B-Line

October 2016

Dee Why B-Line Road Infrastructure

Review of Environmental Factors

Transport Roads & Maritime Services

NSW GOVERNMENT

NSW MAKING IT HAPPEN

Contents

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Abbreviations

Term	Meaning
ABS	Australian Bureau of Statistics
AHIMS	Aboriginal Heritage Information Management System
ARI	Average Recurrence Interval
Blue Book	Managing Urban Stormwater: Soils and Construction
CBD	Central Business District
CEMP	Construction Environmental Management Plan
CLM Act	*Contaminated Land Management Act 1997*
CPTED	Crime Prevention Through Environmental Design
DBH	Diameter at Breast Height
DBYD	Dial Before You Dig
DDA	*Disability Discrimination Act 1992* (Commonwealth)
ECM	Environmental Controls Map
EIS	Environmental Impact Statement
EMS	Environmental Management System
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
EPL	Environment Protection Licence
ESCP	Erosion and Sediment Control Plan
ESD	Ecologically Sustainable Development (refer to Definitions)
Heritage Act	*Heritage Act 1977*
Infrastructure SEPP	*State Environmental Planning Policy (Infrastructure) 2007*
LEP	Local Environmental Plan
LGA	Local Government Area
LoS	Level of Service

Term	Meaning
NES	National Environmental Significance
NPI	National Pollutant Inventory
NPW Act	*National Parks and Wildlife Act 1974*
NSW	New South Wales
NW Act	*Noxious Weeds Act 1993*
OEH	NSW Office of the Environment and Heritage
POEO Act	*Protection of the Environment Operations Act 1997*
REF	Review of Environmental Factors (this document)
Roads Act	*Roads Act 1993*
Roads and Maritime	NSW Roads and Maritime Services (formerly Roads and Traffic Authority)
SEPP	State Environmental Planning Policy
SEPP 19	*State Environmental Planning Policy No. 19 - Bushland in Urban Areas*
SEPP 55	*State Environmental Planning Policy 55 – Remediation of Land*
SHR	State Heritage Register
SRD SEPP	*State Environmental Planning Policy (State and Regional Development) 2011*
TCP	Traffic Control Plan
TEC	Threatened ecological community
TfNSW	Transport for NSW
TMP	Traffic Management Plan
TSC Act	*Threatened Species Conservation Act 1995*
WARR Act	*Waste Avoidance and Resource Recovery Act 2001*

Definitions

Term	Meaning
Average Recurrence Interval	The likelihood of occurrence, expressed in terms of the long-term average number of years, between flood events as large as or larger than the design flood event. For example, floods with a discharge as large as or larger than the 100-year ARI flood will occur on average (ARI) once every 100-years.
Asset Standards Authority	The Asset Standards Authority is an independent body within TfNSW, responsible for engineering governance, assurance of design safety, and ensuring the integrity of transport and infrastructure assets.
Concept Design	The Concept Design is the preliminary design presented in the REF, which would be refined by the Contractor (should the Proposal proceed) to a design suitable for construction (subject to TfNSW and/or Roads and Maritime acceptance). TfNSW contracts a single entity (the Contractor) to further develop the design to a level suitable for construction. The Contractor therefore becomes responsible for all work on the project.
Commuter model	Traffic modelling software
Disability Standards for Accessible Public Transport	The Commonwealth *Disability Standards for Accessible Public Transport 2002* ("Transport Standards") (as amended) are a set of legally enforceable standards, authorised under the Commonwealth *Disability Discrimination Act 1992* (DDA) for the purpose of removing discrimination 'as far as possible' against people with disabilities. The Transport Standards cover premises, infrastructure and conveyances, and apply to public transport operators and premises providers.
Ecologically Sustainable Development	As defined by clause 7(4) Schedule 2 of the EP&A Regulation. Development that uses, conserves and enhances the resources of the community so that ecological processes on which life depends are maintained, and the total quality of life, now and in the future, can be increased.
Feasible	A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements.
Noise sensitive receiver	In addition to residential dwellings, noise sensitive receivers include, but are not limited to, hotels, entertainment venues, pre-schools and day care facilities, educational institutions (e.g. schools, TAFE colleges), health care facilities (e.g. nursing homes, hospitals), recording studios and places of worship/religious facilities (e.g. churches).
Proponent	A person or body proposing to carry out an activity under Part 5 of the EP&A Act - in this instance, TfNSW.
Reasonable	Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure.
Sensitive receivers	Land uses which are sensitive to potential noise, air and visual impacts, such as residential dwellings, schools and hospitals.
SIDRA	SIDRA traffic modelling software

Term	Meaning
The Proposal	The construction and operation of the roadworks in Dee Why necessary to support the B-Line Program.
Vegetation Offset Guide	The TfNSW guide that applies where there is vegetation clearing proposed, and where the impact of the proposed clearing is not deemed 'significant' for the purposes of section 111 of the EP&A Act. The Guide provides for planting of a minimum of eight trees for each large tree with a diameter at breast height (DBH) of more than 60 cm, four trees where the DBH is 15-60 cm, or two trees where DBH is less than 15 cm.
VISSIM	VISSIM traffic modelling software

Executive summary

Overview

The NSW Government is proposing to deliver transport improvements for the Northern Beaches, including an integrated program of service and infrastructure improvements to support a new B-Line bus service. The B-Line Program of works includes:

- roadworks including new bus lanes, bus bays, minor lane widening and other road improvements to support bus services
- nine B-Line stops at Mona Vale, Warriewood, Narrabeen, Collaroy, Dee Why, Brookvale, Manly Vale, Spit Junction (Mosman) and Neutral Bay including real-time passenger information and improved facilities for customers
- new commuter car parks at Warriewood, Narrabeen, Dee Why, Brookvale and Manly Vale providing around 900 spaces, as well as bicycle parking, to encourage customers to park and ride
- transport interchange works to ensure integrated pedestrian and bicycle links to commuter car parks and B-Line stops
- modifications to the bus network to provide for a turn-up-and-go B-Line service with an average five minute wait for the bus during peak periods
- a new B-Line double decker bus fleet for improved on-board capacity and comfort.

Roads and Maritime Services (Roads and Maritime) is the government agency responsible for the roadworks necessary to support the B-Line Program and is the proponent for the B-Line roadworks in Dee Why (the Proposal).

The Proposal is part of the B-Line Program – a NSW Government initiative to provide a more frequent and reliable bus service between the Northern Beaches and Sydney's Central Business District (CBD). The program includes on-road and off-road infrastructure improvements and enhancements to the broader Northern Beaches bus network. The on-road and off-road elements would be delivered as a number of individual projects, primarily by Roads and Maritime and Transport for NSW (TfNSW).

The B-Line service is expected to be operational in late 2017.

This Review of Environmental Factors (REF) has been prepared to assess the environmental impacts associated with the construction and operation of the Proposal under the provisions of Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Description of the Proposal

The key features of the Proposal are:

- construction of a new indented bus bay south of the Pittwater Road and Hawkesbury Avenue intersection (southbound), relocation of the existing bus stop and reconfiguration of existing line markings
- narrowing of the existing median between Dee Why Parade and Oaks Avenue to create an additional southbound lane to accommodate the southbound Dee Why bus stop
- new line marking and adjustments to existing signage to designate a "left turn only buses excepted" lane for approximately 60 metres of Pittwater Road (southbound) between Dee Why Parade and Howard Avenue

- new line marking and adjustments to existing signage to designate an extension of the operational hours of the current clearway between Dee Why Parade and Howard Avenue to operate 24/7
- new line marking and adjustments to existing signage to designate a “bus only” lane for the existing Dee Why bus stop on Pittwater Road (southbound) between Howard Avenue and Oaks Avenue
- construction of a kerb ‘blister’ on the southbound carriageway of Pittwater Road immediately north of Oaks Avenue
- new line marking and adjustments to existing signage to designate an extension to the hours of operation of the existing clearway between Oaks Avenue and Fisher Road from 6am to 10am Monday to Friday to 6am to 8pm Monday to Sunday
- extension of the existing right turn lane from Pittwater Road (northbound) into Oaks Avenue
- ancillary works associated with the above elements including road regrading, services diversion and/or relocation, minor drainage works, adjustments to lighting, upgrades to pedestrian fencing and landscaping, new line marking and improved/new traffic signal infrastructure.

Subject to approval, construction of the Proposal is expected to commence in early 2017 and take around nine months to complete. A detailed description of the Proposal is provided in Chapter 3 of this REF.

Need for the Proposal

Improving transport customer experience is a key focus of NSW Government transport initiatives. The B-Line Program has been identified as a key infrastructure project under the ‘Building Infrastructure’ priority in *NSW: Making it Happen* to be delivered in 2016–2019.

The B-Line Program aims to address the immediate issues facing Northern Beaches bus customers by providing a more frequent and reliable bus service between the Mona Vale and the Sydney CBD.

The Proposal is integral to the delivery of the B-Line Program, which is included in the NSW Government’s Northern Beaches Transport Action Plan. The Transport Action Plan, along with other government initiatives and strategies, aims to support forecasted growth in the Northern Beaches region by improving the transport network across the region.

The specific objectives of the Proposal are to:

- reduce the peak and off-peak bus journey times in both directions through Dee Why
- improve customer experience with improved frequency, capacity and reliability of bus services
- improve road safety along Pittwater Road through Dee Why.

The Proposal, as part of the integrated program of bus service and infrastructure improvements to deliver the B-Line Program, aims to contribute to the above identified goals.

Design options considered

Options for improving bus transport on the Northern Beaches were developed during the early planning stages and development of the concept design for the Proposal. Two options were developed including a do nothing option whereby no action would be taken, and a preferred option to upgrade the on-road infrastructure along Pittwater Road through Dee Why.

The ‘do nothing’ option was not considered a feasible alternative as would not meet the objectives of the Proposal and would therefore be inconsistent with NSW Government objectives to support the identified need for a more frequent and more reliable bus service through the region.

The preferred option to upgrade on-road infrastructure along Pittwater Road through Dee Why was as part of a design refinement process developed through a series of meetings, field inspections, workshops, and technical specialist input (such as traffic and noise), in consultation with internal and external stakeholders. This option was selected as it met the required design objectives with minimum disruption to existing roads, general traffic and other urban development.

Statutory considerations

The EP&A Act provides for the environmental impact assessment of development in NSW. Part 5 of the EP&A Act generally specifies the environmental impact assessment requirements for activities undertaken by public authorities, such as Roads and Maritime, which do not require development consent under the EP&A Act.

State Environmental Planning Policy (Infrastructure) 2007 (the Infrastructure SEPP) is the primary environmental planning instrument relevant to the proposed development. Clause 94(1) of the Infrastructure SEPP allows for the development of ‘road infrastructure facilities’ by or on behalf of a public authority without consent on any land. Clause 93 defines ‘road infrastructure facilities’ as including elements such as ‘bus lanes, transit lanes, rest areas and road related areas’, ‘associated public transport facilities for roads used to convey passengers by means of regular bus services’ and ‘bus layovers that are integrated or associated with roads’.

As Roads and Maritime is a public authority and the proposed activity falls within the definition of road infrastructure facilities under the Infrastructure SEPP, the Proposal is permissible without consent. Consequently the environmental impacts of the Proposal have been assessed by Roads and Maritime under Part 5 of the EP&A Act.

This REF has been prepared to assess the environmental impacts of the Proposal during construction and operation. The REF has been prepared in accordance with clause 228 of the *Environment Planning and Assessment Regulation 2000* (the EP&A Regulation).

In accordance with section 111 of the EP&A Act, Roads and Maritime, as the proponent and determining authority, must examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the proposed activity.

Chapter 6 of this REF presents the environmental impact assessment for the Proposal, in accordance with these requirements.

Community and stakeholder consultation

Under the Infrastructure SEPP, consultation is required with local councils or public authorities in certain circumstances, including where Council-managed infrastructure is affected.

Consultation has been undertaken with Northern Beaches Council and emergency services during the development of design options for the broader B-Line Program. Consultation with these stakeholders would continue through the detailed design and construction of the Proposal.

The following activities are also proposed for consultation regarding the Proposal:

- direct notification of affected community stakeholders
- public display of the REF.

Community consultation activities for the Proposal would be undertaken during the public display period of this REF. The REF would be displayed for a period of two weeks. Further information about these specific activities is included in Section 5 of this REF.

During this period, the REF would also be available for viewing at the following locations:

- Northern Beaches Council office - 725 Pittwater Road, Dee Why
- Dee Why Library – 725 Pittwater Road, Dee Why.

The REF would also be available to download from the B-Line Program website (http://www.b-line.transport.nsw.gov.au/environment-and-planning). Members of the public can make enquiries via phone (1800 048 751) or email (projects@transport.nsw.gov.au).

Roads and Maritime would review and assess all feedback received during the public display period, prior to determining whether or not to proceed with the Proposal.

Should the Proposal proceed to construction, the community would be kept informed throughout the duration of the construction period.

Environmental impact assessment

This REF identifies the potential environmental benefits and impacts of the Proposal and outlines the mitigation measures to reduce the identified impacts.

The following key impacts have been identified should the Proposal proceed:

- temporary changes to vehicle, pedestrian and cycle movements to, from and around the Proposal area during construction. This includes temporary road and footpath diversions on Pittwater Road around the proposed indent south of Hawkesbury Avenue and between Dee Why Parade and Fisher Road
- temporary noise and vibration impacts during construction including exceedances of highly affected noise levels during night works around construction areas
- permanent loss of street parking along Pittwater Road between Dee Why Avenue and Fisher Road. This would involve the loss of 29 parking spaces in total, with around seven of these spaces remaining available between 8:00pm and 6:00am
- removal of trees and vegetation that would require planting offsets. Specifically this would include the loss of existing vegetation within the median Howards and Oaks Avenues.

Further information regarding these impacts is provided in Chapter 6 of the REF.

To mitigate the impacts identified above the following key mitigations have been proposed:

- a Construction Environmental Management Plan (CEMP) would be prepared and would outline
    - road closures and alternatives
    - pedestrian and cycle provisions throughout the construction period
    - the consultation process to inform the community of any road, pedestrian or cycle changes
- A Construction Noise and Vibration Management Plan (CNVMP) would be prepared. The CNVMP would include the following:
    - identification of nearby residences and other sensitive land uses
    - description of all approved hours of work
    - description and identification of all construction activities, including work areas, equipment and duration

- description of what work practices (generic and specific) would be applied to minimise noise and vibration
- a complaints handling process
- noise and vibration monitoring procedures
- overview of community consultation required for identified high impact works.
- A Traffic Management Plan would form part of the CEMP for the construction phase of the Proposal and would outline
- road closures and alternatives
- pedestrian and cycle provisions throughout the construction period
- the consultation process to inform the community of any road, pedestrian or cycle changes

- Vegetation offsets and/or landscaping would be undertaken in accordance with the Roads and Maritime *Environmental Impact Assessment Practice Note – Guidelines for Landscape Character and Visual Impact Assessment* (2013), the Roads and Traffic Authority *Biodiversity Guidelines* (2011) and the TfNSW *Vegetation Offset Guide* (TfNSW, 2013b)/ All planting would be undertaken in consultation with the Northern Beaches Council, and/or the owner of the land upon which the vegetation would be planted.

Conclusion

This REF has been prepared having regard to sections 111 and 112 of the EP&A Act, and clause 228 of the EP&A Regulation, to ensure that Roads and Maritime takes into account to the fullest extent possible, all matters affecting or likely to affect the environment as a result of the Proposal.

The detailed design of the Proposal would also be designed taking into account the principles of ecologically sustainable development (ESD).

Should the Proposal proceed, potential associated adverse impacts would be appropriately managed in accordance with the mitigation measures outlined in this REF. This would ensure the Proposal is delivered to maximise benefit to the community and minimise any adverse impacts on the environment.

In light of the potential impacts and proposed mitigation measures outlined in this REF, the Proposal is considered unlikely to result in a significant impact upon the environment including any critical habitat or threatened species, populations, ecological communities or their habitats. Accordingly, an Environmental Impact Statement (EIS) and Species Impact Statement (SIS) are not required for the Proposal, in accordance with Part 5.1 of the EP&A Act.

1. Introduction

This REF assesses the environmental impact associated with the construction and upgrade of sections of road through Dee Why in support of the B-Line Program (the Proposal). Roads and Maritime Services (Roads and Maritime) is the government agency responsible for the roadworks and is the proponent for this Proposal.

The Proposal is part of an integrated program of bus service and infrastructure improvements to deliver the B-Line Program – a NSW Government initiative to provide a more frequent and reliable bus service between the Northern Beaches and Sydney's Central Business District (CBD).

1.1. The B-Line Program

The NSW Government is proposing to deliver transport improvements for the Northern Beaches, including an integrated program of service and infrastructure improvements to support a new B-Line bus service. The B-Line Program of works includes the following elements:

- A new B-Line bus service from Mona Vale to the Sydney CBD. The B-Line would provide a more frequent and reliable service, and would generally operate between the hours of about 5:30am to 12.30am. Service frequencies during this time would generally be as follows:
  - every five minutes during the southbound morning peak and northbound afternoon peak commute periods on weekdays
  - every 10 minutes at other times of the day, and on weekends, up to 11pm
  - every 15 minutes between 11pm and 12.30am every day.
- on-road infrastructure improvements, including new bus lanes, bus indents, minor lane widening and other road improvements to support faster and more reliable bus journeys on the north-south corridor
- nine B-Line stops at Mona Vale, Warriewood, Narrabeen, Collaroy, Dee Why, Brookvale, Manly Vale, Spit Junction (Mosman) and Neutral Bay, including real-time passenger information and improved facilities for customers
- new commuter car parks at Warriewood, Narrabeen, Dee Why, Brookvale and Manly Vale providing around 900 spaces, as well as bicycle parking, to encourage customers to park and ride
- transport interchange works to ensure integrated pedestrian and bicycle links to commuter car parks and B-Line stops
- modifications to the bus network to provide for the turn-up-and-go B-Line service, improved network legibility and better connections between key centres
- a new double decker bus fleet for improved on-board capacity and comfort.

Subject to approval, construction for the new B-Line service is expected to commence in early 2017 and take around nine months to complete. The B-Line service is expected to be operational in late 2017.

Figure 1 provides an overview of the new B-Line service.

1.1.1. Delivery of the B-Line Program

The above listed on-road and off-road elements of the B-Line Program would be delivered as a number of individual projects primarily by Roads and Maritime and Transport for NSW (TfNSW).

Roads and Maritime is responsible for the assessment and construction of all on-road infrastructure improvements, including new bus lanes, bus indents, minor lane widening and other road improvements to support faster and more reliable bus journeys through the overall Mona Vale to CBD corridor.

TfNSW is responsible for the assessment and construction of all off-road infrastructure improvements, including new commuter car parks and new B-Line bus stops at Warriewood, Narrabeen and Manly Vale. Two commuter car parks are to be delivered by third parties at Dee Why and Brookvale.

Proposals to build commuter car parks and B-Line bus infrastructure at Narrabeen, Warriewood and Manly Vale have received planning approval. Other on-road projects associated with B-Line will be assessed and put on public display during late 2016 and early 2017.

Further detail on the B-Line Program is available at the Program's website: http://www.b-line.transport.nsw.gov.au/environment-and-planning.

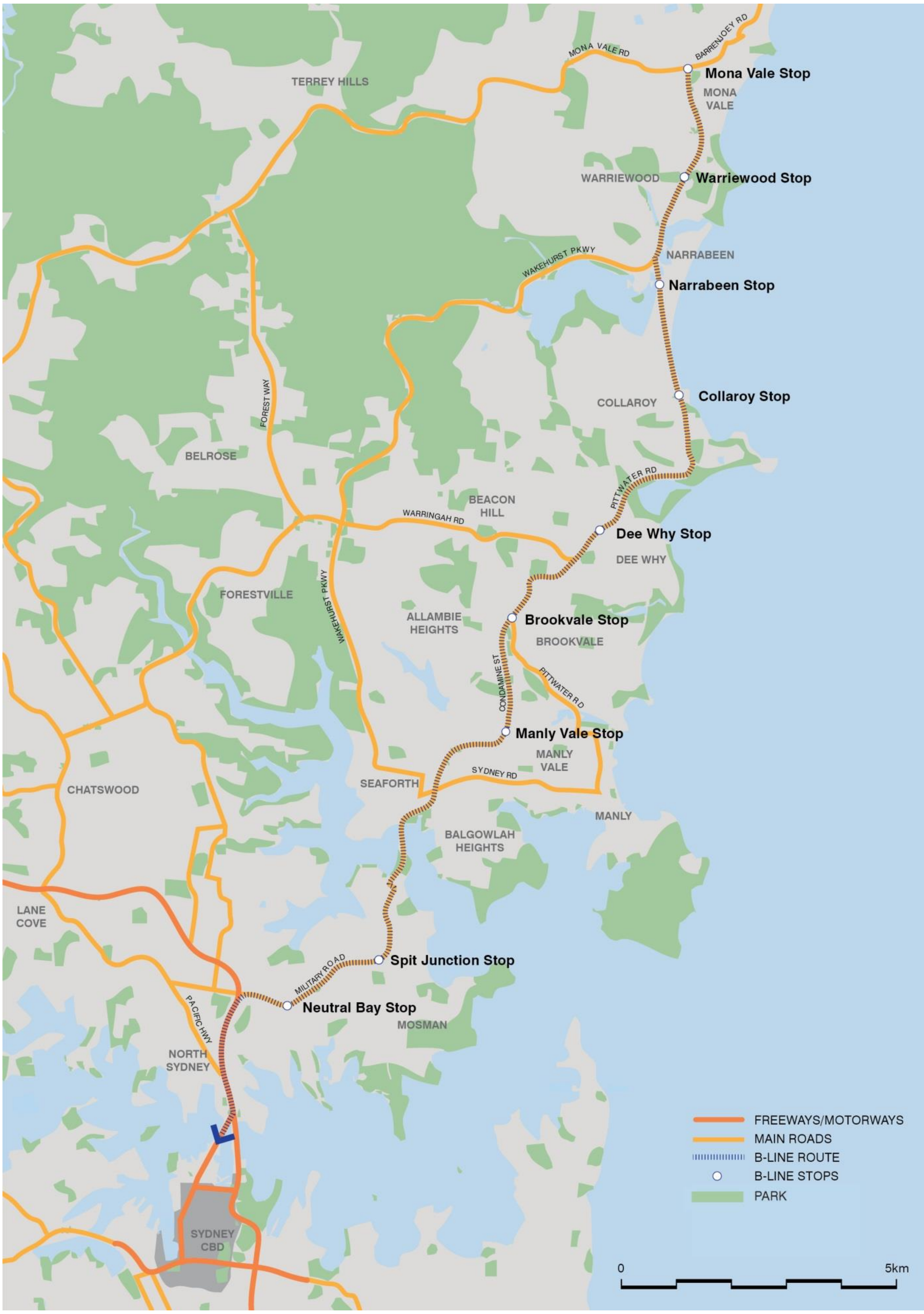

Figure 1 Overview of the B-Line Program

1.2. Overview of the Proposal

This REF assesses the impacts of the on-road infrastructure required to support the B-Line Program along Pittwater Road through Dee Why, between Hawkesbury Avenue and Sturdee Parade (the Proposal).

The Proposal has been identified as a critical element to be delivered as part of the B-Line Program. The Proposal aims to:

- reduce the peak and off-peak bus journey times through Dee Why for both local and B-Line services
- improve customer experience with improved frequency, capacity and reliability of bus services
- improve road safety along the corridor
- optimise journey time reliability and network efficiency for all traffic including cars, trucks, taxis and bicycles.

1.2.1. Key features of the Proposal

The key features of the Proposal include:

- construction of a new indented bus bay south of the Pittwater Road and Hawkesbury Avenue intersection (southbound), relocation of the existing bus stop and reconfiguration of existing line markings
- narrowing of the existing median between Dee Why Parade and Oaks Avenue to create an additional southbound lane to accommodate the southbound Dee Why bus stop
- new line marking and adjustments to existing signage to designate a “left turn only buses excepted” lane for approximately 60 metres of Pittwater Road (southbound) between Dee Why Parade and Howard Avenue
- new line marking and adjustments to existing signage to designate an extension of the operational hours of the current clearway between Dee Why Parade and Howard Avenue to operate 24/7
- new line marking and adjustments to existing signage to designate a “bus only” lane for the existing Dee Why bus stop on Pittwater Road (southbound) between Howard Avenue and Oaks Avenue
- construction of a kerb ‘blister’ on the southbound carriageway of Pittwater Road immediately north of Oaks Avenue
- new line marking and adjustments to existing signage to designate an extension to the hours of operation of the existing clearway between Oaks Avenue and Fisher Road from 6am to 10am Monday to Friday to 6am to 8pm Monday to Sunday
- extension of the existing right turn lane from Pittwater Road (northbound) into Oaks Avenue
- ancillary works associated with the above elements including road regrading, services diversion and/or relocation, minor drainage works, adjustments to lighting, upgrades to pedestrian fencing and landscaping, new line marking and improved/new traffic signal infrastructure.

Subject to approval, construction of the Proposal is expected to commence in early 2017 and take around nine months to complete.

A detailed description of the Proposal is provided in Chapter 3 of this Review of Environmental Factors (REF). A visual description of the Proposal is shown in Figure 6 and Figure 7.

1.3. Location of the Proposal

The Proposal is located within the Northern Beaches Local Government Area (LGA) around 16 km north of the Sydney CBD. The location of the Proposal in the regional context is shown in Figure 1. The Proposal is located along Pittwater Road in the suburb of Dee Why and has been separated into two construction zones; Zone A and Zone B (refer to Figure 2) as follows:

- Zone A: along Pittwater Road between Hawkesbury Avenue and Dee Why Parade
- Zone B: along Pittwater Road between Dee Why Parade and Sturdee Parade.

Under the *Warringah Local Environmental Plan 2011*, Pittwater Road is zoned as infrastructure (classified road). The area surrounding the Proposal is zoned as commercial core and mixed use and consists of shops, small businesses, community facilities and high density residential dwellings.

The Proposal would involve works along Pittwater Road from Hawkesbury Avenue to Sturdee Parade. Figure 2 provides an overview of the Proposal area. The land zoning relevant to the Proposal is shown in Figure 3. Pittwater Road is a classified road operated and maintained by Roads and Maritime. Works would also be undertaken on the adjoining road/footpath network within areas which are the responsibility of the Northern Beaches Council, including Oaks Avenue.

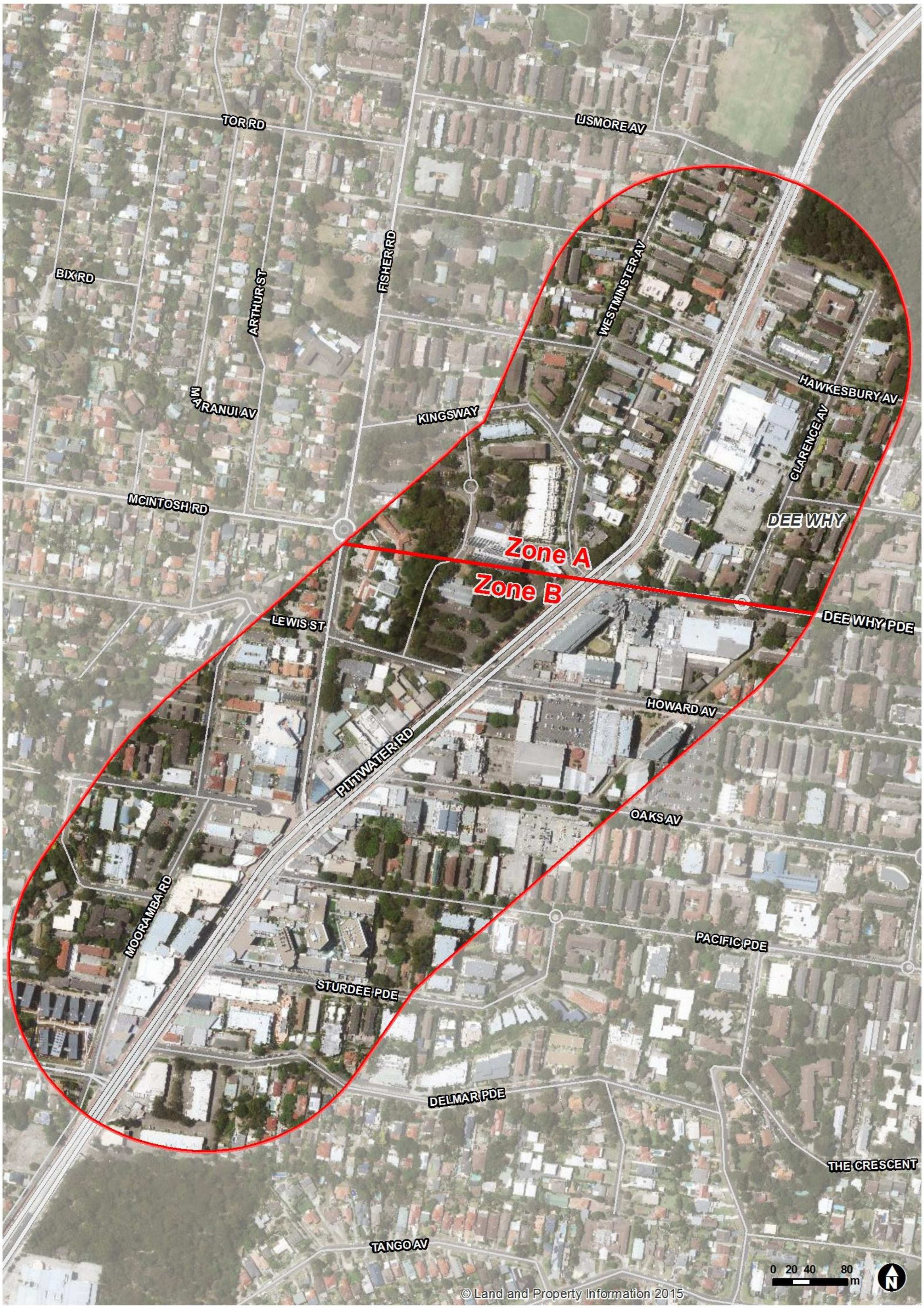

Figure 2 Overview of the Proposal area

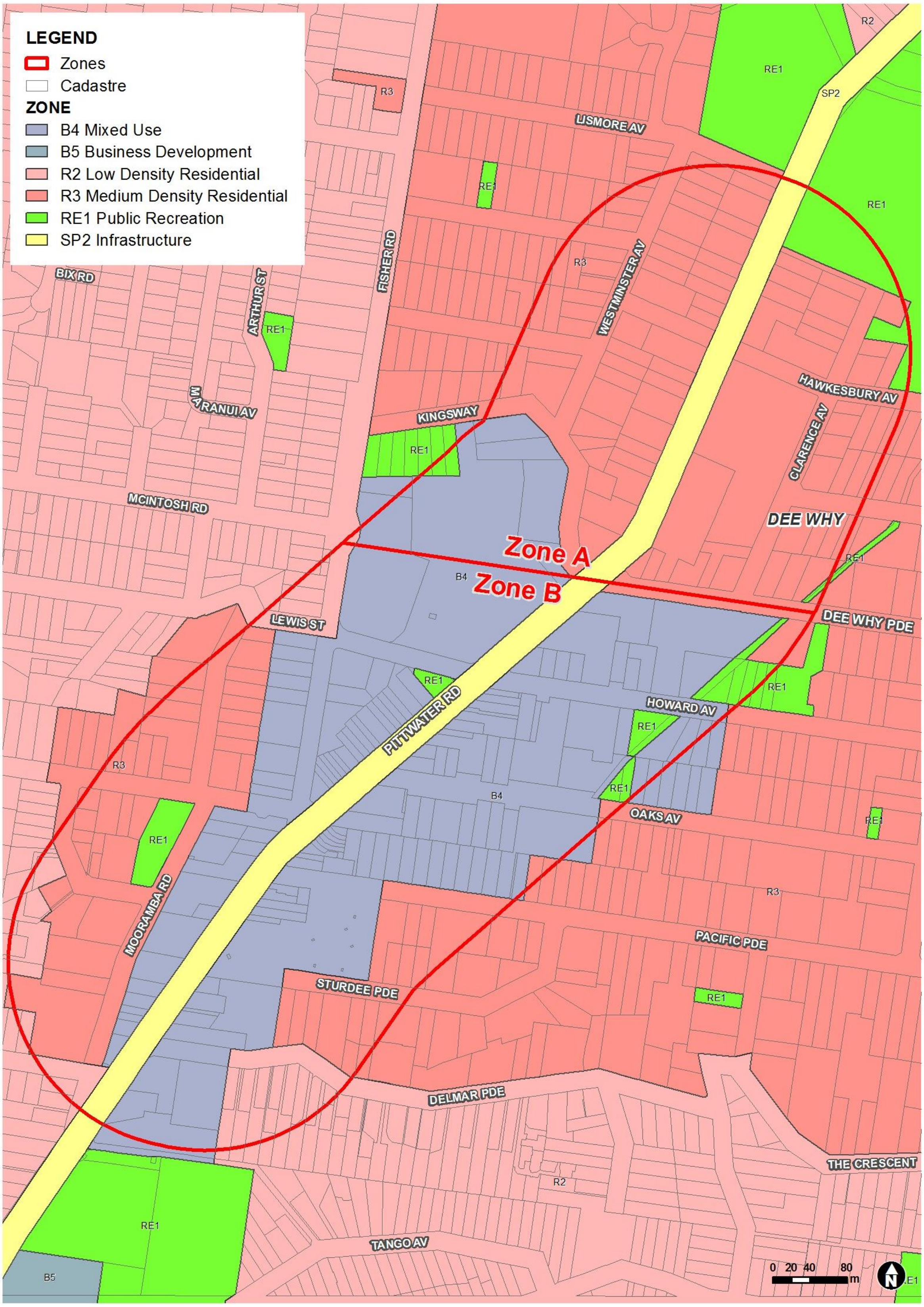

Figure 3 Land zoning relevant to the Proposal area

1.4. Existing infrastructure and land uses

Pittwater Road is characteristic of a main arterial road in an urban environment with residential and commercial areas located in close proximity to both sides of the road. The visual landscape along Pittwater Road in Dee Why is dominated by commercial land uses and road infrastructure. The road corridor is characteristic of a highly modified urban environment with vehicles, signage and advertising dominating the landscape. Street trees currently provide landscape features, screening for residential and business frontages, motorists and shading for pedestrians.

The suburb of Dee Why is largely residential with substantial commercial areas along and near Pittwater Road. Specific points of interest of the area include the following:

- Dee Why RSL Club
- Dee Why Public School
- Dee Why police station
- Dee Why Library
- Northern Beaches Council offices
- Dee Why Lagoon
- Stony Range Regional Botanic Garden
- several commercial areas including small shopping malls and retail areas along Pittwater Road
- open space including reserves and parks.

Figure 4 shows relevant points of interest within the Proposal area.

The Proposal area currently accommodates the following transport elements:

- *Bus services:* multiple bus services stop at existing bus stops along the northbound and southbound sides of Pittwater Road. These bus services provide for local trips around the Northern Beaches and express trips to the Sydney CBD and North Sydney. Existing bus stops are shown in Figure 5
- *Taxi facilities:* there is a designated taxi rank on the southern side of Howard Avenue, about 150 metres from the Pittwater Road intersection. The taxi rank provides capacity for four to five taxis
- *Cycling:* there is a dedicated cycleway located about 120 metres north of the Pittwater Road/Hawkesbury Avenue intersection. This cycleway provides off road access from Pittwater Road to Dee Why Beach. Bus lanes located along Pittwater Road are often used by cyclists as they provide some segregation from general traffic.
- *Pedestrian facilities:* footpaths along Pittwater Road provide pedestrian access to the existing bus stops within the Proposal area (northbound and southbound), as well as residences and businesses generally. Signalised intersections with pedestrian crossing facilities are located at every intersection along Pittwater Road within the Proposal area, including Hawkesbury Avenue, Dee Why Parade, Howard Avenue, Oaks Avenue, Fisher Road, Pacific Parade and Sturdee Parade.

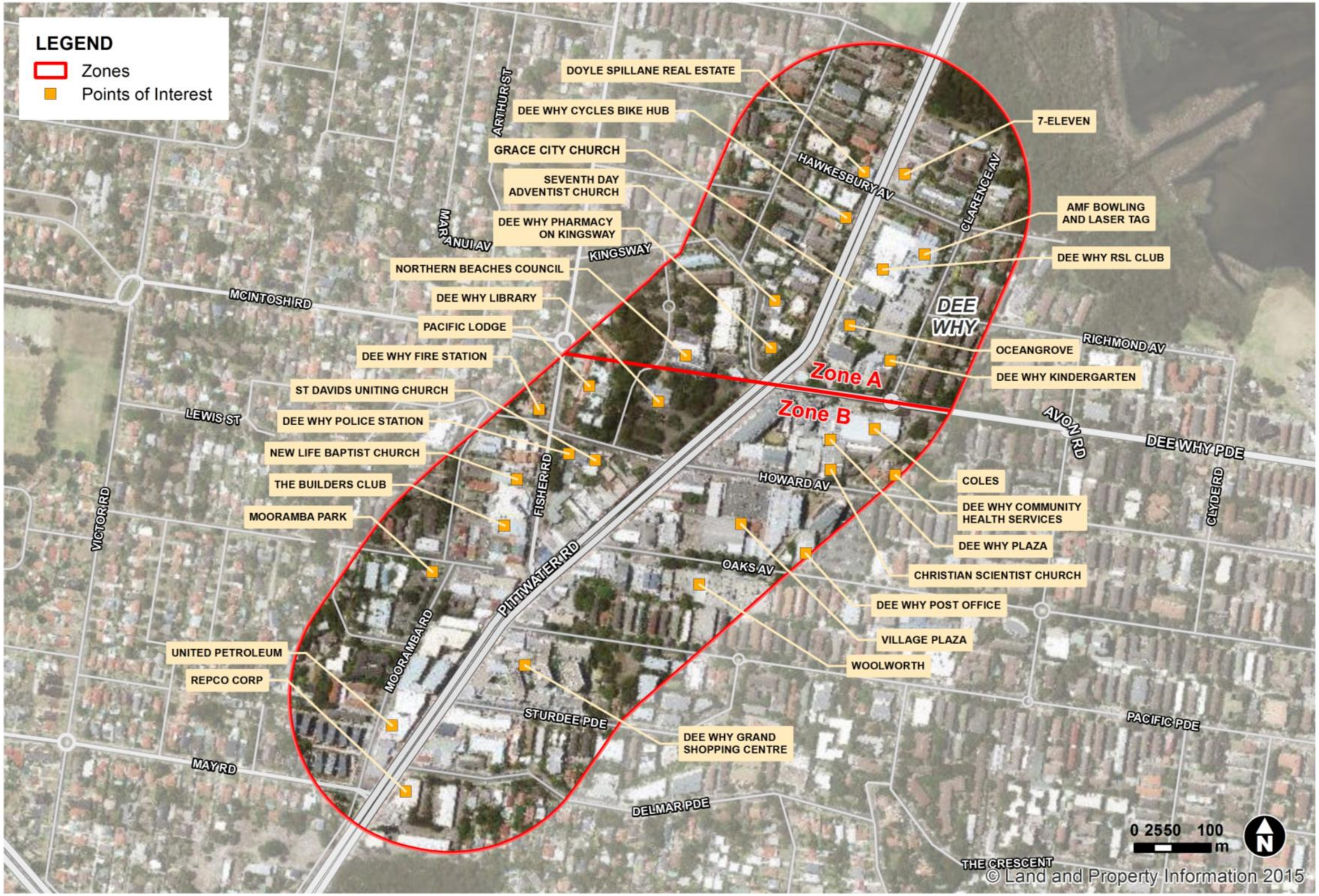

Figure 4 Points of interest surrounding the Proposal

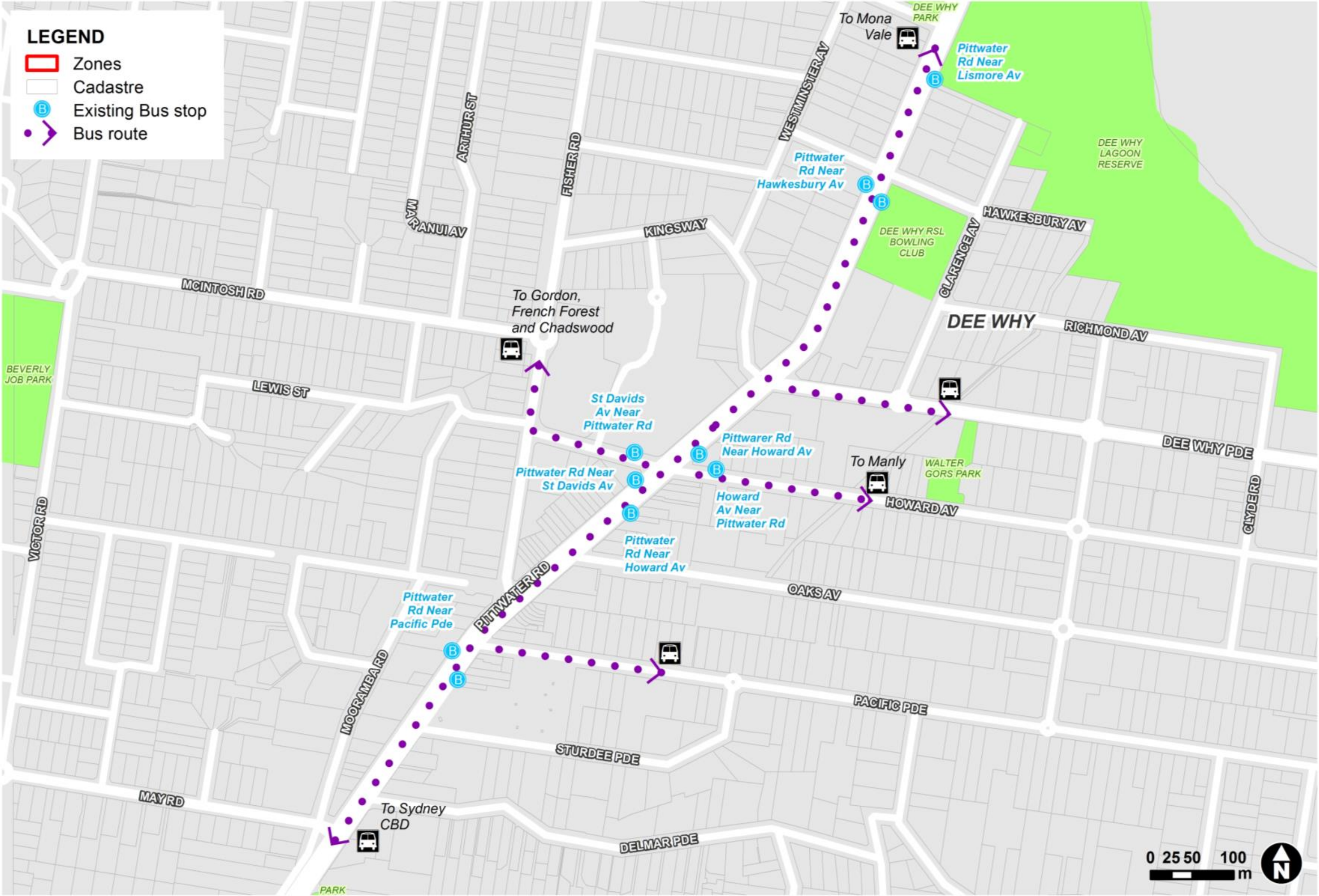

Figure 5 Existing bus stops and transport routes within the Proposal area

1.5. Purpose of this Review of Environmental Factors

This REF has been prepared by AECOM on behalf of Roads and Maritime to assess the potential impacts of the B-Line roadworks (the Proposal) through Dee Why. For the purposes of the Proposal, Roads and Maritime is the proponent and the determining authority under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The purpose of this REF is to describe the Proposal, to assess the likely impacts of the Proposal having regard to the provisions of section 111 of the EP&A Act, and to identify mitigation measures to reduce the likely impacts of the Proposal. This REF has been prepared in accordance with clause 228 of the *Environment Planning and Assessment Regulation 2000* (the EP&A Regulation).

This assessment has also considered the relevant provisions of other relevant environmental legislation, including the *Threatened Species Conservation Act 1995* (TSC Act), *Protection of the Environment Operations Act 1997* (POEO Act) and the *Roads Act 1993* (Roads Act).

Having regard to the provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), this REF considers the potential for the Proposal to have a significant impact on matters of National Environmental Significance (NES) or Commonwealth land, and the need to make a referral to the Commonwealth Department of the Environment for any necessary approvals under the EPBC Act. Refer to Chapter 4 for more information on statutory considerations.

2. Need for the Proposal

This chapter discusses the need and objectives of the Proposal, having regard to the objectives of the B-Line Program generally. This chapter also provides a summary of the options that have been considered during the Proposal's development and why the preferred option has been chosen.

2.1. Strategic justification

2.1.1. Overview

Improving transport customer experience is the focus of the NSW Government's transport initiatives. The NSW Government's *NSW Making it Happen* identifies 30 key priorities to grow the economy, deliver infrastructure, and improve health, education and other services across the State.

'Building Infrastructure' is one of these key priorities, as the State's growing population continues to place pressure on existing infrastructure. The NSW State Plan predicts that over the next 15 years NSW will require infrastructure to support 40 per cent more train trips, 30 per cent more car trips and 31 per cent more households.

The B-Line Program has been identified as a key infrastructure project under the 'Building Infrastructure' priority. This project is due to be delivered between 2016 and 2019.

NSW 2021 is the NSW Government's ten year plan to guide budget and decision making. This plan includes the following goals, targets and priority actions relevant to the Proposal (NSW Department of Premier and Cabinet, 2011):

- reduce travel times
- minimise public transport waiting times for customers
- improve coordination and integration between transport modes
- grow patronage on public transport
- improve public transport reliability
- improve customer experience with transport services.

Further details of the application of NSW Government policies and strategies are discussed in Section 4.5 of this REF.

2.1.2. Strategic options assessment

During development of the B-Line Program, Roads and Maritime and TfNSW considered a series of strategic options for improvements to bus travel times along the B-Line corridor. These included:

- Option1: continuous bus lanes (24/7)
- Option 2: enhance AM peak direction, congestion points and some off-peak flow
- Option 3: enhance AM and PM peak, congestion points and some off-peak flow.

The strategic options assessment considered the following factors:

- cost estimates
- maximum passenger benefits
- corridor bus travel times (travel time variability and delay)

- parking survey (number of spaces affected and subsequent parking demand offset)
- traffic modelling (intersection delays, private vehicle travel time, net change in all passenger delay).

The strategic options assessment indicated that Option 2 was the preferred option. Table 1 provides an overview of the strategic options assessment.

Table 1 Strategic options assessment

Strategic assessment	Option 1	Option 2 (Preferred option)	Option 3
Bus travel time and variability	• improved bus travel times and variability in the northern part of the corridor • insufficient capacity at Dee Why and Neutral Bay[2].	• improved inbound bus travel times and variability in the AM peak • some outbound and contra peak improvements through addressing congestion points. [2]	• improved bus travel times and variability in the AM and PM peak • Some contra peak improvements through addressing congestion points[3].
Impact on all road users	• permanent 24 hours per day reduction in capacity for general traffic[1].	• minimal impact on road users (two lanes of general traffic would be maintained at all times) [3].	• a PM bus tidal flow would impact on traffic and bus services inbound through Neutral Bay (generally reducing inbound to two lanes) [2].
Impact on parking, business and property	• all kerbside parking removed[1].	• parking impacted by extended clearways • commercial and business parking maintained during the off peak • right turn access to local areas largely maintained[3].	• parking impacted by extended clearways • commercial and business parking maintained during the off peak • right turn bans would decrease access to local areas[2].
Value for money (cost versus benefit)	• over investment in the north and underinvestment in the south[1].	• focussed investment where the Proposal provides the greatest benefit. Value for money approach[3].	• high capital investment than AM option due to additional road widening to maintain local access • pm outbound tidal flow justification is insufficient to warrant impact on the inbound PM traffic[2].

Notes:

1. *Negative impact*
2. *Positive and negative impacts*
3. *Positive impact (improvement)*

2.1.3. Objectives of the B-Line Program

The B-Line Program aims to address key issues relating to the effectiveness of bus transport on the Northern Beaches, including:

- existing low bus speeds during peak periods leading to long travel times on the north-south corridor
- unreliable bus journey times on the north-south corridor
- uneven passenger loadings on buses on the north-south corridor
- crowding at major bus stops on the north-south corridor
- long wait times for bus services in off-peak periods
- customer dissatisfaction with bus stop amenity
- a complex bus network that lacks legibility.

The B-Line Program would provide on-road and off-road infrastructure improvements and enhancements to the broader Northern Beaches bus network. Details of separate on-road and off-road infrastructure improvements and enhancements are provided in Section 1.1.

2.1.4. Objectives of the Proposal

The specific objectives of the Proposal are to:

- reduce the peak and off-peak bus journey times in both directions along Pittwater Road through Dee Why
- improve customer experience with improved frequency, capacity and reliability of bus services
- improve road safety along Pittwater Road through Dee Why.

The Proposal, as part of the integrated program of bus service and infrastructure improvements to deliver the B-Line Program, aims to contribute to the above identified goals.

2.2. Alternative options considered

Options for improving bus travel times through Dee Why were developed through an iterative process stemming from the preparation of the B-Line Program's Strategic and Final Business Cases, completed May 2015 and February 2016 respectively. These documents outlined the strategic need for the Proposal and included preliminary discussion of potential on-road works to be implemented in support of improved travel times for B-Line and local bus services. The specific recommendations for on-road works within the business case were further developed by RMS in conjunction with TfNSW, relevant stakeholders (including Sydney Transit Authority) and the project design team. This involved a series of workshops and discussions to examine the Proposal in light of its objectives (see Section 2.1.4) and any potential alternative designs. These discussions were informed by:

- the strategic need for the proposal within the context of delivering the B-Line BRT Program generally
- the scale of potential benefits and improvements to be provided for all users and affected stakeholders including bus passengers, general traffic, nearby landowners, businesses and the community in general
- engineering, environmental and community constraints present throughout the Proposal area
- road safety considerations

- cost-benefit considerations, including minimising the need for property acquisition
- the potential for disruption to existing traffic and the public generally during construction and operation in terms of congestion and public amenity.

This process resulted in the generation of two distinct alternatives for Pittwater Road through Dee Why:

- a ‘do nothing’ option whereby no action would be taken to upgrade on-road infrastructure in support of the B-Line Program
- an option to upgrade certain bus stops, create more on-road space through the narrowing of the existing median, extension of turning lanes and alterations to parking and clearways (‘the Option’).

Further specific detail of the scope of the proposed alternatives, and options that were not adopted, are included in the following sections. The options are assessed within this report to determine the preferred option in relation to the objectives outlined in Section 2.1.4.

2.2.1. The ‘do-nothing’ option

Under a ‘do-nothing’ option the peak and off-peak bus journey times, customer experience and road safety along Pittwater Road through Dee Why would remain unchanged. The NSW Government transport, safety and amenity objectives for this area would also remain unchanged. This would also not met the proposal objectives outlined in Section 2.1.4, which includes not delivering a more frequent and reliable bus service along Pittwater Road, Dee Why .

The ‘do nothing’ option was not considered a feasible alternative as it is does not meet the objectives of the Proposal identified in Section 2.1.4.

2.2.2. Preferred option

The preferred option would include:

- construction of a new indented bus bay south of the Pittwater Road and Hawkesbury Avenue intersection (southbound), relocation of the existing bus stop and reconfiguration of existing line markings
- narrowing of the existing median between Dee Why Parade and Oaks Avenue to create an additional southbound lane to accommodate the southbound Dee Why bus stop
- new line marking and adjustments to existing signage to designate a “left turn only buses excepted” lane for approximately 60 metres of Pittwater Road (southbound) between Dee Why Parade and Howard Avenue
- new line marking and adjustments to existing signage to designate an extension of the operational hours of the current clearway between Dee Why Parade and Howard Avenue to operate 24/7
- new line marking and adjustments to existing signage to designate a “bus only” lane for the existing Dee Why bus stop on Pittwater Road (southbound) between Howard Avenue and Oaks Avenue.
- construction of a kerb ‘blister’ on the southbound carriageway of Pittwater Road immediately north of Oaks Avenue
- new line marking and adjustments to existing signage to designate an extension in the hours of operation of the existing clearway between Oaks Avenue and Fisher Road from 6am to 10am Monday to Friday to 6am to 8pm Monday to Sunday

- extension of the existing right turn lane from Pittwater Road (northbound) into Oaks Avenue
- ancillary works associated with the above elements including road regrading, services diversion and/or relocation, minor drainage works, adjustments to lighting, upgrades to pedestrian fencing and landscaping, new line marking and improved/new traffic signal infrastructure.

The design of the preferred option would be further refined during detail design.

This option was selected as it meets the objectives of the Proposal while satisfying relevant NSW Government objectives relating to transport efficiency, amenity and road safety through Dee Why.

2.2.3. Alternatives to the preferred option

As part of the concept design development, Roads and Maritime considered a number of alternatives which were not selected for the Proposal, including the widening of Pittwater Road from Dee Why Parade to Oaks Avenue. This option would require the replacement of the existing wide median with a narrow median between these streets. Preliminary survey information indicated a significant difference in levels between the southbound and northbound sides of Pittwater Road, with the northbound carriageway being approximately 500 mm higher than the southbound carriageway. It would not be possible to accommodate this level difference as part of road widening generally, and therefore this option was not recommended for further development.

Opportunities to retain the trees within the median strip on Pittwater Road between Dee Why Parade and Howard Avenue were investigated. The aim in this location was to provide three general traffic lanes around the B-Line and local bus stop between Howard Avenue and Oaks Avenue. In order to do so without requiring property acquisition it was deemed necessary to widen the existing road into the median. The moving of the bus stop away from this location was not considered appropriate given its existing central location and other traffic constraint to the immediate north and south.

2.2.4. Justification for the preferred option

The preferred option to upgrade on-road infrastructure along Pittwater Road through Dee Why was selected to meet the objectives of the Proposal (refer to Section 2.1.4). The option was selected as part of a design refinement process developed through a series of meetings, field inspections, workshops, and technical specialist input (such as traffic and noise), in consultation with internal and external stakeholders. The preferred option would allow the objectives of the B-Line Program to be met, in particular:

- reduce the peak and off-peak bus journey times in both directions along Pittwater Road through Dee Why for customers
- improve customer experience with improved frequency, capacity and reliability of bus services through reduced journey times
- improve road safety along the corridor through construction of new indented bus bays.

3. Description of the Proposal

This chapter describes the Proposal and summarises key design parameters, construction methods, and associated infrastructure and activities. The description of the Proposal is based on the concept design and is subject to further refinement during detailed design.

3.1. The Proposal

As described in Section 1.2, the Proposal includes on-road infrastructure improvements along Pittwater Road to support faster and more reliable bus journeys on the north-south corridor through Dee Why. Activities included as part of the Proposal would include a new indented bus bay, traffic efficiencies (including improvements to existing and installation of new traffic signage and signalling), widening into the median and other road improvements to improve the travel time of buses along Pittwater Road through Dee Why.

The Proposal would include the following key elements:

- construction of a new indented bus bay south of the Pittwater Road and Hawkesbury Avenue intersection (southbound), relocation of the existing bus stop and reconfiguration of existing line markings
- narrowing of the existing median between Dee Why Parade and Oaks Avenue to create an additional southbound lane to accommodate the southbound Dee Why bus stop
- new line marking and adjustments to existing signage to designate a “left turn only buses excepted” lane for approximately 60 metres of Pittwater Road (southbound) between Dee Why Parade and Howard Avenue
- new line marking and adjustments to existing signage to designate an extension of the operational hours of the current clearway between Dee Why Parade and Howard Avenue to operate 24/7
- new line marking and adjustments to existing signage to designate a “bus only” lane for the existing Dee Why bus stop on Pittwater Road (southbound) between Howard Avenue and Oaks Avenue
- construction of a kerb ‘blister’ on the southbound carriageway of Pittwater Road immediately north of Oaks Avenue
- new line marking and adjustments to existing signage to designate an extension to the hours of operation of the existing clearway between Oaks Avenue and Fisher Road from 6am to 10am Monday to Friday to 6am to 8pm Monday to Sunday
- extension of the existing right turn lane from Pittwater Road (northbound) into Oaks Avenue
- ancillary works associated with the above elements including road regrading, services diversion and/or relocation, minor drainage works, adjustments to lighting, upgrades to pedestrian fencing and landscaping, new line marking and improved/new traffic signal infrastructure.

3.1.1. Scope of works

The Proposed construction and operational activities would be required at strategic locations within the Proposal area. These activities have been categorised into the following zones and are described below:

Zone A - Pittwater Road/south of the Hawkesbury Avenue intersection

- construction of a new indented bus bay on Pittwater Road (southbound) immediately to the south (around 40 metres) of the intersection of Pittwater Road and Hawkesbury Avenue and reconfiguration of existing line markings:
  - relocation of existing below ground service utilities in the eastern road verge of Pittwater Road towards existing property boundaries between Hawkesbury Avenue and Dee Why Parade
  - demolition of the existing concrete road verge, kerbs and pedestrian pathway along the eastern verge of Pittwater Road
  - construction of new road pavement for the indented bus bay (about 26 metres long), including kerbs, pedestrian pathway and road verge
  - removal of sections of existing road pavement to allow for tie in of the new pavement
  - installation of new concrete pavement sub-base at tie in locations
  - installation of bitumen overlay
  - new line marking
  - relocation of the existing bus stop, shelter and sign
- *Reason for scope item:* to allow B-Line and local buses (and other bus lane traffic) to pass buses stopped to pick or set down passengers at this location.

Zone B - Pittwater Road from Dee Why Parade to Sturdee Parade

- narrowing of the existing median between Dee Why Parade and Oaks Avenue to create an additional southbound lane to accommodate the southbound Dee Why bus stop:
  - removal of existing vegetation within the median of Pittwater Road between Howard Avenue and Oaks Avenue
  - installation of low retaining wall between the opposing northbound and southbound carriageways to account for differing grade heights, including pedestrian safety fencing along retaining wall
  - longitudinal regrading of the road pavement to account for variation in existing pavement levels
  - construction of new road pavement for the new southbound lane:
    - removal of sections of existing concrete road pavement to allow for tie in of the new pavement
    - installation of new concrete pavement sub-base at tie in locations
    - installation of bitumen overlay
  - installation of fittings and foundation for new median
  - construction of a new median within Pittwater Road at Howard Avenue
  - installation of new traffic island within Pittwater Road at Oaks Avenue intersection
- new line marking and adjustments to existing signage to designate a “left turn only buses excepted” lane for approximately 60 metres of Pittwater Road (southbound) between Dee Why Parade and Howard Avenue
- new line marking and adjustments to existing signage to designate an extension of the operational hours of the current clearway between Dee Why Parade and Howard Avenue to operate 24/7

- new line marking and adjustments to existing signage to designate a “bus only” lane for the existing Dee Why bus stop on Pittwater Road (southbound) between Howard Avenue and Oaks Avenue.
- construction of a kerb ‘blister’ on the southbound carriageway of Pittwater Road immediately north of Oaks Avenue:
    - demolition of existing kerb and road pavement
    - construction of kerb blister including concreting to connect to existing footpath level
    - installation of new concrete pavement sub-base at tie in with new kerb
    - new line marking and adjustments to existing traffic signal infrastructure
- new line marking and adjustments to existing signage to designate an extension in the hours of operation of the existing clearway between Oaks Avenue and Fisher Road from 6am to 10am Monday to Friday to 6am to 8pm Monday to Sunday
- extension of the existing right turn lane from Pittwater Road (northbound) into Oaks Avenue:
    - demolition of existing kerbs and road concrete in median
    - reinstatement of the concrete median and kerbs
    - construction of new road pavement for the new right turn lane (about 30 metres):
        - removal of sections of existing concrete pavement to allow for tie in of the new pavement
        - installation of new concrete pavement sub-base at tie in locations
        - installation of bitumen overlay
    - new line marking and adjustments to existing traffic signal infrastructure.
- *Reason for scope item*: to provide space for buses to stop within Dee Why, particularly during the AM peak, whilst minimising obstruction to general traffic lanes by the provision of three through traffic lanes around the new local and B-Line bus stops.

Manly Vale Commuter Car Park construction compound

- continued use of the temporary construction compound used for the Manly Vale Commuter Car Park beyond the initial construction period
- *Reason for scope item*: to provide a base from which construction activities may be coordinated and managed.

Figure 6 and Figure 7 show the general layout of key elements for the Proposal. Figure 8 shows the location of the proposed construction compound.

Figure 6 Key elements of the Proposal – Zone A

Indicative only, subject to detailed design

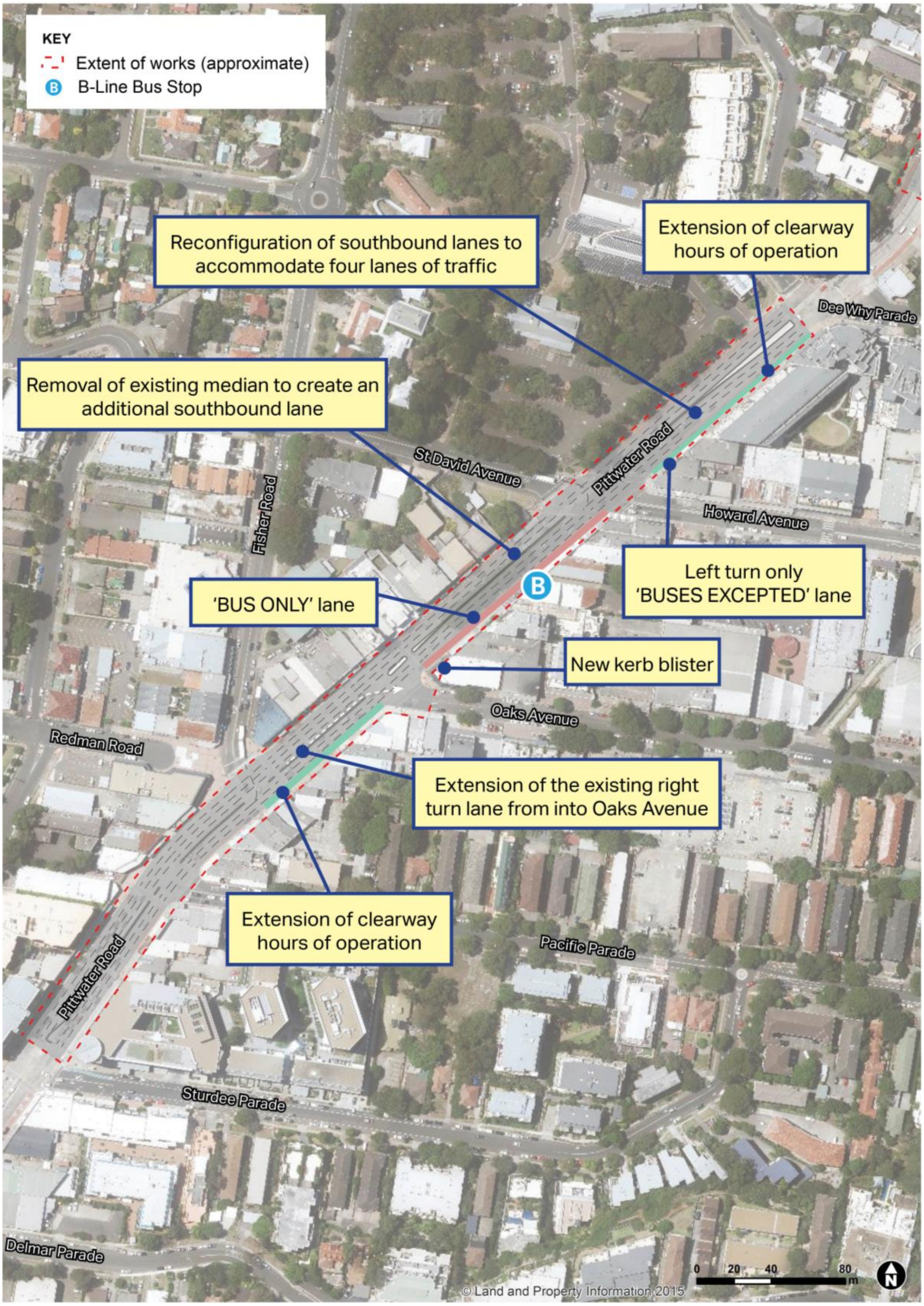

Figure 7 Key elements of the Proposal – Zone B

Indicative only, subject to detailed design

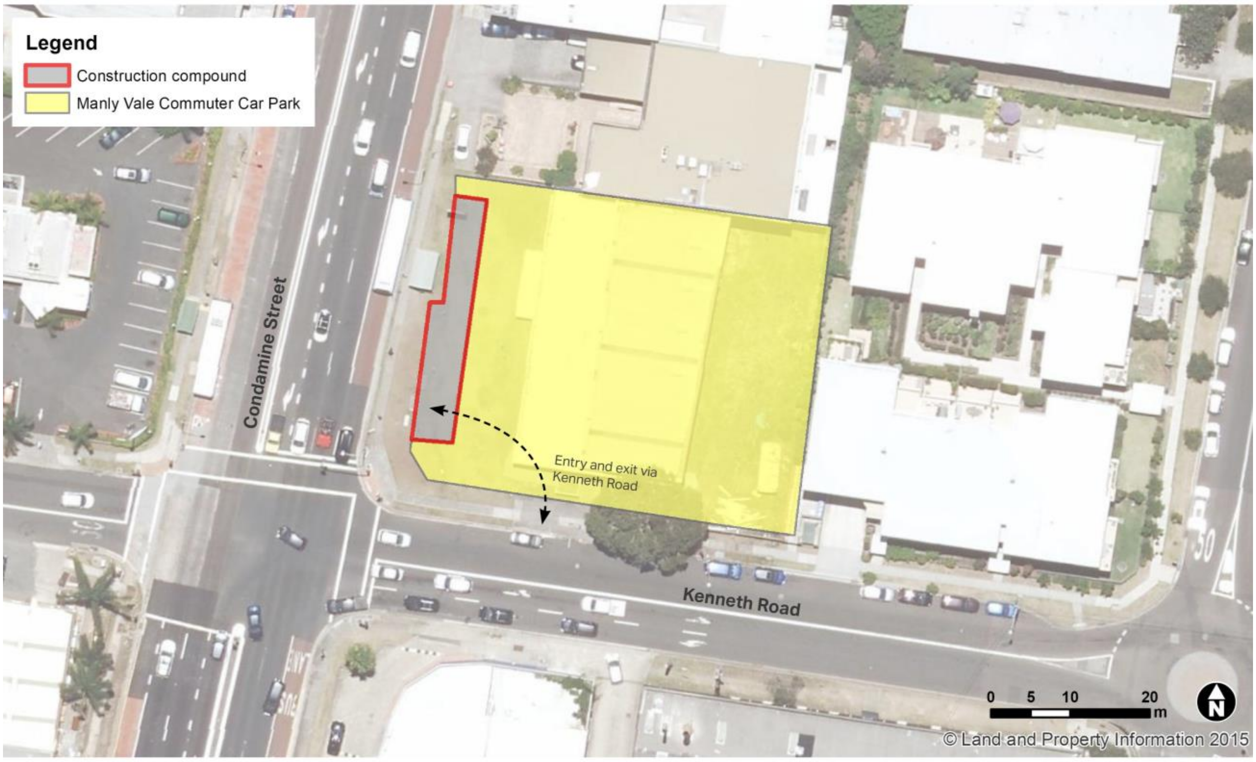

Figure 8 Manly Vale commuter car park construction compound

3.1.2. Engineering constraints

There are a number of constraints which have influenced the development of the concept design. These include:

- existing road levels and widths
- minimum travel lane widths
- existing above and below ground services
- existing trees.

3.1.3. Design standards

The Proposal has been designed having regard to the following:

- *Disability Standards for Accessible Public Transport 2002* (issued under the Commonwealth *Disability Discrimination Act 1992*)
- Building Code of Australia
- relevant Australian Standards
- Roads and Maritime Road Design Guidelines
- TfNSW Asset Standards Authority standards
- TfNSW Wayfinding Design Guide
- *NSW Sustainable Design Guidelines – Version 3.*0 (TfNSW, 2013a)
- *Guidelines for the Development of Public Transport Interchange Facilities* (Ministry of Transport, 2008)
- AustRoads Guide to Road Design (AustRoads 2015)

- *Warringah Local Environmental Plan 2011*
- *Warringah Development Control Plan 2011*.

3.1.4. Sustainability in design

An overarching sustainability strategy has been prepared for the Northern Beaches B-Line Program. This strategy describes how the program will address sustainability generally throughout construction and operation.

The design of the Proposal has been undertaken in accordance with the project targets identified in TfNSW's *NSW Sustainable Design Guidelines - Version 3.0* (TfNSW, 2013a) which groups sustainability into seven themes:

- energy and greenhouse gases
- climate resilience
- materials and waste
- biodiversity and heritage
- water
- pollution control
- community benefit.

Within each theme, potential initiatives are prioritised into two categories of requirements:

- **compulsory** – the initiative is required to be implemented when applicable to the project as they refer to a corporate target, or are fundamental to the delivery of sustainable assets
- **discretionary** – the initiative has benefits to be implemented, however may not be the most appropriate.

The Sustainable Design Guidelines also specify a minimum level of compliance within each category: 100 per cent of applicable compulsory initiatives and 50 per cent of the applicable discretionary points are to be explored through each stage of design.

It is currently anticipated that the Proposal would achieve a 'gold' sustainability in design rating. This corresponds with around 80 per cent of applicable discretionary points being achieved.

Further assessment of the Proposal against the Sustainable Design Guidelines would be undertaken during the detailed design phase. Notably, during detailed design some discretionary initiatives may prove unfeasible, in which case they would be excluded. Refer to Section 6.11.3 for further detail.

3.2. Construction activities

3.2.1. Work methodology

Subject to approval, construction of the Proposal is expected to commence in early 2017 and take around nine months to complete. The B-Line service is expected to be operational by late 2017. The construction methodology would be further developed during the detailed design of the Proposal by the nominated construction contractor in consultation with Roads and Maritime.

The proposed construction activities for the Proposal are identified in Table 2. This staging is indicative and is based on the current concept design, which may be subject to change once the detailed design methodology is finalised. The staging is also dependent on the construction contractor's preferred methodology, program and sequencing of work. In the event that construction staging results in environmental impacts above those assessed in this REF, further environmental assessment would be required to be approved by Roads and Maritime.

Table 2 Indicative construction staging for key activities

Stage	Activities
Site mobilisation and establishment	• establishment of site compound (i.e. erect fencing, tree protection zones, site offices, amenities and plant/material storage areas) • establishment of temporary facilities as required (i.e. traffic controls).
Enabling works	• survey and potholing • removal of identified vegetation • investigation and relocation of services (where required).
Road works	• demolition of the existing concrete road, road verge, kerbs and pedestrian pathways • resurfacing • construction of new road pavement for slip lanes, bus bays, right/left hand turns etc.
Drainage, line marking and signalling	• upgrades to kerbs, gutters and footpaths • line marking and new signalling

3.2.2. Working hours

The majority of works would need to occur outside standard NSW Environment Protection Authority (EPA) standard construction hours in order to minimise disruption to traffic and access. This includes the use of night works throughout the construction period. Approval from Roads and Maritime would be required for all such works. The affected community would be notified as outlined in the *Construction Noise and Vibration Guideline* (Roads and Maritime, 2016) (refer to Section 6.3 for further details).

Where possible, and where works would not significantly obstruct traffic, works would be undertaken during standard construction hours, which are as follows:

- 7.00am to 6.00pm Monday to Friday
- 8.00am to 1.00pm Saturdays
- no work on Sundays or public holidays.

3.2.3. Earthworks

The Proposal would require excavation and earthworks for the following:

- trenching excavation for the relocation of existing and installation of new services around the proposed bus indent in Zone A
- demolition of existing and construction of new road pavement, medians, road verges and kerbs, footpaths etc.
- other minor civil works including longitudinal regrading
- removal of non-contaminated soil from the works area (quantities to be determined during detailed design)

- use of imported clean fill where required (quantities to be determined during detailed design).

All excavated material would be disposed of in accordance with relevant legislative requirements (Sections 3.2.4 and 6.8). Works would be undertaken in accordance with a Construction Environmental Management Plan (CEMP) and appropriate erosion and sediment controls would be installed and maintained in accordance with the requirements of the 'Blue Book' *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004), (hereafter referred to as the Blue Book).

3.2.4. Source and quantity of materials

The source and quantity of materials would be determined during the detailed design phase of the Proposal, and would consider the requirements of the *NSW Sustainable Design Guidelines – Version 3.0* (TfNSW, 2013a). Materials would be sourced from local suppliers where practicable. Reuse of existing and recycled materials would be undertaken where practicable.

3.2.5. Traffic, access and vehicle movements

Traffic and transport impacts associated with the Proposal are assessed in Section 6.1 of this REF. The potential traffic and access impacts expected during the construction of the Proposal include:

- temporary impacts to pedestrians, cyclists and bus customers through changes in access during construction (e.g. demolition of road verges and pedestrian pathways)
- higher road safety risk levels associated with construction vehicle-pedestrian interactions
- delivery and removal of materials to and from the Proposal area during construction including concrete and general waste
- permanent loss of some street parking along Pittwater Road
- interruptions to traffic flow along Pittwater Road and adjoining local roads, particularly during road works
- a minor increase in construction-related traffic on the local road network.

A detailed construction methodology and associated management plans (including a CEMP) would be developed during the detailed design phase of the Proposal to manage impacts.

3.2.6. Ancillary facilities

A temporary construction compound would be required to accommodate a site office, amenities, machinery, and laydown and storage area for materials. A construction compound site has been proposed in the same location as the compound utilised for the new Manly Vale B-Line commuter car park on the corner of Condamine Street and Kenneth Road.

The Proposal would utilise the same construction compound footprint though would extend the length of time that it would be in use by around six months. The environmental assessment of the Manly Vale Commuter Car Park was undertaken as part of the *Manly Vale Commuter Car Park and B-Line Stops Review of Environmental Factors* (TfNSW, March 2016).

During detailed design an alternative location for the construction compound may be deemed to be required. Should this occur the alternative compound location would be the subject of a separate and additional environmental assessment and approval.

An overview of the proposed Manly Vale Commuter Car Park construction compound is provided in Figure 8.

3.2.7. Public utility adjustments

Temporary connections to utilities would be required for the construction compound and site facilities including but not limited to potable water, electricity, sewer and communication services.

The Proposal has been designed to avoid the relocation of services; however utility adjustments would be required for the construction of the bus indent south of Hawkesbury Avenue. This would require the relocation of existing below ground service utilities in the eastern road verge of Pittwater Road towards existing property boundaries between Hawkesbury Avenue and Dee Why Parade.

The utility design would be further investigated during detailed design.

3.3. Property acquisition

The Proposal does not require the acquisition of any property.

4. Statutory considerations

This chapter provides a summary of the statutory considerations relating to the Proposal including a consideration of NSW Government polices/strategies, NSW legislation (particularly the EP&A Act), environmental planning instruments, and Commonwealth legislation.

4.1. Commonwealth legislation

4.1.1. Environment Protection and Biodiversity Conservation Act 1999

The (Commonwealth) EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places - defined in the EPBC Act as ‘matters of National Environmental Significance (NES)’. The EPBC Act requires the assessment of whether the Proposal is likely to result in a significant impact upon matters of NES or Commonwealth land. These matters are considered in full in Appendix A.

The Proposal would not impact on any matters of NES or on Commonwealth land. Therefore a referral to the Commonwealth Minister for the Environment is not required.

4.2. NSW legislation and regulations

4.2.1. Environmental Planning and Assessment Act 1979

The EP&A Act establishes the system of environmental planning and assessment in NSW. This Proposal is subject to the environmental impact assessment and planning approval requirements of Part 5 of the EP&A Act. Part 5 of the EP&A Act specifies the environmental impact assessment requirements for activities undertaken by public authorities, such as Roads and Maritime, which do not require development consent under Part 4 of the EP&A Act.

In accordance with section 111 of the EP&A Act, Roads and Maritime, as the proponent and determining authority, must examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the Proposal.

Clause 228 of the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) defines the factors which must be considered when determining if an activity assessed under Part 5 of the EP&A Act would have a significant impact on the environment.

Chapter 6 of the REF provides an environmental impact assessment of the Proposal in accordance with clause 228. Appendix B specifically responds to the factors for consideration under clause 228.

4.2.2. Other NSW legislation and regulations

Table 3 provides a review of other relevant legislation applicable to the Proposal.

Table 3 Other legislation applicable to the Proposal

Applicable legislation	Considerations
Crown Lands Act 1987 (NSW)	The Proposal does not involve works on any Crown Land.
Disability Discrimination Act 1992 (DDA) (Commonwealth)	The Proposal would be designed having regard to the requirements of the DDA.

Applicable legislation	Considerations
Fisheries Management Act 1994 (NSW)	Adequate stormwater quality measures would prevent any adverse impacts on any natural watercourse. The Proposal would not affect any listed threatened species, populations, ecological communities or marine vegetation or involve dredging or dam works.
Heritage Act 1977 (Heritage Act) (NSW)	The Heritage Act provides for the conservation of environmental heritage in NSW. Development affecting State-listed heritage items or activities cannot be carried out without the following: • Sections 57 and 60 (approval) where items listed on the State Heritage Register would be affected • Sections 139 and 140 (permit) where relics are likely to be exposed • Section 170 (consultation) where items listed on a government agency Heritage and Conservation Register would be affected. A search of NSW State Heritage Register (SHR) and State Heritage Inventory, the Australian Heritage Database (including Commonwealth and National Heritage lists and the Register of the National Estate (RNE)), and local planning instrument (Warringah LEP 2011) revealed no listed State-heritage items within the Proposal area. Refer to Section 6.5.
National Parks and Wildlife Act 1974 (NPW Act) (NSW)	Sections 86, 87 and 90 of the NPW Act require consent from OEH for the destruction or damage of Indigenous objects. It is considered unlikely that the Proposal would disturb any objects of Aboriginal heritage significance (refer Section 6.4). However, if unexpected archaeological items or items of Aboriginal heritage significance are discovered during the construction of the Proposal, all works would cease and appropriate advice sought.
Noxious Weeds Act 1993 (NW Act) (NSW)	The *Noxious Weeds Act 1993* (NW Act) establishes a system for the identification and control of noxious weeds in NSW. Under section 13 of the NW Act, public authorities are required to control weeds that are likely to spread to adjoining land. The majority of the Proposal would be undertaken in previously cleared and disturbed areas, and noxious weeds are not expected to be encountered or disturbed. However, if noxious weeds are encountered, they would be managed and disposed of in accordance with the NW Act to an appropriate waste facility.
Protection of the Environment Operations Act 1997 (POEO Act) (NSW)	The Proposal does not involve a 'scheduled activity' under Schedule 1 of the POEO Act. Accordingly, an Environment Protection Licence (EPL) is not required for the Proposal. However, in accordance with Part 5.7 of the POEO Act, Roads and Maritime would notify the EPA of any pollution incidents that occur on site. This would be managed within the CEMP to be prepared and implemented by the Contractor.
Roads Act 1993 (Roads Act) (NSW)	Section 138 of the Roads Act requires consent from the relevant road authority for the carrying out of work in, on or over a public road. Clause 5(1) in Schedule 2 of the Roads Act states that public authorities do not require consent for works on unclassified roads. The Proposal would involve works on Pittwater Road, a classified road maintained by Roads and Maritime. Consultation with the Northern Beaches Council has commenced and is ongoing regarding potential impacts to local roads under Council management. Consent under the Roads Act is not required; however Road Occupancy Licence/s would be obtained from the relevant roads authority by the Contractor for on-road works and any temporary road closures. Refer to Section 6.1 for more information.

Applicable legislation	Considerations
Sydney Water Act 1994 (NSW)	The Proposal would not involve discharge of wastewater to the sewer.
Threatened Species Conservation Act 1995 (TSC Act) (NSW)	The Proposal area does not contain suitable habitat for any listed threatened species, population or community listed under the TSC Act and as such, the Proposal is unlikely to result in a significant impact upon same (refer Section 6.7).
Waste Avoidance and Resource Recovery Act 2001 (WARR Act) (NSW)	Roads and Maritime would carry out the Proposal having regard to the requirements of the WARR Act. A site specific Waste Management Plan would be prepared and implemented during construction as part of the CEMP.
Water Management Act 2000 (NSW)	The Proposal would not involve any water use, water management works, drainage or flood works, controlled activities or aquifer interference.

4.3. State Environmental Planning Policies

4.3.1. State Environmental Planning Policy (Infrastructure) 2007

Permissibility

State Environmental Planning Policy (Infrastructure) 2007 (the Infrastructure SEPP) is the key environmental planning instrument which determines the permissibility of a Proposal and outlines under which part of the EP&A Act an activity or development may be determined.

Clause 94(1) of the Infrastructure SEPP allows for the development of *"a road or road infrastructure facilities*" by or on behalf of a public authority without consent on any land. Clause 93 defines "*road infrastructure facilities*" as including elements such as *"bus lanes, transit lanes, associated public transport facilities for roads used to convey passengers by means of regular bus services, bus layovers that are integrated or associated with roads, traffic control facilities and safety works".*

Clause 5 defines *"associated public transport facilities"* as including "*bus bays and bus layovers".* In addition, Clause 94(2) allows development that is in connection with a "*road or road infrastructure facility"* and includes "*alterations or additions to an existing road (such as widening, duplication or reconstruction of lanes, changing the alignment or strengthening of the road".*

The Proposal falls within the definition of "*road or road infrastructure facilities"* and "*associated public transport facilities"* and is therefore permissible without development consent and can be assessed under Part 5 of the EP&A Act.

Part 2 of the Infrastructure SEPP contains provisions for public authorities to consult with local councils and other agencies prior to the commencement of certain types of development. Section 5.2 of this REF outlines the consultation undertaken in accordance with the requirements of the Infrastructure SEPP.

The Infrastructure SEPP prevails over all other environmental planning instruments except where *State Environmental Planning Policy (Major Development) 2005*, *State Environmental Planning Policy No 14 – Coastal Wetlands* or *State Environmental Planning Policy No 26 – Littoral Rainforest* applies. The Proposal is not of a type or located on land to which these SEPPs apply and therefore these SEPPs are not considered further within this REF.

4.3.2. State Environmental Planning Policy (State and Regional Development) 2011

State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP) provides that development by or on behalf a public authority for the purposes listed in the schedules of the SRD SEPP be designated as State Significant Infrastructure. State Significant Infrastructure requires approval from the Minister of Planning under Part 5.1 of the EP&A Act.

The Proposal does not trigger the State Significant Infrastructure provisions of the SRD SEPP. In addition the Proposal is not listed as State Significant Development under the SRD SEPP.

4.3.3. State Environmental Planning Policy No. 71 - Coastal Protection

This policy has been made under the EP&A Act to ensure that development in the NSW coastal zone is appropriate and suitably located, to ensure that there is a consistent and strategic approach to coastal planning and management and to ensure there is a clear development assessment framework for the coastal zone.

The Proposal area is around 200 metres from Dee Why Lagoon though is not located within the coastal protection zone.

4.3.4. State Environmental Planning Policy No. 55 – Remediation of Land

SEPP 55 provides a State-wide approach to the remediation of contaminated land for the purpose of minimising the risk of harm to the health of humans and the environment. While development consent for the Proposal is not required, the provisions of SEPP 55 have still been considered in the preparation of this REF.

Section 6.8 of this REF contains an assessment of the potential contamination impacts of the Proposal.

4.3.5. State Environmental Planning Policy No. 19 - Bushland in Urban Areas

SEPP 19 aims to protect and preserves bushland within certain urban areas, as part of the state's natural heritage or for recreational, educational and scientific purposes. SEPP 19 is designed to protect bushland in public open space zones and reservations, and to ensure that bush preservation is given a high priority when local environmental plans for urban development are prepared.

Schedule 1 of the SEPP lists areas/part areas to which the Policy applies. Warringah LGA is listed within Schedule 1. The SEPP states that public authorities cannot disturb bushland zoned or reserved for open space without consideration of the aims of the SEPP.

The Proposal involves the removal of a strip of trees within the median of Pittwater Road. This is not within land zoned for open space and therefore this SEPP does not apply. The Proposal would however include landscaping and offsetting of the proposed tree removal. Refer to Section 6.7 for an assessment of potential biodiversity impacts resulting from the Proposal.

4.4. Local environmental planning instruments and development controls

The Proposal is located within the Northern Beaches LGA. The provisions of the Infrastructure SEPP mean that Local Environmental Plans (LEPs), prepared by councils for an LGA, do not apply. However, during the preparation of this REF, the provisions of the Warringah LEP 2011 and associated strategic plans were considered.

4.4.1. Warringah Local Environmental Plan 2011

The Warringah LEP is the governing plan for this part of the Northern Beaches LGA (formerly the Warringah LGA). Under the Warringah LEP 2011, Pittwater Road is zoned as Infrastructure (classified road). The area surrounding the Proposal in Dee Why is zoned as Commercial Core and Mixed Use and consists of shops, small businesses, community facilities and high density residential dwellings.

Part 7 of the Warringah LEP 2011 outlines provisions for development within the Dee Why Town Centre. Table 4 summarises the relevant aspects of these provisions applicable to the Proposal.

Table 4 Provisions for the Dee Why Town Centre under the Warringah LEP 2011

Provision	Relevance to the Proposal
Clause 2.3 – Zone objectives and Land Use Table	Under the Warringah LEP 2011: • Pittwater Road is zoned as SP2 Infrastructure – classified road • shops and businesses along Pittwater Road in Dee Why are zoned B3 Commercial Core and B4 Mixed Use • there is an area zoned RE1 Public recreation that includes Dee Why bus stop (northbound) on the corner of Pittwater Road and St David Avenue The Proposal is consistent with the objectives of the SP2 Infrastructure, B3 Commercial Core, B4 Mixed Use, B5 Business Development and RE1 Public Recreation zoning.
Clause 5.9 - Preservation of trees or vegetation	Clause 5.9 of the Warringah LEP 2011 is aimed at the preservation of trees and development consent is required for tree removal in most instances. However by virtue of clause 5(3) and 79 of the Infrastructure SEPP, the clearing of vegetation for the Proposal is permissible without development consent and would be approved by Part 5 of the EP&A Act. A discussion of potential impacts to vegetation is discussed in Section 6.7.
Clause 5.10 – Heritage conservation	Clause 5.10 of the Warringah LEP 2011 aims to conserve the heritage significance of heritage items within the Northern Beaches LGA. There are no known Aboriginal or non-Aboriginal heritage items located within the Proposal area. A discussion of potential impacts to non- Aboriginal heritage is discussed in Section 6.5.
Clause 6.1 – Earthworks	Clause 6.1 of the Warringah LEP 2011 aims to ensure that earthworks for which development consent is required will not have a detrimental impact upon environmental functions and processes, waterways and riparian land, neighbouring uses, cultural or heritage items or features of the surrounding land. By virtue of clause 5(3) and 79 of the Infrastructure SEPP, the Proposal is permissible without development consent and would be approved under Part 5 of the EP&A Act. Consideration of earthworks for the Proposal is outlined in Section 6.8.
Clause 7.1 – Mobility, traffic management and parking in Dee Why Town Centre	Clause 7.13 aims to ensure improved vehicle access and circulation in the Dee Why Town Centre through good design and the management of traffic flows within the existing and new roads servicing the centre. The Proposal would support the B-Line Program by providing on-road infrastructure to ease existing congestion and improve traffic flow through the Dee Why Town Centre. As such the Proposal would be consistent with this clause.

Local strategies and plans

A number of local plans and studies within the Warringah LGA are relevant to the Proposal. These are briefly outlined in Table 5.

Table 5 Local strategies and/or plans relevant to the Proposal

Strategy/Plan	Comment
Warringah Creek Management Study (Warringah Council, 2004)	
This management study aims to develop an understanding of the water quality and ecological processes of creeks and associated habitats in Warringah. The study identifies existing and future development pressures confronting creeks, and provides Council with the necessary information and recommendations to implement effective short and long-term creek management strategies and action policies. The study splits Warringah into separate catchment boundaries.	The Proposal is located within the Dee Why Lagoon South and Brookvale Creek catchment boundaries. This catchment includes riparian zones and buffer zones. The Proposal would be confined to existing road infrastructure and would not traverse any riparian and/or buffer zones.
Dee Why Lagoon Wildlife Refuge Plan of Management (Warringah Council, 2002)	
This management plan provides a framework for managing Dee Why Lagoon Wildlife Refuge (a designated area as Specified by Council). The Refuge plays an important role in Warringah's open space system and is a valuable conservation area for migratory birds and estuarine flora and fauna.	The Proposal is located adjacent to the boundary of the management plan. The Proposal is not expected to extend into the open space and vegetation area of Dee Why Lagoon, and is not expected to have a significant impact on biodiversity values within the Proposal area.
Dee Why Town Square Plan of Management (Warringah Council, 2003)	
This management plan provides the framework for managing the new Dee Why Town Square. The Plan solidifies a vision for Dee Why that Council and the community have developed over a number of years.	The Proposal is located within Dee Why Town Centre. The Proposal would support improved public transport through Dee Why by providing on-road infrastructure to ease existing congestion and improve traffic flow through the town centre.

4.5. NSW Government policies and strategies

Table 6 provides an overview of other NSW Government policies and strategies relevant to the Proposal.

Table 6 NSW Government policies and strategies applicable to the Proposal

Policy/ Strategy	Commitment	Relevance to Proposal
The State Infrastructure Strategy 2012 – 2032 (Infrastructure NSW, 2012)	This strategy: • recognises that bus rapid transit projects can facilitate high quality connections on some of Sydney's existing corridors at relatively low cost • recommends investigating a range of potential enhancements to bus priority on the Northern Beaches corridor to develop a value for money improvement plan for the coming decade.	The Proposal supports investment in transport (bus) infrastructure, and aligns with the reservation of funds for urban public transport to support Sydney's population, that is expected to reach almost six million by 2031.
A Plan for Growing Sydney (Department of Planning and Environment, 2014)	This plan: • sets a vision for Sydney to be a more compact, networked city with improved accessibility to support jobs, homes and lifestyle opportunities • commits to managing demand on the road network through measures such as investment in strategic road upgrades • identifies improving local opportunities for walking, cycling and using public transport as a key policy • recognises that Pittwater Road is a key corridor in the strategy and is critical over the longer term to ensure a connected city with efficient travel options.	The Proposal is consistent with the objectives of this Plan in that it would deliver improved public transport, encourage greater public transport use and better integrate interchanges with the role and function of town centres. The Proposal would also assist in responding to forecasted growth in the region and as such would support growth in residential development and the local economy.

Policy/ Strategy	Commitment	Relevance to Proposal
NSW Long Term Transport Master Plan (TfNSW, 2012a)	This master plan: • sets out the framework for the NSW Government to deliver an integrated, modern transport system that puts the customer first • identifies the transport challenges that need to be addressed and identifies a planned and coordinated set of actions • identifies the Northern Beaches corridor (from Mona Vale to the Sydney CBD) as a highly constrained corridor. Bus transport is the only public transport in this region and there is high variability in bus travel times. This unreliability has effects across the bus network, with delays moving along the service chain and holding up the next services • identifies that the level of public transport demand and current operating conditions on the Northern Beaches may support a bus rapid transit system, which would provide congestion relief through provision of better services for customers • lists the Northern Beaches bus rapid transit system, subject to feasibility assessments, as a medium term (5-10 years) action of the master plan.	The Proposal implements the following key themes in the master plan: • improving customers' journey experience • making better use of existing assets • providing improved public transport within the Northern Beaches corridor (from Mona Vale to the Sydney CBD) • providing a bus rapid transit system, which would provide congestion relief through provision of better services for customers.

Sydney's Bus Future (TfNSW, 2013b)	This plan:
	• aims to deliver a modern and customer focused bus system
	• identifies a three-tiered network for bus operation. Each tier would deliver a defined level of service consistency and reliability:
	  ○ rapid service routes
	  ○ suburban service routes, consisting of a mix of timetabled and frequent, 'turn up and go' type services that do not require timetables
	  ○ local service routes comprising timetabled services with stops around every 400 metres.
	• identifies Mona Vale to the CBD as a rapid bus route.
		The Proposal supports the plan by:
		• providing improved public transport within the Northern Beaches corridor (from Mona Vale to the Sydney CBD)
		• improving customers' journey experience
		• making better use of existing assets.

Northern Beaches Regional Action Plan (Department of Premier and Cabinet, 2012)	This plan: • identifies that residents on the Northern Beaches rely heavily on private vehicles and public buses for travel • outlines that a bus rapid transit for the Northern Beaches be investigated.	The Proposal supports the plan by providing improved public transport within the Northern Beaches corridor which could potentially result in a reduction of private vehicle use and reliance.

Policy/ Strategy	Commitment	Relevance to Proposal
Northern Beaches Transport Action Plan (NSW Government, 2014)	This plan: • identifies transport improvements to be delivered to the Northern Beaches, as well as planning for future growth. • outlines that additional funds are being invested to deliver kerbside bus rapid transit on the Northern Beaches.	The Proposal supports the plan by providing improved public transport within the Northern Beaches corridor and would also assist in responding to forecasted growth in the region.

4.6. Ecologically sustainable development

Roads and Maritime are committed to ensuring that their projects are implemented in a manner that is consistent with the principles of ecologically sustainable development (ESD). The principles of ESD are generally defined under the provisions of clause 7(4) of Schedule 2 of the EP&A Regulation as:

- **the precautionary principle** – if there are threats of serious or irreversible damage, a lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
- **intergenerational equity** – the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations
- **conservation of biological diversity and ecological integrity** – the diversity of genes, species, populations and their communities, as well as the ecosystems and habitats they belong to, should be maintained or improved to ensure their survival
- **improved valuation, pricing and incentive mechanisms** – environmental factors should be included in the valuation of assets and services.

The principles of ESD have been adopted by Roads and Maritime throughout the development and assessment of the Proposal. Section 3.1.4 summarises how ESD would be incorporated in the design development of the Proposal. Section 6.11 includes an assessment of the Proposal on climate change and sustainability, and Section 7.2 lists mitigation measures to ensure ESD principles are incorporated during the construction phase of the Proposal.

5. Community and stakeholder consultation

This chapter discusses the consultation undertaken to date for the Proposal and the consultation proposed for the future, including the consultation strategy adopted for the Proposal.

5.1. Consultation strategy

The consultation strategy for the Proposal was developed to encourage stakeholder and community involvement and foster interaction between stakeholders, the community and the project team. The consultation strategy that was developed, having regard to the requirements of the planning process, ensures that stakeholders, customers and the community are informed of the Proposal and have the opportunity to provide input.

The objectives of the consultation strategy are to:

- provide accurate and timely information about the Proposal and REF process to relevant stakeholders
- raise awareness of the various components of the Proposal and the specialist environmental investigations
- ensure that directly affected community stakeholders are aware of the REF and consulted where appropriate
- provide opportunities for stakeholders and the community to express their views about the Proposal
- understand and access local knowledge from the community and stakeholders
- record the details and input from community engagement activities
- build positive relations with identified community stakeholders
- ensure a comprehensive and transparent approach.

5.2. Consultation to date

A range of community engagement activities and tools have been used to raise awareness of the Proposal and provide opportunities for stakeholders and the community to express their views. The community engagement program will continue during the public display of this REF and, if the Proposal proceeds, during the construction phase. Further details on these phases of consultation are provided in Section 5.3.2 and 5.5. Community engagement undertaken to date is described in Table 7.

Table 7 Consultation to date

Engagement activity	Details
Contact mechanisms	A Project Infoline number (1800 048 751) and email address (projects@transport.nsw.gov.au) was established at the commencement of the Program to enable all stakeholders to provide feedback to the project team. The dedicated website (see below) also includes an engagement portal, which allows individuals to post questions and vote on elements of the project that are important to them. All feedback received to date has been considered during preparation of the REF.

Engagement activity	Details
B-Line Program website	Information about the Proposal was provided on dedicated Dee Why page on the B-Line Program website (www.b-line.transport.nsw.gov.au). The website was also used to advertise the community information sessions and public display period. Information on how to lodge a submission was made available.
Community newsletter	A community newsletter providing details of the Proposal was distributed to around 8,500 properties within a 500 metre radius of the Proposal area. The newsletter outlined the Proposal and its benefits, explained that an environmental impact assessment was being undertaken and invited feedback. Newsletters were also provided to Northern Beaches Council for their Civic Centre office.
Stakeholder meetings/briefings	Meetings were held with Northern Beaches Council to discuss a range of issues associated with the B-Line Program, including the Proposal.
Advertisements	Advertisements will be placed in the Manly Daily to notify the community about the Proposal, explain that an environmental impact assessment has been prepared and inviting comments.

5.3. Consultation requirements under the Infrastructure SEPP

5.3.1. Consultation requirements

Part 2, Division 1 of the Infrastructure SEPP contains provisions for public authorities to consult with local councils and other public authorities prior to the commencement of certain types of development. Clauses 13, 14, 15 and 16 of the Infrastructure SEPP require that public authorities undertake consultation with councils and other agencies, when proposing to carry out development that does not require development consent under the SEPP.

Table 8 provides details of consultation requirements under the Infrastructure SEPP for the Proposal.

Table 8 Infrastructure SEPP consultation requirements

Clause	Requirements	Relevance to the Proposal
Clause 13 Consultation with Councils – development with impacts on council related infrastructure and services	Consultation is required where the Proposal would result in: • substantial impact on stormwater management services • generating traffic that would place a local road system under strain • involve connection to or impact on a council owned sewerage system • involve connection to and substantial use of council owned water supply • significantly disrupt pedestrian or vehicle movement • involve significant excavation to a road surface or footpath for which a council has responsibility.	The Proposal includes works that would: • temporarily disrupt pedestrian and vehicle movements • impact on road pavements under Council's care and control • affect council-operated footpaths. Consultation with the Northern Beaches Council has commenced in accordance with clause 13 of the Infrastructure SEPP and would continue throughout the detailed design and construction phases.

