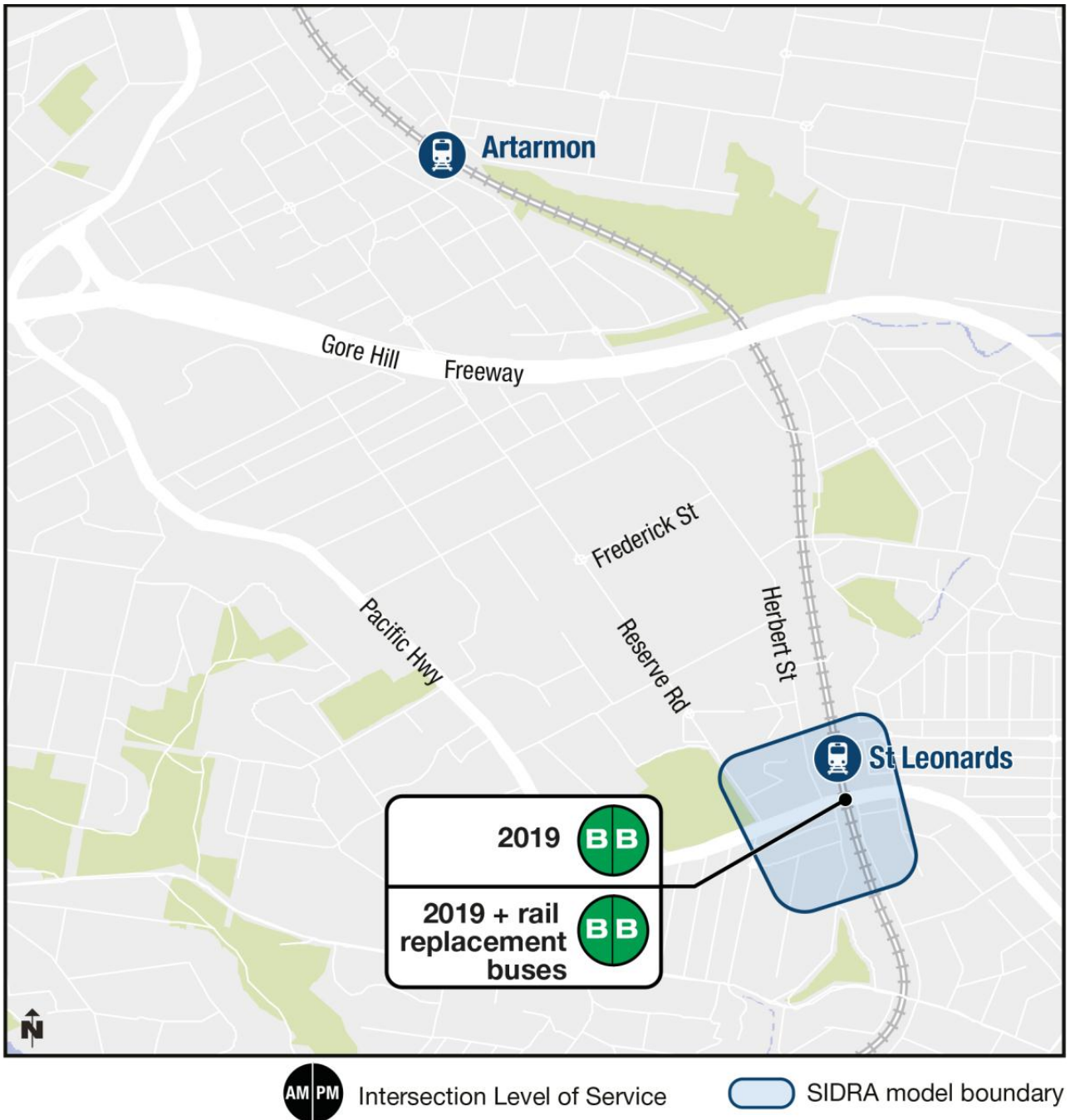


Figure 4.32 Traffic modelling results at St Leonards Station

4.10.5 Parking and temporary facilities

The existing short term parking behind the Artarmon Loop bus stop would need to be temporarily removed during peak periods, to provide space for Route 3 buses. This would create a single bus zone between the pedestrian overbridge and the existing bus shelter near the Pacific Highway.

Current short term parking arrangements include a length of kerb for three hour parking (8.30 am to 6.00 pm Monday to Saturday, approximately five car spaces) and a length of kerb for 3 minute parking (approximately five car spaces). During the times of operation of rail replacement buses, both these sections of Herbert Street would be limited to parking on weekdays between approximately 11.00 am and 3.00 pm, and after 8.00 pm.

All temporary parking removal will revert to existing conditions once the Epping to Chatswood railway Rapid Transit Conversion Program is complete. Installation of temporary shelters and seating would be required at the extended Herbert Street stop.

Figure 4.33 shows the proposed scope of works for temporary facilities associated with St Leonards Station.

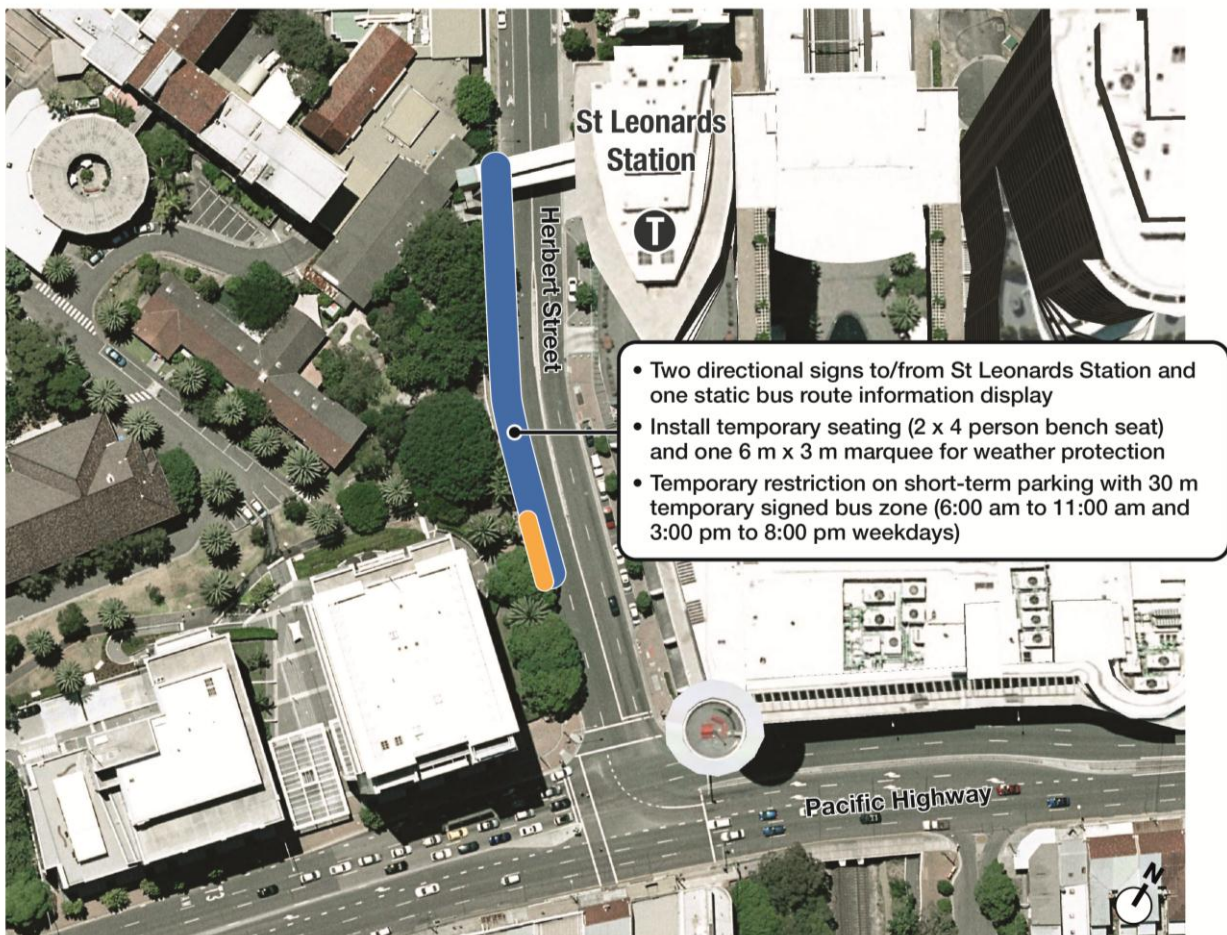


Figure 4.33 Proposed scope of works for temporary facilities - St Leonards Station

4.11 Summary

4.11.1 Parking impacts

The temporary changes to parking required as a result of the Temporary Transport Plan are summarised in Table 4.37. All changes to parking will be restored once the works associated with the Epping to Chatswood railway Rapid Transit Conversion Program are complete.