Clause	Requirements	Relevance to the Proposal
Clause 14 Consultation with Councils – development with impacts on local heritage	Consultation with Council is required where the Proposal would: • substantially impact on local heritage item (if not also a State heritage item) • substantially impact on a heritage conservation area.	There are several heritage items listed under the Warringah LEP 2011 located adjacent to the Proposal including the following: • Dee Why Lagoon and Reserve • a street tree on the corner of St David Avenue and Pittwater Road • Civic Centre landscaping • Dee Why Library • Commonwealth Bank, Dee Why. The Proposal is not expected to result in an impact upon these heritage items and accordingly, consultation is not required. Refer to Section 6.5.
Clause 15 Consultation with Councils – development with impacts on flood liable land	Consultation is required where the Proposal would: • impact on land that is susceptible to flooding – reference would be made to *Floodplain Development Manual: the management of flood liable land.* • change flood patterns other than to a minor extent	Flooding can occur along sections of Pittwater Road (and adjacent roads such as Oaks Avenue and Howard Avenue). The Proposal is not expected to change flood patterns and would not affect flood behaviour. Consultation with the Northern Beaches Council has commenced and would continue throughout the detailed design and construction phases.
Clause 16 Consultation with public authorities other than Councils	Consultation is required for specified development. 'Specified development' is defined as the following with the relevant authority: • development adjacent to land reserved under the NPW Act – the Department of Environment and Climate Change • development adjacent to a marine park declared under the *Marine Parks Act 1997* – the Marine Parks Authority • development adjacent to an aquatic reserve declared under the *Fisheries Management Act 1994* – the Department of Environment and Climate Change • development in the foreshore area within the meaning of the *Sydney Harbour Foreshore Act 1998* – the Sydney Harbour Foreshore Authority • development comprising a fixed or floating structure in or over navigable waters – the Maritime Authority of NSW.	The Proposal is not: • adjacent to land reserved under the NPW Act • adjacent to a marine park declared under the *Marine Parks Act 1997* • adjacent to an aquatic reserve declared under the *Fisheries Management Act 1994* • development in the foreshore area within the meaning of the *Sydney Harbour Foreshore Act 1998* • development comprising a fixed or floating structure in or over navigable waters.

Northern Beaches Council has been consulted in accordance with the provisions of the ISEPP. A response from Council was received on 24 August 2016. The response included the following requests:

- Zone A:
  - that any proposed works in St David Avenue are consistent with the Dee Why Town Centre Masterplan
  - consideration of a left turn restriction for heavy vehicles turning into Howard Avenue are considered
  - consideration of landscaping
  - clarification around bus lane design and structure
- Zone B:
  - further design clarifications
  - consideration of recent drainage works in Oaks Avenue
  - clarification around parking impacts
  - vegetation offsetting
  - consideration of incorporating the Merriton bus bay into the design.

These responses have been considered by Roads and Maritime, who will continue to consult with Council as the detailed design for the Proposal develops.

5.3.2. Summary of issues raised by stakeholders

A summary of key issues identified to date are provided in Table 9. Some of these issues are limited to the construction phase and therefore would be temporary in nature while others are related to permanent changes which would occur as a result of the Proposal.

Table 9 also highlights the relevant section in the REF where the relevant potential impacts are assessed and the mitigation measures are described in more detail. These issues will be expanded upon during upcoming phases of consultation.

Table 9 Summary of issues raised by stakeholders

Issue	Response and where addressed
Traffic impacts: • increased traffic congestion during construction • impact on traffic flow during operation • coordination with Council's plans for Dee Why Town Centre.	• traffic impacts during construction would not have a major impact on the performance or capacity of the surrounding road network • general traffic would not be significantly disadvantaged by the proposed upgrades during operation • RMS have prepared the design with view to Council's Dee Why Town Centre proposal and would continue consultation throughout detailed design and construction. See Section 6.1 Traffic and transport for more detail.
Parking impacts: • temporary loss of parking during construction • permanent loss of street parking • provision of offset parking • impact on deliveries to businesses.	• a marginal increase in demand for parking within local streets would be expected during construction. A TMP would be prepared to manage this impact • there would be a permanent loss of approximately 29 parking spaces along

Issue	Response and where addressed
	Pittwater Road during operation though seven of these would remain available for parking between 8:00pm and 6:00am • No offset parking has been provided as per RMS policy on removal of parking in existing bus lanes • Deliveries to some businesses would be affected by the loss of on-street parking along some parts of Pittwater Road. See Section 6.1 Traffic and transport for more detail.
Noise and vibration impacts: • night works • respite periods • cumulative impacts caused by multiple construction projects in the area.	• night works would be required for the majority of construction to avoid traffic disruption during peak periods • respite has been factored into the proposal through the avoidance of noisy works after midnight • cumulative road construction impacts would be managed through RMS's Traffic Management Centre. The cumulative impact alongside other nearby developments is no considered to be significant See Section 6.3 Noise and vibration for more detail.
Visual amenity: • loss of trees and vegetation on the median between Howard Avenue and Oaks Avenue • visual amenity during construction and operation.	• trees within the median between Howard Avenue and Oaks Avenue would be removed during construction • temporary visual amenity impacts during construction would be expected See Section 6.2 Urban design, landscape and visual Amenity for more detail
Pedestrian access: • safe access around construction sites • access to bus stops during construction.	• alternative pedestrian routes around all construction sites would be made available, including proper signposting • access to all bus stops would be maintained during construction See Section 6.1 Traffic and transport for more detail. This would also be addressed in the CEMP.
Proposal need and alternatives: • justification for the proposed roadworks • cost versus benefits.	• justification for the Proposal has been provided in the context of improving bus journey times through the Northern Beaches • cost versus benefits have been addressed in the Strategic and Final Business Cases for the B-Line Program See Section 2 Need for the Proposal for more detail.

5.4. Consultation during public display

The REF will be placed on public display for a period of two weeks and written submissions will be invited during this period. Further community consultation will be undertaken during the public display period to enable the community to comment and ask questions about the Proposal.

Planned consultation activities associated with the public display include:

- Two community information sessions to give local residents and businesses an opportunity to view the plans and discuss the Proposal with members of the project team at Dee Why Civic Centre at the following times:
  - Monday 24 October between 5:00 and 7:00pm
  - Wednesday 2 November between 5:00pm and 7:00pm
- Advertisements in the Manly Daily to publicise the REF display and community information sessions
- A letterbox drop to properties within 500 metres of the Proposal area publicising the REF display and community information sessions and inviting feedback
- Public display of the REF documents at the following locations:
  - Northern Beaches Council office - 725 Pittwater Road, Dee Why
  - Dee Why Library – 725 Pittwater Road, Dee Why.
- All documents available on the B-Line website at www.b-line.transport.nsw.gov.au
- Targeted meetings and briefings for key stakeholders to provide an overview of the REF findings and identify potential issues
- Project Infoline 1800 048 751 and projects@transport.nsw.gov.au

5.5. Post-public display consultation

5.5.1. Submissions report

At the conclusion of the public display period for the REF, Roads and Maritime will acknowledge receipt of feedback from each respondent. The issues raised by respondents will be consolidated and considered by Roads and Maritime.

A Submissions Report will be prepared summarising the key impacts identified in this REF, demonstrating how Roads and Maritime has considered issues raised during the public display period, and including a summary of mitigation measures proposed to minimise the impacts of the Proposal. The Submissions Report will be made available on the B-Line website and everyone who made a submission will be individually notified of the outcome.

5.5.2. Construction phase

Should Roads and Maritime proceed with the Proposal, consultation activities would continue up to and during construction. These consultation activities would ensure that:

- the community and stakeholders have a high level of awareness of all processes and activities associated with the Proposal
- accurate, up to date and accessible information is made available
- a timely response is given to issues and concerns raised by the community.

The project team would keep the community, Northern Beaches Council and other key stakeholders informed of progress, identify further issues as they arise, and develop additional mitigation measures to minimise potential impacts of the Proposal. Targeted consultation activities such as door knocks, meetings, newsletters, notifications, advertising, signage and verbal communications would continue during the construction phase. The B-Line website would include frequent updates and the project infoline and email address would continue to operate during the construction phase.

6. Environmental impact assessment

This chapter of the REF provides a detailed description of the potential environmental impacts associated with the construction and operation of the Proposal. For each potential impact, the existing environment is characterised and an assessment is undertaken as to how it would be affected by the Proposal.

This environmental assessment has been undertaken in accordance with clause 228 of the EP&A Regulation. A checklist of clause 228 factors and how they have been specifically addressed in this REF is included at Appendix B.

6.1. Traffic and transport

A Traffic and Transport Assessment was undertaken for the Proposal (AECOM 2016a). The assessment included an analysis of the existing bus and general traffic movements along the corridor and assessment of the future bus and general traffic scenarios with and without the Proposal.

A key focus of the traffic impact assessment has been the operation of the study area road network for buses and general traffic. The network operational assessment for the current situation (Base Year) and in the future (2021) was undertaken for individual intersections (using SIDRA 6) to undertake optioneering of the B-Line proposal in Dee Why prior to a network assessment using VISSIM traffic modelling.

VISSIM and SIDRA modelling are different methods of assessing traffic flow and/or intersection performance. SIDRA modelling focuses upon intersection performance and is generally used to compare alternative treatments of individual intersections. For this Proposal it has been employed to analyse the intersection of Pittwater Road and:

- Hawkesbury Avenue
- Kingsway
- Howard Avenue
- Oaks Avenue
- Fisher Road
- Pacific Parade
- Sturdee Parade.

VISSIM modelling assesses traffic flow and intersection performance on the basis of a ‘microscopic simulation’. That is, it models the movement of each entity (car, bus, truck) individually, allowing interaction between these entities to be demonstrated and analysed.

The findings of the traffic and transport assessment, including modelling predictions, are summarised in this section.

6.1.1. Existing environment

Traffic and road network

Pittwater Road is a state road that serves as a primary arterial route and provides connections between the Sydney CBD in the south (via the M1 Motorway) and the Northern Beaches in the north (terminating at Mona Vale). Warringah Road is a state road and connects with Pittwater Road at the boundary of Dee Why and Brookvale. Warringah Road provides a primary arterial east-west route between the Northern Beaches suburbs and Chatswood in the west.

The primary north-south road corridor through the Northern Beaches LGA comprises Pittwater Road, Condamine Street, Burnt Bridge Creek Deviation and Manly Road. This corridor accommodates around 40,000 vehicles per day and functions as an arterial road providing access to various urban centres including Dee Why. The corridor intersects with a number of local and roads within Zones A and B of the Proposal. Local roads surrounding the Proposal include Hawkesbury Avenue, Kingsway, Dee Why Parade, Howard Avenue, Oaks Avenue, Fisher Road, Pacific Parade and Sturdee Parade.

On-street parking is permitted at various locations within Zone A and Zone B along Pittwater Road. Bus lanes are operational in the southbound direction in the AM peak period between 6am and 10am; and in the northbound direction in the PM peak between 3pm and 7pm. The posted speed limit through the Proposal area is 60 kilometres per hour.

Travel mode

A review of the 2011 ABS Journey to Work data indicated that around 60 per cent of travel in and out of the (former) Warringah LGA is made by private car (as either a driver or passenger) and around 20 per cent is made by public transport (predominantly by bus). This trend is broadly consistent with that of metropolitan Sydney, which has a slightly higher rate of private car journeys. The remainder of journeys are undertaken on foot or bicycle.

Intersection performance

Intersection performance within the Proposal area was assessed by assessing vehicle delay at relevant intersections. Intersection performance modelling determines the average delay that vehicles encounter at a particular intersection and provides a measure of the level of service (LoS). This is a qualitative measure of vehicle delay. There are six levels of performance, which are expressed in terms of LoS which range from ‘A’ (best level with good intersection performance,) to ‘F’ (worst level with saturated conditions, long queues and delays).

Table 10 summarises the existing overall LoS at each intersection within the Proposal area for the AM and PM weekday peaks.

Table 10 Intersection LoS within the Proposal area (AM and PM weekday peaks). Worst case of each of the two hours of the peak presented.

Zone	Intersection	AM 7 m to 9am	PM 4:30pm to 6:30pm
A	Pittwater Road/Hawkesbury Avenue	C	**B**
B	Pittwater Road/Kingsway	B	**B**
B	Pittwater Road/Howard Avenue	C	**B**
B	Pittwater Road/Oaks Avenue	B	**A**
B	Pittwater Road/Fisher Parade	C	B
B	Pittwater Road/Pacific Parade	B	C
B	Pittwater Road/Sturdee Parade	B	B

All intersections along Pittwater Road within the Proposal area currently operate at a satisfactory LoS ‘C’ or better. In some cases, intersection performance slightly deteriorates in the second peak hour as the congestion worsens due to the sustained increase of traffic demands. This LoS is considered acceptable under the National Construction Code as determined by the Building Code of Australia.

The following trends were identified from site observations within the Proposal area:

- during the AM weekday peak, southbound traffic on Pittwater Road experiences moderate delays and congestion between Dee Why Parade and Sturdee Parade. This is partly due to the closely spaced traffic signals and the competing traffic demands from the side roads connecting to the Dee Why town centre
- during the AM and PM weekday peak, the right-turn bay from Pittwater Road into Oaks Avenue (eastbound) experiences traffic queuing back towards Fisher Road
- frequent bus activities occur at the bus stop on the eastern side of Pittwater Road between Howard Avenue and Oaks Avenue (southbound). During the AM and PM weekday peak, up to three buses service the bus stop for passenger boarding and alighting. The adjacent footpath is relatively narrow and often is often congested with bus passengers queuing for bus services
- during the PM weekday peak, traffic on Pittwater Road slows significantly in both directions (northbound and southbound) between Oaks Avenue and Sturdee Parade.

Pedestrian and bicycle facilities

Pedestrian footpaths are located along both sides of Pittwater Road and the adjoining local roads throughout the Proposal area. These footpaths connect to provide access to services, facilities and destinations to and from key transport locations.

There are no dedicated bicycle routes along Pittwater Road in the Proposal area. There is a dedicated cycleway located about 120 metres north of the Pittwater Road/Hawkesbury Avenue intersection (southbound). This cycle way provides off road access from Pittwater Road to Dee Why Beach. Bus lanes located along Pittwater Road are often used by cyclists as they provide some segregation from traffic.

Bus services

Various local buses travel through and service routes along Pittwater Road within the Proposal area. A map of the existing bus services operating within the Proposal area is shown in Figure 9.

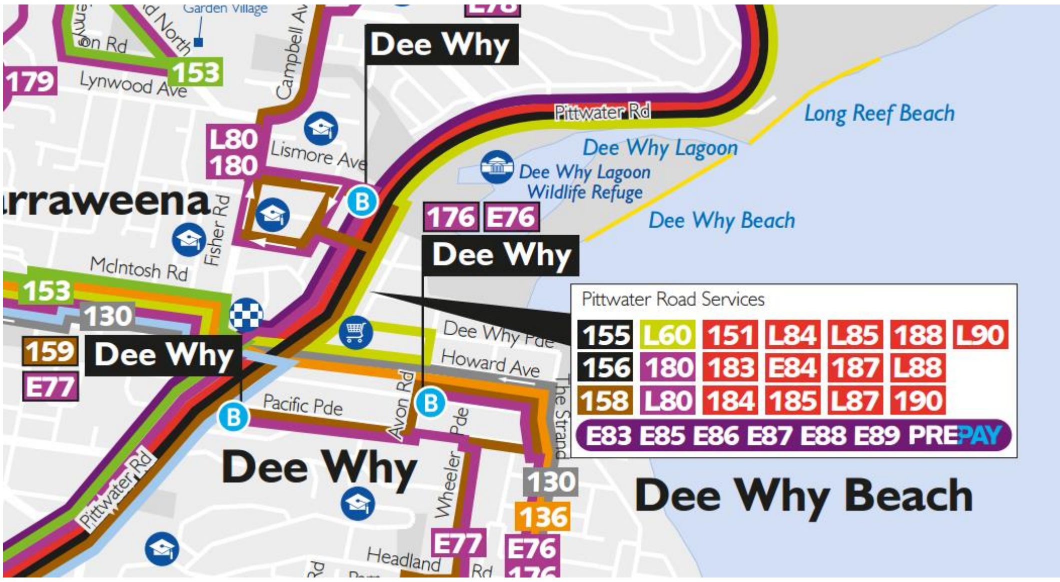

Figure 9 Existing bus services operating within the Proposal area (TfNSW, 2016)

Bus lanes are present on Pittwater Road in both southbound and northbound directions. These lanes are operational in the AM and PM weekday peaks (6am to 10am southbound and 3pm to 7pm northbound). Outside peak hours, the bus lanes generally provide short term parking (typically ½ hour maximum stay).

Parking

On-street parking is currently permitted in the kerbside lane of Pittwater Road in both directions outside of the hours of operation of peak period clearways. Parking restrictions vary throughout the Proposal area from ½ hour to 1 hour.

The area in the vicinity of the proposed bus indent south of Hawkesbury Avenue is currently a no parking zone.

Along the southbound carriageway of Pittwater Road between Howard Avenue and the intersection with Fisher Road in Dee Why town centre parking is either prohibited (within existing bus zones), or available only outside of the weekday AM clearway period of 6am to 10am. Parking in non-bus zones is restricted to ½ hour maximum stay between 10am and 6pm Monday to Friday and 8:30am to 12:30pm Saturdays. Parking in this location is unrestricted outside of these hours.

Parking demand in this section of Pittwater Road generally arises from the mixed land uses present including medium density housing, businesses and recreational areas. The Dee Why Town Centre also accounts for a significant proportion of the overall parking demand in the area.

6.1.2. Potential impacts

Construction phase

Traffic

The impact upon movement of traffic around the bus indent at Zone A during construction is expected to be minor given that the majority of the works would be undertaken within the existing verge. It is probable that at least the kerbside lane would be closed during these works, which are likely to be undertaken at night in order to avoid disruption to peak period traffic.

Within Zone B it would be necessary for temporary road and lane closures to be put in place. In particular this would be required within the southbound carriageway of Pittwater Road adjacent to Oaks Avenue, as well as potentially within the western extent of Oaks Avenue itself in order to support the construction of the kerb blister.

The removal of vegetation and expansion of the road into the median within Zone B would require temporary disruptions and slowing of traffic along Pittwater Road. This would include the likely closure of the innermost lanes of both the northbound and southbound carriageways. In certain scenarios it may be necessary for both directions of traffic to be diverted onto a single carriageway while works are undertaken on the opposite carriageway. This would be managed by the Construction Contractor according to a detailed Traffic Management Plan (TMP).

Access to all residential property driveways within the Proposal area would maintained throughout the construction period. After hours deliveries to businesses along Pittwater Road may be affected by the presence of construction activities. Based on the general type of businesses present in this location and the availability of parking in nearby side streets this impact is not expected to be significant. Consultation would be undertaken with all affected businesses to establish those that may be affected and to organise construction so as to minimise overall impacts upon their operation.

As mentioned above, it is likely that the majority of construction activities would be undertaken outside of standard construction hours. This would minimise traffic disruptions given that there would be less traffic on Pittwater Road during the night.

Access for emergency vehicles along the Pittwater Road corridor would be maintained in accordance with emergency vehicle requirements. All emergency services would be advised of all planned temporary changes to traffic arrangements during construction prior to their implementation.

Overall, provided the proposed traffic management measures are implemented, the likely impact to local traffic during construction is expected to be manageable and would not have a major impact on the performance or capacity of the surrounding road network.

Road network

During construction, additional vehicle movements would be generated along Pittwater Road within the Proposal area. These movements would generally be between Zone A, Zone B and the Manly Vale Commuter Car Park construction compound.

Heavy vehicle traffic would mainly be generated by activities associated with the following:

- delivery of construction materials
- spoil and waste removal
- delivery and removal of construction equipment and machinery
- movement of construction personnel.

Up to five heavy vehicles would be required at each zone daily, resulting in around 10 daily heavy vehicles movements in and out of each zone. These heavy vehicle movements are likely to be spread through the day, however in adopting a worst-case assessment of the traffic impacts it has been assumed that 10 per cent, or one vehicle movement, would occur during the peak hour.

Construction vehicles would access the site via Pittwater Road wherever possible. Given the high volume of traffic currently experienced along Pittwater Road it is not anticipated that the additional heavy vehicle movements generated by the Proposal would have a significant impact above what is currently experienced. Additional construction traffic would be well within the range of daily variation in traffic along Pittwater Road.

To minimise impacts on the local road network, heavy vehicle traffic would use the regional road network for access routes to and from construction areas. Any disruptions to existing traffic conditions or property access would be minimised and would only be undertaken following consultation with the community and individual property owners affected by the works.

The movement of construction materials would be managed through the scheduling of deliveries and the availability of fleet, and would aim to minimise the number of haulage and delivery vehicles required during peak periods and weekends. Modelling undertaken for the Proposal (AECOM 2016a) concluded that this slight increase in vehicular traffic would result in a negligible impact on the local road network operation.

Light vehicle traffic generation would be associated with staff movements to and from each zone. Staff would comprise of project managers, various trades, and general construction staff. Light vehicles used to transport staff to and from each zone would be parked on nearby local streets or public car parks.

The workforce arrival and departure periods represent the peak construction traffic generation periods for the Proposal. These periods may coincide within the existing road network AM and PM peak periods. The traffic generated from light construction vehicles for works during standard construction hours is likely to result in increases of up to 18 vehicles per hour in the AM and PM peak periods, which is well within the daily variation traffic on the local road network.

Pedestrian and bicycle facilities

During construction, there is the potential for temporary disruptions to the existing pedestrian facilities along Pittwater Road between Hawkesbury Avenue and Sturdee Parade, and on surrounding local roads. This has the potential to increase safety risks for pedestrians due to possible interactions with construction plant and vehicles. Specifically there would be temporary disruptions to pedestrian access at the location of the proposed bus indent south of Hawkesbury Avenue. In this location it may be necessary to divert pedestrian access temporarily to the opposite footpath, adjacent to the northbound carriageway.

Through Dee Why pedestrian access would be temporarily disrupted at the location of the proposed kerb blister north of the Oaks Avenue intersection with Pittwater Road. During construction pedestrian access may be diverted to the opposite footpath, adjacent to the northbound carriageway.

The impact of the above pedestrian diversions would be minor given that a majority of the works in this location would be undertaken as night works when pedestrian traffic would be very low.

Works at the above locations would also involve minor disruptions to bicycle access during construction. The impacts upon cyclists in these locations are expected to be minor, though this may also include temporary diversions.

Potential impacts to pedestrians during construction would be managed through the development of a construction TMP. Appropriate signs and/or traffic controllers would be positioned to notify pedestrians of temporary arrangements and manage their interaction with construction vehicles.

Bicycle users may also be temporarily affected during construction. Temporary bicycle diversions would be minimised where possible and adequately sign-posted, with notification provided to the community. All bicycle diversions would be made via the safest possible alternative routes

Bus services

During construction there is the potential for existing local bus services to be disrupted. Impacts may occur during road works as a result of temporary lane and road closures, the majority of which would be carried out as night works and hence would result in minimal impact upon bus services. During these times there may be reduced speeds and diversions put in place, however buses would continue to service the bus stops at Dee Why RSL and in central Dee Why. Any temporary traffic diversions and changes to (or relocation of) bus services (including zones and stops) that may be required would be minimised where possible and adequately sign-posted, with notification provided to the community.

Parking

During construction it would be necessary to temporarily suspend parking along certain parts of Pittwater Road whilst construction is undertaken. Specifically this would affect parking at and adjacent to the proposed bus indent south of Hawkesbury Avenue and that around the proposed kerb blister and clearway extension within central Dee Why. Parking suspensions in these locations may be active during night working times only or may extend 24 hours, as determined by the specific construction activities.

The Northern Beaches B-Line Offset Parking Assessment (TfNSW, 2015a) assessed the parking occupancy along Pittwater Road within the Proposal area. Currently, around 49% of available parking is utilised along the eastern side of Pittwater Road (southbound), and 63% of available parking is utilised along the western side of Pittwater Road (northbound). It should also be noted that the majority of construction activity throughout the Proposal area would be undertaken after hours, likely commencing after 9pm at night. Considering available parking along Pittwater Road is not at full occupancy, the use of night works and the availability of on-street parking and car parks within the wider Dee Why area, the impact to on-street parking demand in the short term would be minor. A construction TMP would be prepared and would outline safeguards to be implemented to minimise potential parking impacts during construction.

Access to all residential property driveways within the Proposal area would be maintained throughout the construction period. After hours deliveries to businesses that depend upon on-street parking along Pittwater Road may be affected by the presence of construction activities. Based on the general type of businesses present in this location and the availability of parking in nearby side streets this impact is not expected to be significant. Consultation would be undertaken with all affected businesses to establish those that may be affected and to organise construction so as to minimise overall impacts upon their operation.

Parking provisions are not proposed for construction staff vehicles within or adjacent to construction areas; instead construction workers would be encouraged to car-pool or utilise public transport services. However it is expected a portion of workers would travel via private vehicles which may also marginally increase the demand for on-street parking within the surrounding local streets. Generally, light vehicles used to transport staff to and from each zone would be parked on nearby local streets or public car parks.

Operational phase

Intersection performance

Operation traffic modelling was undertaken to assess intersection LoS and bus and general traffic travel times for the year 2021 with (‘Proposal’ scenario) and without the Proposal (‘do nothing’ scenario). The ‘Proposal’ scenario assumes that the entire B-Line Program is in place.

Generally, the LoS at key intersections within the Proposal area is not expected to change significantly between the 2021 ‘do-nothing’ and ‘Proposal’ scenarios.

Table 11 summarises the expected LoS for 2021 under the ‘do nothing’ and ‘Proposal’ scenarios during the AM and PM weekday peak.

Table 11 Intersection LoS for year 2021 - 'do nothing' and ‘Proposal’ scenarios. Worst case of each of the two hours of the peak presented.

Zone	Intersection	AM peak (7am to 9am) ‘Do nothing’	AM peak (7am to 9am) ‘Proposal’	PM peak (4:30pm to 6:30pm) ‘Do nothing’	PM peak (4:30pm to 6:30pm) ‘Proposal’
A	Pittwater Road/ Hawkesbury Avenue	C	**C**	**B**	**B**
B	Pittwater Road/ Kingsway	C	**B**	**B**	**B**
B	Pittwater Road/ Howard Avenue	C	**C**	**B**	**B**
B	Pittwater Road/ Oaks Avenue	B	**B**	**A**	**A**
B	Pittwater Road/ Fisher Parade	C	C	B	B

Zone	Intersection	AM peak (7am to 9am) ‘Do nothing’	AM peak (7am to 9am) ‘Proposal’	PM peak (4:30pm to 6:30pm) ‘Do nothing’	PM peak (4:30pm to 6:30pm) ‘Proposal’
B	Pittwater Road/ Pacific Parade	B	B	C	C
B	Pittwater Road/ Sturdee Parade	B	B	B	B

Generally, the overall network would operate at an acceptable LoS for year 2021 'Proposal' scenario, with no intersections operating worse than LoS ‘C’. The LoS at intersections within the Proposal area does not significantly deteriorate between 2016 and 2021. This indicates there is capacity at most intersections during the AM weekday peak to cater for the expected growth in traffic volumes.

The Proposal is anticipated to result in a comparable level of intersection performances throughout the Dee Why area, and in some cases an improvement, when compared to the 2021 ‘do nothing’ scenario.

Road network

Average operational travel times for buses and general traffic along Pittwater Road through the Proposal area were modelled (AECOM 2016a). The results of this modelling indicated that during the AM weekday peak:

- operational travel times for general traffic in both directions are largely consistent between the 2021 Do-nothing and Option scenarios, though both scenarios indicate an increase in travel time compared to the 2016 baseline
- travel time variations in both directions along the corridor between the 2021 option and do nothing scenario are within five seconds. This suggests that the B-Line proposal is not expected to significantly affect general traffic travel times in the AM peak when considered alongside the forecasted traffic growth.

During the PM weekday peak:

- the proposed option would decrease travel time through the Proposal area in the southbound direction by around one minute compared to the do nothing scenario. This is likely due to the proposed implementation of additional clearways and no-stopping zones in the counter-peak direction and associated increase in capacity that this would allow
- travel times in the northbound direction are forecast to be relatively consistent between the 2021 do nothing and option scenarios.

On this basis it is expected that the overall impact upon general traffic travelling through the Proposal area would be neutral during operation.

See ‘Bus Services’ below for detail of travel time impacts upon bus movements.

Pedestrian and bicycle facilities

Impacts upon pedestrian movements during operation of the Proposal would be limited to the slight diversion of pedestrians around the newly created bus indent south of Hawkesbury Avenue and slight alterations to kerb ramps at the new kerb blister north of Oaks Avenue. These would involve minimal change to ease of access or travel times for pedestrians and as such the overall impact is upon pedestrians is considered to be negligible.

The movement of bicycles through the Proposal area would be slightly improved through the implementation of extended bus lane hours through Dee Why. This extension would remove existing car parking along the southbound carriageway of Pittwater Road between Howard Avenue and Fisher road. This would eliminate the potential for interaction between parked vehicles and cyclists, including the opening of car doors into the path of cyclists and interactions whilst vehicles enter and depart parking spaces. On this basis the Proposal would have a minor positive impact for cyclists during operation.

Bus services

Average operational travel times for buses along Pittwater Road through the Proposal area were modelled (AECOM 2016a). Bus travel times would be improved through the Proposal area through the provision of the bus indent south of Hawkesbury Avenue and the provision of additional general traffic lanes separated from stopping buses within Dee Why. Travel times would also benefit from the extension of the bus lane operating hours south of Oaks Avenue in Dee Why, which would allow more efficient passage of all buses (local and B-Line) between the extended operation hours (extended to be 6am to 8pm).

The results of traffic modelling for this location indicated that during the AM weekday peak:

- under the 'Proposal' scenario in the southbound direction, there is a consistent benefit for travel times for all buses. Local bus travel times are expected to reduce by around one minute (9%), while B-Line bus times are expected to be around 100 seconds (15%) faster than local buses
- general traffic travel times in both directions are largely consistent between the 2021 'do nothing' and 'Proposal' scenarios. Variation in travel time between each scenario is within five seconds, suggesting that the Proposal (in addition to forecast growth) is not expected to significantly affect general traffic travel times.

During the PM weekday peak:

- bus travel times in the southbound direction would reduce by between 30 and 90 seconds when compared to the 'do nothing' scenario
- general traffic travel times in the northbound direction are expected to reduce by around one minute in the first peak hour, and would improve by around 80 seconds in the second hour.

During operation bus users would experience a beneficial impact through the provision of safer bus stops and overall improvements to travel times. This improvement would be experienced by both existing local bus passengers and those of the new B-Line service. Increases in safety would arise from the provision of the new bus indent south of Hawkesbury Avenue. This facility would allow stopping buses to depart the main carriageway; eliminating the need for general traffic to queue behind the bus while stopped and hence preventing the potential for rear-end crashes generally.

The provision of additional traffic lanes around the B-Line and local bus stop in central Dee Why would also improve safety in the same manner.

Parking

No parking spaces are expected to be lost as a result of the operation of the bus indent on Pittwater Road south of Hawkesbury Avenue (Zone A).

The operation of the Proposal within Zone B would result in the loss of parking currently available outside of the AM peak within central Dee Why. Specifically, these spaces would be lost along the southbound carriageway of Pittwater Road between Dee Why Parade and the intersection with Fisher Road. This would include the loss 29 parking spaces in total, including:

- around 14 parking spaces between Dee Why Parade and Howard Avenue (proposed to be no parking 24 hours)

- around eight parking spaces between Howard Avenue and Oaks Avenue (proposed to be no parking 24 hours)
- around seven parking spaces between Oaks Avenue and Fisher Road (proposed to be no parking between the hours of 10am and 8pm Monday to Sunday but remaining available between 8pm and 6am).

All of the above locations are currently designated as clearway between 6am and 10am Monday to Friday. All spaces lost within this location are currently ½ hour occupancy between 10am and 6pm Monday to Friday and 8:30 to 12:30pm Saturday. These spaces are unrestricted at all other non-clearway times.

Assuming each parking space in this location is currently occupied for its maximum duration during business hours (outside of clearway times) the Proposal would result in the loss of an estimated 406 total parking opportunities per day during the week.

The Northern Beaches B-Line Offset Parking Assessment (TfNSW, 2015a) indicated that around 49% of available parking is currently utilised along the eastern side of Pittwater Road (southbound). On this basis it is calculated that 199 parking occupants would be affected per day during the week (i.e. 49 percent of 406).

As part of a review of parking availability throughout Dee Why RMS commissioned parking occupancy surveys of this location. This investigation surveyed the number of vehicles parked along this section of Pittwater Road and within nearby side streets (within 500 m) between 11am and 2pm during the week and between 10am and 2pm on the weekend. The results of this survey indicated that demand for parking on Pittwater Road peaked at 29 vehicles at any time during the week with weekend demand typically peaking at 25 vehicles.

The survey further identified that at all times during the week adequate vacancies were available on side streets to accommodate the number of vehicles parked along Pittwater Road. During the weekend however demand exceeded vacancies between 10am and 12 pm on Saturday and Sunday by up to 15 spaces. During all other weekend survey periods vacancies exceeded demand.

Considering parking along Pittwater Road is not at full occupancy, and that alternative parking is available within a three to five minute walk of this location during the vast majority of the week, the impact upon parking within the vicinity of the Proposal would be minor.

6.1.3. Mitigation measures

A construction Traffic Management Plan would be prepared by the Contractor in consultation and included in the Contractors Environment Management Plan (CEMP), and provided to Northern Beaches Council. The construction TMP would be the primary management tool to manage potential traffic and pedestrian impacts associated with construction. The construction TMP, at a minimum, would include:

- Outline of the road closures and alternatives
- Pedestrian and cycle provisions throughout the construction period
- Outline of the consultation process to inform the community of any road, pedestrian or cycle changes.
- A commitment to maintain property accesses during the works. Any unexpected disturbances to property access would be discussed with the affected resident(s).

To manage the potential for cumulative traffic impacts, the Roads and Maritime Traffic Management Centre would coordinate road occupancy licences throughout the corridor.

Refer to Table 28 in Section 7.2 for a full list of mitigation measures.

6.2. Urban design, landscape and visual amenity

A visual impact assessment was undertaken for the Proposal in line with the Roads and Maritime *EIA-N04 Guideline for Landscape Character and Visual Impact Assessment* (Roads and Maritime, 2013). The findings of the assessment are summarised in this section.

6.2.1. Existing environment

The visual character of the Proposal area is typical of a main arterial road within an established urban environment. This includes residential and commercial land uses located in close proximity to Pittwater Road. Visual features dominating the Proposal area comprise road (and related) infrastructure, traffic, pedestrian and cycle paths and commercial buildings. In some locations landscaped street trees provide visual screening from the road corridor for customers, pedestrians, commercial and residential receivers and motorists.

Visual receivers within the Proposal area include:

- residents
- community facility users (e.g. Dee Why Library)
- local businesses
- vehicle-based receptors (i.e. drivers and passengers)
- pedestrians and cyclists.

Three visual receiver locations have been identified to represent key viewpoints to and from the Proposal. A qualitative assessment was undertaken to understand the potential impacts on views as a result of the Proposal at these locations. These locations are described in Table 12 and shown in Figure 10.

Table 12 Visual receivers within the Proposal Area

Zone	Receiver ID	Address	Land use	Purpose
A	A1	755 Pittwater Road, Dee Why	Residential and business	To assess the visual impact on staff and customers at a commercial property and residents.
B	B1	882 Pittwater Road, Dee Why	Residential and business	To assess the visual impact on staff and customers at a commercial property and residents.
B	B2	699 Pittwater Road, Dee Why	Local business	To assess the visual impact on staff and customers at a commercial property.

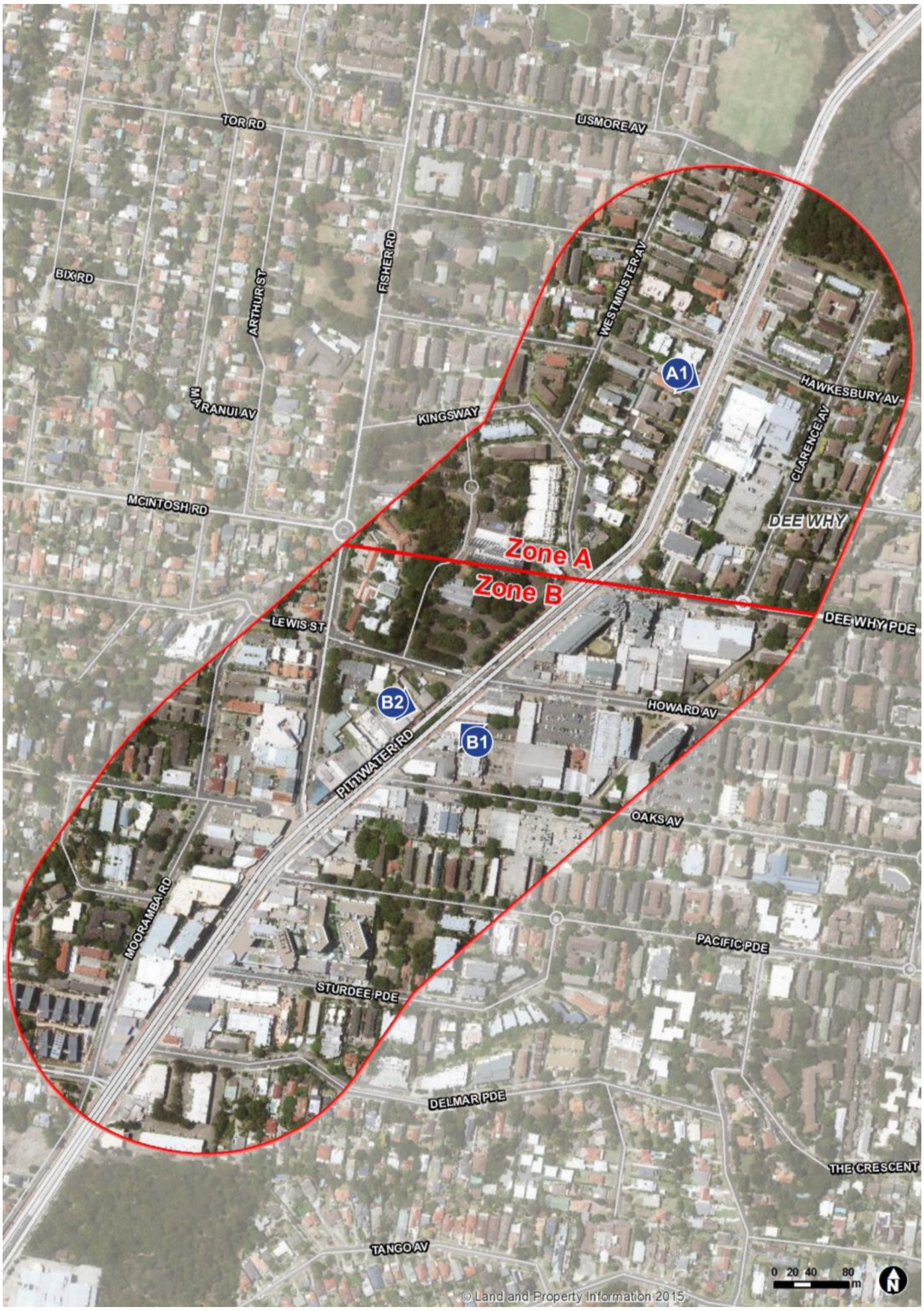

Figure 10 Visual impact assessment receiver locations

6.2.2. Potential impacts

Construction phase

Construction of the Proposal would result in temporary visual amenity impacts upon surrounding receivers within or adjacent to the Proposal area. General construction features that may affect visual amenity throughout all Zones would include:

- the presence of construction vehicles, machinery, equipment and personnel
- open excavations

- vegetation clearance
- temporary construction compounds including demountable buildings, storage containers, stockpiling areas, amenities and a perimeter fence with gates
- safety barriers/fencing
- stockpiled materials.

It should be noted that the majority of works within the Proposal area would be carried out at night in order to minimise impacts to traffic and access. As such construction would include temporary lighting for operational, safety and security purposes. Lighting installations would be placed to minimise light spill to adjoining road corridors and occupied residential or commercial areas.

The Proposal would be undertaken progressively along Pittwater Road. Therefore the majority of visual amenity impacts would move along the alignment resulting in rolling temporary visual impacts at isolated locations (i.e. Zones) for short-term periods.

Visual impacts during construction within Zone A would include the presence of several of the above elements including construction plant and materials, open excavations, and safety barriers. It may be necessary to temporary stockpile materials at this location though these would generally be temporary and would be utilised or removed within the space of each construction shift i.e. these would not be left at the site outside of active construction.

Visual impacts within Zone B would include the same construction related impacts as Zone A, with the added impact associated with the removal of vegetation within the median between Howard Avenue and Oaks Avenue.

The visual impact associated with the presence of construction elements would be mitigated by the use of night works. This would naturally limit views to the Proposal area during construction. The number of potentially affected receivers would also be naturally reduced during this period.

The overall construction duration for the Proposal would be around nine months. Construction activities would not occupy the entire Proposal area for this entire period but would move progressively as certain sections are completed.

The Manly Vale Commuter Car Park construction compound would include a site office, construction vehicles, equipment, fencing, signage material stockpiling and storage. Impacts upon the local visual scenario would be mitigated through the use of opaque or semi-opaque shade coth to cover all temporary fencing. At night, the site compound would be lit for passive security and surveillance. Such lighting would be located so at minimise light spill off site, particularly into nearby residential areas.

Generally the environmental impacts of the construction compound would largely be consistent with those previously assessed in the Manly Vale Commuter Car Park and B-Line Stops Review of Environmental Factors (TfNSW 2016). The additional impact of the Proposal would be limited to a longer occupation of the site than originally anticipated. This would extend the duration of previously identified impacts upon surrounding businesses and residents by around nine months.

The overall visual impact of the construction of the Proposal is considered to be moderate, given the scale and length of construction activities in the context to the existing urban environment and the temporary nature of the proposed works.

Mitigation measures to manage impacts to visual amenity and urban design during construction of the Proposal are outlined in Section 6.2.3. With the implementation of these measures, construction of the Proposal is not expected to result in a significant impact on the urban design, landscape and visual amenity of the Proposal area.

Operational phase

An assessment of the visual sensitivity and magnitude of each visual receiver location was undertaken for the operational phase of the Proposal. The sensitivity of the receiver is assessed based upon the extent to which it can accept change of a particular type and scale without adverse impacts on its character. The magnitude of change affecting a visual receiver depends on factors such as extent of visibility, degree of obstruction of existing features, degree of contrast with the existing view, angle of view, duration of view and distance from the Proposal. The visual impact grading matrix was used to assign a rating to each visual receiver (refer to Table 13).

The results of the assessment are provided in Table 14.

Table 13 Visual impact grading matrix

Sensitivity \ Magnitude	High change	Moderate change	Low change	Negligible change
High	High	High-moderate	Moderate	Negligible
Moderate	High-moderate	Moderate	Moderate-low	Negligible
Low	Moderate	Moderate-low	Low	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible

Table 14 Operational visual impact assessment

ID	Proposed works	Sensitivity	Magnitude	Rating
A1	A new indented bus bay south of the Pittwater Road and Hawkesbury Avenue intersection (southbound) and reconfiguration of existing line markings.	Commercial customers and residents would have direct and immediate views towards the Proposal. The sensitivity would be moderate.	Visibility of the Proposal would be direct, however the land use would not change and the new elements to be introduced are consistent with road infrastructure. The magnitude of change would be moderate.	Moderate

ID	Proposed works	Sensitivity	Magnitude	Rating
B1	Reconfiguration of southbound lanes on Pittwater Road from Howard Avenue to Oaks Avenue to accommodate four lanes of traffic, including vegetation removal.	Commercial customers and residents would have direct and immediate views towards the Proposal. The loss of median vegetation would open up views to the northbound lane of Pittwater Road. The sensitivity would be moderate.	Visibility of the Proposal would be direct, however the land use would not change and the new elements to be introduced are consistent with road infrastructure. Visual changes would be limited to lane reconfiguration, which is considered a minor change. The magnitude of change would be low.	Moderate to low
B2	Extension of the existing right turn lane from Pittwater Road (northbound) into Oaks Avenue.	Commercial customers would have direct and immediate views towards the Proposal. Visual changes would be minor and would comprise a rearrangement of road infrastructure. No vegetation loss or land use change is proposed. The sensitivity would be low.	Visibility of the Proposal would be direct, however the land use would not change and the new elements to be introduced are consistent with road infrastructure. Visual changes would be limited to lane reconfiguration, which is considered a minor change. The magnitude of change would be low.	Low

Overall, the Proposal is considered to have a moderate to low visual impact on the majority of people living, working in or travelling through the urban landscape of Dee Why during operation.

6.2.3. Mitigation measures

The following mitigation measures are proposed to manage visual impacts:

- the site would be kept tidy and well maintained during construction, including removal of all rubbish at regular intervals. There should be no storage of materials beyond the construction boundaries
- light spill from the road corridor into adjacent visually sensitive properties is to be minimised by the use of cut-off lighting, directing construction lighting into the construction areas and ensuring the site is not over-lit. This includes the sensitive placement and specification of lighting to minimise any potential increase in light pollution
- temporary hoardings, barriers, traffic management and signage would be removed when no longer required
- work/site compounds would be screened where practical, with shade cloth or similar material to minimise visual impacts
- the construction contractor would restore any areas that are affected by construction with appropriate landscape treatments
- an urban design and landscape plan would be prepared as part of the CEMP in consultation with relevant stakeholders.
- Vegetation replacement in accordance with the TfNSW Vegetation Offset Guide (TfNSW, 2013b)

Refer to Table 28 in Section 7.2 for a full list of mitigation measures.

6.3. Noise and vibration

A Noise and Vibration Impact Assessment was undertaken by AECOM for the Proposal (AECOM 2016b). The assessment applied the Roads and Maritime Construction Noise Estimator tool to prepare the construction noise assessment and to determine construction noise levels, noise impacts at the most affected sensitive receivers and, where necessary, recommend appropriate mitigation measures to reduce and manage noise and vibration impacts from the Proposal.

As operational noise levels are expected to remain largely unchanged, no quantitative modelling of operational noise impacts was undertaken. The findings of the assessment are summarised in this section.

6.3.1. Existing environment

Sensitive noise receivers

Attended and unattended noise monitoring was undertaken in August and September 2016 at two representative receiver locations within the Proposal area (946 Pittwater Road and 727 Pittwater Road). Monitoring locations are shown in Figure 11 and reflect Zones A and B of the Proposal.

To assist in determining noise criteria for the receivers surrounding the Proposal, three noise catchment areas (NCA) were identified. NCA_A (logger location 2) comprises the area of Zone A, NCA_B (logger location 1) comprises the area of Zone B, and NCA_C covers non-facing properties away from the immediate construction area (refer to Figure 2). Both NCA_A and NCA_B have a similar existing noise environment.

Figure 11 Noise catchment areas and noise logger locations

Background noise levels

Monitoring determined that the existing noise environment at both logging locations are typical of suburban/urban noise environments alongside major transport corridors, where day time and evening background levels are high due to heavy and continuous traffic flows. The night time background noise level tends to decrease substantially as a result of reduced traffic flows.

A summary of the existing background noise during the day, evening and night for both monitoring locations is provided in Table 15.

Table 15 Existing background and ambient noise levels (dB(A))

NCA	Logger number	Period[1]	Rating Background Level (RBL) (L_{90})[2]	Ambient noise levels (L_{Aeq})[3]
NCA_A	**2**	Day	51 dB(A)	62 dB(A)
		Evening	48 dB(A)	62 dB(A)
		Night	37 dB(A)	55 dB(A)
NCA_B	**1**	Day	58 dB(A)	71 dB(A)
		Evening	55 dB(A)	70 dB(A)
		Night	42 dB(A)	66 dB(A)
Construction compound		Day	54 dB(A)	-
		Evening	48 dB(A)	-
		Night	38 dB(A)	-

Notes:

1. *day is defined as 7am to 6pm, Monday to Saturday and 8am to 6pm Sundays and public holidays*
   evening is defined as 6pm to 10pm, Monday to Sunday and public holidays
   night is defined as 10pm to 7am, Monday to Saturday and 10pm to 8am Sundays and public holidays.
2. *the rating background level (RBL) (L_{A90}) represents the noise level exceeded for 90 per cent of the monitoring period.*
3. *the ambient noise level represents the average noise level over the monitoring period.*

Construction noise criteria

The EPA's *Interim Construction Noise Guideline* (ICNG) (Department of Environment and Climate Change, 2009) is the principal guideline for the assessment and management of construction noise in NSW. The ICNG recommends standard hours of construction as:

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm
- Sundays and public holidays: no works.

Noise management levels (NMLs) have been determined for receivers in accordance with the ICNG. The ICNG outlines NMLs for non-residential receivers such as commercial properties, schools and places of worship. NMLs for residential receivers are calculated based on the rating background level (RBL) + 10 dB(A) (for daytime periods) or the RBL + 5 dB(A) (for evening and night time periods). A 'highly noise affected' level of 75 dB(A) for residential receivers represents the point above which there may be strong community reaction to noise.

Where works exceed the NMLs, all reasonable and feasible measures (such as equipment selection and location, construction scheduling and respite periods) should be implemented to reduce noise levels as far as practicable.

The construction NMLs developed for the Proposal for sensitive receivers are listed in Table 16 and Table 17.

Table 16 Construction NMLs for residential receivers

NCA	Period	RBL (L_{A90})	Standard hours NMLs ($L_{Aeq,15min}$)	Out of hours NMLs ($L_{Aeq,15min}$)
NCA_A	Day	51 dB(A)	61 dB(A)	61 dB(A)
	Evening	48 dB(A)	N/A	53 dB(A)
	Night	37 dB(A)	N/A	42 dB(A)
NCA_B	Day	58 dB(A)	68 dB(A)	68 dB(A)
	Evening	55 dB(A)	N/A	60 dB(A)
	Night	42 dB(A)	N/A	47 dB(A)

Table 17 Construction noise management levels for non-residential receivers

Land use	NMLs, $L_{Aeq,15min}$ (applies when properties are in use)
Classrooms at schools and other educational institutions	55 dB(A)
Places of worship	55 dB(A)
Childcare centres	55 dB(A)
Medical facilities	55 dB(A)
Library	55 dB(A)
Girl Guide Hall	65 dB(A)
Commercial premises	70 dB(A)

Notes:

1. *these external NMLs are based upon a 45 dB(A) internal NML and a 10 dB reduction from outside to inside through an open window.*

Sleep disturbance noise goals have been established for residential receivers based on the *NSW Road Noise Policy* (Department of Environment, Climate Change and Water, 2011). Based on this policy, the sleep disturbance criteria for both NCAs are a screening level of 45 dB(A) $L_{A1(1\ minute)}$ and an awakening reaction at 60-65 dB(A) $L_{A1(1\ minute)}$.

Construction vibration criteria

When assessing vibration there are two categories to consider: one related to the impact of vibration to human comfort and one relating to the impact on building structures (cosmetic damage).

Human comfort

The assessment of intermittent vibration outlined in the NSW EPA guideline *Assessing Vibration: A Technical Guideline* (AVTG) is based on Vibration Dose Values (VDVs). Maximum and preferred VDVs for intermittent vibration arising from construction activities are listed in

Table 18. The VDV criteria are based on the likelihood that a person would be annoyed by the level of vibration over the entire assessment period.

Table 18 Preferred and maximum vibration dose values for intermittent vibration (m/s1.75)

Location	Period	Preferred	Max
Critical areas[1]	Day or night time	0.1	0.2
Residences	Daytime[3]	0.2	0.4
Residences	Night time[4]	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or night time	0.4	0.8
Workshops[2]	Day or night time	0.8	1.6

Notes:

1. *Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. Places where sensitive equipment is stored or delicate tasks are undertaken require more stringent criteria than the residential criteria specified above.*
2. *Examples include automotive repair shops, manufacturing or recycling facilities. This includes places where manufacturing, recycling or repair activities are undertaken but do not require sensitive or delicate tasks.*
3. *Daytime period is defined as 7am – 10pm under BS 6472-1992 Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz).*
4. *Night period is defined as 10pm – 7am under BS 6472-1992.*

Structural damage to buildings

There is currently no Australian Standard that provides guidance for assessing cosmetic building damage caused by vibration. However, the German standard (DIN 4150) provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are presented in Table 19. DIN 4150 states that buildings exposed to higher levels of vibration than recommended limits would not necessarily result in damage. The vibration criteria provided below in Table 19 would be adopted for the management of vibration impacts on structures, and include more conservative values for heritage structures.

Table 19 DIN 4150: Structural damage safe limits for building vibration velocity

Group	Type of Structure	At foundation - less than 10 Hz	At foundation - 10 to 50 Hz	At foundation - more than 50 Hz	At the horizontal plane of the highest floor – all frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20 mm/s	20 to 40 mm/s	40 to 50 mm/s	40 mm/s
2	Dwellings and buildings of similar design and/or use	5 mm/s	5 to 15 mm/s	15 to 20 mm/s	15 mm/s

Group	Type of Structure	At foundation - less than 10 Hz	At foundation - 10 to 50 Hz	At foundation - more than 50 Hz	At the horizontal plane of the highest floor – all frequencies
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. heritage listed buildings)	3 mm/s	3 to 8 mm/s	8 to 10 mm/s	8 mm/s

Notes:

1. At frequencies above 100 Hz, the values given in this column may be used as minimum values.

6.3.2. Potential impacts

Construction phase

To assess the potential noise impacts from the proposed construction works, the construction stages described in Chapter 3 were further divided into indicative scenarios. Scenarios for each construction stage were modelled based on the likely construction equipment that would be used to understand the potential noise impact for each stage. Scenarios are outlined in Table 20.

Table 20 Construction assessment scenarios

Scenario	Activity	Scenario/ Stage	Equipment	Timing
Site mobilisation and establishment	Establishment of site compound (erect fencing, tree protection zones, site offices, amenities and plant/material storage areas), establish temporary facilities as required (e.g. traffic control)	1	• trucks • scissor lift • franna crane	Standard hours
Enabling works	survey and potholing, removal of identified vegetation and investigation and relocation of services (where required)	2	• excavator • dump truck • franna crane • pneumatic hammer • concrete saw • vacuum truck • backhoe • generator	Outside standard hours

Scenario	Activity	Scenario/ Stage	Equipment	Timing
Road works	Demolition of the existing concrete road, road verge, kerbs and pedestrian pathways, resurfacing and construction of new road pavement for slip lanes, bus bays, right/left hand turns etc.	3	• pavement laying machine • dump truck • asphalt truck and sprayer • concrete truck • smooth drum roller • concrete saw	Outside standard hours
Drainage, line marking and signalling	Upgrades to kerbs, gutters and footpaths and line marking and new signalling	4	• backhoe • franna crane • excavator • concrete truck • truck compressor • vibratory roller • truck	Standard hours

A summary of the predicted construction noise levels for each scenario during standard working hours for sensitive receivers is shown in Table 21.

Table 21 Predicted construction noise levels for each scenario during standard hours (dB(A)) for receivers

NCA	Distance to closest receiver	NML	1	2	3	4
NCA_A	15 metres	61	**79**	**80**	**79**	**82**
NCA_B	10 metres	68	**80**	**81**	**80**	**83**
NCA_C	115 metres	60	**42**	**43**	**42**	**45**

*Note: Items in **BOLD** indicate a predicted noise impact above the NML and a 'highly affected' residential receiver with a noise level of 75 dB(A) or greater.*

The predicted noise levels indicate that there would be exceedances of the residential and non-residential noise management levels during standard hours within NCA_A and NCA_B for all stages of construction. There would be no exceedance of noise management levels within the non-facing noise catchment area (NCA_C)

For NCA_A, noise would be associated with the construction of the proposed bus indent along Pittwater Road adjacent to Dee Why RSL. In this noise catchment area, the most affected receivers would be patrons of Dee Why RSL. During construction, not all equipment would be operating simultaneously at all times in any one location (which is the worst case scenario assumed in the assessment). This would result in a slight reduction in predicted noise levels. Further, patrons would be located inside and all windows on the western face of Dee Why RSL are permanently closed. The level of impact may change depending on the final construction methodology and further assessment would be undertaken if required.

For NCA_B, noise would be associated with the narrowing of the existing median and installation of the kerb 'blister' along Pittwater Road as described in Section 3.1. The most affected receivers in this noise catchment area would be businesses and residents adjacent to these areas of works along Pittwater Road. During construction, not all equipment would be operating simultaneously at all times in any one location (which is the worst case scenario assumed in the assessment). This would result in a slight reduction in predicted noise levels. Further, no noisy works would be undertaken after midnight.

No exceedances of noise management levels are predicted for NCA_C.

The exceedances shown above in Table 21 would be mitigated by implementing standard Roads and Maritime noise mitigation measures where feasible and reasonable (refer to Section 7.2). The exceedances would be short-term and limited to the duration of the construction period.

Out of hours works

Out of hours works would be required for the Proposal to facilitate the road works along Pittwater Road to minimise traffic impacts.

The predicted construction noise levels for each scenario (refer to Table 20 for scenarios) during out of hours works during the day, evening and night for sensitive receivers is shown in Table 25, Table 23 and Table 24.

Table 22 Predicted construction noise levels for each scenario during out of hours (day) works (dB(A)) for receivers

NCA	Distance to closest receiver	NML	1	2	3	4
NCA_A	15 metres	61	**79**	**80**	**79**	**82**
NCA_B	10 metres	68	**80**	**81**	**80**	**83**
NCA_C	115 metres	60	**42**	**43**	**42**	**45**

*Note: Items in **BOLD** indicate a predicted noise impact above the NML and a 'highly affected' residential receiver with a noise level of 75 dB(A) or greater.*

Table 23 Predicted construction noise levels for each scenario during out of hours (evening) works (dB(A)) for receivers

NCA	Distance to closest receiver	NML	1	2	3	4
NCA_A	15 metres	53	**79**	**80**	**79**	**82**
NCA_B	10 metres	60	**80**	**81**	**80**	**83**
NCA_C	115 metres	50	**42**	**43**	**42**	**45**

*Note: Items in **BOLD** indicate a predicted noise impact above the NML and a 'highly affected' residential receiver with a noise level of 75 dB(A) or greater.*

Table 24 Predicted construction noise levels for each scenario during out of hours (night) works (dB(A)) for receivers

NCA	Distance to closest receiver	NML	1	2	3	4
NCA_A	15 metres	42	**79**	**80**	**79**	**82**
NCA_B	10 metres	47	**80**	**81**	**80**	**83**
NCA_C	115 metres	45	**43**	**42**	**43**	**45**

*Note: Items in **BOLD** indicate a predicted noise impact above the NML and a 'highly affected' residential receiver with a noise level of 75 dB(A) or greater.*

The predicted noise levels indicate that exceedances of the residential and non-residential noise management levels during out of hours works would likely occur during all assessed stages of construction for NCA_A and NCA_B. There would be no exceedances within NCA_C.

The most affected receivers would be consistent with those affected during standard working hours as outlined above.

Where feasible, construction activities would be scheduled to be undertaken during standard hours, however for a number of reasons (including safety of workers/general public and traffic impacts) some construction activities would be required to be undertaken outside of standard working hours. If extended out of hours works are required, additional mitigation measures such as respite periods would be applied (refer to Section 6.3.3).

Out of hours works would be assessed in more detail following confirmation of the construction methodology by the Contractor and may be subject to further approval by Roads and Maritime. This would include appropriate community notification and mitigation measures in accordance with appropriate Roads and Maritime policies.

Sleep disturbance

Noise from loud construction activities has the potential to cause sleep disturbance at the nearest residential receivers.

The predicted results for the Proposal indicates that the sleep awakening reaction criterion of 60 to 65 dB(A) is predicted to be exceeded within NCA_A and NCA_B during all construction stages. Where feasible, noisy works would be undertaken during the daytime and would not occur after midnight.

The predicted construction noise levels are typically the worst case noise levels and the majority of actual noise levels are likely to be less than those predicted. The potential for sleep disturbance would be considered further following confirmation of the construction methodology by the Contractor and would be subject to additional mitigation measures, if required.

Construction traffic

The Traffic and Transport Assessment (AECOM 2016a) identified that approximately five heavy vehicles would be required on site per day. It is estimated that a maximum of two vehicles per hour would access the site. Additionally, 18 light vehicles would make two-way trips. Light vehicles would generally arrive between 6.30am and 7am and depart between 5pm and 5.30pm. Existing hourly movements (both heavy and light vehicles combined) on Pittwater Road are between approximately 500 movements per hour at 5am with an afternoon peak of 3,500 movements at 5pm. The movements associated with the construction traffic are relatively insignificant and may increase noise levels by up to 0.2 dB(A). This increase in noise would not have a perceptible change on existing road traffic throughout the Proposal area.

Construction vibration

During construction, vibration generating machinery would be required including jackhammers, wacker packers and bored piling rigs. Construction activities that require the use of this machinery have the potential to create vibration which can disturb nearby sensitive receivers.

The Noise and Vibration Impact Assessment (AECOM 2016b) concluded that the distances from the nearest receivers to the operation of vibration intensive machinery and/or plant would be sufficient to mitigate potential building impacts, including cosmetic damage, and would not result in exceedances of human comfort criteria at nearby receivers.

In order to avoid structural impacts, the proposed works would need to be undertaken in accordance with the safe working distances outlined in Table 25. Where work is required within the safe working distances of structures, site-specific safe working distances would be established on-site prior to the vibration generating works commencing. In addition, building surveys of sensitive structures would be undertaken in order to assess potential for increased susceptibility to building damage from vibration.

Vibration intensive work would not proceed within the safe working distances unless a permanent vibration monitoring system is installed approximately one metre from the building footprint, to warn operators in real time (e.g. flashing lights, SMS, or alarm system) when vibration levels are approaching the maximum vibration criteria.

Table 25 Safe working distances of vibration intensive equipment (in metres)

Machinery/plant	Rating/ Description	Safe work distance: Cosmetic damage – residential/commercial	Safe work distance: Cosmetic damage - heritage
Vibratory roller	1 - 2 Tonnes	5	15 - 20
	2 - 4 Tonnes	6	20
	4 - 6 Tonnes	12	40
	7 - 13 Tonnes	15	100
	Typically 13 - 18 Tonnes	20	100
	Less than 18 Tonnes	25	100
Small hydraulic hammer	5 - 12 Tonnes	2	7
Small hydraulic hammer	5 - 12 Tonnes	7	23
Medium hydraulic hammer	12 - 18 Tonnes	22	73
Large hydraulic hammer	18 - 34 Tonnes	2 - 20	20
Vibratory pile driver	Sheet piles	2	N/A
Pile boring	≤ 800 mm	Avoid contact with structure	Avoid contact with structure
Jack hammer	Handheld	5	15 - 20

Operational phase

No substantial noise or vibration impacts associated with the operation of the Proposal are anticipated.

6.3.3. Mitigation measures

Table 26 Mitigation measures specific to each works Zone as per RMS *Construction Noise and Vibration Guideline*

Zone	Standard hours	Day out of hours	Evening out of hours	Night out of hours
A	Notification, verification, phone calls, respite offer	Verification, individual briefings, notifications, respite period 1, duration respite, phone calls, specific notification	Verification, individual briefings, notifications, respite period 1, duration respite, phone calls, specific notifications	Alternative accommodation, verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite
B	Notification, verification	Verification, individual briefings, notifications, respite period 1, duration respite	Verification, individual briefings, notifications, respite period 1, duration respite, phone calls, specific notifications	Alternative accommodation, verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite
Construction compound	Notification	Notification, respite period 1, duration respite	Notification, respite period 1, duration respite	Verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite

- A Construction Noise and Vibration Management Plan (CNVMP) would be prepared. The CNVMP would include the following:
    - identification of nearby residences and other sensitive land uses
    - description of all approved hours of work
    - description and identification of all construction activities, including work areas, equipment and duration
    - description of what work practices (generic and specific) would be applied to minimise noise and vibration
    - a complaints handling process
    - noise and vibration monitoring procedures
    - overview of community consultation required for identified high impact works.
- all residents impacted by noise from the proposed works which are expected to exceed the construction noise management levels should be consulted prior to the commencement of construction. The highest consideration should be given to those that are predicted to be most affected as a result of the works. Information provided to residents should include:
    - programmed times and locations of construction work
    - the hours of proposed works
    - construction noise and vibration impact predictions

    - construction noise and vibration mitigation measures to be implemented on site
- community consultation regarding construction noise and vibration would be detailed in the Community Involvement Plan for the construction of the project and would include a 24 hour hotline and complaints management process.
- for out-of-hours works, consultation would take place with consideration to measures outlined in Roads and Maritime's Construction Noise and Vibration guideline and Strategy 2 of the ICNG
- induction and training would be provided to relevant staff and sub-contractors outlining their responsibilities with regard to noise and vibration
- deliveries would be carried out during standard construction hours where feasible and reasonable
- a protocol would be developed to identify the need for, and provision of, respite measures for residential receivers in accordance with the ICNG. Respite measures may include appropriate timetabling of noisy works or the restriction to the hours of construction activities resulting in impulsive or tonal noise (such as rock hammering, pile driving), or other appropriate measures agreed between the contractor and residential receiver such as temporary alternative accommodation
- the following measures would be implemented to reduce and manage noise and vibration impacts associated with construction traffic:
    - truck drivers would be advised of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (i.e. minimising/restricting the use of engine compression brakes, and no extended periods of engine idling)
    - site access and egress points would be located away from residences and other sensitive land uses, where feasible and reasonable
    - deliveries and spoil removal would be planned to avoid queuing of trucks on or around the compounds
    - construction sites would be arranged to limit the need for reversing associated with regular/repeatable movements (e.g. trucks transporting spoil) to minimise the use of reversing alarms
    - where feasible and reasonable, non-tonal reversing alarms would be used, taking into account the requirements of the Workplace Health and Safety legislation
    - spoil would be moved during the day where practical, and feasible and reasonable management strategies would be investigated in consultation with the NSW Environment Protection Authority to minimise the volume of heavy vehicle movements at night
- Appropriate plant would be selected for each task to minimise the noise contributions
- alternative works methods such as the use of hydraulic or electric-controlled units in place of diesel units would be considered and implemented where feasible and reasonable. The use of alternative machines that perform the same function, such as rubber wheeled plant, would be considered in place of steel tracked plant
- all equipment would be regularly inspected and maintained to ensure it is in good working order
- plant should be located on site with as much distance as possible between the plant and noise sensitive receivers. Noisy equipment would be orientated away from residential receivers where feasible and reasonable

- a noise monitoring program would be implemented to assist in confirming and controlling the site specific potential for disturbance at particularly sensitive localities at the commencement of activities and periodically during construction. The results would be reviewed to determine if additional mitigation measures are required. All measurements would be undertaken in accordance with Australian Standard 1055.1-1997 – Acoustics – Description and measurement of environmental noise, Part 1: General procedures.
- if regenerated noise is reported to be a problem during vibration intensive works, attended and/or unattended noise measurements would be undertaken within the relevant building spaces to determine the level of regenerated noise
- equipment size would be selected taking into account the safe working distances and the distance between the area of construction and the most affected sensitive receiver. The use of less vibration intensive methods of construction or equipment would be considered where feasible and reasonable when working in proximity to existing structures.
- wherever reasonable and reasonable, vibration intensive works should be limited to less sensitive times of the day
- if the use of vibration intensive plant cannot be avoided within the safe working distance for cosmetic damage to existing structures the following procedure would occur as a minimum:
    - notification of the works to the affected residents and community
    - works would not proceed until attended vibration measurements are undertaken.
- If ongoing works are required a temporary relocatable vibration monitoring system would be installed to warn operators (via flashing light, audible alarm, short message service (SMS) etc.) when vibration levels are approaching the cosmetic damage objective
- no noisy works (including concrete sawing) are to be undertaken after midnight.

Refer to Table 28 in Section 7.2 for a full list of mitigation measures.

6.4. Aboriginal heritage

6.4.1. Existing environment

The Proposal area is located around 800 metres west of the Tasman Sea with Zone A located approximately 200 metres south-west of Dee Why Lagoon. The Proposal area forms part of a landscape that was used by the traditional Aboriginal owners, the Guringai for many thousands of years prior to European settlement.

There are more than 300 known Aboriginal heritage sites in the Warringah LGA. The potential for the discovering of new sites in undisturbed areas is considered to be relatively high, due to the area’s unique landscape features with sandstone, beaches, lagoons and creek lines (Warringah Council, 2016).

Certain landscape features can often indicate the likely presence of Aboriginal objects, such as nearby waterways, sand dune systems, ridge tops, ridge lines, headlands, cliff faces and rock caves/shelters. Given its proximity to the coast line, the Proposal is considered to be located within a high risk Aboriginal landscape. However, the extensive landscape modification and high level of ground disturbance that has occurred within the Proposal area as a result of general road and other urban development suggests that the presence of previously unidentified culturally sensitive buried items within the Proposal area is unlikely.

A due diligence assessment was undertaken for the Proposal in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (DECCW, 2010). An Aboriginal Heritage Information Management System (AHIMS) search was undertaken for the Proposal area with a 200 metre radial buffer for the entire Proposal area on 11 July 2016. Five registered AHIMS sites were identified in the search including:

- 45-6-0018 – located about 350 metres east of Zone B
- 45-6-2793 – located about 350 metres east of Zone B
- 45-6-2791 – located about 400 metres south-east of Zone B
- 45-6-0727 – located about 750 metres south-east of Zone B
- 45-6-1253 – located about 900 metres north-west of Zone A.

There are no registered AHIMS sites located within 300 metres of proposed works.

6.4.2. Potential impacts

Construction phase

Construction of the Proposal would involve excavation and other ground disturbing activities associated with the demolition and construction of new road (and related) infrastructure, and trenching for the relocation of services. Such activities have the potential to affect Aboriginal heritage sites, if present.

As no previously identified Aboriginal heritage items are known to be located in the vicinity of the Proposal site and the land subject to proposed works has been the subject of extensive historical disturbance the potential for unknown Aboriginal items to be present is considered to be low. However, the Proposal is located within a high risk Aboriginal landscape being within proximity of the coast and Dee why lagoon.

An unexpected finds procedure for the management of previously unidentified Aboriginal heritage items is outlined in Section 6.4.3 and would be implemented in the unlikely event that any are encountered.

Operational phase

A Stage 1 assessment was undertaken by Roads and Maritime in accordance with the Procedure for Aboriginal cultural heritage consultation and investigation (RMS 2011). The assessment determined that the Proposal is unlikely to have an impact on Aboriginal cultural heritage. The assessment was based on the following due diligence considerations:

- the Proposal is unlikely to harm known Aboriginal objects or places
- the AHIMS search did not indicate any known Aboriginal objects or places in the immediate study area
- plotting of identified Aboriginal heritage items places all items outside the Proposal footprint
- the study area does not contain landscape features that indicate the presence of Aboriginal objects, based on the Office of Environment and Heritage's Due diligence Code of Practice for the Protection of Aboriginal objects in NSW and the Roads and Maritime Services' procedure.

A Stage 1 Clearance Letter has been issued by the Roads and Maritime Cultural Heritage Officer for the Proposal.

6.4.3. Mitigation measures

The following mitigation measure is proposed to minimise impacts on Aboriginal heritage:

- If Aboriginal heritage items are uncovered during the works, all works in the vicinity of the find must cease and Roads and Maritime Environment staff contacted immediately. Steps in the Roads and Maritime Services *Standard Management Procedure: Unexpected Heritage Items* must be followed.

Refer to Table 28 in Section 7.2 for a full list of mitigation measures.

6.5. Non-Aboriginal heritage

6.5.1. Existing environment

A search of World Heritage List, National Heritage List, Commonwealth Heritage List, the Register of the National Estate (non-statutory archive), NSW State Heritage Register, State Agency Section 170 Heritage and Conservation Resisters and the Warringah LEP 2011 was undertaken for the Proposal. Non-indigenous heritage listed items within 200 metres of the Proposal are listed in Table 27.

Table 27 Non-Indigenous heritage items within the vicinity of the Proposal area

Listing	Item	Significance	Proximity to the Proposal
Zone A			
Warringah LEP 2011	Dee Why Lagoon and Reserve (ID C5)	Local	200 metres to the north
Zone B			
Warringah LEP 2011	Street tree on the corner of David Avenue and Pittwater Road (ID I39)	Local	Adjacent to the west of Pittwater Road
Warringah LEP 2011	Civic Centre landscaping (ID I137)	Local	Adjacent to the west of Pittwater Road
Warringah LEP 2011	Dee Why Public Library (ID I50)	Local	Adjacent to the west of Pittwater Road
Warringah LEP 2011	Pacific Lodge (Salvation Army) (ID I43)	Local	150 metres west
Warringah LEP 2011	Dee Why Fire Station (ID I42)	Local	170 metres west
Warringah LEP 2011	Commonwealth Bank (ID I48)	Local	Adjacent to the west of Pittwater Road
NSW Fire Brigades S.170 Register	Dee Why Fire Station (ID 4690021)	State	170 metres west

Figure 12 shows the location of heritage items surrounding the Proposal.

No non-indigenous heritage items were identified within 200 metres of the Manly Vale Commuter Car Park construction compound.

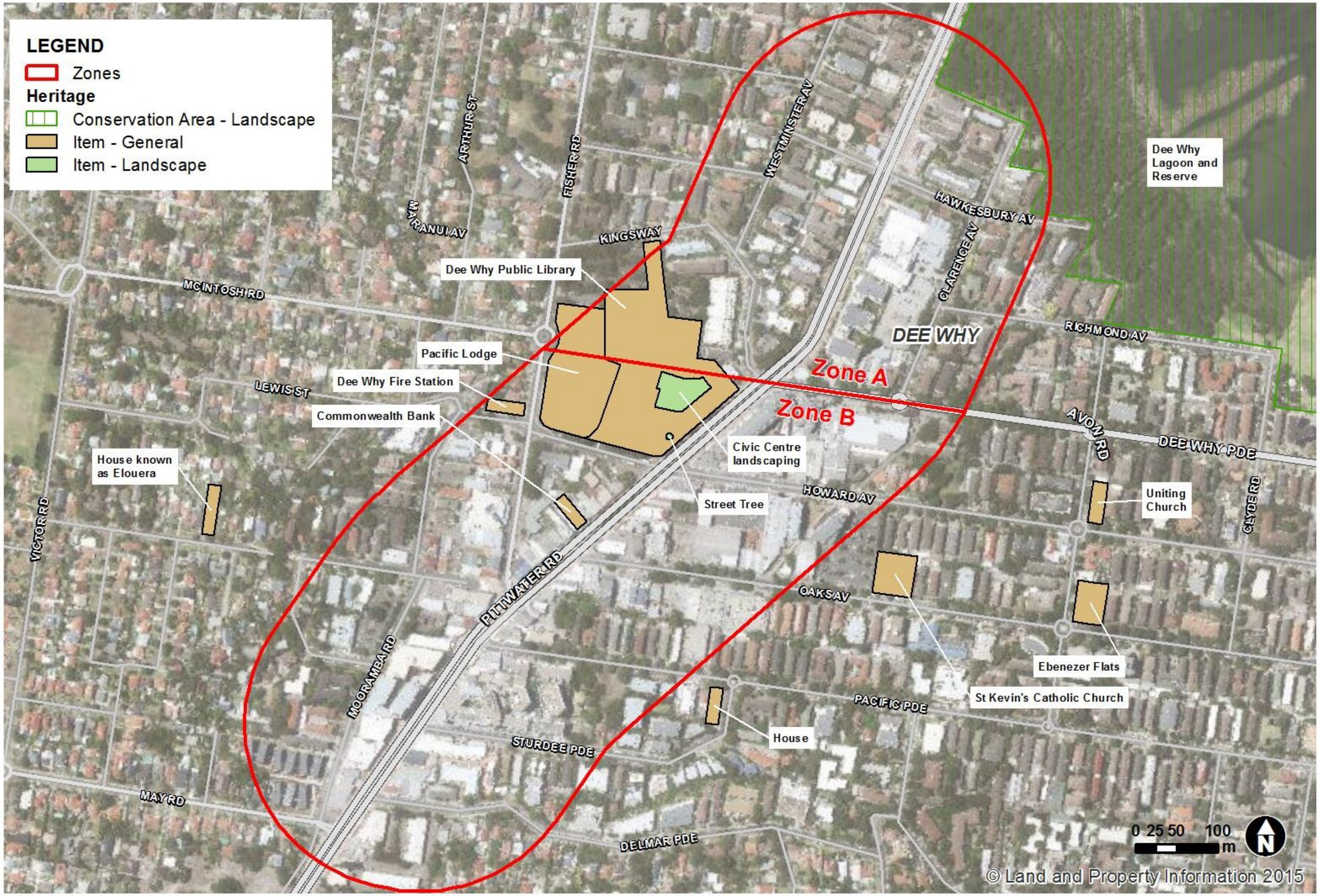

Figure 12 Non-Aboriginal heritage items within the vicinity of the Proposal

6.5.2. Potential impacts

Construction phase

There are no known non-Aboriginal heritage items located within the Proposal area. While there are several heritage items located adjacent to the proposed works, generally the structures within these listings are located at an adequate buffer distance from the Proposal so as to not be affected (e.g. Dee Why Library). The closest heritage structure is the Commonwealth Bank building listed on the Warringah LEP 2011 (ID I48), located about five metres from the proposed works.

Although proposed works would not extend into the curtilage of heritage items identified in Table 27, there is potential for structural impacts from vibration generating activities associated with construction (such as excavation).

Operational phase

The operation of the Proposal would result in any additional impact upon non-indigenous or archaeological heritage.

6.5.3. Mitigation measures

The following mitigation measures would be implemented to minimise impact upon non-indigenous heritage items:

- If unexpected archaeological remains are uncovered during the works, all works must cease in the vicinity of the material/find and the steps in the Roads and Maritime Services *Standard Management Procedure: Unexpected Heritage Items* must be followed. Roads and Maritime Environment staff must be contacted immediately
- If any items defined as relics under the NSW *Heritage Act 1977* are uncovered during the works, all works must cease in the vicinity of the find and the Roads and Maritime Environment staff must be contacted immediately
- If an existing heritage item or item identified on the Roads and Maritime Services s.170 register is on site or in the near vicinity of the works, the item is to be protected to prevent any damage or disturbance.

Refer to Table 28 in Section 7.2 for a full list of mitigation measures.

6.6. Socio-economic impacts

6.6.1. Existing environment

Dee Why is a predominantly residential area with a generally linear commercial precinct located along and near Pittwater Road. The area also includes several parks, local community facilities and the Northern Beaches Council administrative offices. Points of interest adjacent to the Proposal area include:

- Dee Why RSL Club
- Dee Why Public School
- Dee Why police station
- Dee Why Library
- Dee Why Lagoon
- Northern Beaches Council administrative offices
- Stony Range Regional Botanic Garden

- several commercial areas including small shopping malls and retail areas along Pittwater Road
- open space including reserves and parks.

Figure 4 shows the location of points of interest in relation to the Proposal.

A review of the Australian Bureau of Statistics (ABS) 2011 Census data was undertaken for Dee Why. The key statistics for Dee Why include:

- population figure of 19,638 people with the largest age group being 25-34 year olds
- land area of 307 hectares
- population density of 63.88 persons per hectare.

In 2011, 21.2% of employed people living in Dee Why travelled to work on public transport (19.1% of which travelled via bus) and 57.0% by car (either as driver or as passenger).

6.6.2. Potential impacts

Construction phase

During construction of the Proposal, there is potential for temporary impacts upon pedestrians, residents, local businesses, motorists, and other receivers arising from:

- temporary changes to vehicular and pedestrian access around the Proposal as a result of partial road closures and diversions
- temporary impacts to local traffic movements
- temporary loss of parking along Pittwater Road in Dee Why
- a minor decrease in local amenity associated with a small increased truck movements delivering materials and equipment, and transporting waste
- a minor decrease in local amenity associated with construction noise, vibration, dust and visual impacts
- A potential minor decrease in local trading due to the obstruction of passing customers

Zone A of the Proposal is adjacent to Dee Why RSL and includes the construction of a new bus indent along Pittwater Road. During construction it would be necessary to implement temporary diversions and/or closures of the footpath, with the footpath eventually being permanently diverted a few metres eastwards around the indent. Any temporary closures of this footpath would be notified to pedestrians further along the block in both directions to allow for the safe crossing of the road at a designated crossing. The alternative route would provide the same connectivity along Pittwater Road. The overall impact of any temporary pedestrian diversions is considered to be minor.

The presence of construction activity along this section of Pittwater Road is likely to result in temporary increases in noise, dust and other air emissions. These impacts have the potential to affect the general amenity of the area. These impacts have been assessed in more detail in Section 6.2, Section 6.3, Section 6.9, Section 6.7 and Section 6.10. Such impacts are considered to be minor in the context of the existing busy road corridor in this location.

Construction in this location would not affect any private property access and would not require any temporary property occupation or permanent property acquisition. Access for emergency services along Pittwater Road would be maintained at all times.

Construction activities in this location may result in traffic delays due to changed traffic conditions and temporary road closures. Local businesses and services that rely on Pittwater Road for delivery of inventory and goods may be affected by changes to access which may lead to a decrease in revenue. Given that the majority of works in this location would be undertaken at night and that general traffic and bus lanes along this section of Pittwater Road would remain open, impacts upon local businesses are considered to be very minor.

Within Zone B the presence of construction activity would result in the loss of around three parking spaces to facilitate the construction of a new kerb blister on the southbound carriageway of Pittwater Road immediately to the north of the intersection with Oaks Road. Parking in this location is currently restricted to a maximum of ½ hour between 10am and 6pm and is unrestricted during the night. This area is a clearway between 6am and 10am.

The loss of parking in this location would potentially result in a minor loss of passing trade for businesses located along this section of Pittwater Road. The potential for losses in revenue arising from lower passing trade is however considered to be low given the very small number of spaces lost and the clear flexibility in parking space selection necessitated when these spaces are full. Further to this many businesses in this immediate area are considered to be restricted retail and would typically involve a specific reason for visiting, such as banks and solicitors. In these cases the loss of immediate on-street parking would be highly unlikely to discourage customers to continue to patronise such businesses.

Construction activities may result in traffic delays due to changed traffic conditions and temporary road closures. Local businesses and services within this Zone that rely on access and parking on Pittwater Road for delivery of inventory and goods may be affected. The impact of such changes would differ according to the business type and the availability of alternative accesses and delivery methods. On the basis that alternative on-street delivery parking is available a short distance away on Oaks Avenue and that the works would be largely carried out at night the impact of such changes is deemed to be minimal.

During construction there would be minor restrictions to parking Pittwater Road between Dee Why Parade and Howard Avenue and Oaks Avenue and the intersection of Fisher Road. This would largely relate to line marking activities and the election of signage and as such impacts would be minimal.

The presence of construction activity in this area may result in beneficial impacts for certain businesses through the increased custom arising from the workforce. This is likely to be particularly relevant to businesses such as such as food and beverage retailers.

Construction of the Proposal in this Zone may require the temporary closure or diversion of the existing pedestrian footpath. Any closures would be notified to pedestrians further along the block to allow for the safe crossing of the road at a designated crossing in order to take an alternative route. The overall impact of any temporary pedestrian diversions is considered to be minor.

The presence of construction activity at the corner of Pittwater Road and Oaks Avenue is likely to result in temporary increases in noise, dust and other air emissions. These, as well as the removal of landscaping vegetation, have the potential to affect the general amenity of the area and the operation of local businesses. These impacts have been assessed in more detail in Section 6.2, Section 6.3, Section 6.9, Section 6.7 and Section 6.10. Such impacts are considered to be minor in the context of the existing busy road corridor in this location. Roads and Maritime would consult with affected business owners and other stakeholders in order to identify additional measures to minimise local socio-economic impacts.

Operational phase

The Proposal forms part of the infrastructure improvements to deliver the B-Line Program, which is included in the NSW Government's Northern Beaches Transport Action Plan. The Transport Action Plan, along with other government initiatives and strategies, aims to support forecasted population growth in the Northern Beaches by improving the transport network across the region.

Pittwater Road plays a critical role in the economic and social functioning of Dee Why and the wider region. The road provides access to dozens of businesses as well as providing the main north-south thoroughfare for local access and access to areas north of Dee Why. The improved efficiency of this road as a transport route as a result of the Proposal would result in a number of positive social and economic impacts, including improved reliability of bus travel and the provision of greater access for customers. Further to this, improved public transport reliability and efficiency is likely to improve travel to work options for Dee Why residents and increase the attractiveness of bus use generally, potentially resulting in a decrease in private vehicle use and hence local traffic.

The operation of the new indented bus stop within Zone A of the Proposal would not require the permanent removal of any existing parking and would not affect any private property access. The indent would not substantially alter the amenity of the area or access to any public open space. The indent would be located closer to Dee Why RSL and adjacent residential properties to the south, potentially leading to a minor increase in noise from stopping and departing buses. Such an impact is considered to be minor in the context of the small change in location of the bus stop and the busy nature of Pittwater Road.

The indent would improve the flow of traffic past stopped buses, which may improve local air quality. On this basis the socio-economic impact of the operation of the indent is considered to be neutral.

The permanent operational aspects of the Proposal in Zone B include the alteration of kerbside lane designations and the construction of a new kerb blister on the southbound carriageway of Pittwater Road immediately to the north of the intersection with Oaks Avenue. The proposed operational scenario in this location would involve the loss of:

- around 14 parking spaces between Dee Why Parade and Howard Avenue
- around eight parking spaces between Howard Avenue and Oaks Avenue
- around seven parking spaces between Oaks Avenue and Fisher Road (between 6am and 8pm only).

Assuming each parking space in this location is currently occupied for its maximum duration and at the parking occupancy rate for Dee Why (49%), during business hours the Proposal would result in the loss of 199 total parking opportunities. Given that a portion of these parking opportunities would currently be utilised for restricted retail trade (such as appointments at banks, solicitors etc.), it is expected that a large portion of the existing opportunistic customers would still seek out alternative parking arrangements. This is further reinforced by the existing flexibility in parking space selection applied when spaces are full. On this basis it is considered that the overall reduction in passing trade, and hence revenue, would be minimal.

The operation of the Proposal within Zone B would result in buses travelling along the kerbside lane for an extended period beyond the current 6am to 10am clearway. This would potentially result in increased noise and decreased air quality for these businesses throughout the day (after 10am). Such impacts would be minor in the context of the existing busy nature of this road corridor through Dee Why.

The Proposal has been designed to minimise long-term adverse traffic and amenity impacts and therefore impacts on property values are not anticipated.

It should be noted that socio-economic impacts would differ according to individual receptors, such that an adverse impact for one individual or group may be a positive for others. For example the removal of parking through part of Dee Why is likely to result in a minor inconvenience for existing businesses and customers however nearby residents are likely to experience a net benefit from increased public transport efficiency arising from the improved road configuration.

6.6.3. Mitigation measures

The following safeguards would be implemented to minimise potential socio-economic impacts upon the local community:

- Community consultation is to be undertaken in accordance with the *Community Involvement Practice Notes and Resource Manual*
- Complaints received are to be recorded and attended to promptly in accordance with the *Community Involvement Practice Notes and Resource Manual*
- Existing access for nearby and adjoining properties is to be maintained at all times during the works unless otherwise agreed to by the affected property owner.

Refer to Section 6.1, 6.2, and 6.3 for discussion on the potential traffic/access, visual and acoustic amenity impacts associated with the Proposal.

Refer to Table 28 in Section 7.2 for a full list of mitigation measures.

6.7. Biodiversity

6.7.1. Existing environment

Landscape context

The Dee Why urban area has a long history of disturbance including clearance of native vegetation. As such no areas of remnant native vegetation are known to be present within the or near the Proposal area. All vegetation currently present within the Proposal area is mapped as either ‘Urban Native’ or ‘Exotic’ (OEH, 2013).

Areas of existing vegetation and potential biodiversity value within broad proximity of the Proposal include:

- Dee Why Lagoon
- Dee Why Oval
- Dee Why Library/Northern Beaches Council offices
- Stony Range Regional Botanic Garden.

In addition to this it is recognised that the urban environment, including buildings and other man-made structures, provides certain habitat opportunities for native fauna. Such biodiversity values are limited to exotic or invasive species and are generally not considered important for conservation purposes.

Vegetation within the Pittwater Road corridor is generally limited to scattered and isolated trees along road verges and a stand of trees in the centre median at Howard Avenue. This vegetation currently provides landscape amenity value, screening for business and residential frontages and shading for pedestrians.

Flora and fauna

Vegetation communities

Desktop assessment of the EPBC Protected Matters Search Tool was undertaken on 2 August 2016. Two threatened ecological communities (TECs) listed under the *NSW Threatened Species Conservation Act 1995* (TSC Act) or the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) were deemed to have the potential to occur within 300 metres of the Proposal, including:

- Coastal Upland Swamps in the Sydney Basin Bioregion
- Subtropical and Temperate Coastal Saltmarsh.

Given the disturbed nature of the Pittwater Road corridor and based on a site inspection by a qualified ecologist these communities are not deemed to be present within the Proposal area.

Flora, fauna and habitat

Desktop assessment of the NSW Environment and Heritage BioNet Atlas was undertaken on 7 July 2016. This identified the following threatened species listed under the TSC Act or EPBC Act as having the potential to occur within a 5 km radius of the Proposal:

- 21 threatened species of flora
- 61 threatened species of fauna

Generally, vegetation within the Proposal area is comprised of exotic or planted species. While the habitat value of such vegetation for native species is considered to be generally limited it is recognised that such vegetation may provide functional structure for occasional roosting or foraging of wide-ranging, mobile species. Such value is however is likely to be low based on the general lack of broad scale and/or contiguous vegetation cover in the area.

The vegetation present within the median in Dee Why provides limited connectivity within the area for mobile fauna species due to its physical isolation from other vegetation. This is further compromised by the presence of large areas of urban development and high-traffic road corridors. In addition to this higher quality and better connected remnant vegetation exists within other areas such as Dee Why lagoon, Dee Why Oval and the Stony Range Regional Botanic Garden.

There is the potential that landscaped areas within the Proposal area may harbour weeds listed as noxious under the NW Act. Given the highly urbanised nature of the Proposal area and the maintenance regime implemented by the Council it is considered highly unlikely that such species are present.

6.7.2. Potential impacts

Construction phase

The Proposal would not require the removal of any remnant native vegetation, however a stand of planted trees would need to be removed from the central median along Pittwater Road south of Howard Avenue. These trees do not form part of a TEC under either the TSC Act or EPBC Act and are not considered optimal foraging habitat for highly mobile threatened species. As such, it is expected that overall habitat impacts would be limited. The Proposal would not result in a significant impact upon any threatened species, population or ecological community.

Figure 13 shows the trees to be removed for the Proposal. While this vegetation is considered to have low ecological value and is not protected under threatened species legislation, the stand of trees currently provides screening to road users, bus customer and adjacent local business and receivers. Landscape amenity and visual impacts associated with the removal of this vegetation has been assessed in Section 6.2. Replacement trees would be provided in accordance with the Roads and Maritime *Environmental Impact Assessment Practice Note – Guidelines for Landscape Character and Visual Impact Assessment* (2013), the Roads and Traffic Authority *Biodiversity Guidelines* (2011) and the TfNSW *Vegetation Offset Guide* (TfNSW, 2013b).

Other trees in the Proposal area would be retained. The implementation of mitigation measures identified in this REF would minimise overall impacts upon vegetation. On this basis the Proposal area is considered unlikely to result in off-site impacts such that existing habitat within the region is likely to be adversely affected.

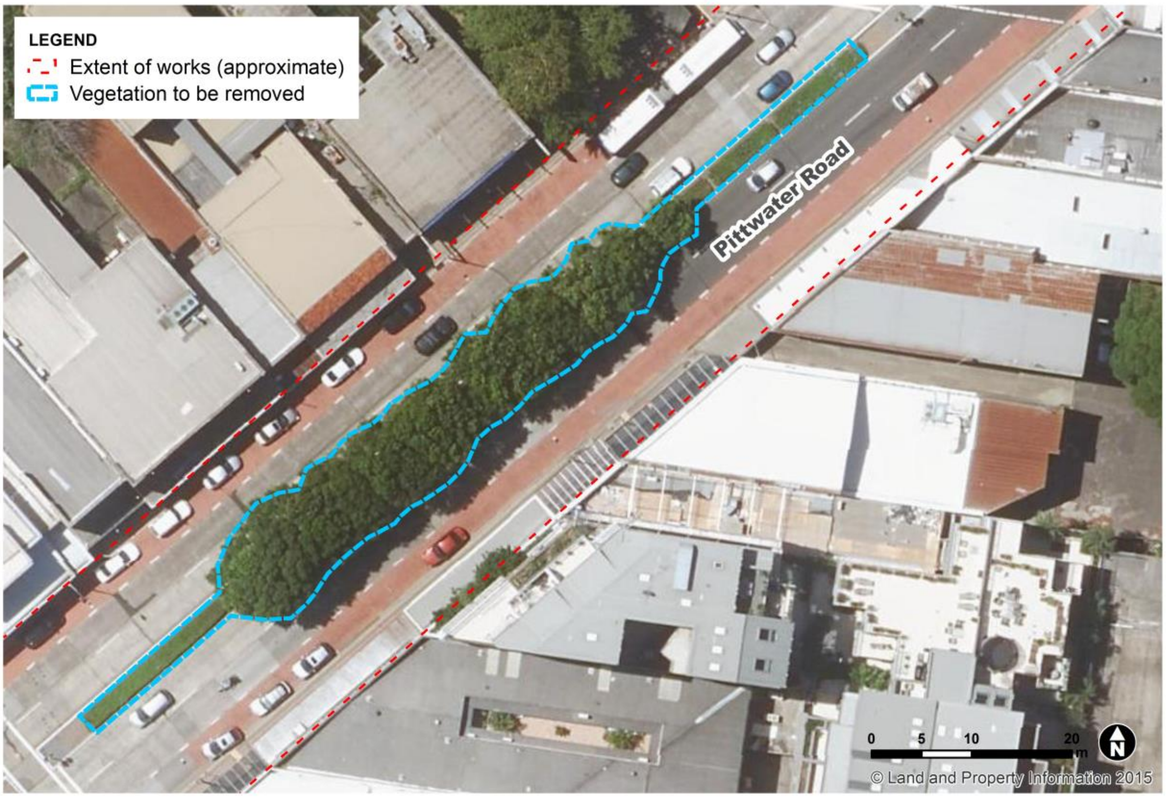

Figure 13 Vegetation to be removed within Zone B

There is a potential for the proliferation of weed species a result of construction activities without the implementation of appropriate management strategies. Construction activities also have the potential to import new weed species into the Proposal area.

The mitigation measures outlined in Section 7.2 would ensure that these indirect impacts are minimised.

Operational phase

There would be no ongoing operational risks to biodiversity as a result of the operation of the Proposal.

6.7.3. Mitigation measures

Replacement trees would be provided in accordance with the Roads and Maritime *Environmental Impact Assessment Practice Note – Guidelines for Landscape Character and Visual Impact Assessment* (2013), the Roads and Traffic Authority *Biodiversity Guidelines* (2011) and the TfNSW *Vegetation Offset Guide* (TfNSW, 2013b). The exact number of offset trees required would be determined at detailed design stage.

Any additional trees that are found to require removal during construction (e.g. for service relocation) would also need to be approved by Roads and Maritime for removal and offsetting.

The following mitigation measures are proposed to manage impacts to biodiversity:

- If unexpected threatened fauna or flora species are discovered, stop works immediately and follow the Roads and Maritime Services *Unexpected Threatened Species Find Procedure* in the *Roads and Maritime Services Biodiversity Guidelines 2011 – Guide 1 (Pre-clearing process)*

- All pathogens (e.g. Chytrid, Myrtle Rust and *Phytophthora*) are to be managed in accordance with the *Roads and Maritime Services Biodiversity Guidelines - Guide 7 (Pathogen Management)* and *DECC Statement of Intent 1: Infection of native plants by Phytophthora cinnamomi* (for *Phytophthora)*
- Declared noxious weeds are to be managed according to requirements under the Noxious Weeds Act 1993 and Guide 6 (Weed Management) of the Roads and Maritime Services Biodiversity Guidelines 2011
- All pruning and trimming of trees is to be in accordance with the *Australian Standard 4373-2007 Pruning of amenity trees.* Pruning of mature trees is to be undertaken by a qualified arborist.

Refer to Table 28 in Section 7.2 for a full list of mitigation measures.

6.8. Soils and water

6.8.1. Existing environment

Soils

The Proposal is located on relatively flat ground predominately within the Warriewood soil landscape (OEH, 2016). This landscape generally features level to gently undulating swales, depressions and infilled lagoons on Quaternary sands. The Proposal area is underlain by Holocene silty to peaty quartz sand, and medium to fine marine sand with podzols. The Warriewood landscape typically includes limitations of localised flooding, high water tables, and highly permeable soil.

The Warringah LEP does not identify the presence of acid sulphate soils within the Proposal area. The *Western Sydney Salinity Map* (Department of Infrastructure, Planning and Natural Resources, 2002) indicates that there is moderate salinity potential within the vicinity of the Proposal.

The Proposal area is not listed on the EPA’s contaminated lands register.

Water

The Pacific Ocean is located between 800 metres and 1.4 km east of the Proposal area. Stormwater drains within the vicinity of the Proposal discharge to the ocean at regular locations along the coast. Dee Why Lagoon is also located near to Zone A.

The Proposal is located within the Dee Why South Catchment which is about 268 hectares in area. This catchment is characterised by a steep escarpment grading down to a low floodplain area, discharging to Dee Why Lagoon. Most of the original creek lines in this area have been disturbed by urban development and are now contained within enclosed culverts. One such culvert adjacent to the Proposal area runs for about 400 metres beneath the commercial area between Pittwater Road and Dee Why Parade, at which point it becomes an open channel discharging to the Dee Why Lagoon.

The majority of the Dee Why South Catchment is paved, which has reduced the amount of permeable land and resulted in increased runoff. Consequently flooding in the catchment is predominantly a result of runoff which exceeds the capacity of the existing underground drainage system (typically following the original creek lines). Inundation from overland flows in particular occurs along Pittwater Road, Oaks Avenue and Howard Avenue (Warringah Council, 2015).

Flooding can pose a risk to residents, businesses and members of the community living and/or working within the catchment. This includes the potential for interruptions to traffic flow, injury, loss of life or property and impacts upon construction activities.

The main overland flow path for the local catchment originates on the escarpment in Narraweena with the convergence of two higher overland flow paths. During high rainfall events flood waters increase in depth and velocity as they approach Dee Why and the local drainage network is overwhelmed. At the intersection of Pittwater Road and Fisher Road, the main overland flow path converges with a number of minor overland flow paths. From this point overland flows are split with flood waters conveyed down either Oaks Avenue or Howard Avenue.

Flood modelling undertaken by Warringah Council to inform the Draft Dee Why South Catchment Floodplain Risk Management Plan (2015) identified a number of locations within the catchment which would experience depths of flooding of more than 0.5 metre in a 100 year Average Recurrence Interval (ARI) event. This is deemed to be due to undersized drainage systems and an absence of underground drainage and dedicated overland flow paths.

Northern Beaches Council is currently installing new drainage infrastructure along Oaks Avenue to improve drainage and reduce instances of flooding in the Dee Why Town Centre. These works are expected to be completed in October 2016.

6.8.2. Potential impacts

Construction phase

Soils

The Proposal would require excavation work for trenching, the relocation of existing and installation of new services, demolition of existing and construction of new road pavement and other minor civil works (including longitudinal regrading).

Excavation and other earthworks such as trenching and stockpiling activities, if not adequately managed, could result in the following impacts:

- erosion of exposed soil and stockpiled materials
- dust generation from excavation and vehicle movements over exposed soil
- increase in sediment loads entering the stormwater system and/or local runoff.

Such impacts can lead to an adverse environmental impact on biodiversity, for example, through the introduction of sediment into waterways.

These impacts are considered to be minor due to the limited level of ground disturbance required and the relatively flat and stable topography of the site. It is expected that erosion risks could be adequately managed through the implementation of standard measures as outlined in *Managing Urban Stormwater: Soils and Construction Guidelines* (Landcom, 2004), (the Blue Book).

Excavation also has the potential to expose contaminants, which if not appropriately managed, can present a health risk to construction workers and the community. The exposure of contaminants could also pose an environmental risk if they were to enter nearby waterways through the stormwater system.

Considering the current land use of the Proposal area as a road corridor, the potential for contamination to be present is considered unlikely. However, all spoil would be classified in accordance with the NSW EPA *Waste Classification Guideline* (EPA, 2014). Where spoil is classified as unsuitable for reuse it would be transferred to an appropriately licensed offsite waste disposal facility.

There is also potential for activities to result in the contamination of soil through accidental fuel or chemical spills from construction plant and equipment. Accidental spills have the potential to entre nearby waterways or the local stormwater system and result in pollution.

The risk of impacts from contamination (if any) on human health (workers) from the construction activities is considered to be low.

Water

Activities which would disturb soil during construction work have the potential to affect local water quality through the release of sediment as a result of erosion. Without appropriate safeguards, such pollutants (as well as fuel, chemicals or wastewater from accidental spills, and sediment from excavations and stockpiles) could potentially reach nearby stormwater drains and flow into waterways.

Direct impacts to the underground stormwater network may arise during demolition and construction activities. Any such impacts would be identified during the detailed design phase of the Proposal. The following design strategy would be adopted for the Proposal:

- the existing drainage layout would be located and confirmed through field surveys and Council GIS information
- the existing drainage regime across the extent of works would be identified for both major and minor events
- areas of the proposed works that require new drainage infrastructure as a result of new sag points or bus bays and pedestrian crossing points would be identified
- the proposed works would be drained to the existing system at the same location where flows would have flowed prior to the works
- the Proposal would not change any network or overland flow regimes in both minor and major storm events.

Appropriate controls would be detailed in the CEMP and established to ensure that drainage points are adequately protected during construction activities so as to avoid damage. Where stormwater drains are affected by the design of the Proposal, these would be relocated during construction in consultation with the Northern Beaches Council so as to avoid any adverse impact upon the local system as a whole.

Given the presence of an overland flood path at the intersection of Pittwater Road and Fisher Road, any pedestrian fencing located along the Pittwater Road median would need to be porous to ensure that flood behaviour in this area would not be affected.

Operational phase

There would be no operational risks to geology or soils as a result of the Proposal.

The Proposal would result in a minor increase in hardstand area. This would be limited to the new bus indent south of Hawkesbury Avenue and the removal of existing vegetation within the median in Dee Why town centre. The total increase in hardstand area as a result of these changes would be minimal. On this basis it is unlikely that Proposal would result in a significant impact on the hydrology of the nearby area or that the Proposal would compromise the viability of the local stormwater system.

Runoff from the upgraded Pittwater Road and adjacent local roads affected by the Proposal (including Oaks Avenue) would continue to drain to the existing street drainage system. All works would be designed and undertaken in accordance with the relevant standards and requirements so as to ensure the efficient operation of stormwater assets is not affected.

The Proposal would result in a negligible impact on overland flows given there would be minimal changes to the ground surface. The final drainage arrangements would be subject to detailed design in consultation with Northern Beaches Council to avoid or minimise operational changes to local drainage.

6.8.3. Mitigation measures

The following measures are proposed to manage the impact of the Proposal on soils and water:

- Erosion and sediment control measures are to be implemented and maintained to:
    - Minimise sediment moving off-site and sediment laden water entering any water course, drainage lines, or drain inlets
    - Reduce water velocity and capture sediment on site
    - Minimise the amount of material transported from site to surrounding pavement surfaces
    - Divert off site water around the site (in accordance with the Landcom/Department of Housing Managing Urban Stormwater, Soils and Construction Guidelines (the Blue Book)).
- erosion and sedimentation controls are to be checked and maintained on a regular basis (including clearing of sediment from behind barriers) and records kept and provided on request
- There is to be no release of dirty water into drainage lines and/or waterways
- Visual monitoring of local water quality (i.e. turbidity, hydrocarbon spills/slicks) is to be undertaken on a regular basis to identify any potential spills or deficient erosion and sediment controls
- Water quality control measures are to be used to prevent any materials (e.g. concrete, grout, sediment etc.) entering drain inlets or waterways
- Measures to control pollutants from stormwater and spills would be investigated and incorporated in the pavement drainage system at locations where it discharges to the receiving drainage lines. Measures aimed at reducing flow rates during rain events and potential scour would also be incorporated in the design of the pavement drainage system
- Potable water is to be used for wash down
- Excess debris from cleaning and washing is removed using hand tools
- Containment material is used to capture/filter water used in wash down
- Potential or actual acid sulphate soils are to be managed in accordance with the Roads and Maritime Services Guidelines for the Management of Acid Sulphate Materials 2005.

Refer to Table 28 in Section 7.2 for a full list of mitigation measures.

6.9. Air quality

6.9.1. Existing environment

Air quality in the vicinity of the Proposal is representative of an urban area, being mainly dominated by vehicle emissions (cars, buses and trucks). The Proposal area is generally surrounded by local business, retail and residential development. There are no significant air-polluting industries located in the vicinity of the Proposal area.

A review of the National Pollutant Inventory (NPI) was undertaken on 29 July 2016 for the Warringah LGA. It should be noted that the NPI has not been updated to reflect the amalgamated council boundaries. The closest registered source of air pollution is the Prysmian Australia factory (production of copper telecom cables from copper wire) located about 1.6 km north-west of Zone A.

Sensitive receivers in the vicinity of the Proposal include waiting bus passengers and pedestrians along Pittwater Road, users of Northern Beaches Library and nearby residential and commercial receivers.

6.9.2. Potential impacts

Construction phase

During construction there is the potential for temporary local air quality impacts arising from plant, equipment and ground disturbance. This includes the release of dust particles and exhaust emissions associated with the combustion of diesel fuel and petrol from construction plant and equipment.

Anticipated sources of dust and dust-generating activities include:

- demolition of existing concrete road verges, medians, kerbs and pedestrian pathways along Pittwater Road
- excavations for construction of new road concrete and relocation of existing and installation of new services
- stockpiling activities
- loading and transfer of material from trucks
- other general construction activities.

The Proposal would not involve extensive excavation or other ground disturbance with the potential to generate significant quantities of dust. Appropriate measures would be established to manage dust emissions from demolition works.

The operation of plant, machinery and trucks may also lead to increases in exhaust emissions. Changes to air quality in the vicinity of the Proposal area during construction are anticipated to be temporary in nature and would be limited by implementation of the measures outlined in Section 6.9.3. Overall the impact of construction of the Proposal on local air quality is expected to be minimal.

Operational phase

The Proposal intends to improve traffic flow, particularly relating to bus movements. As a result of this air emissions from operational traffic are expected to remain broadly similar to the existing scenario. Also, as the Proposal would increase reliability and quality of public transport, the use of this service would be expected to increase, leading to a relative reduction in the amount of private vehicle related emissions in the long-term.

6.9.3. Mitigation measures

The following mitigation measures are proposed to manage impacts on air quality:

- Measures (such as watering or covering exposed areas) are to be used to minimise or prevent air pollution and dust
- Vegetation or other materials are not to be burnt on site
- Vehicles transporting waste or other materials that may produce odours or dust are to be covered during transportation
- Stockpiles or areas that may generate dust are to be managed to suppress dust emissions in accordance with the Roads and Maritime Services *Stockpile Site Management Guideline (EMS-TG-10).*

Refer to Table 28 in Section 7.2 for a full list of mitigation measures.

6.10. Cumulative impacts

Cumulative impacts occur when two or more projects are carried out concurrently and in close proximity to one another. The impacts may be caused by both construction and operational activities and can result in a greater impact to the surrounding area than would be expected if each project was undertaken in isolation.

A search of the Department of Planning and Environment's Major Projects Register, Sydney East Joint Regional Planning Panel Development and Planning Register, and Northern Beaches Council Development Application Registers in August 2016 identified the following development applications in the vicinity of the Proposal:

- 884-896 Pittwater Road (including Howard Avenue and Oaks Avenue), Dee Why (DA 2016SYE076): Construction of a mixed use development comprising retail, commercial and residential uses and a child care centre. Currently being assessed by Council.
- 932 Pittwater Road, Dee Why (DA 2016SYE075): Demolition works and redevelopment of part of the Dee Why RSL Club. Currently being assessed by Council.
- 40 Kingsway & 725 Pittwater Road, Dee Why (DA 2016SYE035): Modification of development consent granted for demolition works and construction of a multi-purpose community facility (Police and Citizens Youth Club). Completed.
- 876 Pittwater Road, Dee Why (DA 2016SYE004): Demolition works and the construction of mixed use development (shop top housing) with basement parking. Currently being assessed by Council.
- 14 Patey Street, Dee Why (DA2016SYE077): Alterations and additions to Delmar Private Hospital. Currently being assessed by Council.

Generally, the above development applications involve demolition and construction of buildings and facilities, which is not anticipated to have a substantial impact on the surrounding road network. Further consultation would be undertaken with Northern Beaches Council to further detail the potential of known future developments to result in cumulative impacts, particularly in regards to construction traffic. Coordination to reduce cumulative impacts would be undertaken during detailed construction planning.

Other impacts associated with the above applications, including air, soil and water quality, biodiversity and socio-economic impacts are not expected to be of a scale that would interact cumulatively with the Proposal during construction or operation.

In addition, the overall delivery of the Northern Beaches B-Line Program would involve construction of a number of projects along the Mona Vale-CBD corridor. To manage the potential cumulative impacts of multiple projects being undertaken simultaneously, Roads and Maritime and TfNSW would establish a coordination group within the project team.

Based on this assessment, it is anticipated that cumulative impacts associated with the Proposal would be minor, provided that consultation with relevant stakeholders and mitigation measures in Section 7.2 are implemented.

The potential cumulative impacts associated with the Proposal would be further considered as the design develops and as further information regarding the location and timing of potential developments is released. Environmental management measures would be developed and implemented as appropriate.

6.11. Climate change and sustainability

6.11.1. Greenhouse gas emissions

A slight increase in greenhouse gas emissions, primarily carbon dioxide, would be expected during construction of the Proposal due to exhaust emissions from construction machinery and vehicles transporting materials and personnel to and from site.

Due to the small scale of the Proposal and the short term nature of the construction works, it is considered that greenhouse gas emissions resulting from the construction of the Proposal would be minimal. Furthermore, greenhouse gas emissions generated during construction would be kept to a minimum through the implementation of the mitigation measures managed through the CEMP.

Once operational, the Proposal would assist in facilitating an increase in the use of public transport. Any resultant shift in transport would encourage public transport use and potentially reduce the amount of fuel consumed by private vehicles, resulting in a relative reduction in associated greenhouse gas emissions generally.

6.11.2. Climate change

The dynamic nature of our climate system indicates a need to focus attention on how to adapt to the changes in climate, while understanding the limitations of adaptation. The effects of climate on the Sydney region can be assessed in terms of weather changes, storm intensity, flooding and increased risk of fire.

Climate change could lead to an increase in the intensity of rainfall events, whereby major flood events would be expected to occur more frequently.

The site is affected by flooding. Details of flood mitigation and water pollutant reduction measures would be determined during detailed design in consultation with Northern Beaches Council.

Climate change could lead to an increase in frequency and severity in bushfires. The Proposal is not situated on land mapped as bush fire prone.

6.11.3. Sustainability

The design of the Proposal would be based on the principles of sustainability, including the incorporation of the *Sustainable Design Guidelines – Version 3.0* (TfNSW, 2013a).

These guidelines require a number of mandatory and discretionary initiatives to be applied. Refer to Section 3.1.4 for more information regarding the application of these guidelines. The following key sustainability initiatives are being considered for the design and construction of the Proposal:

- **Materials and waste:** ensure at least 95 per cent of construction and demolition waste (by weight) is diverted from landfill, and either recycled or reused
- **Materials and waste**: for all projects generating more than 300 cubic metres of spoil, ensure that 100 per cent of usable spoil (by weight) is beneficially reused, on-site or nearby off-site. Usable spoil is not to be sent to landfill
- **Biodiversity and heritage:** for non-significant biodiversity impacts, offsetting is to be in accordance with the TfNSW *Vegetation Offset Guide* (TfNSW, 2013b) as applicable
- **Biodiversity and heritage:** 100 per cent of significant heritage items are identified during project development and design and are protected or beneficially reused where practical
- **Pollution control:** the Proposal could comply with the TfNSW Construction Noise Strategy and related conditions of approval
- **Community benefit:** incorporate Crime Prevention Through Environmental Design (CPTED) principles during design (including lighting).

7. Environmental management

This chapter identifies how the environmental impacts of the Proposal would be managed through environmental management plans and mitigation measures. Section 7.2 collates the proposed mitigation measures for the Proposal as identified in Chapter 6.

7.1. Environmental management plans

A CEMP for the construction phase of the Proposal would be prepared in accordance with the requirements of TfNSW's Environmental Management System (EMS). The CEMP would provide a centralised mechanism through which all potential environmental impacts relevant to the Proposal would be managed, and outline a framework of procedures and controls for managing environmental impacts during construction.

The CEMP would incorporate as a minimum all environmental mitigation measures identified below in Section 7.2, any conditions from licences or approvals required by legislation, and a process for demonstrating compliance with such mitigation measures and conditions. The following plans would be included in the CEMP:

- Construction Traffic and Access Management Plan
- Construction Noise and Vibration Management Plan
- Erosion and Sediment Control Plan
- Waste Management Plan.

7.2. Mitigation measures

Mitigation measures for the Proposal are listed in Table 28. These proposed measures would minimise the potential adverse impacts of the Proposal identified in Chapter 6, should the Proposal proceed.

Table 28 Proposed mitigation measures

Ref	Mitigation measure
	General
G1	If the scope of the works changes at any time, review under the Roads and Maritime Services *Environmental assessment procedure for routine and minor works* (EIA-PO5-1) to determine any new measures to take.
G2	An environmental management plan is prepared and implemented prior to the commencement of works.
G3	No new access tracks to be created for the works.
G4	Parking of vehicles and storage of plant/equipment is to occur on existing paved areas. Where this is not possible, vehicles and plant/equipment are to be kept away from environmentally sensitive areas and outside the dripline of trees.

Ref	Mitigation measure
	Traffic and site access
T1	A Traffic Management Plan would form part of the CEMP for the construction phase of the Proposal and would outline – road closures and alternatives – pedestrian and cycle provisions throughout the construction period – the consultation process to inform the community of any road, pedestrian or cycle changes
T2	Property accesses are to be maintained during the works. Any unexpected disturbances to property access would be discussed with the affected resident(s).
	Urban design, landscape and visual amenity
V1	the site would be kept tidy and well maintained during construction, including removal of all rubbish at regular intervals. There should be no storage of materials beyond the construction boundaries
V2	light spill from the road corridor into adjacent visually sensitive properties is to be minimised by the use of cut-off lighting, directing construction lighting into the construction areas and ensuring the site is not over-lit. This includes the sensitive placement and specification of lighting to minimise any potential increase in light pollution
V3	temporary hoardings, barriers, traffic management and signage would be removed when no longer required
V4	work/site compounds would be screened where practical, with shade cloth or similar material to minimise visual impacts
V5	the construction contractor would restore any areas that are affected by construction with appropriate landscape treatments
V6	an urban design and landscape plan would be prepared as part of the CEMP in consultation with relevant stakeholders
	Noise and vibration
N1	A Construction Noise and Vibration Management Plan (CNVMP) would be prepared. The CNVMP would include the following: – identification of nearby residences and other sensitive land uses – description of all approved hours of work – description and identification of all construction activities, including work areas, equipment and duration – description of what work practices (generic and specific) would be applied to minimise noise and vibration – a complaints handling process – noise and vibration monitoring procedures – overview of community consultation required for identified high impact works.

Ref	Mitigation measure
N2	all residents impacted by noise from the proposed works which are expected to exceed the construction noise management levels should be consulted prior to the commencement of construction. The highest consideration should be given to those that are predicted to be most affected as a result of the works. Information provided to residents should include: – programmed times and locations of construction work – the hours of proposed works – construction noise and vibration impact predictions – construction noise and vibration mitigation measures to be implemented on site.
N3	community consultation regarding construction noise and vibration would be detailed in the Community Involvement Plan for the construction of the project and would include a 24 hour hotline and complaints management process
N4	for out-of-hours works, consultation would take place with consideration to Practice Note vii of Roads and Maritime’s Environmental Noise Management Manual (ENMM) and Strategy 2 of the ICNG
N5	induction and training would be provided to relevant staff and sub-contractors outlining their responsibilities with regard to noise and vibration
N6	deliveries would be carried out during standard construction hours where feasible and reasonable
N7	a protocol would be developed to identify the need for, and provision of, respite measures for residential receivers in accordance with the ICNG. Respite measures may include appropriate timetabling of noisy works or the restriction to the hours of construction activities resulting in impulsive or tonal noise (such as rock hammering, pile driving), or other appropriate measures agreed between the contractor and residential receiver such as temporary alternative accommodation
N8	the following measures would be implemented to reduce and manage noise and vibration impacts associated with construction traffic: – truck drivers would be advised of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (i.e. minimising/restricting the use of engine compression brakes, and no extended periods of engine idling) – site access and egress points would be located away from residences and other sensitive land uses, where feasible and reasonable – deliveries and spoil removal would be planned to avoid queuing of trucks on or around the compounds – construction sites would be arranged to limit the need for reversing associated with regular/repeatable movements (e.g. trucks transporting spoil) to minimise the use of reversing alarms – where feasible and reasonable, non-tonal reversing alarms would be used, taking into account the requirements of the Workplace Health and Safety legislation – spoil would be moved during the day where practical, and feasible and reasonable management strategies would be investigated in consultation with the NSW Environment Protection Authority to minimise the volume of heavy vehicle movements at night
N9	Appropriate plant would be selected for each task to minimise the noise contributions

Ref	Mitigation measure
N10	alternative works methods such as the use of hydraulic or electric-controlled units in place of diesel units would be considered and implemented where feasible and reasonable. The use of alternative machines that perform the same function, such as rubber wheeled plant, would be considered in place of steel tracked plant
N11	all equipment would be regularly inspected and maintained to ensure it is in good working order
N12	plant should be located on site with as much distance as possible between the plant and noise sensitive receivers. Noisy equipment would be orientated away from residential receivers where feasible and reasonable
N13	a noise monitoring program would be implemented to assist in confirming and controlling the site specific potential for disturbance at particularly sensitive localities at the commencement of activities and periodically during construction. The results would be reviewed to determine if additional mitigation measures are required. All measurements would be undertaken in accordance with Australian Standard 1055.1-1997 – Acoustics – Description and measurement of environmental noise, Part 1: General procedures
N14	if regenerated noise is reported to be a problem during vibration intensive works, attended and/or unattended noise measurements would be undertaken within the relevant building spaces to determine the level of regenerated noise
N15	equipment size would be selected taking into account the safe working distances and the distance between the area of construction and the most affected sensitive receiver. The use of less vibration intensive methods of construction or equipment would be considered where feasible and reasonable when working in proximity to existing structures
N16	– wherever reasonable and reasonable, vibration intensive works should be limited to less sensitive times of the day
N17	if the use of vibration intensive plant cannot be avoided within the safe working distance for cosmetic damage to existing structures the following procedure would occur as a minimum: – notification of the works to the affected residents and community – works would not proceed until attended vibration measurements are undertaken.
N18	If ongoing works are required a temporary relocatable vibration monitoring system would be installed to warn operators (via flashing light, audible alarm, short message service (SMS) etc.) when vibration levels are approaching the cosmetic damage objective
	Aboriginal heritage
B1	If Aboriginal heritage items are uncovered during the works, all works in the vicinity of the find must cease and Roads and Maritime Environment staff contacted immediately. Steps in the Roads and Maritime Services Standard Management Procedure: Unexpected Heritage Items must be followed.
	Non- Aboriginal heritage
H1	If unexpected archaeological remains are uncovered during the works, all works must cease in the vicinity of the material/find and the steps in the Roads and Maritime Services Standard Management Procedure: Unexpected Heritage Items must be followed. Roads and Maritime Services Environment staff must be contacted immediately.

Ref	Mitigation measure
H2	If any items defined as relics under the NSW Heritage Act 1977 are uncovered during the works, all works must cease in the vicinity of the find and the Roads and Maritime Services Environment staff must be contacted immediately.
H3	If an existing heritage item or item identified on the Roads and Maritime Services s.170 register is on site or in the near vicinity of the works, the item is to be protected to prevent any damage or disturbance.
	Socio-economic
C1	Community consultation is to be undertaken in accordance with the *Community Involvement Practice Notes and Resource Manual*.
C2	Complaints received are to be recorded and attended to promptly in accordance with the *Community Involvement Practice Notes and Resource Manual*.
C3	Existing access for nearby and adjoining properties is to be maintained at all times during the works unless otherwise agreed to by the affected property owner.
	Biodiversity
F1	If unexpected threatened fauna or flora species are discovered, stop works immediately and follow the Roads and Maritime Services Unexpected Threatened Species Find Procedure in the Roads and Maritime Services Biodiversity Guidelines 2011 – Guide 1 (Pre-clearing process).
F2	All pathogens (e.g. Chytrid, Myrtle Rust and Phytophthora) are to be managed in accordance with the Roads and Maritime Services Biodiversity Guidelines - Guide 7 (Pathogen Management) and *DECC Statement of Intent 1: Infection of native plants by Phytophthora cinnamomi* (for Phytophthora).
F3	Declared noxious weeds are to be managed according to requirements under the Noxious Weeds Act 1993 and Guide 6 (Weed Management) of the Roads and Maritime Services Biodiversity Guidelines 2011.
F4	All pruning and trimming of trees is to be in accordance with the Australian Standard 4373-2007 Pruning of amenity trees. Pruning of mature trees is to be undertaken by a qualified arborist.
F5	Vegetation offsets and/or landscaping would be undertaken in accordance with the Roads and Maritime Environmental Impact Assessment Practice Note – Guidelines for Landscape Character and Visual Impact Assessment (2013), the Roads and Traffic Authority Biodiversity Guidelines (2011) and the TfNSW Vegetation Offset Guide (TfNSW, 2013b)/ All planting would be undertaken in consultation with the Northern Beaches Council, and/or the owner of the land upon which the vegetation would be planted.
	Soils and contamination
E1	Erosion and sediment control measures are to be implemented and maintained to:

Ref	Mitigation measure
	– Minimise sediment moving off-site and sediment laden water entering any water course, drainage lines, or drain inlets – Reduce water velocity and capture sediment on site – Minimise the amount of material transported from site to surrounding pavement surfaces – Divert off site water around the site (in accordance with the Landcom/Department of Housing Managing Urban Stormwater, Soils and Construction Guidelines (the Blue Book)).
E2	Erosion and sedimentation controls are to be checked and maintained on a regular basis (including clearing of sediment from behind barriers) and records kept and provided on request.
	Hydrology and water quality
W1	There is to be no release of dirty water into drainage lines and/or waterways.
W2	Visual monitoring of local water quality (i.e. turbidity, hydrocarbon spills/slicks) is to be undertaken on a regular basis to identify any potential spills or deficient erosion and sediment controls.
W3	Water quality control measures are to be used to prevent any materials (e.g. concrete, grout, sediment etc.) entering drain inlets or waterways.
W4	Measures to control pollutants from stormwater and spills would be investigated and incorporated in the pavement drainage system at locations where it discharges to the receiving drainage lines. Measures aimed at reducing flow rates during rain events and potential scour would also be incorporated in the design of the pavement drainage system.
W5	Potable water is to be used for wash down.
W6	Excess debris from cleaning and washing is removed using hand tools.
W7	Containment material is used to capture/filter water used in wash down.
W8	Potential or actual acid sulphate soils are to be managed in accordance with the Roads and Maritime Services Guidelines for the Management of Acid Sulphate Materials 2005.
	Air quality
A1	Measures (including watering or covering exposed areas) are to be used to minimise or prevent air pollution and dust.
A2	Vegetation or other materials are not to be burnt on site.
A3	Vehicles transporting waste or other materials that may produce odours or dust are to be covered during transportation.
A4	Stockpiles or areas that may generate dust are to be managed to suppress dust emissions in accordance with the Roads and Maritime Services *Stockpile Site Management Guideline (EMS-TG-10)*

8. Conclusion

This REF has been prepared in accordance with the provisions of section 111 of the EP&A Act, taking into account to the fullest extent possible, all matters affecting or likely to affect the environment as a result of the Proposal.

The Proposal would support the delivery of the B-Line Program by providing the following benefits:

- reducing peak and off-peak bus journey times between the Northern Beaches and the Sydney CBD
- improving customer experience with improved frequency, capacity and reliability of bus services
- improving road safety along the corridor
- optimising journey time reliability and network efficiency for all traffic including cars, trucks, taxis and bicycles.

The following key impacts have the potential to occur, should the Proposal proceed:

- temporary changes to vehicle, pedestrian and cycle movements to, from and around the affected areas during construction
- temporary noise and vibration impacts during construction
- permanent loss of street parking along Pittwater Road
- removal of trees and vegetation that would require planting offsets.

The Proposal has been designed to minimise traffic impacts and is considered to have a minor overall impact during operation.

This REF has considered and assessed the above impacts in accordance with clause 228 of the EP&A Regulation and the requirements of the EPBC Act (refer to Chapter 6, Appendix A and Appendix B). Based on the assessment within this REF, it is considered that the Proposal is not likely to have a significant impact upon the environment or any threatened species, populations or ecological communities. Accordingly an EIS is not required, nor is approval by the Minister for Planning.

The Proposal has taken into account the principles of ESD (refer to Section 3.1 and Section 6.11). These would be considered further during the detailed design, construction and operational phases of the Proposal. This would ensure the Proposal is delivered to maximum benefit to the community, is cost effective and minimises any further adverse impacts on the environment.

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Appendix A Consideration of matters of National Environmental Significance

The table below demonstrates Roads and Maritime's consideration of the matters of NES under the EPBC Act. These matters are to be considered in order to determine whether the Proposal should be referred to Commonwealth Department of the Environment.

Matters of NES	Impacts
Any impact on a World Heritage property? The Proposal would not have any impact on a World Heritage property.	Nil
Any impact on a National Heritage place? The Proposal would not have any impact on a National Heritage place.	Nil
Any impact on a wetland of international importance? The Proposal would not have any impact on a wetland of international importance.	Nil
Any impact on a listed threatened species or communities? The Proposal would not have an impact on a listed threatened species, population or communities.	Nil
Any impacts on listed migratory species? The Proposal would not have any impacts on listed migratory species.	Nil
Does the Proposal involve a nuclear action (including uranium mining)? The Proposal does not involve a nuclear action.	Nil
Any impact on a Commonwealth marine area? The Proposal would not have any impact on a Commonwealth marine area.	Nil
Does the Proposal involve development of coal seam gas and/or large coal mine that has the potential to impact on water resources? The Proposal is for a transport facility and is not related to coal seam gas or mining.	Nil
Additionally, any impact (direct or indirect) on Commonwealth land? The Proposal would not have a direct or indirect impact on Commonwealth land.	Nil

Appendix B Consideration of clause 228

The table below demonstrates RMS's consideration of the specific factors of clause 228 of the EP&A Regulation in determining whether the Proposal would have a significant impact on the environment.

Factor	Impacts
(a) Any environmental impact on a community? There would be some temporary impacts to the community during construction, particularly in relation to noise, traffic, access and visual amenity. The Proposal would have a positive benefit on the community by improving public transport services.	Minor
(b) Any transformation of a locality? The Proposal would result in minor visual changes of the surrounding locality, however these changes would be consistent with the existing infrastructure and would not change the land use.	Minor
(c) Any environmental impact on the ecosystem of the locality? The Proposal would require removal of several trees. Given the Proposal's location with an urbanised environment, the low habitat value of the trees to be removed and the proposed offsets, impacts to biodiversity and ecosystems are expected to be negligible.	Minor
(d) Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality? There would be some temporary impacts during construction particularly in relation to noise, traffic and access and visual amenity. During operation the Proposal would have positive impacts to the community through improving public transport services. The visual impact of the Proposal is anticipated to be negligible.	Minor
(e) Any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations? The Proposal would have a positive effect on public transport access and would be sympathetic to the existing surroundings.	Nil
(f) Any impact on the habitat of protected fauna (within the meaning of the *National Parks and Wildlife Act 1974*)? The Proposal is unlikely to have any impact on the habitat of protected fauna.	Nil
(g) Any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air? The Proposal is unlikely to result in the endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air.	Nil
(h) Any long-term effects on the environment? The Proposal is unlikely to have any long term effects on the environment.	Nil

Factor	Impacts
(i) Any degradation of the quality of the environment? During construction there is potential for noise, visual and traffic and access impacts. During operation, the Proposal is unlikely to have any degradation of the quality of the environment.	Minor
(j) Any risk to the safety of the environment? The Proposal is unlikely to cause any pollution or safety risks to the environment provided the recommended mitigation measures are implemented.	Nil
(k) Any reduction in the range of beneficial uses of the environment? The Proposal is unlikely to have any reduction in the range of beneficial uses of the environment.	Nil
(l) Any pollution of the environment? The Proposal is unlikely to cause any pollution of the environment provided the recommended mitigation measures are implemented.	Nil
(m) Any environmental problems associated with the disposal of waste? The Proposal is unlikely to cause any environmental problems associated with the disposal of waste. All waste would be managed and disposed of with a site-specific Waste Management Plan. Mitigation measures would be implemented to ensure waste is reduced, reused or recycled where practicable.	Nil
(n) Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply? The Proposal is unlikely increase demands on resources that are or are likely to become in short supply.	Nil
(o) Any cumulative environmental effect with other existing or likely future activities? Cumulative effects of the Proposal are described in Chapter 6. Where feasible, environmental management measures would be coordinated to reduce cumulative construction impacts. The Proposal is unlikely to have any significant long term impacts.	Nil
(p) Any impact on coastal processes and coastal hazards, including those under projected climate change conditions? The Proposal would not affect or be affected by any coastal processes or hazards.	Nil

Appendix C Brookvale-Dee Why B-Line On-Road Infrastructure – Traffic and Transport Assessment

Northern Beaches B-Line
Roads and Maritime Services NSW
20-Oct-2016

Brookvale-Dee Why B-Line On-Road Infrastructure

Traffic and Transport Assessment (Oct 2016)

Brookvale-Dee Why B-Line On-Road Infrastructure

Traffic and Transport Assessment (Oct 2016)

Client: Roads and Maritime Services NSW

ABN: 76 236 371 088

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20-Oct-2016

Quality Information

Document Brookvale-Dee Why B-Line On-Road Infrastructure

Ref

Date 20-Oct-2016

Prepared by John Bennett / Fariza Hoque / Muneem Anwar

Reviewed by Andersen Hui

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
1	13-Sep-2016	DRAFT	Andersen Hui	
2	7-Oct-2016	FINAL	Andersen Hui	
3	20-Oct-2016	FINAL_v2	Andersen Hui	

Table of Contents

Glossary of Terms

Term	Meaning
A	
Active Travel / Active Transport	Walking and cycling.
VPD	Vehicles Per Day
Arterial Road	Inter-regional roads, urban freeways / motorways, the main function of which is to provide for the safe and efficient movement of people and freight.
B	
BBCD	Burnt Bridge Creek Deviation
Bottleneck	The location on the road network where traffic is held up.
BRT	Bus Rapid Transit
BTS	NSW Bureau of Transport Statistics
Bus priority	Measures to enable buses to have priority over other modes of transport, such as a bus jump at an intersection.
C	
Carriageway	The portion of a roadway used by vehicles including shoulders and ancillary lanes.
Casualty	A person killed or injured as a result of a crash.
CBD	Central Business District
D	
Do Nothing	A scenario in which the upgrades in the B-line proposal do not occur.
DOS	Degree of Saturation
G	
GEH Value	A non-linear statistic used to compare two sets of traffic volumes (i.e. those obtained from the traffic survey and those generated by the VISSIM microsimulation traffic model).
H	
HGVs	Heavy Goods Vehicles are vehicles classified as a Class 3 vehicle (a two axle truck) or larger, in accordance with the Austroads Vehicle Classification System. (i.e. trucks, tankers, B-Doubles)
I	
Interchange	A place where people can change between different modes of transport, or from one service to another.
IDM	Intersection Diagnostic Monitor
J	
JTW	Journey To Work

Term	Meaning
L	
Left-in / left-out	Restricted turning movements for vehicles entering and leaving the road. Only left hand turns would be permitted due to the central median barrier to prevent conflicting traffic movements.
LEP	Local Environmental Plan
Level of Service (LoS)	The measure for determining the performance of an intersection.
LGA	Local Government Area
M	
Median	A line, barrier or area running down the centre of a road that separates opposing traffic lanes.
Microsimulation	A detailed form of traffic modelling analysis used to simulate traffic flows.
Mid-block	Refers to traffic volumes on sections of road located between intersections.
Mode share	The proportion of people using a particular mode of transport.
O	
OD	The Origin and Destination (of a trip).
P	
Peak hours	The AM and PM traffic peak periods in the Study Area.
R	
REF	Review of Environmental Factors
RMS	Roads and Maritime Services of New South Wales.
Roads and Maritime	Roads and Maritime Services of New South Wales.
RTA	The former Roads and Traffic Authority of New South Wales.
S	
SCATS	Sydney Coordinated Adaptive Travel System
Seed	Term to describe values selected at random by the microsimulation traffic model that provide for different variables to occur within the traffic flow.
Shoulder	The portion of the carriageway beyond the traffic lanes adjacent to and flush with the surface of the pavement.
SIDRA	A modelling software used for intersection and network analysis
Signalising	Upgrading an intersection to include traffic signals.
STFM	Sydney Strategic Forecasting Model
State Road	Road managed by Roads and Maritime Services.
T	
TfNSW	Transport for New South Wales
TMAS	Transport Management and Accessibility Study
Travel time surveys	Data obtained from GPS recorders located within vehicles travelling along the B-line corridor
TZ	Travel Zone (statistical area)

Term	Meaning
V	
V/C Ratio / Volume Capacity Ratio	A method of assessing the level of traffic congestion on a road by relating the theoretical capacity of the road to expected traffic volumes. A factor of 1.0 is used to represent the capacity of an intersection or approach/movement.
Veh/hr	Vehicles per hour
VISSIM	A microsimulation traffic model used to simulate traffic

1.0 Introduction

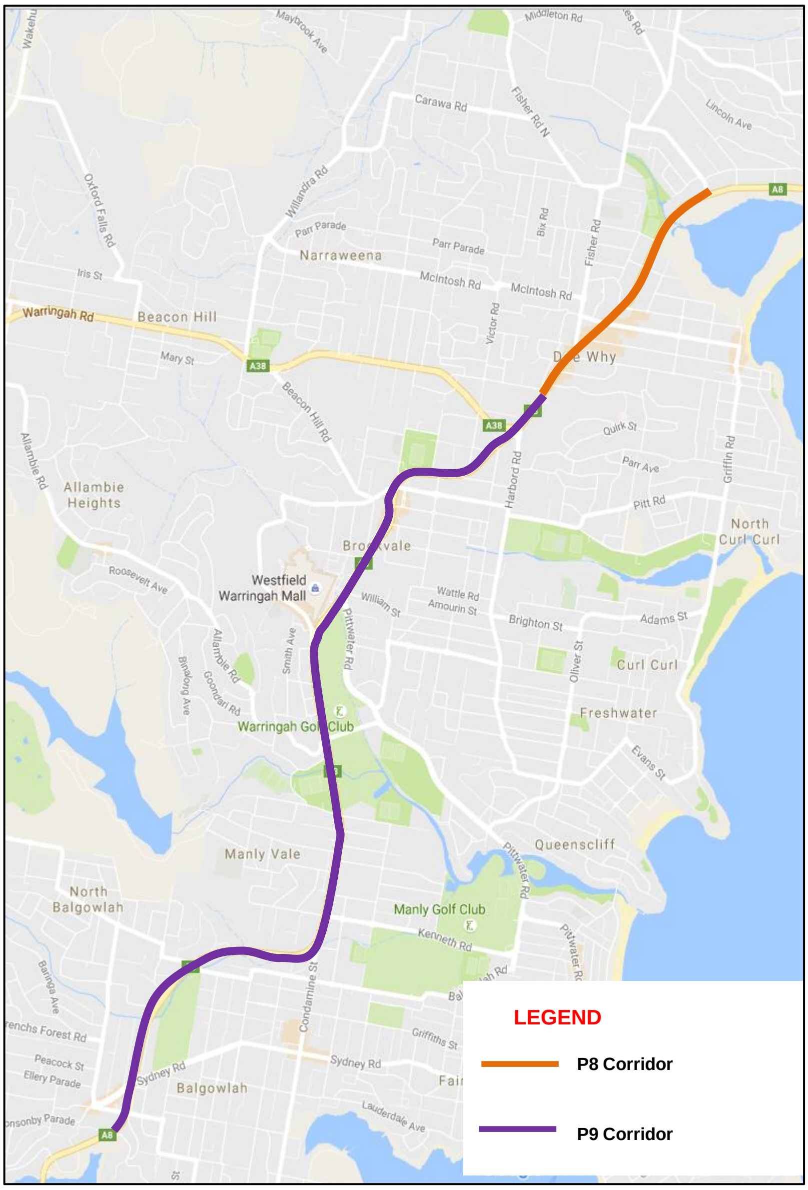
1.1 Background

NSW Roads and Maritime Services (Roads and Maritime) is proposing a series of road infrastructure improvements along Pittwater Road at Brookvale and Dee Why in Sydney, as part of the overarching Northern Beaches B-Line Program (otherwise referred to as 'the B-Line Program'). A traffic and transport assessment is being prepared by AECOM as part of the project's Review of Environmental Factors (REF).

The entire B-Line program is divided into different work packages which will be assessed as separate bodies of works by RMS and TfNSW. Specifically, the following two sections of the Pittwater Road B-Line corridor in Sydney's Northern Beaches as shown in **Figure 1**, are the focus of this report:

- B-line Package (P8) - between Pittwater Road / South Creek Road and Pittwater Road / Warringah Road.
- B-line Package (P9) - between Pittwater Road / Warringah Road and Manly Road / Avona Crescent.

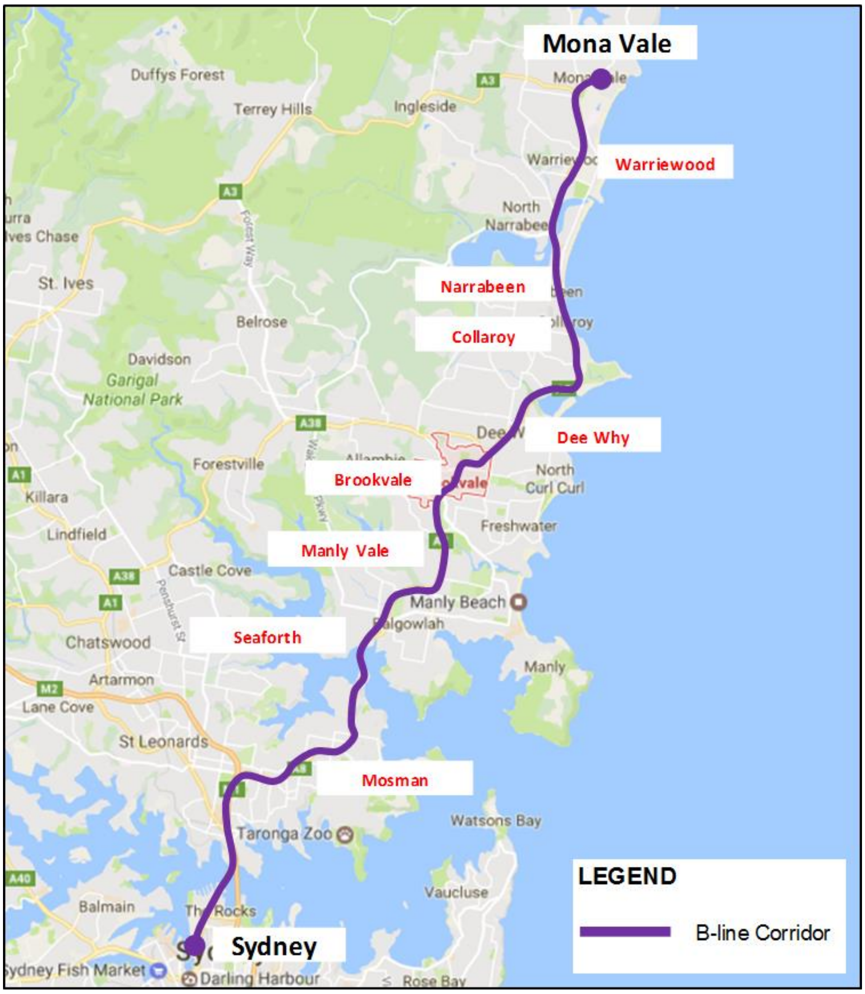
Figure 1 B-Line bus corridor locations (P8 and P9)



Background source: Google Maps

The overarching Northern Beaches B-Line program is an integrated program of bus service and infrastructure improvements that aims to deliver more frequent and reliable services for customers travelling between the Northern Beaches and Sydney CBD. The program includes on-road and off-road infrastructure improvements and enhancements to the broader Northern Beaches bus network, with a focus on improvements in bus travel times. The extents of the entire B-Line corridor are illustrated in **Figure 2.**

Figure 2 B-Line Corridor (Mona Vale to CBD)



The overall aim of the program is to improve the efficiency of the bus transport network within the Northern Beaches by addressing the following key existing issues:

- Unreliable and inconsistent bus journey times on the main north-south corridor.
- Long wait times for bus services in off-peak periods when frequency is reduced.
- A lack of network legibility due to the complexity of the bus network, which leads to bus congestion.
- Low peak-period average bus speeds, combined with long travel times and delays along the north-south corridor.
- Uneven passenger loadings across similar services on the north-south corridor.
- Passenger crowding and poor pedestrian levels of service at major bus stops along the corridor.
- User dissatisfaction with current level of bus stop amenity.

1.2 Proposal outline

The B-Line program proposes the following key improvements and traffic management measures along the P8 and P9 sections of the corridor as part of the overall B-Line work packages.

- Extension of the existing bus lane operation periods in the PM Peak to five hours between 3pm and 8pm.
- Implementation of new clearways and extension of existing clearways.
- Consolidation of existing local bus stops to reduce dwell times and improve bus travel times.
- Construction of indented bus bays to remove in lane bus stops.
- Provision of a new double decker bus fleet.
- Targeted intersection upgrades to provide additional capacity and improve bus priority / traffic flow / safety.

Further details of the proposed upgrades are provided in **Section 1.3**.

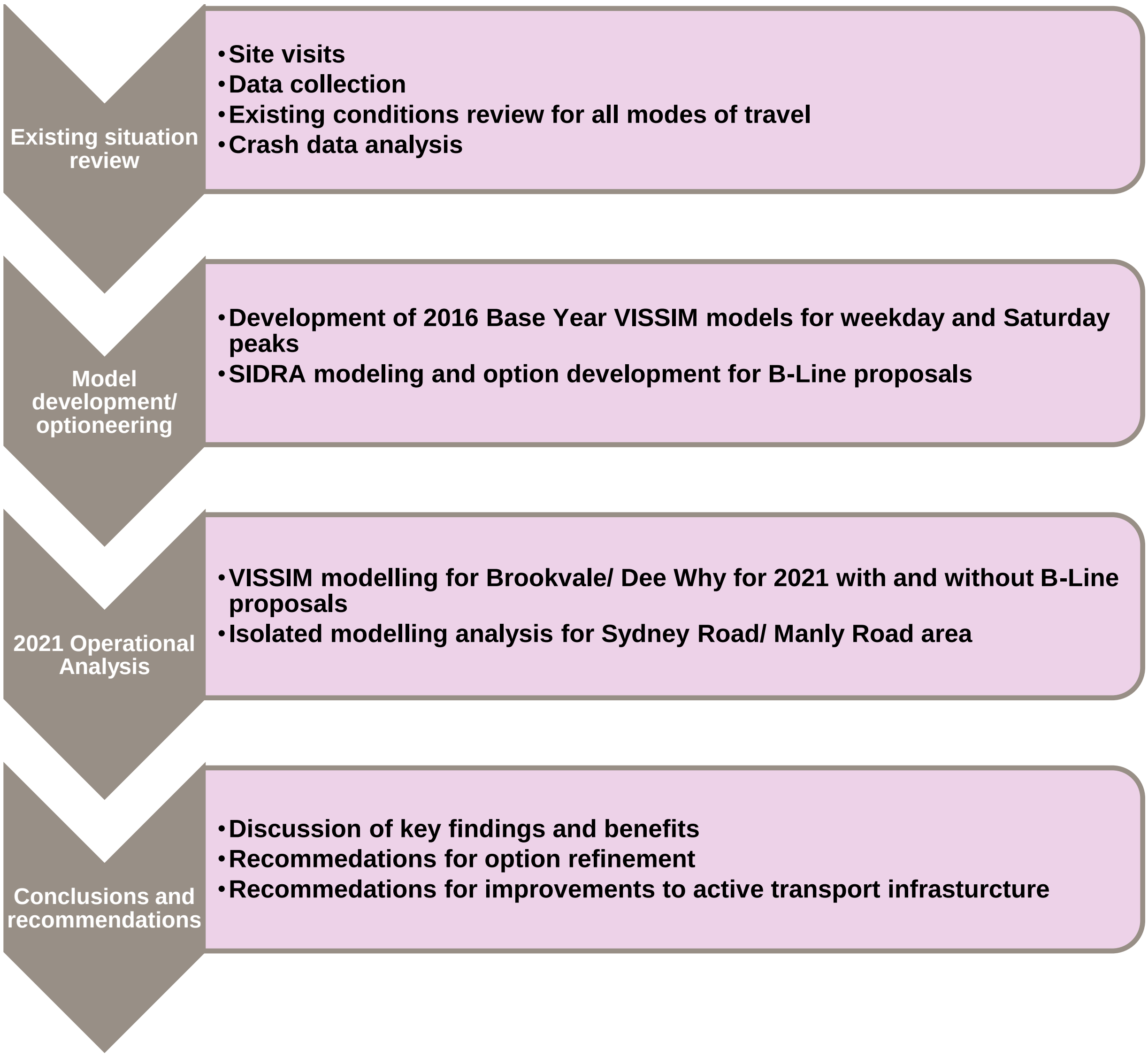
1.3 Study objectives

This report provides details of the traffic and transport assessment methodology, assumptions, findings and recommendations. The key objectives for this study relate to the assessment and analysis of on-road upgrades proposed along the P8 and P9 sections of B-Line, including:

- Analysis of the current operation of the corridor for buses and general traffic to determine existing issues.
- Assessment of the future operation of the corridor for buses and general traffic with and without the proposed B-Line upgrades.
- Optioneering of the proposed on-road infrastructure upgrades to identify preferred options.
- Assessment of current active transport provision along the P8 and P9 sections of the B-Line corridor.

A key focus of the assessment has been the operation of the study area road network for buses and general traffic. The network operational assessment for the current situation (Base Year) and in the future was undertaken using SIDRA and VISSIM traffic modelling. The overall study approach is illustrated in **Figure 3**. Details of the modelling assessment methodology, assumptions and findings are presented in the later sections of this report.

Figure 3 **Overall study approach**



1.4 Report structure

The remainder of this report takes the following structure:

Section 2 – B-Line proposal

Section 3 – Existing conditions

Section 4 – Future traffic growth

Section 5 – Traffic operational assessment

Section 6 – Future transport provision

Section 7 – Summary and conclusion

2.0 B-Line proposal

The B-Line proposal will include a number of physical upgrades to the road network to accommodate the high frequency bus service. In addition, a range of other traffic management measures such as indented bus bay, clearways and local road closure are proposed to improve traffic flow and reduce delay for the B-Line and local bus services. The B-Line proposal is described in detail in the following sections.

2.1 Network upgrades

Details of the road network upgrades proposed as part of the P8 and P9 work packages are provided in **Table 1**.

Table 1 Upgrades proposed in the P8 and P9 work packages

Location	Proposed upgrade	Corridor section
Pittwater Rd south of Hawkesbury Ave	Provision of indented bus bay on Pittwater Road, south of Hawkesbury Avenue to accommodate two local buses.	P8
Pittwater Rd near Howard Ave	Provision of local bus stop on Pittwater Road south of Howard Avenue to accommodate two local buses. Provision of an additional southbound lane on Pittwater Road between Oaks Avenue and Howard Avenue.	P8
Pittwater Rd / Oaks Ave	Extension of northbound right turn pocket for vehicles turning right from Pittwater Road into Oaks Road.	P8
Pittwater Rd / Cross St	Provision of an additional northbound left turn lane into Cross Street. Modification of signals to provide protection for pedestrian crossing the Cross Street west approach.	P9
Pittwater Rd / Orchard Rd	Banning of the northbound right turn into Orchard Road from Pittwater Road by closing the existing median opening.	P9
Manly Rd / Heaton Ave	Provision of an indented bus bay at Heaton Avenue, south of the Manly Road / Sydney Road intersection, facilitated by the closure of access to and from Manly Road.	P9
Sydney Rd / Manly Rd	Extension of the southbound right turn lane from Burnt Bridge Creek Deviation to Sydney Road. Extension of the westbound through lane from Sydney Road east to Sydney Road west. Extension of the northbound right turn lane from Manly Road to Sydney Road. Extension of the northbound left turn slip lane from Manly Road to Sydney Road. Provision of an additional eastbound left turn lane from Sydney Road west approach to Burnt Bridge Creek Deviation. Provision of two exit lanes on Sydney Road east approach.	P9

Additional upgrades are proposed along the corridor as part of the C3 Clearway program and Health Infrastructure packages of works. Whilst these upgrades are not directly associated with the subject REF, they will work in tandem with the B-Line proposal to improve bus operation along the corridor. Therefore, a majority of these proposed improvements have been included in the modelling to provide a holistic understand of the future traffic conditions.

Work package C3 proposes the removal/ relocation of existing bus stops, whilst Health Infrastructure proposes the construction of a commuter carpark and intersection upgrades. Detailed inputs of the Health Infrastructure works were not confirmed at the time of model development and therefore not included as part of the modelling assessment. The C3 and Health Infrastructure works are detailed in **Table 2**.

Table 2 Upgrades proposed in the C3 and other package of works

Location	Proposed upgrades	Section	Package of works	Included / excluded from modelling
Pittwater Rd near Howard Ave	Provision of two new B-Line bus stops (northbound and southbound) to accommodate two B-Line buses on Pittwater Road south of Howard Avenue.	P8	C3	Included
Pittwater Rd near May Rd	Removal of outbound bus stop on Pittwater Rd near May Road (bus stop 209911).	P8	C3	Included
Dee Why adjacent to Kingsway and Fisher Rd	TFNSW is proposing to acquire the bottom level of the existing PCYC carpark in Dee-Why. This is expected to generate 120 additional trips.	P8	Warringah Council	Included
North of Brookvale Interchange (Pittwater Rd / Condamine St / William St)	Provision of two new B-Line bus stops (northbound and southbound) north of Condamine Street to accommodate three B-line buses	P9	C3	Included
Brookvale (adjacent to Pittwater Road / Condamine Street / William Street)	Construction of a new commuter carpark in Brookvale.	P9	Health Infrastructure	Excluded
Pittwater Rd / Condamine St / William St	Removal of existing at-grade pedestrian crossing. Modification of traffic signals at Pittwater Road/ Condamine Street/ William Street to facilitate the right turn out of William Street into Pittwater Road.	P9	Health Infrastructure	Excluded
Pittwater Rd / Condamine St / William St	Construction of pedestrian bridge to provide a pedestrian walk-way between the southbound bus stand and Warringah Mall precinct.	P9	Health Infrastructure	Excluded
Pittwater Rd near Roger St	Removal of outbound bus stop near Roger Street (bus stop 210015).	P9	C3	Included
Pittwater Rd near Orchard Rd	Removal of inbound bus stop near Orchard Road (bus stop 210026).	P9	C3	Included
Condamine Street near Fishbourne Road	Remove outbound bus stop on Condamine Street near Fishbourne Road (bus stop 2100109)	P9	C3	Included
Condamine Street near James Street	Relocate bus stop 210011 to opposite 210028.	P9	C3	Included

2.2 B-Line bus services

Details of the proposed B-Line bus service frequencies and operation are outlined in the *Northern Beaches B-Line Program Final Business Case* report. It is proposed that the B-Line service will run at 3-4 minute intervals on the AM peak; at five minute intervals in the PM peak; and at 10 minute intervals on weekends.

The B-Line services are intended to provide a high frequency express service that will be similar in operation to a bus rapid transit or light rail service. For this reason the B-Line will operate at limited stops along the corridor to keep dwell time delay to a minimum, with local bus services catering for the shorter localised journeys.

2.3 Clearways

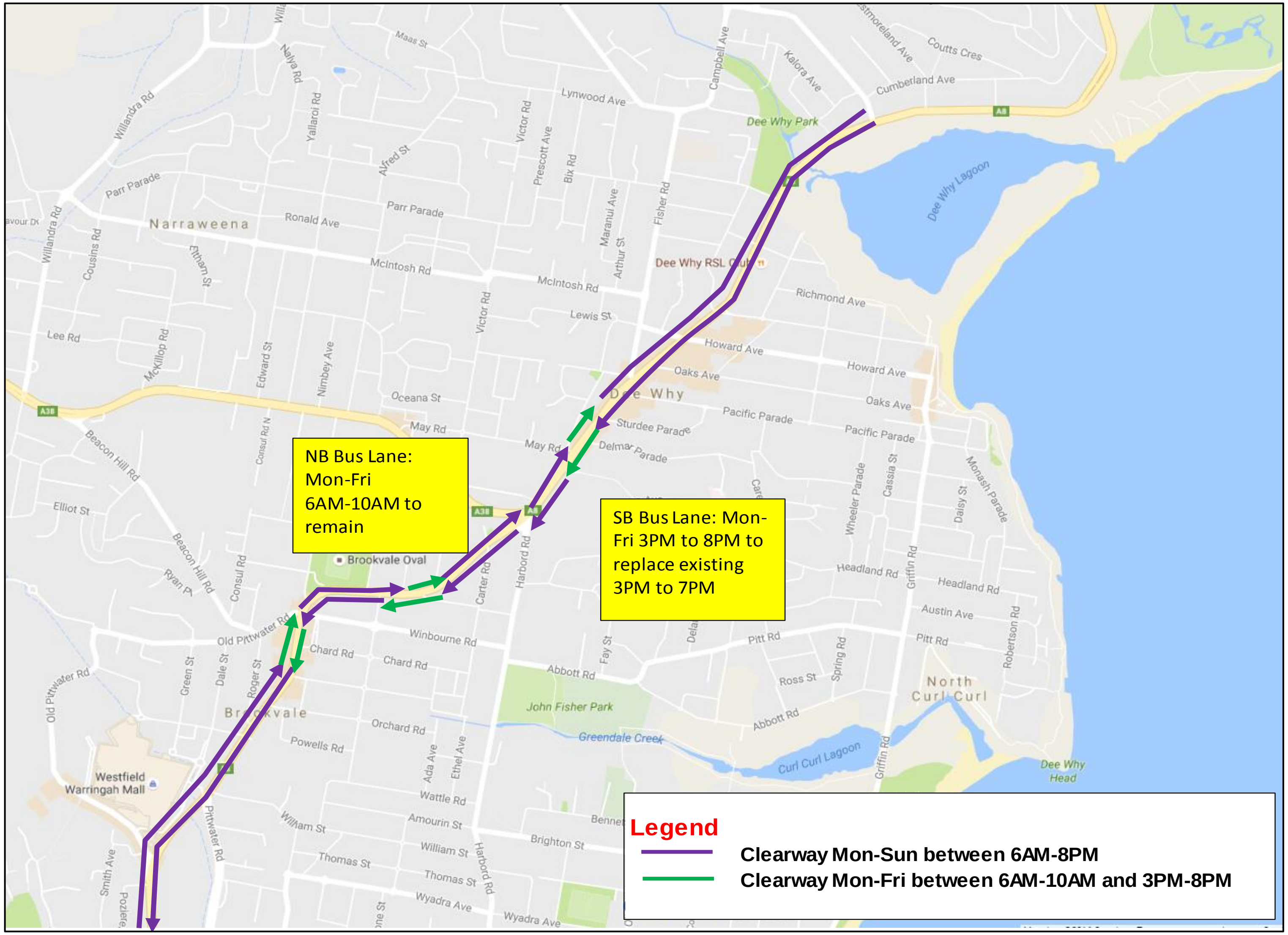
The Northern Beaches B-line Program Final Business Case, February 2016 proposes a number of clearways along the corridor to improve flow progression and reduce delays for buses. The Clearways proposed in Brookvale and Dee Why are summarised in **Table 3** and graphically represented in **Figure 4**.

In brief, the proposed clearways will be operational either five days a week between 6AM-10AM and 3PM-8PM or seven days a week between 6AM and 8PM.

Table 3 Clearways proposed in the study area

Clearways (7-days between 6AM and 8PM)		Clearways (5-days between 6AM-10AM and 3PM-PM	
Pittwater Road (NB)	Pittwater Road (SB)	Pittwater Road (NB)	Pittwater Road (SB)
• Warringah Road to May Road, Dee Why • Sturdee Parade to South Creek Road, Dee Why • King Street, Manly Vale, to Sydenham Road, Brookvale • Winbourne Road to between Pine Avenue and Victor Road • Victor Road to Warringah Road	• South Creek Road to Sturdee Parade • Stony Range Regional Botanic Garden carpark access to Warringah Road, Dee Why • Warringah Road to Victor Road • North of Mitchell Road to Winbourne Road, Manly Vale • Sydenham Road to King Street, Manly Vale	• May Road to Sturdee Parade, Dee Why • Sydenham Road to Winbourne Road • North of Pine Avenue to Victor Road	• Sturdee Parade to Stony Range Regional Botanic Garden, Dee Why, carpark access • Victor Road to north of Mitchell Road • Winbourne Road to Sydenham Road

Figure 4 Clearways proposal in the study area



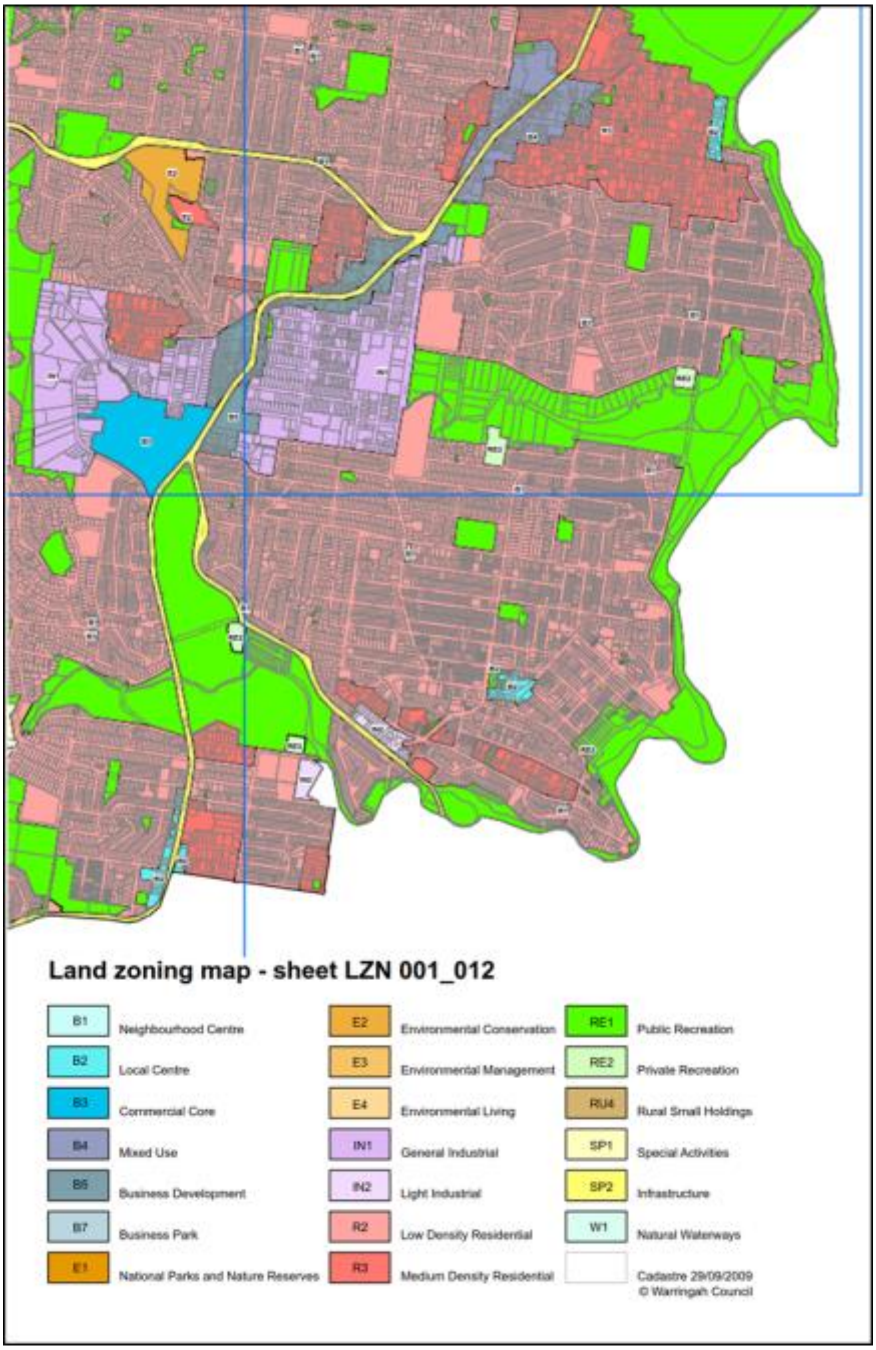
3.0 Existing conditions

This section of the report provides details of the existing conditions along the corridor for all modes of travel. This includes a review of existing infrastructure for vehicles and active transport; details of existing land uses and key developments; existing travel patterns; and current performance of intersections along the corridor.

3.1 Existing land uses

Existing land uses in the study area consist of a mix of retail, commercial and residential development. The current land use plan for the study area is shown in **Figure 5**.

Figure 5 Study area land zoning map



Source: Warringah Council

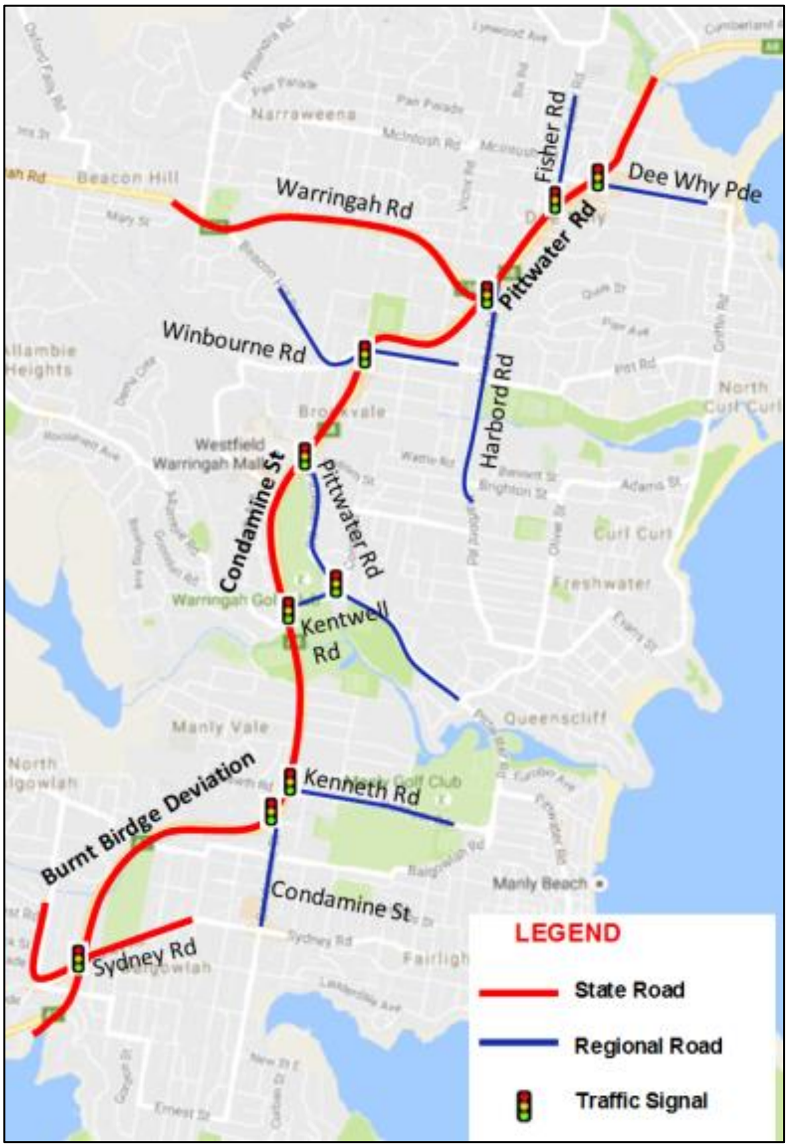
The study area generally consists of low density residential development, with sections of the northern and southern end of the corridor zoned as medium density residential. The central section of the corridor is zoned as B4 Mixed Use, B5 Business Development and IN1 General Industrial. Land adjacent to Pittwater Road / Condamine Street intersection is zoned as B3 Commercial Core, which includes Warringah Mall. Land to the south of Pittwater Road / Condamine Street intersection is zoned as RE1 Public Recreation.

3.2 Road network

The Pittwater Road / Condamine Street / Burnt Bridge Creek Deviation corridor is a state road that serves as a primary arterial route and provides connections between the Sydney CBD in the south (via the M1 Motorway) and the Northern Beaches in the north (terminating at Mona Vale). Warringah Road is also a state road and connects with Pittwater Road in the central section of the study area. It provides a primary arterial east-west route between the Northern Beaches suburbs and Chatswood in the west.

Within the study area, numerous lower-order side roads connect with Pittwater Road and Warringah Road that provide access into the residential areas and retail / commercial areas in the area surrounding Warringah Mall, Brookvale and Manly Vale commercial centres. An overview of the road hierarchy and signalised intersections along the corridor at the connections with the regional roads are illustrated in **Figure 6.**

Figure 6 Existing intersection control types along the corridor



Background source: Google Maps

Pittwater Road / Condamine Street / Burnt Bridge Creek Deviation / Manly Road

The main north-south corridor through the study area accommodates between 40,000 to 60,000 vehicles per day (vpd) and functions as an arterial road providing access to various urban centres; including Mona Vale, Warriewood, Narrabeen, Collaroy, Dee-Why, Brookvale, Manly Vale and Balgowlah. The corridor intersects with a number of local and sub-regional roads along the P8 and P9 corridor sections.

On-street parking is permitted along the sealed shoulders at various points on either side of the corridor. Kerbside bus lanes are operational in the southbound direction in the AM peak period between 6AM and 10AM; and in the northbound direction in the PM peak between 3PM and 7PM.

The posted speed limit along the corridor varies between 60 kilometres per hour (kph) along Pittwater Road / Condamine Street to 80 kph along Burnt Bridge Creek Deviation.

Warringah Road

Warringah Road is a state road which connects with Pittwater Road at the intersection with Harbord Road. It carries about 41,000 vpd. Warringah Road functions as an arterial road and provides a key east-west route between the Northern Beaches and Sydney's central suburbs.

Harbord Road

Harbord Road is a regional road forming the eastern leg of Pittwater Road/ Warringah Road intersection. Harbord Road functions as a sub-arterial road and provides access to a number of residential developments to the east and commercial developments to the west. Harbord Road provides access to Curl Curl and Freshwater town centres. The posted speed limit is 60 kilometres per hour.

Winbourne Road

Winbourne Road is a sub-arterial road and provides access to number of residential and commercial areas. Winbourne Road forms a four-way intersection with Pittwater Road. The posted speed limit along the road is 50 kilometres per hour.

Fisher Road

Fisher Road is a sub-arterial road and provides access to shopping complex and residential areas. Fisher Road forms a signalised T-intersection with Pittwater Road. It has a posted speed limit of 50 kilometres per hour.

Dee-Why Parade

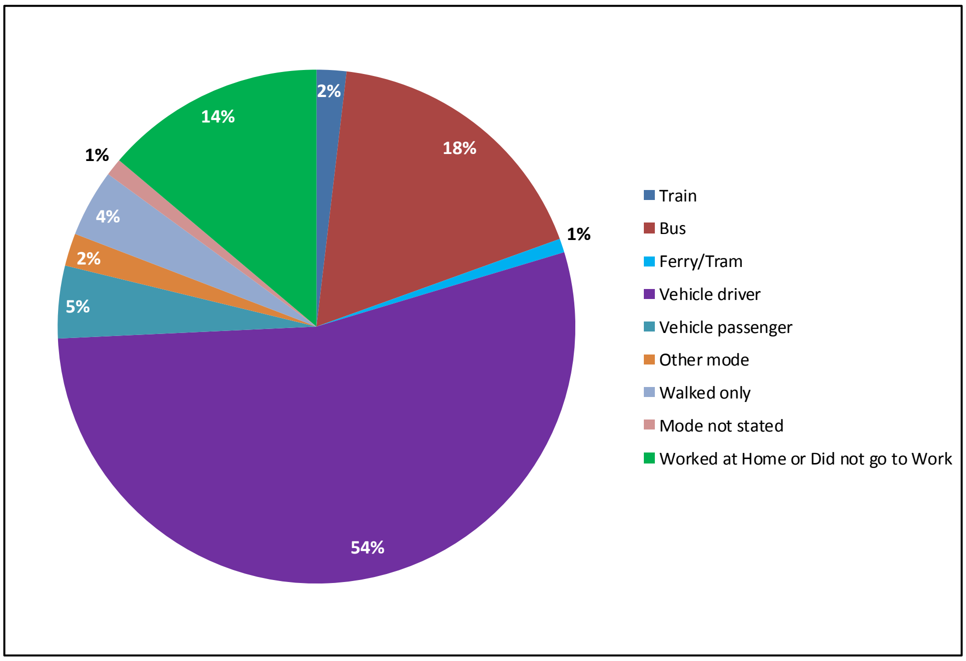
Dee-Why Parade is a sub-arterial road and provides access to commercial and residential areas. Dee-Why Parade forms a signalised T-intersection with Pittwater Road. It has a posted speed limit of 50 kilometres per hour.

3.3 Travel mode shares

A review of 2011 journey-to-work data was undertaken to determine the current travel patterns for the study area.

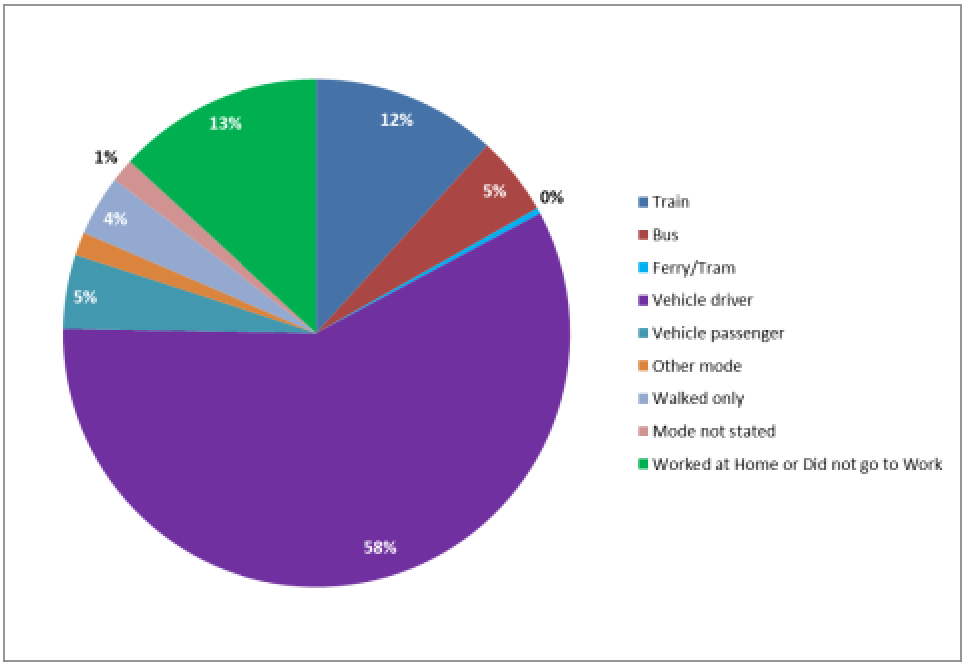
Figure 7 shows the mode shares for journey-to-work trips in the Warringah LEP, which aligns with the extent of subject study area. The data shows that around 60% of travel from the area is made by private car or car passenger travel; with around 20% of journeys undertaken by public transport (predominantly by bus). The mode share data for Warringah is broadly consistent with that of metropolitan Sydney, which has a slightly higher mode share of car driver / car passenger and slightly lower mode share of public transport journeys (refer **Figure 8).**

Figure 7 Journey to work mode share data for the study area



Source: Journey to Work (2011), NSW Bureau of Transport Statistics

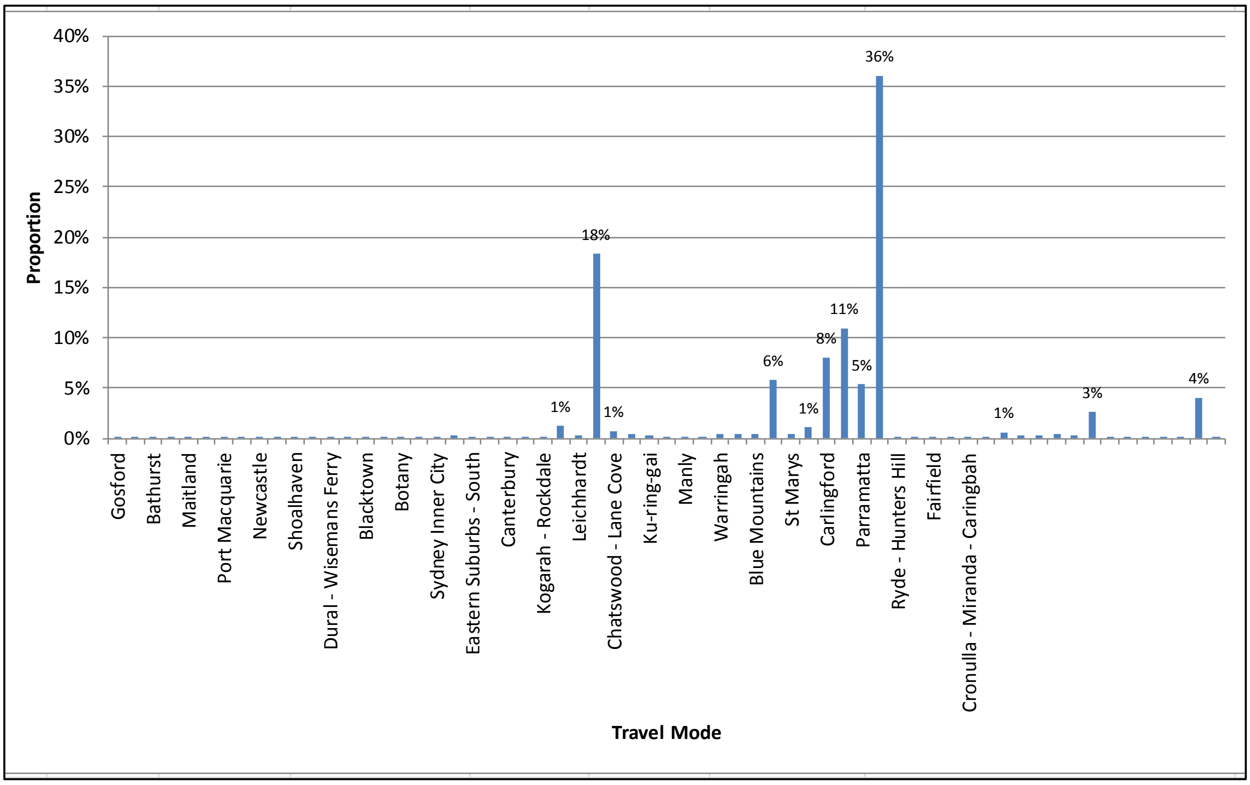
Figure 8 Journey to work mode share data for metropolitan Sydney



Source: Journey to Work (2011), NSW Bureau of Transport Statistics

Figure 9 shows that 36% of journey to work trips in the Warringah Council LGA are generated within the LGA itself, with the remaining be generated from outside the LGA. Approximately 18% are generated from Sydney Inner City and 11% are generated from Manly. These trends seem sensible given that Pittwater Road and Condamine Street provide a major arterial route between the Northern Beaches and the Sydney CBD; and therefore accommodate a large amount of longer journeys and through traffic.

Figure 9 BTS Journey to work – Modes of Transport



Source: Journey to Work (2011), NSW Bureau of Transport Statistics

3.4 Traffic flow profiles

Midblock tube counts were extracted for a seven day period between 25 October 2011 and 31 October 2011. The midblock counts were located on Pittwater Road, north of South Creek Road; and Condamine Street, south of Old Pittwater Road.

The daily traffic flow profile of the two-way traffic along Pittwater Road, north of South Creek Road and Condamine Street, south of Old Pittwater Road are illustrated in **Figure 10** and **Figure 11**. The flow profiles indicate that the average weekday peak occurs between 7-9am in the morning and between 4-6pm in the evening.

Figure 10 Daily traffic flow profile at Pittwater Road, north of South Creek Road

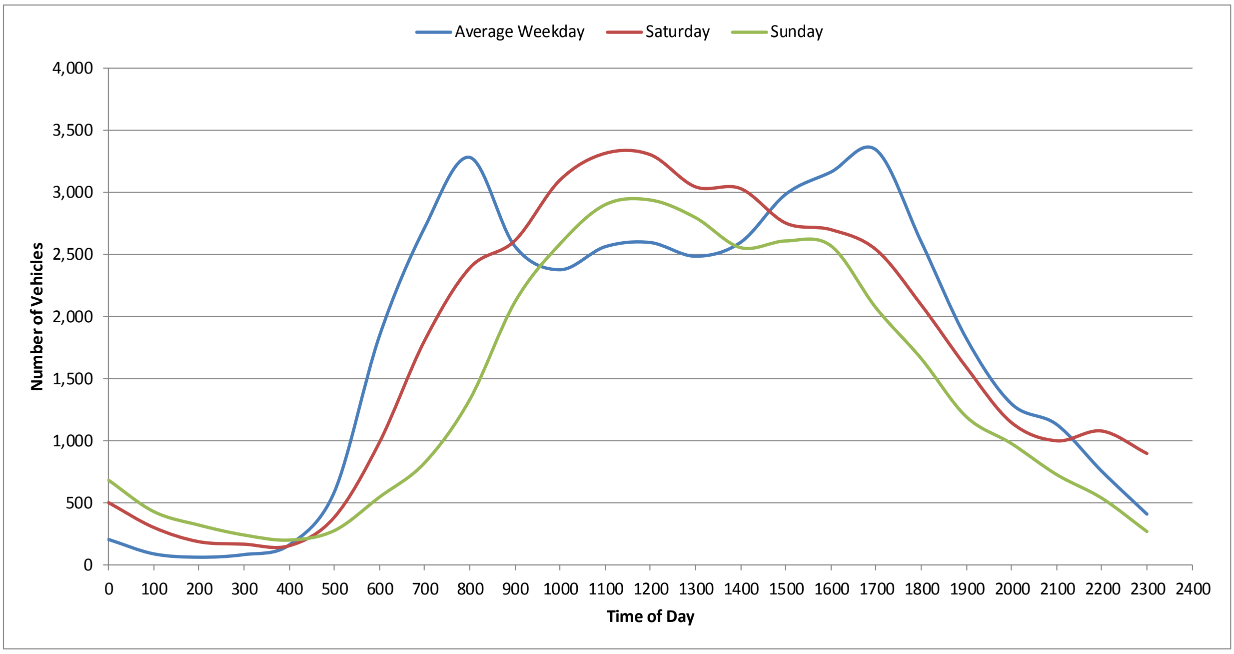
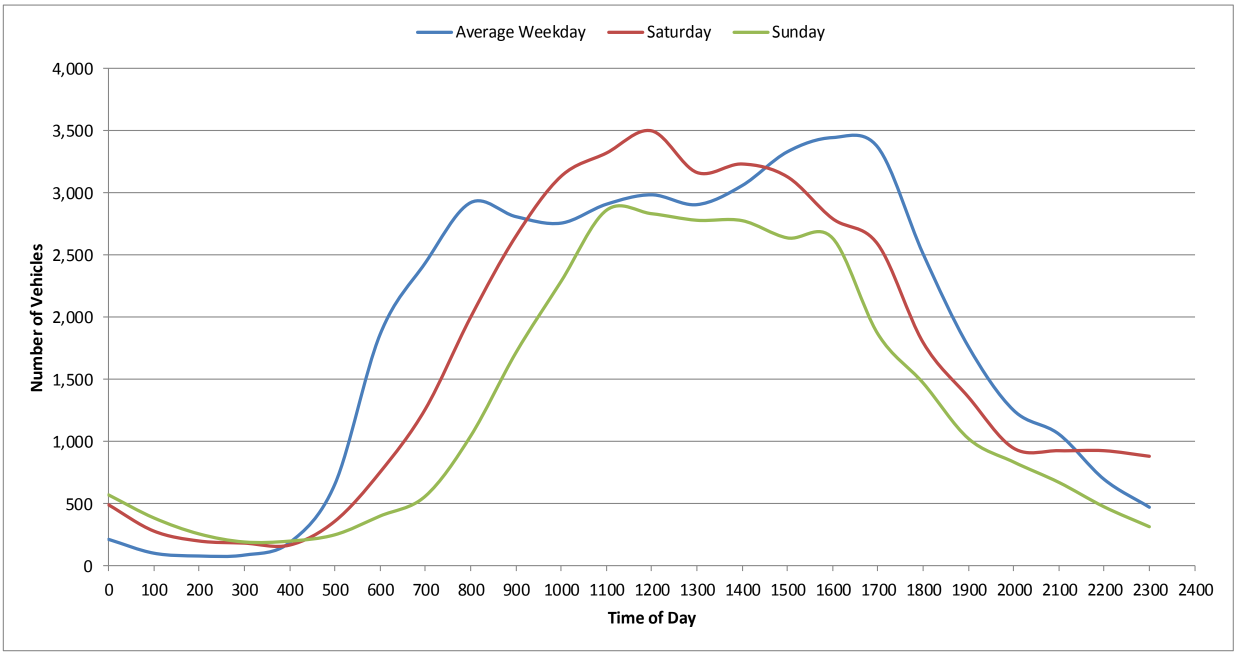


Figure 11 Daily traffic flow profile at Condamine Street, south of Old Pittwater Road



3.5 Existing network operation

As discussed in **section 1.3**, the operation of the study area road network was assessed using a VISSIM microsimulation model. The model was developed for the 2016 Base Year and for 2021 with and without the B-Line proposed upgrades. Details of the 2016 Base Year VISSIM model development are provided in the AECOM report '*Northern Beaches B-Line Program On-Road Infrastructure – VISSIM Base Model Calibration and Validation Report'*, which is contained within **Appendix B** of this report.

As well as the VISSIM model, an isolated SIDRA model of the Sydney Road / Manly Road intersection was developed and the associated Manly Road / Heaton Road closure was assessed using a Commuter microsimulation model of the southern section of the study area.

(Note that the Commuter model is being developed with the intent for a separate package of works (i.e. P12) of the B-Line program, but adopted to supplement this assessment to provide vital information such as travel time forecast.)

The following sections provide details of the 2016 Base Year network operation as forecast by the traffic modelling.

3.5.1 Intersection LOS

Intersection Level of Service (LOS) is a measure of average intersection delay across all movements. The different categories of LOS are defined in **Table 4.**

Table 4 Summary of LOS performance levels

Level of Service (LOS)	Average delay per vehicle (s)	Description
A	≤ 14.5	Best operation
B	14.5 seconds ≤ Delay ≤ 28.5	Operating well
C	28.5 seconds ≤ Delay ≤ 42.5	Desirable minimum level of operation
D	42.5 seconds ≤ Delay ≤ 56.5	Operating near capacity
E	56.5 seconds ≤ Delay ≤ 70.5	Significant congestion expected
F	70.5 ≤ Delay	Worst operation

The overall LOS for each of the key signalised intersections reported in the VISSIM model and the SIDRA model for the Sydney Road / Manly Road intersection only are summarised in **Table 5.** Summaries of the LOS by approach are provided in **Appendix A**.

Table 5 2016 Base Year LOS at key intersections

Intersection	AM peak		PM peak		Saturday	
	0700-0800	0800-0900	1630-1730	1730-1830	1130-1230	1230-1330
Pittwater Rd / Hawkesbury Ave	B	C	B	B	B	C
Pittwater Rd / Kingsway	B	B	A	B	B	B
Pittwater Rd / Howard Ave	B	C	B	B	C	C
Pittwater Rd / Oakes Ave	A	B	A	A	C	C
Pittwater Rd / Fisher Rd	B	C	B	A	B	B
Pittwater Rd / Pacific Pde	B	B	B	C	B	B
Pittwater Rd / Sturdee Pde	A	B	A	B	B	B
Pittwater Rd / Delmar Pde	B	C	B	C	C	D
Pittwater Rd / Warringah Rd	D	D	E	E	F	F
Pittwater Rd / Victor Rd	B	A	D	B	B	B
Pittwater Rd / Pine Ave	B	B	C	C	B	B
Pittwater Rd / Winbourne Rd	B	C	E	C	C	C
Pittwater Rd / Sydenham Rd	A	A	C	B	A	A
Pittwater Rd / Orchard Rd	B	C	B	B	C	B
Pittwater Rd / Cross St	B	B	C	C	C	C

Intersection	AM peak		PM peak		Saturday	
	0700-0800	0800-0900	1630-1730	1730-1830	1130-1230	1230-1330
Pittwater Rd / Condamine St	C	C	D	E	C	C
Sydney Rd / Manly Rd	F		F		n/a	

In the AM peak period the outputs show that:

- Most intersections along the corridor operate at a satisfactory LOS (LOS D or better). The only exception being the Sydney Road / Manly Road intersection, primarily due to the downstream congestion and capacity constraints experienced by road traffic south of the Spit Bridge.
- Most intersections operate at the same LOS during both AM peak hours, with the exceptions of the Hawkesbury Avenue, Howard Avenue, Fisher Road, Sturdee Parade and Winbourne Road intersections; where the LOS deteriorates slightly in the second hour as the congestion worsens due to the sustained increase of traffic demands.
- Some side road movements operate at high levels of service (E or F) even though the overall intersection LOS remains satisfactory. This is primarily due to the prioritisation of green time along the corridor for the mainline movements, which results in limited allocation of green time for the side roads.

In the PM peak period the outputs show that:

- Generally the corridor operates at a poorer LOS with increased congestion compared to the AM peak.
- The Warringah Road intersection operates at capacity (LOS E) with average delays approaching 60 seconds during both PM peak hours.
- There are a number of other intersections which approach the limits of acceptable operation (LOS D), including the Condamine Street and Victor Road intersections. The Condamine Street intersection also deteriorates to LOS E in the second hour of the PM peak.
- The Sydney Road / Manly Road intersection continues to operate unsatisfactorily in the PM peak with competing traffic demands from most approaches. The tidal flow arrangement at Spit Bridge with a single traffic lane for southbound traffic also induces downstream delays, affecting the performance of the Sydney Road intersection. This is in line with the general observation collected on site.

In the Saturday peak period the outputs show that:

- Overall corridor operates at LOS C or better with the sole exception of the Warringah Road intersection.
- The Warringah Road intersection operates at LOS F during both peak hours due to high traffic volumes on the east approach, where delays approach over 100 seconds. Despite the high side-road delays driving up the overall intersection LOS, the mainline Pittwater Road approaches still operate at LOS C and LOS D.

3.5.2 Site observations and network performance

Observation of traffic conditions was undertaken during site visits for validation against the available inputs used for the traffic modelling. In addition, operational characteristics of the road network were observed to develop an understanding of any issues and opportunities within the existing road network.

Site observations generally indicated that areas within the study area with a higher level of congestion and delays are most predominant along the Pittwater Road on approach to the Brookvale and Dee Why town centres. This is primarily due to the higher concentration and mix of various land use functions such as commercial, retail and employment activities that are typically associated with the town centres.

3.5.2.1 Dee Why

- In the morning peak, southbound traffic along Pittwater Road was observed to experience moderate delays and congestion along the section between Dee Why Parade and Sturdee Parade, partly due to the closely spaced signals and the competing traffic demands from side roads connecting to the commercial centre. Transient traffic queues were frequently observed along this section of Pittwater Road in the morning peak.
- The right turn bay on Pittwater Road on approach to Oaks Avenue was observed with traffic queuing towards Fisher Road in both the morning and evening peak periods.

- Frequent bus activities were observed at the bus stop on the eastern side of the Pittwater Road between Howard Avenue and Oaks Avenue. In both peak periods during the site visit, up to three buses were observed at the kerbside lane with passengers boarding and alighting. The relatively narrow footpath adjacent to the bus stop is also observed to have a moderate number of bus passengers queuing for bus services.
- In the evening peak, slow moving traffic was observed in both the peak (northbound) and counter-peak (southbound) directions for the section of Pittwater Road between Oaks Avenue and Sturdee Parade.

3.5.2.2 Brookvale

- In the morning peak, moderate level of delays were observed for southbound traffic on approach to the Pittwater Road / Old Pittwater Road / Winbourne Road intersection from near Brookvale Oval, west of Mitchell Road. This is due to a combination of delays from the signals and the speed reduction of the school zone effective between 8.00-9.30am.
- In the evening peak, intermittent northbound traffic queues were observed along Pittwater Road on approach to the Cross Street, Old Pittwater Road and Warringah Road intersections. The northbound queues on approach to Warringah Road could propagate south to Mitchell Road. A mix of left-turn traffic with buses using the kerbside bus lane with queues close to approximately 50 metres were also observed at approach to Cross Street.
- Frequent bus and passenger activities were observed along Pittwater Road adjacent to Warringah Mall, where the existing 'Bus-Only' lanes are located, in both directions during the peak periods.

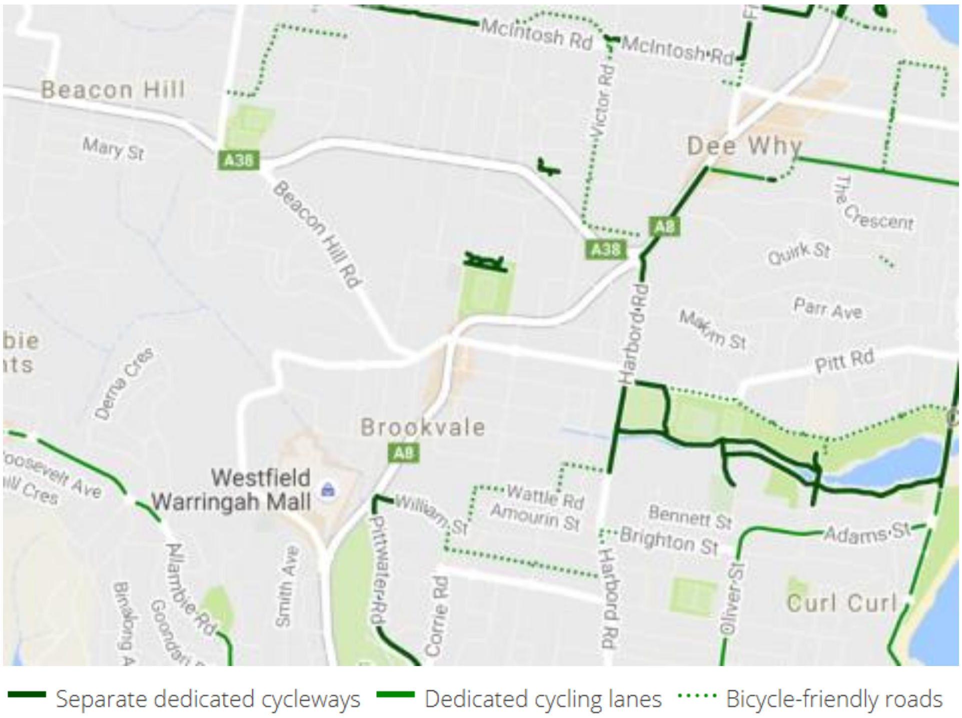
3.6 Walking and cycling

Pedestrian footpaths exist along both sides of Condamine Street, Pittwater Road and the key side roads connecting to the corridor. These paths broadly connect to provide adequate facilities to / from key transport nodes and other local area facilities and destinations.

Connected bicycle routes are not currently provided along the entire length of the Condamine Street and Pittwater Road corridor. Segregated and on-road bicycle lanes are provided along relatively short sections of the corridor in Dee Why (between Warringah Road and Sturdee Parade) and in Manly Vale (between the Condamine Street / Pittwater Road intersection and Sydney Street). Connections do exist, however, between the corridor and residential areas to the west in Brookvale and Dee Why; and Manly Vale/ North Balgowlah to the east of the corridor.