Table 4.37 Summary of temporary parking changes

Station	Location	Existing parking arrangement	Change in parking	Approximate number car parking spaces affected
Epping	Langston Place (western side)	Short term parking (½P): <ul style="list-style-type: none"> 8.30 am–6.00 pm Monday–Friday 8.30 am–12.30 pm Saturday. 	Temporary removal of short term parking so that all space is for buses and taxis.	6 spaces
	Langston Place (eastern side)	Short term (½P): <ul style="list-style-type: none"> 8.30 am–6.00 pm Monday–Friday 8.30 am–12.30 pm Saturday. 	Temporary extension of the existing weekday 'no parking' restriction from 8.30 am until peak hour operation of Route 2 ends (at approximately 10.00 am).	10 spaces x 1½ hours
	Pembroke Street (southern side, east of Langston Place)	Short term parking (1P): <ul style="list-style-type: none"> 8.30 am–6.00 pm Monday–Friday 8.30 am–12.30 pm Saturday). 	The temporary removal of short term parking.	4 spaces
Chatswood	Victoria Avenue (northern side, Pacific Highway to Railway Street)	Short term parking (½P): <ul style="list-style-type: none"> 8.30 am–6.00 pm Monday–Friday 8.30 am to 4.00 pm Saturday. 	Temporary removal of all parking behind the taxi rank in Victoria Avenue.	10 spaces
	Railway Street (eastern side, north of Help Street)	Short term parking (2P): <ul style="list-style-type: none"> 8.00 am–6.00 pm Monday–Friday 8.30 am–4.30 pm Saturday). 	Temporary removal of short term parking in Railway Street (eastern side, north of Help Street).	8 spaces
	Brown Street (south side, west of Railway Street)	Short term parking (1P): <ul style="list-style-type: none"> 8.30 am–6.00 pm Monday–Friday 8.30am–4.30 pm Saturday. 	Temporary extension of the existing weekday 'no parking' restriction between the car park driveways from 8.30 am until 10.00 am.	4 spaces x 1½ hours
St Leonards	Herbert Street, (northern side, Pacific Highway to the pedestrian bridge)	Short term parking: <ul style="list-style-type: none"> a length of kerb (3P), 8.30 am to 6.00 pm Monday to Saturday a length of kerb for 3 minute parking. 	For rail replacement bus purposes, both these sections of Herbert Street would be limited to parking on weekdays between approximately 11.00 am and 3.00 pm, and after 8.00 pm.	10 spaces x 1½ hours in the morning and 3 hours in the evening peak

Impacts associated with the temporary removal of car parking at Epping and St Leonards have been minimised where reasonable and feasible. At some locations impacts have been minimised by temporarily extending the existing weekday 'no parking' restriction times.

4.11.2 Bus stop capacity

The results for the bus stop capacity analysis indicated that most bus stops have sufficient capacity to accommodate the rail replacement buses. The following locations have been identified as having potential capacity constraints and will require bus service supervision (bus marshals):

- Chatswood Station – Railway Street (east side) during the morning peak period
- Epping Station – Langston Place during the morning peak period
- Macquarie Park (Waterloo Road) eastbound during both the morning and evening peak periods
- Macquarie University Herring Road evening peak periods.

Further analysis of bus stop dwell times at these locations will be undertaken, and the results used in further analyses of bus stop capacity.

4.11.3 Traffic impacts

Existing situation (2013)

The results of the 2013 existing situation intersection modelling confirms on-site observations that parts of the road network currently experience heavy congestion. In particular:

- Delhi Road, Epping Road, Lane Cove Road, Beecroft Road and the Pacific Highway experience a high traffic demand
- signal coordination is given (where possible) to these roads at the signalised intersections, however there are still high levels of congestion in both the morning and evening peak periods
- at many locations, queues were observed to extend from one intersection through to the next, impacting on intersection throughput
- a number of the assessed intersections are operating with a Level of Service D, E or F in either or both peaks, equating to an average vehicle delay of 43 seconds up to 83 seconds.

Future base scenario (2019)

The intersection modelling results for 2019 (without rail replacement buses) indicate a general deterioration of intersection performance and increase in delays and queue length. Modelling results showed the following decreases in Level of Service:

- from D to E at the Beecroft Road and Carlingford Road intersection during the morning peak with an associated 9 second increase in average delays
- from D to F at the Epping Road, Langston Place and Blaxland Road intersection during the evening peak
- from D to F at the Epping Road and Balaclava Road intersection during both peak periods
- from D to E/F at the Lane Cove Road and Epping Road intersection in the morning and evening peak periods respectively
- from D to F at the Epping Road and Wicks Road intersection in the evening peak period
- from D to E at the Blaxland Road and Balaclava Road intersection in the morning peak period.

Rail replacement buses (2019)

In most instances the addition of the rail replacement buses has minimal impact on the intersections modelled. Slight decreases in the Level of Service for the morning peak period was modelled as occurring at the following intersections:

- Epping Road/Langston Road/Blaxland Road
- Talavera Road and Herring Road
- Waterloo Road and Khartoum Road
- Lane Cove Road and Waterloo Road
- Delhi Road and the M2 Motorway on/off ramps.

Once operational, the NWRL will reduce car trips by 14 million a year.

4.11.4 Future development projects

Throughout the area covered by the Temporary Transport Plan a number of future development and redevelopment projects have been identified. These are summarised in Table 4.38. In instances where there is certainty (i.e. funding) that these development opportunities will progress and road infrastructure changes have been highlighted, these have been incorporated into the traffic intersection modelling undertaken for this Temporary Transport Plan. Others may need to be given further consideration in terms of implications for traffic movements in a review of the Temporary Transport Plan at a future date.

Table 4.38 Proposed future development projects

Station	Proposed developments
Epping	<ul style="list-style-type: none"> ■ Epping Town Centre UAP
Macquarie University	<ul style="list-style-type: none"> ■ 120–128 Herring Road ■ 110–114 Herring Road – Mix Use Development of Stamford Hotel site ■ Herring Road UAP ■ Macquarie Shopping Centre redevelopment
North Ryde	<ul style="list-style-type: none"> ■ North Ryde UAP ■ M2 redevelopment site
Gordon	<ul style="list-style-type: none"> ■ Gordon Town Centre

5. Estimated travel times

Changes to customer journey time are dependent on the customer's origin and destination, road network conditions as well as the time of day of travel. Bus journey times are longer than train travel times due to a range of factors including:

- the nature of Sydney's traffic, which experiences fluctuations in volume and traffic flow from hour to hour
- fluctuations in customer demand
- different travel times of vehicles in the morning compared to the evening peak periods, and across all other hours of the day
- the absence of a dedicated corridor.

Bus travel times have been minimised where practical through:

- the provision of a limited stops service during peak periods (Route 2)
- services to/from non-Epping to Chatswood railway stations which operate direct to Macquarie Park and Macquarie University during peak periods (Routes 3, 4 and 5).

As a general guide, customers will need to allow an additional 10 to 45 minutes (based on preliminary estimates), depending on the replacement bus trip, time of day of travel and interchange to other modes. Customers travelling between the T1 Northern and North Shore lines who do not require access to Epping to Chatswood railway stations are encouraged to use the rail alternative via Strathfield or via Hornsby. For some customers, these alternative rail options may be potentially quicker than using the rail replacement bus service. Bus travel times will be refined leading up to implementation.

This chapter outlines the estimated travel time and average speed for each rail replacement bus route. Further supporting information is provided in Appendix H.

5.1 Methodology

5.1.1 Calculating travel times and average speed

Travel speeds have been estimated for each of the rail replacement bus routes. The morning peak and evening peak travel speed estimates were tested against travel time information for existing bus routes where available, as captured through the Public Transport Information Priority System (PTIPS). The travel speeds are based on existing bus travel times over portions of common sections of route and assumes a general deterioration in road speeds over time. The morning peak and evening peak hour travel time data has been compiled using the following methodology:

1. PTIPS data (2013) as supplied by Transport for NSW is used where available:
 - a) GPS systems and radio communication data are used to collect information about buses, their location and travel times.
 - b) Traffic signal priority can be directed towards buses caught in congestion and falling behind schedule.
 - c) 2013 PTIPS data was provided by Transport for NSW (for morning and evening peak periods) for those sections of rail replacement bus routes which share common portions of route for regular route services.

2. Where no PTIPS data is available, the scheduled bus travel time is compared with real time traffic information:
 - a) Real time traffic information comes from data provider, Intelomatics Australia, and is sourced from data from other motorists.
 - b) If real time traffic information (which was sourced over a period of 5 continuous weekdays) is greater than the scheduled bus time, it is then assumed that PTIPS would also show that buses are not keeping to schedule. The real time traffic information is therefore used for the rail replacement buses.
3. Where scheduled bus times are greater than real time traffic information, the scheduled time is used, as there is no specific bus data available to show that buses are running ahead of schedule.

Travel times and average speeds have been calculated for the morning peak, the evening peak, the off peak and weekends. The off peak travel times have been used for early morning and late nights. Full details of the methodology and assumptions used in the calculations are outlined in Appendix H.

Estimated travel times and average speed

Table 5.1 shows the summary of morning peak estimated travel times and speeds for each rail replacement bus route.

Table 5.1 Morning peak estimated travel time and travel speed summary

Route No.	Between	Distance (km)		Estimated average travel times and speed
1	Epping to Chatswood	13.7	Speed (kph)	22
			Travel time (mins)	38
	Chatswood to Epping	11.6	Speed (kph)	20
			Travel time (mins)	35
2	Epping to Chatswood	12.9	Speed (kph)	29
			Travel time (mins)	27
3	Beecroft to St Leonards	17.3	Speed (kph)	28
			Travel time (mins)	37
	St Leonards to Macquarie University	9.8	Speed (kph)	25
			Travel time (mins)	24
4	Eastwood to Macquarie Park	5.5	Speed (kph)	15
			Travel time (mins)	22
5	Gordon to Macquarie University	6.9	Speed (kph)	12
			Travel time (mins)	34

Table 5.2 shows the summary of evening peak estimated travel times and speeds for each rail replacement bus route.

Table 5.2 Evening peak estimated travel time and travel speed summary

Route No.	Between	Distance (km)		Estimated travel times and speed
1	Epping to Chatswood	12.1	Speed (kph)	17
			Travel time (mins)	44
	Chatswood to Epping	13.5	Speed (kph)	21
			Travel time (mins)	39
2	Chatswood to Epping	13.5	Speed (kph)	30
			Travel time (mins)	27
3	St Leonards to Beecroft	17.3	Speed (kph)	23
			Travel time (mins)	45
	Macquarie University to St Leonards	9.9	Speed (kph)	24
			Travel time (mins)	25
4	Macquarie Park to Eastwood	6.0	Speed (kph)	14
			Travel time (mins)	25
5	Macquarie University to Gordon	6.9	Speed (kph)	19
			Travel time (mins)	22

Travel times will be reviewed prior to implementation of the Temporary Transport Plan.