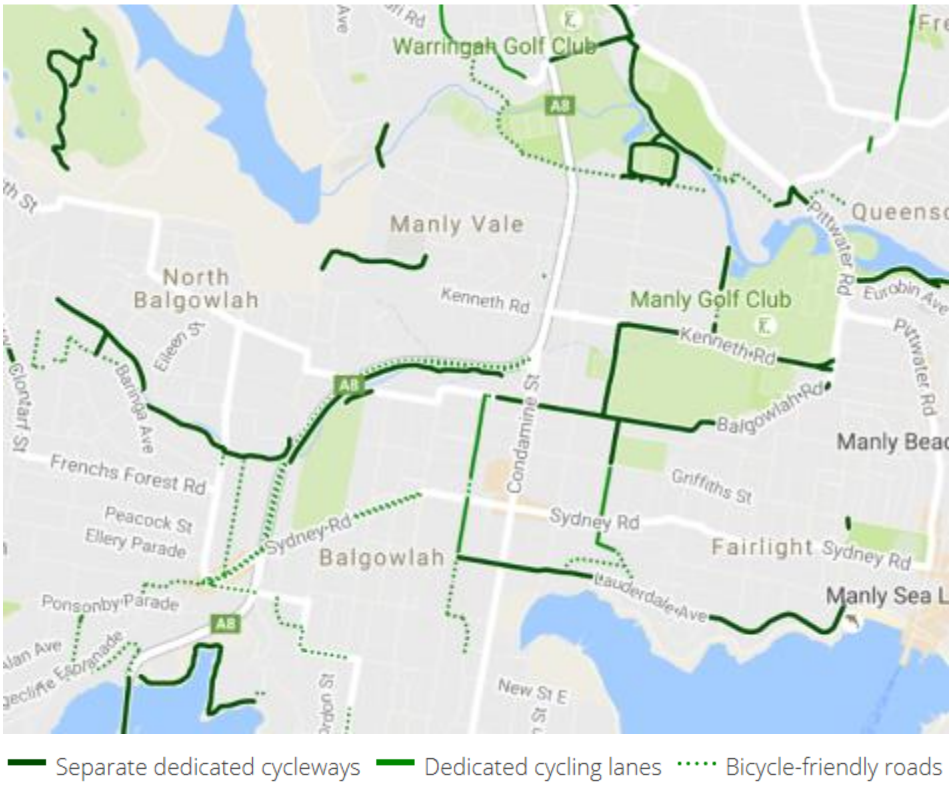
The locations of existing bicycle routes and infrastructure in the study area are illustrated in **Figure 12** and **Figure 13.**

Figure 12 Existing bicycle infrastructure in Brookvale and Dee Why (P8 and northern P9 corridor)



Source: www.sydneycycleways.net

Figure 13 Existing bicycle infrastructure in Manly Vale (southern P9 corridor)



Source: www.sydneycycleways.net

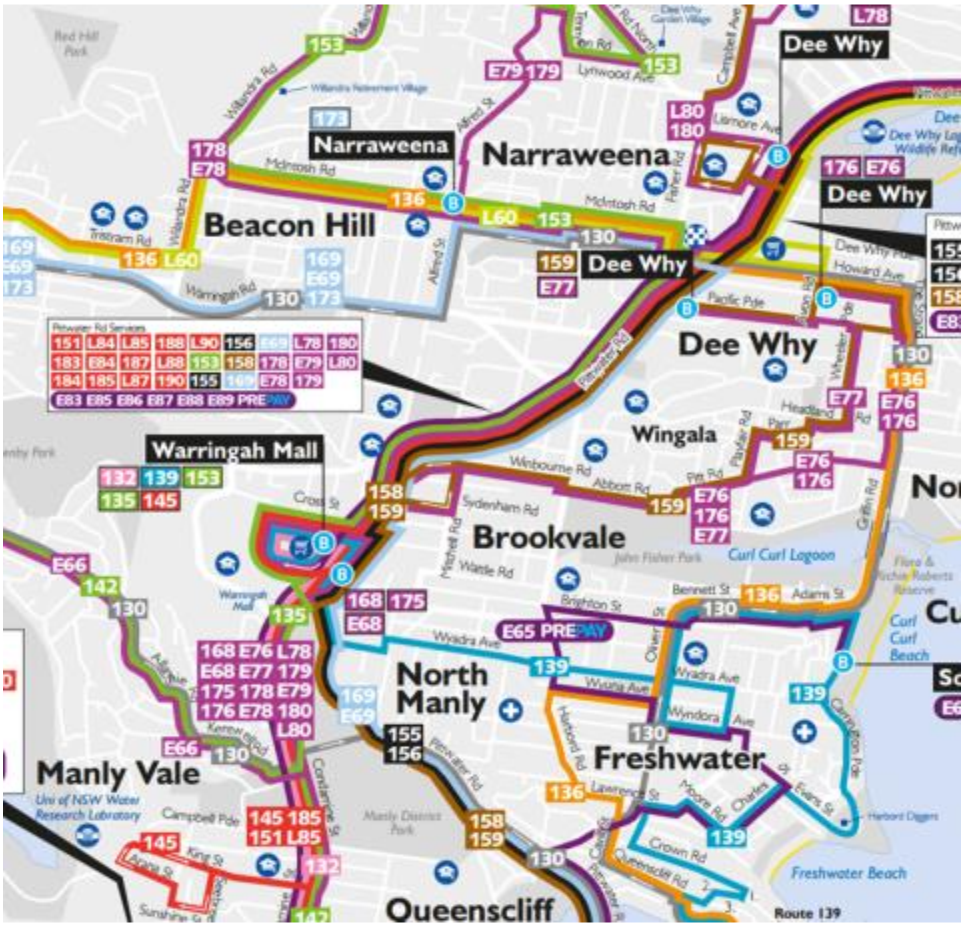
3.7 Public transport

The study area is currently served by a range of local buses that service routes along Pittwater Road / Condamine Street and the surrounding local areas. A summary of the existing bus services is provided in **Table 6.** A map of the existing bus services operating in the study area is shown in **Figure 14.**

Table 6 Existing bus services operating in the study area

Route type	Service pattern	Routes
Sydney CBD radial services along the key North-South trunk corridor between Mona Vale and Sydney CBD or Milsons Point	Peak hour express	E65, E66, E68, E69, E76, E77, E78, E79, E83, E84, E85, E86, E87, E88, E89
	Limited stops	L78, L80, L84, L85, L87, L88, L90
	All stops	151, 168, 169, 175, 176, 178, 179, 180, 183, 184, 185, 188, 190
Cross regional routes linking the Northern Beaches to Gordon, Frenchs Forest and Chatswood	Limited stops	L60
	All stops	196, 197, 280 (Forest Coaches)
Local routes which provide feeder services to the trunk corridor and provide access to key local destinations	All stops	130, 131, 132, 135, 136, 137, 139, 142, 143, 144, 145, 153, 155, 156, 158, 159, 182, 187, 189

Figure 14 Existing bus services operating in the study area



Source: Transport for NSW

Peak direction bus priority and traffic measures along the corridor and are shown in **Figure 15** to **Figure 18.**

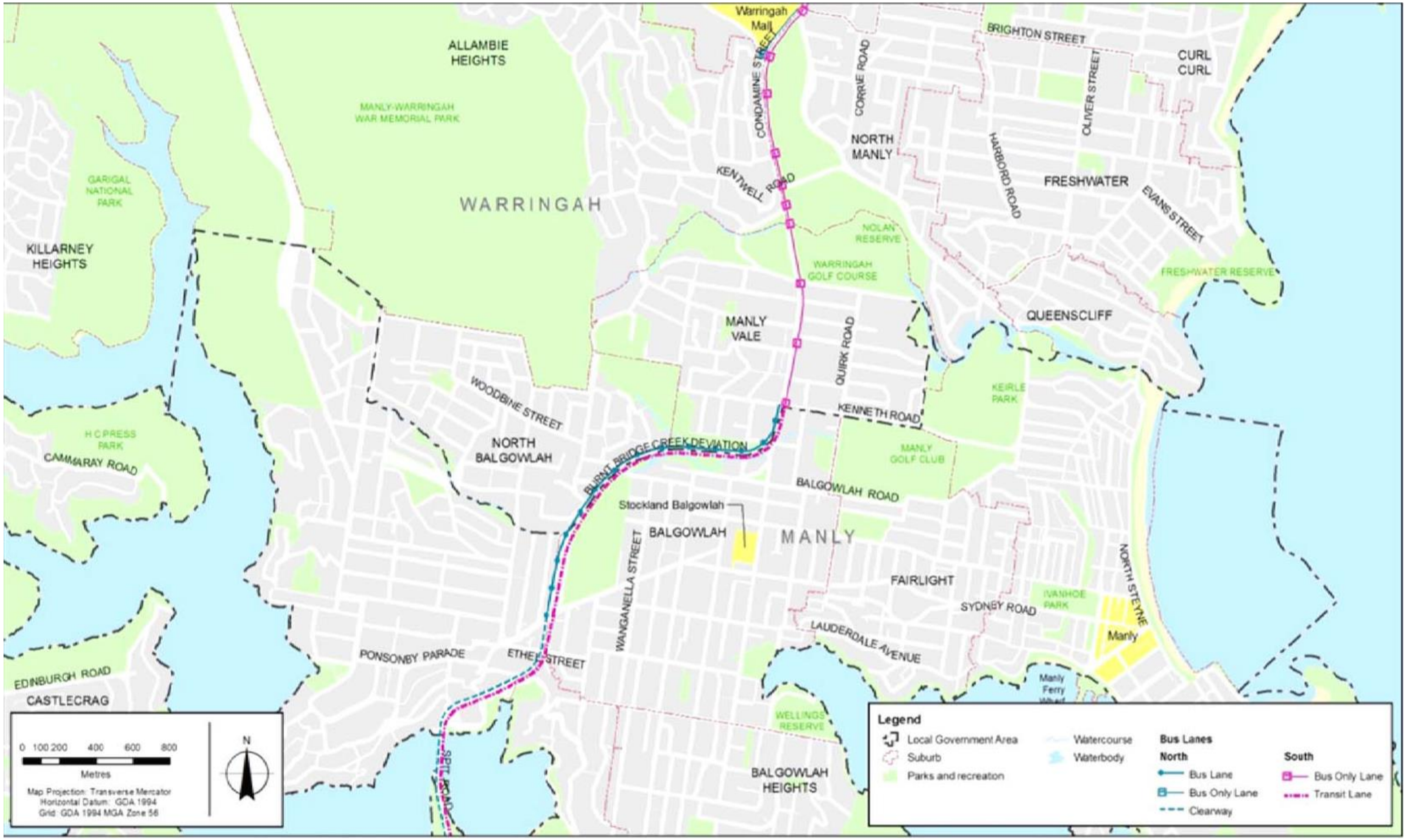
Figure 15 AM peak bus lanes and T3 lanes in Brookvale and Dee Why

Source: TfNSW 2014

Figure 16 PM peak bus lanes and T3 lanes in Brookvale and Dee Why

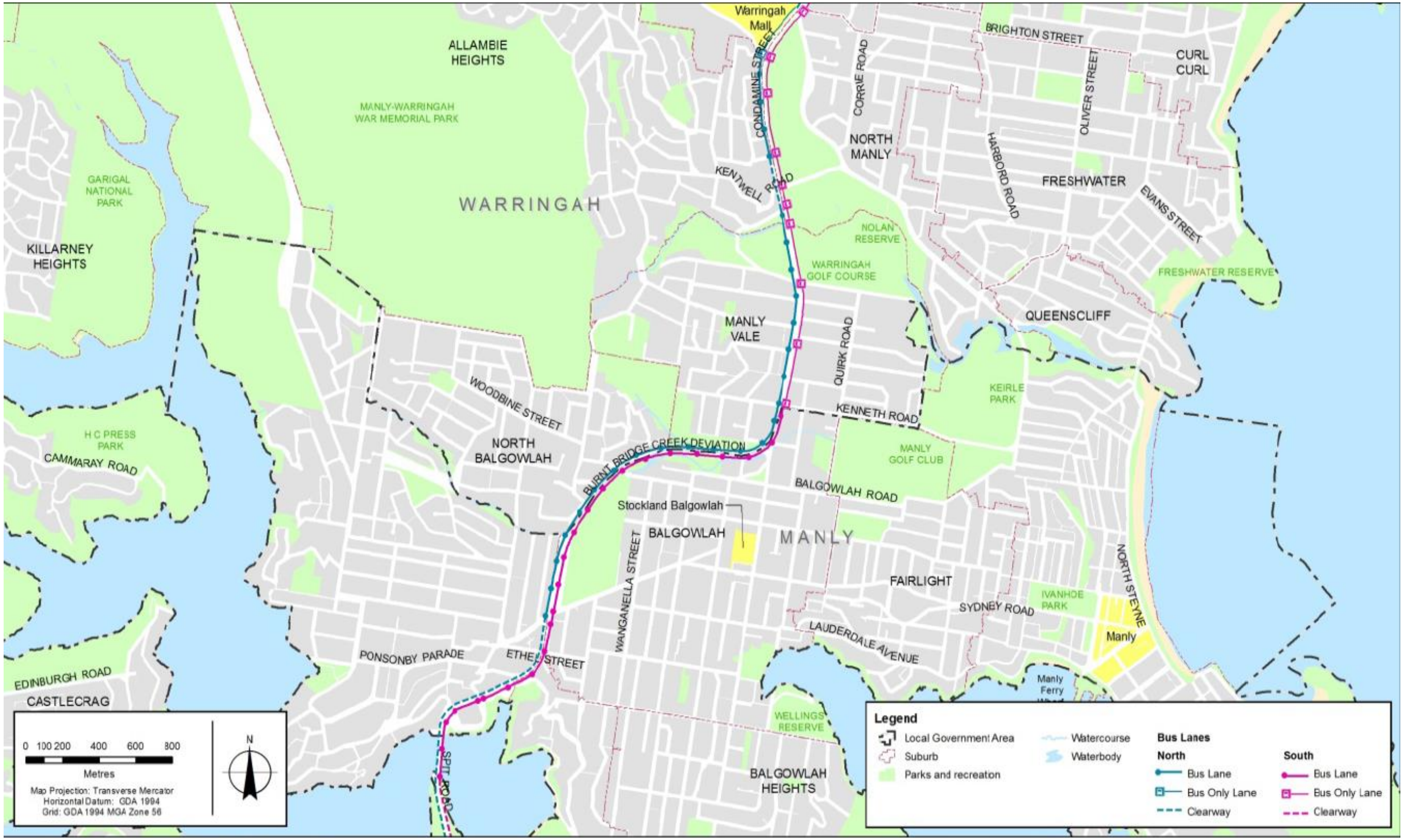
Source: TfNSW 2014

Figure 17 AM peak bus lanes and T3 lanes in Warringah and Manly Vale



Source: TfNSW 2014

Figure 18 PM peak bus lanes and T3 lanes in Warringah and Manly Vale



Source: TfNSW 2014

3.8 Parking

Dee Why

The P8 B-Line corridor consists of approximately 2 km of the Pittwater Road section between South Creek Road to the north, and Warringah Road to the south. Currently, there are existing kerbside bus lanes for the southbound and northbound peak directions respectively for the weekday morning (6-10am) and evening peaks (3-7pm). On-street parking is allowed in the kerbside lane in the morning and evening contra-peak directions and during off-peak periods. Parking restrictions vary from half hour to one hour, with a certain amount of unrestricted parking.

This section has a total supply of 253 parking spaces according to the *Northern Beaches B-Line Offset Parking Assessment* commissioned by Transport for NSW (TfNSW) in November 2015 for the B-Line program. A total of 138 and 115 parking spaces are provided respectively on the eastern and western sides of the Pittwater Road corridor.

The study also identifies the parking utilisation at 49% and 63% occupancy respectively in the southbound and northbound directions. This section of Pittwater Road has mixed land usage together with medium density housing, business and recreational areas. The Dee Why commercial centre accounts for a significant proportion of the overall parking demand in the area.

Brookvale

The P9 B-Line corridor consists of approximately 6 km of the B-line corridor between Warringah Road to the north, and Avona Crescent to the south. Currently, there are existing kerbside bus lanes between Warringah Road and Kenneth Road for the southbound and northbound peak directions respectively for the weekday morning (6-10am) and evening peaks (3-7pm). On-street parking is allowed in the kerbside lane in the morning and evening contra-peak directions and during off-peak periods. Parking restrictions vary from one to two hours, with a certain amount of unrestricted parking.

This section has a total supply of 206 parking spaces according to the *Northern Beaches B-Line Offset Parking Assessment* commissioned by Transport for NSW (TfNSW) in November 2015 for the B-Line program. A total of 48 and 158 parking spaces are provided respectively on the eastern and western sides of the Pittwater Road corridor.

The study also identifies the parking utilisation at 74% and 54% occupancy in the southbound and northbound directions respectively. This section of the corridor comprises residential, business and recreational facilities. The Brookvale commercial centre, north of Orchard Road also accounts for a significant proportion of the overall parking demand in the area.

Note that for the section of the corridor south of Kenneth Road, there is a 24-hour bus lane in the northbound direction and in the southbound direction there is a T3 Transit Lane in the morning (6-10am) and a bus lane in the evening (3-7pm) weekdays. Existing parking restrictions do not allow any parking throughout the week and there is no proposal as part of the B-Line program to change this situation.

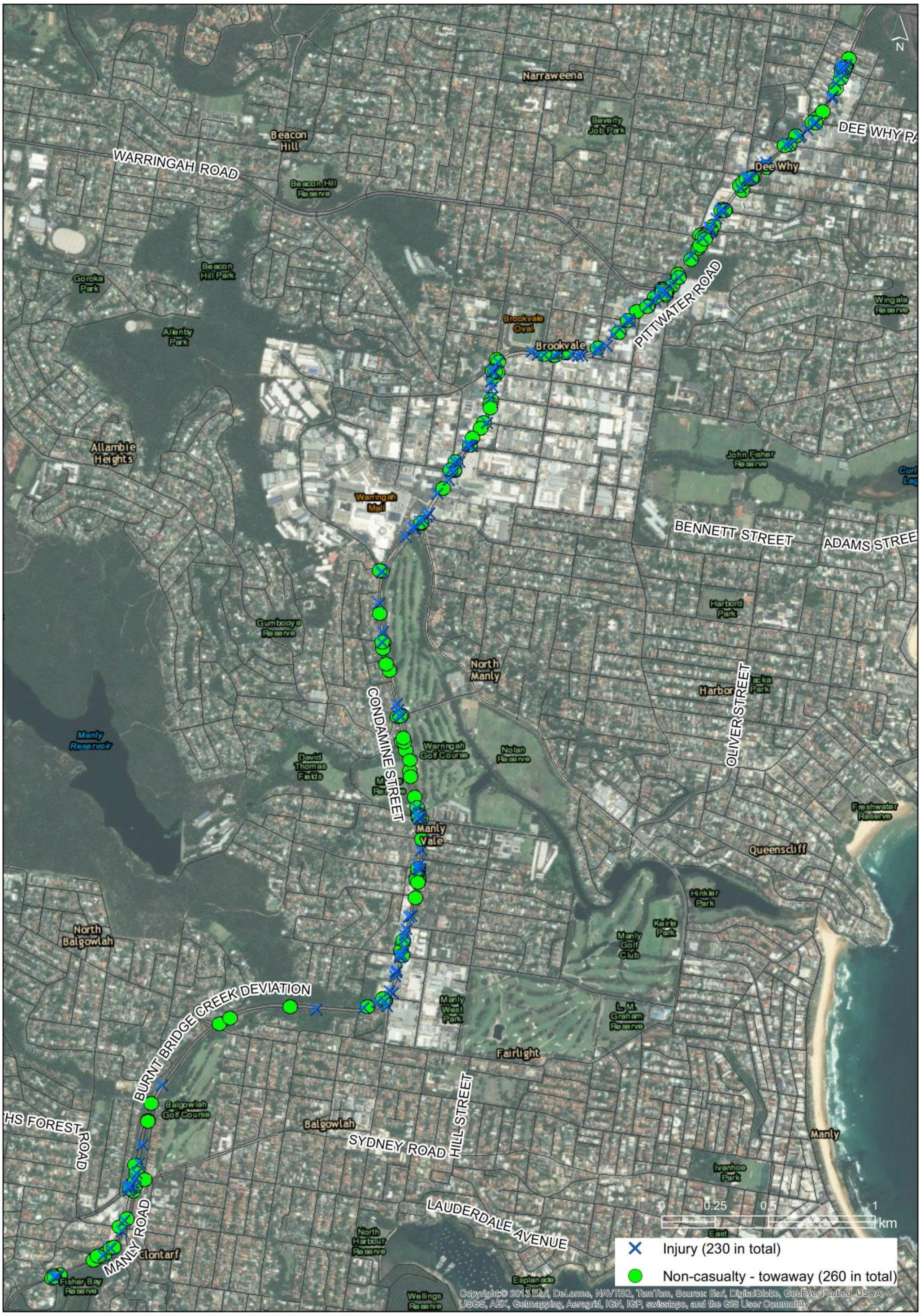
3.9 Existing road safety trends

Roads and Maritime supplied crash statistics for key roads within the study area between South Creek Road and Avona Crescent over a five year period from January 2010 to December 2015. A summary of the crash trends by accident types along the main north-south corridor in the study area is presented in **Table 7** below. The crash statistics are also graphically represented in **Figure 19** to aid the visualization of the spread of crashes along the corridor.

Table 7 Crash statistics summary by crash types for the study area (January 2011 – December 2015)

Type of crash	Number of crashes
Pedestrian	30
Intersection	31
Head on	5
Head on (Right Through)	96
Head on (Left Through)	2
Rear end	180
Side swipe / lane change	91
Entering road way / off-carriageway	14
On path	8
Off path on straight	21
Off path on curve / turning	11
Miscellaneous	1
Total Crashes	**490**

Figure 19 Reported crash locations along the B-Line route (January 2011 – December 2015)



A review of the crash summary indicates a total of 490 reported crashes that have occurred along the proposed B-Line route during the 5-year period between 2010 and 2015. 230 of these crashes resulted in injuries. Of all the crashes, 37% were rear end type crashes and 18% occurred between vehicles traveling in the same direction (e.g. side swipe and lane changing). The other predominant type of crashes is head on crashes with vehicles turning right. This makes up 20% of the total crash data.

Rear-end crashes are common on roads that experience reasonable queuing and congestion and tend to be low in severity. Head on right-turning type of crashes are also common however can be high in severity as this involves crashes with vehicles traveling from opposing directions.

In addition, summary of crash statistics are provided in **Table 8** for areas where the proposed on-road infrastructure improvements may provide benefits from a road safety perspective. A review of the summary suggests the following:

Table 8 Crash Statistics at key areas

Type of crash	Manly Rd / Heaton Ave	Pittwater Rd / Cross St	Pittwater Rd / Orchard Rd
Pedestrian	0	2	1
Intersection	2	0	0
Head on	1	0	0
Head on (Right Through)	0	2	3
Rear end	5	4	1
Side swipe / lane change	2	6	1
Entering road way / off-carriageway	1	2	2
On path		1	
Off path on straight	0	2	0
Off path on curve / turning	0	0	0
Total Crashes	**11**	**19**	**8**

Crash Mitigation

- **Manly Road / Heaton Avenue:** the proposed closure of Heaton Avenue will eliminate intersection and entering crashes. The indented bus bay and closure of Heaton Avenue will reduce the potential for rear end and side swipe crashes. This is achieved through elimination of the conflicting traffic movement exiting Heaton Avenue with descending southbound buses, cyclist and taxi traversing on the kerbside T3/bus lane. Site observations had also identified a high risk for cyclists with relatively fast travel speeds and vehicles entering from Heaton Avenue. The closure of Heaton Avenue will mitigate such risk.
- **Pittwater Road / Cross Street:** reduction of rear end crash rates through segregation of different traffic movements into dedicated traffic lanes as a result of the proposed left-turn bay for northbound traffic at approach to Cross Street.
- **Pittwater Road / Orchard Street:** the proposed restriction of traffic movements at Orchard Road with Left-in and Left-out arrangement at the priority control intersection will potentially reduce crash rates for potential collision (i.e. right-through collision) between southbound mainline traffic with right-turning vehicles accessing Orchard Road from Pittwater Road.

4.0 Future traffic growth

A key component of the future year traffic modelling assessments was the forecast level of future background traffic growth in the study area. The Base Year traffic models were developed to represent the operation of the road network in 2016; however it was important for the 2021 modelling scenarios to provide an adequate forecast of how the network may operate in 2021, with and without B-Line proposal.

The forecast level of background traffic growth between 2016 and 2021 was calculated using a range of data and information sources. These sources are described in the following sections.

4.1 Historical traffic growth

A review of available traffic count data along the Pittwater Road corridor was undertaken to determine historical levels of traffic growth within the study area. The traffic counts were obtained from the RMS traffic count database for the period between 2011 and 2015 in the following locations:

- Site 34016: Pittwater Road 90m south of Sloane Crescent
- Site 55022: Pittwater Road 120m north of William Street
- Site 55138: Pittwater Road 70m south of May Road
- Site 55030: Pittwater Road 50m north of Lismore Avenue

The availability of traffic count data for the above sites during the defined time period was sporadic; however comparisons of daily and peak hour volumes at the different sites indicated a clear pattern of either very minor positive or negative traffic growth.

The most complete sample of data was available for site 34016. Comparisons of the two-way daily and peak hour traffic volumes recorded at this site between 2011 and 2014 for weekdays and on Saturdays are illustrated in **Figure 20** and **Figure 21.**

Figure 20 Weekday volume comparisons along Pittwater Road 2011-2014

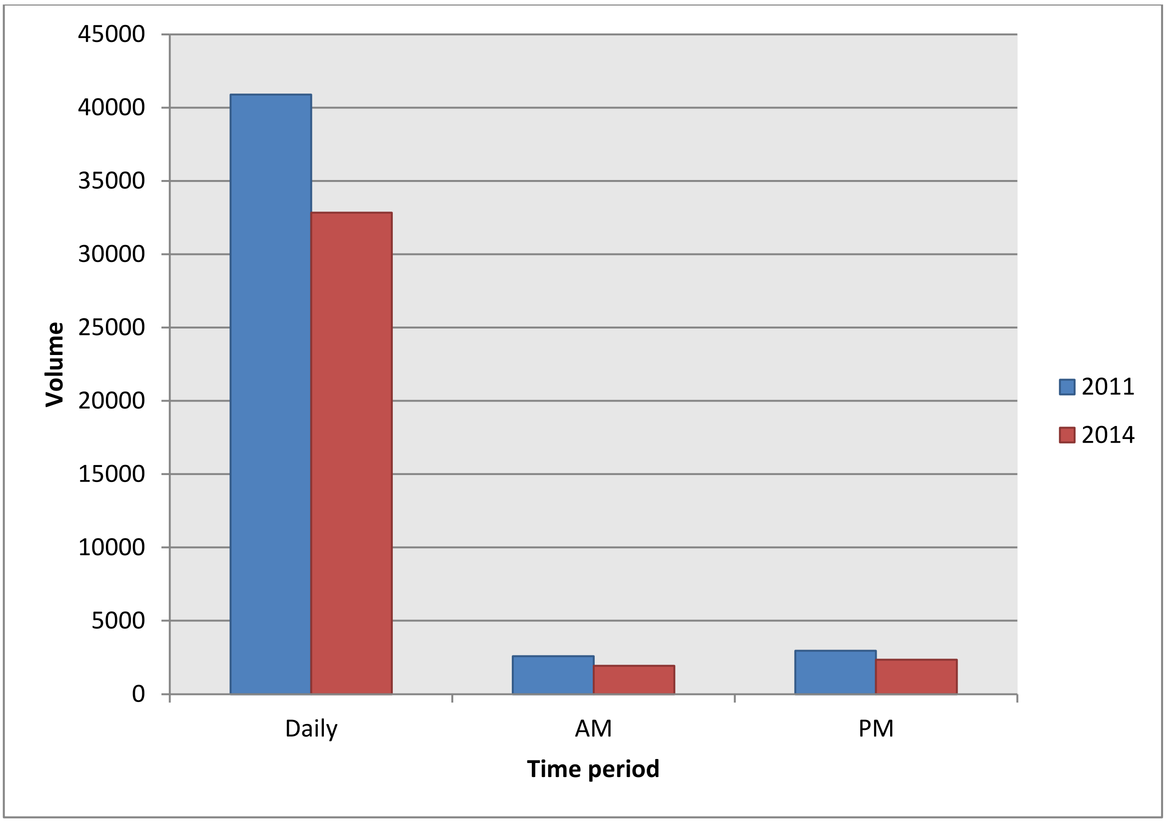
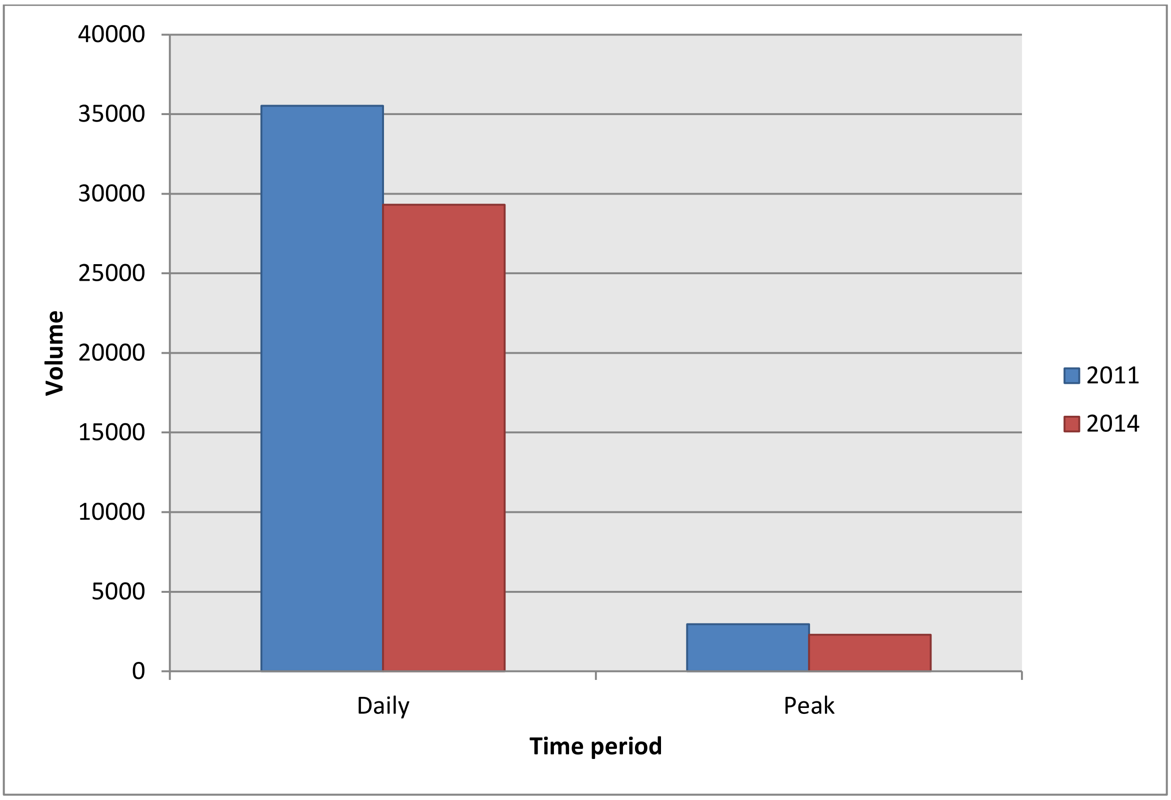


Figure 21 Saturday volume comparisons along Pittwater Road 2011-2014



4.2 Population forecasts for Sydney and the Northern Beaches

Population forecasts are commonly used to inform decision making in planning for transport and infrastructure and are a key input into strategic travel demand models. The forecasts are generally based on transport and planning policies (at a local, regional and national level); and committed / aspirational developments.

To inform the calculation of future background traffic growth along the Pittwater Road corridor, population forecasts for the Northern Beaches were sourced from the TfNSW report '*Northern Beaches BRT Demand Report Addendum 2*'. The forecasts are summarised in **Table 9.**

Table 9 Population forecasts for the Northern Beaches

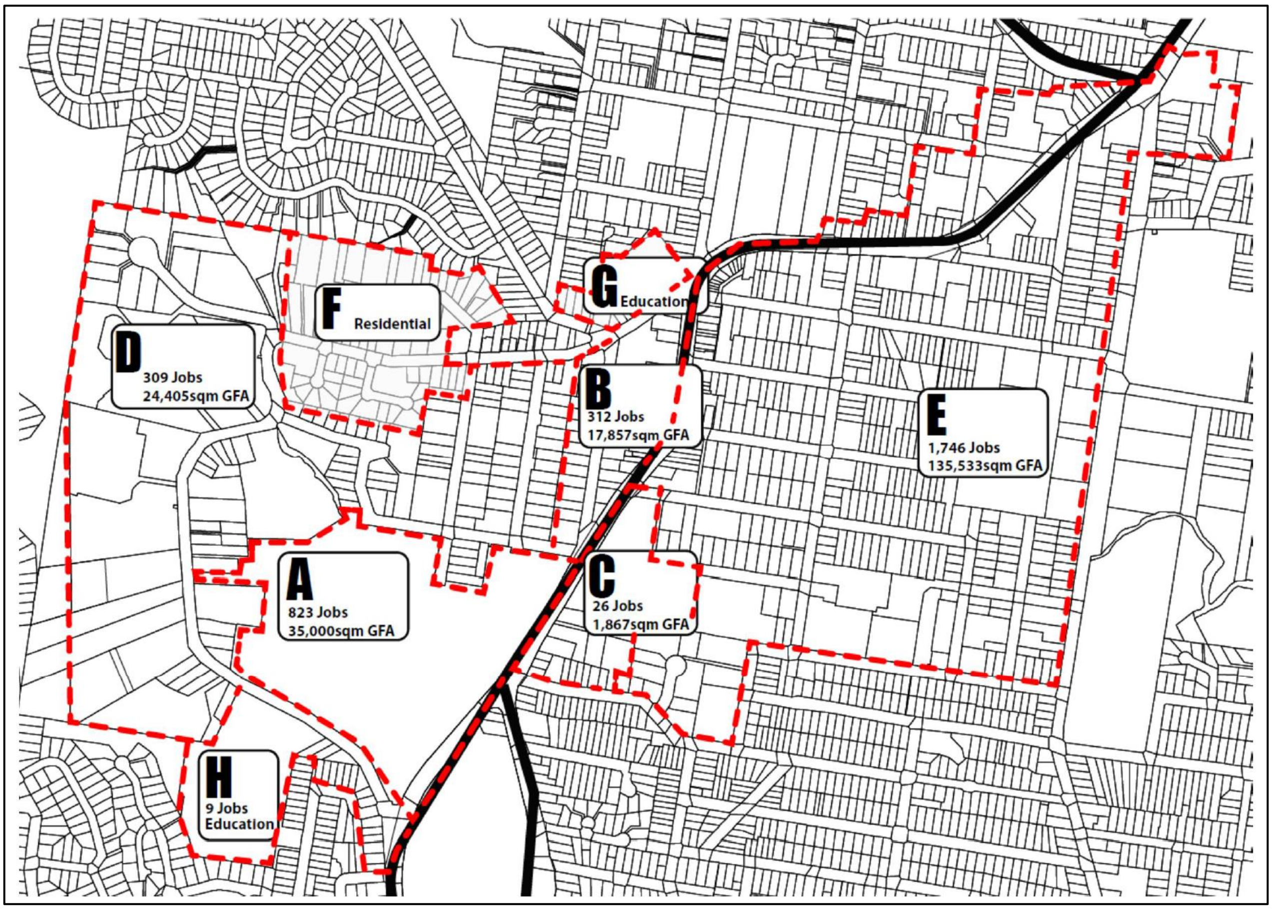
Area	People			Growth 2011 – 2031	
	2011	2021	2031	No.	%
Pittwater	60,460	68,570	77,590	17,130	28%
Warringah East	102,520	115,350	124,070	21,550	21%
Warringah West	45,900	49,360	55,520	9,620	21%
Manly	42,820	47,680	53,600	10,780	25%
Total	**251,700**	**280,970**	**310,770**	**59,070**	**23%**

It is forecast that the population of the Northern Beaches will increase by 23% between 2011 and 2031. Assuming linear growth across this period this would equate to approximately 1% population growth per annum.

4.3 Future developments within the study area

Information on potential future development within the study and associated forecasts on development traffic was sourced from the *Brookvale Dee Why Transport Management and Accessibility Study* (TMAS) produced by GHD on behalf of Warringah Council in 2012. The information contained within the study suggests that the majority of development planned for the study area is likely to take place at Warringah Mall and surrounding areas. Development yield forecasts to 2036 from the TMAS study report are illustrated in **Figure 22.**

Figure 22 2012 TMAS development yield forecasts for Brookvale Dee Why 2011 - 2036



Source: Brookvale Dee Why TMAS, GHD 2012

4.4 STFM forecasts

Peak hour traffic forecasts for the Pittwater Road corridor and major side roads were obtained from the Sydney Strategic Forecasting Model (STFM) for 2015 and 2021 to determine the forecast level of traffic growth in the model. Strategic traffic models such as the STFM provide a good source of information for calculating future background traffic growth as the models generally contain up-to-date inputs on population, employment and infrastructure changes.

To inform the calculation of future background traffic growth for the study area, 2015 volumes from the STFM were extracted for the following locations:

- Condamine Street south of Pittwater Road.
- Pittwater Road east of Condamine Street.
- Old Pittwater Road at intersection with Condamine Street and Pittwater Road.
- Cross Street west of Pittwater Road.
- Old Pittwater Road at intersection with Pittwater Road and Winbourne Road.
- Warringah Road west of Pittwater Road.
- Harbord Road south of Pittwater Road.

The volume forecasts for Old Pittwater Road and Cross Street were combined to calculate overall forecasts the area including Warringah Mall and the surrounding land uses. The forecasts were combined as the zoning in the

STFM in this location is relatively coarse and does not accurately reflect the vehicle access arrangements for the mall and adjacent land uses. So by combining the volumes an overall forecast for this area was calculated.

Comparisons of the STFM volume forecasts between 2015 and 2021 for the key roads in the study area are provided in **Table 10** and **Table 11.**

Table 10 STFM AM peak hour volume forecasts for 2015 and 2021

Location	2015	2021	Growth per annum	2016-2021
Condamine St south of Pittwater Rd NB	1,489	1,579	0.98%	5%
Condamine St south of Pittwater Rd SB	1,587	1,689	1.04%	5%
Warringah Mall area inbound	724	832	2.34%	12%
Warringah Mall area outbound	900	925	0.46%	2%
Warringah Rd west of Pittwater Rd EB	1,201	1,304	1.39%	7%
Warringah Rd west of Pittwater Rd WB	973	1,071	1.61%	8%
Harbord Rd NB	624	657	0.86%	4%
Harbord Rd SB	883	931	0.89%	5%

Table 11 STFM PM peak hour volume forecasts for 2015 and 2021

Location	2015	2021	Growth per annum	2016-2021
Condamine St south of Pittwater Rd NB	1,557	1,613	0.59%	3%
Condamine St south of Pittwater Rd SB	1,423	1,489	0.76%	4%
Warringah Mall area inbound	736	843	2.29%	12%
Warringah Mall area outbound	1,110	1,188	1.14%	6%
Warringah Rd west of Pittwater Rd EB	1,038	1.131	1.44%	7%
Warringah Rd west of Pittwater Rd WB	1,234	1,367	1.72%	9%
Harbord Rd NB	869	935	1.23%	6%
Harbord Rd SB	689	734	1.06%	5%

The forecast show that Pittwater Road and the major connecting roads are estimated to increase by between 0.8% and 1.8% per annum between 2015 and 2021; equating to an overall increase of between 3% and 9% between 2016 and 2021. These forecasts align reasonably well to the population forecasts for the Northern Beaches presented in **Section 4.2**.

Traffic using the roads that provide access into the Warringah Mall area is forecast to increase by between 1 and 2.5% per annum between 2015 and 2021; equating to an overall increase of between 2% and 12% between 2016 and 2021. This aligns reasonably well to the development yield forecasts outlined in the Brookvale Dee Why TMAS report and suggests that the STFM model includes the forecast increase in population and employment for the Warringah Mall area.

The link volume plots used to determine the above analysis are provided in **Appendix C**.

4.5 Background traffic growth for traffic modelling

The above sections have presented forecasts from a variety of sources relating to population growth, future development and future volumes within the study area; as well as a comparison of historical traffic growth through the comparison of traffic count data along Pittwater Road between 2008 and 2015. The analysis has shown that:

- There has been very little traffic growth along the corridor in the last 10 years. This may be due to low population growth, limited development and a shift in travel mode from car to public transport.
- The population within the study area is forecast to increase by 1% per annum between 2016 and 2021.

- The majority of future development within the study area is expected to take place at and around Warringah Mall.
- 2021 traffic volume forecasts for the study area in the STFM are generally well aligned to the population forecasts and indicate an increase in traffic around the Warringah Mall area in line with the forecasts provided in the Brookvale Dee Why TMAS report.

In light of the above analysis it was decided to base the future background traffic growth between 2016 and 2021 in the VISSIM modelling on the STFM volume forecasts as they are generally consistent with the other key sources of information available (population forecasts and the Brookvale Dee Why TMAS).

The STFM forecasts were applied to the VISSIM model demand matrices by factoring the trips originating from the zones at Condamine Street, Pittwater Road, Warringah Road and Harbord Street by the growth percentages shown in **Table 10** and **Table 11.** For the Warringah Mall zone, trips were factored by the inbound and outbound growth forecasts to make sure that the model provided a good representation of the expected future increase in development traffic in this area.

For all other zones in the model (which predominantly represent local access streets) the 2016 trip origins were factored by 1% per annum in line with the future population growth forecasts for the Northern Beaches. A review of the assigned volumes for 2021 revealed that volumes increase by between 3% and 7% in mid-block locations. This is in line with the forecast increases shown in the STFM.

It is important to note that the STFM forecasts do not take into consideration of potential travel mode shift as a result of the proposal (i.e. reduction of vehicle demands due to a higher usage of public transport such as the proposed B-Line services). Therefore, the forecast adopted for the modelling depicts a conservative representation of the future traffic conditions with the proposal.

5.0 Traffic operational assessment

This section of the report presents the analysis and findings of the traffic modelling that was undertaken to assess the operation of the study area road network in the 2016 Base Year and in 2021 without and with the B-Line proposal.

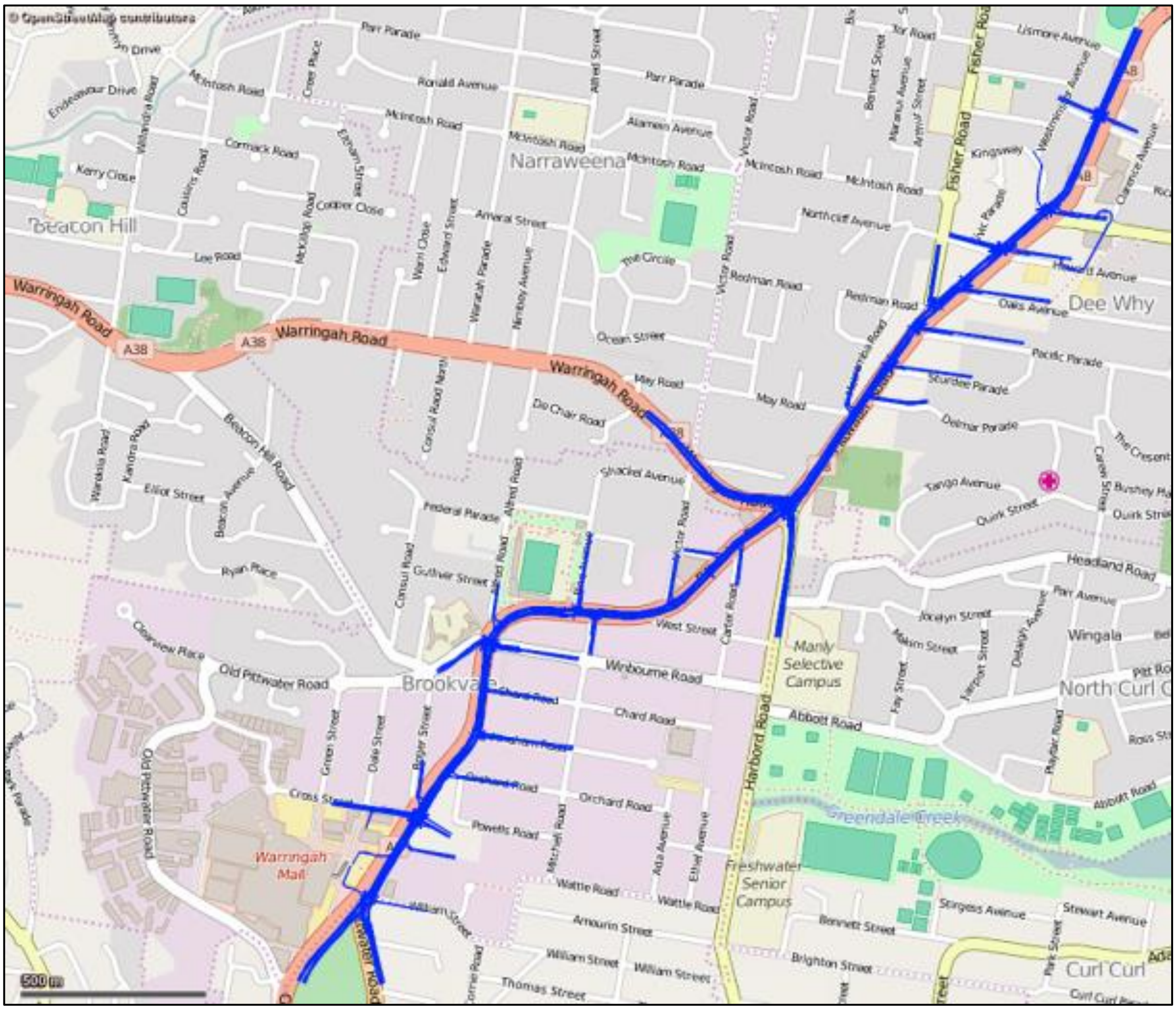
5.1 Modelling approach and assumptions

5.1.1 Assessments

The modelling approach adopted for the network operational assessment consisted of the following assessment elements:

- Individual intersection assessments (using SIDRA 6) to undertake optioneering of the B-Line proposal in Brookvale and Dee Why prior to a network assessment using VISSIM.
- Microsimulation modelling (using VISSIM V7) of the northern section of the study area (indicated by the blue shading in **Figure 23**), to assess the operation of the network in Brookvale and Dee Why, where the majority of the upgrades are proposed.

Figure 23 Dee-Why and Brookvale model coverage



Background source: OpenStreetMap

- SIDRA and Commuter modelling of the Sydney Road / Manly Road and Manly Road / Heaton Avenue intersections to assess the impacts of closing Heaton Avenue with traffic displacement and its interaction with downstream pinch-points at the Spit Bridge. (Note that the Commuter model is being developed with the intent for a separate package of works (i.e. P12) of the B-Line program, but adopted to supplement this assessment to provide vital information such as travel time comparison.)

All of the above modelling elements assessed the 2016 Base Year and 2021 with and without the B-Line proposals (Do-nothing and Option scenarios), with the exception of the Commuter modelling which focuses based on 2016 demands only. Details of the 2016 Base Year VISSIM model development and calibration are provided in **Appendix B**.

The SIDRA modelling undertaken for intersections within the VISSIM model extents were based on 2021 volumes which aligns with the forecast in the VISSIM modelling (refer to **Section 4.0**). The SIDRA model developed for Sydney Road / Manly Road used observed survey volumes for the Base Year and factored observed volumes for the 2021 assessments. Further details of the modelling assessments are provided in the following sections.

5.1.2 Dee Why Park n' Ride expansion

To provide additional Park n' Ride capacity in Dee Why for the B-Line, TfNSW is proposing to acquire the bottom level of the existing PCYC carpark located off Fisher Road in Dee Why. The parking is anticipated to generate an additional 120 trips commuter trips.

The *Manly Vale Traffic and Transport Assessment, February* 2016 indicates that the commuter carpark peak is generally between 6:30-7:30AM (61% vehicles arrive) and 5:30-6:30PM (45% vehicles depart). As such, impacts of additional car park traffic are likely to be negligible during the modelled peak hours. This is especially the case since the carpark has multiple access routes (via Kingsway, Civic Parade and Fisher Road) where carpark traffic is unlikely to converge at one particular intersection. The traffic generation for the additional parking was therefore not explicitly included in the traffic modelling.

5.1.3 Diversion of Orchard Street traffic

As discussed previously in **Section 2.0**, it is proposed that the existing un-signalised right turn movement from Pittwater Road into Orchard Street is prohibited to mitigate current safety concerns associated with slow right-turning vehicles potentially conflicting with relatively free flowing southbound buses in the bus lane in the AM peak. The displaced right turn traffic was diverted to the Sydenham Road signal in the VISSIM model for the Option scenario assessment.

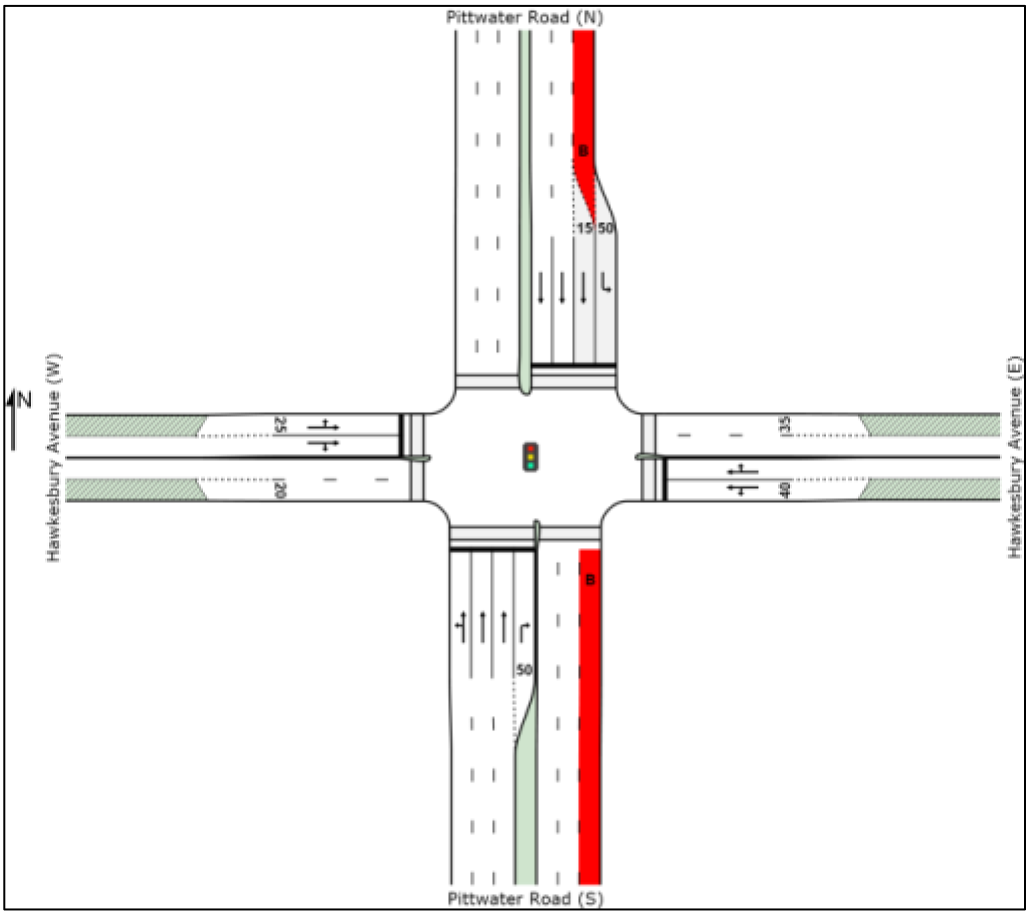
5.2 Brookvale / Dee Why SIDRA optioneering

As part of the preliminary option development process, isolated SIDRA intersection modelling was undertaken for the key intersection upgrades to determine preferred configurations, prior to assessment in the VISSIM modelling. The SIDRA modelling approach and findings are summarised in the following sections.

5.2.1 Pittwater Road / Hawkesbury Avenue

The initial proposed option for this intersection involved the implementation of a dedicated left turn pocket for the movement from Pittwater Road north to Hawkesbury Avenue east. There is currently a high demand for this movement in the AM peak (over 450 vehicles per hour). The proposed segregation of the currently shared movements on the kerbside lane could also benefit bus prioritisation measures at approach to the signal in the future. The configuration assessed is illustrated in **Figure 24.**

Figure 24 Upgrade option for Pittwater Road / Hawkesbury Avenue



It is important to note that the existing signal phasing arrangement at the intersection does not allow for pedestrian protection from turning traffic. During the assessment process, Roads and Maritime advised that any modification proposed to an existing intersection would require consideration of pedestrian protection to align with the latest principles for safety. As such potential implications on stop line / turning capacities were included in the modelling.

Results from the SIDRA modelling suggest that the option may result in minor benefits during the AM peak, but the performance of the intersection may reduce in the PM peak, due to the requirement for pedestrian protection.

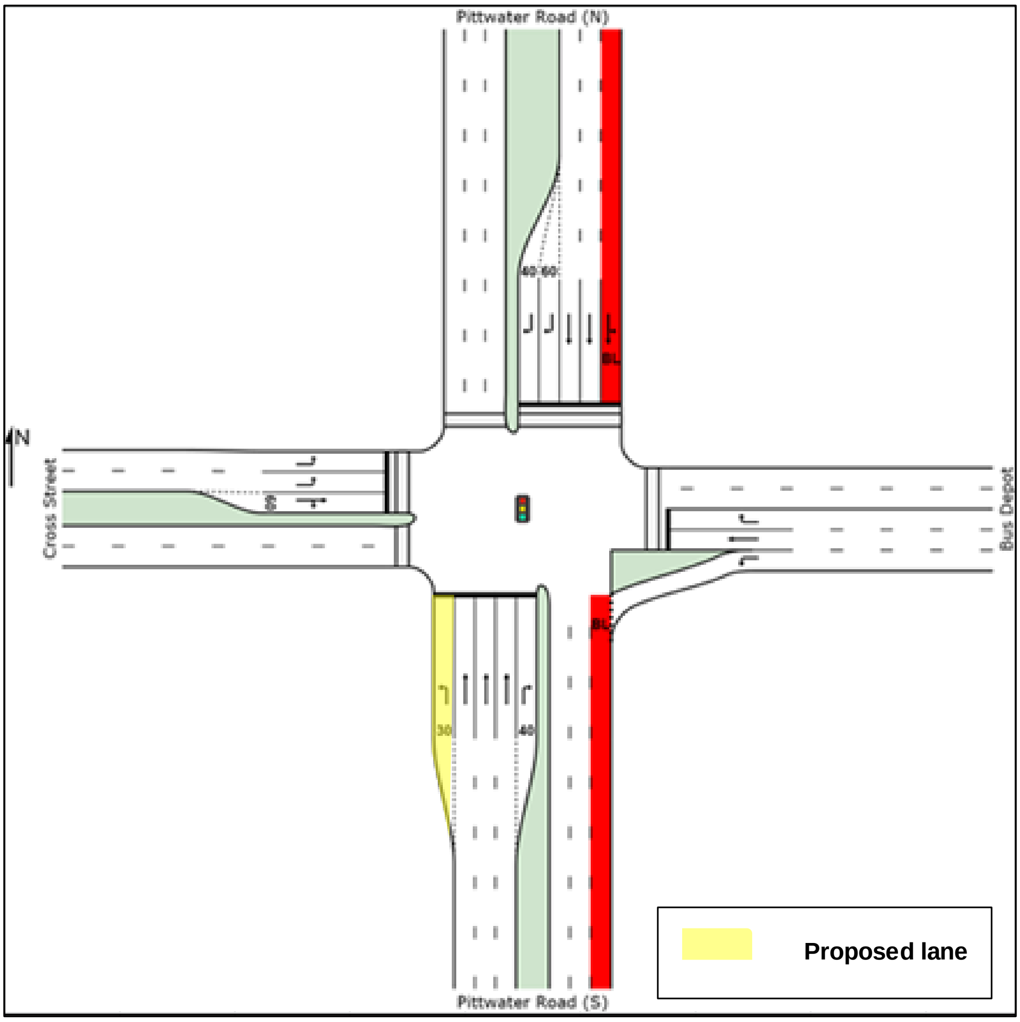
Therefore, the option was not considered to be significantly beneficial and was excluded in the subsequent VISSIM modelling assessment.

An eastern side indented bus bay for local buses south of Hawkesbury Avenue was considered to be feasible from a road design perspective, which minimises the potential requirement of bus priority measures at the intersection.

5.2.2 Pittwater Road / Cross Street

The proposed option for this intersection involves the implementation of an additional left turn lane for the left turn movement from Pittwater Road south into Cross Street. The intent of this option is to separate the left turn traffic from the existing kerbside lane to reduce the delay of turning traffic on northbound buses, particularly in the PM peak due to the higher traffic flows. The assessed option is illustrated in **Figure 25.**

Figure 25 Upgrade option for Pittwater Road / Cross Street



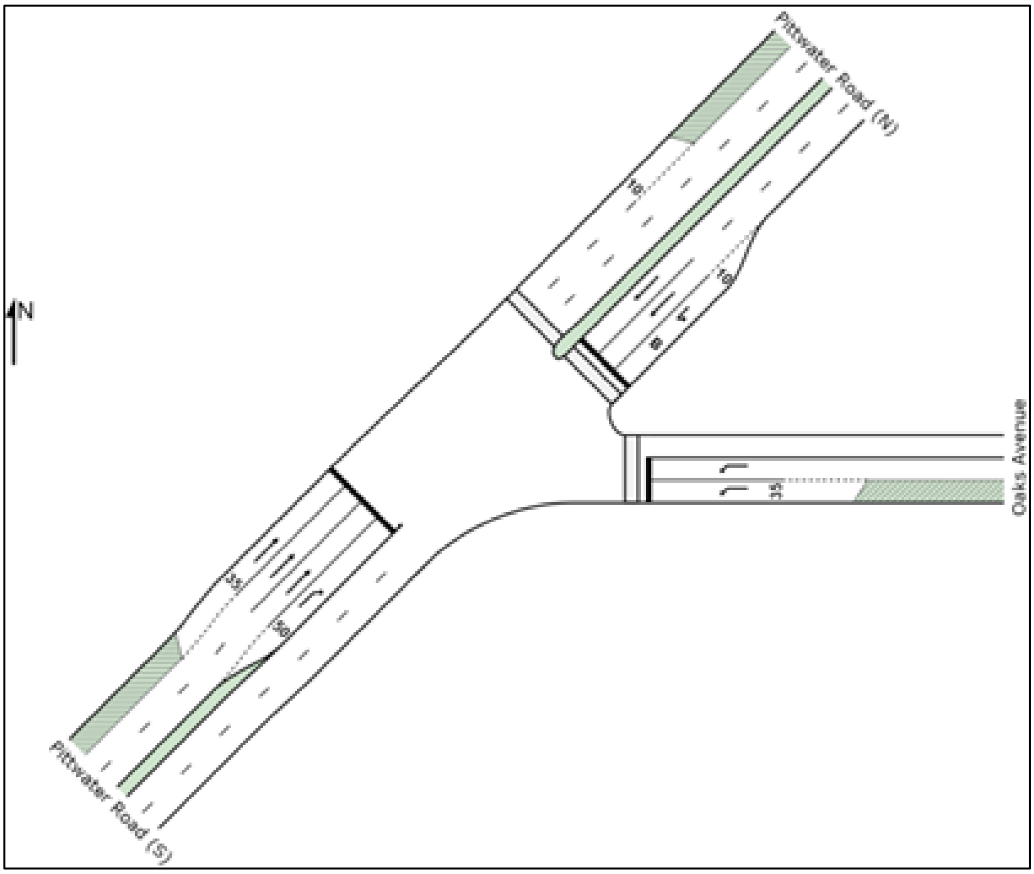
Similar to the earlier intersection analysis, pedestrian protections are taken into consideration as part of the modelling to provide a plausible assessment of the proposed intersection improvement.

In brief, the preliminary SIDRA modelling indicated that the option could improve the intersection performance, and the flow progression for buses, which is in line with the B-Line objectives. The minimum required left turn pocket length was estimated to be 45 metres, upon consideration and consultation with respect to minimising potential property acquisition. This option has also been taken forward and included in the VISSIM modelling assessment for further validation.

5.2.3 Pittwater Road / Oaks Avenue

The proposed option for this intersection involves the extension of the right turn bay for vehicles turning right into Oaks Avenue to accommodate increases in future traffic volumes into the Dee Why town centre and to minimise any impedance on through traffic along the mainline. The existing layout of the intersection is illustrated in **Figure 26.**

Figure 26 Pittwater Road / Oaks Avenue existing layout



Options for the upgrade included extension of the turn pocket to either the intersection of Pacific Parade or to Sturdee Parade, if required. The SIDRA modelling forecast that a turn pocket length for a minimum of 135 metres will be required to accommodate the right turn volumes in 2021. This upgrade has been included in the VISSIM modelling for further analysis.

5.3 Brookvale / Dee Why VISSIM modelling

For the Brookvale and Dee Why microsimulation modelling, three key performance measures are provided to analyse the operation of the proposed options in comparison to the 'Do-nothing' scenario in 2021. The performance criteria are defined as follows:

- Overall intersection Level of Service (LOS) – for each key intersection based on the average delay thresholds shown in **Table 4.**
- Average travel times – compared between options with a focus on identifying the level of improvement in local bus and B-Line bus travel times.
- Overall network performance statistics – including average vehicle delay and average network speed to determine the network-wide performance of the model.

5.3.1 Intersection LOS

5.3.1.1 AM peak period

A summary of the AM peak period LOS outputs for the 2016 Base Year and 2021 scenarios is provided in **Table 12**.

Table 12 AM peak period LOS outputs

Intersection	2016 Base Case		2021 Do Nothing		2021 Option	
	07:00 to 08:00	08:00 to 09:00	07:00 to 08:00	08:00 to 09:00	07:00 to 08:00	08:00 to 09:00
Pittwater R / Hawkesbury Ave	B	C	B	C	B	C
Pittwater Rd / Kingsway / Dee-Why Pde	B	B	B	C	B	B
Pittwater Rd / Howard Ave / St David Ave	B	C	B	C	B	C
Pittwater Rd / Oakes Ave	A	B	A	B	A	B
Pittwater Rd / Fisher Rd	B	C	B	C	B	C
Pittwater Rd / Pacific Pde	B	B	B	B	B	C
Pittwater Rd / Sturdee Pde	A	B	A	B	B	B
Pittwater Rd / Delmar Pde	B	C	B	C	B	B
Pittwater Rd / Warringah Rd / Harbord Rd	D	D	D	D	D	D
Pittwater Rd / Victor Rd	B	A	B	B	B	B
Pittwater Rd / Pine Ave / Mitchell Rd	B	B	B	B	B	B
Pittwater Rd / Winbourne Rd	B	C	B	C	B	C
Pittwater Rd / Sydenham Rd	A	A	A	A	A	B
Pittwater Rd / Orchard Rd	B	C	B	D	A	B
Pittwater Rd / Cross St	B	B	B	B	B	B
Pittwater Rd / Condamine St	C	C	C	C	C	C

The key findings from the AM peak period LOS outputs are as follows:

- Overall, the network is forecast to operate relatively well with no intersections expected to operate at worse than LOS D.
- The LOS at intersections across the network does not significantly deteriorate between 2016 and 2021, indicating that there is capacity at most intersections in the AM peak to cater for the expected growth in traffic volumes.
- For a minimum, the proposal is anticipated to have a comparable level of intersection performances, and in some cases marginal improvement, when compared to the 2021 Do-Nothing scenario.

5.3.1.2 PM peak period

A summary of the AM peak period LOS outputs for the 2016 Base Year and 2021 scenarios is provided in **Table 13**.

Table 13 PM peak period LOS outputs

Intersection	2016 Base Case		2021 Do Nothing		2021 Option	
	16:30 to 17:30	17:30 to 18:30	16:30 to 17:30	17:30 to 18:30	16:30 to 17:30	17:30 to 18:30
Pittwater R / Hawkesbury Ave	B	B	B	B	B	B
Pittwater Rd / Kingsway / Dee-Why Pde	A	B	A	B	A	B
Pittwater Rd / Howard Ave / St David Ave	B	B	B	B	A	B
Pittwater Rd / Oakes Ave	A	A	A	A	A	A
Pittwater Rd / Fisher Rd	B	A	B	A	B	A
Pittwater Rd / Pacific Pde	B	C	B	C	B	C
Pittwater Rd / Sturdee Pde	A	B	A	B	A	B
Pittwater Rd / Delmar Pde	B	C	C	B	B	B
Pittwater Rd / Warringah Rd / Harbord Rd	E	E	E	E	E	E
Pittwater Rd / Victor Rd	D	B	D	C	D	D
Pittwater Rd / Pine Ave / Mitchell Rd	C	C	C	C	C	D
Pittwater Rd / Winbourne Rd	E	C	E	C	F	F
Pittwater Rd / Sydenham Rd	C	B	D	B	C	B
Pittwater Rd / Orchard Rd	B	B	C	B	A	A
Pittwater Rd / Cross St	C	C	D	C	D	C
Pittwater Rd / Condamine St	D	E	E	F	E	D

The key findings from the PM peak period LOS outputs are as follows:

- At an overall level, the network operates at a poorer LOS during the PM peak in comparison to the AM peak period. This supports the observations made during site visits in relation to congestion along the corridor on approach Warringah Road, Winbourne Road and Condamine Street intersections.
- There is marginal change in forecast LOS at the intersections between the 2021 Do-nothing and Option scenarios, with the exception of the intersection at Winbourne Road, which deteriorates from LOS E to LOS F in the Option scenario.

  A review of the corridor volumes indicates that in the Option scenario, there is an increase in northbound throughput at the Cross Street intersection of around 100 vehicles per hour (likely due to the implementation of the dedicated left turn pocket). The additional throughput increases delay along the already congested section of the corridor between Cross Street and Winbourne Road, which is sensitive to additional demands, likely leading to the deterioration in LOS at the Winbourne Road intersection.
- It is worthwhile noting that the existing right turn movement from Pittwater Road to Orchard Road is proposed to be banned as part of the proposal. The banned right turn traffic will be diverted to the Pittwater Road / Sydenham Road signalised intersection. In the 2021 option scenario model, the additional right turn demand is observed to generate a maximum queue length of up to 150m for the right turning movement from Pittwater Road to Sydenham Road. These traffic queues are contained within the right turn bay which is approximately 175 meters in length. The aforementioned traffic queues are most pronounced in the PM peak that has the highest right turn traffic demand forecast of all modelled peak periods.
- The congested Warringah Road intersection operates at LOS E in all scenarios. This suggests that the proposal (at a minimum) results in comparable operational performance as per the Do-nothing scenario.

5.3.1.3 Saturday peak period

A summary of the Saturday peak period LOS outputs for the 2016 Base Year and 2021 scenarios is provided in Table 14.

Table 14 Saturday peak period LOS outputs

Intersection	2016 Base Case		2021 Do Nothing		2021 Option	
	11:30 to 12:30	12:30 to 13:30	11:30 to 12:30	12:30 to 13:30	11:30 to 12:30	12:30 to 13:30
Pittwater R / Hawkesbury Ave	B	C	C	C	B	C
Pittwater Rd / Kingsway / Dee-Why Pde	B	B	B	C	A	A
Pittwater Rd / Howard Ave / St David Ave	C	C	C	D	B	B
Pittwater Rd / Oakes Ave	C	C	C	C	B	B
Pittwater Rd / Fisher Rd	B	B	B	C	B	B
Pittwater Rd / Pacific Pde	B	B	B	B	B	B
Pittwater Rd / Sturdee Pde	B	B	B	B	B	B
Pittwater Rd / Delmar Pde	C	D	C	E	B	C
Pittwater Rd / Warringah Rd / Harbord Rd	F	F	F	F	F	F
Pittwater Rd / Victor Rd	B	B	B	B	B	B
Pittwater Rd / Pine Ave / Mitchell Rd	B	B	B	B	B	B
Pittwater Rd / Winbourne Rd	C	C	D	D	D	D
Pittwater Rd / Sydenham Rd	A	A	A	A	A	A
Pittwater Rd / Orchard Rd	C	B	C	B	A	A
Pittwater Rd / Cross St	C	C	C	C	C	C
Pittwater Rd / Condamine St	C	C	C	C	B	C

The key findings from the Saturday peak period LOS outputs are as follows:

- The majority of intersections do not experience a significant increase in overall delay between 2016 and 2021; and the LOS outputs are relatively comparable between all scenarios. This suggests that the forecast traffic growth along the corridor is not anticipated to have a significant impact and that the proposed upgrades also demonstrate a marginal performance improvement in the Saturday peak.
- Most intersections operate at an acceptable LOS (LOS D or better) with the exception of the Warringah Road intersection, which is observed to be operating at capacity in the base year. The overall delay for this intersection reduces slightly between the 2021 Do-Nothing and Option scenario (from 85 seconds to 77 seconds). This is likely due in part to the increase in capacity as a result of the proposed parking restrictions on Pittwater Road.

5.3.2 Travel times

Average travel times for general traffic, local buses and B-Line buses were extracted from the VISSIM models for the sections of P9 (Section 1) and P8 (Section 2) routes included within the VISSIM model extents. The travel time routes are illustrated in **Figure 27**. Travel time comparisons for each time period are presented graphically in the following sections. Detailed travel time output tables are provided in **Appendix D**.

Figure 27 Travel time analysis routes

Background source: Google Maps

5.3.2.1 AM peak period

Average travel time outputs for the AM peak period are illustrated in **Figure 28** to **Figure 31.**

Figure 28 AM peak period Section 1 general traffic travel time comparisons

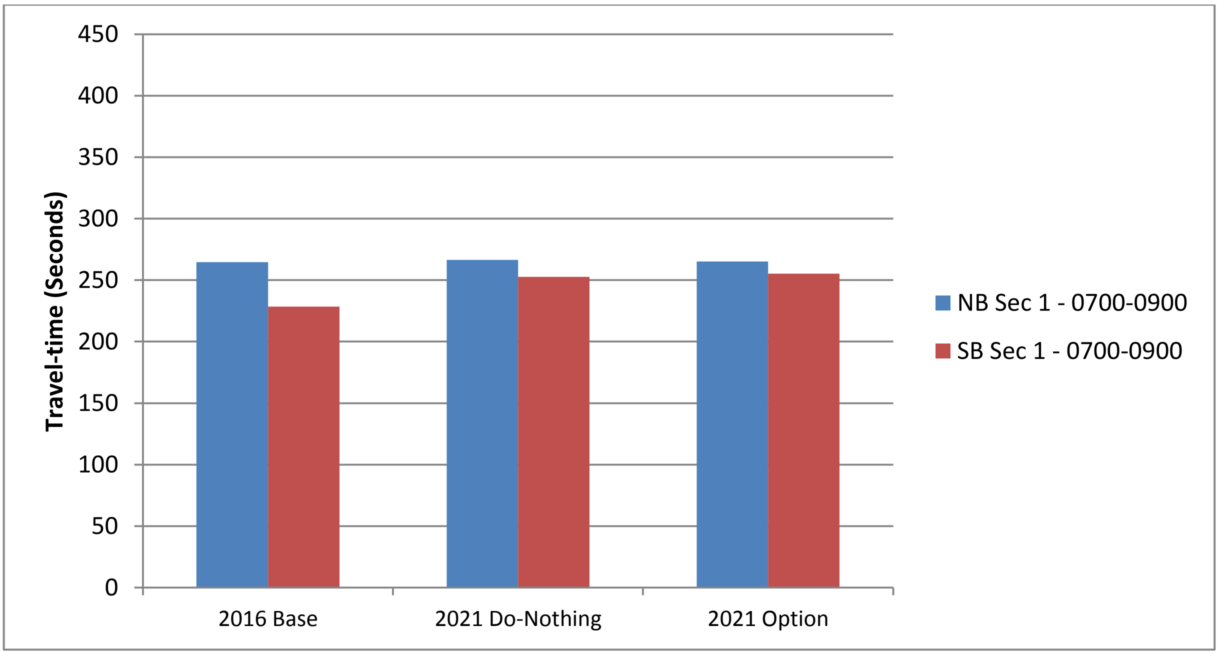
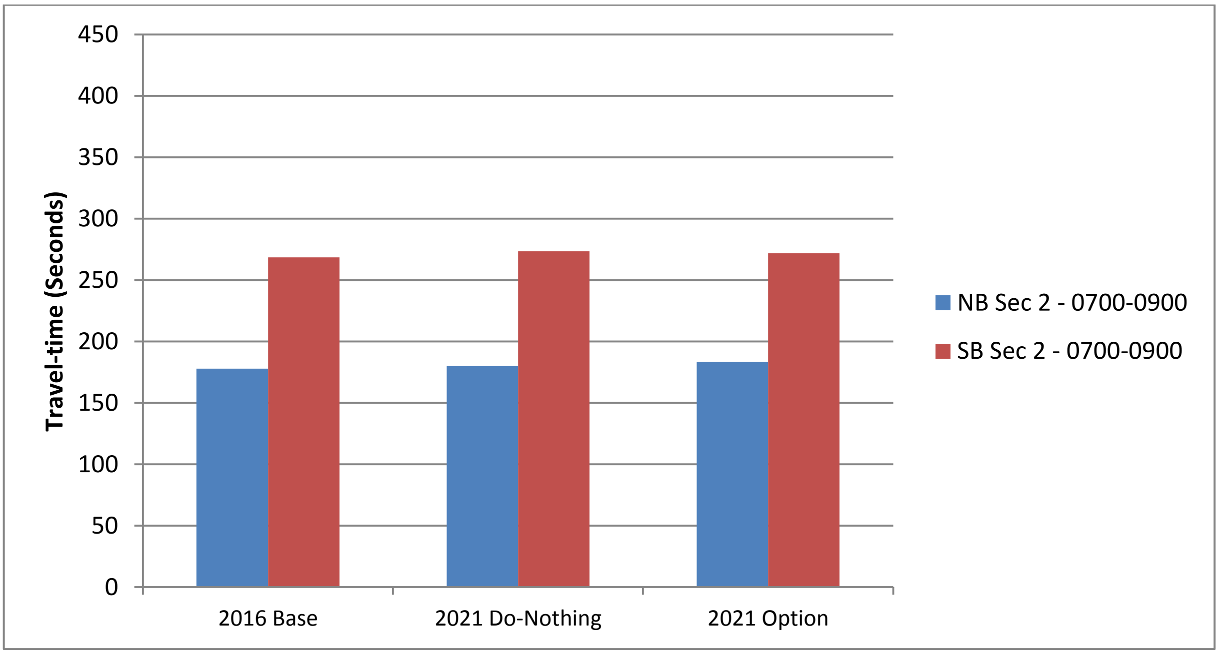


Figure 29 AM peak period Section 2 general traffic travel time comparisons



The general traffic travel time outputs for the AM peak period show that:

- Travel times in both directions are largely consistent between the 2021 Do-nothing and Option scenarios.
- Travel time variations in both directions along the corridor between each scenario are within five seconds. This suggests that the forecast traffic growth and the B-Line proposal is not expected to significantly impact on general traffic travel times in the AM peak.

Figure 30 AM peak period Section 1 bus travel time comparisons

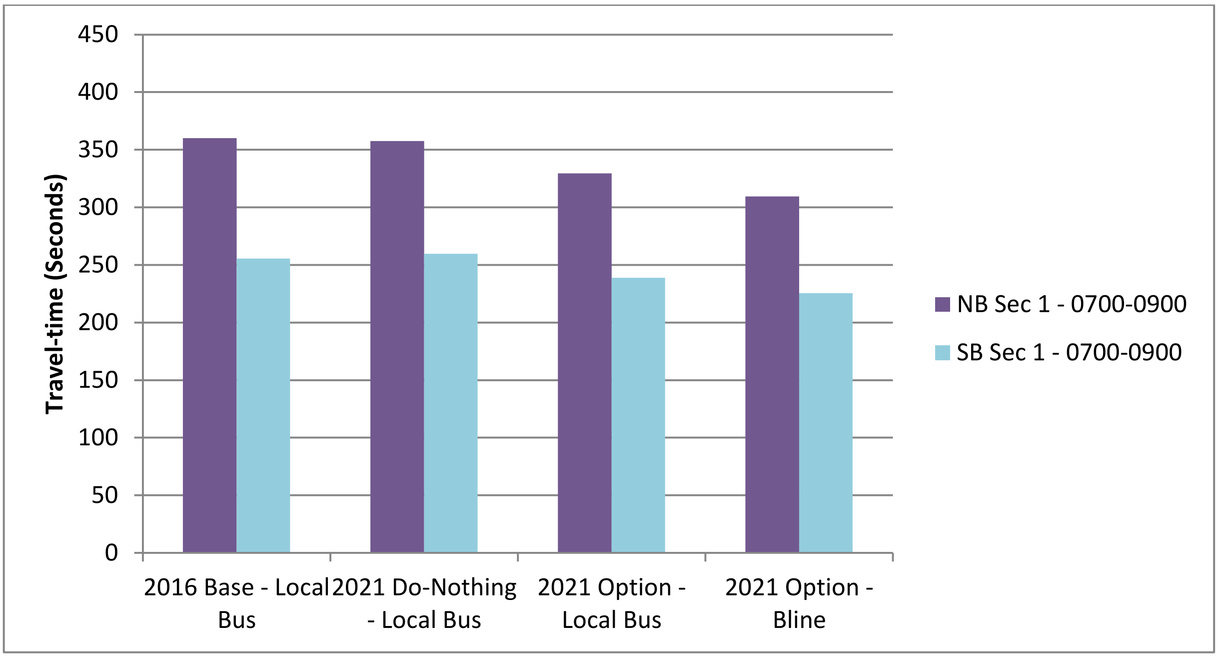
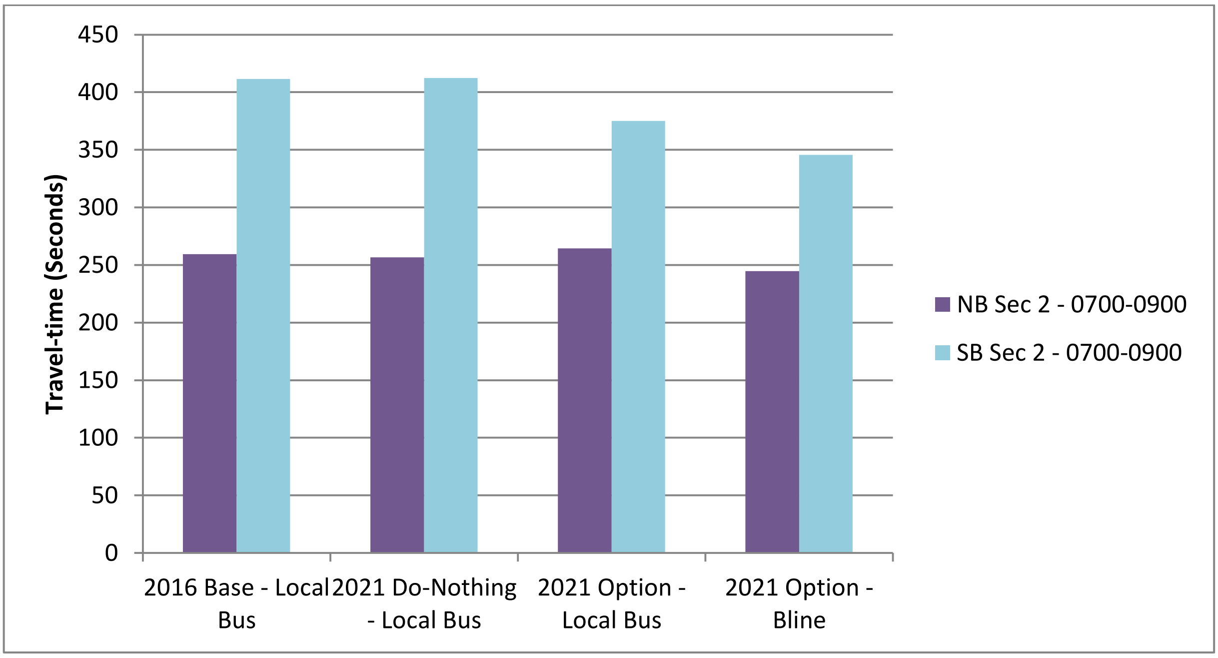


Figure 31 AM peak period Section 2 bus travel time comparisons



The bus travel time outputs for the AM peak period show that:

- In the northbound direction, local bus times are forecast to improve by approximately 20 seconds (3%) between the 2021 Do-nothing and Option scenarios. This improvement is forecast for Section 1.
- In the southbound direction, the modelling shows a consistent benefit for buses in 2021 in the Option scenario in comparison to the Do-Nothing scenario. Local bus times are forecast to reduce by around one minute (9%); B-Line bus times are forecast to be approximately 100 seconds (15%) faster than Do-Nothing.
- The outputs suggest that the B-line proposal should have a positive impact on bus flow and operation along the corridor and should provide moderate benefits in terms of bus travel times, especially in the morning peak southbound direction in comparison to the Do-nothing scenario.

5.3.2.2 PM peak period

Average travel time outputs for the PM peak period are illustrated in **Figure 32** to **Figure 35.**

Figure 32 PM peak period Section 1 general traffic travel time comparisons

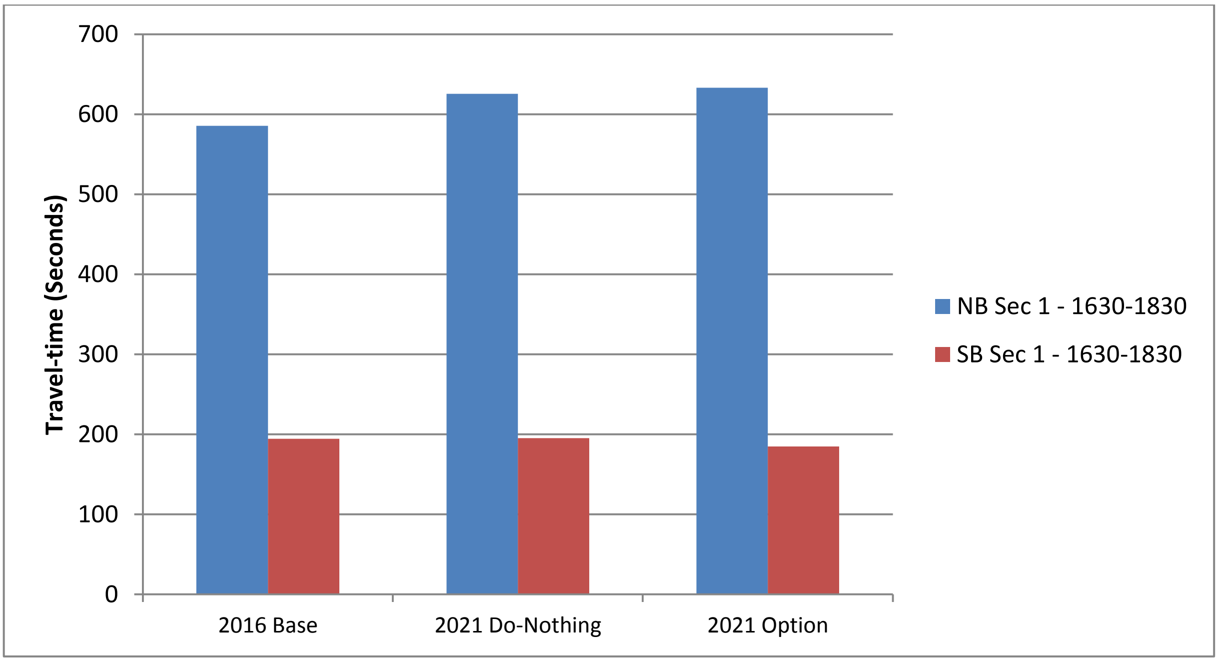
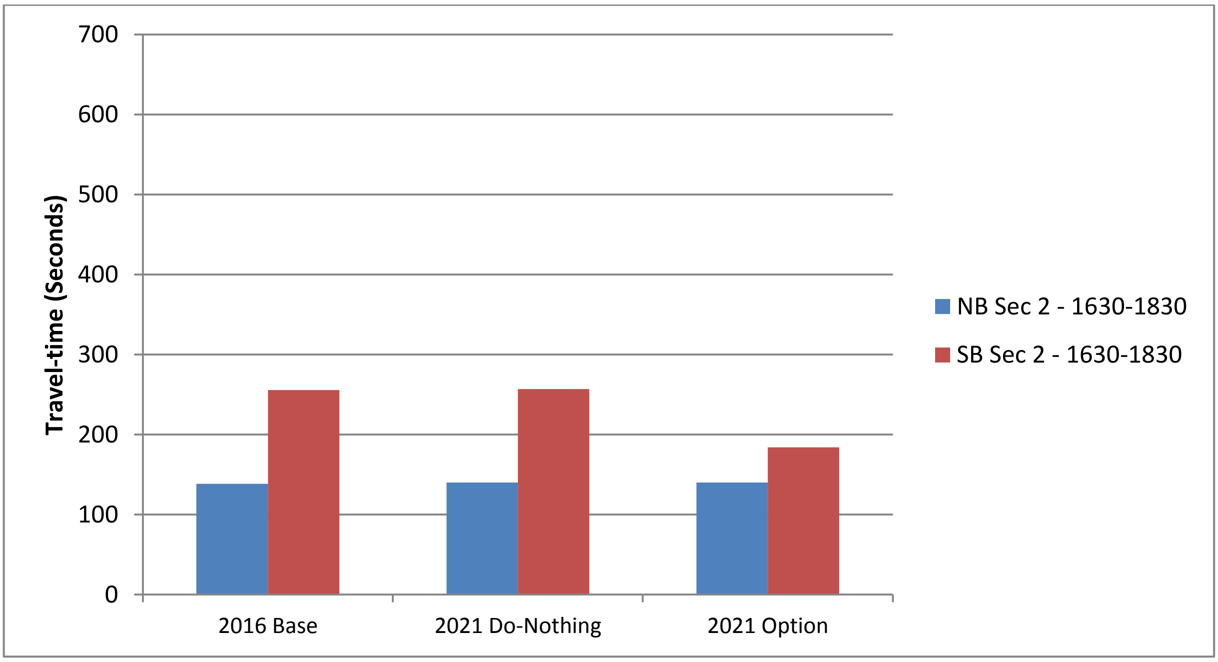


Figure 33 PM peak period Section 2 general traffic travel time comparisons



The general traffic travel time outputs for the PM peak period show that:

- Travel times in the southbound direction are forecast to reduce by around one minute between the 2021 Do-nothing and Option scenarios. This is likely due to the proposed implementation of additional clearways and no-stopping zones in the counter-peak direction and associated increase in capacity. The southbound improvement is forecast to be achieved along Section 2.
- Travel times in the northbound direction are forecast to be relatively consistent between the 2021 Do-Nothing and Option scenarios.

Figure 34 PM peak period Section 1 bus travel time comparisons

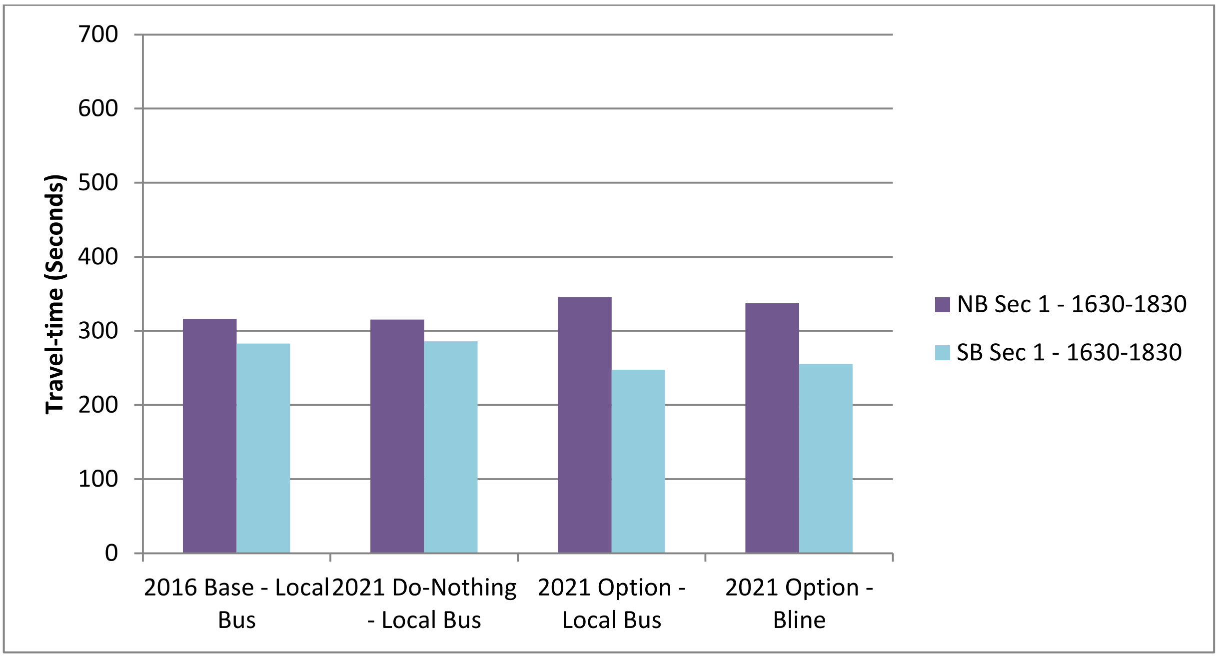
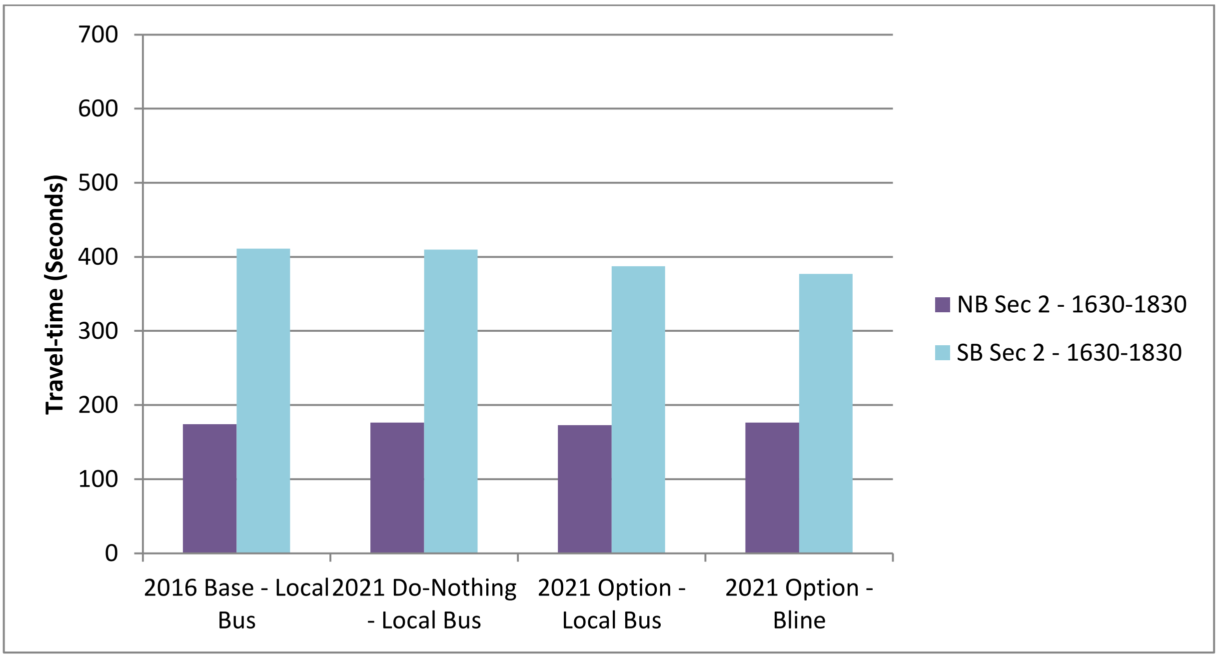


Figure 35 PM peak period Section 2 bus travel time comparisons



The bus travel time outputs for the PM peak period show that:

- Local bus times in the southbound direction reduce by around one minute (9%) between the 2021 Do-nothing and Option scenario. This benefit is likely due to the proposed addition of clearways and no-stopping zones in the counter-peak direction. The outputs show that the majority of the travel time benefit is forecast along Section 1.
- Local bus times and B-Line service times in the northbound direction increase by around 20 seconds. This increase in travel time may due to additional northbound throughput in the Option model at the Cross Street intersection (approximately 100 vph), which exacerbates existing congestion along this stretch of already congested corridor. The increase is however so minor that it is well within the stochasticity of the model along this congested section of corridor and is considered to be insignificant.

5.3.2.3 Saturday peak period

Average travel time outputs for the Saturday peak period are illustrated in **Figure 36** to **Figure 39**.

Figure 36 Saturday peak period Section 1 general traffic travel time comparisons

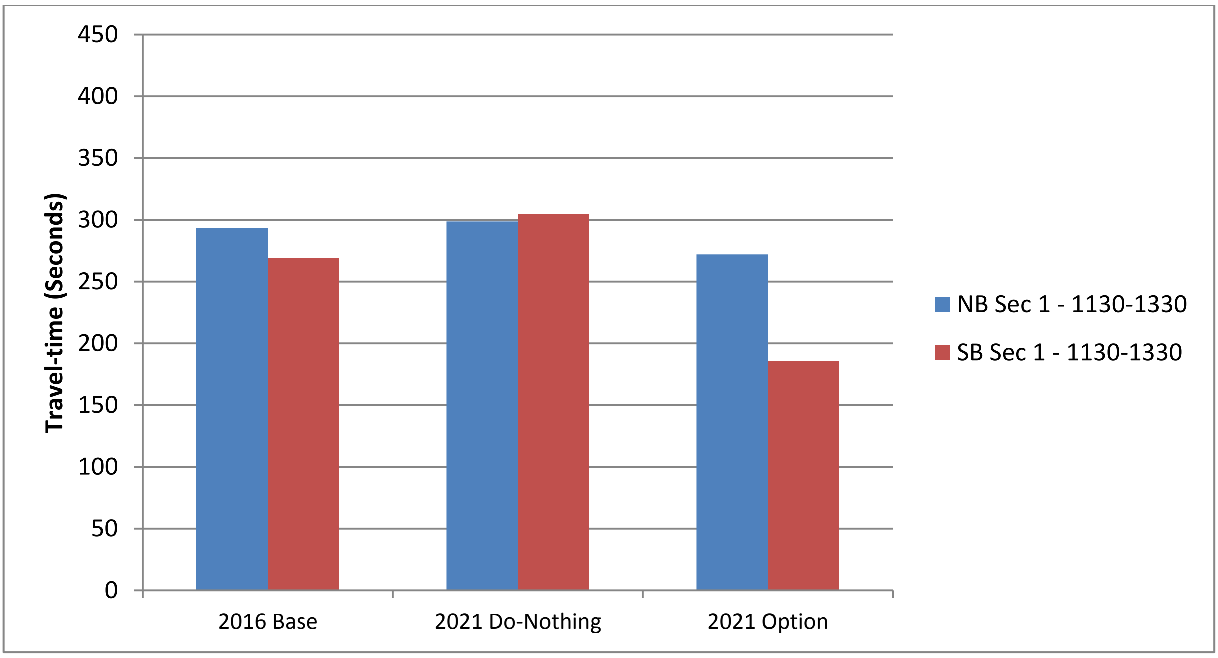
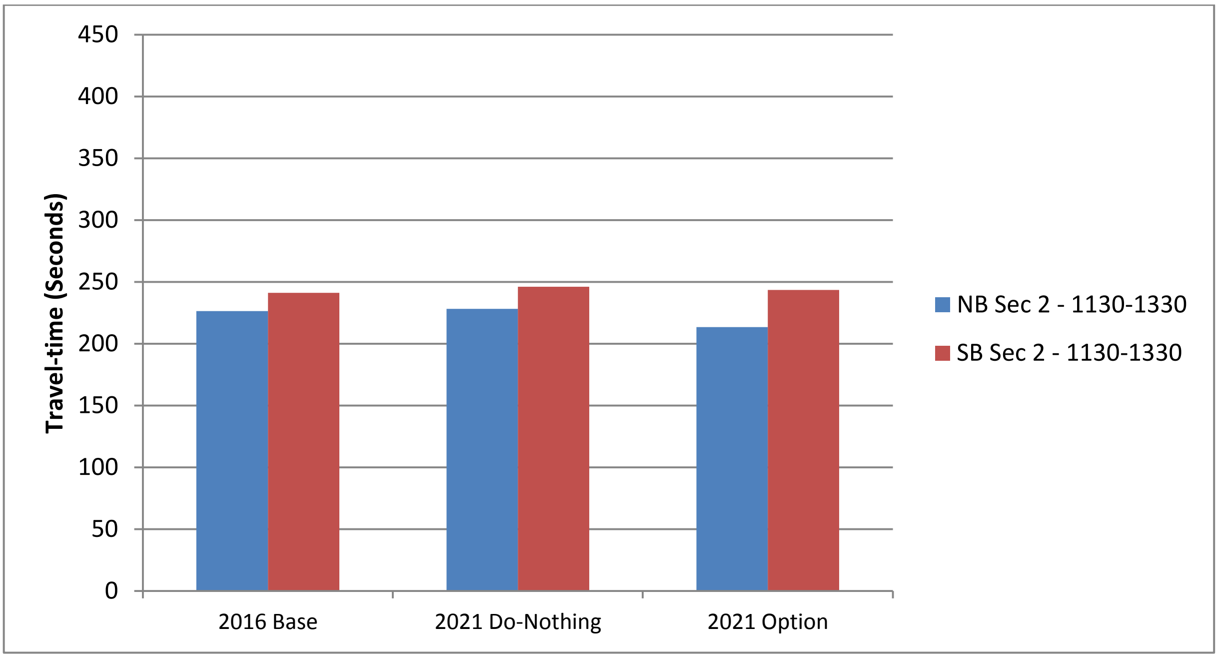


Figure 37 Saturday peak period Section 2 general traffic travel time comparisons



The general traffic travel time outputs for the Saturday peak period show that:

- The 2021 Option scenario is forecast to result in significant improvements in travel times compared to the Do-nothing scenario (around 40 seconds northbound and two minutes southbound). This improvement is likely due to the implementation of additional clearways in the Saturday peak.
- The majority of the travel time improvement is forecast to occur along Section 1, particularly in the southbound direction.

Figure 38 Saturday peak period Section 1 bus travel time comparisons

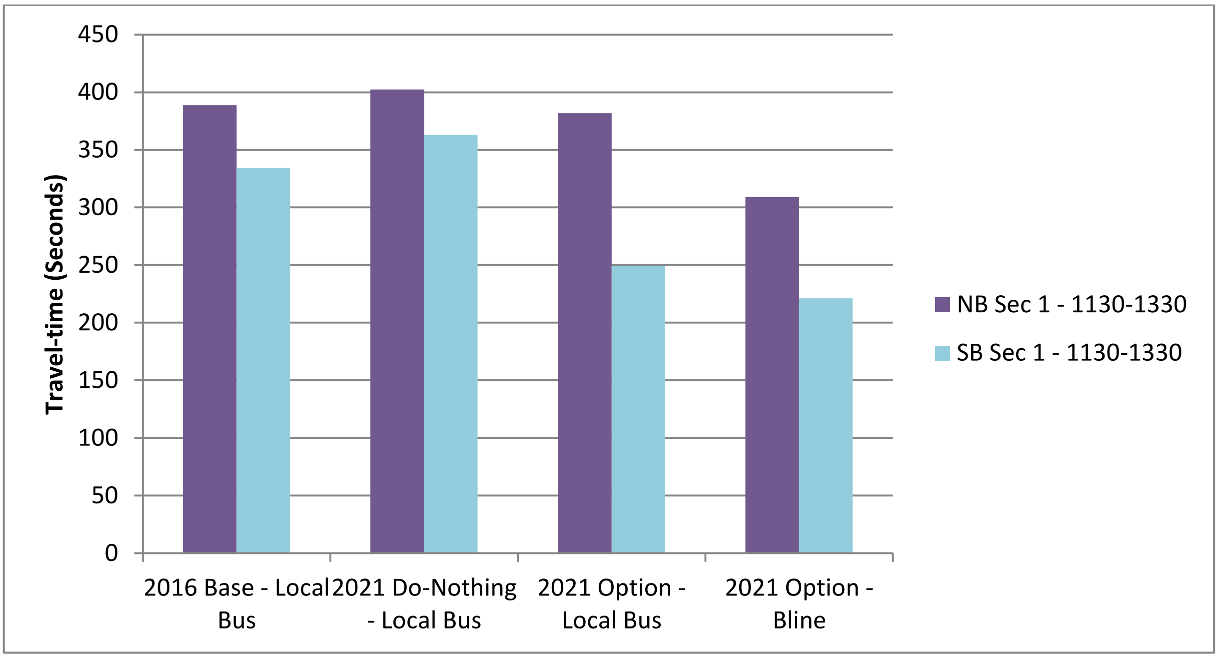
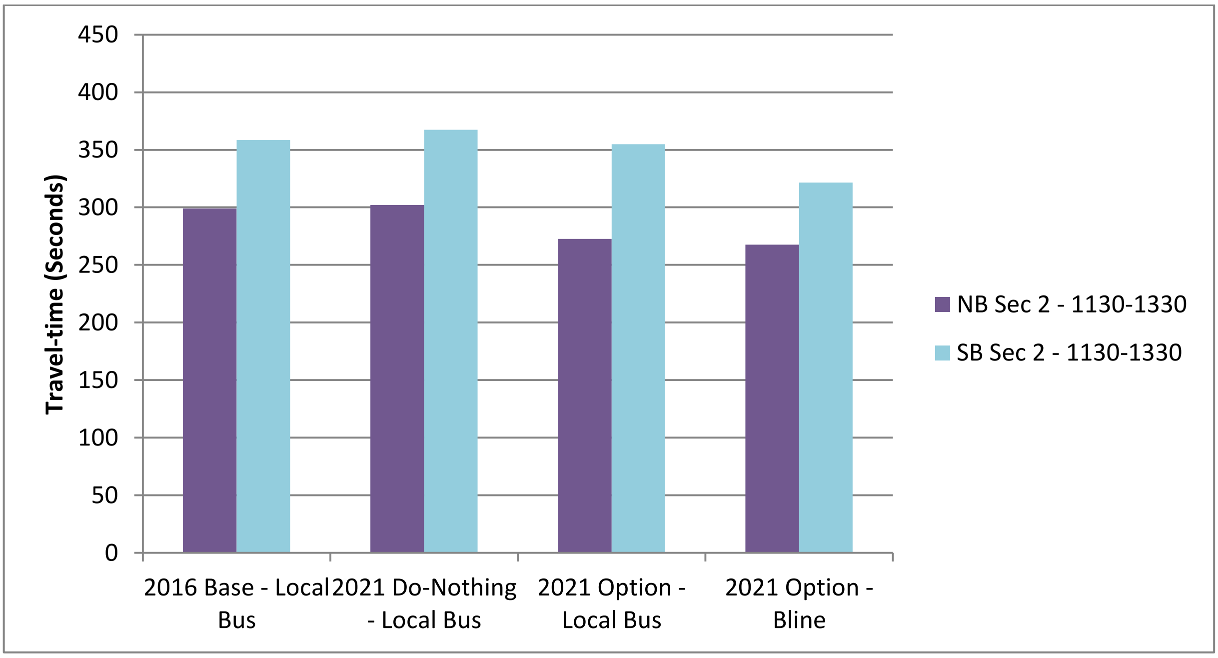


Figure 39 Saturday peak period Section 2 bus travel time comparisons



The bus travel time outputs for the Saturday peak period show that:

- Local bus travel times are forecast to reduce by around 50 seconds (7%) in the northbound direction and by two minutes (16%) in the southbound direction between the 2021 Do-nothing and Option scenarios. Again, this forecast benefit is likely due to the implementation of additional clearways in the Saturday peak.
- Further travel time benefits are forecast for B-Line buses in the Option scenario, with time savings of approximately two minutes (17%) forecast northbound and three minutes (25%) southbound in comparison to the Do-nothing scenario.
- The majority of the travel time savings are forecast to occur along Section 1.