6. Strategic scope of works

To support the operation of the rail replacement buses during the Epping to Chatswood railway Rapid Transit Conversion Program there are specific temporary facilities associated with the functional and operational needs identified for each station in sections 4.2 to 4.10. Table 7.1 provides a summary of the temporary facilities required to support the Temporary Transport Plan. The scope items may be adjusted following design work and further demand forecasting. Figures showing the scope for works for temporary facilities at selected locations are provided in section 4.2 through to section 4.10. In addition, to the identification of specific temporary facilities, this chapter also includes estimated bus fleet requirements.

Table 6.1 Temporary facilities to support the rail replacement bus operations

Station	Location	Item
Epping	Langston Place, western side, northbound, north of Epping Road	<ul style="list-style-type: none"> ■ New 30 m temporary signed bus zone to replace current taxi rank. ■ New temporary signed taxi zone to replace kiss and ride (kiss-and-ride to be relocated to Pembroke Street for the duration of the Epping to Chatswood railway Rapid Transit Conversion Program). ■ Appropriate directional signs to/from the rail station and bus route set-down sign/information display (static).
	Langston Place, southbound, north of Epping Road	<ul style="list-style-type: none"> ■ Temporary extension of the weekday ‘no parking’ restriction, with new 30 m temporary signed bus zone (6.00 am to 10.00 am weekdays). ■ Appropriate directional signs to/from the rail station and bus route information display (static).
	Pembroke Street, westbound, east of Langston Place	<ul style="list-style-type: none"> ■ New temporary signed bus zone to replace current car parking.
	Cambridge Street, Stand A	<ul style="list-style-type: none"> ■ Appropriate directional signs to/from the rail station and bus route information displays (static).
	Intersection of Epping Road and Langston Place	<ul style="list-style-type: none"> ■ B signal to allow buses to turn right from Langston Place into Epping Road.
	Oxford Street, western side, eastbound	<ul style="list-style-type: none"> ■ Temporary relocation of pick-up for regular bus routes 295 and 994 (Optus) from Cambridge Street to Oxford Street. ■ Pick-up stop to include J Pole and timetable information (static), for use by regular bus routes. Seating currently exists.
Macquarie University	Waterloo Road, eastbound, east of Herring Road	<ul style="list-style-type: none"> ■ Extend and re-sign the existing bus zone eastwards by 14.5 m. ■ Install temporary seating (2 x 4 people seat) and two 6 m by 3 m marquees for weather protection. ■ Appropriate directional signs and bus route information display (static).
	Herring Road, westbound. East of Waterloo Road	<ul style="list-style-type: none"> ■ Install temporary seating (2 x 4 people seat) and two 6 m by 3 m marquees for weather protection. ■ Appropriate directional signs and bus route information displays (static).

Station	Location	Item
Macquarie Park	Waterloo Road, eastbound, west of Lane Cove Road	<ul style="list-style-type: none"> ■ Install temporary seating (1 x 4 person bench seat) and one 6 m by 3 m marquee for weather protection. ■ Appropriate directional signs and bus route information displays (static).
	Waterloo Road, westbound, west of Lane Cove Road	<ul style="list-style-type: none"> ■ Install temporary seating (1 x 4 person bench seat) and one 6 m by 3 m marquee for weather protection. ■ Appropriate directional signs and bus route information displays (static).
	Lane Cove Road, western side, westbound, south of Waterloo Road	<ul style="list-style-type: none"> ■ Install temporary seating (1 x 4 person bench seat) and one 6 m by 3 m marquee for weather protection. ■ Appropriate directional signs and bus route information displays (static).
North Ryde	Delhi Road bus stop, eastbound side	<ul style="list-style-type: none"> ■ Appropriate directional signs and bus route information displays (static). ■ Install temporary seating (1 x 4 person bench seat) and one 6 m by 3 m marquee for weather protection.
	Delhi Road bus stop, westbound side	<ul style="list-style-type: none"> ■ Appropriate directional signs and bus route information displays (static). ■ Install temporary seating (1 x 4 person bench seat) and one 6 m by 3 m marquee for weather protection.
Chatswood	Victoria Avenue, eastbound, east of Pacific Highway	<ul style="list-style-type: none"> ■ Two new temporary signed bus zones to replace current car parking. Each zone approximately 30 m to accommodate 2 buses: <ul style="list-style-type: none"> ▶ The easternmost bus zone to include J Pole, seating (1 x 4 person bench seat) and timetable information (static), for use by regular bus routes. ▶ The westernmost zone requires bus zone signs (x 2).
	Railway Street, western side, between Victoria Avenue and Brown Street	<ul style="list-style-type: none"> ■ Appropriate directional signs and static bus route information display. ■ Install temporary seating (2 x 4 person bench seat) and two 6 m by 3 m marquees for weather protection.
	Brown Street, westbound, south of Railway Street	<ul style="list-style-type: none"> ■ Extension of the existing weekday 'no parking' restriction from 8.30 am to 10.00 am, with new 30 m temporary signed bus zone (6.00 am to 10.00 am weekdays). ■ Appropriate directional signs and bus route information display (static).
	Railway Street, eastern side, north of Help Street	<ul style="list-style-type: none"> ■ New temporary peak hour signed 30 m bus zone to replace current car parking, to provide a holding point for buses starting at Chatswood.
Beecroft	Wongala Crescent, southbound alongside the rail line	<ul style="list-style-type: none"> ■ Appropriate directional signs to/from Beecroft Station and static bus route information display. ■ Install temporary seating (1 x 4 person bench seat) and one 6 m by 3 m marquee for weather protection.
Eastwood	Ethel Street, westbound, east of Railway Parade	<ul style="list-style-type: none"> ■ Appropriate directional signs to/from Eastwood Station and static bus route information displays. Seating currently exists.
Gordon	Bus Interchange, Stand A	<ul style="list-style-type: none"> ■ Appropriate directional signs to/from Gordon Station and static bus route information display. ■ Install temporary seating (1 x 4 person bench seat) and one 6 m by 3 m marquee for weather protection.

Station	Location	Item
St Leonards	Herbert Street, northbound, north of Pacific Highway	<ul style="list-style-type: none"> ■ Appropriate directional signs and static bus route information display. ■ Install two temporary seating (1 x 4 person bench seat) and two 6 m by 3 m marquees for weather protection. ■ Extension of the existing weekday 'no parking' restriction, with new 30 m temporary signed bus zone (6.00 am to 11.00 am weekdays and 3.00 pm to 8.00 pm).

Further works such as the provision of facilities and some minor relocation of bus stop poles at rail replacement Route 1 bus stops may be required to support provision for accessible services. This will be examined in further detail as part of design development for the temporary facilities at these bus stops.

6.1 Operating requirements

Operating hours and ticketing

The base rail replacement buses will operate to cover the hours of operation for rail services in place at the time. Customers will be able to use their OPAL cards on the buses.

Marshalling requirements

Marshals will provide an important function for bus operations for the Temporary Transport Plan. Specifically, these marshals will:

- provide a customer service function for customers
- enforce bus dwell times to support the efficient departure of buses
- ensure bus stops remain for the exclusive use of buses and are kept clear of general traffic
- support the efficient movement of buses from stand by locations to the bus stop for departure.

The proposed allocation of marshals for the Temporary Transport Plan is based on providing bus marshals:

- for the Route 1 base service which is also proposed as the accessible service
- at departure locations for the non-Epping to Chatswood railway rail replacement bus services (Routes 3 to 5) to facilitate efficient departure
- during periods of higher demand including the peak periods.

The proposed allocation of marshals are summarised in Table 6.2.

Table 6.2 Marshalling requirements by station and by time period (number of persons)

Station/Location	Timings			
	4.00 am–12.00 am (weekdays & weekends)	7.00 am–7.00 pm (weekdays only)	6.00 am–9.30 am (weekdays only)	3.00 pm–6.30 pm (weekdays only)
Beecroft			1	
Epping	1	1		
Macquarie University	2	2		
Macquarie Park	1		1	1
North Ryde	1		1	1
Chatswood	1	1		
St Leonards			2	2
Gordon			1	
Eastwood			1	

6.2 Indicative fleet requirements

The estimated average travel speeds for each of the rail replacement bus routes have been used to calculate the rail replacement bus fleet requirements. The travel times of the rail replacement buses as identified in Chapter 5: *Estimated travel times*, will determine the size of the bus fleet required to provide the services.

The calculation of the indicative bus fleet size required to provide the peak hour levels of service identified in Chapter 3: *Demand assessment* is based on:

- the estimated average speed for each bus route identified in Chapter 5: *Estimated travel times*
- assumed peak hour headways (the most frequent headway is used where buses operate in both directions) based on the number of trips per hour identified in Chapter 3: *Demand assessment*
- an assumed turnaround time of 5 minutes at each terminal point for buses making a return trip, increased during the evening peak to 10 minutes at Chatswood for Route 1 buses which are required to set-down in the Chatswood Interchange and then travel empty back to Railway Street.

The calculation methodology uses round trip cycle times based on in service travel times, and also allocates the assumed layover time to all trips, regardless of whether or not a bus may in fact run out of service, via the most direct route to its next starting point (and therefore not require the layover time allocated). Also, the methodology does not make any assumptions about how buses may inter-work between routes. The fleet size estimate will be refined as specific schedules are developed.

The fleet size calculated using this method is shown in Table 6.3.