5.3.3 Network performance outputs

The overall performance of the network was analysed for the following parameters for the two-hour peak periods:

- Average vehicle delay – the average delay per vehicle across the network in seconds.
- Average network speed – The average speed of vehicles across the network.
- Latent demand – The number of vehicles blocked outside the network at the end of the model period.

The overall network performance outputs for the 2016 Base Year and 2021 scenarios are presented in the following sections.

5.3.3.1 AM peak period

The overall network performance outputs for the AM peak period are summarised in **Table 15** and **Table 16**.

Table 15 AM peak period network performance outputs 0700 – 0800

Scenario	Ave delay (s)	Ave network speed (kph)	Latent demand
2016 Base	93	21.6	2
2021 Do-nothing	95	21.4	2
2021 Option	97	21.3	2

Table 16 AM peak period network performance outputs 0800 – 0900

Scenario	Ave delay (s)	Ave network speed (kph)	Latent demand
2016 Base	110	18.8	83
2021 Do-nothing	120	17.6	121
2021 Option	123	17.5	88

- The outputs appear to show a slight deterioration of network speed and increase of delays in the 2021 Option. However, it is important to note that network performance statistics should be considered in conjunction with latent demands between scenarios. The 2021 Option demonstrates a reduction of latent demands indicating an improvement of efficiency in moving traffic across the network. Such improvement is considered be beneficial and outweighed the slight increase of network delays which is normal given more traffic traversing into the network.
- As such, the average network speed and delays are at a minimum considered to be comparable between the Do-Nothing and Option scenarios indicating that the proposal will not induce any adverse impact to the overall performance of the study road network.

5.3.3.2 PM peak period

The overall network performance outputs for the PM peak period are summarised in **Table 17** and **Table 18**.

Table 17 PM peak period network performance outputs 1630 – 1730

Scenario	Ave delay (s)	Ave network speed (kph)	Latent demand
2016 Base	132	16.2	272
2021 Do-nothing	140	14.9	390
2021 Option	133	16.1	310

Table 18 PM peak period network performance outputs 1730 – 1830

Scenario	Ave delay (s)	Ave network speed (kph)	Latent demand
2016 Base	122	14.7	136
2021 Do-nothing	130	12.6	285
2021 Option	136	12.8	112

- Similar to the AM peak, there appears to be a slight deterioration of overall network performance in the PM peak 2021 Option. However, there is a considerable reduction of latent demands which suggests an improvement of network efficiency in moving traffic across the road network as a result of the B-Line proposal. Therefore, it is considered that the overall network performance is at a minimum comparable between the 2021 Do-Nothing and Option scenarios.

5.3.3.3 Saturday peak period

The overall network performance outputs for the Saturday peak period are summarised in **Table 19** and **Table 20**.

Table 19 Saturday peak period network performance outputs 1130 – 1230

Scenario	Ave delay (s)	Ave network speed (kph)	Latent demand
2016 Base	122	18.2	46
2021 Do-nothing	130	17.2	82
2021 Option	116	18.7	51

Table 20 Saturday peak period network performance outputs 1230 – 1330

Scenario	Ave delay (s)	Ave network speed (kph)	Latent demand
2016 Base	126	17.7	1
2021 Do-nothing	140	15.9	22
2021 Option	114	19.2	1

- The outputs show that under the existing and 2021 Do-Nothing scenarios, the second hour of the Saturday peak period experiences more congestion that the first hour.
- Average network speeds reduce by approximately 1kph in the second hour between 2016 and 2021 Do-nothing scenarios.
- Average speeds in the 2021 Option scenario are approximately 3kph higher than in the Do-nothing scenario in the second hour. Average network delay and latent demand are also reduced. This indicates that the

B-Line proposal will provide a moderate improvement in overall network operation in the Saturday peak period.

5.3.4 VISSIM modelling summary and conclusion

The improvement of bus travel times and efficiency is the primary objective of the B-Line program. Based on the VISSIM modelling analysis, the following conclusions can be made in relation to the future performance of buses in Brookvale and Dee Why with and without the B-Line proposals:

- In the AM peak, travel times for local buses are forecast to improve by approximately 9% southbound and 3% northbound with the B-Line proposals. Travel times southbound for B-Line services are forecast to be around 15% faster than Do-nothing. These improvements are partly attributed to the implementation of the southbound indented bay near Hawkesbury Avenue and the provision of an additional southbound traffic lane near Howard Avenue and Oak Avenue.
- In the PM peak, travel times for local buses are forecast to reduce by around 9% in the southbound direction between the 2021 Do-nothing and Option scenarios. Local bus and B-Line northbound travel times are forecast to remain relatively consistent between the Do-nothing and Option scenarios.
- In Saturday peak, travel times for local buses are forecast to improve by approximately 7% northbound and 16% southbound between the 2021 Do-Nothing and Option scenarios. Travel times for B-Line buses are forecast to improve by around 17% northbound and 25% southbound. These significant benefits can be partly attributed to the indented bus bay and implementation of clearways in both directions.

In relation to general traffic and overall intersection operation, the VISSIM modelling has forecast that:

- The LOS at the key intersections across the network is not forecast to change significantly between the 2021 Do-nothing and the Option scenarios.
- In the AM peak, general traffic travel times in both directions along the corridor are forecast to remain largely consistent between the 2021 Do-nothing and Option scenarios.
- In the PM peak, general traffic travel times in the southbound direction are forecast to reduce by around one minute. Northbound times are forecast to remain relatively consistent between the 2021 Do-Nothing and Option scenarios.
- In the Saturday peak period, the B-Line proposal is forecast to reduce general traffic travel times by between 40 seconds and two minutes in comparison to Do-nothing. This significant improvement is likely due to the implementation of clearways and the associated increase in road capacity.

From an overall network operation perspective, the modelling has shown that:

- The global network performances for a minimum are comparable between the 2021 Do-Nothing and Option scenarios in the weekday peak periods. Indeed, there is a consistent reduction of latent traffic demands with the B-Line proposal indicating an improved efficiency of the network in moving traffic to their destinations.
- On the Saturday peak, there network performance metrics shows moderate improvements with an increase in average network speed as well as a reduction of average delays with the B-Line proposal.
- The above suggests that the B-Line proposal could provide travel time benefits to buses while maintaining a similar level of network performance. In other words, the proposal’s focus on bus related improvement measures is not anticipated to have any adverse impact to other traffic and road users.

5.4 Sydney Road / Manly Road and Heaton Avenue assessment

5.4.1 Existing issues

Towards the southern end of the study area corridor it was identified that there is currently a significant amount of traffic turning left out of Heaton Road onto Manly Road during the peak periods. Heaton Avenue forms a left-in / left-out (LILO) connection with Manly Road and is located approximately 350 metres south of the major signalised intersection with Sydney Road.

The traffic turning out of Heaton Avenue uses the existing kerbside T3 lane along Manly Road as an acceleration lane. This interferes with the smooth running and operation of buses at an existing bus stop located approximately 20 metres north of the intersection. There are also safety concerns for traffic exiting Heaton Avenue merges onto the mainline with a steep downward gradient.

In addition, buses stopping at the existing bus stop north of Heaton Avenue are observed to cause delays to other southbound buses and T3 traffic along the corridor. These issues are most prominent in the AM peak period, when the southbound direction along Manly Road is the peak direction for buses and general traffic.

The traffic exiting from Heaton Avenue is surveyed to be at most 300 vehicles per hour in the morning peak period between 7:30-8.30am (or up to 550 vehicles between 7.30-9.30am), with another 30 to 40 vehicles per hour entering Heaton Avenue from Manly Road.

5.4.2 Proposed upgrade

To mitigate the existing issues detailed in the section above, it is proposed to close the Heaton Avenue access at Manly Road and to construct an indented bus bay for replacing the existing bus stop currently located north of Heaton Avenue. This would require that the traffic currently using Heaton Avenue to divert to the signalised intersection upstream at Sydney Road which is also proposed to be upgraded as part of this proposal. The proposed diversion routes for Heaton Avenue traffic will be discussed in the forthcoming sections in conjunction with supplementary Origin-Destination survey data for validation of traffic modelling and assessment assumptions.

5.4.3 Assessment approach

To assess the potential impacts of closing the Heaton Avenue access on the operation of the surrounding network, the following two-tiered modelling assessment was undertaken:

- SIDRA assessment of the Sydney Road / Manly Road intersection to ascertain the proposed intersection upgrades able to satisfactorily cater for the displacement of Heaton Avenue traffic. The traffic volumes used in the SIDRA assessment assumed 6% background traffic growth between 2016 and 2021, in line with the STFM forecasts and population growth forecasts for the Northern Beaches. Two scenarios were tested:
  - **Scenario 1 – all traffic currently using Heaton Avenue is diverted to the eastern approach of the Sydney Road / Manly Road intersection.**
  - **Scenario 2 – 50% of the diverted traffic originates from the eastern side of Manly Road and 50% from the west.**
- Preliminary assessment of the Heaton Avenue / Sydney Road locality is facilitated by a microsimulation model of the corridor, which was developed as part of the P12 work package of the B-Line program. The proprietary modelling tool is called ‘Commuter’ (referred to as ‘Commuter modelling’). This assessment was undertaken for the 2016 Base Year only and tested the same scenarios considered in the SIDRA assessment in terms of traffic diversions. The benefits of the Commuter modelling assessment allow consideration of the proposed upgrade in a connected network to holistically understand traffic issues in conjunction with other network constraints such as the downstream bottleneck at Spit Bridge.

Both modelling assessments were undertaken for the AM and PM peak periods. Assumed upgrades at Sydney Road / Manly Road intersection includes:

- Extension of the existing right turn lane from Burnt Bridge Creek Deviation into Sydney Road (westbound).
- Construction of a new left turn lane from Sydney Road into Burnt Bridge Creek Deviation (northbound)
- Upgrade of the existing left turn slip lane from Burnt Bridge Creek Deviation into Sydney Road (eastbound).
- Extension of the Sydney Road through traffic lane on the eastern side of the Burnt Bridge Creek Deviation/ Manly Road intersection.

- Extension of the existing right turn lane from Manly Road into Sydney Road (eastbound).

5.4.4 SIDRA assessment

Outputs from the SIDRA analysis are summarised in **Table 21.** Detailed outputs from the SIDRA modelling are also provided in **Appendix E**.

Table 21 Sydney Road / Manly Road SIDRA outputs

Scenario	Total veh	Delay (s)	LOS	DOS
2016 AM	4,757	37.3	LOS C	1.107
2016 PM	5,722	32.5	LOS C	1.052
2021 Do-nothing AM	5,048	41.6	LOS C	1.169
2021 Do-nothing PM	6,076	38.4	LOS C	1.126
2021 Scenario 1 AM	5,322	41.1	LOS C	1.169
2021 Scenario 1 PM	6,223	43	LOS D	1.009
2021 Scenario 2 AM	5,322	33.3	LOS C	0.927
2021 Scenario 2 PM	6,223	45.2	LOS D	1.126

The key findings of the SIDRA analysis are as follows:

- Review of the SIDRA analysis outputs indicates that the displaced traffic resulting from the closure of Heaton Avenue, being re-routed via the Sydney Road intersection can be satisfactorily mitigated with the proposed intersection improvements.
- Comparison of the 2021 'Do Nothing' scenario with the upgrade scenarios suggests that the overall intersection performance could be maintained. It is however noted that the reported intersection performances should only be used for comparative analysis only.
- It is anticipated based on recent site investigation that the rerouted traffic on Sydney Road (east) will likely exhibit similar merging behaviours (i.e. first merging on to the kerbside T3 lane, prior to moving into the general traffic lanes). Notwithstanding the above, this is considered to be a better alternative from a safety perspective given the relatively better visibility and level gradient.

5.4.5 SIDRA modelling limitation

The subject intersection was modelled in SIDRA in isolation. The complex downstream delays from Spit Bridge and beyond are not necessarily replicated. As a result the reported intersection LOS is likely to be under estimated.

Notwithstanding the above, the SIDRA analysis is intended to provide a comparative analysis to demonstrate that the displaced traffic from Heaton Avenue would not significantly worsen the operational performance of the intersection, when compared to the 2021 'Do Nothing' scenario (i.e. without the Heaton Avenue Closure and intersection upgrades).

5.4.6 Commuter microsimulation modelling assessment

The objective of the Commuter modelling is to supplement the SIDRA analysis undertaken for the Sydney Road / Manly Road intersection, and to assess the proposed Heaton Avenue closure. The Commuter simulation model covers approximately 8.3 km of the Spit Road / Military Road corridor, including the intersections of Sydney Road and Heaton Avenue.

In the model simulation, the congestion at Parriwi Road / Spit Road in the AM peak and at the Spit Bridge in PM peak spills back to impede exit flows from the Sydney Road / Manly Road intersection. The model also captures delay caused by buses stopping to pick up passengers on the southern exit from the Sydney Road intersection.

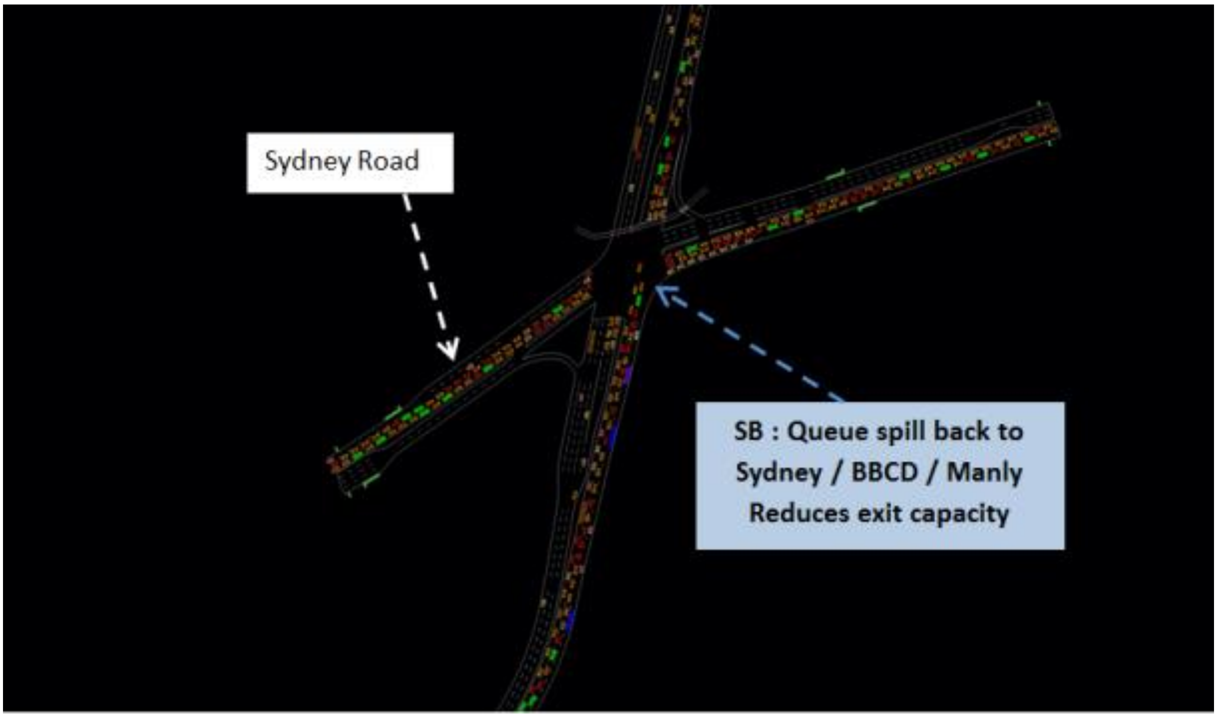
These exit delays are a close representation to actual traffic operation and provided a good basis to test for assumed traffic re-routing resulting from the proposed closure of Heaton Avenue.

The modelled periods are 6.00am to 10.00am and 3.00pm to 7.00pm. The models include road gradients and use fixed time signal control as a proxy to SCATS adaptive control.

5.4.6.1 Existing network operational issues

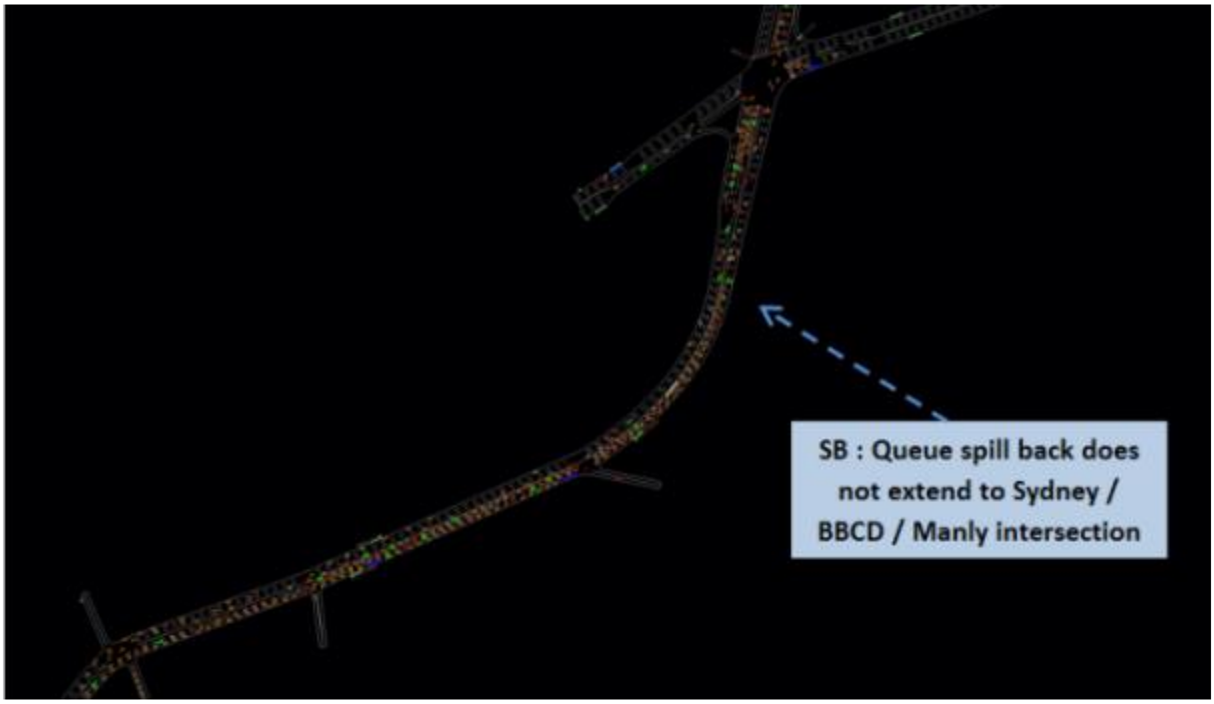
In the AM peak congestion builds for southbound traffic causing queues to spill back from Parriwi Road / Spit Road. These queues eventually reach the Sydney Road / Manly Road intersection and reduce the exit capacity at this intersection (refer to **Figure 40** for typical AM traffic queue pattern). This is in line with the traffic conditions observed on site.

Figure 40 2016 AM Commuter model operation at Sydney Road/ Manly Road



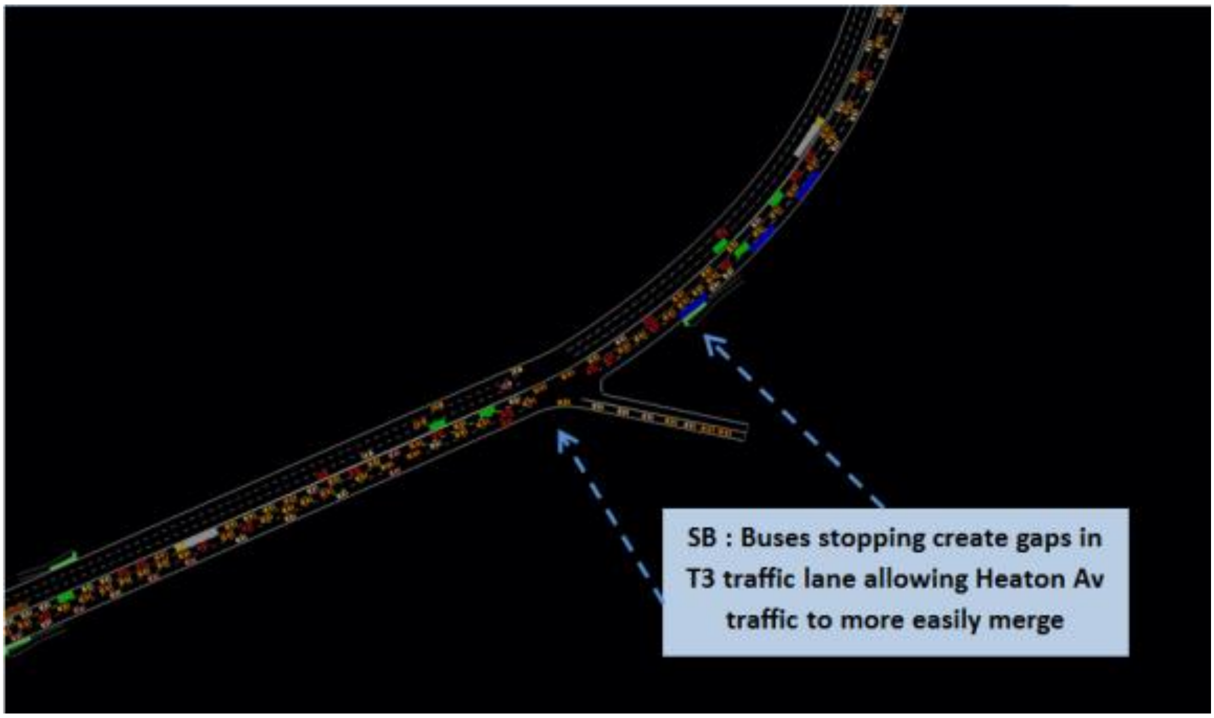
During the PM peak southbound traffic queues form where the tidal flow arrangement on Spit Bridge forces 3 lanes to merge to 1 lane (refer to **Figure 41** for typical southbound PM queuing pattern). Queues for southbound traffic extend to the north, but do not normally reach the Sydney Road / BBCD / Manly Road intersection.

Figure 41 2016 PM Commuter model operation at Sydney Road and Heaton Avenue



Southbound buses stopping at the bus stop on Manly Road between Sydney Road and Heaton Avenue create gaps in traffic in the T3 kerbside lane. These gaps make it easier for traffic from Heaton Avenue to join the T3 lane and then merge into the general traffic in lanes 2 and 3. This behaviour was observed on site and is replicated in the simulation models, as shown in **Figure 42**.

Figure 42 Existing issues at Heaton Avenue



The existing conditions shown in the Commuter model are consistent with observations made during peak hour site visits.

5.4.6.2 Upgrade options assessment

The upgrade options in the Commuter modelling take into consideration the following upgrades of the proposal:

- Provision of an indented bus bay at Heaton Avenue, south of the Manly Road / Sydney Road intersection, facilitated by the closure of access to and from Manly Road.
- Upgrade at Sydney Road / Manly Road intersection to accommodate for the traffic diversion from Heaton Avenue closure.

Other upgrades proposed south of the Manly Road / Heaton Avenue intersection as part of the overarching B-Line proposal have not been included in this phase of the commuter modelling assessment.

The screenshots in **Figure 43** and **Figure 44** show typical queuing patterns for the upgrade scenarios for AM and PM periods. **Figure 45** and **Figure 46** illustrate the typical peak hour performance of the Sydney Road / Manly Road intersection with the proposed upgrades in place.

Figure 43 AM peak corridor queuing in upgrade scenarios

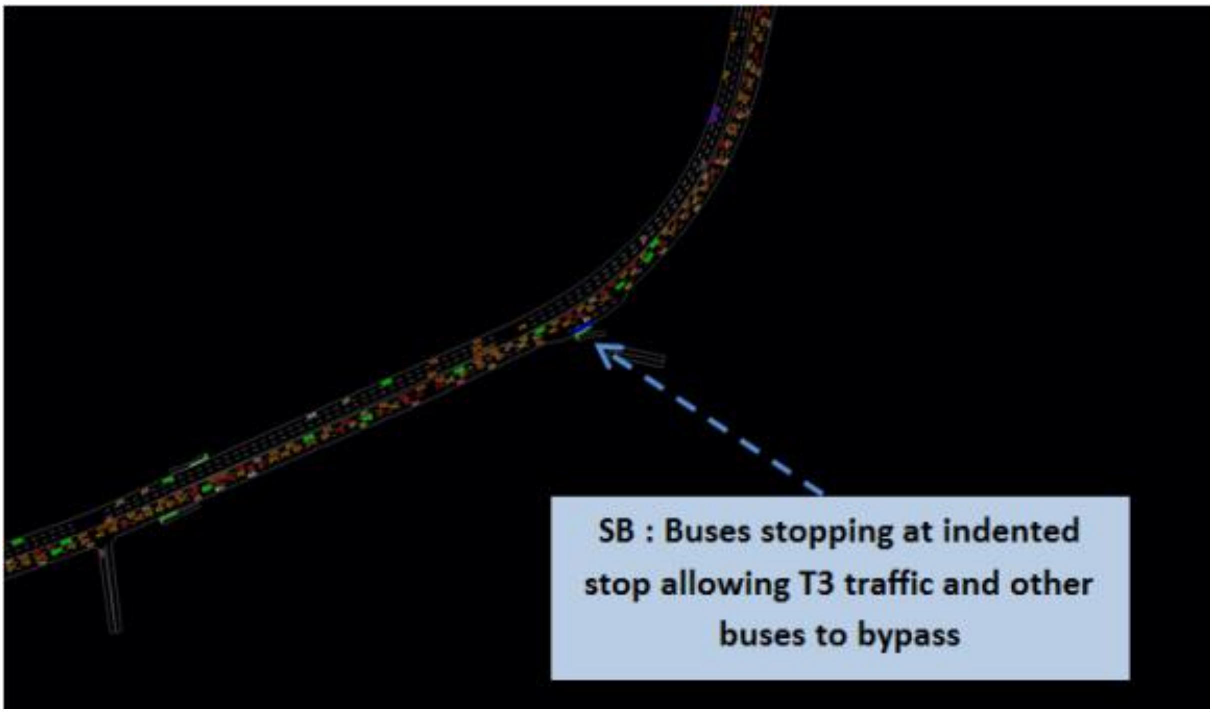


Figure 44 PM peak corridor queuing in upgrade scenarios

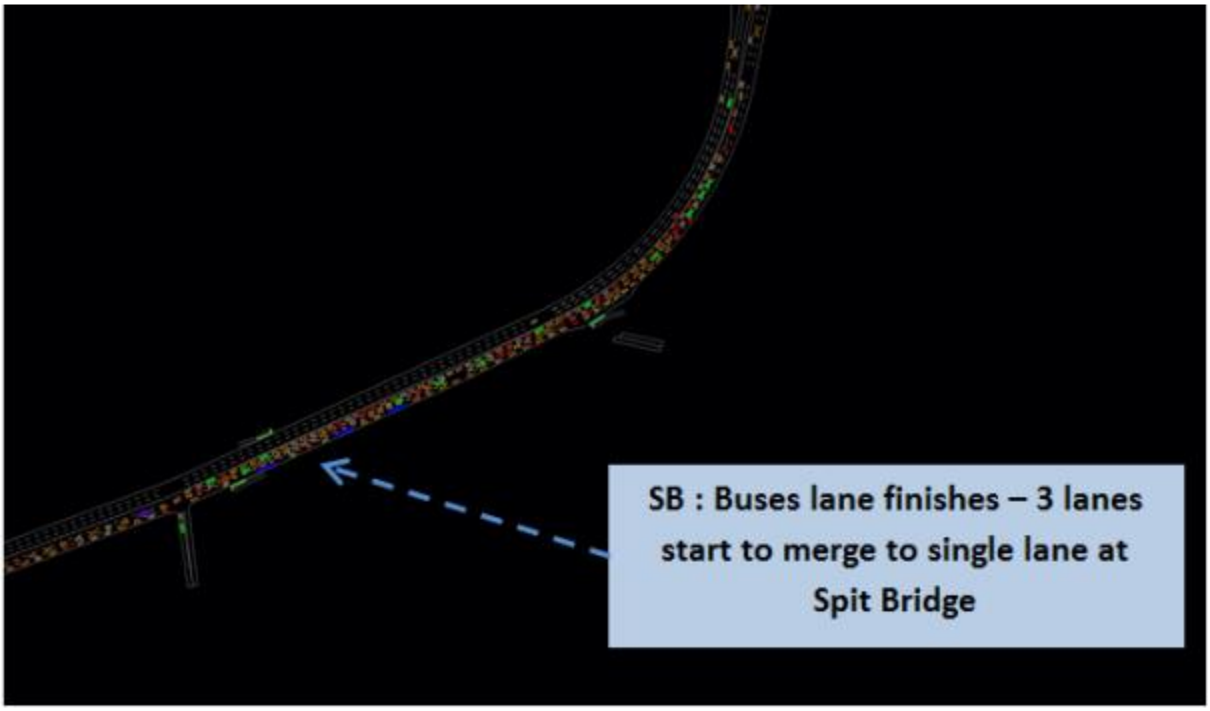


Figure 45 AM peak Sydney Road / Manly Road operation in upgrade scenarios

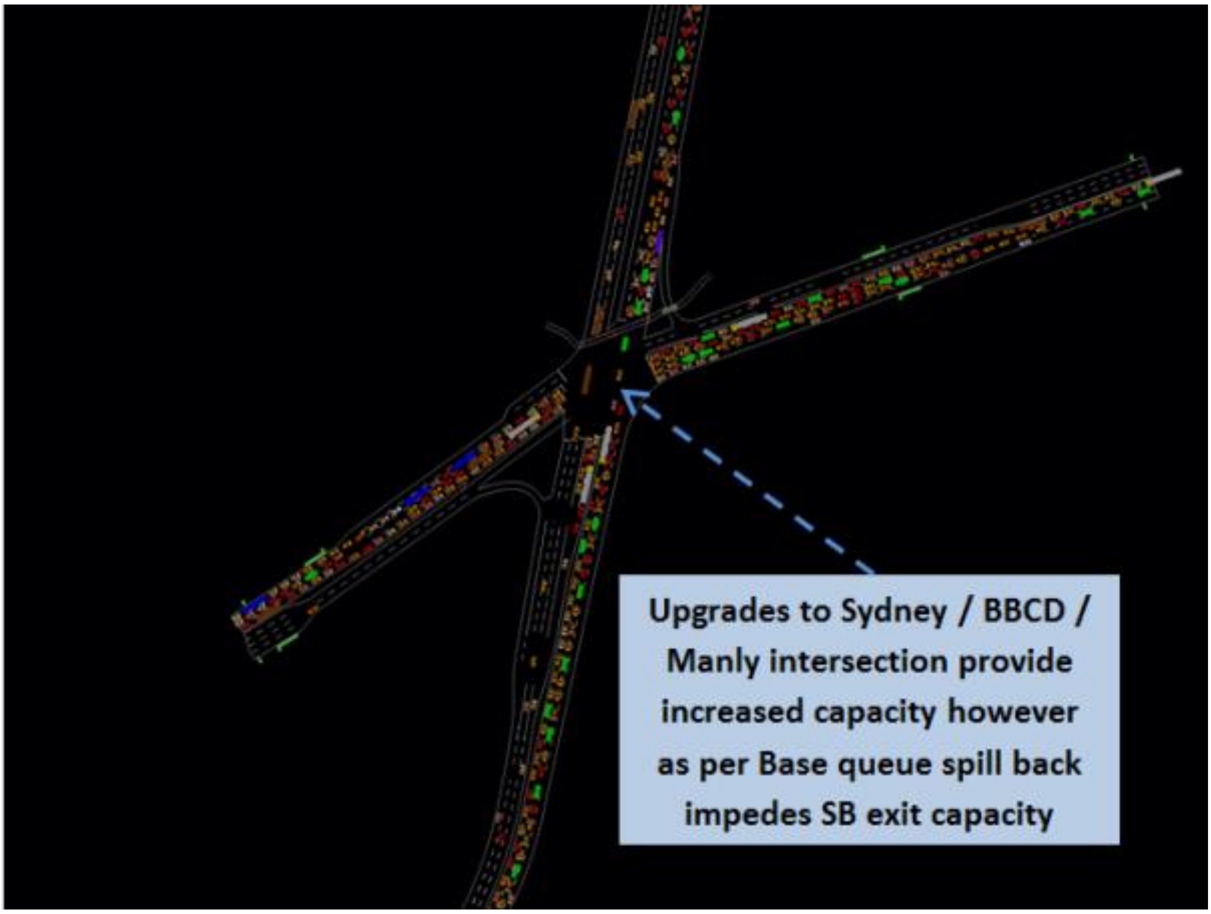


Figure 46 PM peak Sydney Road / Manly Road operation in upgrade scenarios

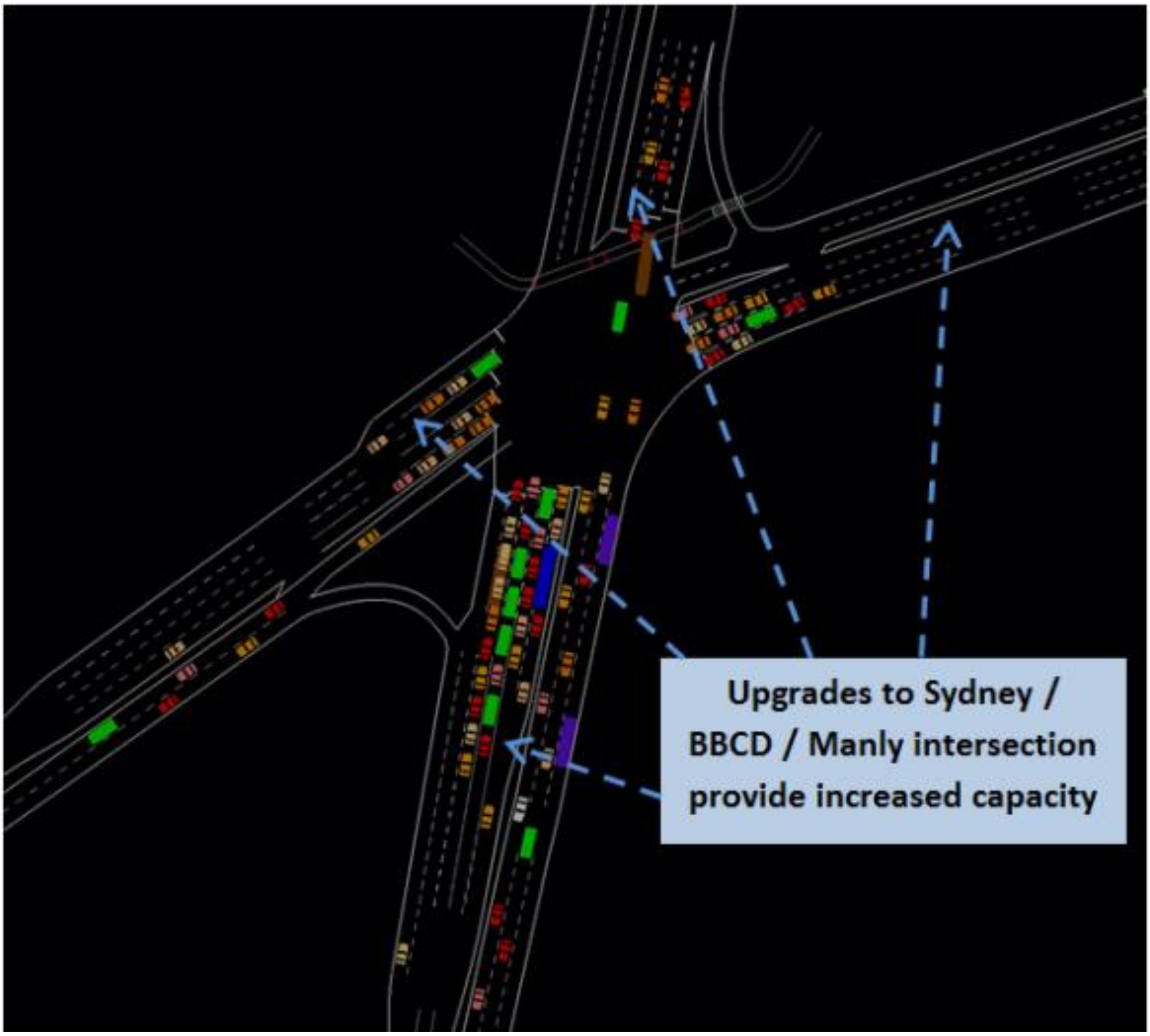


Table 22 summaries travel time outputs from the Commuter modelling for southbound buses between Sydney Road and Parriwi Road for discussion. **Table 23** summaries travel time outputs from the Commuter modelling for southbound general traffic and T3 vehicles between Sydney Road and Parriwi Road for discussion. Other detailed Commuter modelling outputs are also provided in **Appendix F**.

Table 22 Summary of SB Bus travel times

Time period	Modelled Travel Time (Sydney Road to Parriwi Road)		
	Existing Base (mm:ss)	Scenario 1 (mm:ss)	Scenario 2 (mm:ss)
AM peak	4:47	3:23	3:06
PM peak	6:15	6:11	6:35

Table 23 Summary of SB General Traffic and T3 vehicles travel times

Time period	Modelled Travel Time (Sydney Road to Parriwi Road)					
	Existing Base (mm:ss)		Scenario 1 (mm:ss)		Scenario 2 (mm:ss)	
	General Traffic	T3 Vehicles	General Traffic	T3 Vehicles	General Traffic	T3 Vehicles
AM Peak	8:34	4:59	8:24	4:36	8:04	4:34
PM peak	8:38	8:28	8:16	8:03	8:54	8:45

- The travel time for buses is shown to improve in both scenarios in the AM period. This is in part due to the removal of traffic entering from Heaton Avenue. However, the main advantage is resulted from the indented bus bay which allows non-stopping buses to bypass stopping buses.
- The Commuter modelling forecasts poorer levels of services than the SIDRA analysis for the Sydney Road / Manly Road intersection (LOS F compared to LOS C). This is expected as the simulation model accounts for downstream capacity constraints which is a more accurate reflection of forecast traffic conditions. In the AM period, the predominant constraint is identified due to traffic blocking back from the Parriwi Road / Spit Road intersection. For the PM period, the major constraint is for southbound traffic as vehicles merge into a single lane on Spit Bridge as a result of the tidal flow arrangement.
- The Sydney Rd / Manly Rd intersection is already very congested in the base year during the peak periods (LOS F). The design scenarios operate at the same levels of services as the base during both peak periods. This indicates that the re-routed traffic from the Heaton Avenue closure should have a minimal effect on the Sydney Road / Manly Road intersection when the intersection upgrades are in place.
- In Scenario 2 during the AM peak, although very congested, has shown better performance when compared to the existing and Scenario 1. In Scenario 2, the distribution of the re-routed Heaton Avenue traffic (i.e. 50/50 to the Sydney Road east and west approaches) means that the side street traffic is less likely to run into the back of southbound queues on Manly Road. This operation is not shown in the PM period largely because the southbound queue in the PM is less of a constraint than the southbound AM queuing.
- In the proposed designs with the indented bus bay, the southbound T3 traffic benefits from being able to bypass the indented bus bay at Heaton Avenue. Thus in the AM peak, the T3 traffic is observed to travel faster than general traffic.
- The travel times in the PM period are similar between existing and the scenarios. This southbound section of road has three traffic lanes which merge to a single lane at Spit Bridge (tidal flow arrangement). The travel times for general traffic and T3 are similar as these vehicles share the same traffic lane over the bridge. The bus travel times are faster than general / T3 because of the kerbside bus lane on the southern exit from the Sydney Rd / BBCD / Manly Rd intersection. This PM peak bus lane extends to Avona Crescent where the buses are required to merge with general traffic.

5.4.7 Qualitative assessment of local network

An Origin-Destination (O-D) survey was undertaken on 13 September 2016 between 7.30-9.30am to understand the travel pattern of Heaton Avenue traffic at Manly Road. The findings of the O-D survey allow further validation of traffic diversion assumptions adopted in the SIDRA and Commuter modellings. Feasible traffic diversion routes in the local road network can also be instigated given the better understanding on the likely origins of traffic currently exiting Heaton Avenue onto Manly Road.

Key findings of the O-D survey is summarised as follows:

- The traffic existing from Heaton Avenue is observed to be around 550 vehicles between 7.30-9.30am in the AM peak.
- 12% of the 550 vehicles access Heaton Avenue from areas west of Manly Road via Ethel Street eastbound.
- 21% of the Heaton Avenue traffic originates from Sydney Road east of Condamine Street.

- The aforementioned traffic (33%) are considered to be 'rat-runners' bypassing the traffic signal through the local road network and Heaton Avenue. These through traffic are generally not encouraged given the intended purpose of local road network are primarily designed to serve local traffic only.
- 31% of the Heaton Avenue traffic is likely originating from the local catchments east of manly Road (i.e. a combined total of 52% including 'rat-running' traffic from the east).
- The remaining 36% are observed to access Heaton Avenue via Peronne Avenue.

Based on the above, the proposed distribution of Heaton Avenue traffic including the proposed diversion routes is shown in **Figure 47** and **Figure 48,** followed by a high level qualitative assessment:

Figure 47 Diversion of affected Heaton Avenue traffic east of Manly Road

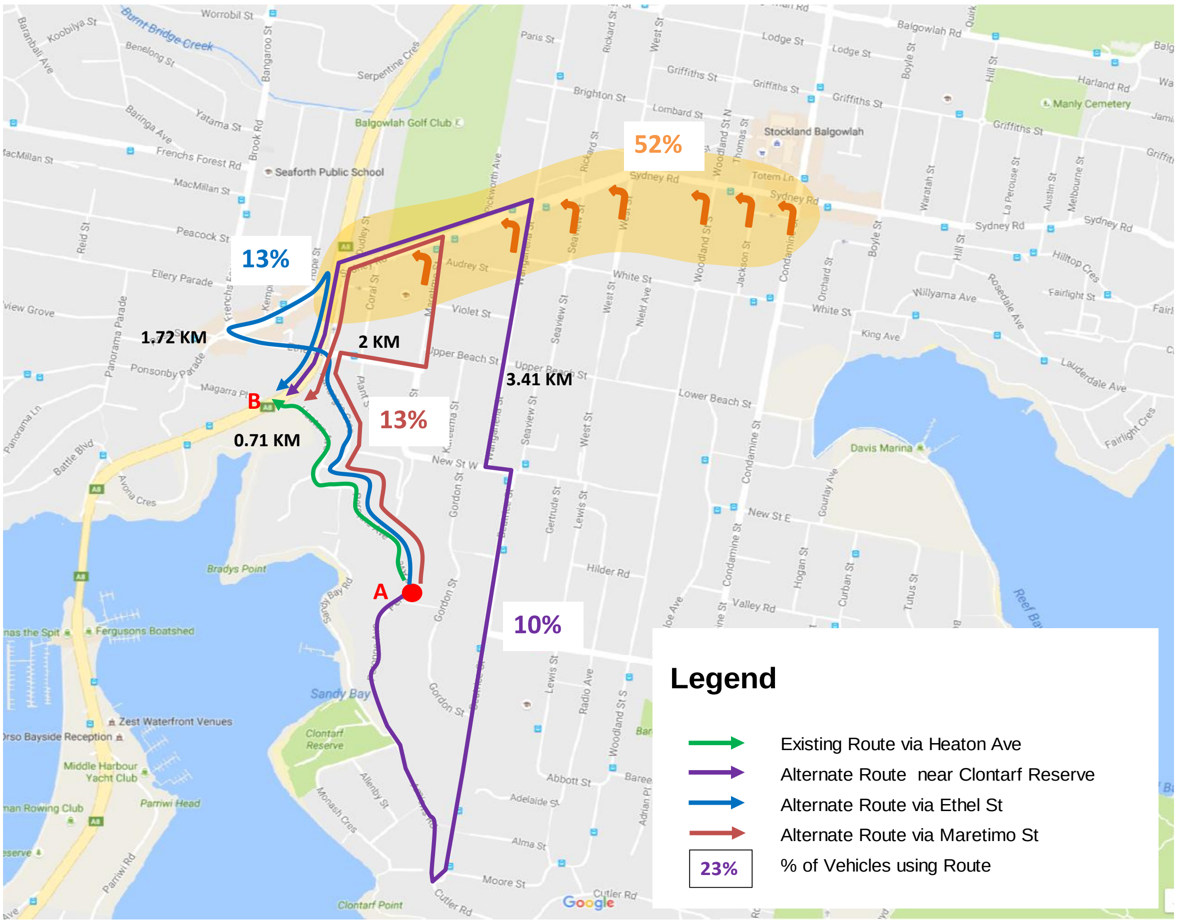
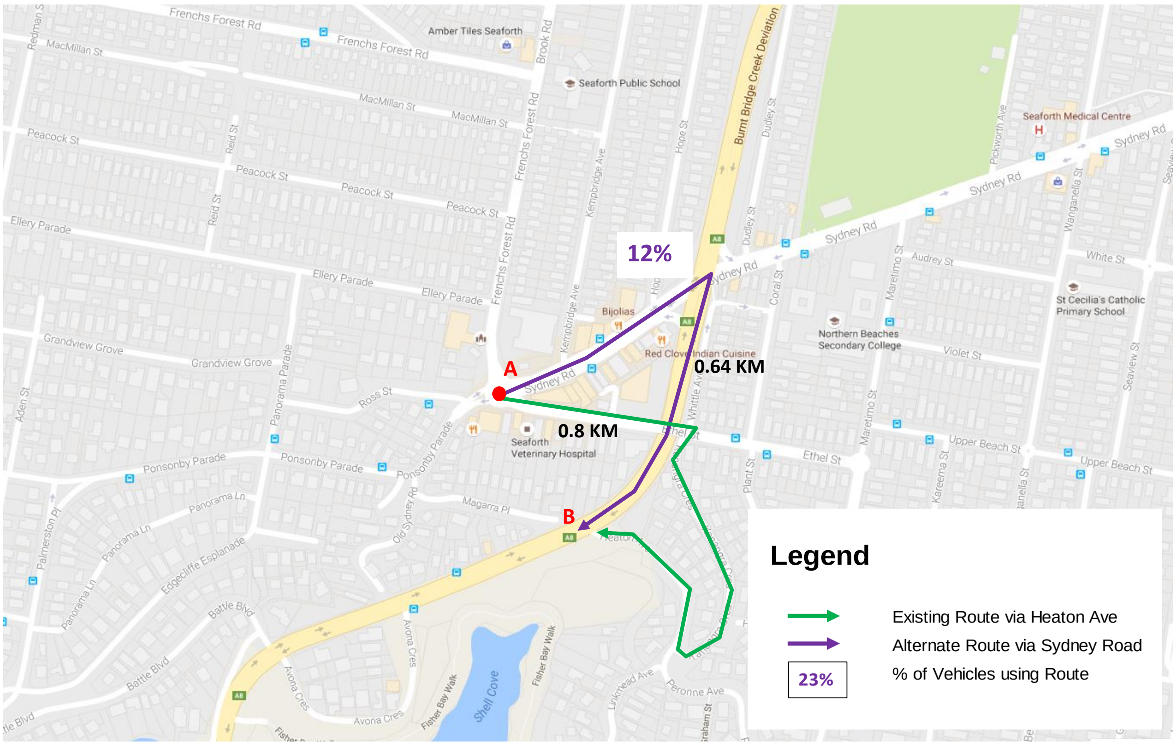


Figure 48 Diversion of affected Heaton Avenue traffic west of Manly Road



Background source: Google Maps

- 12% of affected Heaton Avenue traffic as shown in **Figure 48** are considered to be 'rat-runners' originating from areas west of Manly Road and will divert via Sydney Road west to access Manly Road southbound.
- A total of 52% of affected Heaton Avenue traffic (21% are 'rat-runners') as shown in **Figure 47** are presented with multiple alternative north-south routes along Sydney Road east between Maretimo Street and Condamine Street, to access Manly Road southbound.
- The remaining 36% (or 100 vehicles per hour) of traffic are considered to be most affected by the proposed closure of Heaton Avenue at Manly Road. 10% of traffic is likely generated from the residential properties along Peronnes Avenue, Amiens Road and the catchment near the Clontarf Reserve. These traffic could travel northbound along Beatrice Street to access Manly Road southbound. The remaining 26% (or 70 vehicles per hour) could travel along Ethel Street to Manly Road via either Sydney Road east or west.

Under the above assumptions, additional traffic volumes re-routing through the moderately congested Sydney Road / Ethel Street roundabout from the eastern catchment are conservatively estimated to be 35 to 50 vehicles per hour. Such increase in traffic demands are likely manageable, with careful planning of local area traffic management measures (e.g. local signage to encourage use of Sydney Road east) and support from the Council. Based on the above assessment significant traffic issues associated with the diversion of traffic on local roads are not anticipated at this stage. However, an increase of journey time due to the proposed diversion is expected particularly for local traffic near the Clontarf Reserve.

It is also concluded that Scenario 1 adopted in both the SIDRA and Commuter microsimulation modellings provides a conservative and adequate estimation of the potential traffic impact in line with the O-D survey (i.e. the vast majority of displaced Heaton Avenue traffic originates east of Manly Road).

5.4.8 Summary of Sydney Road and Heaton Avenue assessment

Summary of key findings for the Heaton Avenue Assessment is highlighted as follows:

- Bus travel times in the AM peak are forecast to reduce by approximately 1.5 minutes (<u>29% as per Commuter modelling Scenario 1</u>) in the southbound direction for the section between Sydney Road and Parriwi Road, which is a significant improvement. This is primarily resulted from the closure of Heaton Avenue which also enables the provision of an indented bus bay for southbound buses.

- In the PM peak hour, bus travel times are fairly consistent between the base and option scenarios, primarily due to the downstream constraint at the Spit Bridge allowing only one southbound traffic lane in this time period.
- Overall, the traffic assessment based on both the SIDRA and Commuter microsimulation modellings indicate that the proposed B-Line upgrades at the Sydney Road intersection would satisfactorily mitigate the traffic impacts arising from the proposed closure of Heaton Avenue under both the existing and future forecast conditions.
- The proposed diversion of Heaton Avenue traffic is not anticipated to cause significant traffic issues in the local road network provided careful planning of traffic management measures are in place. However, increased journey times to a varying degree will be experienced for local traffic travelling from the Clontarf and Balgowlah areas.
- There are also potential benefits in reducing crash rates by eliminating the conflicting movement of traffic exiting Heaton Avenue from mainline buses or other road users including cyclists.

Details of intersection LOS and travel time outputs from the Commuter modelling are provided in **Appendix F**.

6.0 Future transport provision

This section of the report provides a qualitative assessment on potential impacts of the proposal with respect to active and public transport amenities, parking provision and construction traffic conditions.

6.1 Walking and cycling

As part of the business case for the B-Line program[1] a significant amount of analysis and option planning was undertaken to identify ways in which the access to the B-Line service could be improved for pedestrians and cyclists. The geographic scope for improvement was defined for areas within an 800 metres walking and 2.5 kilometre cycling catchment; with a focus on the key urban centres of Brookvale, Dee Why, Neutral Bay and Spit Junction. A summary of the proposed upgrades for active transport (as outlined in the business case) is provided in **Figure 49**.

Figure 49 Proposed upgrades for active transport as part of the B-Line program

Scope element	Description
Pedestrian	
Upgrade or installation of new kerbside ramp	Inclined section of an access way, generally at road crossing to assist safe and accessible crossing. It has a gradient ramp and flare on both sides to transition the footpath/ sidewalk level. It may also include tactile indicators.
Kerb extension	Used for traffic calming measure, primarily to extend the sidewalk, reducing the crossing distance and allowing pedestrians and allowing pedestrians and drivers to see each other.
Personal security	Defined as areas with lack of passive or active surveillance and adequate lighting. It also considers graffiti, presence of rubbish that creates perceptions of a lack of security in a public area. The recommendations include removal of graffiti, provision of additional bins, CCTV and signage, additional lighting facilities and/or improvements to lighting quality.
Pedestrian refuse	Defined as a small area of a pavement / sidewalk completely surrounded by asphalt or other road materials where pedestrians can stop before crossing a road. Locations have been identified where the kerb width was too narrow or length was too short
Zebra crossing	Defined as a crossing location on a road that gives priority to pedestrians or cyclists to cross the road. The recommendations for improvement include measures such as providing new line marking, new or upgraded zebra crossings, kerb extensions or installation/removal of signage.
Signalised pedestrian crossing	Defined as providing signalised crossings for pedestrian with green light signal priority to cross the street at both intersections and mid-blocks. Recommendations include providing audio indicators, installing / moving signage, investigating provision of pedestrian crossing facilities on missing legs and widening the crossing line marking to 3.3m (where applicable).
Addressing path obstruction or bike / ped conflict	The obstructions can be street furniture, vegetation, bins and others. The bike / ped conflicts are pinch points where shared path facility is not wide enough for both to move and overtake.
Addressing difficulties in crossing roads	These are defined as dangerous crossing points for pedestrians because they lack facilities and impede their ability to cross safely. This includes driveway and other pedestrian and vehicle conflict locations. Recommendations include warning equipment and mirrors.
Cycling	
Addressing difficulties in crossing roads	Defined as existing infrastructures where defects, in terms of cyclist safety and lack of amenity, have been identified. These defects include lack of clear signage, conflict potential, missing bike lane, road / street approach angle, pedestrian refuge not compliant and lack of separation from vehicles at intersections. The recommendations to rectify these defects include signage, bike lanterns at intersections, wider staging points and vehicle warning signage, separate facility at

[1] Details provided in the February 2016 TfNSW report '*Northern Beaches B-Line Program Final Business Case*'.

	intersection and new pedestrian refuges.
Improving merge and/ or termination points	Defined as merging facilities for cyclists where a shared path ends and bicycle riders are required to move onto the road to continue their journey. The specific defects identified include lack of warning signs, lack of clear path connections, lack of bicycle priority for merging and lack of guiding road markings. The recommendations include new signage / markings.
Addressing conflict and obstructions	Defined as areas where there are pinch points along the bicycle routes that impact rider safety and convenience. These potential hazards include lack of sight distance to / from driveway, parked car conflict, on road bicycle lane in car door zones, pedestrian and bicycle conflict points and lack of signage. The recommendations to rectify these defects include convex mirrors, buffers between parked car and bike lanes, removal or reconfiguration of parking and new bike lanes.
Improving cyclist comfort	Improving cyclist rider comfort is defined as providing a better environment for cyclists. This includes better separating car and bike movements and implementing parking facilities for riders.
New or upgraded kerb ramps	Inclined section of an access way, generally at road crossings, to assist with safe and accessible crossings. It has a gradient ramp and flare on both sides to transition to the footpath/ sidewalk level. It may also include tactile indicators. Identified location includes kerb ramps that need to be upgraded or where ramps are required.

Source: TfNSW 2016

The measures outlined in **Figure 49** will address the objectives of the B-Line program by improving access to B-Line stops with associated commuter car parks; and by improving active transport connections at selected stops not associated with commuter car parks. It is anticipated that the proposals for active transport will achieve the following key benefits:

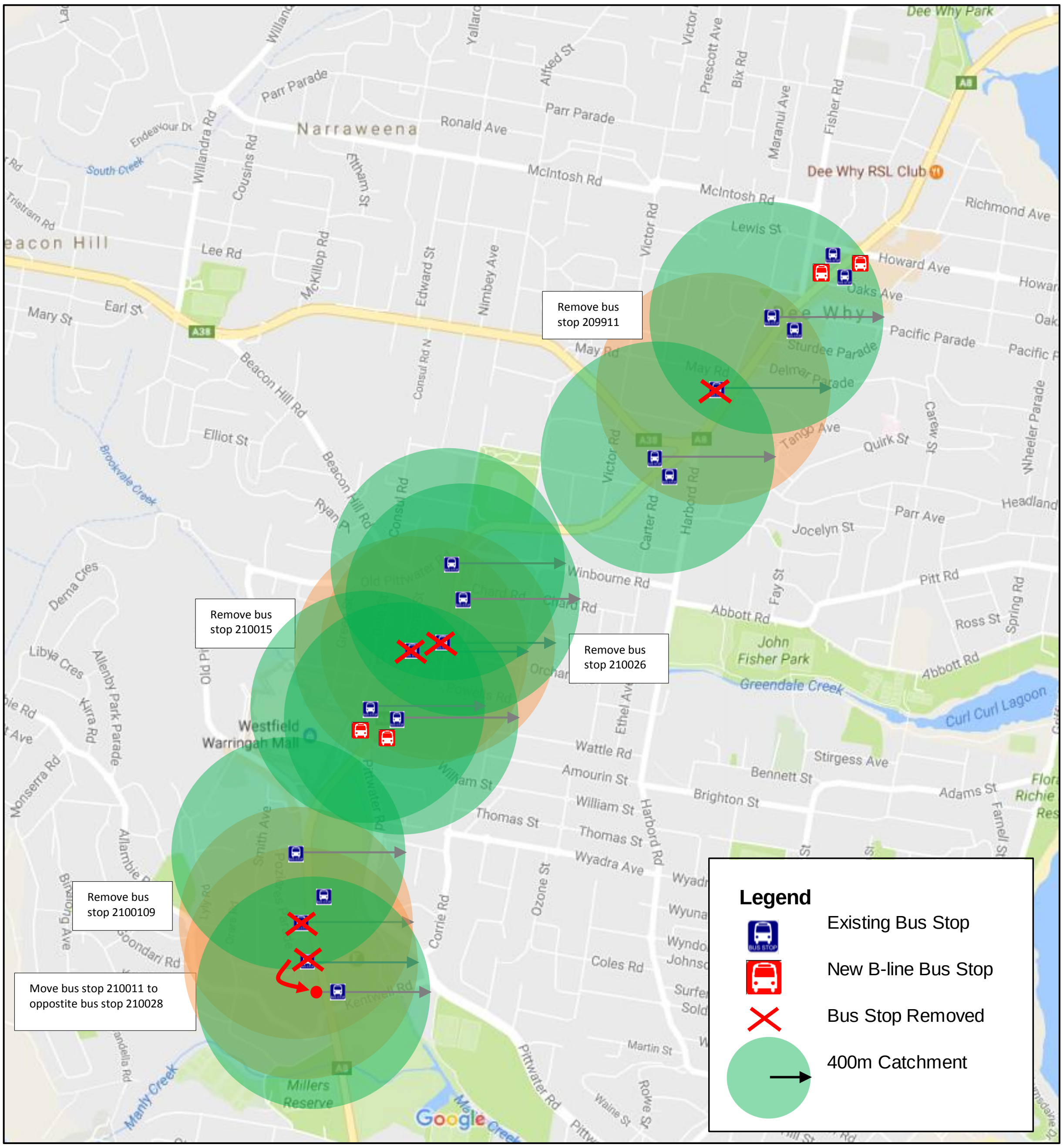
- B-Line bus stops will have improved walking and cycling connections.
- More passengers will use commuter parking, active transport links and local bus services to access the B-Line.
- All B-Line interchanges will be located at or near key customer activity centres and major road intersections to maximise access and network utility.

6.2 Public transport

The B-Line program proposes the removal and consolidation of up to five existing bus stops within the study extent of the P8 and P9 work packages (refer to **Table 2** for details). It is anticipated that a separate body of work in conjunction with work package C3 will provide further details once the proposed future bus network is finalised. Notwithstanding the above, **Figure 50** shows the locations of the proposed removal and remaining existing bus stops within a 400 metre walking catchment to provide an understanding on the adequacy of the bus stop provision. The figure also shows the proposed locations of new B-Line stops.

A review of the walking catchment indicates that there are existing bus stops within the vicinity of the proposed bus stop removals to provide an adequate coverage within the desirable walking distance of 400 metres. In addition, the likely benefits of the new B-Line stops with 'turn-up-and-go' services and the associated off-road improvements are anticipated to outweigh the inconvenience of the existing bus stop removals.

Figure 50 Bus stop catchment of B-Line proposal



6.3 Parking provision

The B-Line proposal of the implementation of clearway restrictions are currently included as part of the C2 work package of the B-Line program. A separate body of works, including the *Northern Beaches B-Line Offset Parking Assessment* commissioned by Transport for NSW, is anticipated to provide a detailed assessment of the associated impacts. As such, detailed analysis is not considered to be part of the scope of this traffic and transport assessment. Nevertheless, a brief overview of the key findings of the forgoing study is discussed in the following sections to provide a holistic understanding of the proposal.

Dee Why

At a strategic level, the B-Line program proposes clearways from 6am-8pm, Monday to Sunday for majority of the P8 corridor between South Creek Road to the north, and Warringah Road to the south. With the exception of a length of weekday clearway (6-10am and 3-8pm) on both sides of Pittwater Road, near May Road to the north of the Warringah Road intersection (refer to **Figure 4** for details).

The detailed analysis of the *Northern Beaches B-Line Offset Parking Assessment* assessed the availability of parking spaces at nearby side streets within reasonable walking distances as offsets for the loss of parking due to the proposal. It has been inferred from the study that the majority of the sections within the P8 corridor will have sufficient vacancies where impacts of the proposal are not considered to be significant, with the exception of the following:

- Eastern side of Pittwater Road from Fisher Road to the Botanic Garden south of Delmar Parade.
- Western side of Pittwater Road from Kingsway to Hawkesbury Avenue.

A part of the recommendations, the study suggests signage changes to convert some unrestricted parking spaces on side streets, such as Kingsway Avenue and Westminster Avenue, to short term parking. Additional off-street parking is also recommended to offset the losses on the eastern side of Pittwater Road.

Brookvale

Similar to the above, the B-Line program proposes a combination of clearway policies for the P9 corridor (refer to **Figure 4** for details). A maximum of 104 (19 inbound and 85 outbound) parking spaces are likely to be impacted by the 6am-8pm, Monday to Sunday clearway proposal; and 73 outbound parking spaces to be impacted by the 3-8pm (extension of one hour from the existing clearway), Monday to Friday clearway proposal.

The study suggests that the overall parking impacts associated with the loss of parking are significantly reduced due to the 'peak hour' only proposal in high demand areas such as the Brookvale and Manly Vale commercial centres.

It is also important to note that offset parking facilities along the corridor at critical locations are being investigated and will be assessed in the relevant work package and subject to community consultation to arrive at an optimum solution as part of the B-Line program. Therefore, it is anticipated that the effects of the proposal on parking will be managed to an acceptable level of impacts.

6.4 Construction traffic impacts

6.4.1 Overview

A construction traffic impact assessment has been undertaken to obtain an understanding of the likely impacts from construction scheduling and sequencing. The construction period of the proposed B-Line road infrastructure works for P8 and P9 work packages is expected to be completed by October 2017.

6.4.2 Proposed working hours

The construction workforce would vary depending on the phase of construction and associated activities and includes both construction and design personnel. An on-site workforce of around 10 to 20 people is expected to be engaged at any given time during the construction period, with a maximum of 50 workers per day during peak construction periods.

Night works are proposed for majority of the construction to minimise disruption to traffic. Night work and normal working hours are assumed to be as follows:

- Night works Monday to Friday: between 10pm-7am.
- Monday to Friday: between 7am-6pm.
- Saturday: between 8am-1pm.
- Sunday and public holidays: no work.

It is considered necessary to undertake night works to minimise disruption to traffic. Further appraisals would be undertaken once the detailed design stage is undertaken and the requirements are known. All night work would be undertaken in accordance with the *Office of Environment and Heritage (formerly DECCW) Interim Construction Noise Guideline (DECC 2009)* and the *Roads and Maritime Services Environmental Noise Management Manual (RTA 2001): Practice Note vii – Road works outside normal working hours*.

Prior notice would be given to the community for any night works planned to be undertaken outside normal construction hours.

6.4.3 Construction vehicles

Heavy vehicles generation

Heavy vehicle traffic would mainly be generated by activities associated with the following:

- Delivery of construction materials.
- Spoil removal.
- Delivery and removal of construction equipment and machinery.
- Movement of construction personnel, including contractors, site labour force and specialist supervisory personnel.

Approximately 5 heavy vehicles would be required on-site per day, resulting in approximately 20 heavy vehicles movements in and out of the site per day. These heavy vehicle movements are likely to be spread through the night work time period. However for a worst case assessment of the traffic impacts, it has been assumed that 10 per cent, or 2 vehicle movements would occur during the peak hour.

Construction vehicles would access the site via arterial roads wherever possible. However, given that these roads already carry high volumes of traffic it is not anticipated that the project would have a high degree of impact above what is currently experienced, as this additional construction traffic would be well within the range of daily variation in traffic on these routes.

As a part of the construction management plan it is expected that heavy vehicle traffic would be constrained, as much as possible, to the regional road network and that the impact on local roads would be minimised. Any disruption to access side streets and properties would be minimised and would only be undertaken following consultation with the community and with individual property owners affected by the works.

The movement of materials would be managed through the scheduling of deliveries and availability of fleet, and would aim to minimise the number of haulage and delivery vehicles required during peak periods and weekends.

Light vehicles generation

Light vehicle traffic generation would be associated with staff movements to the site. Staff would comprise of project managers, various trades, and general construction staff. Light vehicles used to transport staff to and from the site would be parked at the main site compound facility or nearby local streets.

Over the construction period, the peak construction workforce is estimated to be around 20 people. Similarly, the worst case scenario in terms of vehicle movement impact during the morning or evening road network peaks is assessed to provide a conservative assessment. It is assumed that the majority of the workforce would arrive between 6.30-7.00am and depart generally between 5.00-5.30pm. The workforce arrival and departure periods represent the worst case scenario with peak construction traffic generation occurring within the existing road network peak periods.

Allowing for some vehicle sharing, it is expected that up to 18 daily two-way trips (assuming 1.1 people per vehicle) would be generated by light vehicles during the peak period. Taking a conservative approach, it is expected that up to 18 vehicle movements would be generated during each of the morning and afternoon construction peak arrival and departure periods. During the construction traffic peak periods, the workforce traffic movements are likely to be distributed based on a 100/0 arrival and departure split in the morning peak period, and the reverse during the afternoon peak period.

Based on the above traffic generation assumptions, construction traffic is likely to result in increases of up to 18 vehicles per hour in the morning and evening peak periods under the worst case scenario, which is still well within the daily variation traffic on the road network within the study area.

It is also important to note that majority of the construction is proposed to be night works, where the impacts will be even less significant given the ample amount of road capacity during the night working hours between 10pm-7am.

6.4.4 Cumulative construction impacts

Cumulative impacts for the construction of other planned infrastructure in the area may also result in traffic impacts to the B-Line corridor. Construction of these infrastructure may also occur at the same time as the construction of the proposed Pittwater Road upgrade. These potentially include the following developments:

- B-Line infrastructure road program south of Spit Bridge (P12 work package)
- Bus stop removal and construction of B-Line shelter and stops (C3 work package)
- Pittwater Road / Condamine Street / William Street pedestrian footbridge (Health Infrastructure).
- Northern Beaches Hospital Road Upgrade.

The majority of the above work packages involve off-road developments, with the exception of the P12 work package and the Northern Beaches Hospital Road Upgrade. These proposed works are spread across the entire Northern Beaches area with separate assessments being developed. Notwithstanding the above, it is recommended to adopt a coordinated and collaborative approach for all B-line packages and the nearby Northern Beaches Hospital Upgrade works within an integrated construction control group to assess and manage the overall impacts through the implementation of a detailed construction traffic management plan.

6.4.5 Construction mitigation measures

The following proposed traffic management principles would be adopted during the construction period:

- Traffic control would need to be provided to manage and regulate traffic movements during construction.
- Disruption to all road users during the construction period would be kept to a minimum.
- In most cases property access would be maintained throughout the construction period with suitable alternative access arrangements provided otherwise.
- Construction and delivery vehicles entering or leaving the site compound and/or stockpile sites would use arterial roads. These movements would be restricted to non-peak traffic periods.
- Development of a detailed construction traffic management plan is recommended as part of the detailed design stage.

6.4.6 Summary of construction traffic generation

The majority of the construction works are proposed to be undertaken as night works. Nevertheless, construction traffic impacts are developed in the forgoing sections for normal work hours as a worst case assessment.

Under the worst case scenario, up to 20 truck movements per day is estimated during the earth moving phase. The majority of these truck movements would take place outside the road network peak periods, with approximately 2 trucks per hour occurring in the peak hours as a conservative assumption.

Worker traffic is assumed to generate 18 inbound and outbound light vehicle trips during each peak period. The majority of these trips are assumed to occur at the start (6.30-7.00am) or end of the day (5.00-5.30pm). The overall construction generation of traffic is considered to be well within the daily variation of road network demands. In addition, given the majority of construction is proposed to be night works, the actual impacts will be even less significant given the ample amount of road capacity available during the night working hours between 10pm-7am.

Based on this assessment, it is concluded that construction of the Proposal in not likely to have a significant impact on the road network in the study area.

7.0 Summary and conclusion

7.1 Overview

The purpose of this study is to assess the traffic and transport impacts on the operation and construction of the Northern Beaches B-Line On-Road Infrastructure Program for the Dee Why (P8) and Brookvale (P9) areas of the B-Line corridor. It is acknowledged that the need for the proposal along the corridor is focused around providing improvements to the existing and proposed B-Line bus services in terms of efficiency and reliability.

7.2 Key findings

The key findings based on evidenced-based analysis, traffic modelling and qualitative assessments are summarised as follows for the B-line proposal:

- Intersection performance measures (LOS) with the proposal indicate that majority of the key intersections along the Pittwater Road corridor are not expected to deteriorate, when compared with the Do-nothing 2021 scenario in all modelled peak periods. Most intersections are expected to operate at LoS D or better, except the Pittwater Road / Warringah Road / Harbord and Pittwater Road / Winbourne Road / Old Pittwater Road intersections. These two intersections are currently operating at close to capacity during the existing PM and Saturday peaks.
- The Pittwater Road / Winbourne Road / Old Pittwater intersection in 2021 PM peak with the proposed B-Line upgrades implemented is the only intersection with worsening performance when compared to the 2021 Do-nothing scenario (from LOS E to LOS F). A review of the corridor volumes indicates that in the Option scenario, there is an increase in northbound throughput (peak direction) at the Cross Street intersection of around 100 vehicles per hour (likely due to the implementation of the dedicated left turn pocket). The additional throughput increases delay along the already congested section of the corridor between Cross Street and Winbourne Road, which is sensitive to additional demands, leading to the deterioration in LOS at the Winbourne Road intersection.
- In the Brookvale and Dee Why areas, travel time savings for buses are most pronounced in the southbound direction in the AM peak period, and for both directions during the Saturday peak. For local and B-Line buses, between one and three minutes of travel time savings are expected respectively for the weekday morning and Saturday peaks. B-Line buses are generally operating with lower journey time when compared with local buses ranging from 30 seconds to one minute in those two peak periods.
- There are no significant travel time savings observed for buses in the northbound peak direction in the PM peak. This is generally as expected given that there is no targeted bus improvement measures on the western side of the carriageway instigated in the PM peak.
- Global network statistics also indicates that the average network speed for a minimum could be maintained for all three peak study periods in 2021 with the B-Line proposal. This suggests that the B-Line proposal not only provides travel time benefits to buses, but also maintaining a similar level of overall network performance. In other words, the proposal's focus on bus related improvement measures is not anticipated to have any adverse impact to other traffic and road users.
- The above travel time and network performance improvements are partly due to the increased capacity resulting from the proposed clearways. This is further enhanced by targeted bus improvement measures such as the provision of indented bus bay south of Hawkesbury Avenue, and the local widening of the southbound carriageway at approach near Howard and Oaks Avenues.
- The proposed closure of Heaton Avenue and implementation of the southbound indented bay are shown to provide bus travel time savings in the AM peak by approximately 1.5 minutes in the southbound direction for the section between Sydney Road and Parriwi Road.
- The SIDRA and Commuter microsimulation modellings for Heaton Avenue also suggest that the proposed intersection upgrades at the Sydney Road / Burnt Bridge Creek Deviation / Manly Road intersection could mitigate the impacts of the diverted traffic in both the AM and PM peak periods.

Appendix A

Intersection Levels of Service (Vissim)

Appendix A

2016 Base Year Intersection Levels of Service

2016 – AM Peak Period		07:00 to 08:00			08:00 to 09:00		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1796	18.2	B	2191	20.6	B
	East - Hawkesbury Avenue	141	50.2	D	137	198.3	F
	South - Pittwater Road	932	9.3	A	1061	6.1	A
	West - Hawkesbury Avenue	106	42.6	D	222	104.2	F
	Intersection	**2975**	**17.8**	**B**	**3611**	**28.2**	**C**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1524	25.9	B	1749	21.8	B
	East - Dee-Why Parade	304	49.1	D	369	59.3	E
	South - Pittwater Road	744	12.1	A	836	2.0	A
	Intersection	**2572**	**24.7**	**B**	**2954**	**20.9**	**B**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1390	14.1	B	1607	21.4	B
	East - Howard Avenue	220	43.2	D	234	50.9	D
	South - Pittwater Road	733	9.1	A	821	29.7	C
	West - St David Avenue	161	43.6	D	229	51.6	D
	Intersection	**2504**	**17.1**	**B**	**2891**	**28.5**	**C**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1386	13.6	A	1627	23.4	B
	East - Oakes Avenue	105	60.8	E	96	109.6	F
	South - Pittwater Road	867	3.0	A	948	4.9	A
	Intersection	**2358**	**11.8**	**A**	**2671**	**19.9**	**B**
Pittwater Road / Fisher Road	North - Pittwater Road	1415	9.9	A	1661	22.4	B
	South - Pittwater Road	1107	8.8	A	1326	8.6	A
	West - Fisher Road	477	51.8	D	435	139.3	F
	Intersection	**2999**	**16.2**	**B**	**3422**	**31.9**	**C**
Pittwater Road / Pacific Parade	North - Pittwater Road	1842	4.6	A	2052	9.8	A
	East - Pacific Parade	244	111.9	F	317	83.7	F
	South - Pittwater Road	1043	20.8	B	1202	37.6	C
	Intersection	**3129**	**18.4**	**B**	**3571**	**25.7**	**B**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1925	9.4	A	2110	10.8	A
	East - Sturdee Parade	308	57.3	E	314	79.7	F
	South - Pittwater Road	1030	4.4	A	1223	9.8	A
	Intersection	**3263**	**12.3**	**A**	**3647**	**16.4**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	2124	0.5	A	2282	1.4	A
	East - Delmar Parade	12	18.5	B	12	26.1	B
	South - Pittwater Road	1059	4.0	A	1283	3.9	A
	Intersection	**3195**	**26.5**	**B**	**3577**	**33.9**	**C**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	2048	44.6	D	2306	44.7	D
	East - Harbord Road	634	55.7	D	656	77.7	F
	South - Pittwater Road	1047	30.8	C	1300	29.2	C
	West - Warringah Road	797	51.5	D	942	65.1	E
	Intersection	**4526**	**44.2**	**D**	**5204**	**48.7**	**D**
Pittwater Road / Victor Road	North - Victor Road	6	3.4	A	16	3.4	A
	East - Pittwater Road	1672	11.0	A	1880	11.6	A
	West - Pittwater Road	1118	2.3	A	1340	2.3	A
	Intersection	**2796**	**16.9**	**B**	**3236**	**13.1**	**A**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	147	52.1	D	168	53.7	D
	East - Pittwater Road	1612	23.0	B	1764	24.4	B
	South - Mitchell Road	150	47.2	D	266	51.4	D
	West - Pittwater Road	1009	4.9	A	1123	5.5	A
	Intersection	**2918**	**19.5**	**B**	**3321**	**21.6**	**B**
Pittwater	North - Pittwater Road	1553	13.0	A	1731	22.6	B

Road / Winbourne Road	East - Winbourne Road	207	41.9	C	345	38.1	C
	South - Pittwater Road	829	32.8	C	934	35.1	C
	West - Winbourne Road	319	40.4	C	332	38.5	C
	Intersection	**2908**	**23.7**	**B**	**3342**	**29.3**	**C**
Pittwater Road / Sydenham Road	North - Pittwater Road	1508	7.1	A	1667	6.6	A
	East - Sydenham Road	91	42.2	D	130	48.2	D
	South - Pittwater Road	1046	6.4	A	1267	8.6	A
	Intersection	**2645**	**8.0**	**A**	**3064**	**9.2**	**A**
Pittwater Road / Orchard Road	North - Pittwater Road	1570	2.7	A	1784	2.6	A
	East - Orchard Road	107	7.0	A	179	13.4	A
	South - Pittwater Road	1186	5.0	A	1440	8.5	A
	Intersection	**2863**	**21.5**	**B**	**3403**	**38.4**	**C**
Pittwater Road / Cross Street	North - Pittwater Road	1583	18.1	B	1859	22.6	B
	South - Pittwater Road	1150	23.9	B	1434	20.6	B
	West - Cross Street	228	44.4	D	346	52.8	D
	Intersection	**2961**	**22.4**	**B**	**3639**	**24.7**	**B**
Pittwater Road / Condamine Road	North - Pittwater Road	1555	33.1	C	1705	41.9	C
	East - Condamine Road	446	43.0	D	592	44.1	D
	South - Pittwater Road	927	21.6	B	1169	26.1	B
	Intersection	**2928**	**30.9**	**C**	**3466**	**37.0**	**C**

2016 - PM Peak Period		16:30 to 17:30			17:30 to 18:30		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1421	18.8	B	1324	19.1	B
	East - Hawkesbury Avenue	311	99.7	F	263	101.6	F
	South - Pittwater Road	1783	4.5	A	1724	10.1	A
	West - Hawkesbury Avenue	200	46.1	D	205	51.8	D
	Intersection	**3715**	**20.2**	**B**	**3516**	**22.8**	**B**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1207	4.2	A	1131	5.5	A
	East - Dee-Why Parade	373	47.7	D	389	52.5	D
	South - Pittwater Road	1639	7.1	A	1566	20.9	B
	Intersection	**3219**	**10.7**	**A**	**3086**	**19.2**	**B**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1127	14.1	B	1040	22.8	B
	East - Howard Avenue	307	41.5	C	297	46.5	D
	South - Pittwater Road	1559	4.5	A	1485	8.7	A
	West - St David Avenue	298	43.2	D	292	47.7	D
	Intersection	**3291**	**14.8**	**B**	**3114**	**20.7**	**B**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1124	10.2	A	1040	3.7	A
	East - Oakes Avenue	181	55.5	D	147	55.6	D
	South - Pittwater Road	1745	1.8	A	1679	3.4	A
	Intersection	**3050**	**8.1**	**A**	**2866**	**6.2**	**A**
Pittwater Road / Fisher Road	North - Pittwater Road	1275	16.6	B	1139	10.2	A
	South - Pittwater Road	2224	1.5	A	2119	2.7	A
	West - Fisher Road	515	66.9	E	515	56.1	E
	Intersection	**4014**	**14.7**	**B**	**3773**	**12.2**	**A**
Pittwater Road / Pacific Parade	North - Pittwater Road	1728	6.7	A	1569	7.0	A
	East - Pacific Parade	407	97.4	F	382	225.7	F
	South - Pittwater Road	1868	11.0	A	1783	13.8	A
	Intersection	**4003**	**17.9**	**B**	**3734**	**32.6**	**C**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1598	10.2	A	1434	18.4	B
	East - Sturdee Parade	221	50.9	D	213	59.1	E
	South - Pittwater Road	1983	5.3	A	1925	9.4	A
	Intersection	**3802**	**10.0**	**A**	**3572**	**16.0**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	1683	0.3	A	1504	0.5	A
	East - Delmar Parade	16	11.0	A	20	13.3	A
	South - Pittwater Road	2010	2.4	A	1964	5.2	A
	Intersection	**3709**	**19.9**	**B**	**3488**	**28.4**	**C**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	1651	44.3	D	1545	41.5	C
	East - Harbord Road	820	79.7	F	813	70.4	F
	South - Pittwater Road	1825	66.6	E	1729	66.3	E
	West - Warringah Road	905	50.8	D	923	54.9	D
	Intersection	**5201**	**58.8**	**E**	**5010**	**57.2**	**E**
Pittwater Road / Victor Road	North - Victor Road	19	55.6	D	12	16.1	B
	East - Pittwater Road	1340	5.1	A	1173	4.8	A
	West - Pittwater Road	2154	31.5	C	1979	15.9	B
	Intersection	**3513**	**55.6**	**D**	**3164**	**21.5**	**B**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	177	66.1	E	118	59.4	E
	East - Pittwater Road	1326	17.0	B	1155	16.2	B
	South - Mitchell Road	398	130.2	F	337	90.7	F
	West - Pittwater Road	1872	26.2	B	1720	9.4	A
	Intersection	**3773**	**35.8**	**C**	**3330**	**21.8**	**B**
Pittwater Road / Winbourne Road	North - Pittwater Road	1270	17.8	B	1058	14.6	B
	East - Winbourne Road	360	36.6	C	241	31.4	C
	South - Pittwater Road	1468	111.3	F	1383	33.9	C
	West - Winbourne Road	539	59.5	E	501	35.4	C
	Intersection	**3637**	**63.6**	**E**	**3183**	**27.5**	**B**

Pittwater Road / Sydenham Road	North - Pittwater Road	1324	8.0	A	1066	8.2	A
	East - Sydenham Road	257	161.9	F	183	151.5	F
	South - Pittwater Road	1749	34.7	C	1612	5.2	A
	Intersection	**3330**	**33.9**	**C**	**2861**	**15.7**	**B**
Pittwater Road / Orchard Road	North - Pittwater Road	1556	3.0	A	1233	2.1	A
	East - Orchard Road	49	7.4	A	31	5.3	A
	South - Pittwater Road	1992	11.8	A	1862	6.5	A
	Intersection	**3597**	**25.0**	**B**	**3126**	**21.2**	**B**
Pittwater Road / Cross Street	North - Pittwater Road	1483	26.7	B	1140	33.7	C
	South - Pittwater Road	1604	41.1	C	1629	42.7	D
	West - Cross Street	690	85.4	F	283	46.1	D
	Intersection	**3777**	**43.5**	**D**	**3052**	**39.7**	**C**
Pittwater Road / Condamine Road	North - Pittwater Road	1610	24.5	B	1184	28.0	C
	East - Condamine Road	451	83.9	F	434	74.0	F
	South - Pittwater Road	1199	109.7	F	1279	152.9	F
	Intersection	**3260**	**64.1**	**E**	**2897**	**90.0**	**F**

2016 – Saturday Peak Period		11:30 to 12:30			12:30 to 13:30		
		Volume	**Delay**	**LOS**	**Volume**	**Delay**	**LOS**
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1747	25.8	B	1621	23.8	B
	East - Hawkesbury Avenue	334	76.8	F	297	71.6	F
	South - Pittwater Road	1303	12.0	A	1291	33.7	C
	West - Hawkesbury Avenue	193	48.1	D	124	46.0	D
	Intersection	**3577**	**26.8**	**B**	**3333**	**32.7**	**C**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1401	12.1	A	1325	24.5	B
	East - Dee-Why Parade	356	49.8	D	338	54.6	D
	South - Pittwater Road	1104	11.9	A	1077	2.2	A
	Intersection	**2861**	**16.7**	**B**	**2740**	**19.4**	**B**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1247	40.3	C	1192	45.4	D
	East - Howard Avenue	248	48.9	D	201	46.4	D
	South - Pittwater Road	1078	10.7	A	1084	14.2	B
	West - St David Avenue	237	48.1	D	248	50.3	D
	Intersection	**2810**	**30.3**	**C**	**2725**	**33.5**	**C**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1244	38.7	C	1203	37.8	C
	East - Oakes Avenue	150	52.4	D	146	54.7	D
	South - Pittwater Road	1267	17.6	B	1274	16.4	B
	Intersection	**2661**	**29.4**	**C**	**2623**	**28.4**	**C**
Pittwater Road / Fisher Road	North - Pittwater Road	1332	16.5	B	1298	19.6	B
	South - Pittwater Road	1729	15.0	B	1751	16.8	B
	West - Fisher Road	377	66.5	E	392	97.0	F
	Intersection	**3438**	**21.2**	**B**	**3441**	**27.0**	**B**
Pittwater Road / Pacific Parade	North - Pittwater Road	1661	8.1	A	1650	9.4	A
	East - Pacific Parade	314	64.4	E	277	66.4	E
	South - Pittwater Road	1512	31.8	C	1575	37.7	C
	Intersection	**3487**	**23.4**	**B**	**3502**	**26.6**	**B**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1669	14.0	B	1650	13.7	A
	East - Sturdee Parade	316	59.2	E	312	64.4	E
	South - Pittwater Road	1713	11.2	A	1740	16.0	B
	Intersection	**3698**	**16.6**	**B**	**3702**	**19.1**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	1898	0.5	A	1875	0.5	A
	East - Delmar Parade	40	16.3	B	40	25.2	B
	South - Pittwater Road	1731	4.0	A	1756	5.8	A
	Intersection	**3669**	**31.2**	**C**	**3671**	**55.9**	**D**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	1904	43.1	D	1888	36.1	C
	East - Harbord Road	752	250.4	F	779	283.1	F
	South - Pittwater Road	1642	49.3	D	1645	47.3	D
	West - Warringah Road	959	67.0	E	998	65.2	E
	Intersection	**5257**	**79.0**	**F**	**5310**	**81.3**	**F**
Pittwater Road / Victor Road	North - Victor Road	20	8.4	A	20	5.9	A
	East - Pittwater Road	1467	6.1	A	1453	5.7	A
	West - Pittwater Road	1756	5.2	A	1712	2.9	A
	Intersection	**3243**	**16.0**	**B**	**3185**	**16.0**	**B**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	136	56.0	E	140	55.3	D
	East - Pittwater Road	1426	15.3	B	1450	11.0	A
	South - Mitchell Road	338	61.8	E	363	63.2	E
	West - Pittwater Road	1570	4.1	A	1534	4.0	A
	Intersection	**3470**	**16.4**	**B**	**3487**	**15.1**	**B**
Pittwater Road / Winbourne Road	North - Pittwater Road	1514	19.7	B	1508	17.6	B
	East - Winbourne Road	340	47.1	D	351	45.8	D
	South - Pittwater Road	1379	43.7	D	1340	54.0	D
	West - Winbourne Road	469	84.7	F	438	74.9	F
	Intersection	**3702**	**39.4**	**C**	**3637**	**40.6**	**C**

Pittwater Road / Sydenham Road	North - Pittwater Road	1692	5.1	A	1652	7.3	A
	East - Sydenham Road	119	59.4	E	123	57.6	E
	South - Pittwater Road	1637	9.9	A	1536	6.3	A
	Intersection	**3448**	**9.3**	**A**	**3311**	**8.7**	**A**
Pittwater Road / Orchard Road	North - Pittwater Road	1756	4.4	A	1709	2.9	A
	East - Orchard Road	17	14.4	B	16	15.7	B
	South - Pittwater Road	1689	4.2	A	1592	2.3	A
	Intersection	**3462**	**29.9**	**C**	**3317**	**17.8**	**B**
Pittwater Road / Cross Street	North - Pittwater Road	1750	29.0	C	1689	23.6	B
	South - Pittwater Road	1631	20.8	B	1511	20.1	B
	West - Cross Street	535	107.1	F	550	86.5	F
	Intersection	**3916**	**36.3**	**C**	**3750**	**31.4**	**C**
Pittwater Road / Condamine Road	North - Pittwater Road	1626	24.7	B	1678	35.3	C
	East - Condamine Road	516	45.6	D	394	40.8	C
	South - Pittwater Road	1152	25.7	B	1156	25.0	B
	Intersection	**3294**	**28.3**	**C**	**3228**	**32.3**	**C**

2021 Do-nothing Intersection Levels of Service

2021 – AM Peak Period		07:00 to 08:00			08:00 to 09:00		
		Volume	**Delay**	**LOS**	**Volume**	**Delay**	**LOS**
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1903	19.1	B	2345	30.6	C
	East - Hawkesbury Avenue	148	49.5	D	137	187.7	F
	South - Pittwater Road	971	9.5	A	1094	6.6	A
	West - Hawkesbury Avenue	109	42.2	D	232	99.9	F
	Intersection	**3131**	**18.4**	**B**	**3808**	**33.6**	**C**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1611	27.8	B	1859	38.4	C
	East - Dee-Why Parade	319	49.1	D	386	58.8	E
	South - Pittwater Road	772	12.1	A	859	2.1	A
	Intersection	**2702**	**25.8**	**B**	**3104**	**30.9**	**C**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1468	14.1	B	1706	22.8	B
	East - Howard Avenue	226	42.1	D	242	53.1	D
	South - Pittwater Road	760	9.1	A	845	29.2	C
	West - St David Avenue	165	43.9	D	239	51.6	D
	Intersection	**2619**	**16.9**	**B**	**3032**	**29.3**	**C**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1457	14.5	B	1720	28.1	C
	East - Oakes Avenue	107	60.1	E	93	113.6	F
	South - Pittwater Road	897	3.5	A	972	5.2	A
	Intersection	**2461**	**12.5**	**A**	**2785**	**22.9**	**B**
Pittwater Road / Fisher Road	North - Pittwater Road	1487	10.9	A	1746	24.0	B
	South - Pittwater Road	1150	8.6	A	1368	8.4	A
	West - Fisher Road	494	55.7	D	425	208.1	F
	Intersection	**3131**	**17.1**	**B**	**3539**	**40.1**	**C**
Pittwater Road / Pacific Parade	North - Pittwater Road	1930	6.0	A	2132	10.6	A
	East - Pacific Parade	248	124.8	F	334	92.6	F
	South - Pittwater Road	1082	22.0	B	1238	37.4	C
	Intersection	**3260**	**20.3**	**B**	**3704**	**26.9**	**B**
Pittwater Road / Sturdee Parade	North - Pittwater Road	2010	9.6	A	2195	11.9	A
	East - Sturdee Parade	318	61.9	E	335	96.0	F
	South - Pittwater Road	1070	4.9	A	1251	11.7	A
	Intersection	**3398**	**13.0**	**A**	**3781**	**19.3**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	2214	0.8	A	2378	2.7	A
	East - Delmar Parade	12	16.7	B	12	25.3	B
	South - Pittwater Road	1101	4.1	A	1311	4.6	A
	Intersection	**3327**	**27.8**	**B**	**3701**	**31.9**	**C**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	2138	45.1	D	2402	49.6	D
	East - Harbord Road	654	56.9	E	684	82.9	F
	South - Pittwater Road	1073	32.0	C	1319	29.3	C
	West - Warringah Road	853	52.4	D	1007	67.9	E
	Intersection	**4718**	**45.1**	**D**	**5412**	**52.3**	**D**
Pittwater Road / Victor Road	North - Victor Road	6	1.9	A	16	4.6	A
	East - Pittwater Road	1745	11.1	A	1980	13.3	A
	West - Pittwater Road	1145	2.1	A	1359	2.7	A
	Intersection	**2896**	**15.8**	**B**	**3355**	**14.8**	**B**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	150	50.2	D	167	51.4	D
	East - Pittwater Road	1679	24.5	B	1862	25.5	B
	South - Mitchell Road	151	47.5	D	274	52.0	D
	West - Pittwater Road	1033	5.1	A	1137	5.5	A
	Intersection	**3013**	**20.3**	**B**	**3440**	**22.3**	**B**
Pittwater	North - Pittwater Road	1616	14.0	A	1819	23.2	B

Road / Winbourne Road	East - Winbourne Road	227	41.4	C	374	39.2	C
	South - Pittwater Road	857	32.9	C	949	35.9	C
	West - Winbourne Road	320	41.9	C	336	39.9	C
	Intersection	**3020**	**24.4**	**B**	**3478**	**30.0**	**C**
Pittwater Road / Sydenham Road	North - Pittwater Road	1555	6.9	A	1730	6.9	A
	East - Sydenham Road	93	45.4	D	141	45.3	D
	South - Pittwater Road	1087	6.2	A	1303	9.0	A
	Intersection	**2735**	**7.9**	**A**	**3174**	**9.4**	**A**
Pittwater Road / Orchard Road	North - Pittwater Road	1626	3.0	A	1852	2.9	A
	East - Orchard Road	12	13.6	A	24	20.7	B
	South - Pittwater Road	1237	5.4	A	1490	9.7	A
	Intersection	**2875**	**24.9**	**B**	**3366**	**44.9**	**D**
Pittwater Road / Cross Street	North - Pittwater Road	1647	18.8	B	1929	23.2	B
	South - Pittwater Road	1205	23.7	B	1505	21.5	B
	West - Cross Street	232	44.9	D	350	54.1	D
	Intersection	**3084**	**22.7**	**B**	**3784**	**25.4**	**B**
Pittwater Road / Condamine Road	North - Pittwater Road	1615	33.0	C	1752	41.8	C
	East - Condamine Road	472	43.6	D	625	45.9	D
	South - Pittwater Road	978	21.7	B	1237	26.8	B
	Intersection	**3065**	**31.0**	**C**	**3614**	**37.4**	**C**

2021 – PM Peak Period		16:30 to 17:30			17:30 to 18:30		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1446	19.0	B	1352	19.1	B
	East - Hawkesbury Avenue	314	126.0	F	282	130.5	F
	South - Pittwater Road	1847	4.5	A	1774	9.8	A
	West - Hawkesbury Avenue	207	45.7	D	212	53.6	D
	Intersection	**3814**	**22.2**	**B**	**3620**	**25.2**	**B**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1226	4.0	A	1161	5.8	A
	East - Dee-Why Parade	390	48.3	D	409	52.7	D
	South - Pittwater Road	1687	6.8	A	1612	20.4	B
	Intersection	**3303**	**10.7**	**A**	**3182**	**19.2**	**B**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1148	14.1	B	1071	21.9	B
	East - Howard Avenue	321	42.5	D	311	47.5	D
	South - Pittwater Road	1603	4.7	A	1521	9.1	A
	West - St David Avenue	312	43.8	D	303	48.6	D
	Intersection	**3384**	**15.1**	**B**	**3206**	**20.9**	**B**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1148	10.8	A	1072	3.8	A
	East - Oakes Avenue	182	55.9	D	147	58.6	E
	South - Pittwater Road	1793	1.9	A	1715	3.4	A
	Intersection	**3123**	**8.3**	**A**	**2934**	**6.3**	**A**
Pittwater Road / Fisher Road	North - Pittwater Road	1301	17.0	B	1171	10.9	A
	South - Pittwater Road	2289	1.6	A	2168	2.7	A
	West - Fisher Road	544	82.6	F	541	63.3	E
	Intersection	**4134**	**17.1**	**B**	**3880**	**13.6**	**A**
Pittwater Road / Pacific Parade	North - Pittwater Road	1778	6.7	A	1626	7.1	A
	East - Pacific Parade	420	162.9	F	382	283.8	F
	South - Pittwater Road	1923	11.5	A	1834	14.0	A
	Intersection	**4121**	**24.9**	**B**	**3842**	**37.9**	**C**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1646	10.4	A	1489	18.0	B
	East - Sturdee Parade	230	49.9	D	216	56.3	E
	South - Pittwater Road	2029	5.6	A	1972	9.9	A
	Intersection	**3905**	**10.2**	**A**	**3677**	**15.9**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	1730	0.3	A	1560	0.5	A
	East - Delmar Parade	16	16.1	B	20	10.1	A
	South - Pittwater Road	2051	2.3	A	2013	5.6	A
	Intersection	**3797**	**28.5**	**C**	**3593**	**22.8**	**B**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	1694	44.5	D	1604	42.3	D
	East - Harbord Road	856	99.3	F	855	79.4	F
	South - Pittwater Road	1838	65.9	E	1754	72.1	F
	West - Warringah Road	966	52.8	D	989	57.1	E
	Intersection	**5354**	**62.1**	**E**	**5202**	**61.3**	**E**
Pittwater Road / Victor Road	North - Victor Road	19	51.7	D	12	28.4	C
	East - Pittwater Road	1392	5.3	A	1222	4.7	A
	West - Pittwater Road	2171	30.6	C	2016	22.0	B
	Intersection	**3582**	**51.7**	**D**	**3250**	**28.4**	**C**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	179	64.4	E	118	61.2	E
	East - Pittwater Road	1380	17.1	B	1207	16.4	B
	South - Mitchell Road	408	127.8	F	358	113.9	F
	West - Pittwater Road	1881	25.3	B	1749	12.8	A
	Intersection	**3848**	**35.0**	**C**	**3432**	**26.3**	**B**
Pittwater Road / Winbourne	North - Pittwater Road	1318	18.2	B	1109	15.1	B
	East - Winbourne Road	397	36.9	C	260	32.1	C
	South - Pittwater Road	1455	112.9	F	1400	37.3	C

Road	West - Winbourne Road	567	61.5	E	524	36.9	C
	Intersection	**3737**	**63.6**	**E**	**3293**	**29.3**	**C**
Pittwater Road / Sydenham Road	North - Pittwater Road	1373	7.9	A	1105	8.8	A
	East - Sydenham Road	263	173.8	F	199	182.7	F
	South - Pittwater Road	1750	39.6	C	1624	5.4	A
	Intersection	**3386**	**37.2**	**C**	**2928**	**18.8**	**B**
Pittwater Road / Orchard Road	North - Pittwater Road	1610	3.1	A	1289	2.1	A
	East - Orchard Road	49	10.8	A	31	5.4	A
	South - Pittwater Road	1984	15.4	B	1873	7.1	A
	Intersection	**3643**	**31.0**	**C**	**3193**	**24.5**	**B**
Pittwater Road / Cross Street	North - Pittwater Road	1539	27.2	B	1190	34.6	C
	South - Pittwater Road	1583	46.6	D	1639	42.1	D
	West - Cross Street	716	98.8	F	296	44.3	D
	Intersection	**3838**	**48.5**	**D**	**3125**	**39.4**	**C**
Pittwater Road / Condamine Road	North - Pittwater Road	1667	24.8	B	1229	29.3	C
	East - Condamine Road	452	88.0	F	435	76.8	F
	South - Pittwater Road	1178	139.4	F	1290	150.6	F
	Intersection	**3297**	**74.4**	**F**	**2954**	**89.3**	**F**