Table 6.3 Indicative bus fleet requirements

	Fleet requirement (number of peak hour buses)	
	Morning peak	Evening peak
Total bus fleet	64	75

These numbers represent the approximate number of buses required to provide the identified levels of service at the estimated average travel speeds. The table also shows an approximate 10 per cent allowance for spare fleet to cover breakdowns and maintenance requirements as well as the provision of standby buses at key locations to cater for variations in service.

The details of the fleet calculation are shown in Appendix I.

7. Meeting the Temporary Transport Plan objectives

Customer experience and bus service objectives for the Temporary Transport Plan were identified in Chapter 2: *Development of the Temporary Transport Plan*. Table 7.1 indicates if and how the Temporary Transport Plan and associated operational arrangements meet these and secondary objectives identified in Table 2.1.

Table 7.1 Meeting the Temporary Transport Plan objectives

Requirements to meet the Temporary Transport Plan objectives	Does the recommended strategy meet the requirements?	Justification
Customer service objectives:		
To minimise the impact for customers of temporarily replacing rail services on the Epping to Chatswood railway with a replacement bus service	✓	<ul style="list-style-type: none"> ■ Customer impacts are minimised through the provision of the five route strategy during peak periods which responds to demand forecasts. ■ Frequent services are provided for customers on all replacement bus routes. ■ The difference between rail and bus travel times is minimised in peak periods by providing a limited-stops route and routes that provide connections to/from other stations direct to Macquarie University and Macquarie Park. Alternative rail routes via Hornsby and Strathfield are also available for customers not requiring access to stations between Epping and Chatswood.
Provide a rail replacement bus service that serves identified customer markets	✓	<ul style="list-style-type: none"> ■ Route 1 provides a replacement bus service that replicates the rail service. ■ In addition to Route 1, the Temporary Transport Plan also includes four bus routes that only operate during peak periods and serve specific customer markets.
Provide an efficient and customer friendly interchange between modes	✓	<ul style="list-style-type: none"> ■ The number of passengers transferring between rail and bus during peak hours are spread across a number of locations, not only at Epping and Chatswood.
Providing a customer friendly waiting environment	✓	<ul style="list-style-type: none"> ■ The Temporary Transport Plan identifies temporary facilities for weather protection, passenger information and bus marshals. Pedestrian crossings or at grade access are available at all bus/rail interchange locations.

Requirements to meet the Temporary Transport Plan objectives	Does the recommended strategy meet the requirements?	Justification
Providing clear communication to customers	~	<ul style="list-style-type: none"> ■ The Temporary Transport Plan includes five separate bus routes, four of which only operate during peak periods and serve specific markets. In addition, morning and evening peak period bus stops are different in some locations (e.g. Chatswood Station). This is a more complicated plan to communicate to customers than a strategy built on a single all stations service. However, peak only rail replacement bus services have been previously used on other parts of the rail network for trackwork and major projects. ■ Bus marshals will be provided at all Route 1 locations at all times as well as at all departure locations for other peak period services. ■ A comprehensive communications plan will be developed to communicate all changes to customers and the alternative transport arrangements. ■ Information on the services will be made available through the existing channels such as the Transport Infoline (131 500), www.transportnsw.info and the transport applications for smart phones as well as appropriate signage.
Maintaining functionality for those not directly affected by the Temporary Transport Plan	~	<ul style="list-style-type: none"> ■ The Temporary Transport Plan results in additional buses sharing road space and bus stops with other routes. In some instances this requires existing bus stops to be relocated (at Epping and Chatswood). ■ In some locations short term car parking is temporarily removed. At other locations weekday “no parking” restrictions will be temporarily extended to commence later in the day, thereby minimising the impacts. ■ Separate pick-up areas for regular bus routes and rail replacement bus routes are identified at Epping and Chatswood. Shared set-down for Route 1 at Epping and Chatswood and Route 2 at Chatswood.
Bus services objectives:		
To provide a balance between minimising customer impacts and efficient use of bus resources	✓	<ul style="list-style-type: none"> ■ The five route bus strategy allows for the efficient use of bus resources by spreading the operation of the buses across a range of locations to minimise congestion impacts whilst serving identified customer markets.
Minimise disruption to existing rail and bus customers	~	<ul style="list-style-type: none"> ■ The Temporary Transport Plan minimises disruption to existing rail customers by providing a range of peak hour services that respond to identified rail customer markets.
Not adversely impact the movement of pedestrians, nor the efficiency of regular bus services	✓	<ul style="list-style-type: none"> ■ The Temporary Transport Plan identifies pedestrian access paths between bus stops and surrounding areas which require either no crossing of roads, or crossing at pedestrian crossings. ■ Regular bus routes continue to operate, with identified separate stops where possible. ■ Temporary relocation of stops for selected regular bus services at Epping and Chatswood are accessed via signalised crossings.
Be operationally effective and efficient	✓	<ul style="list-style-type: none"> ■ The Temporary Transport Plan provides services that respond to identified demand. Services operate to routes that meet customer needs. ■ The Temporary Transport Plan identifies temporary facilities that support efficient bus operations and improve customer outcomes. Traffic modelling analyses and bus stop capacity analyses has been used to test the feasibility and effectiveness of the Plan.

Requirements to meet the Temporary Transport Plan objectives	Does the recommended strategy meet the requirements?	Justification
Bus and rail staff communicate with the customers to ensure that the travel options and changes are clearly understood	~	<ul style="list-style-type: none"> ■ Refer to the customer service objective of 'Providing clear communication to customers'.
Provide sufficient capacity for passengers	✓	<ul style="list-style-type: none"> ■ The Temporary Transport Plan provides a range of routes to address specific customer markets. It minimises capacity constraints at interchange locations by spreading demand across a number of locations, not only at Epping and Chatswood. Service frequencies have been based on the forecast demand.

Key



Compliance with target achieved



Compliance with target is partially achieved at this stage and/or further work is required.



Compliance with target cannot be achieved without significant disruption to other customers.

8. Conclusions

A key part of the NWRL is the Epping to Chatswood railway which will be converted to rapid transit standards. Works to be undertaken for this conversion program will require an extended period of dedicated access. To provide this access, rail services between Epping and Chatswood will be temporarily removed for a period of about 7 months. During the temporary removal of Epping to Chatswood rail services which is expected to commence during the second half of 2018, rail replacement bus services will be required to continue the direct public transport connections between Epping, Chatswood and intermediate stations including Macquarie University, Macquarie Park and North Ryde.

This Epping to Chatswood railway Temporary Transport Plan has been prepared to guide the development of a rail replacement bus service strategy that meets customer needs during the temporary removal of rail services between Epping and Chatswood. It achieves this by:

- identifying customer experience and bus service objectives
- identifying the markets to be served by the rail replacement buses (along with the specific needs of these markets)
- outlining a service strategy (in terms of a rail replacement bus network) to meet the market needs.

The Temporary Transport Plan outlines the rail replacement bus services that will operate during the rail hours of operation. It includes the provision of additional services at interchange locations other than Epping and Chatswood to minimise the impact to customer journey times and minimise the potential increase in bus congestion at these locations. At the same time the Plan seeks to provide efficient and customer friendly interchanges between modes and a customer friendly waiting environment.

The replacement rail services between Epping and Chatswood with temporary bus services will result in:

- increased customer journey times
- an increase in the number of buses operating on the existing road network
- the relocations of some existing bus services at Epping and Chatswood to accommodate the additional rail replacement buses
- the temporary removal of some car parking Epping, Chatswood and St Leonards in order to accommodate the operational requirements of the rail replacement buses.

Overall, the addition of the rail replacement buses has little impact on intersection performance; however some movements/approaches are affected more than others. The largest increase in average intersection delay is 25 seconds per vehicle at the intersection of Waterloo Road/Khartoum Road in the evening peak.

Changes to customer journey time are dependent on the customer's origin and destination, road network conditions as well as the time of day of travel. Bus travel times have been minimised where practical through the provision of:

- limited-stops service during peak periods
- services to/from non-Epping to Chatswood railway stations which operate direct to Macquarie Park and Macquarie University during peak periods
- bus journey times are however longer than train travel times due to the varying day to day road network conditions and the absence of a dedicated corridor.

The five route Temporary Transport Plan responds to market needs, customer experience objectives and bus service objectives. The Plan provides a balance between minimising customer impacts and minimising impacts on surrounding areas.

The Temporary Transport Plan responds to customer needs by:

- identifying customer markets and forecast levels of demand
- providing limited-stops service in peak periods and connections to/from non-Epping to Chatswood railway stations
- minimising congestion impacts at Epping and Chatswood transport interchanges in the peak periods
- minimising transfer times between rail and bus for Epping to Chatswood railway customers by providing rail replacement bus stops close to the rail stations
- identifying bus stop and temporary facilities to provide a customer friendly environment.

Operational needs are met by:

- minimising the impacts on regular route buses by providing separate pick-up and set-down areas for rail replacement buses at locations where practical
- identifying bus stop and supporting temporary facilities to provide an efficient environment for buses to operate
- providing common pick-up stops for all rail replacement bus routes, where possible, minimising customer confusion
- responding to the specific functional requirements at each station served by rail replacement bus routes.

Impacts on surrounding areas and other customers have been minimised by:

- having bus routes operate across many locations to minimise congestion impacts at Epping and Chatswood transport interchanges
- providing bus stops which are separate to existing bus services where possible
- providing only temporary facilities to support bus operations which will be removed following opening of NWRL when the temporary bus services cease to operate
- continuing the operation of existing bus services and minimising the impact to these by relocating only selected existing bus services at Epping and Chatswood which are of a lower frequency compared to the rail replacement bus services.

The Epping to Chatswood railway Temporary Transport Plan will be refined in the lead up to implementation.

9. References

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