2021 – Saturday Peak Period		11:30 to 12:30			12:30 to 13:30		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1803	28.0	C	1648	26.0	B
	East - Hawkesbury Avenue	349	93.1	F	311	77.7	F
	South - Pittwater Road	1349	12.2	A	1334	34.0	C
	West - Hawkesbury Avenue	200	47.3	D	129	45.8	D
	Intersection	**3701**	**29.4**	**C**	**3422**	**34.5**	**C**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1432	20.5	B	1369	54.5	D
	East - Dee-Why Parade	374	56.2	E	357	55.1	D
	South - Pittwater Road	1137	11.7	A	1111	2.3	A
	Intersection	**2943**	**21.7**	**B**	**2837**	**34.1**	**C**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1282	44.3	D	1236	65.6	E
	East - Howard Avenue	257	48.3	D	210	50.6	D
	South - Pittwater Road	1109	10.3	A	1116	14.0	B
	West - St David Avenue	246	47.8	D	260	52.8	D
	Intersection	**2894**	**31.9**	**C**	**2822**	**42.9**	**D**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1280	40.4	C	1247	46.7	D
	East - Oakes Avenue	154	53.0	D	150	55.9	D
	South - Pittwater Road	1293	17.6	B	1309	16.6	B
	Intersection	**2727**	**30.3**	**C**	**2706**	**32.7**	**C**
Pittwater Road / Fisher Road	North - Pittwater Road	1372	16.8	B	1345	20.0	B
	South - Pittwater Road	1763	15.8	B	1813	16.8	B
	West - Fisher Road	391	74.8	F	401	136.3	F
	Intersection	**3526**	**22.7**	**B**	**3559**	**31.5**	**C**
Pittwater Road / Pacific Parade	North - Pittwater Road	1712	8.4	A	1705	9.2	A
	East - Pacific Parade	329	67.7	E	289	66.4	E
	South - Pittwater Road	1538	34.5	C	1628	38.3	C
	Intersection	**3579**	**25.1**	**B**	**3622**	**26.9**	**B**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1725	14.5	B	1709	13.3	A
	East - Sturdee Parade	333	63.3	E	328	76.9	F
	South - Pittwater Road	1740	12.4	A	1798	16.4	B
	Intersection	**3798**	**17.8**	**B**	**3835**	**20.2**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	1968	0.4	A	1947	0.4	A
	East - Delmar Parade	41	18.2	B	40	27.1	B
	South - Pittwater Road	1756	4.1	A	1814	6.1	A
	Intersection	**3765**	**37.4**	**C**	**3801**	**59.4**	**E**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	1971	39.5	C	1960	35.1	C
	East - Harbord Road	750	264.5	F	799	305.7	F
	South - Pittwater Road	1663	50.2	D	1683	48.2	D
	West - Warringah Road	1028	72.5	F	1068	76.6	F
	Intersection	**5412**	**80.2**	**F**	**5510**	**86.4**	**F**
Pittwater Road / Victor Road	North - Victor Road	20	9.0	A	20	5.8	A
	East - Pittwater Road	1533	6.6	A	1531	5.6	A
	West - Pittwater Road	1792	5.4	A	1748	3.5	A
	Intersection	**3345**	**19.7**	**B**	**3299**	**21.2**	**B**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	136	56.7	E	140	57.5	E
	East - Pittwater Road	1493	15.4	B	1526	11.4	A
	South - Mitchell Road	349	60.9	E	378	75.2	F
	West - Pittwater Road	1612	4.1	A	1562	4.3	A
	Intersection	**3590**	**16.3**	**B**	**3606**	**16.8**	**B**
Pittwater Road / Winbourne Road	North - Pittwater Road	1589	20.2	B	1585	18.5	B
	East - Winbourne Road	375	47.2	D	382	48.5	D
	South - Pittwater Road	1418	44.8	D	1366	54.9	D
	West - Winbourne Road	508	136.3	F	461	104.6	F
	Intersection	**3890**	**46.9**	**D**	**3794**	**45.1**	**D**

Pittwater Road / Sydenham Road	North - Pittwater Road	1780	5.2	A	1734	7.6	A
	East - Sydenham Road	124	56.3	E	129	54.8	D
	South - Pittwater Road	1662	10.3	A	1571	6.7	A
	Intersection	**3566**	**9.3**	**A**	**3434**	**9.0**	**A**
Pittwater Road / Orchard Road	North - Pittwater Road	1852	6.3	A	1791	4.4	A
	East - Orchard Road	29	17.7	B	29	11.2	A
	South - Pittwater Road	1718	4.5	A	1623	2.6	A
	Intersection	**3599**	**35.0**	**C**	**3443**	**21.4**	**B**
Pittwater Road / Cross Street	North - Pittwater Road	1842	31.3	C	1774	25.3	B
	South - Pittwater Road	1681	21.7	B	1553	20.3	B
	West - Cross Street	544	132.9	F	572	135.7	F
	Intersection	**4067**	**40.9**	**C**	**3899**	**39.5**	**C**
Pittwater Road / Condamine Road	North - Pittwater Road	1684	26.0	B	1736	35.7	C
	East - Condamine Road	527	46.1	D	403	41.2	C
	South - Pittwater Road	1198	25.0	B	1201	26.0	B
	Intersection	**3409**	**28.8**	**C**	**3340**	**32.9**	**C**

2021 Option Intersection Levels of Service

2021 – Option AM Peak		07:00-08:00			08:00-09:00		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1924	19.4	B	2358	28.6	C
	East - Hawkesbury Avenue	149	44.9	D	184	139.0	F
	South - Pittwater Road	971	15.4	B	1087	7.8	A
	West - Hawkesbury Avenue	109	39.2	C	239	55.0	D
	Intersection	**3153**	**20.1**	**B**	**3868**	**29.6**	**C**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1628	25.6	B	1878	32.7	C
	East - Dee-Why Parade	320	49.5	D	386	59.3	E
	South - Pittwater Road	774	11.6	A	851	2.1	A
	Intersection	**2722**	**24.4**	**B**	**3115**	**27.6**	**B**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1486	15.6	B	1725	23.9	B
	East - Howard Avenue	226	42.4	D	243	54.1	D
	South - Pittwater Road	764	9.2	A	837	29.7	C
	West - St David Avenue	165	45.6	D	238	60.0	E
	Intersection	**2641**	**17.9**	**B**	**3043**	**30.7**	**C**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1464	16.9	B	1742	29.4	C
	East - Oakes Avenue	105	62.2	E	94	114.1	F
	South - Pittwater Road	900	3.4	A	964	5.1	A
	Intersection	**2469**	**13.9**	**A**	**2800**	**23.9**	**B**
Pittwater Road / Fisher Road	North - Pittwater Road	1493	11.1	A	1769	15.7	B
	South - Pittwater Road	1151	10.5	A	1345	13.4	A
	West - Fisher Road	490	57.9	E	419	239.6	F
	Intersection	**3134**	**18.2**	**B**	**3533**	**41.4**	**C**
Pittwater Road / Pacific Parade	North - Pittwater Road	1931	6.5	A	2154	6.7	A
	East - Pacific Parade	253	114.7	F	326	132.3	F
	South - Pittwater Road	1087	20.3	B	1217	48.8	D
	Intersection	**3271**	**19.4**	**B**	**3697**	**31.7**	**C**
Pittwater Road / Sturdee Parade	North - Pittwater Road	2016	9.6	A	2228	11.9	A
	East - Sturdee Parade	313	78.5	F	320	162.3	F
	South - Pittwater Road	1070	4.7	A	1252	14.0	A
	Intersection	**3399**	**14.4**	**B**	**3800**	**25.2**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	2214	0.5	A	2393	2.5	A
	East - Delmar Parade	12	16.8	B	12	19.6	B
	South - Pittwater Road	1100	2.7	A	1309	3.6	A
	Intersection	**3326**	**27.0**	**B**	**3714**	**26.2**	**B**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	2143	45.4	D	2401	52.1	D
	East - Harbord Road	653	56.0	D	677	85.8	F
	South - Pittwater Road	1075	31.2	C	1318	29.9	C
	West - Warringah Road	854	52.8	D	1007	67.7	E
	Intersection	**4725**	**45.0**	**D**	**5403**	**53.8**	**D**
Pittwater Road / Victor Road	North - Victor Road	6	0.9	A	16	0.6	A
	East - Pittwater Road	1762	12.0	A	1978	13.2	A
	West - Pittwater Road	1146	0.9	A	1362	1.0	A
	Intersection	**2914**	**14.1**	**B**	**3356**	**16.8**	**B**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	149	50.0	D	167	51.5	D
	East - Pittwater Road	1692	26.2	B	1867	25.8	B
	South - Mitchell Road	151	46.9	D	272	51.9	D
	West - Pittwater Road	1031	5.2	A	1141	5.5	A
	Intersection	**3023**	**21.2**	**B**	**3447**	**22.4**	**B**
Pittwater Road /	North - Pittwater Road	1631	13.9	A	1823	22.0	B
	East - Winbourne Road	227	42.1	D	375	39.1	C

Winbourne Road	South - Pittwater Road	855	35.0	C	952	36.2	C
	West - Winbourne Road	323	44.5	D	336	42.0	D
	Intersection	**3036**	**25.2**	**B**	**3486**	**29.7**	**C**
Pittwater Road / Sydenham Road	North - Pittwater Road	1573	10.1	A	1736	8.9	A
	East - Sydenham Road	106	38.1	C	166	39.6	C
	South - Pittwater Road	1230	8.2	A	1493	22.7	B
	Intersection	**2909**	**10.3**	**A**	**3395**	**16.5**	**B**
Pittwater Road / Orchard Road	North - Pittwater Road	1642	3.1	A	1856	4.4	A
	East - Orchard Road	99	7.2	A	164	14.4	B
	South - Pittwater Road	1243	0.5	A	1493	5.4	A
	Intersection	**2984**	**7.2**	**A**	**3513**	**14.4**	**B**
Pittwater Road / Cross Street	North - Pittwater Road	1662	17.4	B	1936	23.3	B
	South - Pittwater Road	1205	22.0	B	1504	17.8	B
	West - Cross Street	232	44.2	D	350	54.5	D
	Intersection	**3099**	**21.2**	**B**	**3790**	**24.0**	**B**
Pittwater Road / Condamine Road	North - Pittwater Road	1625	30.2	C	1767	39.9	C
	East - Condamine Road	471	42.5	D	624	45.4	D
	South - Pittwater Road	979	21.7	B	1238	26.7	B
	Intersection	**3075**	**29.4**	**C**	**3629**	**36.3**	**C**

2021 – Option PM Peak		16:30-17:30			17:30-18:30		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1450	16.4	B	1356	16.7	B
	East - Hawkesbury Avenue	328	76.6	F	272	72.8	F
	South - Pittwater Road	1855	4.4	A	1799	9.8	A
	West - Hawkesbury Avenue	207	45.2	D	213	51.6	D
	Intersection	**3840**	**17.3**	**B**	**3640**	**19.5**	**B**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1231	3.3	A	1156	3.9	A
	East - Dee-Why Parade	392	48.0	D	409	52.1	D
	South - Pittwater Road	1702	7.0	A	1633	20.7	B
	Intersection	**3325**	**10.5**	**A**	**3198**	**18.7**	**B**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1151	10.4	A	1071	20.5	B
	East - Howard Avenue	321	42.4	D	311	47.0	D
	South - Pittwater Road	1615	5.1	A	1555	9.5	A
	West - St David Avenue	313	43.7	D	302	49.0	D
	Intersection	**3400**	**14.0**	**A**	**3239**	**20.4**	**B**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1146	8.2	A	1072	3.5	A
	East - Oakes Avenue	183	49.2	D	147	56.5	E
	South - Pittwater Road	1802	1.9	A	1751	3.3	A
	Intersection	**3131**	**7.0**	**A**	**2970**	**6.0**	**A**
Pittwater Road / Fisher Road	North - Pittwater Road	1296	16.8	B	1171	8.5	A
	South - Pittwater Road	2303	1.5	A	2184	3.0	A
	West - Fisher Road	542	62.8	E	543	54.2	D
	Intersection	**4141**	**14.3**	**B**	**3898**	**11.8**	**A**
Pittwater Road / Pacific Parade	North - Pittwater Road	1772	7.6	A	1627	6.9	A
	East - Pacific Parade	425	126.0	F	389	259.2	F
	South - Pittwater Road	1933	10.7	A	1845	14.6	B
	Intersection	**4130**	**21.2**	**B**	**3861**	**36.0**	**C**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1648	6.6	A	1484	17.7	B
	East - Sturdee Parade	229	47.5	D	217	53.0	D
	South - Pittwater Road	2042	4.4	A	1993	7.6	A
	Intersection	**3919**	**7.8**	**A**	**3694**	**14.4**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	1733	0.2	A	1556	0.2	A
	East - Delmar Parade	16	15.4	B	20	8.0	A
	South - Pittwater Road	2065	1.8	A	2035	4.8	A
	Intersection	**3814**	**24.5**	**B**	**3611**	**16.8**	**B**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	1698	45.8	D	1600	42.1	D
	East - Harbord Road	854	99.5	F	854	78.6	F
	South - Pittwater Road	1846	66.0	E	1778	72.8	F
	West - Warringah Road	970	52.6	D	987	56.8	E
	Intersection	**5368**	**62.5**	**E**	**5219**	**61.3**	**E**
Pittwater Road / Victor Road	North - Victor Road	19	43.7	D	12	44.2	D
	East - Pittwater Road	1396	5.0	A	1219	4.5	A
	West - Pittwater Road	2179	30.5	C	2082	35.4	C
	Intersection	**3594**	**43.7**	**D**	**3313**	**44.2**	**D**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	179	64.0	E	119	70.2	F
	East - Pittwater Road	1383	17.8	B	1203	17.6	B
	South - Mitchell Road	410	143.7	F	270	236.3	F
	West - Pittwater Road	1896	25.5	B	1912	29.3	C
	Intersection	**3868**	**37.1**	**C**	**3504**	**42.6**	**D**
Pittwater Road / Winbourne Road	North - Pittwater Road	1325	19.3	B	1100	17.7	B
	East - Winbourne Road	397	36.0	C	262	31.8	C
	South - Pittwater Road	1472	130.3	F	1588	117.4	F
	West - Winbourne Road	568	70.1	F	522	67.5	E

	Intersection	**3762**	**72.2**	**F**	**3472**	**71.8**	**F**
Pittwater Road / Sydenham Road	North - Pittwater Road	1390	10.0	A	1090	12.0	A
	East - Sydenham Road	304	63.1	E	196	55.6	D
	South - Pittwater Road	2005	38.1	C	2108	21.5	B
	Intersection	**3699**	**29.6**	**C**	**3394**	**20.4**	**B**
Pittwater Road / Orchard Road	North - Pittwater Road	1655	1.7	A	1265	0.9	A
	East - Orchard Road	40	1.8	A	25	1.0	A
	South - Pittwater Road	2017	10.4	A	2091	3.6	A
	Intersection	**3712**	**10.4**	**A**	**3381**	**3.6**	**A**
Pittwater Road / Cross Street	North - Pittwater Road	1591	26.7	B	1163	29.0	C
	South - Pittwater Road	1613	48.1	D	1865	31.0	C
	West - Cross Street	716	95.4	F	296	44.3	D
	Intersection	**3920**	**48.1**	**D**	**3324**	**31.5**	**C**
Pittwater Road / Condamine Road	North - Pittwater Road	1704	23.4	B	1213	27.5	B
	East - Condamine Road	449	73.4	F	434	53.7	D
	South - Pittwater Road	1217	85.6	F	1504	67.1	E
	Intersection	**3370**	**52.5**	**D**	**3151**	**50.0**	**D**

2021 – Option Saturday Peak		11:30 to 12:30			12:30 to 13:30		
		Volume	**Delay**	**LOS**	**Volume**	**Delay**	**LOS**
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1809	18.7	B	1680	18.4	B
	East - Hawkesbury Avenue	346	101.6	F	313	83.7	F
	South - Pittwater Road	1360	12.2	A	1345	29.3	C
	West - Hawkesbury Avenue	198	46.9	D	128	45.9	D
	Intersection	**3713**	**25.6**	**B**	**3466**	**29.5**	**C**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1474	2.8	A	1425	4.2	A
	East - Dee-Why Parade	375	47.1	D	355	51.1	D
	South - Pittwater Road	1156	10.4	A	1116	1.7	A
	Intersection	**3005**	**11.3**	**A**	**2896**	**9.0**	**A**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1332	18.9	B	1270	10.8	A
	East - Howard Avenue	258	45.2	D	210	47.0	D
	South - Pittwater Road	1125	12.0	A	1127	14.4	B
	West - St David Avenue	246	49.7	D	258	56.5	E
	Intersection	**2961**	**21.2**	**B**	**2865**	**19.0**	**B**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1342	14.9	B	1264	10.0	A
	East - Oakes Avenue	154	51.9	D	149	52.5	D
	South - Pittwater Road	1306	16.1	B	1320	14.7	B
	Intersection	**2802**	**17.5**	**B**	**2733**	**14.6**	**B**
Pittwater Road / Fisher Road	North - Pittwater Road	1434	15.5	B	1361	9.3	A
	South - Pittwater Road	1789	10.0	A	1820	12.7	A
	West - Fisher Road	391	76.6	F	418	66.8	E
	Intersection	**3614**	**19.4**	**B**	**3599**	**17.7**	**B**
Pittwater Road / Pacific Parade	North - Pittwater Road	1780	7.0	A	1743	6.3	A
	East - Pacific Parade	327	61.5	E	289	64.7	E
	South - Pittwater Road	1563	26.4	B	1640	31.1	C
	Intersection	**3670**	**20.1**	**B**	**3672**	**22.0**	**B**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1791	8.6	A	1742	12.5	A
	East - Sturdee Parade	338	70.8	F	327	97.6	F
	South - Pittwater Road	1772	11.5	A	1801	13.5	A
	Intersection	**3901**	**15.3**	**B**	**3870**	**20.2**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	2043	0.8	A	1981	0.6	A
	East - Delmar Parade	40	13.0	A	40	16.9	B
	South - Pittwater Road	1794	5.7	A	1812	5.6	A
	Intersection	**3877**	**24.0**	**B**	**3833**	**31.3**	**C**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	2041	44.5	D	1995	38.0	C
	East - Harbord Road	783	255.6	F	836	249.6	F
	South - Pittwater Road	1686	38.3	C	1667	37.5	C
	West - Warringah Road	1028	72.8	F	1068	61.2	E
	Intersection	**5538**	**77.7**	**F**	**5566**	**74.1**	**F**
Pittwater Road / Victor Road	North - Victor Road	20	0.5	A	20	0.6	A
	East - Pittwater Road	1580	7.0	A	1553	6.8	A
	West - Pittwater Road	1797	1.6	A	1765	1.4	A
	Intersection	**3397**	**15.8**	**B**	**3338**	**18.4**	**B**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	135	59.5	E	140	57.4	E
	East - Pittwater Road	1540	15.7	B	1546	12.0	A
	South - Mitchell Road	347	60.9	E	379	72.6	F
	West - Pittwater Road	1615	4.0	A	1572	4.1	A
	Intersection	**3637**	**16.4**	**B**	**3637**	**16.6**	**B**
Pittwater Road / Winbourne Road	North - Pittwater Road	1633	20.1	B	1606	17.3	B
	East - Winbourne Road	376	47.1	D	383	48.7	D
	South - Pittwater Road	1426	42.2	D	1370	50.0	D
	West - Winbourne Road	513	131.9	F	461	122.1	F

	Intersection	**3948**	**45.2**	**D**	**3820**	**44.8**	**D**
Pittwater Road / Sydenham Road	North - Pittwater Road	1821	4.9	A	1756	7.1	A
	East - Sydenham Road	140	55.9	D	146	55.1	D
	South - Pittwater Road	1725	15.1	B	1628	6.7	A
	Intersection	**3686**	**11.6**	**A**	**3530**	**8.9**	**A**
Pittwater Road / Orchard Road	North - Pittwater Road	1888	3.0	A	1817	2.2	A
	East - Orchard Road	12	3.4	A	12	3.1	A
	South - Pittwater Road	1729	1.3	A	1626	0.3	A
	Intersection	**3629**	**3.4**	**A**	**3455**	**3.1**	**A**
Pittwater Road / Cross Street	North - Pittwater Road	1877	30.3	C	1806	24.9	B
	South - Pittwater Road	1684	21.5	B	1560	19.9	B
	West - Cross Street	566	93.4	F	583	84.2	F
	Intersection	**4127**	**35.4**	**C**	**3949**	**31.7**	**C**
Pittwater Road / Condamine Road	North - Pittwater Road	1726	23.7	B	1781	33.0	C
	East - Condamine Road	526	45.7	D	403	40.0	C
	South - Pittwater Road	1206	25.2	B	1206	26.0	B
	Intersection	**3458**	**27.6**	**B**	**3390**	**31.3**	**C**

Appendix B

Base Model Calibration and Validation Report (Vissim)

Appendix B

Northern Beaches B-Line Program On-Road Infrastructure

VISSIM Base Model - Calibration and Validation Report

Northern Beaches B-Line Program On-Road Infrastructure

VISSIM Base Model - Calibration and Validation Report

Client: Roads and Maritime Services

ABN: 89 600 377 397

Prepared by

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			Name/Position	Signature
1	04-Jun-2016	Draft report	Andersen Hui Principal Transport Planner	
2	20-Oct-2016	FINAL	Andersen Hui Principal Transport Planner	

Table of Contents

1.0 Introduction

1.1 Preamble

AECOM was commissioned by Roads and Maritime Services (Roads and Maritime) to develop VISSIM microsimulation traffic models for the Narrabeen and Brookvale areas of Sydney to assist in the planning and development of the Northern Beaches B-Line program. This technical report provides details of the development of the VISSIM models; including data inputs, modelling assumptions, approach and, calibration and validation processes.

The base year models were developed for the mid-week AM and PM and Saturday peak periods; and were calibrated and validated to 2016 existing traffic conditions. The models will be used to analyse the operational performance of the proposed B-line Program on-road infrastructure works along the Pittwater Road which aims to improve the efficiency and reliability of bus services (including the proposed new B-Line Bus service).

1.2 Project Background

The Northern Beaches B-Line program (otherwise referred to as 'the B-Line Program') is an integrated program of service and infrastructure improvements that will deliver a high quality, high frequency bus service for passengers within Sydney's Northern Beaches area. The program will improve the frequency and reliability of bus services between the Northern Beaches and the Sydney CBD. The improved, high-frequency bus services will be supported by additional on-road and off-road infrastructure improvements and enhancements to the broader Northern Beaches bus network.

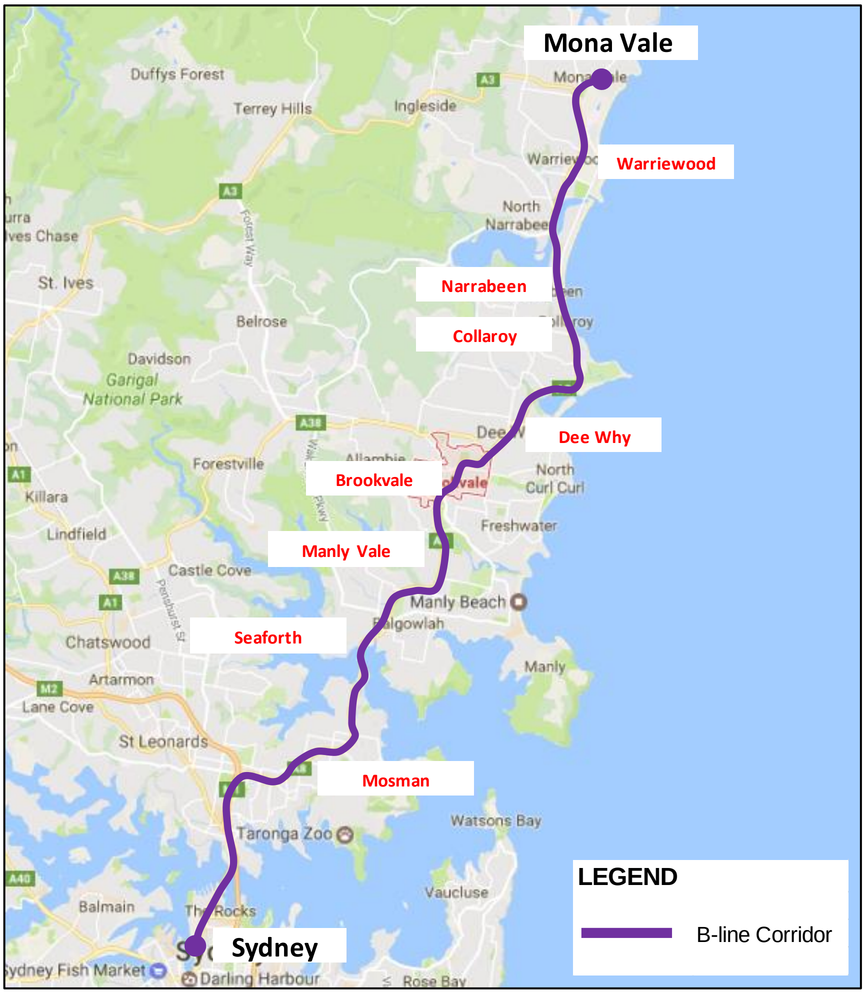
The overall aim of the program is to improve the effectiveness and attractiveness of the bus transport network within the Northern Beaches by addressing the following key existing issues:

- A lack of network legibility due to the complexity of the bus network, which leads to bus congestion;
- Low peak period average bus speeds, combined with long travel-times and delays along the north-south corridor;
- Unreliable and inconsistent bus journey times on the main north-south corridor;
- Uneven passenger loadings across similar services on the north-south corridor;
- Passenger crowding and poor pedestrian levels of service at major bus stops along the corridor;
- Long wait times for bus services in off-peak periods when frequency is reduced; and
- Customer dissatisfaction with current level of bus stop amenity.

At the core of the program is the introduction of a new high-frequency bus service called the B-Line service, which will run between Mona Vale and the Sydney CBD along the Northern Beaches north-sound corridor as shown in **Figure 1-1**.

The B-Line service is intended to be introduced as a higher frequency, more reliable, limited stops service which will benefit commuters and off-peak customers alike. While the existing express buses will continue to provide a fast service for commuters and local connections (especially those from the northern most suburbs), the B-Line service will still provide substantial benefits to passengers travelling along the Mona Vale to CBD corridor.

Figure 1-1 Map of Northern Beaches arterial, north-south (Mona Vale to CBD) corridor and east-west corridor



Source: Transport for NSW 2012, Long Term Transport Master Plan

1.3 Modelling Objectives

The key objectives of the VISSIM modelling are:

- To forecast the performance of the corridor for general traffic and buses in 2021 without and with the B-Line services, associated network upgrades and committed works from other REF programs.
- To identify preferred options for upgrade of the corridor to facilitate the B-Line service for input into the strategic design process.

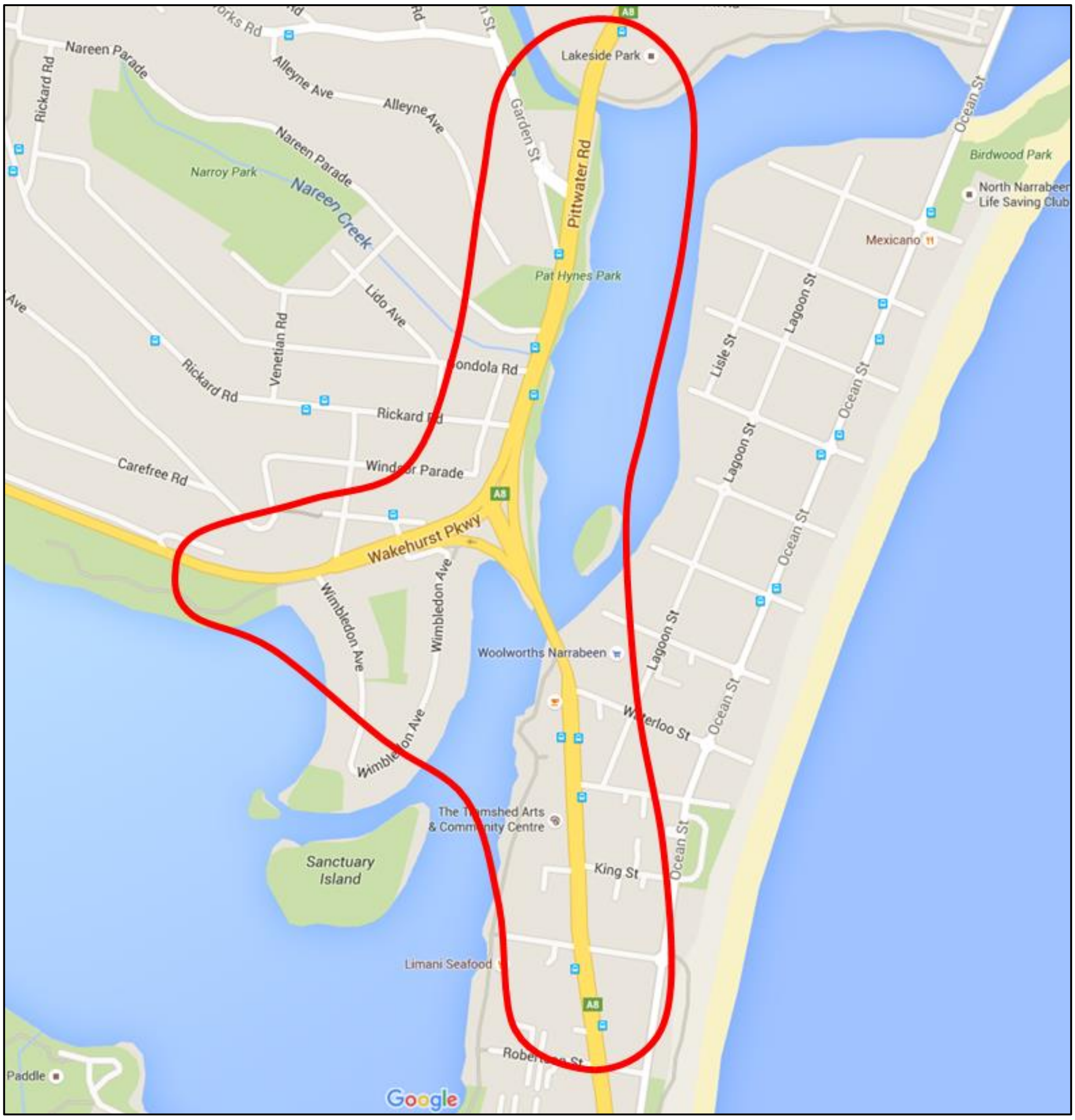
The base year traffic models are required to meet the calibration and validation criteria set out in the *RMS Traffic Modelling Guidelines* (2013) and will form the basis for the assessment of the network in 2021.

1.4 Study Area and VISSIM Model Extents

The VISSIM models were developed to cover the key areas of the Pittwater Road corridor in Narrabeen (between north of Pittwater Road/ Garden Street and south of Pittwater Road/ Albert Street) and in Brookvale / Dee Why (between Hawkesbury Avenue and Condamine Street).

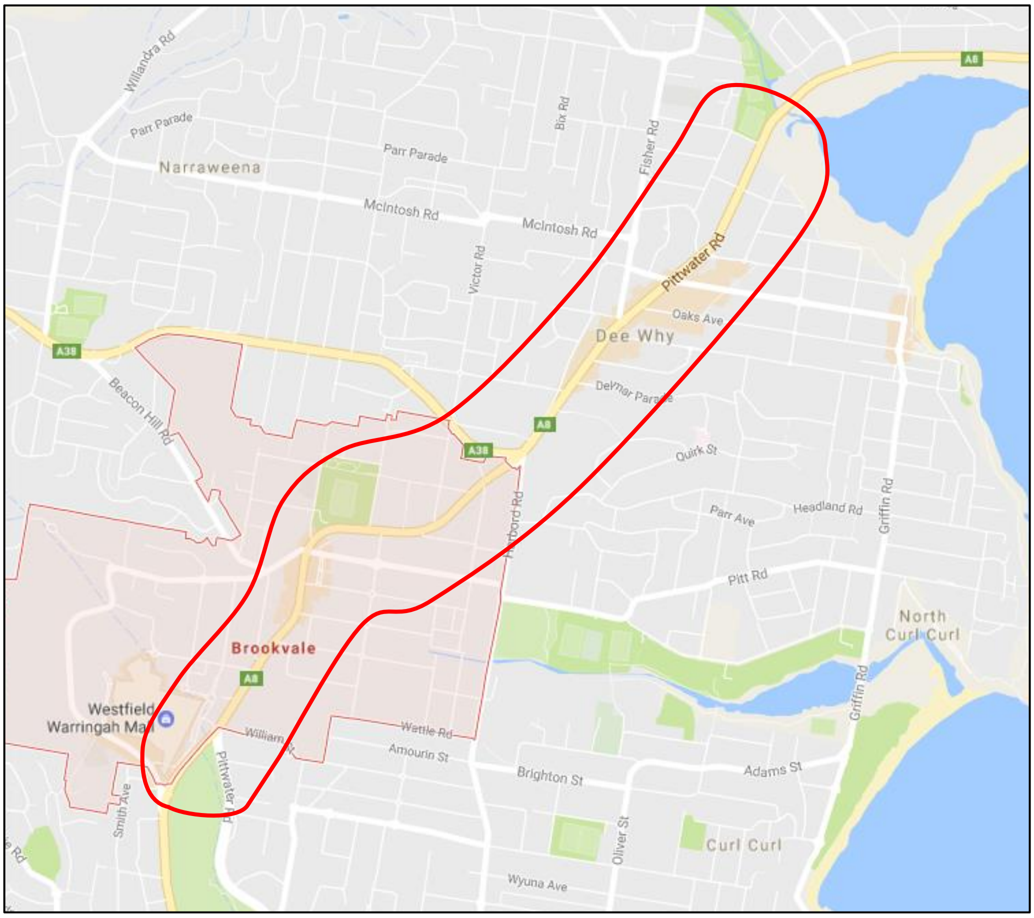
Figure 1-2 and **Figure 1-3** illustrate the extents of the modelled road network for Narrabeen and Brookvale / Dee Why respectively (within the red boundaries). The areas in Narrabeen and Brookvale / Dee Why have been modelled separately and have not been linked within a single model. However, as the demand matrices have been developed based on observed traffic counts any traffic impacts due to upstream congestion towards Narrabeen will also be reflected in the Brookvale demand matrices.

Figure 1-2 Narrabeen VISSIM Model Coverage



Source: Google Maps, 2016

Figure 1-3 Brookvale / Dee Why VISSIM Model Coverage



Source: Google Maps, 2016

1.5 Report Structure

The following sections of the report outline the main processes involved in developing and calibrating the VISSIM models:

Section 2.0: Data Inputs

Section 3.0: Model Development

Section 4.0: Model Calibration

Section 5.0: Model Validation

Section 6.0: Summary and Conclusion

2.0 Data Inputs

This section of the report provides details of the data used in the development, calibration and validation of the Narrabeen and Brookvale/ Dee Why VISSIM models.

2.1 Site Observations

Site visit was undertaken in the morning and evening peak periods on Tuesday, 31 May 2016 for the study area. Information collected such as sign posted speed limits, lane arrangement at intersections, traffic queues on Pittwater Road, parking restrictions and bus movements were used to validate the inputs for the modelling. In addition to this, travel time samples were collected and videos of the corridor drive through were recorded. A site visit during the Saturday peak period was also undertaken.

Observation in relation to the overall network operation generally indicates that areas within the study area with a relatively higher level of congestion and delays are most pronounced along the Pittwater Road approaching the Brookvale and Dee Why town centres. This is primarily due to the higher concentration and mix of various land use functions such as commercial, retail and employment activities typically associated with the town centres. There is no significant traffic issues observed in Narrabeen during the site visits.

2.1.1 Dee Why

- In the morning peak, the southbound peak traffic along the Pittwater Road is expected to experience moderate delays and congestion for the section between Dee Why Parade and Sturdee Parade, partly due to the closely spaced signals and the competing traffic demands from the side roads connecting to the town centre. Transient traffic queues are frequently observed along this section of Pittwater Road in the morning peak.

- The right-turn bay on Pittwater Road at approach to Oaks Avenue is occasionally observed with traffic queuing towards Fisher Road in both the morning and evening peak periods.
- Frequent bus activities at the bus stop on the eastern side of the Pittwater Road section between Howard Avenue and Oaks Avenue are observed. In both peak periods during the site visit, up to three (3) buses are observed at the kerbside lane with passenger boarding and alighting. The relatively narrow footpath adjacent to the bus stop is also observed to have a moderate number of bus passengers queuing for bus services.
- In the evening peak, slow moving traffic is observed in both the peak (northbound) and counter-peak (southbound) directions for the section of Pittwater Road between Oaks Avenue and Sturdee Parade.

2.1.2 Brookvale

- In the morning peak, moderate level of delays are expected for southbound traffic at approach to the Pittwater Road / Old Pittwater Road / Winbourne Road intersection from near the Brookvale Oval, west of Mitchell Road. This is due to a combination of delays from the traffic signal and the speed reduction of school zone effective between 8.00-9.30am.
- In the evening peak, intermittent northbound traffic queues are observed along Pittwater Road at approach to Cross Street, Old Pittwater Road and Warringah Road intersections. The northbound queues at approach to Warringah Road could propagate back south close to Mitchell Road. A mix of left-turn traffic with buses using the kerbside bus lane with queues close to approximately 50 metres is also observed at approach to Cross Street.
- Frequent bus and passenger activities are observed along Pittwater Road adjacent to Warringah Mall, where the existing ‘Bus-Only’ lanes are located, in both the southbound and northbound directions during the peak periods.

2.2 Traffic Data

An extensive traffic data collection and collation exercise was undertaken to inform the calibration and validation of the VISSIM models. The data was provided by RMS and consisted of the following:

- Manual classified turn count surveys in 15 minute intervals;
- Sydney Coordinated Adaptive Traffic System (SCATS) detector counts for signalised intersections in 15 minute intervals (collected for some locations where manual turn counts were not available);
- Travel time surveys for buses (including express buses and limited stops buses); and
- Travel time surveys for general traffic (all vehicle classes).

Further details of the traffic data inputs used in the traffic modelling are provided in the following sections.

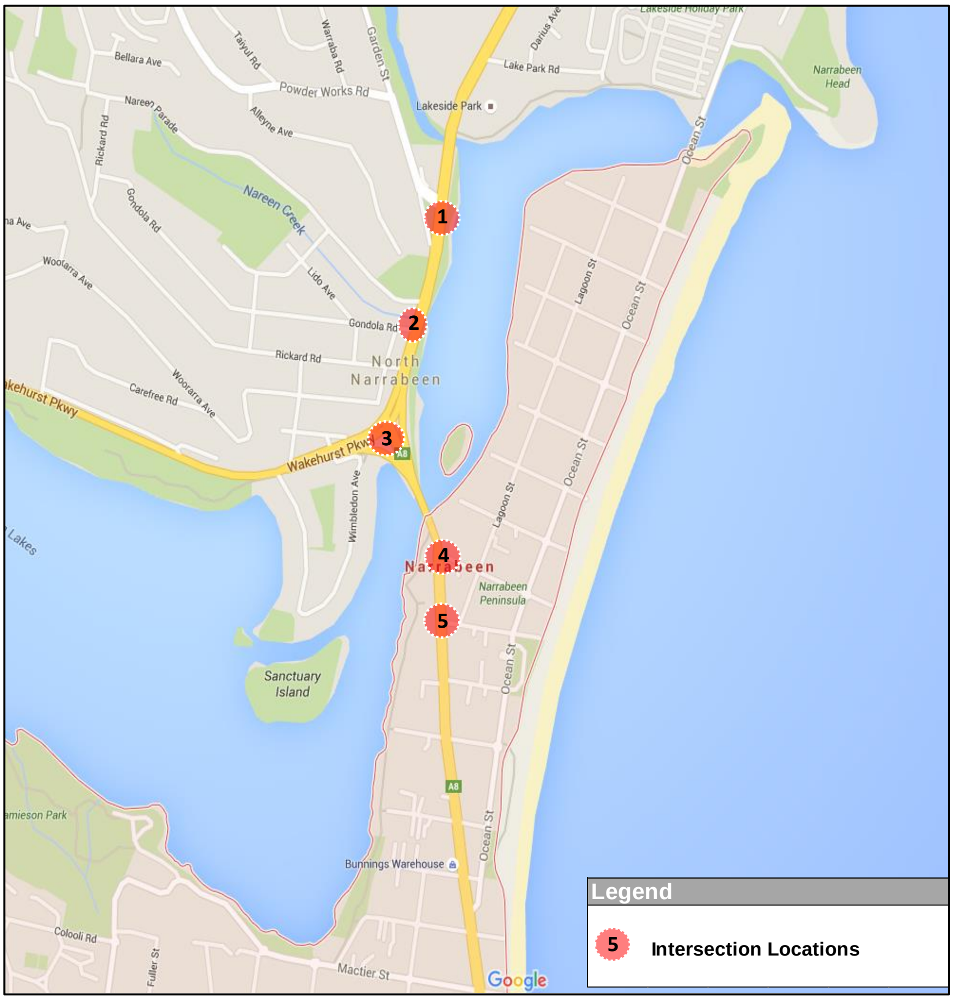
2.2.1 Manual Classified Turn Count Surveys

Manual classified turn count surveys were undertaken between 06.00 – 10.00 in the morning and 15.00 – 19.00 in the evening on a weekday; and between 11.00 and 14.00 on a Saturday. In some locations, where turning counts were not available, SCATS detector counts for the same time periods were collated in 15 minute intervals.

Figure 2-1 shows the traffic survey locations for the Brookvale / Dee Why traffic model, as summarised in **Table 2-1. Figure 2-2** shows the traffic survey locations for the Narrabeen model, as summarised in **Table 2-2**.

The observed volumes for each movement at each of the surveyed intersections are summarised in **Appendix A**.

Figure 2-1 Traffic Survey Locations (Intersection Counts and SCATS Counts) in Narrabeen

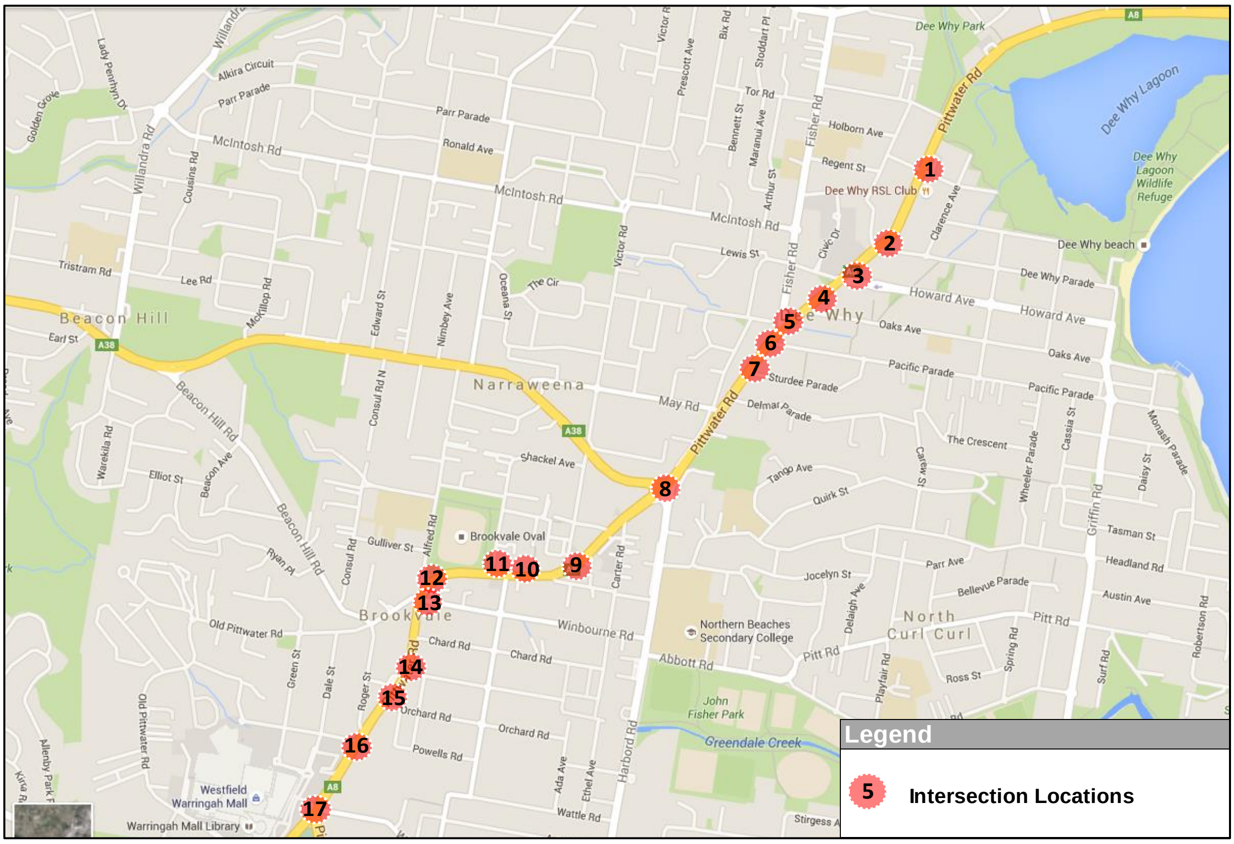


Source: Google Maps, 2016

Table 2-1 Traffic Survey s in Narrabeen

Site Number	Intersection	Intersection Control	Weekday Data Used	Weekend Data Used
1	Pittwater Road / Garden Street	Signal	**SCATS Counts -** Thursday 5 November 2015 and Wednesday 2 March 2016 (24 hours)	**Turning Movement Counts –** Saturday 5 March 2016 (from 11AM to 2PM)
2	Pittwater Road / Gondola Road	Signal	**Turning Movement Counts -** Wednesday 22 October, 2014 (from 7AM to 9AM, and 4PM to 6PM)	**Turning Movement Counts –** Saturday 5 March 2016 (from 11AM to 2PM)
3	Pittwater Road / Wakehurst Parkway	Signal	**Turning Movement Counts -** Tuesday 24 March 2015 (from 6AM to 10AM and 3PM to 7PM)	**Turning Movement Counts –** Saturday 5 March 2016 (from 11AM to 2PM)
4	Pittwater Road / Waterloo Street	Signal	**Turning Movement Counts -** Wednesday 11 November 2015 (from 6AM to 9AM and 4PM to 7PM)	**Turning Movement Counts –** Saturday 5 March 2016 (from 11AM to 2PM)
5	Pittwater Road / Albert Street	Signal	**Turning Movement Counts -** Monday 12 October 2015 (from 6AM to 9AM and 3PM to 6PM)	**Turning Movement Counts –** Saturday 5 March 2016 (from 11AM to 2PM)

Figure 2-2 Traffic Survey Locations (Intersection Counts and SCATS Counts) in Brookvale / Dee Why



Source: Google Maps, 2016

Table 2-2 Traffic Surveys in Brookvale

Site Number	Intersection	Control	Weekday Data Used	Weekend Data Used
1	Pittwater Road / Hawkesbury Avenue	Signal	**SCATS Count** – Thursday 5 November 2015 (24 hours)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
2	Pittwater Road / Kingsway / Dee-Why Parade	Signal	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
3	Pittwater Road / St David Avenue	Signal	**SCATS Count** – Thursday 5 November 2015 (24 hours)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
4	Pittwater Road / Oaks Avenue	Signal	**SCATS Count** – Thursday 5 November 2015 (24 hours)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
5	Pittwater Road / Fisher Road	Signal	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
6	Pittwater Road / Pacific Parade	Signal	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
7	Pittwater Road / Sturdee Parade	Signal	**Turning Movement Counts –** Thursday 10 October 2013 (from 7AM to 9AM and 4PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
8	Pittwater Road / Warringah Road / Harbord Road	Signal	**SCATS Count –**Wednesday 2 March 2016 (24 hours)	**Turning Movement Counts –** Saturday 5 March 2016 (from 11AM to 2PM)
9	Pittwater Road / Victor Road	Priority	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	Nominal volumes were assumed due to a lack of data
10	Pittwater Road / Mitchell Road	Signal	**SCATS Count –**Thursday 5 November 2015 (24 hours)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
11	Pittwater Road / Pine Avenue	Signal	**SCATS Count –**Thursday 5 November 2015 (24 hours)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
12	Pittwater Road / Alfred Road	Priority	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	Nominal volumes were assumed due to a lack of data
13	Pittwater Road / Old Pittwater Road / Winbourne Road	Signal	**SCATS Count –**Thursday 5 November 2015 (24 hours)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)

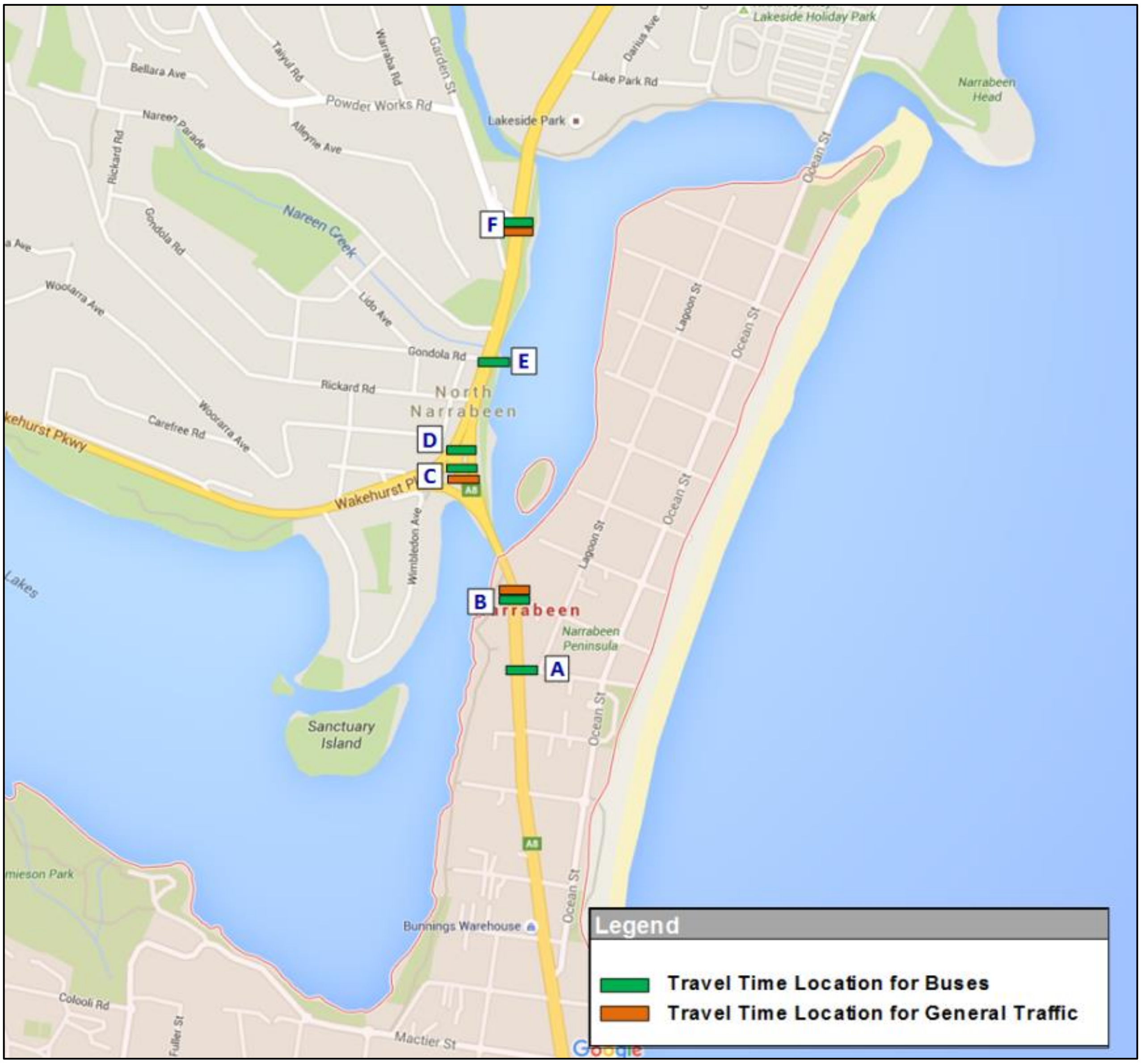
Site Number	Intersection	Control	Weekday Data Used	Weekend Data Used
14	Pittwater Road / Sydenham Road	Signal	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
15	Pittwater Road / Orchard Road	Priority	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	Nominal volumes were assumed due to a lack of data
16	Pittwater Road / Cross Street / Bus Depot	Signal	**Turning Movement Counts –** Tuesday 13 October 2015 (from 6AM to 9AM and 3PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
17	Pittwater Road / Condamine Road	Signal	**Turning Movement Counts –** Tuesday 13 October 2015 (from 6AM to 9AM and 3PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)

2.2.2 Travel Time Data

Travel time data for general traffic was derived from Roads and Maritime's database of GPS travel times; and bus travel time data was derived from PTIPS data provided by Roads and Maritime. Although the available GPS travel data for general traffic on weekdays provided a relatively large sample size, it should be noted that the sample size of data for the Saturday period was small in comparison (between 2-5 surveys in most locations) and was not available for some sections of the corridor in the study area.

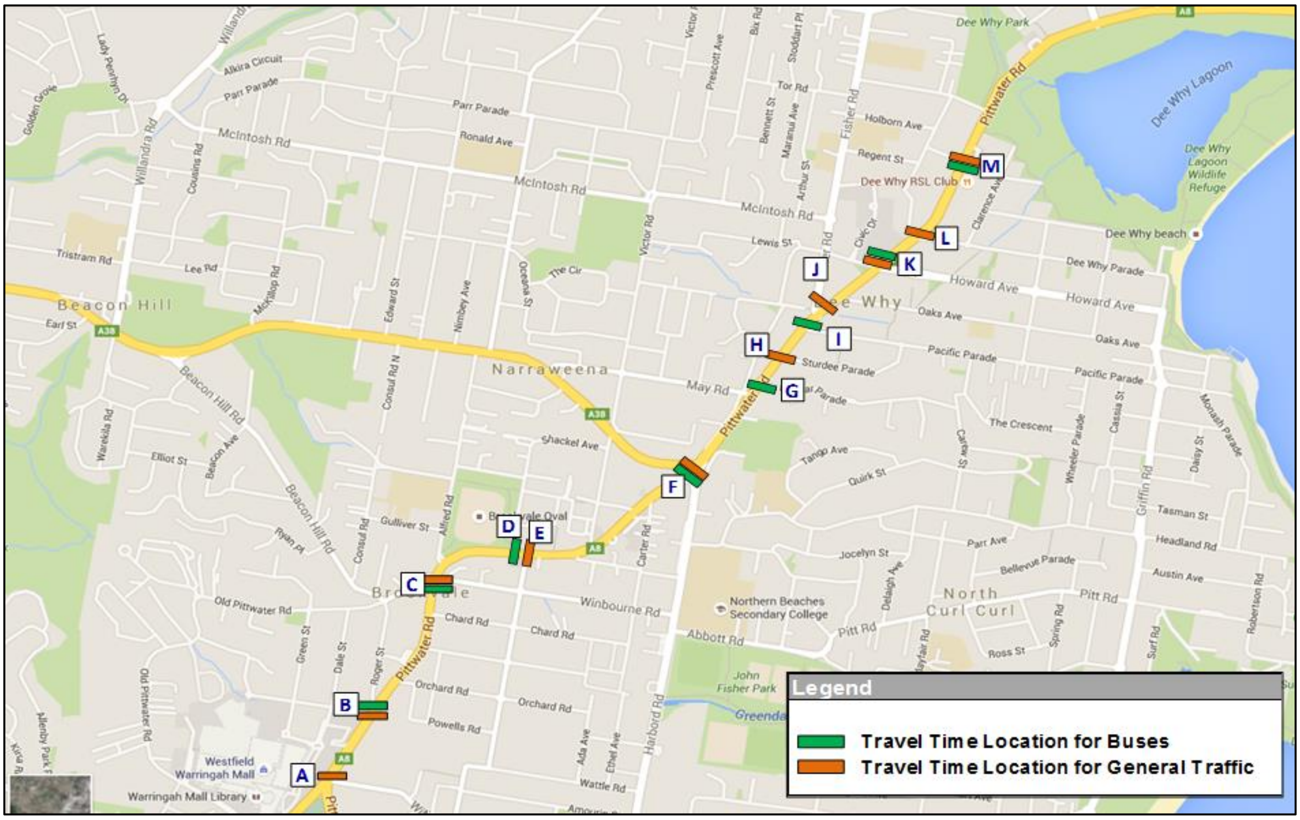
Figure 2-3 and **Figure 2-4** show the travel time sections analysed for general traffic and buses for the Narrabeen and Brookvale/ Dee Why study areas. A summary of the observed travel-time data used in the model validation process is provided in **Appendix B**.

Figure 2-3 Travel Time sections in Narrabeen



Source: Roads and Maritime, 2016

Figure 2-4 Travel Time sections in Brookvale / Dee Why



Source: Roads and Maritime, 2016

3.0 Model Development

This section of the report provides details of the VISSIM models development and network calibration.

3.1 Time Periods

The VISSIM models were developed and calibrated for two-hour peak periods for the mid-week AM/ PM and Saturday periods. The following peak periods were identified from the available traffic count data for the study areas:

- AM Peak: 07:00 to 09:00
- PM Peak: 16:30 to 18:30
- Saturday Peak: 11:30 to 13:30

The models include a 30 minute warm-up period and a 30 minute cool-down period, prior to/ following the peak periods listed above. The purpose of the warm-up period is to make sure that there is a representative level of traffic and congestion within the network at the start of the peak period. The purpose of the cool-down period is to allow all vehicles released during the evaluation period to complete their trips and to allow congestion to dissipate.

The warm-up and cool-down period demand matrices were calculated as a percentage of the peak period demand matrices, based on the available traffic count data for the study area.

3.2 Network Coding

3.2.1 Network Geometry and Intersection Coding

The VISSIM models road networks and intersection geometries were coded according to spatial data (which includes Google Maps and Street View) and aerial imagery. Observations and notes collected from the site visits were also used to further verify and confirm the details for the following key network attributes:

- Number of lanes;
- Turn restrictions;
- Intersection layouts, control mechanisms and lane arrangements;
- Posted speed limits;
- Bus stop locations;
- Stop lines at intersections; and
- Pedestrian crossings.

Non-signalised priority control movements were coded into the model using conflict areas and priority rules where appropriate. This included conflict areas for controlled pedestrian crossing where vehicles are required to give way to pedestrians.

VISSIM does not automatically calculate speed decreases associated with geometry or curved movements; therefore reduced speed areas were implemented on turn movements and curves where required. To make sure that vehicles merge into the correct lane early enough as they approach a turn, lane change parameters were adjusted from the default value as required.

3.2.2 Zone System

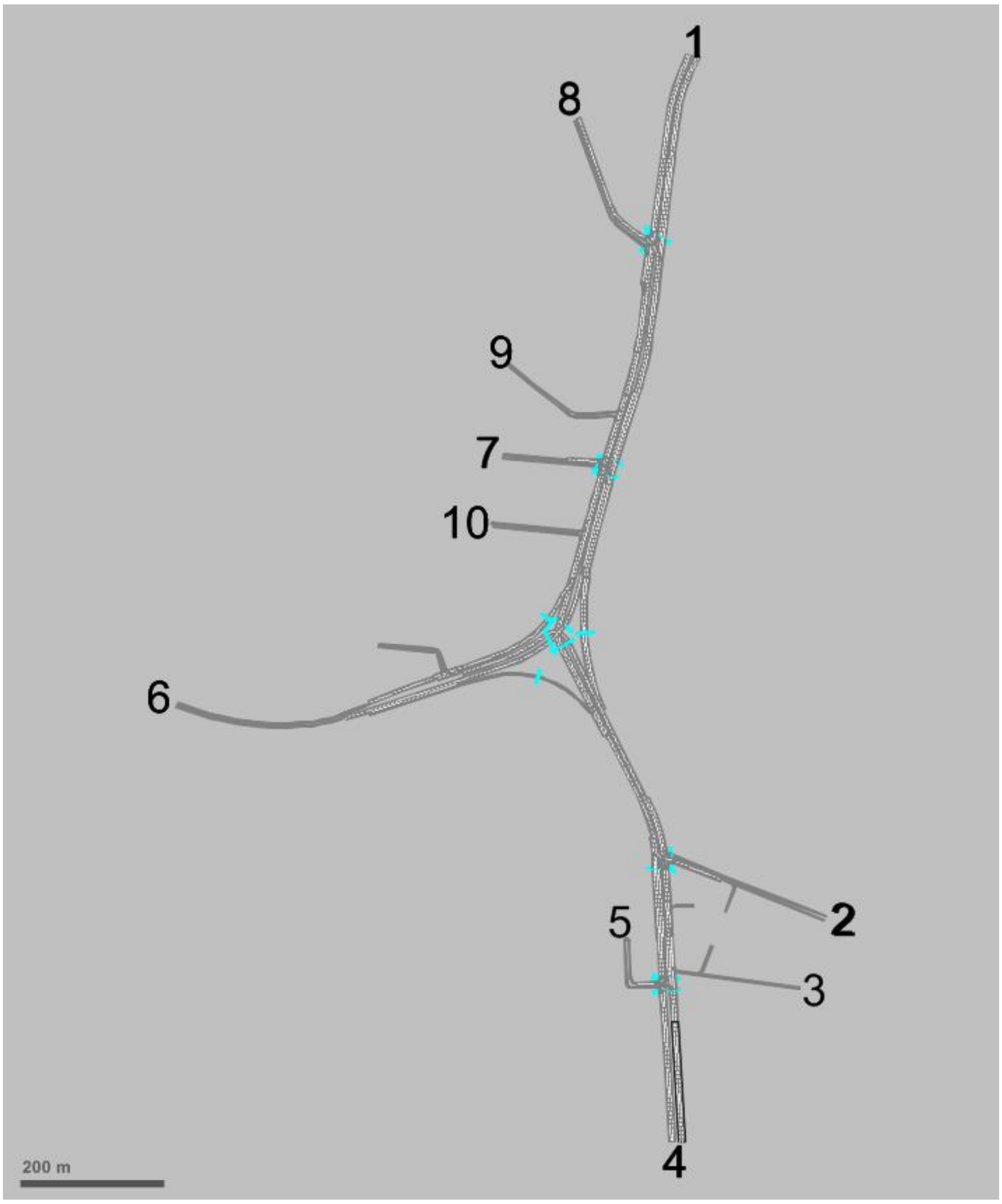
A total of 10 demand zones were defined within the Narrabeen model to cover the main traffic entry/ exit points in the network. The zones are summarised in **Table 3-1** and illustrated in **Figure 3-1**.

Table 3-1 Zone Structure for Narrabeen

Zone Number	Description
Zone 1	Pittwater Road, north of Pittwater Road / Garden Street intersection
Zone 2	Waterloo Street, east of Pittwater Road / Waterloo Street intersection
Zone 3	Albert Street, east of Pittwater Road / Albert Street intersection

Zone Number	Description
Zone 4	Pittwater Road, south of Pittwater Road / Albert Street intersection
Zone 5	Berry Carpark, west of Pittwater Road / Albert Street intersection
Zone 6	Wakehurst Parkway, west of Pittwater Road / Wakehurst Parkway intersection
Zone 7	Gondola Road, west of Pittwater Road / Gondola Road intersection
Zone 8	Garden Street, west of Pittwater Road / Garden Street intersection
Zone 9	Nareen Parade, west of Pittwater Road / Nareen Parade intersection
Zone 10	Rikard Road, west of Pittwater Road / Rikard Road intersection

Figure 3-1 Zone System for Narrabeen



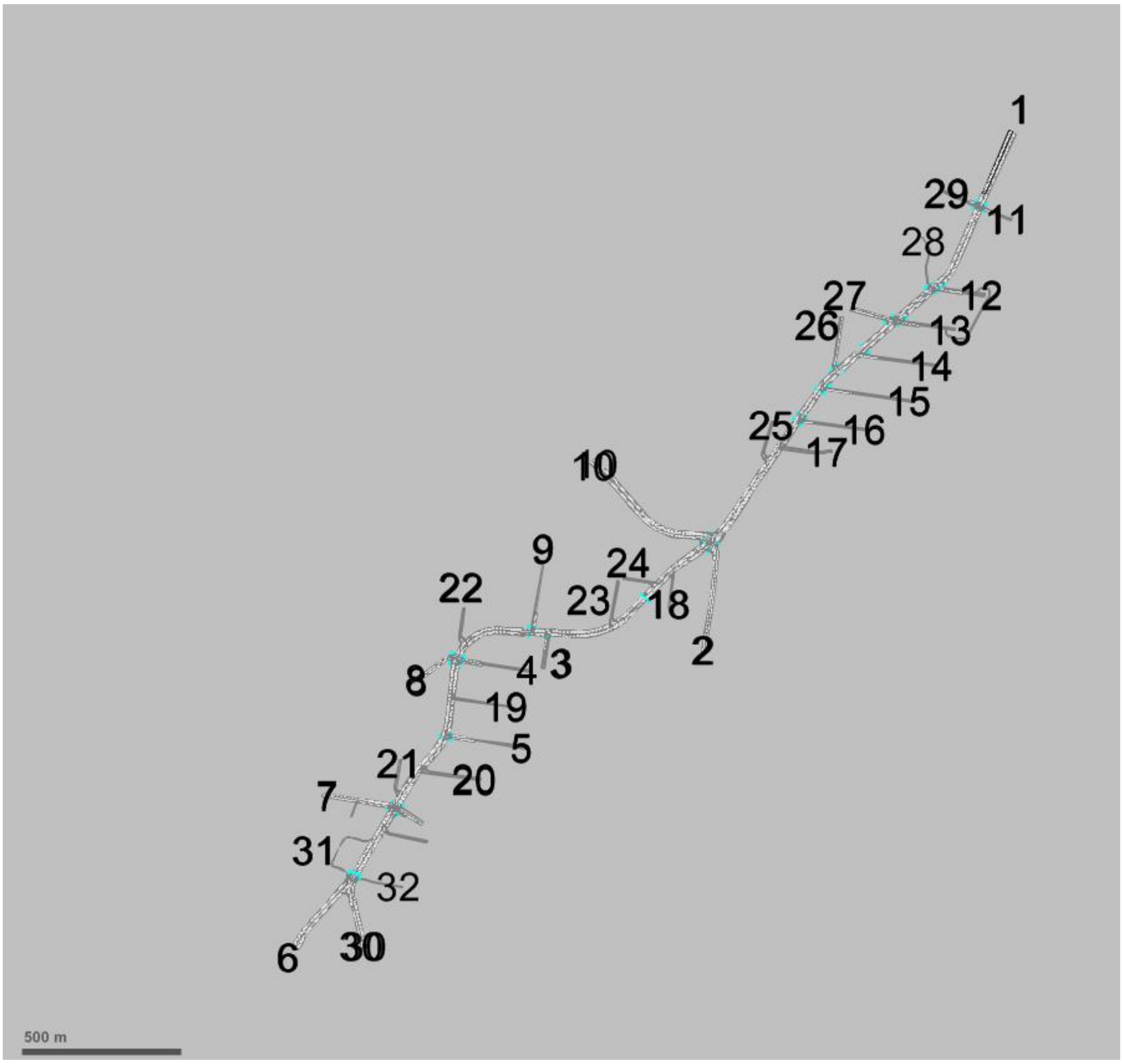
A total of 32 demand zones were defined for the Brookvale model. The zones are summarised in **Table 3-2** and illustrated in **Figure 3-2**.

Table 3-2 Zone Structure for Brookvale

Zone Number	Description
Zone 1	Pittwater Road, north of Pittwater Road / Hawkesbury Road intersection
Zone 2	Harbord Road, east of Pittwater Road / Harbord Road / Warringah Road intersection
Zone 3	Mitchell Road, east of Pittwater Road / Mitchell Road intersection
Zone 4	Winbourne Road, east of Pittwater Road / Winbourne Road / Old Pittwater Road intersection
Zone 5	Sydenham Road, east of Pittwater Road / Sydenham Road intersection
Zone 6	Condamine Road, south of Pittwater Road / Condamine Road intersection
Zone 7	Cross Street, west of Pittwater Road / Cross Street intersection
Zone 8	Old Pittwater Road, west of Pittwater Road / Winbourne Road intersection
Zone 9	Pine Avenue, west of Pittwater Road / Pine Avenue intersection
Zone 10	Warringah Road, west of Pittwater Road / Harbord Road / Warringah Road intersection
Zone 11	Hawkesbury Avenue, east of Pittwater Road / Hawkesbury Road intersection
Zone 12	Dee-Why Parade, east of Pittwater Road / Kingsway / Dee-Why Parade intersection
Zone 13	Howard Avenue, east of Pittwater Road / St David Avenue / Howard Avenue intersection
Zone 14	Oaks Avenue, east of Pittwater Road / Oaks Avenue intersection
Zone 15	Pacific Parade, east of Pittwater Road / Pacific Parade intersection
Zone 16	Sturdee Parade, east of Pittwater Road / Sturdee Parade intersection
Zone 17	Delmar Parade, east of Pittwater Road / Delmar Parade intersection
Zone 18	Carter Road, east of Pittwater Road / Carter Road intersection
Zone 19	Chard Road, east of Pittwater Road / Chard Road intersection
Zone 20	Orchard Road, east of Pittwater Road / Orchard Road intersection
Zone 21	Roger Street, west of Pittwater Road / Roger Street intersection
Zone 22	Alfred Road, west of Pittwater Road / Alfred Road intersection
Zone 23	Victor Road, west of Pittwater Road / Victor Road intersection
Zone 24	Federal Parade, west of Pittwater Road / Federal Parade intersection
Zone 25	Mooramba Road, west of Pittwater Road / Mooramba Road intersection
Zone 26	Fisher Road, west of Pittwater Road / Fisher Road intersection
Zone 27	St David Avenue, west of Pittwater Road / St David Avenue / Howard Avenue intersection
Zone 28	Kingsway
Zone 29	Hawkesbury Avenue, west of Pittwater Road / Hawkesbury Road intersection

Zone Number	Description
Zone 30	Pittwater Road, south of Pittwater Road / Condamine Road intersection
Zone 31	Warringah Mall
Zone 32	William Street, east of Pittwater Road / William Street

Figure 3-2 Zone System for Brookvale/Dee Why



3.2.3 Traffic Signal Operation

The Narrabeen and Brookvale / Dee Why models consist of a number of signalised intersections, which operate under SCATS control. All of the signal plans in the models were coded with fixed phase times. The phase times were based on average phase time data calculated from IDM data provided by RMS. The phase times were broken down into 30 minute intervals to reflect the changes in signal plans and average timings across the peak periods.

Details of link plans and offsets between groups of intersections were obtained from SCATS and coded into the models to provide a representation of the corridor operation as a network of connected signals. Co-ordination between networks of signals was achieved by maintaining common cycle times.

Coding of the link plans and offsets was important to achieve a good representation of observed traffic flow progression along the corridor. Adjustments were made to the signal offsets and timings where necessary to maintain the observed flow progression across the 30 minute intervals within the peak periods and to assist in the model validation process.

Within the VISSIM models, the signalised intersections were coded in VisVAP so that the cycle times and phase times could be varied by 30 minute intervals according to the IDM data. The signal coding in VisVAP will also allow easier implementation of bus priority signal actuation if required for future scenario testing.

3.3 Traffic Demands

3.3.1 Matrix Development

Traffic demand matrices were developed using a matrix furnessing technique to calibrate the modelled demands to the observed count data. Manual adjustments were made to the demand matrices for a small number of O-D pairs in order to achieve a good level of calibration to the observed counts. High-level trip length distribution checks were undertaken to make sure the model was not producing an excessive number of short trips between adjacent zones and illogical zone pairs.

The demand matrices were developed for light and heavy vehicles separately for individual 15-minute periods to reflect the variability and inter-hour peaking effects of the traffic entering the network.

There are a number of minor intersections within the models' areas for which traffic counts were unavailable. These intersections are all relatively minor priority controlled intersections and a large proportion of them are Left-In / Left-Out (LILO) and are not considered to have a significant impact on the operation of the corridor. As such, a nominal demand was added to these intersections for visualisation purposes. These locations include:

- Narrabeen:
  - Pittwater Road / Nareen Parade (LILO)
  - Pittwater Road / Rickard Road (LILO)
- Brookvale / Dee Why:
  - Pittwater Road / Delmar Parade (Three-way, priority controlled)
  - Pittwater Road / Mooramba Road (LILO)
  - Pittwater Road / Carter Road (LILO)
  - Pittwater Road / Federal Parade (Three-way, priority controlled)
  - Pittwater Road / Chard Road (LILO)
  - Pittwater Road / Roger Street (LILO

3.3.2 Demand Release Profiles

Demand release profiles control the rate of release of vehicles from the demand matrix into the model network over the course of the model period. The demand release profiles were developed for 15 minute intervals for each zone in the model using traffic count data for the study area. The profiles were then applied to the overall 3-hour demand matrices to produce demand matrices in 15 minute time slices.

3.3.3 Public Transport

All existing bus services along the corridor were included in the models. The frequencies and headways were coded according to timetable information published by Transport for NSW. The Pittwater Road corridor is utilised by three types of bus service including:

- All stops;
- Limited stops; and
- Express services.

A number of bus services are directional services or peak hour express type services, which only operate during specific times of day i.e. AM or PM, peak only. In such cases, the corresponding public transport lines were included in the model for completeness, but do not generate any bus trips (i.e. the corresponding PT line for an AM peak service is present in the PM peak model however it does not produce any buses). The Pittwater Road Corridor has bus lanes that are active depending upon the time of the day, i.e. bus lane is active in peak direction. When a bus lane is not active, it may be used for parking.

Comprehensive bus stop dwell time data was not available at the time of model development. As an initial starting point, the dwell time assumptions from the Northern Beaches B-Line AIMSUN base model (developed by Jacobs as part of the Business Case) was adopted. During the travel time validation process, the bus dwell times were further manipulated to closely match bus travel times calculated from PTIPS data.

3.3.4 Pedestrians

Count data for pedestrian movements was not available for input into the model development process. It was however possible to determine pedestrian activity across the study area by interrogating the SCATS IDM data for the signalised intersections to see how often pedestrian phases are called during the peak periods.

Analysis of the IDM data revealed that pedestrian phases are generally called over 70% of the time at most signalised intersections, which indicates that there is currently a reasonable level of pedestrian demand for the controlled crossing facilities.

In the absence of pedestrian count data, a nominal demand of 50 pedestrians per hour was coded for each crossing location. This is to ascertain that there is some level of interaction in the model between vehicles and pedestrians; and will allow for the analysis of pedestrian movements in the future year scenarios.

In locations in the model where pedestrian movements caused significant delay to turning vehicles, reviews against site observations were made and the pedestrian demands adjusted accordingly.

4.0 Model Calibration

This section of the report provides details of the model demand calibration process and outcomes.

4.1 Calibration Criteria

The model calibration exercise involved comparisons between modelled and observed traffic count data. The GEH statistic was used during the calibration of the models to compare the difference between observed flow and assigned flow on each turn movement.

The GEH statistic is calculated using the following equation:

$$GEH = \sqrt{\frac{(E-V)^2}{\frac{E+V}{2}}}$$

Where:

E = modelled flow

V = observed flow

Comparisons between the modelled and observed flow are made using the GEH statistic as it is able to cope with a wide range of traffic flows. For example, a difference of 100 vehicles per hour is significant in a flow of 200 vehicles per hour but it is insignificant in a flow of thousands of vehicles per hour.

The model was calibrated against the criteria outlined in the *RMS Traffic Modelling Guidelines 2013.* The guidelines recommend that 85% of counts across the model networks should be within 5 GEH of the observed counts.

To reflect the impact of daily traffic variation, VISSIM randomises the release of vehicles into the network using different seed values. A run of the model using a single seed value may produce a random event that increases delays in a certain area of the model, leading to unrepresentative results. An example would be the simultaneous arrival of HGVs at a certain intersection. It is therefore a good practice to run the model using a range of seed values to compare an average of the model results to the observed data.

The base models were calibrated and validated over an average of 5 model seeds values, in line with the criteria recommended in the *RMS Traffic Modelling Guidelines 2013*. The RMS recommended seed values used are 560, 28, 7771, 86524 and 2849.

4.2 Flow Comparisons

4.2.1 Narrabeen Model

Table 4-1 to **Table 4-3** provide summaries of the model calibration outputs for the Narrabeen base model for each time period.

Table 4-1 AM Period Calibration Results Summary Narrabeen

Time	Measurements	Target	Total Counts Considered	No. of Counts GEH < 5	% of Counts GEH < 5
7:00 AM-8:00AM	GEH < 5	>85%	33	32	97%
8:00 AM-9:00AM	GEH < 5	>85%	33	30	91%

Table 4-2 PM Period Calibration Results Summary Narrabeen

Time	Measurements	Target	Total Counts Considered	No. of Counts GEH < 5	% of Counts GEH < 5
4:30PM-5:30PM	GEH < 5	>85%	33	33	100%
5:30PM-6:30PM	GEH < 5	>85%	33	32	97%

Table 4-3 Saturday Period Calibration Results Summary Narrabeen

Time	Measurements	Target	Total Counts Considered	No. of Counts GEH < 5	% of Counts GEH < 5
11:30AM-12:30PM	GEH < 5	>85%	33	32	97%
12:30PM-1:30PM	GEH < 5	>85%	33	29	88%

The outputs indicate that over 90% of the observed flows are within 5 GEH of the observed flows for majority of the calibrated hourly time periods. In addition, no movement was found to have a GEH of greater than 10. It was therefore considered that the Narrabeen base year model is sufficiently calibrated to the observed traffic count data.

4.2.2 Brookvale / Dee Why Model

Table 4-4 to **Table 4-6** provide summaries of the model calibration outputs for the Brookvale base model for each time period.

Table 4-4 AM Period Calibration Results Summary Brookvale / Dee Why

Time	Measurements	Target	Total Counts Considered	No. of Counts GEH < 5	% of Counts GEH < 5
7:00 AM-8:00AM	GEH < 5	>85%	110	107	97%
8:00 AM-9:00AM	GEH < 5	>85%	110	100	91%

Table 4-5 PM Period Calibration Results Summary Brookvale / Dee Why

Time	Measurements	Target	Total Counts Considered	No. of Counts GEH < 5	% of Counts GEH < 5
4:30PM-5:30PM	GEH < 5	>85%	110	104	95%
5:30PM-6:30PM	GEH < 5	>85%	110	100	91%

Table 4-6 Saturday Period Calibration Results Summary Brookvale / Dee Why

Time	Measurements	Target	Total Counts Considered	No. of Counts GEH < 5	% of Counts GEH < 5
11:30-12:30	GEH < 5	>85%	101	96	95%
12:30-13:30	GEH < 5	>85%	101	99	98%

It should be noted that for the Saturday model, there were several turning movements where observed traffic volumes were not available and as such the observed traffic volumes for these movements could not be compared to the modelled volume. For this reason the 'Total Counts Considered' value is slightly lower for Saturday than during the weekday peak periods.

The outputs indicate that over 90% of the observed flows are within 5 GEH of the observed flows for each hour in each time period. In addition, no movement was found to have a GEH of greater than 10. It was therefore considered that the Brookvale/Dee Why base year model is sufficiently calibrated to the observed traffic count data.

Flow comparisons for each of the modelled vs. observed turn movements in the models are provided in **Appendix A**.

5.0 Model Validation

Model validation is a term used to describe the independent process undertaken to demonstrate that a model has been calibrated to a sufficient extent to accurately reproduce on-the-ground traffic conditions. This process involves a comparison of model outputs to an independent set of data that has not been used in the model calibration.

For this assessment traffic count data was used to calibrate the model demands, with the model subsequently validated against travel time data for general traffic and buses. The model travel times have been validated against the RMS modelling criteria:

- *Average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times.*

This section of the report provides details of the validation processes undertaken and summarises the validation results for the Narrabeen and Brookvale / Dee Why base models. Detailed outputs for the model validation process, including graphical comparisons, are provided in **Appendix B**.

5.1 Narrabeen Model

A summary of the travel time validation comparisons for the Narrabeen base year model are presented in **Table 5-1** and **Table 5-2**.

Table 5-1 Narrabeen Base Year Model Travel Time Comparisons Hour 1 (mm:ss)

Vehicle Type/ Route	AM Peak 0700-0800			PM Peak 1630-1730			Saturday 1130-1230		
	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)
General traffic NB	1:57	2:02	5	2:05	2:33	28	1:56	2:40	43
General traffic SB	0:57	1:21	24	1:19	1:22	2	1:45	1:30	-15
Buses NB	3:44	3:16	-27	3:19	2:50	-29	4:16	4:25	9
Buses SB	3:48	2:58	-50	3:28	3:15	-4	3:51	3:18	-33

Table 5-2 Narrabeen Base Year Model Travel Time Comparisons Hour 2 (mm:ss)

Vehicle Type/ Route	AM Peak 0800-0900			PM Peak 1730-1830			Saturday 1230-1330		
	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)
General traffic NB	2:06	1:37	-29	2:11	2:52	40	2:50	1:57	-52
General traffic SB	0:56	1:21	25	1:16	1:22	7	2:00	1:01	-59
Buses NB	3:19	3:43	24	3:17	3:29	13	3:45	4:26	42
Buses SB	3:20	3:25	5	2:57	2:53	-4	3:12	2:39	-33

The comparisons show that the modelled travel times for general traffic and buses are within one minute of the observed times for all routes and in all time periods. This indicates that the model achieves a good level of validation to observed conditions in terms of general traffic and bus travel times and flow progression along the corridor in both directions.

In the PM period it was found that the signal link plans and offsets obtained from SCATS produced significant congestion in the northbound direction along Pittwater Road that did not align with the observed travel time data. The signal offsets were therefore adjusted in line with site video observations to validate the model to the observed northbound flow progression and travel times.

5.2 Brookvale / Dee Why Model

A summary of the travel time validation comparisons for the Brookvale / Dee Why base year model are presented in **Table 5-3** and **Table 5-4**.

Table 5-3 Brookvale / Dee Why Base Year Model Travel Time Comparisons Hour 1 (mm:ss)

Vehicle Type/ Route	AM Peak 0700-0800			PM Peak 1630-1730			Saturday 1130-1230		
	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)
General traffic NB	05:56	06:06	3%	08:31	09:45	14%	05:41	06:09	8%
General traffic SB	07:14	07:02	-3%	07:16	06:31	-10%	06:52	06:07	-11%
Buses NB	09:16	09:31	3%	07:59	07:17	-9%	10:07	10:01	-1%
Buses SB	10:12	10:09	-1%	10:02	10:10	1%	12:34	10:30	-16%

Table 5-4 Brookvale / Dee Why Base Year Model Travel Time Comparisons Hour 2 (mm:ss)

Vehicle Type/ Route	AM Peak 0800-0900			PM Peak 1730-1830			Saturday 1230-1330		
	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)
General traffic NB	05:59	06:36	10%	08:23	09:09	9%	06:01	06:54	15%
General traffic SB	09:07	07:58	-13%	07:22	06:54	-6%	06:31	06:14	-4%
Buses NB	08:45	09:50	12%	07:06	07:18	3%	09:05	10:30	16%
Buses SB	10:13	10:47	6%	09:04	10:46	19%	09:34	11:01	15%

The comparisons show that the modelled general traffic travel times are within 15% of the observed times for all routes and in all time periods. This indicates that the model achieves a good level of validation to observed conditions in terms of general traffic travel times and flow progression along the corridor in both directions.

For the bus travel time comparisons, the modelled times are within 15% of the observed for nine of the 12 routes. For the remaining three routes the average modelled travel time falls slightly outside the recommended criteria, but within 20% of the observed times in all cases. The travel time differences on these routes may be due to minor differences in bus dwell times on the survey days and are not considered to be a significant issue in terms of the model’s ability to replicate existing conditions. This is supported by the good level of validation achieved for general traffic travel times.

During the development and validation of the Saturday model for Brookvale/ Dee Why it was determined that the observed travel times southbound along the corridor could not be achieved in the model when adopting the signal link plans and offsets extracted from SCATS (i.e. the modelled times were consistently higher than the observed in the southbound directions).

To validate the Saturday model, a number of changes were made to the signal offsets that adjusted the co-ordination of intersections north of Warringah Road. These changes resulted in more delay along the corridor north of Fisher Road, but resulted in a reasonable match between the observed and modelled travel times.

The most likely reason for the difficulty in validating the Saturday model is that the observed travel time survey sample size was very small. The signal coordination implemented in the 2016 Saturday model should be carried forward for the 2021 scenarios for a like-to-like comparison amongst the models.

6.0 Summary and Conclusion

This report has provided details of the development of VISSIM microsimulation models for the Pittwater Road corridor in Narrabeen and Brookvale / Dee Why in Sydney's Northern Beaches. The models were developed as part of the B-Line REF assessment and will be used to inform option development for bus priority improvement and the implementation of the B-Line service along the corridor.

An extensive data collection and collation exercise was undertaken to develop an understanding of the existing network conditions and to provide a comprehensive set of data for use in the model development process. The key data inputs included:

- On-site observations during the peak periods.
- Manual classified turn counts and SCATS counts at the key intersections and mid-block locations.
- Existing public transport service routes and frequencies.
- Signal data in the form of IDM recordings, link plans and offsets.
- Bus and general traffic travel time data for the corridor during the peak periods

The models were developed in line with best practice the midweek AM / PM and Saturday peak periods and were calibrated and validated to a satisfactory level in line with criteria recommended in the *RMS Traffic Modelling Guidelines 2013*.

The outputs presented in this report show that for each model:

- Over 90% of modelled flows are within 5 GEH of the observed flows for majority of the modelled time periods.
- 100% of the modelled flows are within 10 GEH of the observed flows in each time period.
- 100% of the modelled general traffic travel time routes are within 15% / one minute (whichever is greater) of the observed in each time period.
- The vast majority of the modelled bus travel time routes are within 15% / one minute (whichever is greater) of the observed in each time period. A small number of routes have modelled bus travel times that are slightly more than 15% different to the observed, potentially due to differences in bus dwell times on the observed survey days.

On the basis of the above analysis, it has been concluded that the base year VISSIM models are satisfactorily calibrated and validated to existing traffic conditions and that the models are suitable for use in future year scenario testing.

Appendix A

Detailed Model Calibration Outputs

Narrabeen Turning Movement Flows – AM Peak (All Vehicles)

Intersection name	Road name	Approach	Turn	Modelled		Observed		GEH	
				7 to 8	8 to 9	7 to 8	8 to 9	7 to 8	8 to 9
Pittwater / Garden	Pittwater Road	South	L	539	598	570	660	1.3	2.5
			T	1210	1525	1184	1520	0.8	0.1
	Pittwater Road	North	T	1791	1868	1744	1828	1.1	0.9
			R	69	64	68	67	0.2	0.3
	Garden Street	West	L	152	180	152	180	0.0	0.0
			R	360	425	390	462	1.5	1.8
Pittwater / Gondola	Pittwater Road	South	L	47	80	30	31	2.7	6.6
			T	1679	2014	1714	2002	0.8	0.3
	Pittwater Road	North	T	2103	2218	2120	2222	0.4	0.1
			R	45	80	63	139	2.4	5.6
	Gondola Street	West	L	67	99	38	82	4.0	1.8
			R	79	109	99	112	2.1	0.3
Pittwater / Wakehurst	Pittwater Road	South	L	315	319	247	261	4.1	3.4
			T	1331	1570	1389	1635	1.6	1.6
	Pittwater Road	North	T	1523	1653	1567	1599	1.1	1.3
			R	673	664	723	742	1.9	2.9
	Wakehurst Parkway	West	L	385	517	407	489	1.1	1.2
			R	248	302	218	328	2.0	1.5
Pittwater / Waterloo	Pittwater Road	South	T	1410	1597	1419	1596	0.2	0.0
			R	67	87	39	41	3.8	5.8
	Waterloo Street	East	L	120	125	63	76	6.0	4.9
			R	255	302	265	287	0.6	0.9
	Pittwater Road	North	L	116	175	136	210	1.8	2.5
			T	1663	1782	1583	1783	2.0	0.0
Pittwater / Albert / Berry Car Park	Pittwater Road	South	L	22	20	22	22	0.0	0.4
			T	1474	1686	1413	1589	1.6	2.4
	Pittwater Road	North	L	47	26	50	25	0.4	0.2
			T	1727	1863	1673	1848	1.3	0.3
			R	20	18	21	23	0.2	1.1
	Berry Car Park	West	L	0	0	0	1	0.0	1.4
			R	14	14	13	14	0.3	0.0
Pittwater / Wakehurst	Pittwater Road	South	T	6	7	10	21	1.4	3.7
	Pittwater Road	North	T	38	12	48	25	1.5	3.0

Narrabeen Turning Movement Flows – PM Peak (All Vehicles)

Intersection name	Road name	Approach	Turn	Modelled		Observed		GEH	
				16.30 to 17.30	17.30 to 18.30	16.30 to 17.30	17.30 to 18.30	16.30 to 17.30	17.30 to 18.30
Pittwater / Garden	Pittwater Road	South	L	569	504	653	587	3.4	3.6
			T	1888	1937	1956	2028	1.6	2.0
	Pittwater Road	North	T	1758	1624	1791	1590	0.8	0.9
			R	86	83	85	87	0.1	0.4
	Garden Street	West	L	302	247	296	245	0.3	0.1
			R	496	396	548	454	2.3	2.8
Pittwater / Gondola	Pittwater Road	South	L	102	97	88	75	1.4	2.4
			T	2354	2330	2497	2122	2.9	4.4
	Pittwater Road	North	T	2077	1872	2190	1862	2.4	0.2
			R	167	152	218	185	3.7	2.6
	Gondola Street	West	L	103	94	82	70	2.2	2.7
			R	82	66	94	80	1.3	1.6
Pittwater / Wakehurst	Pittwater Road	South	L	187	147	176	146	0.8	0.1
			T	1549	1467	1704	1590	3.8	3.1
	Pittwater Road	North	T	1552	1389	1496	1427	1.4	1.0
			R	609	543	571	494	1.6	2.2
	Wakehurst Parkway	West	L	915	948	963	941	1.6	0.2
			R	376	353	366	367	0.5	0.7
Pittwater / Waterloo	Pittwater Road	South	T	1571	1352	1543	1448	0.7	2.6
			R	89	99	72	70	1.9	3.2
	Waterloo Street	East	L	55	48	82	83	3.3	4.3
			R	203	224	193	193	0.7	2.1
	Pittwater Road	North	L	247	310	236	312	0.7	0.1
			T	1685	1414	1839	1684	3.7	6.9
Pittwater / Albert / Berry Car Park	Pittwater Road	South	L	14	10	13	11	0.3	0.3
			T	1649	1449	1505	1279	3.6	4.6
	Pittwater Road	North	L	16	15	18	15	0.5	0.1
			T	1692	1416	1521	1293	4.3	3.3
			R	39	33	38	32	0.2	0.1
	Berry Car Park	West	L	2	2	3	3	0.6	0.4
			R	25	19	25	21	0.0	0.5

Narrabeen Turning Movement Flows – Sat Peak (All Vehicles)

Intersection name	Road name	Approach	Turn	Modelled 1130 to 1230	Modelled 1230 to 1330	Observed 1130 to 1230	Observed 1230 to 1330	GEH 1130 to 1230	GEH 1230 to 1330
Pittwater / Garden	Pittwater Road	South	L	29	34	29	39	0.0	0.8
			T	2234	2096	2153	2073	1.7	0.5
	Pittwater Road	North	T	2136	1826	2320	2017	3.9	4.4
			R	240	198	233	200	0.5	0.1
	Garden Street	West	L	54	19	49	20	0.7	0.2
			R	87	62	98	80	1.1	2.1
Pittwater / Gondola	Pittwater Road	South	L	77	80	48	59	3.7	2.5
			T	2164	2061	2113	2023	1.1	0.8
	Pittwater Road	North	T	2101	1763	2196	2059	2.0	6.8
			R	129	116	174	177	3.7	5.0
	Gondola Street	West	L	93	65	77	59	1.7	0.8
			R	94	65	105	87	1.1	2.5
Pittwater / Wakehurst	Pittwater Road	South	L	336	324	216	240	7.2	5.0
			T	1437	1388	1364	1322	2.0	1.8
	Pittwater Road	North	T	1604	1366	1750	1640	3.6	7.1
			R	602	460	592	498	0.4	1.7
	Wakehurst Parkway	West	L	794	762	812	798	0.6	1.3
			R	414	402	357	349	2.9	2.7
Pittwater / Waterloo	Pittwater Road	South	T	1544	1472	1579	1522	0.9	1.3
			R	86	93	87	99	0.1	0.6
	Waterloo Street	East	L	117	116	100	75	1.6	4.2
			R	220	224	249	254	1.9	1.9
	Pittwater Road	North	L	200	188	167	167	2.4	1.6
			T	1816	1575	1661	1568	3.7	0.2
Pittwater / Albert / Berry Car Park	Pittwater Road	South	L	26	23	26	22	0.0	0.2
			T	1627	1562	1656	1608	0.7	1.2
	Pittwater Road	North	L	46	21	41	22	0.8	0.2
			T	1855	1647	1749	1601	2.5	1.1
			R	25	35	27	34	0.4	0.2
	Berry Car Park	West	L	6	0	5	2	0.4	2.0
			R	27	19	20	18	1.4	0.2

Brookvale Turning Movement Flows – AM Peak (All Vehicles)

Intersection name	Road name	Approach	Turn	Modelled		Observed		GEH	
				7 to 8	8 to 9	7 to 8	8 to 9	7 to 8	8 to 9
Pittwater / Hawkesbury	Pittwater Road	South	L	11	14	16	19	1.3	1.3
			T	892	996	921	1120	1.0	3.8
			R	29	52	37	60	1.4	1.1
	Hawkesbury Avenue	East	L	7	11	14	21	2.2	2.5
			T	33	32	33	50	0.1	2.8
			R	101	94	101	152	0.0	5.2
	Pittwater Road	North	L	315	498	323	497	0.4	0.0
			T	1480	1692	1359	1613	3.2	1.9
	Hawkesbury Avenue	West	L	13	24	12	26	0.3	0.3
			T	68	137	68	147	0.0	0.9
			R	25	60	29	63	0.8	0.4
Pittwater / Dee Why / Kingsway	Pittwater Road	South	L	18	33	24	40	1.3	1.2
			T	727	803	760	935	1.2	4.5
	Dee Why Parade	East	L	19	34	65	61	7.1	3.9
			T	72	84	75	84	0.3	0.0
			R	213	251	230	292	1.1	2.5
	Pittwater Road	North	L	141	188	157	199	1.3	0.8
			T	1382	1562	1408	1512	0.7	1.3
Pittwater / Howard / St David	Pittwater Road	South	L	25	29	33	38	1.5	1.5
			T	708	793	682	780	1.0	0.5
	Howard Avenue	East	L	43	41	32	35	1.7	1.0
			T	151	163	147	160	0.3	0.3
			R	26	30	55	60	4.6	4.5
	Pittwater Road	North	L	55	54	61	58	0.8	0.5
			T	1336	1552	1315	1239	0.6	8.4
	St David Avenue	West	L	10	14	25	37	3.6	4.5
			T	126	183	127	185	0.0	0.2
			R	25	32	10	15	3.5	3.4
Pittwater / Oaks	Pittwater Road	South	T	733	821	713	815	0.7	0.2
			R	134	127	140	143	0.5	1.4
	Oaks Avenue	East	L	105	96	103	92	0.2	0.4
	Pittwater Road	North	L	58	60	61	56	0.4	0.6
			T	1327	1567	1331	1215	0.1	9.4
Pittwater / Fisher	Pittwater Road	South	L	283	422	316	472	1.9	2.4
			T	824	905	825	1007	0.0	3.3
	Pittwater Road	North	T	1415	1661	1507	1560	2.4	2.5
	Fisher Road	West	L	43	43	37	49	0.9	0.9
			R	434	386	481	461	2.2	3.6
Pittwater / Pacific	Pittwater Road	South	T	1043	1203	991	1242	1.6	1.1
	Pacific Parade	East	L	165	194	123	90	3.5	8.7
			R	78	123	153	244	7.0	8.9

	Pittwater Road	North	L	68	130	79	138	1.3	0.7
			T	1774	1917	1913	1959	3.2	1.0
Pittwater / Sturdee	Pittwater Road	South	T	958	1110	1098	1182	4.4	2.1
			R	71	114	115	163	4.6	4.2
	Sturdee Parade	East	L	220	214	259	278	2.5	4.1
			R	88	100	50	39	4.6	7.3
	Pittwater Road	North	L	22	41	15	40	1.6	0.2
			T	1905	2064	2036	2082	3.0	0.4
Pittwater / Warringah / Harbord	Pittwater Road	South	L	119	143	82	102	3.7	3.7
			T	819	1030	846	950	0.9	2.5
			R	107	129	105	123	0.2	0.5
	Harbord Road	East	L	25	27	26	34	0.2	1.3
			T	350	363	344	387	0.3	1.2
			R	259	266	263	269	0.2	0.2
	Pittwater Road	North	L	364	413	453	447	4.4	1.6
			T	1414	1607	1596	1586	4.7	0.5
			R	270	283	298	308	1.7	1.5
	Warringah Road	West	L	67	86	108	128	4.4	4.1
			T	418	469	419	485	0.0	0.7
			R	312	386	336	448	1.3	3.0
Pittwater / Mitchell	Mitchell Road	South	L	25	44	28	48	0.6	0.6
			R	125	222	134	225	0.8	0.2
	Pittwater Road	East	L	38	45	15	15	4.6	5.5
			T	1573	1721	1744	1807	4.2	2.0
	Pittwater Road	West	T	1003	1113	860	1163	4.7	1.5
			R	36	41	86	89	6.4	5.9
Pittwater / Pine	Pittwater Road	East	T	1495	1653	1675	1718	4.5	1.6
			R	103	112	84	104	2.0	0.8
	Pine Avenue	North	L	82	93	44	74	4.8	2.1
			R	65	75	104	97	4.2	2.4
	Pittwater Road	West	L	51	61	23	29	4.7	4.7
			T	957	1061	882	1146	2.5	2.6
Pittwater / Old Pittwater / Winbourne	Pittwater Road	South	L	30	37	30	39	0.1	0.4
			T	799	896	772	999	1.0	3.3
	Winbourne Road	East	L	59	98	59	97	0.0	0.1
			T	148	247	152	249	0.3	0.1
	Pittwater Road	North	L	10	12	10	11	0.1	0.3
			T	1365	1475	1213	1268	4.2	5.6
			R	177	244	204	247	2.0	0.2
	Old Pittwater Road	West	L	97	96	85	89	1.2	0.8
			T	134	140	136	142	0.2	0.1
			R	88	96	132	138	4.2	3.9
Pittwater / Sydenham	Pittwater Road	South	T	871	1035	885	1113	0.5	2.4
			R	176	232	190	255	1.0	1.5
	Sydenham	East	L	91	130	96	143	0.5	1.1

	Road		R	0	0	2	0	2.0	0.0
	Pittwater Road	North	L	18	22	21	29	0.7	1.4
			T	1490	1644	1385	1519	2.8	3.1
Pittwater / Cross / Bus Station	Pittwater Road	South	L	80	161	129	234	4.8	5.2
			T	1072	1272	1106	1403	1.0	3.6
	Pittwater Road	North	T	1445	1509	1506	1451	1.6	1.5
			R	140	347	135	311	0.4	2.0
	Cross Road	West	L	93	148	75	148	2.0	0.0
			R	135	198	126	185	0.8	0.9
Pittwater / Condamine / William	Condamine Street	South	L	25	76	26	78	0.2	0.2
			T	927	1169	851	1160	2.5	0.3
	Pittwater Road	East	L	78	137	79	132	0.1	0.4
			T	23	70	23	70	0.0	0.0
			R	368	455	309	409	3.2	2.2
	Pittwater Road	North	L	330	479	338	411	0.4	3.2
			T	1228	1225	1323	1215	2.7	0.3

Brookvale Turning Movement Flows – AM Peak (Buses)

Pittwater / Hawkesbury	Pittwater Road	South	T	13	16	27	23	3.1	1.6
	Pittwater Road	North	T	68	37	51	39	2.2	0.3
Pittwater / Condamine / William	Condamine Street	South	T	10	15	11	31	0.3	3.3
	Condamine Street	North	T	64	40	96	57	3.6	2.4

Brookvale Turning Movement Flows – PM Peak (All Vehicles)

Intersection name	Road name	Approach	Turn	Modelled		Observed		GEH	
				16.30 to 17.30	17.30 to 18.30	16.30 to 17.30	17.30 to 18.30	16.30 to 17.30	17.30 to 18.30
Pittwater / Hawkesbury	Pittwater Road	South	L	24	24	31	28	1.3	0.8
			T	1702	1644	1709	1556	0.2	2.2
			R	64	66	74	77	1.2	1.3
	Hawkesbury Avenue	East	L	30	23	23	19	1.3	0.8
			T	104	90	105	87	0.1	0.3
			R	177	150	176	147	0.1	0.3
	Pittwater Road	North	L	275	258	274	258	0.1	0.0
			T	1146	1066	1142	1047	0.1	0.6
	Hawkesbury Avenue	West	L	28	28	25	29	0.5	0.2
			T	132	133	121	137	1.0	0.4
			R	40	44	34	39	0.9	0.8
Pittwater / Dee Why / Kingsway	Pittwater Road	South	L	70	76	64	60	0.7	1.9
			T	1572	1508	1614	1624	1.1	2.9
	Dee Why Parade	East	L	50	49	79	62	3.6	1.7
			T	91	105	91	104	0.0	0.1
			R	232	235	318	340	5.2	6.2
	Pittwater Road	North	L	125	146	116	150	0.8	0.3
			T	1082	985	1037	1024	1.4	1.2
Pittwater / Howard / St David	Pittwater Road	South	L	37	41	35	35	0.3	1.0
			T	1523	1467	1346	1320	4.7	3.9
	Howard Avenue	East	L	54	51	63	60	1.1	1.1
			T	170	165	165	157	0.4	0.7
			R	83	81	107	102	2.5	2.2
	Pittwater Road	North	L	66	55	64	58	0.3	0.5
			T	1061	985	1097	1006	1.1	0.7
	St David Avenue	West	L	40	41	59	58	2.7	2.4
			T	251	243	247	240	0.3	0.2
			R	7	8	4	4	1.1	1.5
Pittwater / Oaks	Pittwater Road	South	T	1562	1505	1397	1357	4.3	3.9
			R	186	199	242	262	3.8	4.1
	Oaks Avenue	East	L	181	147	154	137	2.1	0.8
	Pittwater Road	North	L	40	44	51	48	1.7	0.6
			T	1084	996	1117	1044	1.0	1.5
Pittwater / Fisher	Pittwater Road	South	L	548	515	592	548	1.8	1.4
			T	1680	1628	1728	1694	1.2	1.6
	Pittwater Road	North	T	1275	1139	1177	1036	2.8	3.1
	Fisher Road	West	L	68	78	43	62	3.4	1.9
			R	448	437	470	436	1.0	0.0
Pittwater / Pacific	Pittwater Road	South	T	1872	1809	1999	1970	2.9	3.7
	Pacific Parade	East	L	51	47	75	78	3.0	3.9

			R	356	334	328	324	1.5	0.6
	Pittwater Road	North	L	185	168	172	168	1.0	0.0
			T	1544	1401	1465	1366	2.0	0.9
Pittwater / Sturdee	Pittwater Road	South	T	1778	1722	1820	1800	1.0	1.9
			R	213	236	313	350	6.2	6.7
	Sturdee Parade	East	L	138	126	196	192	4.5	5.2
			R	83	87	56	50	3.2	4.5
	Pittwater Road	North	L	54	56	86	56	3.8	0.0
			T	1546	1377	1508	1434	1.0	1.5
Pittwater / Warringah / Harbord	Pittwater Road	South	L	156	133	134	101	1.8	3.0
			T	1526	1510	1579	1457	1.3	1.4
			R	153	124	124	114	2.5	0.9
	Harbord Road	East	L	15	13	29	26	3.0	2.9
			T	440	406	439	409	0.0	0.1
			R	365	394	353	380	0.6	0.7
	Pittwater Road	North	L	314	359	397	449	4.4	4.5
			T	1051	930	997	886	1.7	1.5
			R	286	256	350	299	3.6	2.6
	Warringah Road	West	L	196	198	243	249	3.2	3.4
			T	441	483	439	492	0.1	0.4
			R	268	242	198	164	4.6	5.5
Pittwater / Mitchell	Mitchell Road	South	L	53	35	43	29	1.5	1.0
			R	348	300	345	239	0.1	3.7
	Pittwater Road	East	L	128	139	187	165	4.7	2.1
			T	1199	1015	1095	962	3.1	1.7
	Pittwater Road	West	T	1827	1752	1770	1642	1.3	2.7
			R	125	93	129	135	0.4	3.9
Pittwater / Pine	Pittwater Road	East	T	1198	1011	1221	1091	0.7	2.5
			R	54	39	60	37	0.8	0.4
	Pine Avenue	North	L	111	78	64	35	5.0	5.7
			R	66	39	90	91	2.7	6.4
	Pittwater Road	West	L	50	48	79	75	3.6	3.4
			T	1841	1767	1756	1667	2.0	2.4
Pittwater / Old Pittwater / Winbourne	Pittwater Road	South	L	59	66	81	77	2.6	1.3
			T	1428	1416	1589	1507	4.1	2.4
	Winbourne Road	East	L	96	64	93	64	0.3	0.0
			T	264	177	255	177	0.5	0.0
	Pittwater Road	North	L	27	24	26	24	0.2	0.1
			T	1140	931	1081	988	1.8	1.9
			R	102	106	113	132	1.1	2.4
	Old Pittwater Road	West	L	270	269	259	229	0.7	2.5
			T	187	166	173	153	1.0	1.0
			R	83	66	96	85	1.4	2.2
Pittwater / Sydenham	Pittwater Road	South	T	1573	1526	1579	1565	0.2	1.0
			R	214	182	302	218	5.5	2.5

	Sydenham Road	East	L	257	183	255	173	0.1	0.7
			R	0	0	1	3	1.4	2.4
	Pittwater Road	North	L	28	18	32	10	0.7	2.1
			T	1295	1049	1353	1202	1.6	4.6
Pittwater / Cross / Bus Station	Pittwater Road	South	L	78	57	120	70	4.2	1.6
			T	1577	1679	1619	1324	1.1	9.2
	Pittwater Road	North	T	1262	1007	1039	742	6.6	9.0
			R	223	131	164	100	4.2	2.9
	Cross Road	West	L	323	112	275	112	2.8	0.0
			R	366	171	317	176	2.7	0.4
Pittwater / Condamine / William	Condamine Street	South	L	47	48	51	42	0.6	0.9
			T	1250	1371	1314	1066	1.8	8.7
	Pittwater Road	East	L	50	51	49	52	0.1	0.1
			T	39	24	38	22	0.2	0.4
			R	398	384	299	284	5.3	5.5
	Pittwater Road	North	L	566	384	491	304	3.3	4.3
			T	1047	796	907	728	4.5	2.5

Brookvale Turning Movement Flows – PM Peak (Buses)

Pittwater / Hawkesbury	Pittwater Road	South	T	32	47	31	46	0.2	0.1
	Pittwater Road	North	T	19	20	25	21	1.3	0.2
Pittwater / Condamine / William	Condamine Street	South	T	37	45	60	59	3.3	1.9
	Condamine Street	North	T	17	16	28	21	2.3	1.2

Brookvale Turning Movement Flows – Sat Peak (All Vehicles)

Intersection name	Road name	Approach	Turn	Modelled		Observed		GEH	
				1130 to 1230	1230 to 1330	1130 to 1230	1230 to 1330	1130 to 1230	1230 to 1330
Pittwater / Hawkesbury	Pittwater Road	South	L	16	15	23	24	1.7	2.1
			T	1240	1222	1365	1412	3.5	5.2
			R	46	56	55	67	1.3	1.4
	Hawkesbury Avenue	East	L	26	26	32	28	1.1	0.5
			T	75	67	76	67	0.1	0.0
			R	233	204	230	204	0.2	0.0
	Pittwater Road	North	L	396	307	393	306	0.2	0.1
			T	1351	1313	1352	1293	0.0	0.6
	Hawkesbury Avenue	West	L	22	14	22	14	0.0	0.1
			T	123	83	126	82	0.3	0.1
			R	48	27	54	35	0.8	1.4
Pittwater / Dee Why / Kingsway	Pittwater Road	South	L	0	0	0	0		
			T	1102	1079	0	0		
	Dee Why Parade	East	L	60	53	64	60	0.5	1.0
			T	80	76	81	76	0.1	0.0
			R	216	210	266	251	3.2	2.7
	Pittwater Road	North	L	201	191	0	0		
			T	1202	1129	0	0		
Pittwater / Howard / St David	Pittwater Road	South	L	40	49	47	55	1.0	0.9
			T	1036	1035	1067	1151	0.9	3.5
	Howard Avenue	East	L	39	30	36	28	0.5	0.3
			T	165	135	164	130	0.1	0.5
			R	44	36	62	49	2.4	2.0
	Pittwater Road	North	L	50	53	52	56	0.2	0.4
			T	1197	1137	1110	1204	2.6	2.0
	St David Avenue	West	L	17	18	38	39	4.0	4.0
			T	193	201	191	199	0.1	0.1
			R	27	29	16	16	2.4	2.6
Pittwater / Oaks	Pittwater Road	South	T	1063	1090	1151	1229	2.6	4.1
			R	200	186	262	241	4.1	3.8
	Oaks Avenue	East	L	150	146	140	130	0.8	1.4
	Pittwater Road	North	L	55	51	51	53	0.6	0.3
			T	1190	1150	1103	1163	2.6	0.4
Pittwater / Fisher	Pittwater Road	South	L	517	519	543	554	1.1	1.5
			T	1208	1233	1259	1284	1.5	1.4
	Pittwater Road	North	T	1333	1296	1264	1258	1.9	1.1
	Fisher Road	West	L	44	44	34	34	1.7	1.5
			R	333	349	365	376	1.7	1.4
Pittwater / Pacific	Pittwater Road	South	T	1509	1577	1586	1632	2.0	1.4
	Pacific Parade	East	L	105	92	88	65	1.7	3.0

			R	209	185	240	220	2.1	2.5
	Pittwater Road	North	L	88	86	91	94	0.4	0.9
			T	1573	1561	1619	1669	1.1	2.7
Pittwater / Sturdee	Pittwater Road	South	T	1467	1507	1498	1497	0.8	0.3
			R	241	237	270	263	1.8	1.6
	Sturdee Parade	East	L	250	243	247	244	0.2	0.1
			R	66	68	66	59	0.0	1.1
	Pittwater Road	North	L	20	19	23	23	0.6	0.8
			T	1649	1628	1695	1665	1.1	0.9
Pittwater / Warringah / Harbord	Pittwater Road	South	L	136	141	83	92	5.1	4.5
			T	1381	1386	1176	1248	5.7	3.8
			R	122	120	149	122	2.3	0.2
	Harbord Road	East	L	66	66	48	48	2.4	2.4
			T	432	451	495	398	2.9	2.6
			R	252	266	343	289	5.3	1.4
	Pittwater Road	North	L	412	401	397	417	0.7	0.8
			T	1147	1136	1151	1152	0.1	0.5
			R	347	346	392	404	2.3	3.0
	Warringah Road	West	L	234	239	274	281	2.5	2.6
			T	492	526	490	526	0.1	0.0
			R	233	233	243	227	0.6	0.4
Pittwater / Mitchell	Mitchell Road	South	L	75	85	56	61	2.4	2.8
			R	263	278	262	290	0.0	0.7
	Pittwater Road	East	L	25	27	14	13	2.6	3.1
			T	1402	1421	1646	1578	6.3	4.1
	Pittwater Road	West	T	1481	1446	1428	1268	1.4	4.8
			R	91	109	92	116	0.1	0.7
Pittwater / Pine	Pittwater Road	East	T	1438	1469	1589	1526	3.9	1.5
			R	39	37	71	65	4.3	3.9
	Pine Avenue	North	L	73	78	50	42	2.9	4.6
			R	63	62	79	89	1.9	3.1
	Pittwater Road	West	L	68	58	37	33	4.3	3.6
			T	1499	1477	1433	1309	1.7	4.5
Pittwater / Old Pittwater / Winbourne	Pittwater Road	South	L	64	64	54	48	1.3	2.1
			T	1314	1279	1377	1228	1.7	1.4
	Winbourne Road	East	L	99	102	97	95	0.3	0.7
			T	241	249	246	244	0.4	0.3
	Pittwater Road	North	L	9	8	11	10	0.6	0.6
			T	1425	1417	1259	1215	4.5	5.6
			R	79	81	110	117	3.2	3.6
	Old Pittwater Road	West	L	119	117	116	107	0.3	1.0
			T	185	172	185	170	0.0	0.1
			R	165	149	180	165	1.1	1.3
Pittwater / Sydenham	Pittwater Road	South	T	1426	1350	0	0		
			R	209	186	171	158	2.8	2.1

	Sydenham Road	East	L	68	69	70	46	0.2	3.0
			R	51	54	74	88	2.9	4.0
	Pittwater Road	North	L	14	11	0	0		
			T	1678	1640	0	0		
Pittwater / Cross / Bus Station	Pittwater Road	South	L	219	183	242	216	1.5	2.4
			T	1412	1329	1628	1456	5.5	3.4
	Pittwater Road	North	T	1350	1327	1261	1178	2.5	4.2
			R	395	365	402	346	0.4	1.0
	Cross Road	West	L	236	220	287	260	3.2	2.6
			R	299	329	282	286	1.0	2.4
Pittwater / Condamine / William	Condamine Street	South	L	61	59	63	61	0.3	0.2
			T	1152	1156	1219	1165	1.9	0.3
	Pittwater Road	East	L	73	64	74	64	0.1	0.0
			T	31	27	32	28	0.2	0.2
			R	443	331	427	312	0.8	1.1
	Pittwater Road	North	L	629	680	595	661	1.4	0.7
			T	994	1000	1028	997	1.1	0.1

Brookvale Turning Movement Flows – Sat Peak (Buses)

Pittwater / Hawkesbury	Pittwater Road	South	T	13	13	12	11	0.3	0.6
	Pittwater Road	North	T	14	14	11	10	0.8	1.2
Pittwater / Condamine / William	Condamine Street	South	T	12	13				
	Condamine Street	North	T	11	13				

Appendix B

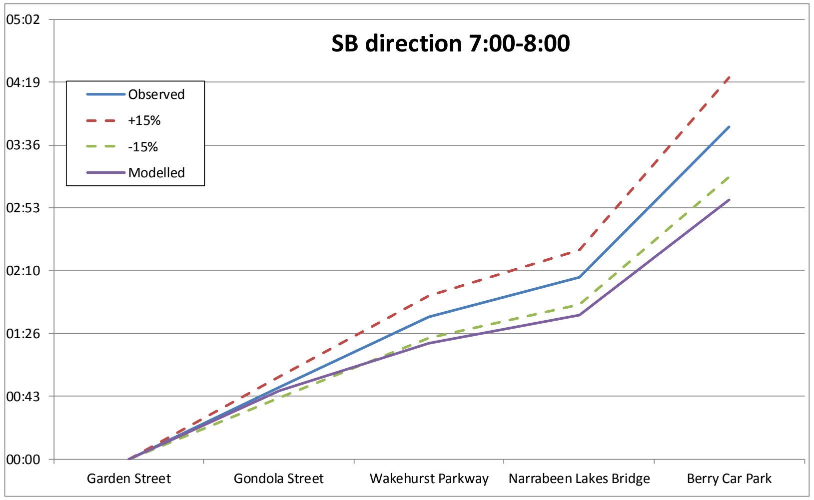
Travel Time Validation Outputs

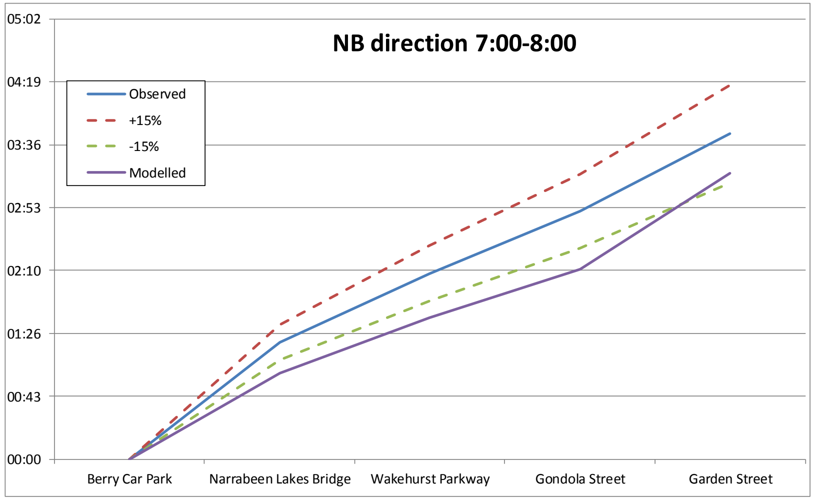
Appendix B-1 Bus Travel Time Comparisons for Narrabeen

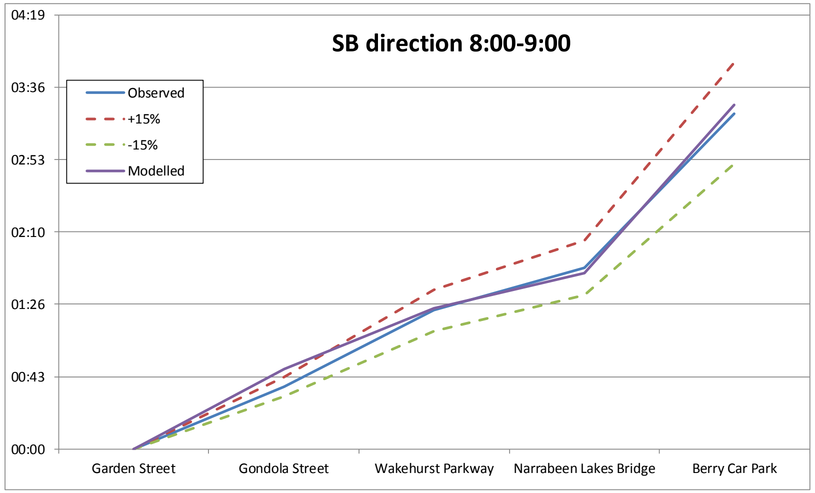
Section between		Southbound						Northbound					
		Observed		Modelled		Difference (s)		Observed		Modelled		Difference (s)	
		7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00
Berry Car Park	Narrabeen Lakes Bridge	01:43	01:32	01:19	01:40	-24	8	01:21	01:06	00:59	01:09	-21	3
Narrabeen Lakes Bridge	Wakehurst Parkway	00:27	00:26	00:19	00:21	-8	-4	00:47	00:47	00:38	00:44	-9	-3
Wakehurst Parkway	Gondola Street	00:48	00:46	00:32	00:36	-16	-9	00:43	00:43	00:33	00:27	-9	-16
Gondola Street	Garden Street	00:49	00:37	00:47	00:48	-2	11	00:53	00:44	01:06	01:23	13	39
Total		**03:48**	**03:20**	**02:58**	**03:25**	**-50**	**5**	**03:44**	**03:19**	**03:16**	**03:43**	**-27**	**24**

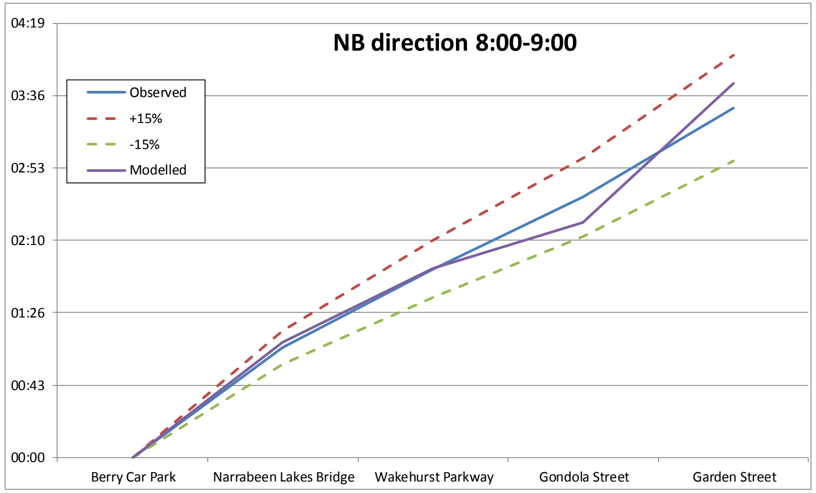
Section between		Southbound						Northbound					
		Observed		Modelled		Difference (s)		Observed		Modelled		Difference (s)	
		16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30
Berry Car Park	Narrabeen Lakes Bridge	01:27	01:17	00:58	00:54	-29	-23	00:57	00:53	00:46	01:08	-11	15
Narrabeen Lakes Bridge	Wakehurst Parkway	00:42	00:29	00:29	00:29	-13	1	00:49	00:51	00:44	00:49	-5	-3
Wakehurst Parkway	Gondola Street	00:41	00:38	00:34	00:36	-7	-3	00:40	00:47	00:34	00:39	-7	-8
Gondola Street	Garden Street	00:38	00:33	01:14	00:54	35	20	00:52	00:46	00:46	00:54	-6	8
Total		**03:28**	**02:57**	**03:15**	**02:53**	**-14**	**-4**	**03:19**	**03:17**	**02:50**	**03:29**	**-29**	**13**

Section between		Southbound						Northbound					
		Observed		Modelled		Difference (s)		Observed		Modelled		Difference (s)	
		11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30
Berry Car Park	Narrabeen Lakes Bridge	01:29	01:25	01:41	01:07	11	-17	01:42	01:20	01:31	01:53	-11	33
Narrabeen Lakes Bridge	Wakehurst Parkway	00:53	00:32	00:17	00:14	-36	-17	00:53	00:43	01:01	00:21	7	-22
Wakehurst Parkway	Gondola Street	00:46	00:37	00:40	00:32	-5	-5	00:56	00:58	00:43	01:16	-13	19
Gondola Street	Garden Street	00:43	00:39	00:39	00:46	-3	7	00:45	00:43	01:10	00:55	25	12
Total		**03:51**	**03:12**	**03:18**	**02:39**	**-33**	**-33**	**04:16**	**03:45**	**04:25**	**04:26**	**9**	**42**

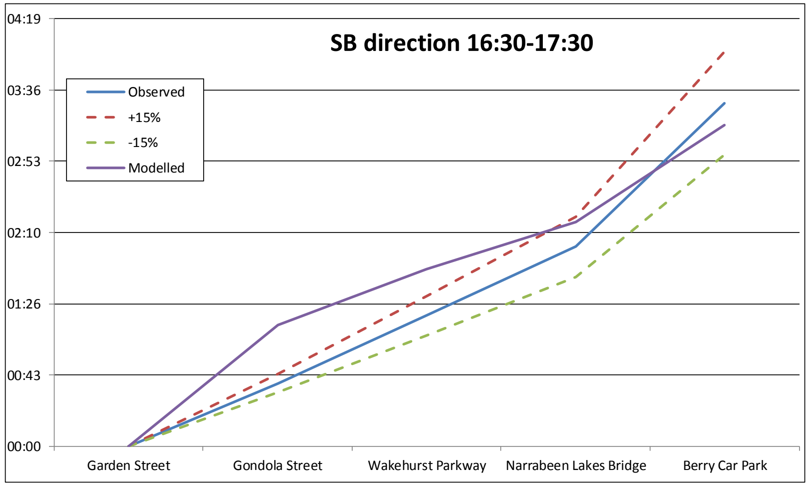


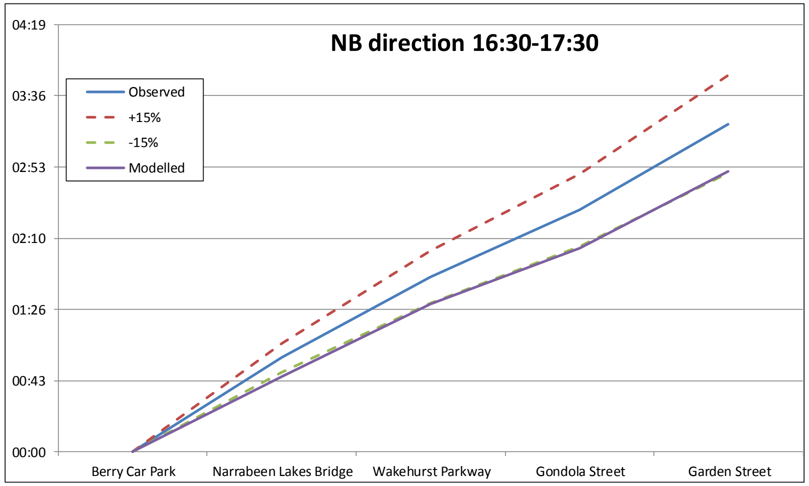


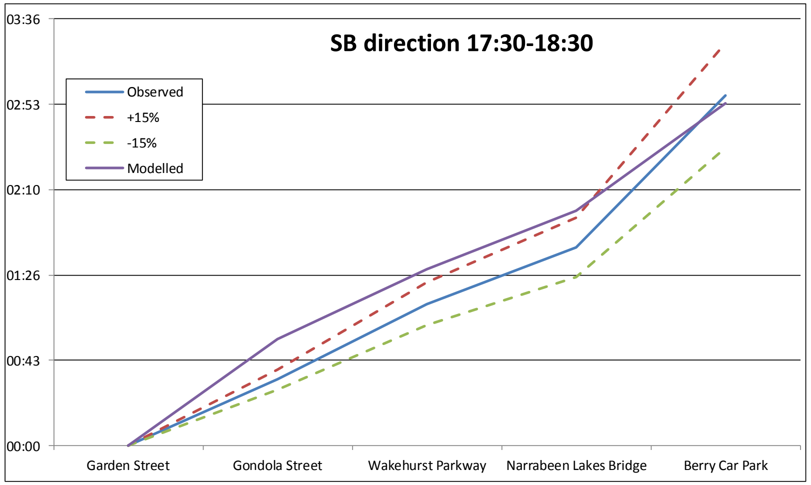


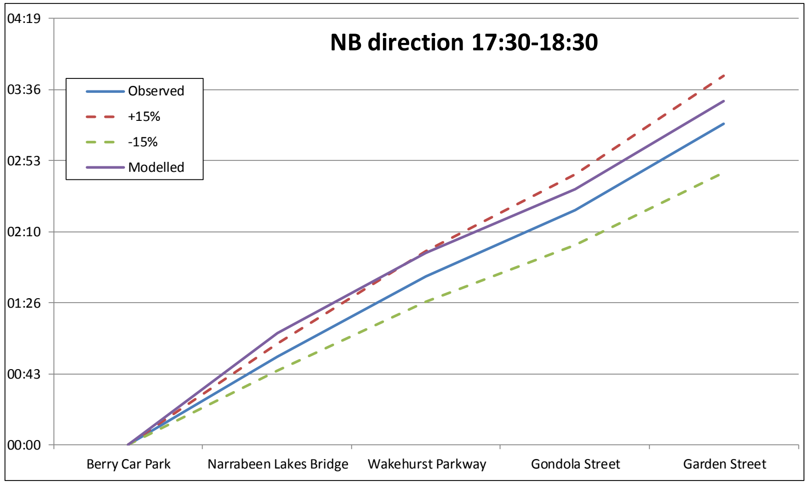


Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.

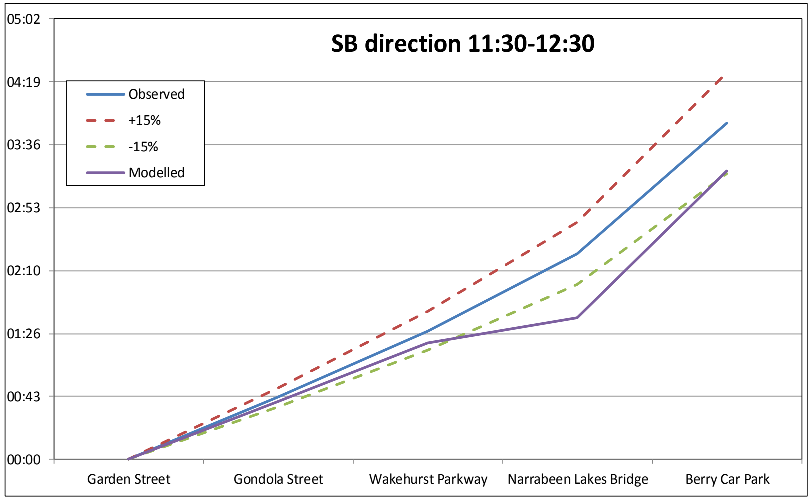


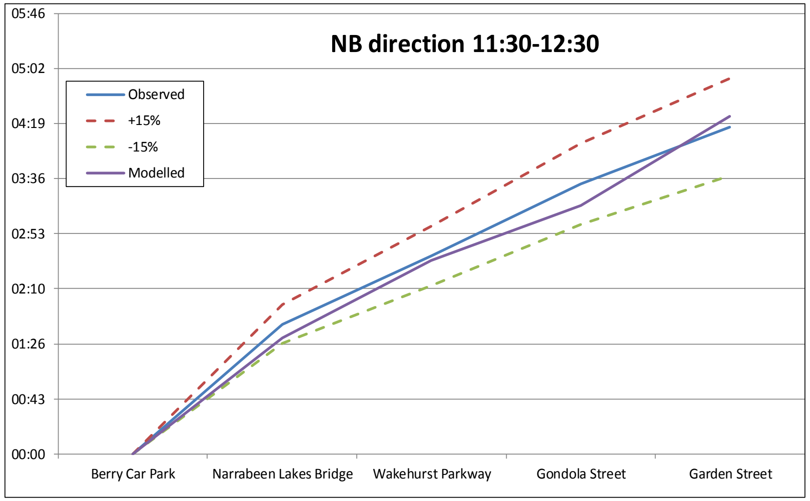


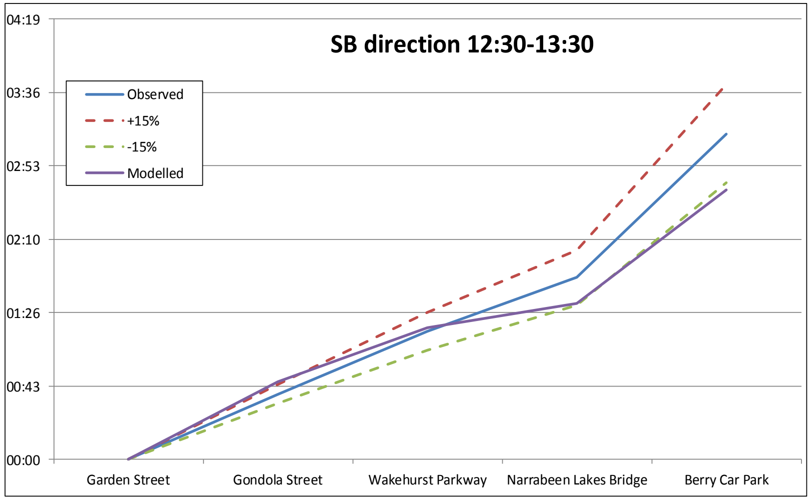


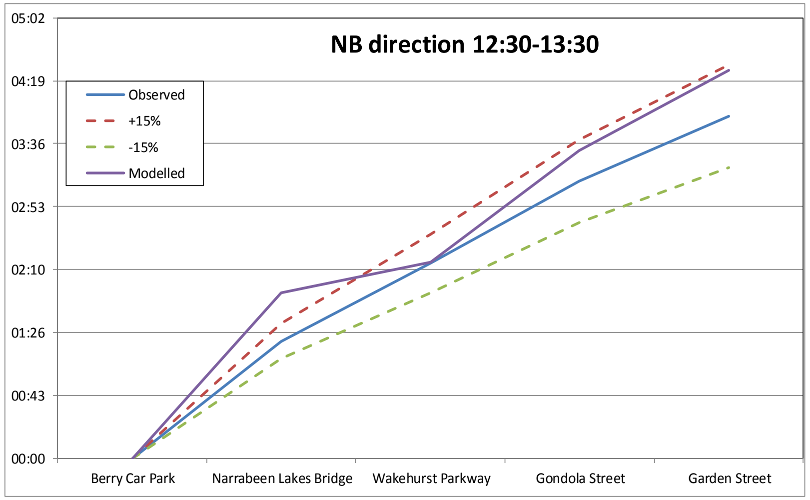


Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.









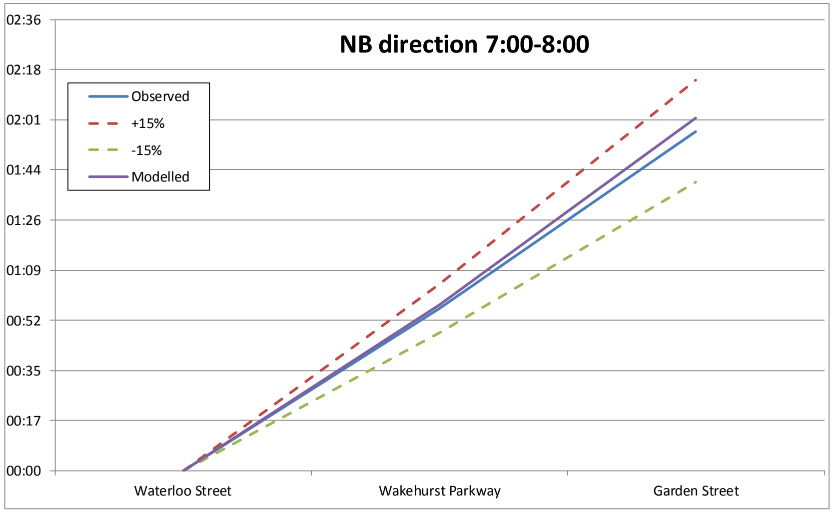
Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.

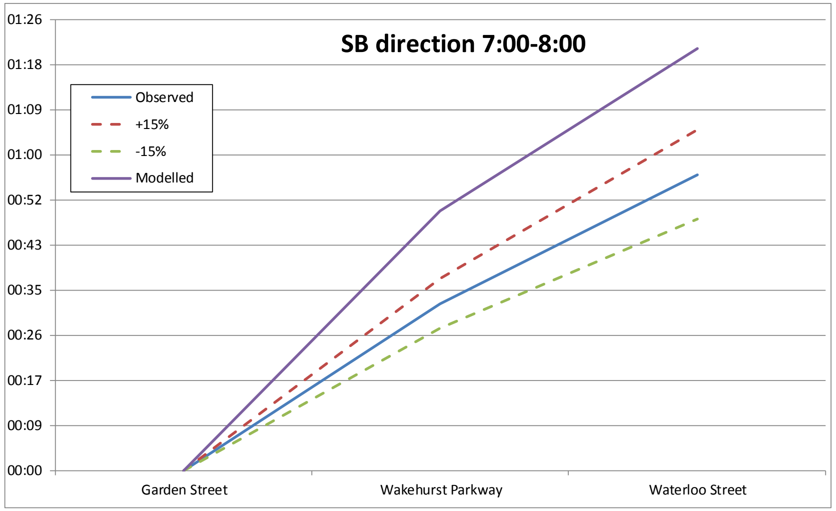
Appendix B-2 General Traffic Travel Time Comparisons for Narrabeen

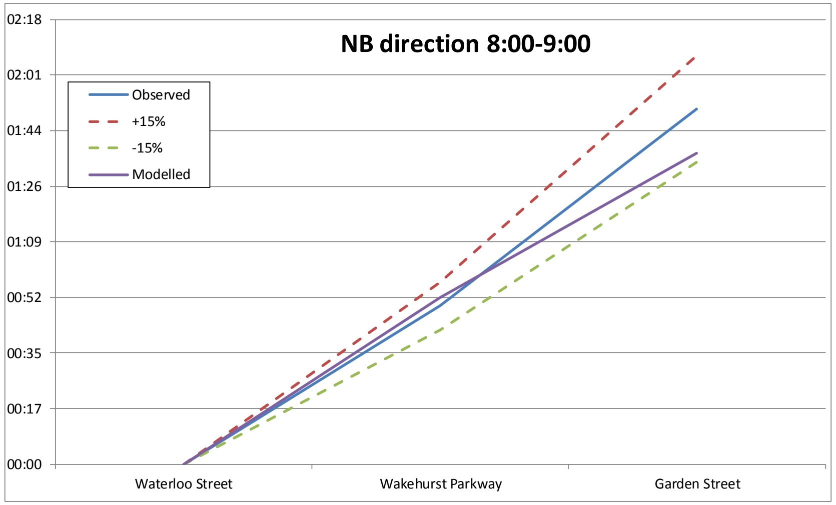
Section between		Southbound						Northbound					
		Observed		Modelled		Difference (s)		Observed		Modelled		Difference (s)	
		7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00
Waterloo Street	Wakehurst Parkway	00:25	00:24	00:31	00:36	6	11	00:56	00:49	00:57	00:52	1	3
Wakehurst Parkway	Garden Street	00:32	00:32	00:50	00:45	18	13	01:01	01:17	01:05	00:45	3	-32
Total		**00:57**	**00:56**	**01:21**	**01:21**	**24**	**25**	**01:57**	**02:06**	**02:02**	**01:37**	**5**	**-29**

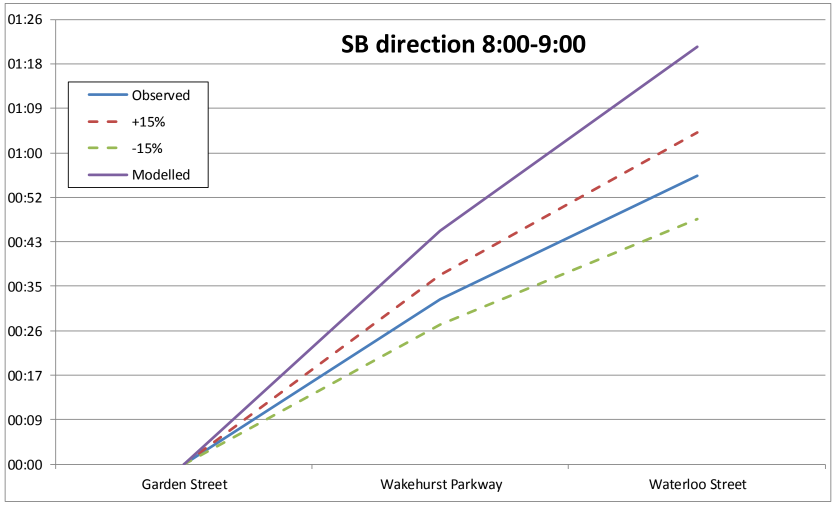
Section between		Southbound						Northbound					
		Observed		Modelled		Difference (s)		Observed		Modelled		Difference (s)	
		16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30
Waterloo Street	Wakehurst Parkway	00:48	00:44	00:42	00:38	-5	-6	00:56	01:11	01:16	01:21	19	10
Wakehurst Parkway	Garden Street	00:32	00:32	00:39	00:44	7	13	01:08	01:00	01:17	01:31	8	31
Total		**01:19**	**01:16**	**01:22**	**01:22**	**2**	**7**	**02:05**	**02:11**	**02:33**	**02:52**	**28**	**40**

Section between		Southbound						Northbound					
		Observed		Modelled		Difference (s)		Observed		Modelled		Difference (s)	
		11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30
Waterloo Street	Wakehurst Parkway	00:40	00:40	00:36	00:25	-5	-15	00:47	01:22	01:11	00:49	25	-33
Wakehurst Parkway	Garden Street	01:04	01:20	00:54	00:36	-10	-44	01:10	01:28	01:28	01:08	19	-20
Total		**01:45**	**02:00**	**01:30**	**01:01**	**-15**	**-59**	**01:56**	**02:50**	**02:40**	**01:57**	**43**	**-52**

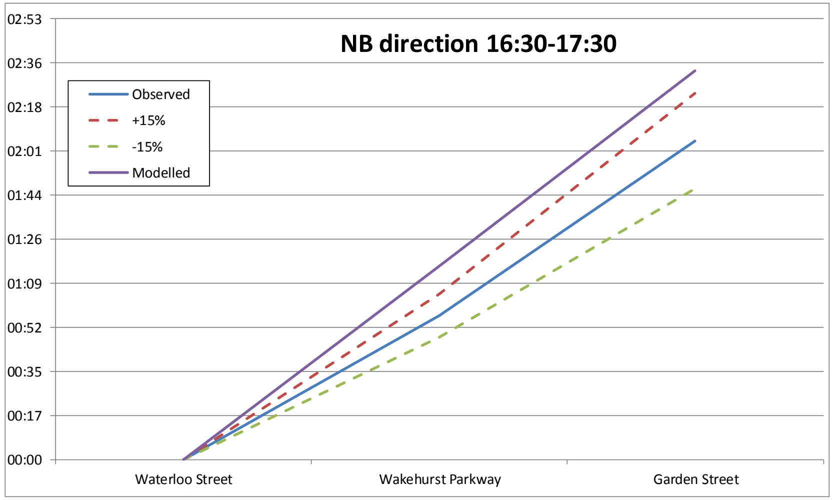


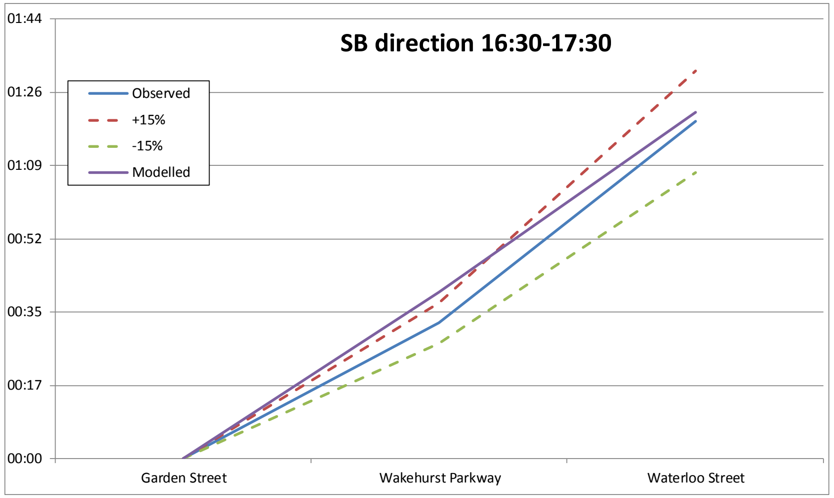


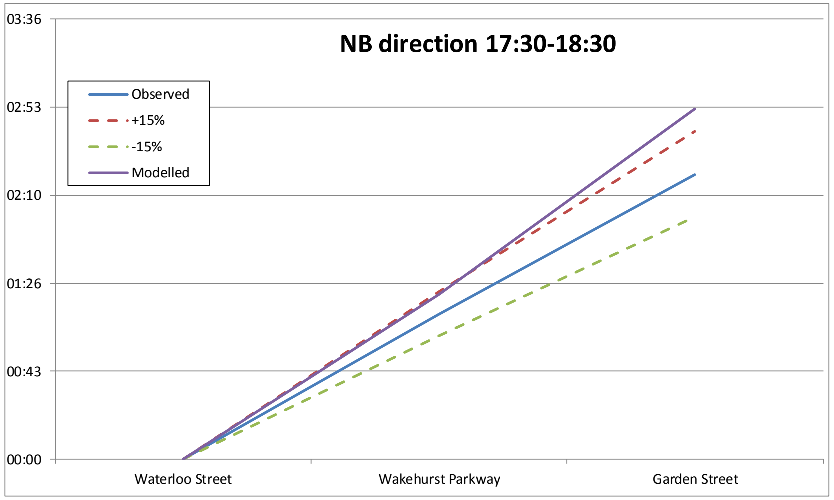


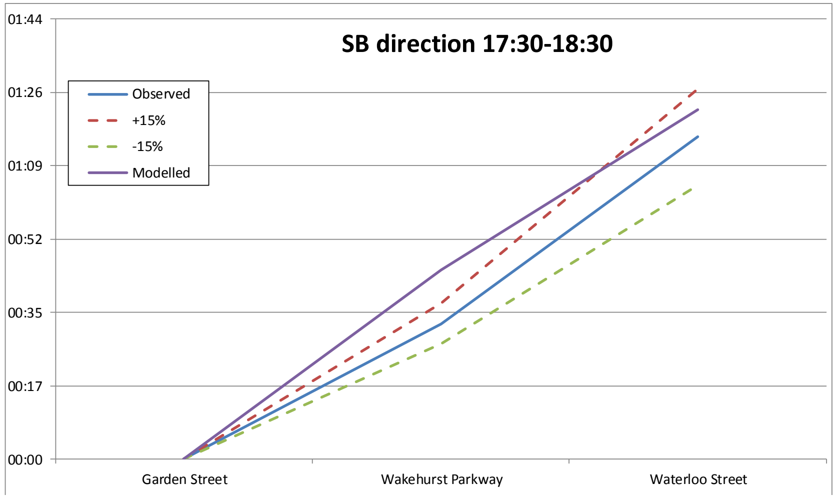


Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.

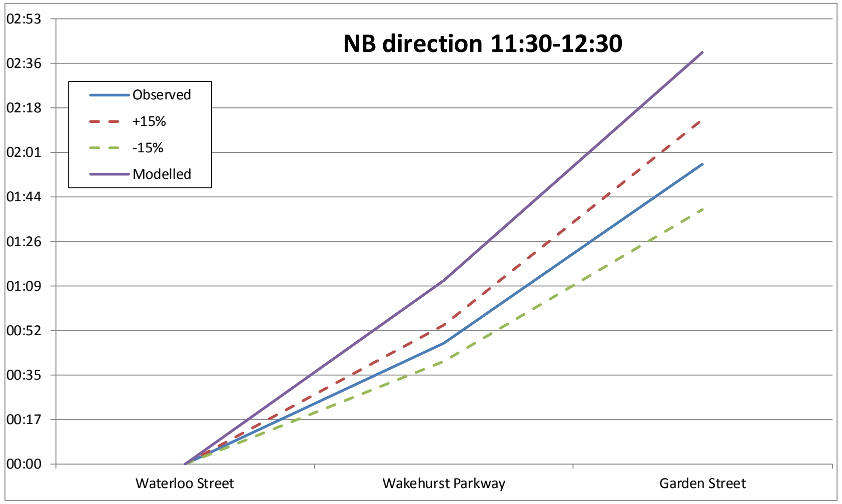


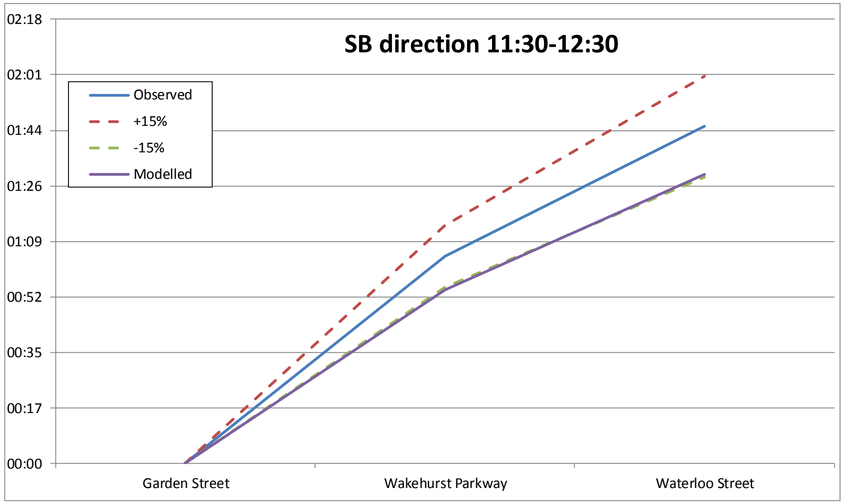


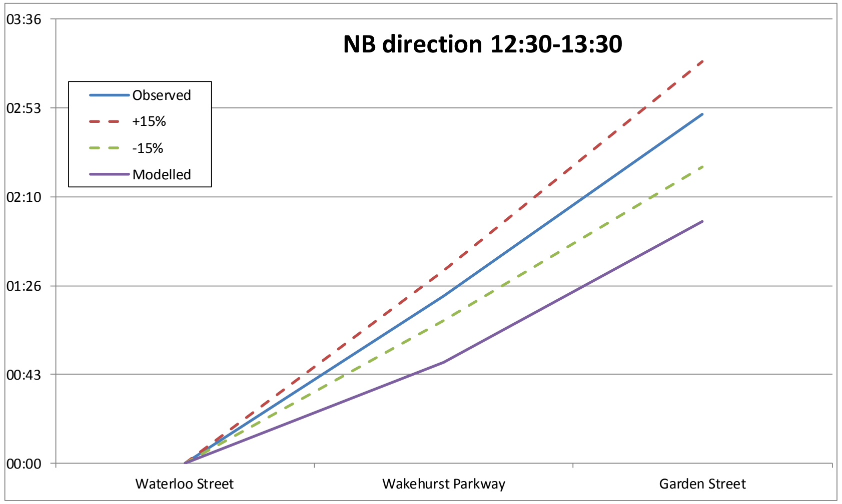


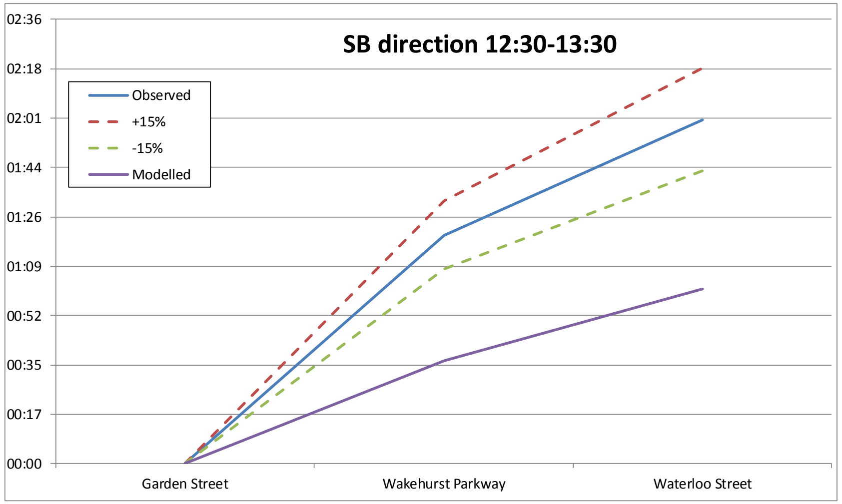


Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.









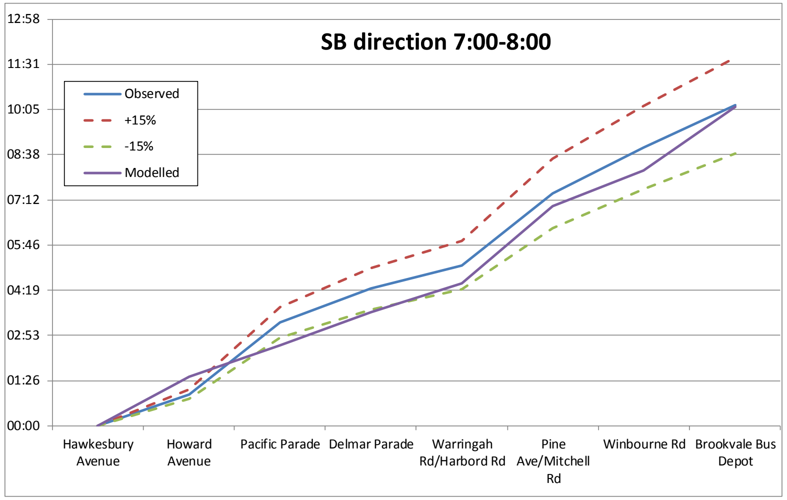
Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.

Appendix B-3 Bus Travel Time Comparisons for Brookvale/Dee Why

Section between		Southbound						Northbound					
		Observed		Modelled		% Difference		Observed		Modelled		% Difference	
		7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00
Brookvale Bus Depot	Winbourne Rd	01:20	01:45	02:00	02:09	50%	23%	01:53	01:53	01:48	01:50	-5%	-3%
Winbourne Rd	Pine Ave/Mitchell Rd	01:28	01:16	01:10	01:24	-21%	10%	00:45	00:36	01:01	01:06	36%	85%
Pine Ave/Mitchell Rd	Warringah Rd/Harbord Rd	02:18	02:02	02:26	02:14	6%	9%	02:09	01:58	02:06	02:11	-2%	11%
Warringah Rd/Harbord Rd	Delmar Parade	00:45	00:42	00:56	00:53	26%	27%	00:31	00:32	00:50	00:51	62%	59%
Delmar Parade	Pacific Parade	01:04	01:07	01:02	01:02	-3%	-8%	01:19	01:13	00:31	00:45	-61%	-38%
Pacific Parade	Howard Avenue	02:18	02:21	01:00	01:21	-56%	-43%	01:35	01:31	02:15	01:52	43%	24%
Howard Avenue	Hawkesbury Avenue	01:00	01:00	01:35	01:46	58%	75%	01:03	01:03	01:00	01:15	-5%	18%
Total		**10:12**	**10:13**	**10:09**	**10:47**	**-1%**	**6%**	**09:16**	**08:45**	**09:31**	**09:50**	**3%**	**12%**

Section between		Southbound						Northbound					
		Observed		Modelled		% Difference		Observed		Modelled		% Difference	
		16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30
Brookvale Bus Depot	Winbourne Rd	01:45	01:24	02:02	02:07	16%	50%	01:18	01:05	01:33	01:22	19%	26%
Winbourne Rd	Pine Ave/Mitchell Rd	01:19	01:04	01:05	00:58	-17%	-9%	00:49	00:35	00:51	00:46	3%	30%
Pine Ave/Mitchell Rd	Warringah Rd/Harbord Rd	02:00	01:47	01:50	01:53	-8%	6%	02:06	01:52	01:55	02:00	-9%	
Warringah Rd/Harbord Rd	Delmar Parade	00:54	00:48	01:12	01:15	34%	55%	00:37	00:38	00:43	00:42	15%	8%
Delmar Parade	Pacific Parade	01:01	01:01	01:16	01:34	24%	55%	00:57	00:56	00:21	00:31	-63%	-44%
Pacific Parade	Howard Avenue	02:00	01:56	01:05	01:26	-45%	-26%	01:18	01:10	01:00	00:58	-23%	-18%
Howard Avenue	Hawkesbury Avenue	01:04	01:03	01:39	01:33	55%	48%	00:54	00:49	00:55	01:01	1%	24%
Total		**10:02**	**09:04**	**10:10**	**10:46**	**1%**	**19%**	**07:59**	**07:06**	**07:17**	**07:18**	**-9%**	**3%**

Section between		Southbound						Northbound					
		Observed		Modelled		% Difference		Observed		Modelled		% Difference	
		11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30
Brookvale Bus Depot	Winbourne Rd	02:08	01:34	01:49	01:58	-15%	26%	01:53	01:38	02:07	02:02	13%	25%
Winbourne Rd	Pine Ave/Mitchell Rd	01:09	00:55	01:07	01:04	-3%	17%	00:34	00:35	00:40	00:48	17%	37%
Pine Ave/Mitchell Rd	Warringah Rd/Harbord Rd	02:12	01:39	01:55	01:58	-13%	19%	02:35	02:23	02:01	02:13	-22%	-7%
Warringah Rd/Harbord Rd	Delmar Parade	00:55	00:43	00:34	00:46	-38%	5%	00:38	00:34	00:51	00:49	32%	46%
Delmar Parade	Pacific Parade	01:08	01:10	01:18	01:05	15%	-7%	01:26	01:15	00:51	00:55	-40%	-26%
Pacific Parade	Howard Avenue	02:49	02:16	01:42	01:50	-40%	-19%	01:47	01:36	02:11	02:29	22%	54%
Howard Avenue	Hawkesbury Avenue	02:13	01:17	02:06	02:19	-5%	81%	01:13	01:04	01:21	01:14	11%	16%
Total		**12:34**	**09:34**	**10:30**	**11:01**	**-16%**	**15%**	**10:07**	**09:05**	**10:01**	**10:30**	**-1%**	**16%**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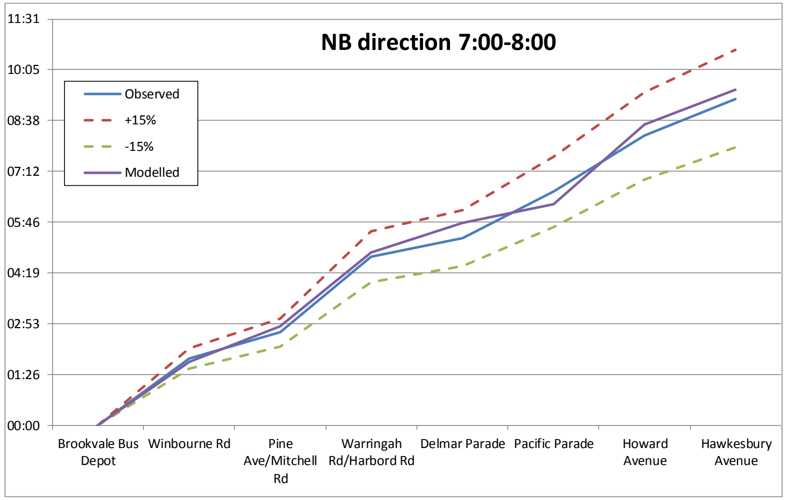
12:58
11:31
10:05
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Observed
+15%
-15%
Modelled
Hawkesbury Avenue
Howard Avenue
Pacific Parade
Delmar Parade
Warringah Rd/Harbord Rd
Pine Ave/Mitchell Rd
Winbourne Rd
Brookvale Bus Depot


NB direction 7:00-8:00
11:31
10:05
08:38
07:12
05:46
04:19
02:53
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+15%
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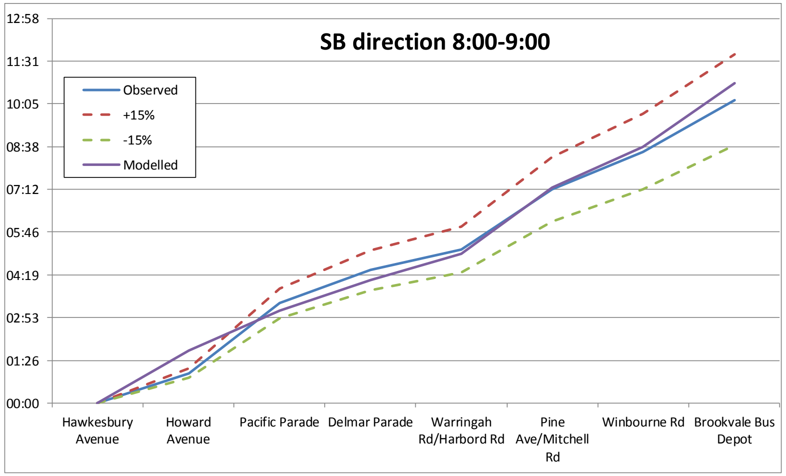
Modelled
Brookvale Bus Depot
Winbourne Rd
Pine Ave/Mitchell Rd
Warringah Rd/Harbord Rd
Delmar Parade
Pacific Parade
Howard Avenue
Hawkesbury Avenue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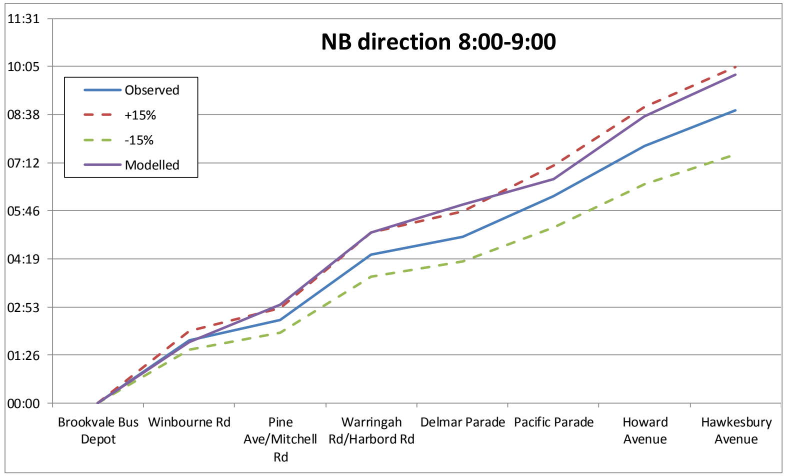
12:58
11:31
10:05
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Observed
+15%
-15%
Modelled
Hawkesbury Avenue
Howard Avenue
Pacific Parade
Delmar Parade
Warringah Rd/Harbord Rd
Pine Ave/Mitchell Rd
Winbourne Rd
Brookvale Bus Depot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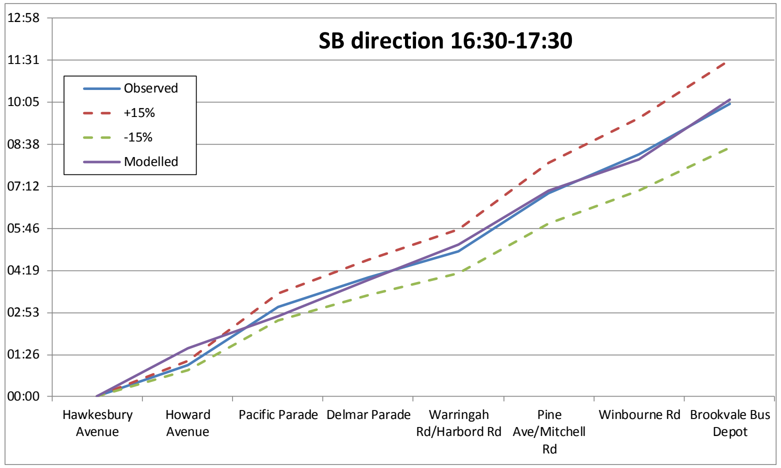
10:05
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Observed
+15%
-15%
Modelled
Brookvale Bus Depot
Winbourne Rd
Pine Ave/Mitchell Rd
Warringah Rd/Harbord Rd
Delmar Parade
Pacific Parade
Howard Avenue
Hawkesbury Avenue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Modelled
12:58
11:31
10:05
08:38
07:12
05:46
04:19
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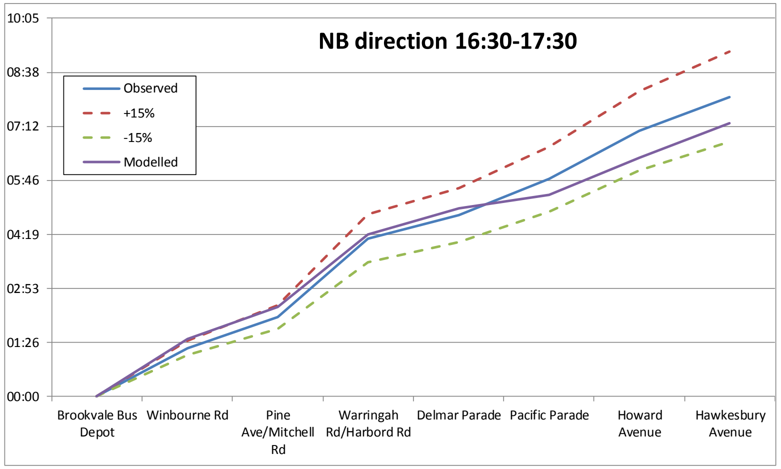
Hawkesbury Avenue
Howard Avenue
Pacific Parade
Delmar Parade
Warringah Rd/Harbord Rd
Pine Ave/Mitchell Rd
Winbourne Rd
Brookvale Bus Depot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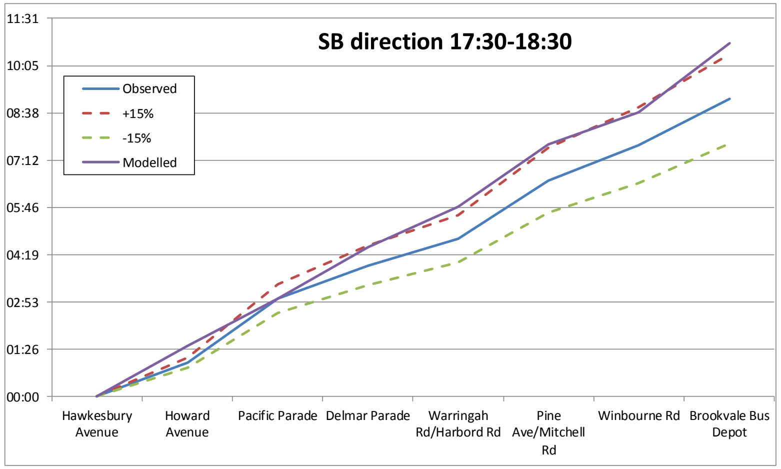
Observed
+15%
-15%
Modelled
10:05
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Brookvale Bus Depot
Winbourne Rd
Pine Ave/Mitchell Rd
Warringah Rd/Harbord Rd
Delmar Parade
Pacific Parade
Howard Avenue
Hawkesbury Avenue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Observed
+15%
-15%
Modelled
11:31
10:05
08:38
07:12
05:46
04:19
02:53
01:26
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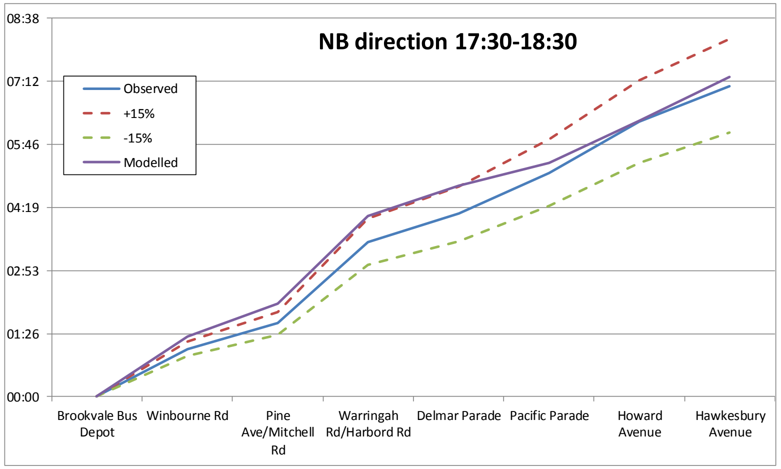
Hawkesbury Avenue
Howard Avenue
Pacific Parade
Delmar Parade
Warringah Rd/Harbord Rd
Pine Ave/Mitchell Rd
Winbourne Rd
Brookvale Bus Depot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-15%
Modelled
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Winbourne Rd
Pine Ave/Mitchell Rd
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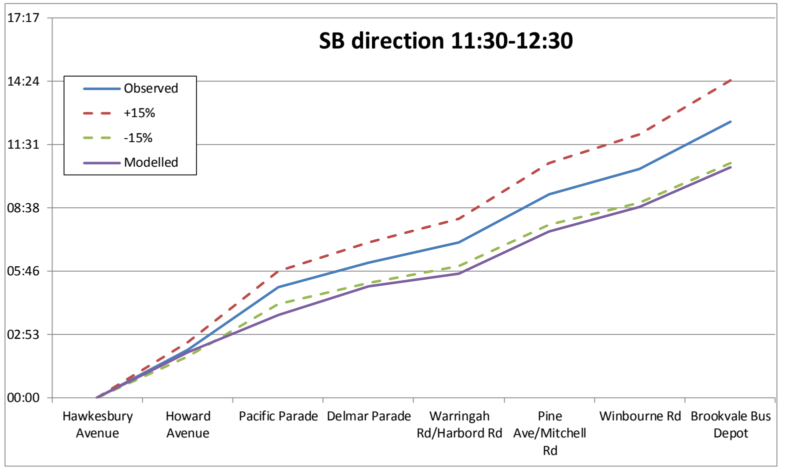
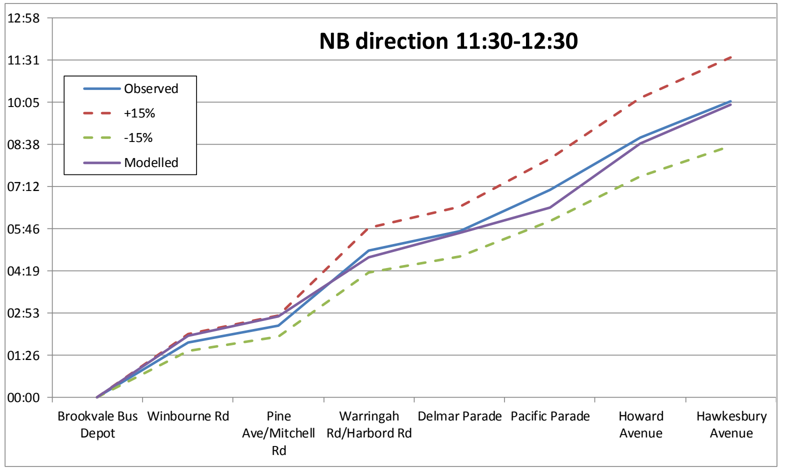
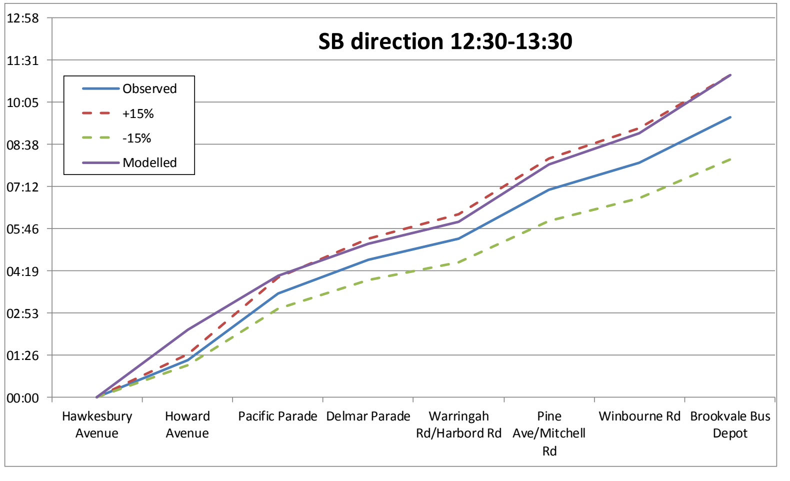
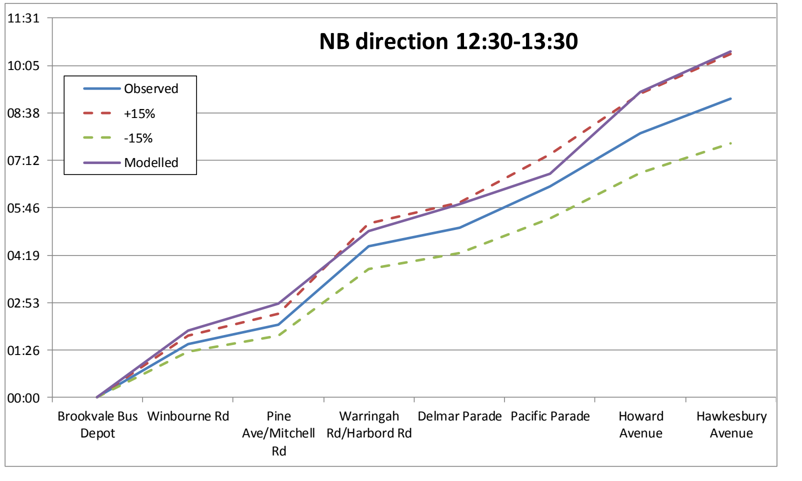
Delmar Parade
Pacific Parade
Howard Avenue
Hawkesbury Avenue









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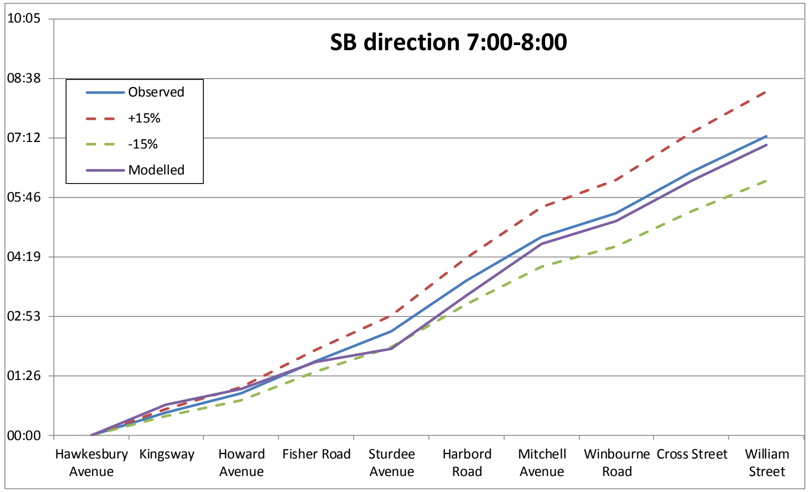
Appendix B-3 General Traffic Travel Time Comparisons for Brookvale/Dee Why

Section between		Southbound						Northbound					
		Observed		Modelled		% Difference		Observed		Modelled		% Difference	
		7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00
William Street	Cross Street	00:52	01:02	00:52	01:03	0%	1%	00:38	00:35	00:40	00:38	7%	10%
Cross Street	Winbourne Road	01:00	00:59	00:58	01:02	-3%	6%	01:02	01:19	00:58	00:59	-7%	-26%
Winbourne Road	Mitchell Avenue	00:34	00:54	00:33	00:43	-3%	-20%	00:28	00:32	00:37	00:47	32%	45%
Mitchell Avenue	Harbord Road	01:04	01:40	01:14	01:20	17%	-20%	01:13	01:09	01:17	01:13	6%	5%
Harbord Road	Sturdee Avenue	01:13	01:27	01:18	01:11	6%	-19%	00:47	00:40	00:34	00:36	-28%	-10%
Sturdee Avenue	Fisher Road	00:43	00:38	00:19	00:27	-56%	-30%	00:28	00:43	00:43	01:01	55%	44%
Fisher Road	Howard Avenue	00:48	00:52	00:40	01:04	-16%	23%	00:26	00:20	00:24	00:47	-8%	132%
Howard Avenue	Kingsway	00:27	00:52	00:23	00:32	-15%	-39%	00:16	00:14	00:22	00:13	38%	-8%
Kingsway	Hawkesbury Avenue	00:34	00:44	00:44	00:38	31%	-14%	00:38	00:28	00:29	00:22	-23%	-19%
Total		**07:14**	**09:07**	**07:02**	**07:58**	**-3%**	**-13%**	**05:56**	**05:59**	**06:06**	**06:36**	**3%**	**10%**

Section between		Southbound						Northbound					
		Observed		Modelled		% Difference		Observed		Modelled		% Difference	
		16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30
William Street	Cross Street	00:31	00:40	00:39	00:46	25%	16%	00:43	00:49	01:14	01:06	70%	35%
Cross Street	Winbourne Road	01:25	01:27	01:04	01:16	-25%	-12%	01:16	01:27	02:15	01:10	78%	-19%
Winbourne Road	Mitchell Avenue	00:43	00:55	00:36	00:33	-15%	-40%	00:50	00:49	01:11	00:54	42%	9%
Mitchell Avenue	Harbord Road	01:01	01:03	01:00	01:00	-1%	-4%	02:55	02:40	03:16	03:26	12%	29%
Harbord Road	Sturdee Avenue	01:29	01:04	01:22	01:17	-8%	20%	00:52	00:53	00:32	00:41	-39%	-23%
Sturdee Avenue	Fisher Road	00:33	00:25	00:26	00:39	-21%	55%	00:43	00:26	00:22	00:28	-47%	10%
Fisher Road	Howard Avenue	00:49	00:56	00:39	00:26	-20%	-53%	00:28	00:21	00:18	00:20	-36%	-6%
Howard Avenue	Kingsway	00:21	00:14	00:23	00:33	11%	133%	00:18	00:24	00:17	00:37	-4%	56%
Kingsway	Hawkesbury Avenue	00:25	00:38	00:22	00:23	-9%	-38%	00:26	00:34	00:20	00:25	-23%	-25%
Total		**07:16**	**07:22**	**06:31**	**06:54**	**-10%**	**-6%**	**08:31**	**08:23**	**09:45**	**09:09**	**14%**	**9%**

Section between		Southbound						Northbound					
		Observed		Modelled		% Difference		Observed		Modelled		% Difference	
		11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30
William Street	Cross Street	00:00	00:00	00:00	00:00	0%	0%	00:37	00:37	00:37	00:38	1%	3%
Cross Street	Winbourne Road	00:43	00:43	01:04	01:00	49%	39%	01:09	01:09	01:01	01:18	-12%	13%
Winbourne Road	Mitchell Avenue	01:29	01:29	00:38	00:34	-57%	-62%	00:26	00:26	00:45	00:44	74%	70%
Mitchell Avenue	Harbord Road	00:58	00:55	00:59	00:55	3%	2%	01:46	02:06	01:45	01:36	-1%	-24%
Harbord Road	Sturdee Avenue	00:39	00:39	00:52	00:54	34%	37%	00:39	00:39	00:35	00:41	-11%	5%
Sturdee Avenue	Fisher Road	00:00	00:00	00:00	00:00	0%	0%	00:31	00:31	00:57	01:05	86%	112%
Fisher Road	Howard Avenue	01:39	01:44	01:22	01:25	-17%	-18%	00:00	00:00	00:00	00:00	0%	0%
Howard Avenue	Kingsway	00:27	00:27	00:46	00:47	70%	76%	00:00	00:00	00:00	00:00	0%	0%
Kingsway	Hawkesbury Avenue	00:58	00:34	00:26	00:39	-55%	13%	00:34	00:34	00:30	00:53	-13%	55%
Total		**06:52**	**06:31**	**06:07**	**06:14**	**-11%**	**-4%**	**05:41**	**06:01**	**06:09**	**06:54**	**8%**	**15%**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-15%
Modelled
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08:38
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04:19
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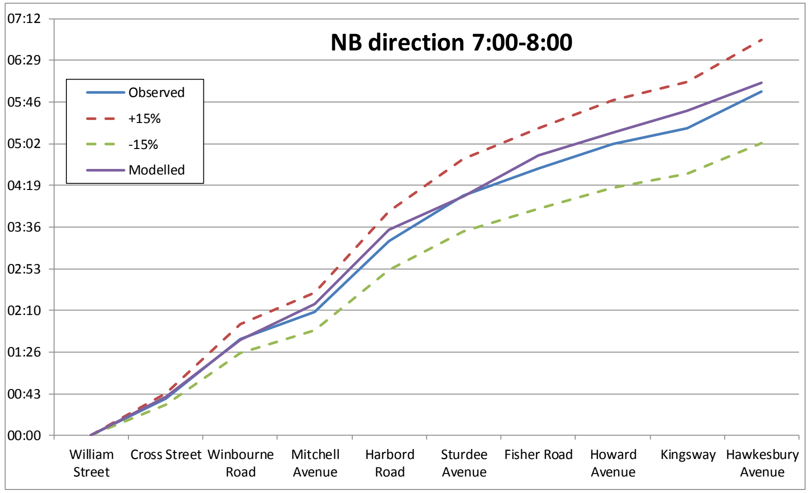
Kingsway
Howard Avenue
Fisher Road
Sturdee Avenue
Harbord Road
Mitchell Avenue
Winbourne Road
Cross Street
William Street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Modelled
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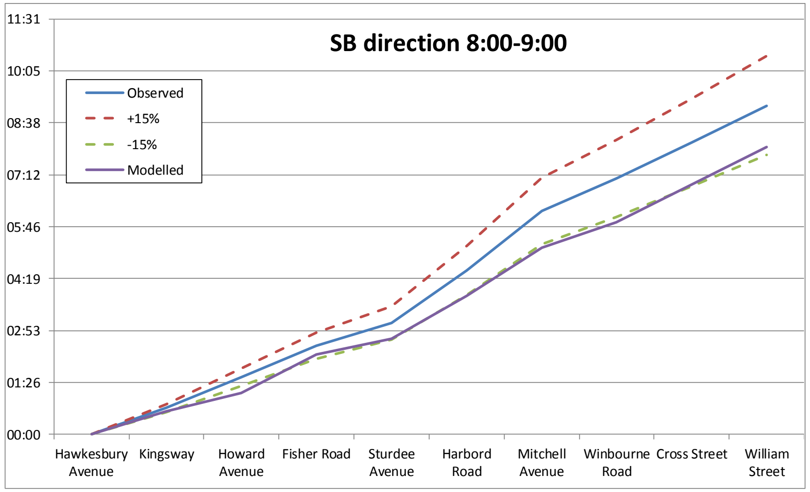
Cross Street
Winbourne Road
Mitchell Avenue
Harbord Road
Sturdee Avenue
Fisher Road
Howard Avenue
Kingsway
Hawkesbury Avenue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Modelled
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10:05
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07:12
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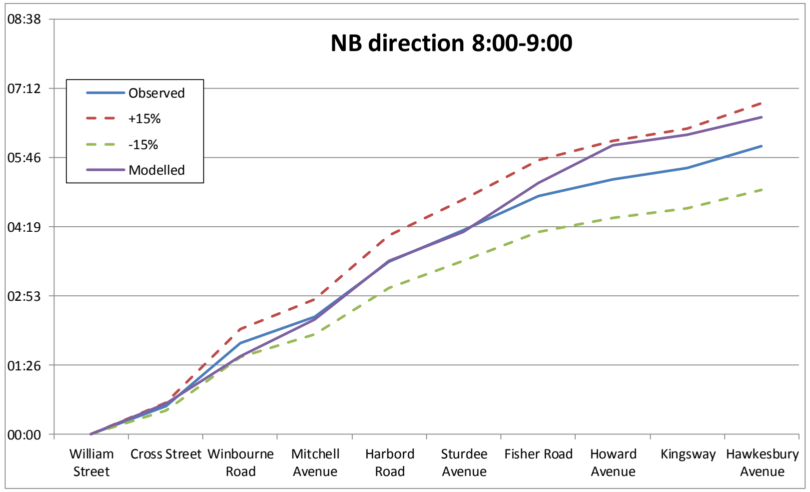
Hawkesbury Avenue
Kingsway
Howard Avenue
Fisher Road
Sturdee Avenue
Harbord Road
Mitchell Avenue
Winbourne Road
Cross Street
William Street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Observed
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-15%
Modelled
08:38
07:12
05:46
04:19
02:53
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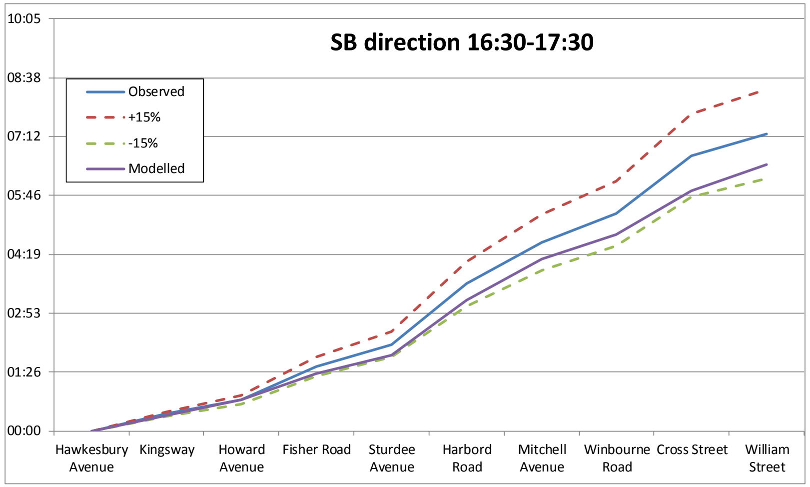
William Street
Cross Street
Winbourne Road
Mitchell Avenue
Harbord Road
Sturdee Avenue
Fisher Road
Howard Avenue
Kingsway
Hawkesbury Avenue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-15%
Modelled
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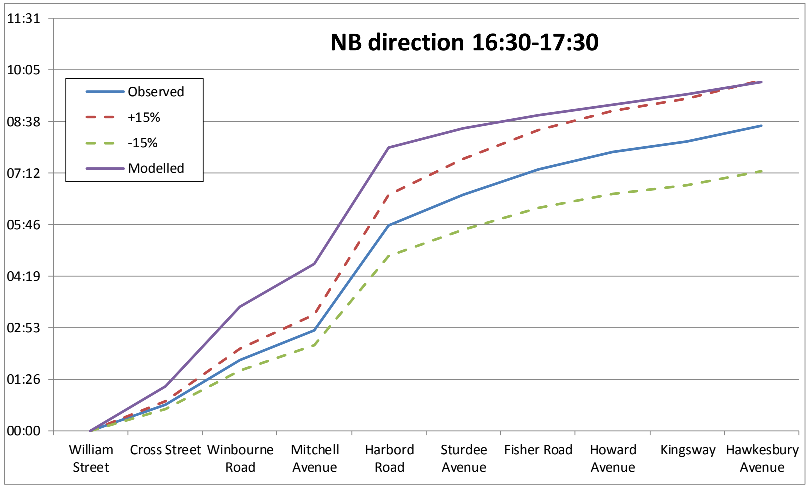
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Hawkesbury Avenue
Kingsway
Howard Avenue
Fisher Road
Sturdee Avenue
Harbord Road
Mitchell Avenue
Winbourne Road
Cross Street
William Street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Observed
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-15%
Modelled
11:31
10:05
08:38
07:12
05:46
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02:53
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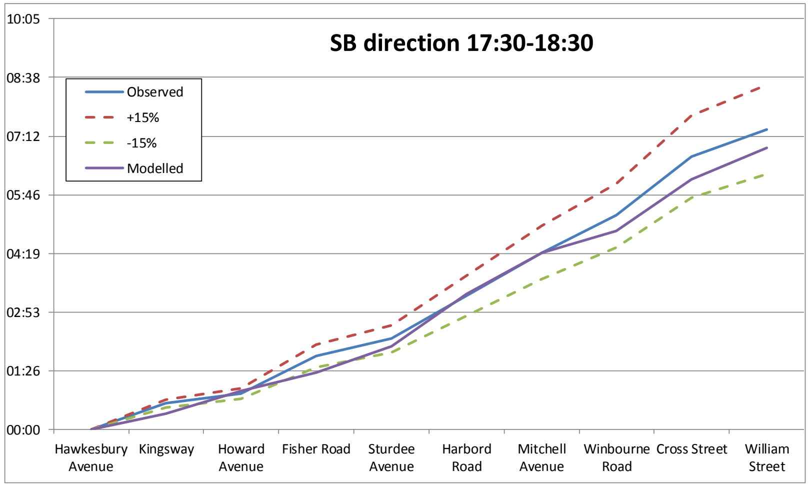
Cross Street
Winbourne Road
Mitchell Avenue
Harbord Road
Sturdee Avenue
Fisher Road
Howard Avenue
Kingsway
Hawkesbury Avenue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Observed
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-15%
Modelled
10:05
08:38
07:12
05:46
04:19
02:53
01:26
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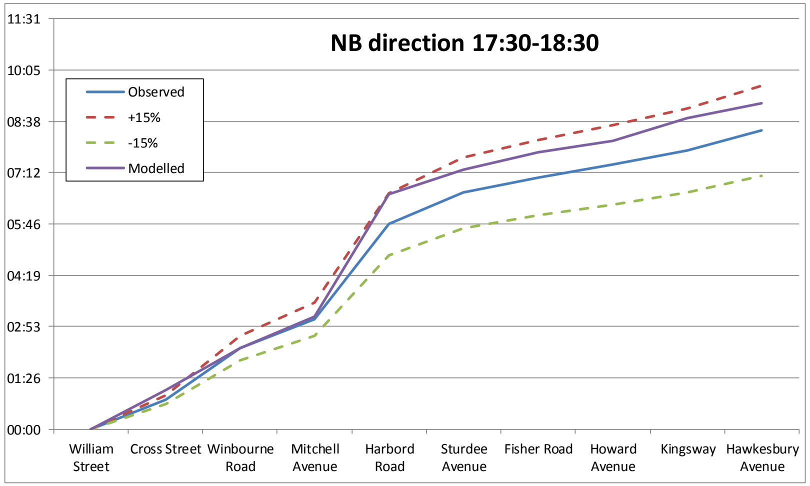
Hawkesbury Avenue
Kingsway
Howard Avenue
Fisher Road
Sturdee Avenue
Harbord Road
Mitchell Avenue
Winbourne Road
Cross Street
William Street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Observed
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-15%
Modelled
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10:05
08:38
07:12
05:46
04:19
02:53
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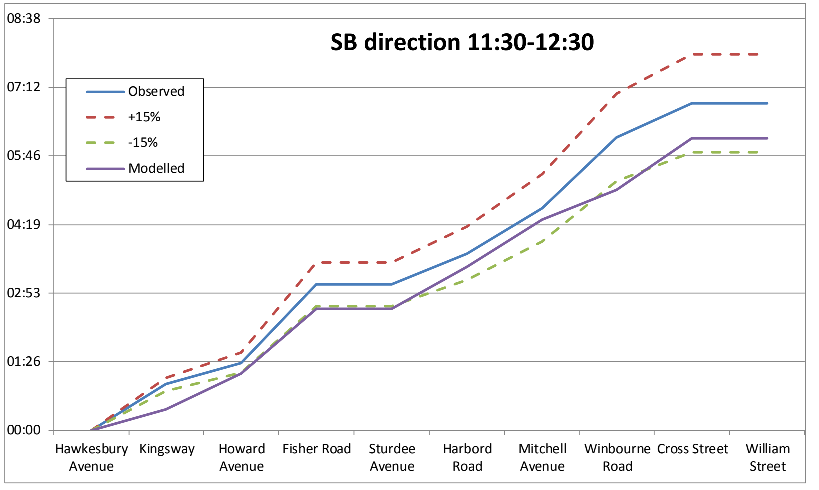
Cross Street
Winbourne Road
Mitchell Avenue
Harbord Road
Sturdee Avenue
Fisher Road
Howard Avenue
Kingsway
Hawkesbury Avenue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Observed
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-15%
Modelled
08:38
07:12
05:46
04:19
02:53
01:26
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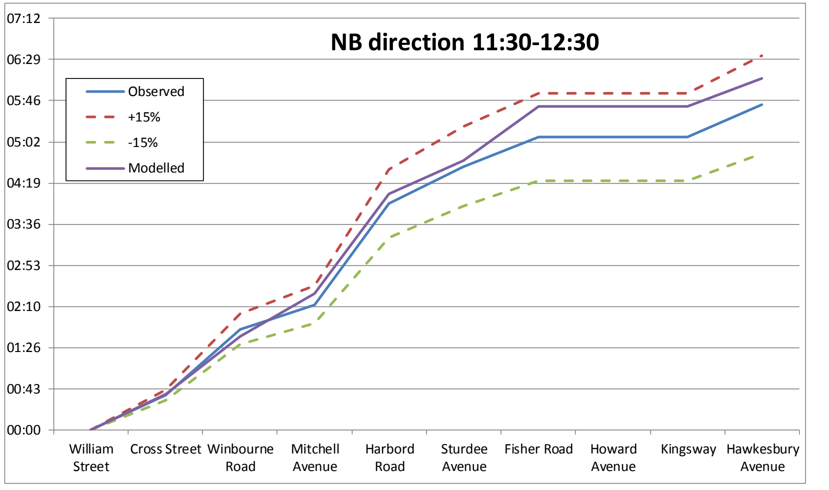
Hawkesbury Avenue
Kingsway
Howard Avenue
Fisher Road
Sturdee Avenue
Harbord Road
Mitchell Avenue
Winbourne Road
Cross Street
William Street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Observed
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-15%
Modelled
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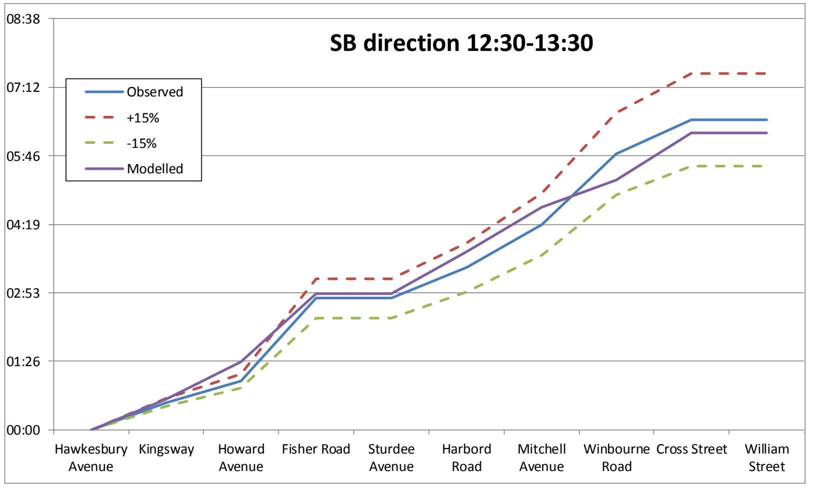
06:29
05:46
05:02
04:19
03:36
02:53
02:10
01:26
00:43
00:00
William Street
Cross Street
Winbourne Road
Mitchell Avenue
Harbord Road
Sturdee Avenue
Fisher Road
Howard Avenue
Kingsway
Hawkesbury Avenue


SB direction 12:30-13:30
Observed
+15%
-15%
Modelled
08:38
07:12
05:46
04:19
02:53
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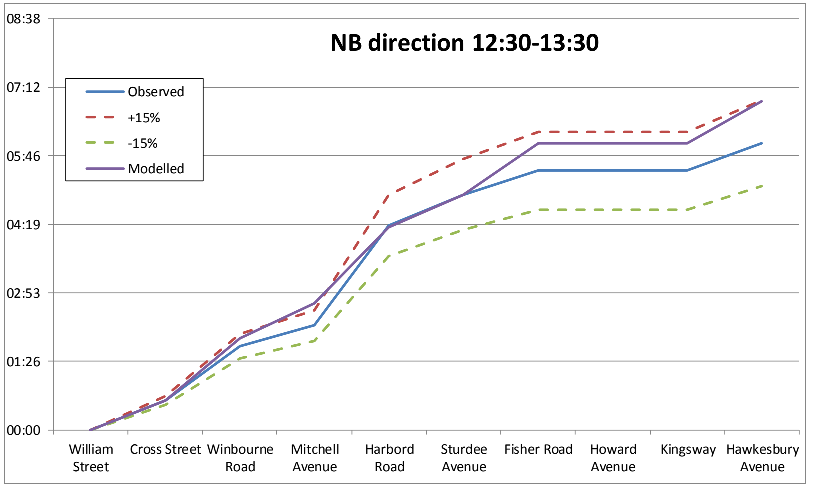
Hawkesbury Avenue
Kingsway
Howard Avenue
Fisher Road
Sturdee Avenue
Harbord Road
Mitchell Avenue
Winbourne Road
Cross Street
William Street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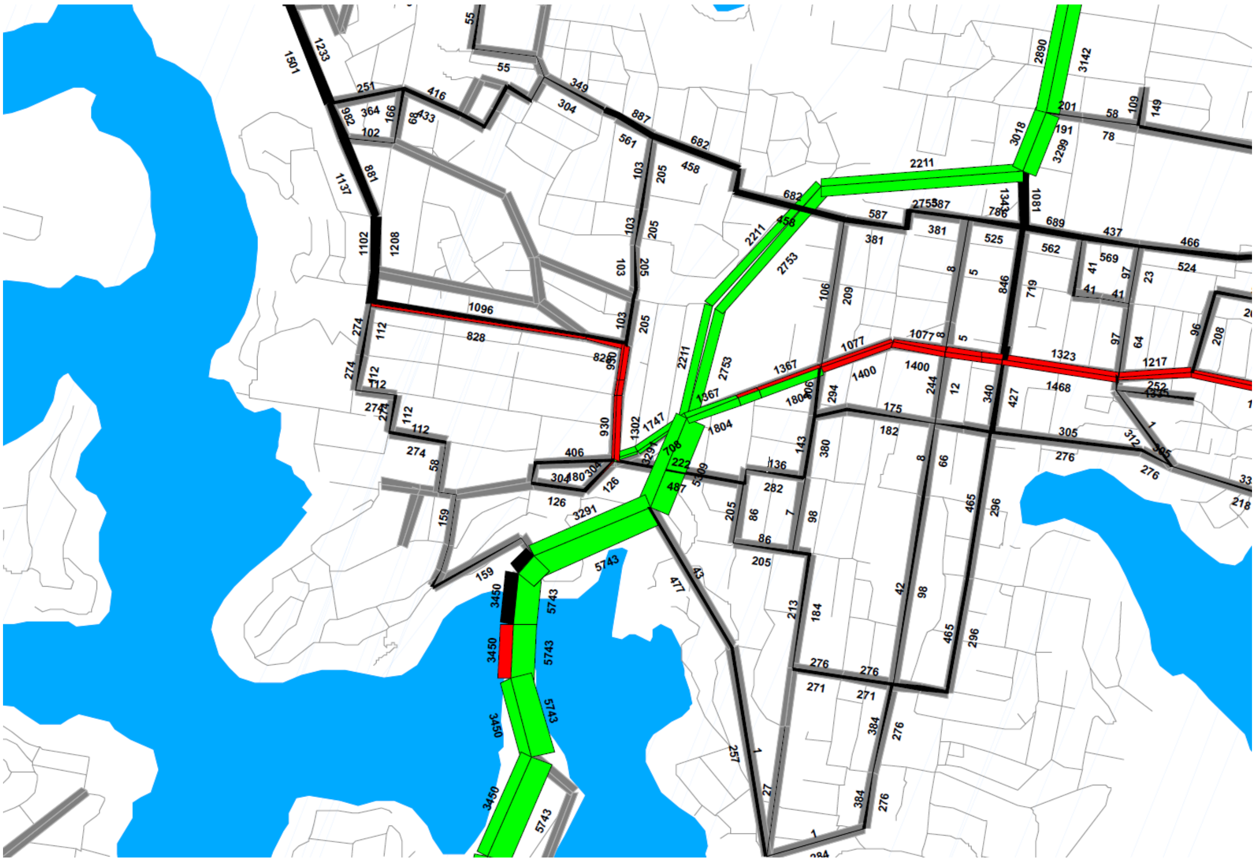
Observed
+15%
-15%
Modelled
08:38
07:12
05:46
04:19
02:53
01:26
00:00
William Street
Cross Street
Winbourne Road
Mitchell Avenue
Harbord Road
Sturdee Avenue
Fisher Road
Howard Avenue
Kingsway
Hawkesbury Avenue

Appendix C

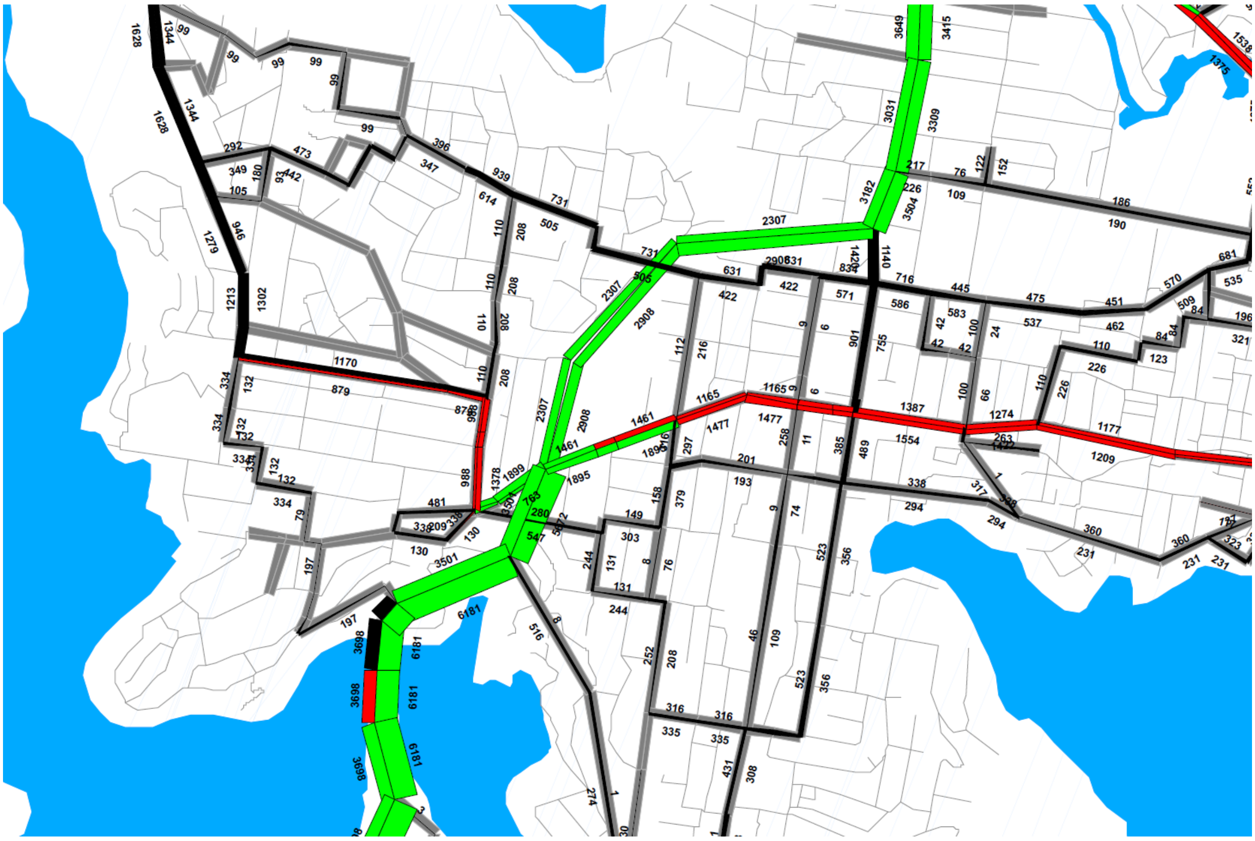
Forecast Link Volumes (STFM)

Appendix C

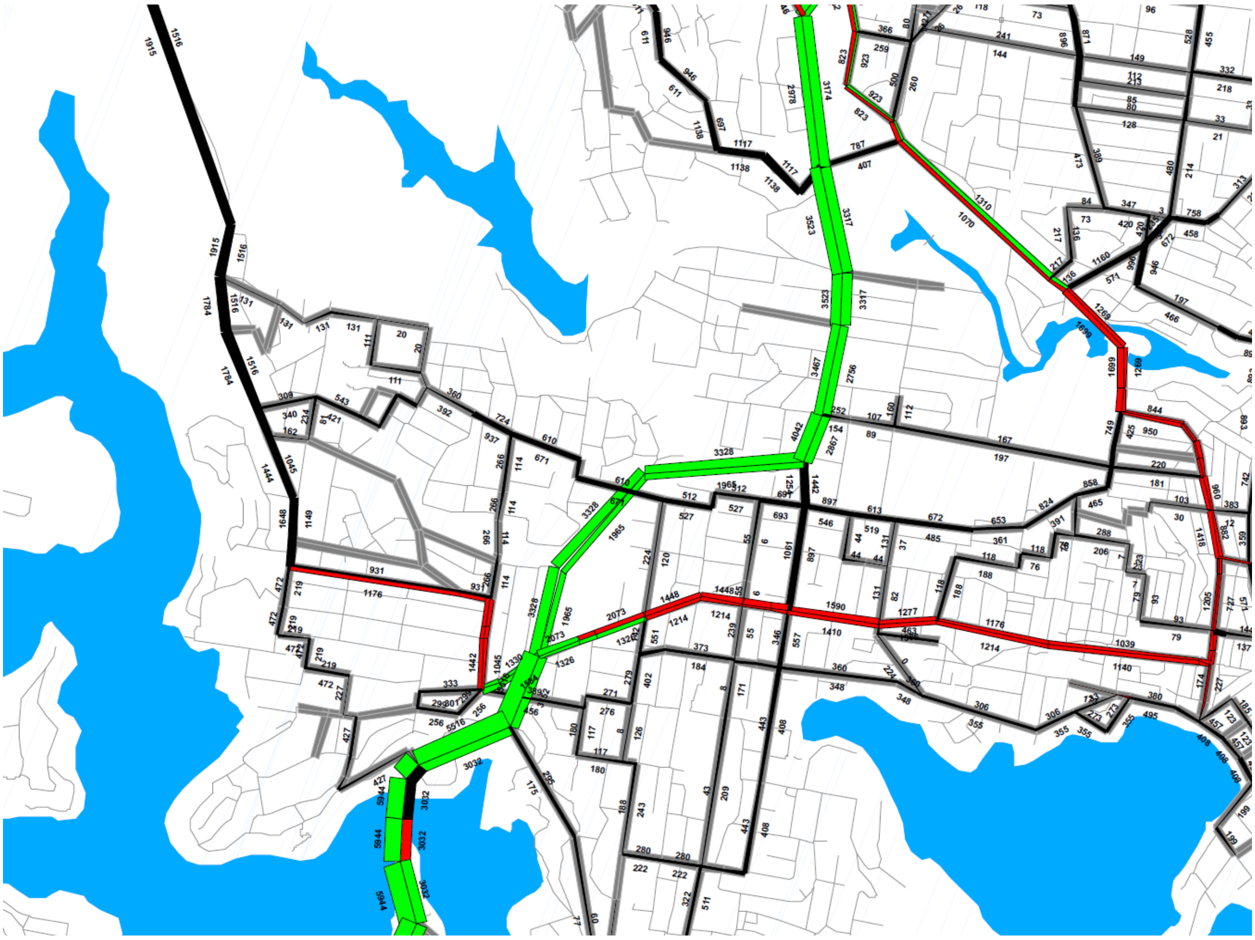
2015 7-9AM STFM Volumes – Spit Bridge



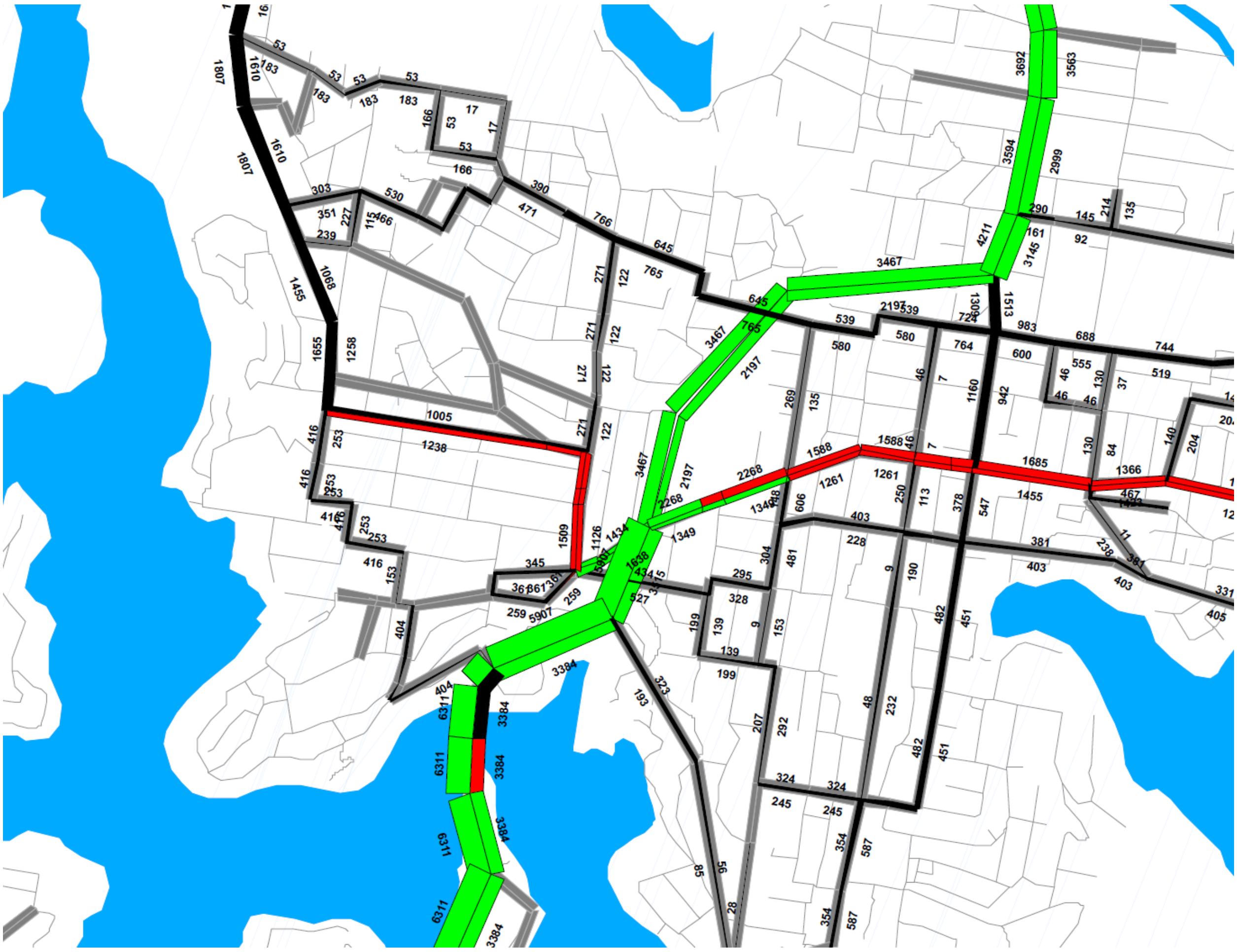
2021 7-9AM STFM Volumes – Spit Bridge



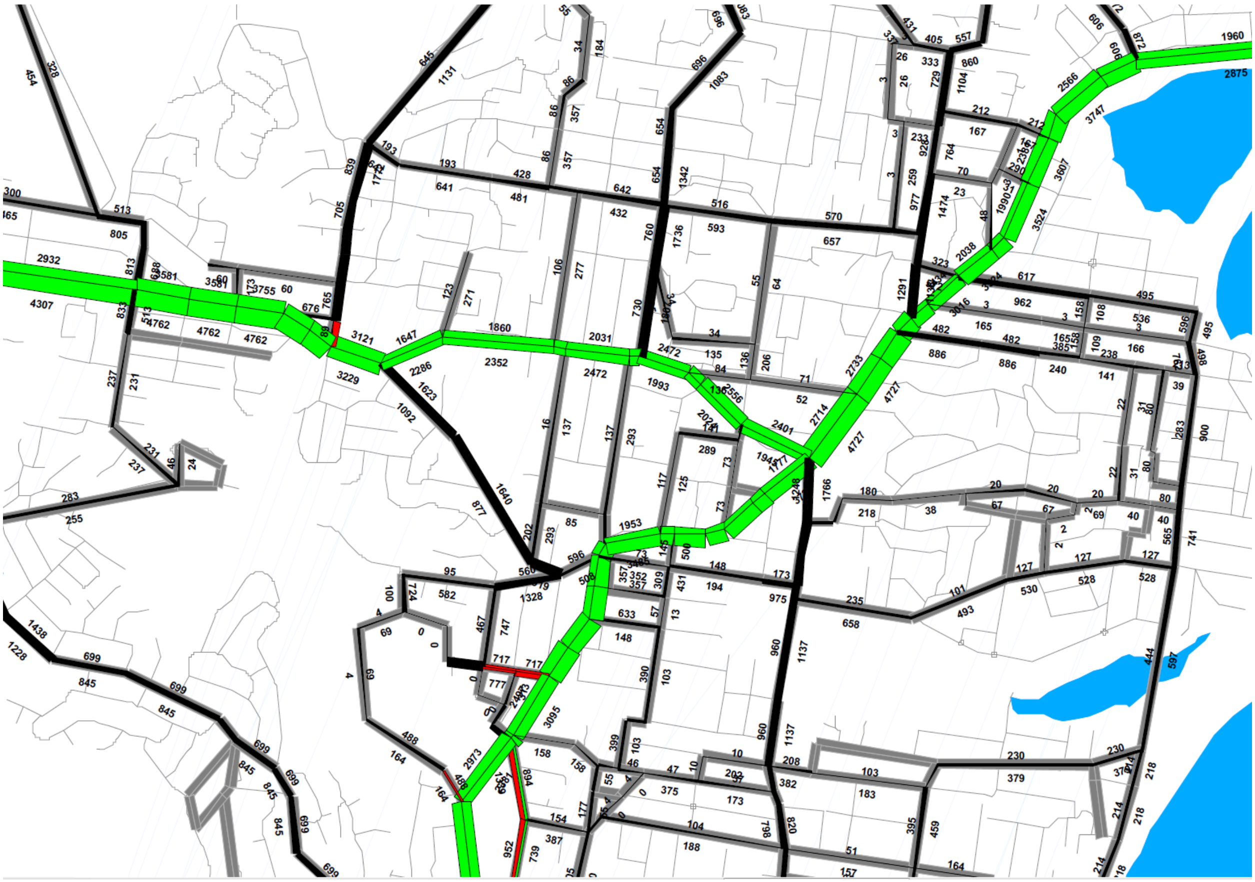
2015 4-6PM STFM Volumes – Spit Bridge



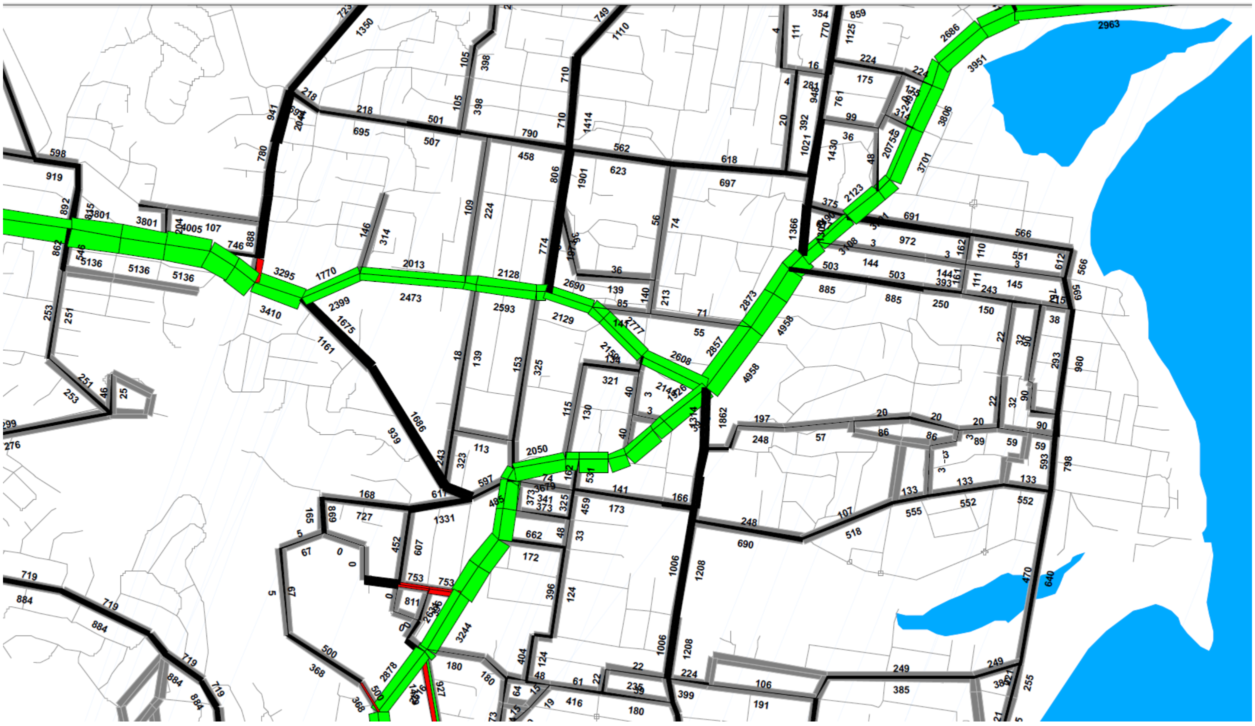
2021 4-6PM STFM Volumes – Spit Bridge



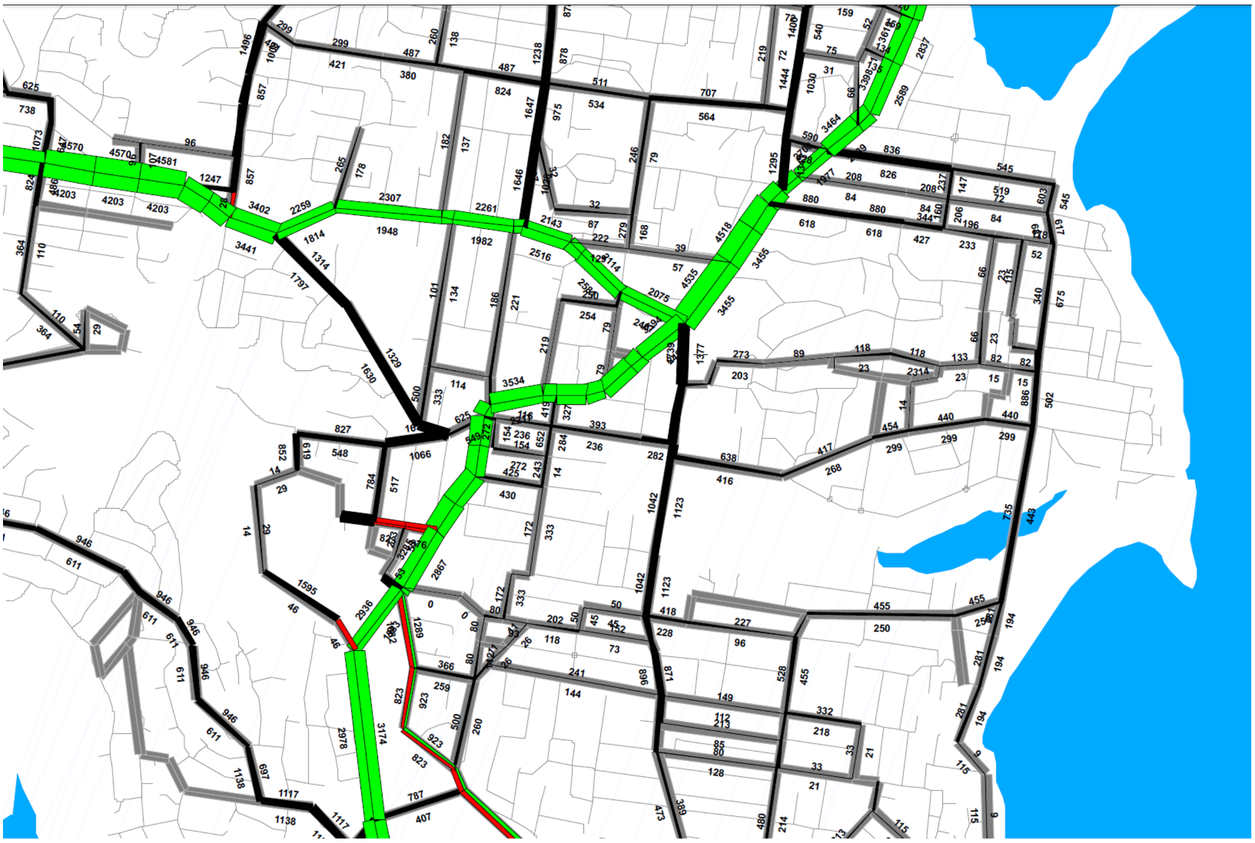
2015 7-9AM STFM Volumes – Brookvale / Dee Why



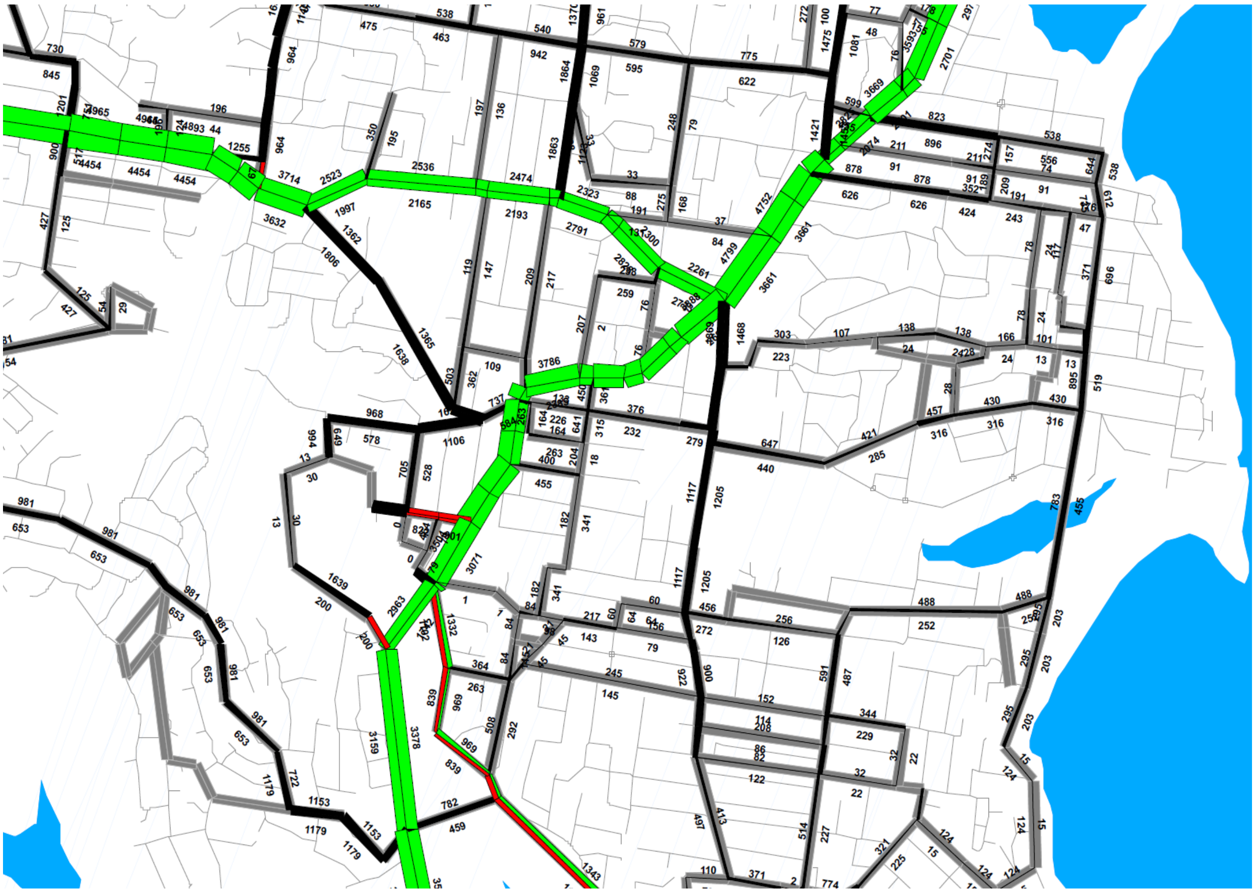
2021 7-9AM STFM Volumes – Brookvale / Dee Why



2015 4-6PM STFM Volumes – Brookvale / Dee Why

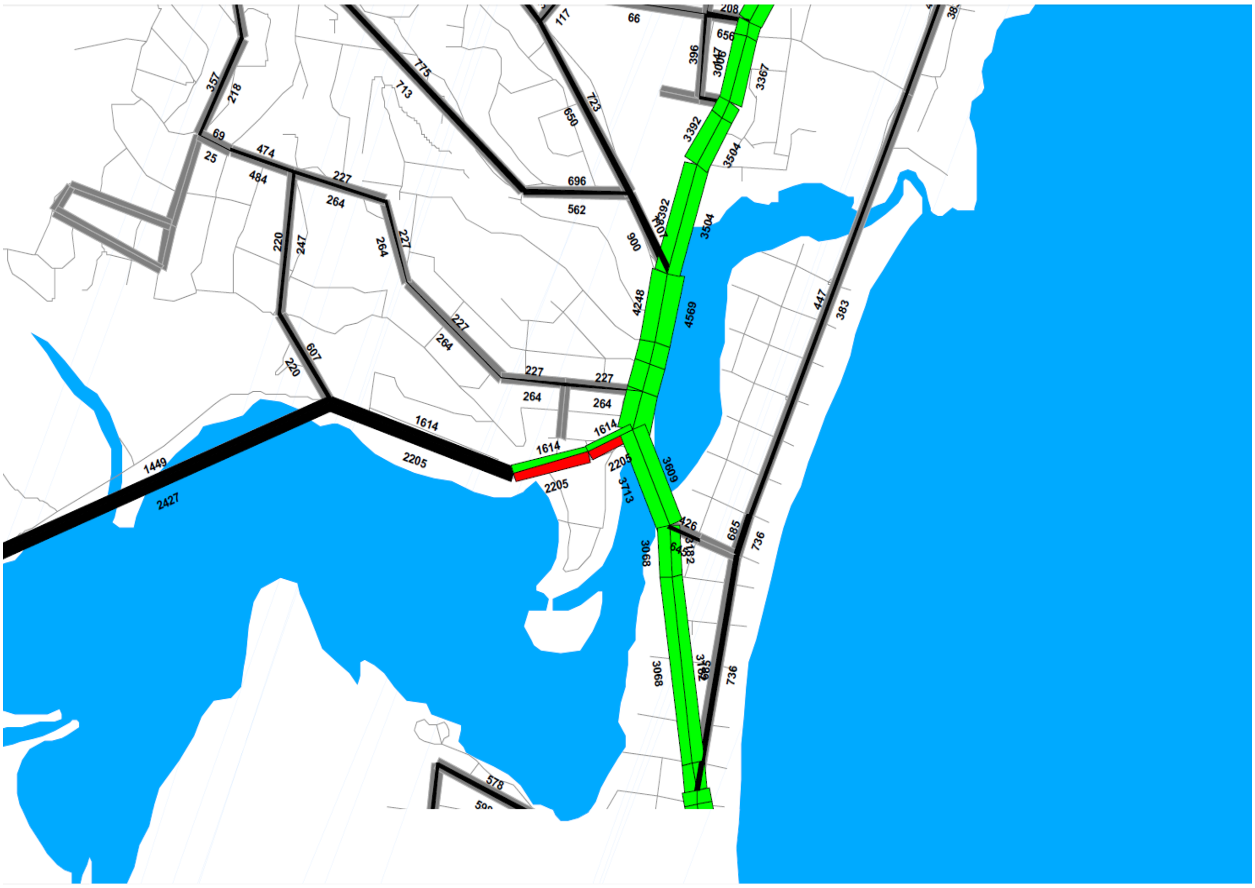


2021 4-6PM STFM Volumes – Brookvale / Dee Why

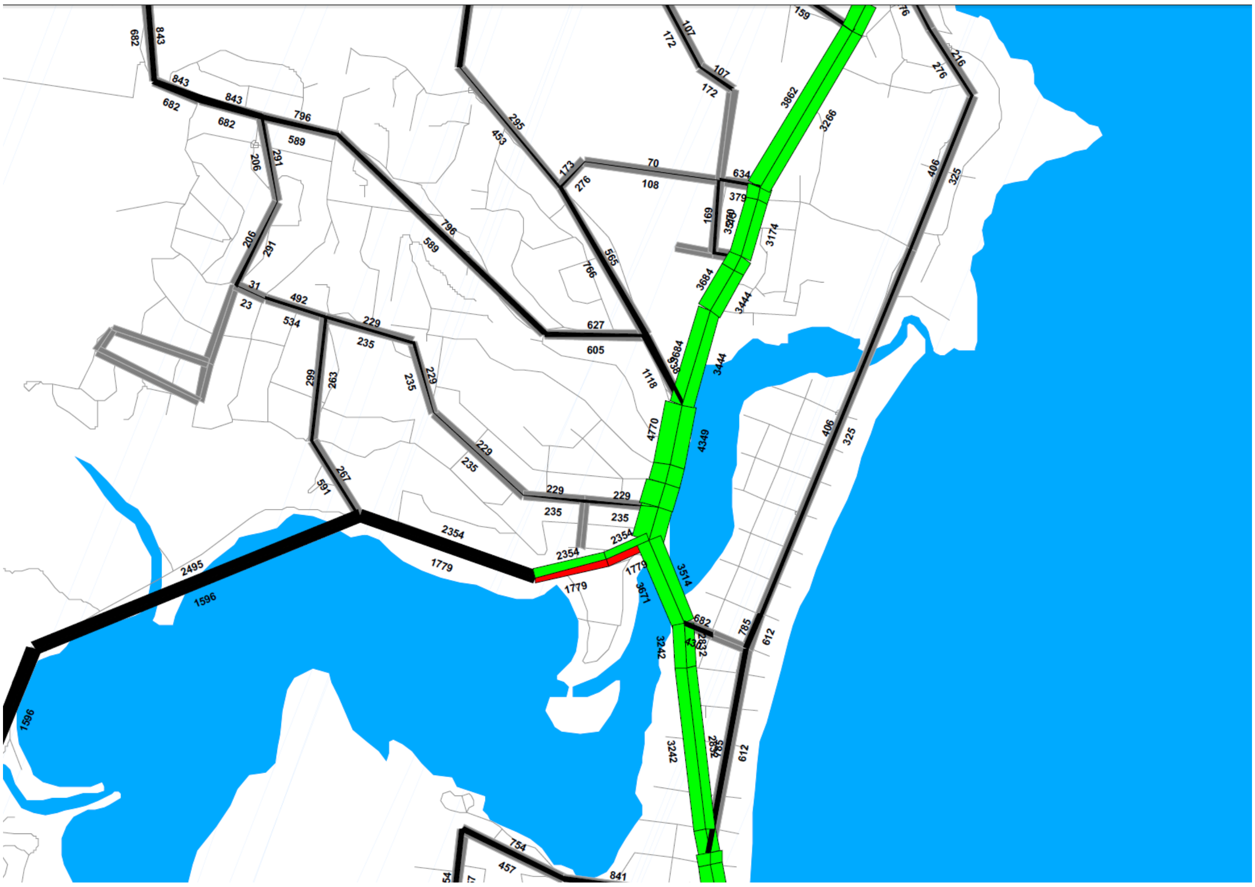


2015 7-9 AM STFM Volumes – Narrabeen

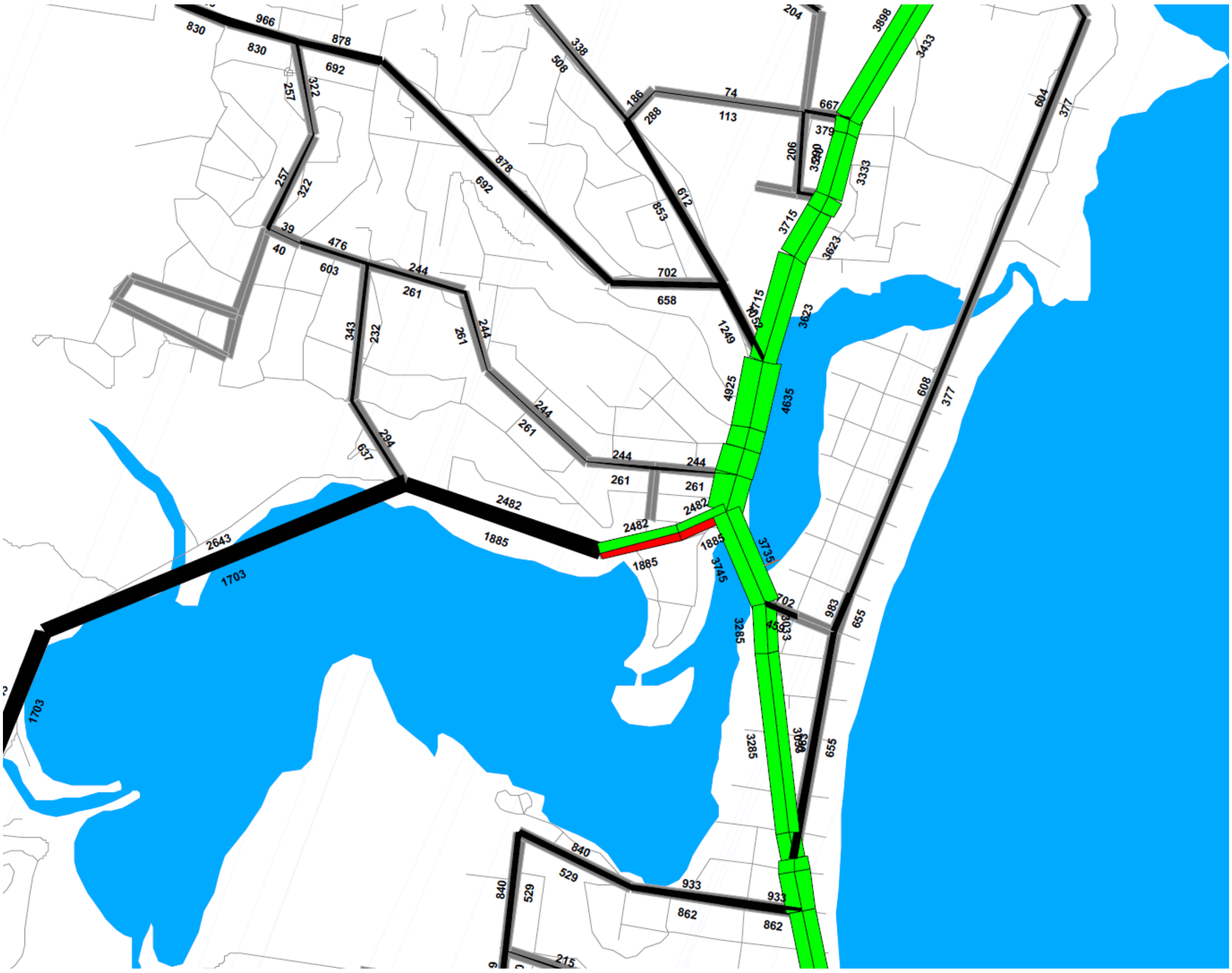
2021 7-9 AM STFM Volumes – Narrabeen



2015 4-6 PM STFM Volumes – Narrabeen



2021 4-6 PM STFM Volumes – Narrabeen



Appendix D

Travel Time Outputs (Vissim)

Appendix D

2016 vs 2021 Travel Time Comparison AM Peak (07:00-09:00) – General Traffic

Route	2016 Base Year		2021 Do-nothing		2021 Option	
	0700-0800	0800-0900	0700-0800	0800-0900	0700-0800	0800-0900
NB Section 1	266	263	266	266	266	264
NB Section 2	167	189	169	191	171	195
NB Total	**433**	**452**	**435**	**458**	**437**	**460**
SB Section 1	209	248	216	289	223	288
SB Section 2	253	283	256	291	255	289
SB Total	**462**	**531**	**472**	**581**	**478**	**577**

2016 vs 2021 Travel Time Comparison AM Peak (07:00-09:00) – Buses

Route	Local Buses						B-Line Buses	
	2016 Base Year		2021 Do-nothing		2021 Option		2021 Option	
	0700-0800	0800-0900	0700-0800	0800-0900	0700-0800	0800-0900	0700-0800	0800-0900
NB Section 1	349	371	347	368	317	342	273	326
NB Section 2	246	273	241	272	245	284	189	240
NB Total	**595**	**644**	**589**	**640**	**562**	**626**	**462**	**566**
SB Section 1	248	263	249	270	232	246	227	224
SB Section 2	410	413	411	414	374	376	352	339
SB Total	**658**	**676**	**660**	**684**	**606**	**622**	**579**	**563**

2016 vs 2021 Travel Time Comparison PM Peak (16:30-18:30) – General Traffic

Route	2016 Base Year		2021 Do-nothing		2021 Option	
	1630-1730	1730-1830	1630-1730	1730-1830	1630-1730	1730-1830
NB Section 1	613	558	657	594	593	673
NB Section 2	121	156	122	159	120	160
NB Total	**733**	**714**	**779**	**753**	**713**	**833**
SB Section 1	190	200	190	200	176	193
SB Section 2	249	262	249	264	237	131
SB Total	**439**	**462**	**439**	**464**	**414**	**324**

2016 vs 2021 Travel Time Comparison PM Peak (16:30-18:30) – Buses

Route	Local Buses						B-Line Buses	
	2016 Base Year		2021 Do-nothing		2021 Option		2021 Option	
	1630-1730	1730-1830	1630-1730	1730-1830	1630-1730	1730-1830	1630-1730	1730-1830
NB Section 1	323	309	321	309	343	348	334	341
NB Section 2	156	192	161	191	150	195	155	198
NB Total	**479**	**501**	**482**	**501**	**493**	**544**	**489**	**538**
SB Section 1	273	292	276	296	256	240	217	233
SB Section 2	412	410	410	409	400	375	373	360
SB Total	**685**	**702**	**686**	**705**	**655**	**615**	**591**	**593**

2016 vs 2021 Travel Time Comparison Sat Peak (11:30-13:30) – General Traffic

Route	2016 Base Year		2021 Do-nothing		2021 Option	
	1130-1230	1230-1330	1130-1230	1230-1330	1130-1230	1230-1330
NB Section 1	295	292	297	300	271	273
NB Section 2	208	244	212	244	197	229
NB Total	**503**	**536**	**509**	**545**	**468**	**502**
SB Section 1	257	281	270	339	199	172
SB Section 2	238	244	244	248	240	247
SB Total	**495**	**525**	**514**	**588**	**439**	**419**

2016 vs 2021 Travel Time Comparison Sat Peak (11:30-13:30) – Buses

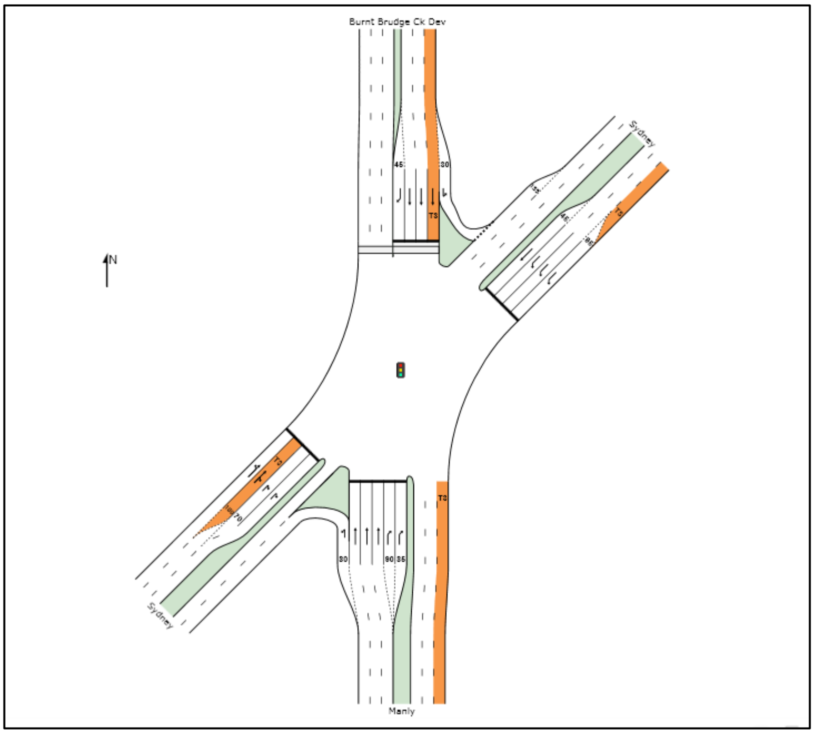
Route	Local Buses						B-Line Buses	
	2016 Base Year		2021 Do-nothing		2021 Option		2021 Option	
	1130-1230	1230-1330	1130-1230	1230-1330	1130-1230	1230-1330	1130-1230	1230-1330
NB Section 1	391	386	405	400	384	379	319	299
NB Section 2	290	309	298	307	273	272	248	288
NB Total	**681**	**695**	**703**	**706**	**657**	**652**	**566**	**587**
SB Section 1	334	335	329	396	254	245	203	239
SB Section 2	345	372	354	381	361	349	330	313
SB Total	**679**	**707**	**683**	**778**	**614**	**594**	**533**	**553**

Appendix E

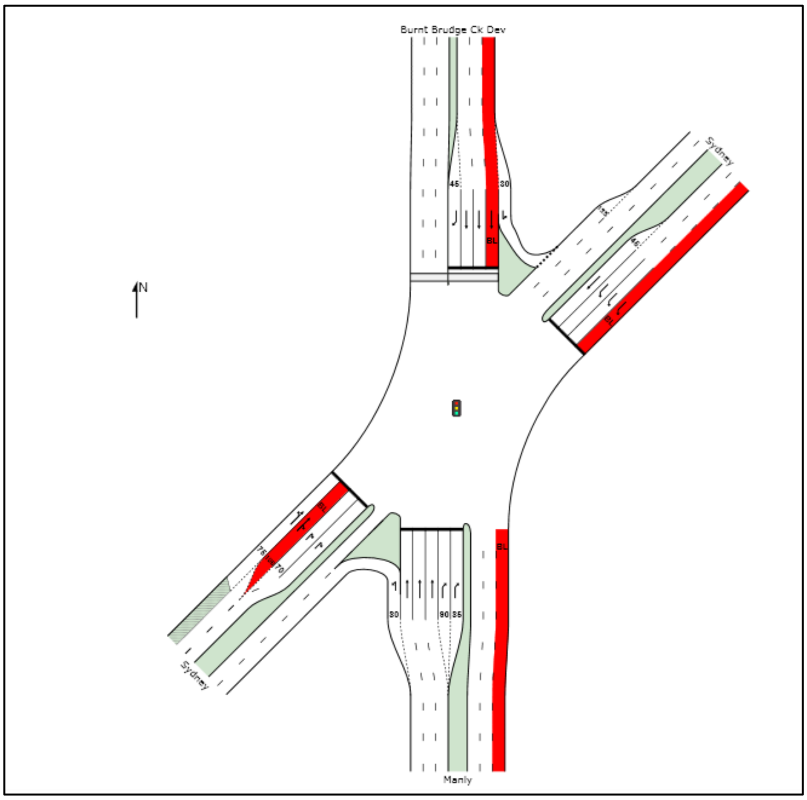
SIDRA Model Outputs

Appendix E

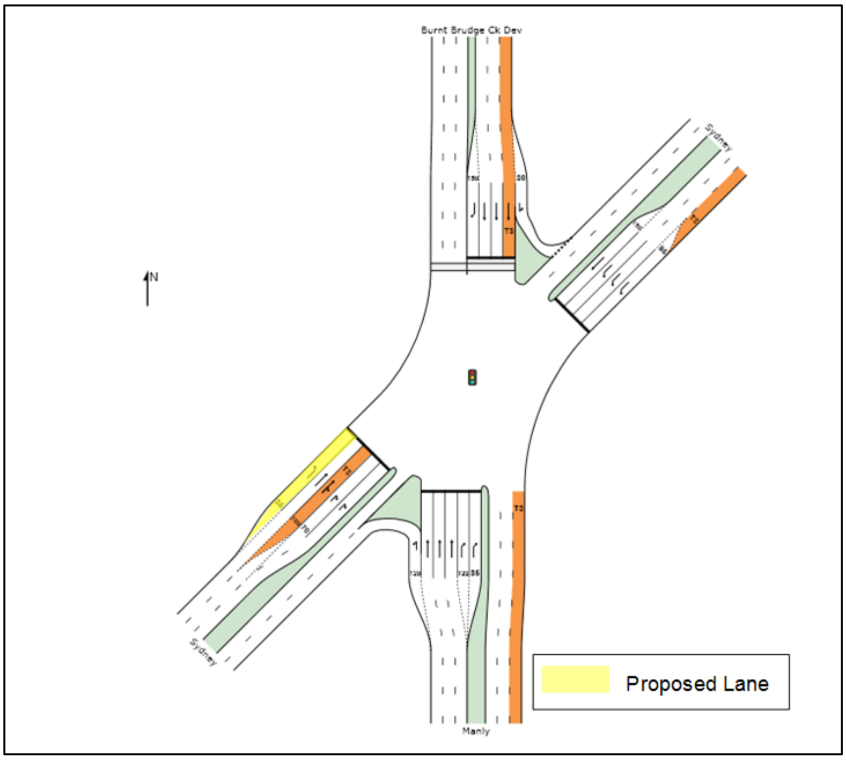
2016 AM Peak – Existing Layout



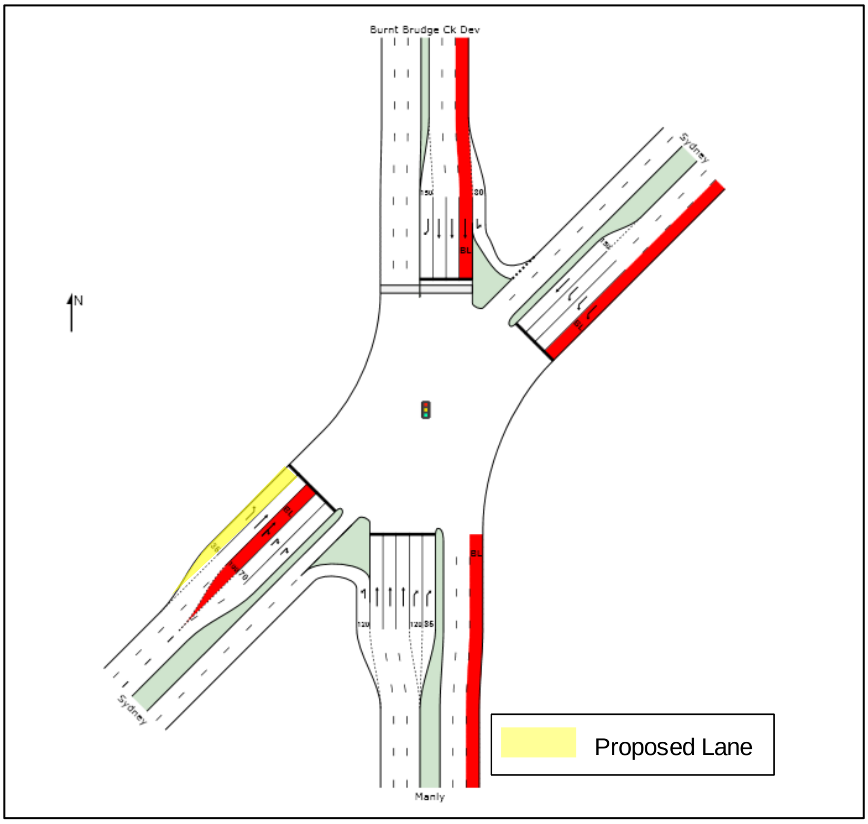
2016 PM Peak – Existing Layout



2021 AM Peak – Upgrade



2021 PM Peak – Upgrade



MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_AM Peak_Existing_2016

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated Cycle Time = 104 seconds (User-Given Phase Times)

Movement Performance - Vehicles											
Mov ID	ODMov	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	345	5.2	0.220	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	972	6.7	0.392	20.9	LOS B	11.0	81.5	0.72	0.62	44.7
3a	R1	463	5.9	0.875	58.6	LOS E	13.3	98.2	1.00	1.09	24.7
Approach		1780	6.2	0.875	27.7	LOS B	13.3	98.2	0.65	0.72	36.8
NorthEast: Sydney											
24a	L1	912	3.7	0.661	37.0	LOS C	15.7	112.2	0.92	0.80	31.9
25	T1	86	9.8	0.612	53.7	LOS D	4.5	34.5	1.00	0.81	22.1
Approach		998	4.2	0.661	38.4	LOS C	15.7	112.2	0.93	0.80	31.1
North: Burnt Brudge Ck Dev											
7b	L3	37	2.9	0.037	12.4	LOS A	0.6	4.3	0.39	0.65	42.8
8	T1	993	9.4	0.473	24.2	LOS B	13.3	98.4	0.78	0.67	43.0
9a	R1	73	5.8	0.374	52.5	LOS D	3.6	26.3	0.97	0.76	26.9
Approach		1102	9.0	0.473	25.7	LOS B	13.3	98.4	0.78	0.68	41.8
SouthWest: Sydney											
30a	L1	175	6.6	0.642	25.8	LOS B	11.1	82.3	0.75	0.71	35.2
31	T1	222	10.0	1.107	73.1	LOS F	12.4	94.6	0.85	1.02	22.1
32b	R3	480	5.7	1.107	85.1	LOS F	12.4	94.6	0.95	1.06	22.4
Approach		877	7.0	1.107	70.2	LOS E	12.4	94.6	0.89	0.98	21.1
All Vehicles		4757	6.6	1.107	37.3	LOS C	15.7	112.2	0.78	0.78	33.0

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_PM Peak_Existing_2016

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated Cycle Time = 97 seconds (User-Given Phase Times)

Movement Performance - Vehicles											
Mov ID	ODMov	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	757	2.4	0.473	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1612	3.7	0.608	20.8	LOS B	18.9	136.6	0.80	0.71	44.8
3a	R1	846	2.0	0.837	46.6	LOS D	21.2	150.9	1.00	0.98	34.0
Approach		3215	2.9	0.837	24.0	LOS B	21.2	150.9	0.67	0.74	41.5
NorthEast: Sydney											
24a	L1	557	3.0	0.339	24.4	LOS B	8.6	60.8	0.71	0.74	42.3
25	T1	184	5.1	1.052	120.4	LOS F	15.2	110.9	1.00	1.43	14.4
Approach		741	3.6	1.052	48.3	LOS D	15.2	110.9	0.79	0.91	31.2
North: Burnt Brudge Ck Dev											
7b	L3	37	2.9	0.044	15.2	LOS B	0.7	5.1	0.48	0.67	47.7
8	T1	848	5.0	0.821	39.1	LOS C	22.0	157.8	0.97	0.93	36.6
9a	R1	155	4.1	0.897	63.1	LOS E	8.6	62.4	1.00	1.03	24.2
Approach		1040	4.8	0.897	41.9	LOS C	22.0	157.8	0.96	0.94	34.9
SouthWest: Sydney											
30a	L1	164	3.8	0.926	35.1	LOS C	20.1	143.0	0.99	0.96	32.2
31	T1	256	4.5	0.926	31.9	LOS C	20.1	143.0	0.99	0.95	32.3
32b	R3	306	3.1	0.896	51.7	LOS D	7.6	53.6	0.99	0.88	26.4
Approach		726	3.8	0.926	41.0	LOS C	20.1	143.0	0.99	0.92	29.4
All Vehicles		5722	3.5	1.052	32.5	LOS C	22.0	157.8	0.78	0.82	37.1

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_AM Peak_Existing_2021

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated   Cycle Time = 104 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMov	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	366	5.2	0.233	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1031	6.6	0.415	21.2	LOS B	11.8	87.5	0.73	0.63	44.6
3a	R1	492	5.8	0.927	66.8	LOS E	15.3	112.8	1.00	1.21	23.4
Approach		1888	6.1	0.927	30.0	LOS C	15.3	112.8	0.66	0.76	36.0
NorthEast: Sydney											
24a	L1	966	3.6	0.701	37.7	LOS C	16.9	121.2	0.93	0.82	31.7
25	T1	93	10.2	0.659	54.3	LOS D	4.9	37.6	1.00	0.84	22.0
Approach		1059	4.2	0.701	39.2	LOS C	16.9	121.2	0.94	0.82	30.9
North: Burnt Brudge Ck Dev											
7b	L3	41	5.1	0.042	12.8	LOS A	0.7	5.0	0.40	0.66	42.6
8	T1	1051	9.2	0.510	24.5	LOS B	14.6	108.2	0.79	0.68	42.8
9a	R1	78	6.8	0.403	52.7	LOS D	3.9	28.5	0.98	0.76	26.8
Approach		1169	8.9	0.510	26.0	LOS B	14.6	108.2	0.79	0.69	41.6
SouthWest: Sydney											
30a	L1	186	6.8	0.685	26.2	LOS B	12.3	91.2	0.78	0.73	35.0
31	T1	237	9.8	1.169	95.7	LOS F	12.4	94.6	0.87	1.13	20.9
32b	R3	508	5.6	1.169	106.3	LOS F	12.4	94.6	0.96	1.16	21.2
Approach		932	6.9	1.169	87.6	LOS F	12.4	94.6	0.90	1.07	18.4
All Vehicles		5048	6.5	1.169	41.6	LOS C	16.9	121.2	0.79	0.81	31.7

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_PM Peak_Existing_2021

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated   Cycle Time = 97 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMov	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	803	2.4	0.502	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1707	3.6	0.723	21.9	LOS B	24.3	175.5	0.84	0.75	44.2
3a	R1	898	2.0	0.888	52.6	LOS D	24.4	174.0	1.00	1.04	32.2
Approach		3408	2.9	0.888	26.1	LOS B	24.4	175.5	0.68	0.77	40.4
NorthEast: Sydney											
24a	L1	591	3.0	0.360	24.6	LOS B	9.3	65.4	0.72	0.74	42.2
25	T1	197	5.3	1.126	179.0	LOS F	20.4	149.2	1.00	1.64	10.7
Approach		787	3.6	1.126	63.2	LOS E	20.4	149.2	0.79	0.97	27.3
North: Burnt Brudge Ck Dev											
7b	L3	40	2.6	0.050	17.1	LOS B	0.9	6.1	0.53	0.68	46.5
8	T1	900	4.9	0.873	44.6	LOS D	25.4	182.1	0.98	1.01	34.7
9a	R1	166	4.4	0.967	77.4	LOS F	10.5	76.1	1.00	1.15	21.3
Approach		1106	4.8	0.967	48.5	LOS D	25.4	182.1	0.96	1.02	32.7
SouthWest: Sydney											
30a	L1	175	4.2	0.997	52.0	LOS D	26.3	187.8	1.00	1.12	26.5
31	T1	273	4.6	0.997	48.3	LOS D	26.3	187.8	0.99	1.11	26.6
32b	R3	326	3.2	0.958	56.6	LOS E	8.7	61.2	0.99	0.95	25.1
Approach		774	3.9	0.997	52.7	LOS D	26.3	187.8	0.99	1.05	25.9
All Vehicles		6076	3.5	1.126	38.4	LOS C	26.3	187.8	0.79	0.88	34.8

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_AM Peak_2021- Upgrade_SC1

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated Cycle Time = 104 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMov	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	366	5.2	0.233	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1031	6.6	0.466	25.1	LOS B	12.9	95.4	0.79	0.68	42.5
3a	R1	492	5.8	0.927	66.8	LOS E	15.3	112.8	1.00	1.21	23.4
Approach		1888	6.1	0.927	32.1	LOS C	15.3	112.8	0.69	0.79	35.2
NorthEast: Sydney											
24a	L1	1240	2.8	0.695	31.2	LOS C	20.7	147.2	0.89	0.81	33.7
25	T1	93	10.2	0.310	42.2	LOS C	4.2	32.3	0.92	0.73	24.7
Approach		1333	3.3	0.695	32.0	LOS C	20.7	147.2	0.89	0.80	33.1
North: Burnt Brudge Ck Dev											
7b	L3	41	5.1	0.052	18.4	LOS B	1.0	7.1	0.54	0.68	40.0
8	T1	1051	9.2	0.633	32.4	LOS C	15.6	115.0	0.90	0.78	39.2
9a	R1	78	6.8	0.634	59.0	LOS E	4.2	30.9	1.00	0.80	25.3
Approach		1169	8.9	0.634	33.7	LOS C	15.6	115.0	0.89	0.77	38.2
SouthWest: Sydney											
30a	L1	186	6.8	0.236	8.0	LOS A	1.6	11.7	0.18	0.48	47.3
31	T1	237	9.8	1.169	87.4	LOS F	12.4	94.6	0.61	0.86	24.1
32b	R3	508	5.6	1.169	106.3	LOS F	12.4	94.6	0.96	1.16	21.2
Approach		932	6.9	1.169	81.8	LOS F	12.4	94.6	0.71	0.95	19.2
All Vehicles		5322	6.2	1.169	41.1	LOS C	20.7	147.2	0.79	0.82	31.7

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_PM Peak_2021 - Upgrade_SC1

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated Cycle Time = 97 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMov	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	803	2.4	0.502	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1707	3.6	0.783	30.6	LOS C	24.9	179.5	0.95	0.88	40.0
3a	R1	898	2.0	1.009	95.5	LOS F	33.8	240.9	1.00	1.35	23.2
Approach		3408	2.9	1.009	41.8	LOS C	33.8	240.9	0.74	0.92	34.1
NorthEast: Sydney											
24a	L1	738	2.4	0.402	21.9	LOS B	11.1	78.0	0.69	0.74	43.6
25	T1	197	5.3	0.596	40.8	LOS C	8.8	64.6	0.97	0.80	27.2
Approach		935	3.0	0.596	25.9	LOS B	11.1	78.0	0.75	0.75	39.9
North: Burnt Brudge Ck Dev											
7b	L3	40	2.6	0.067	20.7	LOS B	1.0	7.2	0.60	0.70	44.5
8	T1	900	4.9	0.971	71.0	LOS F	29.3	210.4	1.00	1.24	27.8
9a	R1	166	4.4	0.967	77.3	LOS F	10.5	76.1	1.00	1.15	21.4
Approach		1106	4.8	0.971	70.1	LOS E	29.3	210.4	0.98	1.21	27.2
SouthWest: Sydney											
30a	L1	175	4.2	0.217	7.6	LOS A	1.4	9.8	0.17	0.48	47.7
31	T1	273	4.6	0.400	13.5	LOS A	5.5	38.7	0.48	0.40	44.0
32b	R3	326	3.2	0.958	56.6	LOS E	8.7	61.2	0.99	0.95	25.1
Approach		774	3.9	0.958	30.4	LOS C	8.7	61.2	0.63	0.65	33.6
All Vehicles		6223	3.4	1.009	43.0	LOS D	33.8	240.9	0.77	0.91	33.2

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_AM Peak_2021-Upgrade_SC2

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated Cycle Time = 104 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMov	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	366	5.2	0.233	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1031	6.6	0.478	25.9	LOS B	13.1	97.0	0.80	0.70	42.1
3a	R1	492	5.8	0.927	66.8	LOS E	15.3	112.8	1.00	1.21	23.4
Approach		1888	6.1	0.927	32.6	LOS C	15.3	112.8	0.70	0.80	35.0
NorthEast: Sydney											
24a	L1	1103	3.1	0.782	40.7	LOS C	20.4	145.2	0.96	0.89	30.9
25	T1	93	10.2	0.659	54.3	LOS D	4.9	37.6	1.00	0.84	22.0
Approach		1196	3.7	0.782	41.7	LOS C	20.4	145.2	0.97	0.88	30.3
North: Burnt Brudge Ck Dev											
7b	L3	41	5.1	0.046	14.3	LOS A	0.8	5.6	0.44	0.67	41.9
8	T1	1051	9.2	0.652	33.4	LOS C	15.8	116.8	0.91	0.79	38.8
9a	R1	78	6.8	0.634	59.0	LOS E	4.2	30.9	1.00	0.80	25.3
Approach		1169	8.9	0.652	34.4	LOS C	15.8	116.8	0.90	0.78	37.9
SouthWest: Sydney											
30a	L1	186	6.8	0.231	7.2	LOS A	1.4	10.1	0.15	0.47	48.0
31	T1	237	9.8	0.721	16.8	LOS B	12.0	91.3	0.52	0.47	31.8
32b	R3	645	4.4	0.721	31.6	LOS C	12.0	91.3	0.79	0.78	33.1
Approach		1068	6.0	0.721	24.1	LOS B	12.0	91.3	0.62	0.66	34.6
All Vehicles		5322	6.2	0.927	33.3	LOS C	20.4	145.2	0.79	0.78	34.3

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_PM Peak_2021_ Upgrade_SC2

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated Cycle Time = 97 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMov	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	803	2.4	0.502	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1707	3.6	0.690	23.9	LOS B	21.8	157.0	0.87	0.77	43.1
3a	R1	898	2.0	1.050	122.2	LOS F	38.4	273.7	1.00	1.50	19.8
Approach		3408	2.9	1.050	45.5	LOS D	38.4	273.7	0.70	0.90	32.9
NorthEast: Sydney											
24a	L1	664	2.7	0.449	28.3	LOS B	11.5	81.1	0.79	0.78	40.5
25	T1	197	5.3	1.126	179.0	LOS F	20.4	149.2	1.00	1.64	10.7
Approach		861	3.3	1.126	62.7	LOS E	20.4	149.2	0.84	0.97	27.5
North: Burnt Brudge Ck Dev											
7b	L3	40	2.6	0.056	16.0	LOS B	0.8	5.9	0.50	0.68	47.2
8	T1	900	4.9	0.770	35.6	LOS C	20.0	143.5	0.97	0.89	37.9
9a	R1	166	4.4	0.967	77.3	LOS F	10.5	76.1	1.00	1.15	21.4
Approach		1106	4.8	0.967	41.1	LOS C	20.0	143.5	0.96	0.92	35.2
SouthWest: Sydney											
30a	L1	175	4.2	0.247	11.7	LOS A	2.4	17.5	0.31	0.54	44.3
31	T1	273	4.6	0.471	18.7	LOS B	7.3	51.5	0.62	0.52	40.1
32b	R3	400	2.6	0.906	48.5	LOS D	9.9	69.9	0.99	0.90	27.2
Approach		847	3.6	0.906	31.3	LOS C	9.9	69.9	0.73	0.70	33.2
All Vehicles		6223	3.4	1.126	45.2	LOS D	38.4	273.7	0.77	0.89	32.4

Appendix F

Commuter Model Outputs

Appendix F

Level of Service: AM Peak

Scenarios	AM Peak Hour														
	Intersection Statistics			Approach Statistics											
	Total	Delay	Level of	Queue Size - number of vehicles				Queue Max - number of vehicles				Number of Stops			
	Vehicle	(sec)	Service	Sydney Rd W	BBCD	Sydney Rd E	Manly Rd	Sydney Rd W	BBCD	Sydney Rd E	Manly Rd	Sydney Rd W	BBCD	Sydney Rd E	Manly Rd
2016 Existing AM Peak	4958	212	F	18	100	11	8	54	273	46	27	1095	3131	927	848
2016 Upgrade - Scenario 1 AM Peak	5303	210	F	24	85	20	8	72	243	65	28	1446	3197	1368	863
2016 Upgrade - Scenario 2 AM Peak	4759	177	F	45	44	9	8	80	166	34	27	1739	2294	851	854

Level of Service: PM Peak

Scenarios	PM Peak Hour														
	Intersection Statistics			Approach Statistics											
	Total	Delay	Level of	Queue Size - number of vehicles				Queue Max - number of vehicles				Number of Stops			
	Vehicle	(sec)	Service	Sydney Rd W	BBCD	Sydney Rd E	Manly Rd	Sydney Rd W	BBCD	Sydney Rd E	Manly Rd	Sydney Rd W	BBCD	Sydney Rd E	Manly Rd
2016 Existing PM Peak	5044	92	F	6	25	4	23	22	62	16	87	581	1373	430	2333
2016 Upgrade - Scenario 1 PM Peak	5211	86	F	7	19	5	28	23	59	21	96	618	914	526	2535
2016 Upgrade - Scenario 2 PM Peak	5221	89	F	10	21	5	22	26	71	19	83	775	1009	487	2222

Travel Times southbound between Sydney Rd and Parriwi Rd

AM Peak

Average Travel Times (SB: Sydney Rd to Parriwi Rd)			
	BASE	Scenario 1	Scenario 2
GT	0:08:34	0:08:24	0:08:04
T3	0:04:59	0:04:36	0:04:34
PT	0:04:47	0:03:23	0:03:06

PM Peak

Average Travel Times (SB: Sydney Rd to Parriwi Rd)			
	BASE	Scenario 1	Scenario 2
GT	0:08:38	0:08:16	0:08:54
T3	0:08:28	0:08:03	0:08:45
PT	0:06:15	0:06:11	0:06:35

Note:

Scenario 1: 100% of Heaton Avenue traffic is diverted to the eastern approach of Sydney Road / Manly Road intersection.

Scenario 2: 50% of the diverted traffic originates from the eastern side of Manly Road and 50% from the west.

GT: General Traffic

T3: Vehicles that have three or more passengers

PT: Public Transport vehicles (i.e. buses in the Commuter model)

Appendix D Construction Noise and Vibration Impact Assessment – Package 8

AECOM

Easing Sydney's Congestion
Roads and Maritime Services
20-Oct-2016

Northern Beaches B-Line - Dee Why

Construction Noise and Vibration Impact Assessment

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Client: Roads and Maritime Services

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1.0 Introduction

1.1 Background

AECOM has been commissioned by Roads and Maritime Services (Roads and Maritime) to carry out an acoustic assessment of the proposed construction of part of the Northern Beaches B-Line Program (hereafter referred to as B-line). The overall B-line Program involves a series of road infrastructure and bus service improvements that will aim to deliver a more frequent and reliable bus service for customers travelling between the Northern Beaches and the Sydney CBD. .

This report provides a construction noise and vibration assessment of the impact of construction of road infrastructure associated within one section of the B-Line Program. The subject section commences at the intersection of Pittwater Road and Hawkesbury Avenue to the north and finishes at the intersection of Pittwater Road and Sturdee Avenue to the south. The assessment also includes activity associated with the proposed construction compound at the Manly Vale commuter car park. This subject section is referred to as Package 8 throughout this report and within the project Review of Environmental Factors (REF).

Roads and Maritime do not expect a change in traffic volumes as a result of the project. As such as an operational noise assessment is not warranted for this project.

1.2 Scope

Provided below is a summary of the construction activities associated with the Proposal separated into the two relevant Zones.

Zone A - Pittwater Road, south of the Hawkesbury Avenue intersection

- Construction of a new bus bay, approximately 40 m south of the existing local bus stop on Pittwater Road (southbound), south of the intersection of Pittwater Road and Hawkesbury Avenue:
  - relocation of existing below ground service utilities in the eastern road verge of Pittwater Road.
  - demolition of the existing concrete road verge, kerbs and pedestrian pathway along the eastern verge of Pittwater Road
  - construction of new road pavement for the indented bus bay (about 3 metres wide and 34 metres long), including kerbs, pedestrian pathway and road verge.
  - removal of sections of existing road pavement to allow for tie in of the new pavement.
  - installation of new concrete pavement sub-base at tie in locations.
  - installation of bitumen overlay.
  - new line marking.

Zone B - Pittwater Road from Dee Why Parade to Sturdee Parade

- Reconfiguration of southbound lanes on Pittwater Road from Howard Avenue to Oaks Avenue to accommodate four lanes of traffic:
  - relocation of any existing below and above ground services and utilities within the median (if required)
  - removal of the existing concrete median within Pittwater Road from Dee Why Parade to Howard Avenue to accommodate an additional southbound lane
  - construction of new road pavement for the new southbound lane

- removal of sections of existing concrete road pavement to allow for tie in of the new pavement
- installation of new concrete pavement sub-base at tie in locations
- installation of bitumen overlay
- installation of low retaining wall between the opposing northbound and southbound carriageways to account for differing grade heights, including pedestrian safety fencing along retaining wall
- longitudinal regrading of the road pavement to account for variation in existing pavement levels
- removal of 18 trees (Lilly Pilly) located within the existing median of Pittwater Road between Howard Avenue and Oaks Avenue
- demolition of existing kerbs and median within Pittwater Road near Howard Avenue to continue the additional southbound lane
- installation of fittings and foundation for new median
- construction of a new median within Pittwater Road at Howard Avenue
- installation of new traffic island within Pittwater Road at Oaks Avenue intersection
- reconfiguration of the existing southbound lanes on Pittwater Road to provide a left turn only lane (buses excepted) for vehicles turning into Oaks Avenue and to move the existing bus lane from the far left lane into the adjacent lane
- new line marking and adjustments to existing traffic signal infrastructure.

- Extension of the existing right turn lane from Pittwater Road (northbound) into Oaks Avenue:
  - relocation of existing below and above ground services and utilities
  - demolition of existing kerbs and road concrete in median
  - reinstatement of the concrete median and kerbs to a width of 0. 5 m
  - construction of new road pavement for the new right turn lane (about 2. 8 metres wide with an additional length of 30 metres)
  - removal of sections of existing concrete pavement to allow for tie in of the new pavement
  - installation of new concrete pavement sub-base at tie in locations
  - installation of bitumen overlay
  - new line marking and adjustments to existing traffic signal infrastructure.

Use of Manly Vale Commuter Car Park as construction compound

2.0 Existing ambient noise environment

2.1 Overview

Package 8 is situated along Pittwater Road, a major arterial road. Pittwater Road facilitates a large proportion north and south vehicle travel within the Northern Beaches. As such the existing noise environment consists primarily of traffic noise.

2.2 Ambient noise monitoring

Ambient noise monitoring was undertaken at two locations throughout the study area from 31 August 2016 to 11 September 2016. Locations deemed appropriate for noise logging were determined through examination of aerial photography and site inspections. However it is noted that the logging locations were ultimately directed by RMS.

Attended noise measurements were also undertaken to determine the nature of the local noise environment and confirm road traffic was the controlling noise source.

The background noise logging locations are illustrated in Appendix B. The noise logging results are provided graphically in Appendix C.

A noise logger measures the noise level over the sample period and then determines L_{A1}, L_{A10}, L_{A90}, L_{Amax} and L_{Aeq} levels of the noise environment. The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for 1 per cent, 10 per cent and 90 per cent of the sample period respectively. The L_{Amax} is indicative of maximum noise levels due to individual noise events. The L_{A90} is taken as the background noise level. The L_{Aeq} is the energy averaged noise level over a defined period.

The results of the noise monitoring have been processed in accordance with the procedures contained in the *NSW EPA Road Noise Policy* (RNP) (Department of Environment, Climate Change and Water NSW, 2011) and the *NSW EPA Industrial Noise Policy* (INP) (Environment Protection Authority). Weather data recorded during the noise monitoring survey periods was obtained from the Bureau of Meteorology weather station, located at Sydney Olympic Park. Periods which were affected by noise from extraneous wind and rain were omitted from the results.

Noise logging has previously been carried out for the construction compound site for a previous B-Line report (Manly Vale Commuter Car Park and B-Line stops - Review of Environmental Factors, Transport for New South Wales, March 2016) in which the results will be used in this report.

Details of each noise logging location and the noise monitoring equipment are provided in Table 1 below.

Table 1 Noise logging locations

No.	Address	Location on property	Logger	Serial number	Measurement period
P8_1	727 Pittwater Road	Reserve adjacent carpark and Pittwater Road	ARL 215	194803	31 Aug 2016 to 11 Sep 2016
P8_2	946 Pittwater Road	Reserve walkway to the north	ARL 215	194528	31 Aug 2016 to 11 Sep 2016
Construction compound	82 Kenneth Road	East of existing Casey's toys building	-	-	30 Nov 2016 to 14 Dec 2016

2.3 Unattended background noise monitoring results

The background noise monitoring results are provided in Table 2. These noise levels were used to define the appropriate construction noise management levels, consistent with the *Interim Construction Noise Guideline* (Department of Environment and Climate Change NSW, 2009).

The assessment background levels (ABL) were established by determining the lowest tenth-percentile level of the L_{A90} noise data acquired over each assessment period of interest. The background noise level or rating background levels (RBL) representing the day, evening and night-time assessment periods were based on the median of individual ABLs determined over the entire monitoring duration.

Table 2 also presents the ambient L_{Aeq} levels at each monitoring location. The L_{Aeq} level is the equivalent continuous sound level and has the same sound energy over the sample period as the actual noise environment with fluctuating sound levels.

The noise levels presented in Table 2 indicate that the noise environment at the measurement locations are typical of suburban/urban noise environments located alongside major transport corridors, where day time and evening background levels are high due to heavy and continuous traffic flows. The night time background levels tend to decrease as a result of reduced traffic flows.

Table 2 Ambient noise measurements

Noise logging location	Rating background level, dB(A)			Ambient L_{Aeq} noise level, dB(A)		
	Day (7am to 6pm) $L_{A90,15\ minute}$	Evening (6pm to 10pm) $L_{A90,15\ minute}$	Night (10pm to 7am) $L_{A90,15\ minute}$	Day (7am to 6pm) $L_{Aeq,15\ hour}$	Evening (6pm to 10pm) $L_{Aeq,4\ hour}$	Night (10pm to 7am) $L_{Aeq,9\ hour}$
P8_1	58	55	42	71	70	66
P8_2	51	48	37	62	62	55
Construction compound	54	48	38	-	-	-

2.4 Attended noise monitoring results

Attended monitoring was conducted at the two unattended noise monitoring locations and also at a receiver set back from the road. These locations are shown in Appendix B. Each attended measurement was conducted over a 15 minute period. The monitoring was carried out on 31 August 2016, and 12 September 2016. Skies were clear with scattered clouds and conditions were calm with a slight breeze during monitoring. Measurement details are provided below in Table 3 and Table 4.

Table 3 Attended noise monitoring results (logger location)

Monitoring location	Date	Time	Description	Attended measurement results, dB(A)			
				$L_{max,15min}$	$L_{10,15min}$	$L_{eq,15min}$	$L_{90,15min}$
Zone A	12 Sep 2016	10:18	• Located by public walkway in reserve • Traffic noise dominates	75	64	61	52

Monitoring location	Date	Time	Description	Attended measurement results, dB(A)			
				$L_{max, 15min}$	$L_{10, 15min}$	$L_{eq, 15min}$	$L_{90, 15min}$
Zone B	31 Aug 2016	11:38	• Located in public reserve next to council carpark • Traffic noise along Pittwater Road dominates • Non-stop traffic at time of measurement	89	75	71	60

Table 4 Attended noise monitoring results (set back receiver location)

Monitoring location	Date	Time	Description	Attended measurement results, dB(A)			
				$L_{max, 15min}$	$L_{10, 15min}$	$L_{eq, 15min}$	$L_{90, 15min}$
Zone A	31 Aug 2016	11:02	• Located in front of 15 Clarence Avenue • Ambient noise controlled by local traffic along Clarence Avenue and passing pedestrians • Background noise controlled by traffic along Pittwater road	68	54	52	49
Zone B	12 Sep 2016	09:57	• Located in front of 5 Kingsway • Ambient noise controlled by intermittent passing traffic along Kingsway • Background noise controlled by traffic along Pittwater Road	71	59	57	49

3.0 Construction noise and vibration criteria

3.1 Construction noise

The risk of adverse impact of construction noise on a community is determined by the extent of its emergence above the existing background noise level, the duration of the event and the characteristics of the noise.

The Interim Construction Noise Guideline is a NSW Government document that sets out ways to deal with the impacts of construction noise on residences and other sensitive land uses. It presents assessment approaches tailored to the scale of the construction project and identifies practices to minimise noise impacts. The Interim Construction Noise Guideline recommends that a quantitative assessment is carried out for all major construction proposals that are typically subject to the environmental impact assessment processes. A quantitative assessment, based on the likely construction scenarios, has been carried out for the project.

Predicted noise levels at nearby noise sensitive receivers are compared to the levels provided in the Interim Construction Noise Guideline. Where an exceedance of the management levels is predicted the Interim Construction Noise Guideline advises that receivers can be considered ‘noise affected’ and the proponent should apply all feasible and reasonable work practices to minimise the noise impact. The proponent should also inform all potentially impacted residents of the nature of the works to be carried out, the expected noise level and duration, as well as contact details.

Where construction noise levels reach 75 dB(A) residential receivers can be considered as ‘highly noise affected’ and the proponent should, in consultation with the community, consider restricting hours to provide respite periods.

The Interim Construction Noise Guideline defines what is considered to be feasible and reasonable as follows:

Feasible - A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements.

Reasonable - Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure.

Work that is proposed outside of standard working hours, as defined in the Interim Construction Noise Guideline, generally requires strong justification.

Noise management levels for residential receivers are derived using the information in Table 5.

Table 5 Construction noise management levels - Residential receivers from the ICNG

Time of day	Management level LAeq (15 min)1	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10 dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected	The highly noise affected level represents the point above which there may be strong

Time of day	Management level LAeq (15 min)1	How to apply
	75 dB(A)	community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB(A)	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see Section 7. 2. 2 of the ICNG.

Note 1: *Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 metres above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.*

3.2 Noise catchment areas

The study area has been divided into four distinct noise catchment areas (NCAs). The noise environment at each of the sensitive receivers within a noise catchment area is considered to have a similar noise environment to the unattended monitoring location within that NCA. As such each of these sensitive receivers is assigned the same background noise level and noise management level. The location of each NCA is provided graphically in Appendix D. Table 6 provides details of the construction noise management levels and the number of residential receivers identified within each NCA. NCA_A and NCA_B are analogous to Zone A and B respectively.

NCA_C described in Table 6 is the catchment area starting one row back from the main road and extending further into the suburbs. Attended noise logging was undertaken to characterise this area. Considering the size of the catchment area and the small logging period, a conservative approach has been used incorporating the background noise levels identified in AS1055.3-1997. Based on operator attended noise measurements in the area, the area has been conservatively has been classed as R3.

Table 6 Noise catchment areas and construction noise management levels

NCA	Representative logger	Period	Rating background level1 (RBL)	Construction noise management levels (NML) 2,3
NCA_A	P8_2	Day	51	61
		Evening	48	53
		Night	37	42
NCA_B	P8_1	Day	58	68
		Evening	55	60
		Night	42	47
NCA_C	AS1055.3 – R3	Day	50	60
		Evening	45	50
		Night	40	45
Construction compound	Note 3	Day	54	64
		Evening	48	53
		Night	38	43

Note 1: *Day noise management levels = RBL + 10 dB(A)*
Note 2: *Evening / night noise management levels = RBL + 5 dB(A)*
Note 3: *Logger data obtained from a previous report*

3.2.1 Non-residential criteria

Noise management levels recommended by the ICNG for other sensitive land uses, such as schools, hospitals or places of worship are shown in Table 7. Noise management levels for commercial and industrial premises are provided in Table 8.

Table 7 Construction noise management levels – sensitive land uses other than residential

Land use	Construction noise management level, LAeq (15 min) (applies when properties are in use)
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by	External noise level 60 dB(A)

Land use	Construction noise management level, LAeq (15 min) (applies when properties are in use)
external noise intrusion, for example, reading, meditation)	
Community centres	Depends on the intended use of the centre. Refer to the recommended “maximum” internal levels in AS2107 for specific uses.

Table 8 Construction noise management levels – commercial and industrial land uses

Land use	Construction noise management level, $L_{Aeq\ (15min)}$ (applies when properties are in use)
Industrial premises	External noise level 75 dB(A)
Offices, retail outlets	External noise level 70 dB(A)

3.2.2 Sleep disturbance (construction)

The ICNG requires a sleep disturbance assessment to be undertaken where construction works are planned to extend over more than two consecutive nights. The ICNG makes reference to the NSW EPA’s *Environmental Criteria for Road Traffic Noise* (ECRTN) (Environment Protection Authority, 1999), now superseded by the RNP), for assessment of sleep disturbance. The *NSW Road Noise Policy* references the recommendations in the ECRTN as providing the most appropriate assessment guidance.

The guidance provided in the *NSW Road Noise Policy* for assessing the potential for sleep disturbance recommends that to minimise the risk of sleep disturbance during the night-time period (10pm to 7am), the $L_{A1(1\ min)}$ noise level outside a bedroom window should not exceed the $L_{A90\ (15\ minute)}$ background noise level by more than 15 dB(A). The EPA considers it appropriate to use this metric as a screening criterion to assess the likelihood of sleep disturbance. If this screening criterion is found to be exceeded then a more detailed analysis must be undertaken and include the extent that the maximum noise level exceeds the background noise level and the number of times this is likely to happen during the night-time period.

The *NSW Road Noise Policy* contains a review of research into sleep disturbance which presents NSW EPA advice on the subject of sleep disturbance due to noise events. It concludes that having considered the results of research to date that, ‘*Maximum internal noise levels below 50-55 dB(A) are unlikely to cause awakening reactions*’. Therefore, given that an open window provides around 10 dB(A) in noise attenuation from outside to inside, external noise levels of 60-65 dB(A) are unlikely to result in awakening reactions.

Table 9 presents the sleep disturbance screening and sleep disturbance awakening reaction criteria.

Table 9 Construction noise sleep disturbance criteria

NCA	Rating background level (RBL), dB(A)	Sleep disturbance screening $L_{A1(1min)}$ criteria, dB(A)	Sleep disturbance awakening reaction $L_{A1(1min)}$ criteria, dB(A)
NCA_A	37	52	65
NCA_B	42	57	65
NCA_C	40	55	65
Construction compound	38	53	65

3.3 Construction vibration criteria

The relevant standards/guidelines for the assessment of construction vibration are summarised in Table 10.

Table 10 Standards/guidelines used for assessing construction vibration

Item	Standard/guideline
Structural damage	German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures (DIN 4150)
Human comfort (tactile vibration) 1	Assessing Vibration: A Technical Guideline (AVATG) 1
Human comfort (regenerated noise)	Interim Construction Noise Guideline (ICNG)

Note 1: *This document is based upon the guidelines contained in British Standard 6472:1992, "Evaluation of human exposure to vibration in buildings (1-80 Hz)". This British Standard was superseded in 2008 with BS 6472-1:2008 "Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting" and the 1992 version of the Standard was withdrawn. Although a new version of BS 6472 has been published, the Environment Protection Authority still requires vibration to be assessed in accordance with the 1992 version of the Standard at this point in time.*

Vibration and its associated effects are usually classified as continuous, impulsive or intermittent as follows:

- Continuous vibration continues uninterrupted for a defined period and includes sources such as machinery and continuous construction activities for example, a tunnel boring machine.
- Impulsive vibration is a rapid build up to a peak followed by a damped decay. It may consist of several cycles at around the same amplitude, with a duration of typically less than two seconds and no more than three occurrences in an assessment period. This may include occasional dropping of heavy equipment or loading activities.
- Intermittent vibration occurs where there are interrupted periods of continuous vibration, repeated periods of impulsive vibration or continuous vibration that varies significantly in magnitude. This may include intermittent construction activity, impact pile driving, jack hammers.

3.3.1 Structural damage

At present, no Australian Standards exist for the assessment of building damage caused by vibration.

DIN 4150 provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are presented in Table 11. DIN 4150 states that buildings exposed to higher levels of vibration than recommended limits would not necessarily result in damage.

Table 11 DIN 4150: Structural damage safe limits for building vibration

Group	Type of structure	Vibration velocity in mm/s			
		At foundation at a frequency of:			Vibration at the horizontal plane of the highest floor
		Less than 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40

2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (eg buildings that are under a preservation order)	3	3 to 8	8 to 10	8

3.3.2 Human comfort

Humans are sensitive to vibration such that they can detect vibration levels well below those required to cause any risk of damage to a building or its contents. Criteria to avoid annoyance are therefore more stringent than those to prevent structural damage.

Intermittent vibration

The assessment of intermittent vibration outlined in Assessing Vibration: A Technical Guideline (DEC, 2006) is based on Vibration Dose Values (VDVs). The VDV accumulates the vibration energy received over the day time and night time periods.

Maximum and preferred VDVs for intermittent vibration arising from construction activities are listed in Table 12. The VDV criteria are based on the likelihood that a person would be annoyed by the level of vibration over the entire assessment period.

Table 12 Preferred and maximum vibration dose values for intermittent vibration (m/s1.75)

Location	Day time		Night time	
	Preferred	Max	Preferred	Max
Critical areas	0.1	0.2	0.1	0.2
Residences	0.2	0.4	0.13	0.26
Offices, schools, educational institutions and places of worship	0.4	0.8	0.4	0.8
Workshops	0.8	1.6	0.8	1.6

Continuous and impulsive vibration

Acceptable levels of human exposure to continuous and impulsive vibration are dependent on the time of day and the activity taking place in the occupied space. *Assessing Vibration: A Technical Guideline* (Department of Environment and Conservation, 2006) provides the preferred values for continuous and impulsive vibration. These are presented in Table 13.

There is low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values in Table 13. Situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances and infrequent events of short duration. Vibration levels above those indicated in Table 13 may be dealt with through negotiation with the regulator of the affected community. The following axes are defined in relation to the human body:

- x – back to chest.
- y – right side to left side.
- z – foot to head.

Table 13 Preferred and maximum peak particle velocity for continuous and impulsive vibration acceleration (mm/s)

Location	Assessment period	Preferred	Maximum	
		z axis x and y axes	z axis	x and y axes
Continuous vibration				
Critical areas[1]	When in use	0.14	0.28	
Residences[2]	Day Night	0.28 0.20	0.56 0.40	
Offices, schools, educational institutions and places of worship	When in use	0.56	1.1	
Workshops	When in use	1.1	2.2	
Impulsive vibration				
Critical areas	When in use	0.14	0.28	
Residences[2]	Day Night	8.6 2.8	17.0 5.6	
Offices, schools, educational institutions and places of worship	When in use	18.0	36.0	
Workshops	When in use	18.0	36.0	

Note 1: *Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria.*
Note 2: *Criteria for residences are lower than schools as people expect to be able to relax/sleep in their homes without annoyance and are generally more concerned about structural damage than would be the case within schools and offices.*

4.0 Construction Noise Assessment

4.1 Construction Scenarios

The construction scenarios used in this assessment are based on the scope of works as outlined in Section 1.2. Specific elements relating to construction of the Proposal have been assigned a specific works activity with a corresponding L_{eq} sound power level. The construction scenarios have been assumed based on the Roads and Maritime construction noise estimator tool.

Table 14 Construction scenarios

Scenario	Equipment	SWL, dBA	No of units	Overall SWL
Mobilisation & Site Establishment	Truck (medium rigid)	103	4 per hour	115
	Road truck	108	4 per hour	
	Scissor Lift	98	1	
	Franna crane	98	1	
Utility, property, service adjustment	Excavator (tracked) 35t	110	1	116
	Dump truck	110	4 per hour	
	Franna crane 20t	98	1	
	Pneumatic hammer	113	-	
	Concrete saw	118	1	
	Vacuum truck	109	-	
	Backhoe	111	-	
	Power generator	103	1	
Drainage infrastructure	Backhoe	110	-	115
	Franna crane 20t	98	1	
	Excavator (tracked) 35t	110	1	
	Concrete truck	109	4 per hour	
	Truck compressor	75	1	
	Vibratory roller	109	1	
	Road truck	108	4 per hour	
Paving/ asphalting (inc concrete sawing)	Pavement laying machine	114	1	118
	Dump truck	110	4 per hour	
	Asphalt truck & sprayer	103	1	
	Concrete truck	109	1	
	Smooth drum roller	107	1	
	Concrete saw	118	1	
Construction compound operation	Front end loader	91	1	114
	Excavator (tracked) 35t	110	-	
	Road truck	108	4 per hour	
	Compressor	109	1	

Scenario	Equipment	SWL, dBA	No of units	Overall SWL
	Welding equipment	105	1	
	Light vehicles	88	12 per hour	
	Power generator	103	1	

4.2 Methodology

The construction noise assessment was carried out using the RMS Construction Noise Estimator tool. The tool has been used to determine construction noise levels, noise impacts at the most affected sensitive receivers and appropriate specific noise mitigation.

4.3 Results

Provided below is a summary of noise levels at the most affected sensitive receiver location. The following information is provided:

- Daytime standard hours work - Table 15
- Daytime out of house work - Table 16
- Out of hours work, evening - Table 17
- Out of hours work - Table 18

Table 15 Predicted noise impacts – standard hours work

Works area	Noise management level	Most affected receiver		
		Offset (m)	Predicted Level	Exceedance
Mobilisation & Site Establishment				
NCA_A	61	15	79	18
NCA_B	68	10	80	12
NCA_C	60	115	42	-
Utility, property, service adjustment				
NCA_A	61	15	80	19
NCA_B	68	10	81	13
NCA_C	60	115	43	-
Drainage infrastructure				
NCA_A	61	15	79	18
NCA_B	68	10	80	12
NCA_C	60	115	42	-
Paving/ asphalting (inc concrete sawing)				
NCA_A	61	15	82	21
NCA_B	68	10	83	15
NCA_C	60	115	45	-

Works area	Noise management level	Most affected receiver		
		Offset (m)	Predicted Level	Exceedance
Construction compound operation				
Construction compound	64	80	65	1

Table 16 Predicted noise impacts – day out of hours work

Works area	Noise management level	Most affected receiver		
		Offset (m)	Predicted Level	Exceedance
Mobilisation & Site Establishment				
NCA_A	56	15	79	23
NCA_B	63	10	80	17
NCA_C	55	115	42	
Utility, property, service adjustment				
NCA_A	56	15	80	24
NCA_B	63	10	81	18
NCA_C	55	115	43	-
Drainage infrastructure				
NCA_A	56	15	79	23
NCA_B	63	10	80	17
NCA_C	55	115	42	-
Paving/ asphalting (inc concrete sawing)				
NCA_A	56	15	82	26
NCA_B	63	10	83	20
NCA_C	55	115	45	-
Construction compound operation				
Construction compound	59	80	65	6

Table 17 Predicted noise impacts –out of hours work, evening

Works area	Noise management level	Most affected receiver		
		Offset (m)	Predicted Level	Exceedance
Mobilisation & Site Establishment				
NCA_A	53	15	79	26
NCA_B	60	10	80	20
NCA_C	50	115	42	-
Utility, property, service adjustment				
NCA_A	53	15	80	27
NCA_B	60	10	81	21

Works area	Noise management level	Most affected receiver		
		Offset (m)	Predicted Level	Exceedance
NCA_C	50	115	43	-
Drainage infrastructure				
NCA_A	53	15	79	26
NCA_B	60	10	80	20
NCA_C	50	115	42	-
Paving/ asphalting (inc concrete sawing)				
NCA_A	53	15	82	29
NCA_B	60	10	83	23
NCA_C	50	55	45	-
Construction compound operation				
Construction compound	53	80	65	12

Table 18 Predicted noise impacts –out of hours work, night

Works area	Noise management level	Most affected receiver		
		Offset (m)	Predicted Level	Exceedance
Mobilisation & Site Establishment				
NCA_A	42	15	79	37
NCA_B	47	10	80	33
NCA_C	45	115	43	-
Utility, property, service adjustment				
NCA_A	42	15	80	38
NCA_B	47	10	81	34
NCA_C	45	115	42	-
Drainage infrastructure				
NCA_A	42	15	79	37
NCA_B	47	10	80	33
NCA_C	45	115	43	-
Paving/ asphalting (inc concrete sawing)				
NCA_A	42	15	82	40
NCA_B	47	10	83	36
NCA_C	45	115	45	-
Construction compound operation				
Construction compound	43	80	65	22

Sleep disturbance

Due to the high noise levels, sleep disturbance can be expected for noise intensive works during the night-time period. Mitigation should be employed in accordance with the recommendations provided in Section 6.0 of this report.

4.4 Construction traffic noise impacts

The traffic report has identified that approximately 5 heavy vehicles would be required on site per day. It is estimated that a maximum of two vehicles per hour would access the site. Additionally 18 light vehicles would make two-way trips. Light vehicles would generally arrive between 6.30 am and 7.00 am and depart between 5.00 pm and 5.30 pm. Existing hourly movements (both heavy and light vehicles combined) on Pittwater road are between approximately 500 movements per hour at 5.00 am with an afternoon peak of 3500 movements at 5.00 pm. The movements associated with the construction traffic are relatively insignificant and may increase noise levels by up to 0.2 dB(A). This increase in noise would not have a perceptible change on existing road traffic throughout the project area.

5.0 Construction vibration assessment

In order to comply with the cosmetic/structural damage and human discomfort criteria presented in Section 3.3 the safe working distances presented in Table 19 should not be encroached.

Table 19 Recommended safe working distances for vibration intensive plant

Plant	Rating/description	Safe working distance	
		Cosmetic damage (metres)	Human response (metres)
Vibratory roller	< 50 kN (Typically 1-2 T)	5	15-20
	< 100 kN (Typically 2-4 T)	6	20
	< 200 kN (Typically 4-6 T)	12	40
	< 300 kN (Typically 7-13 T)	15	100
	> 300 kN (Typically 13-18 T)	20	100
	> 300 kN (> 18 T)	25	100
Small hydraulic hammer	(300 kg – 5-12 T excavator)	2	7
Medium hydraulic hammer	(900 kg – 12-18 T excavator)	7	23
Large hydraulic hammer	(1,600 kg – 18-34 T excavator)	22	73
Vibratory pile driver	Sheet piles	2-20	20
Pile boring	≤ 800 mm	2 nominal	N/A
Jack hammer	Handheld	Avoid contact with structure	Avoid contact with structure

Note: More stringent conditions may apply to heritage or other sensitive structures. Any heritage property would need to be considered on a case by case basis

Depending on the construction equipment that is used, the safe working distances outlined in Table 19 may be encroached. The primary form of mitigation of vibration would be ensuring vibration intensive works do not occur where safe working distances would be encroached by sensitive receivers. If vibration intensive works are required within the safe working distances identified, alternative equipment should be identified and vibration monitoring implemented. Further mitigation of vibration would not be required where the safe working distances do not coincide with sensitive receivers.

In some circumstances, construction activity within the safe working distance cannot be avoided due to the work required and the prevalent geological site conditions. These conditions may not be fully understood until work has commenced, resulting in a potential change in operating equipment. Approaches to manage such circumstances are discussed in Chapter 6.7.

6.0 Recommended mitigation measures

This section of the report presents construction noise and vibration mitigation measures to be considered for implementation to avoid and/or manage construction noise and vibration impacts.

The construction noise and vibration assessment presented in Chapter 4.0 of this report detailed a number of exceedances of the noise management levels associated with the Proposal. These were predicted as a result of various construction activities. A number of exceedances of the 'highly noise affected' criteria were also predicted. As a result of these exceedances, and potential exceedances of vibration criteria, generic and receiver-specific mitigation measures have been identified.

Specific noise mitigation has been recommended in accordance with the *RMS Construction Noise Guideline*. Provided below is a summary of the details of various types of noise mitigation.

Table 20 Specific noise mitigation measures

Measure	Description
Notification (letterbox drop or equivalent)	Advanced warning of works and potential disruptions can assist in reducing the impact on the community. The notification may consist of a letterbox drop (or equivalent) detailing work activities, time periods over which these will occur, impacts and mitigation measures. Notification should be a minimum of 5 working days prior to the start of works. The approval conditions for projects may also specify requirements for notification to the community about works that may impact on them.
Specific notifications	Specific notifications are letterbox dropped (or equivalent) to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. The specific notification provides additional information when relevant and informative to more highly affected receivers than covered in general letterbox drops. This form of communication is used to support periodic notifications, or to advertise unscheduled works.
Phone calls	Phone calls detailing relevant information made to identified/affected stakeholders within seven calendar days of proposed work. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs. Where the resident cannot be telephoned then an alternative form of engagement should be used.
Individual briefings	Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Project representatives would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project. Where the resident cannot be met with individually then an alternative form of engagement should be used.
Respite offer	Respite Offers should be considered made where there are high noise and vibration generating activities near receivers. As a guide work should be carried out in continuous blocks that do not exceed 3 hours each, with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers. The purpose of such an offer is to provide residents with respite from an ongoing impact. This measure is evaluated on a project-by-project basis, and may not be applicable to all projects.

Measure	Description
Respite Period 1 **Mon-Fri** 6pm – 10pm **Sat** 7am-9am & 1pm-10pm **Sun/Pub Hol** 8am-6pm	Out of hours construction noise in out of hours period 1 shall be limited to no more than three consecutive evenings per week except where there is a Duration Respite. For night work these periods of work should be separated by not less than one week and no more than 6 evenings per month
Respite Period 2 **Mon-Fri** 10pm-7am **Sat** 10pm-8am **Sun/Pub Hol** 6pm-7am	Night time construction noise in out of hours period 2 shall be limited to two consecutive nights except for where there is a Duration Respite. For night work these periods of work should be separated by not less than one week and 6 nights per month. Where possible, high noise generating works shall be completed before 11pm.
Duration respite	Respite offers and respite periods 1 and 2 may be counterproductive in reducing the impact on the community for longer duration projects. In this instance and where it can be strongly justified it may be beneficial to increase the work duration, number of evenings or nights worked through Duration Respite so that the project can be completed more quickly. The project team should engage with the community where noise levels are expected to exceed the NML to demonstrate support for Duration Respite. Where there are few receivers above the NML each of these receivers should be visited to discuss the project to gain support for Duration Respite. Support may be demonstrated from surveys, online feedback, contact phone numbers and community events.
Alternative accommodation	Alternative accommodation options may be offered to residents living in close proximity to construction works that are likely to experience highly intrusive noise levels . The specifics of the offer will be identified on a project-by-project basis. Additional aspects for consideration shall include whether the highly intrusive activities occur throughout the night or before midnight.
Verification	Verification should include measurement of the background noise level and construction noise. Note this is not required for projects less than three weeks unless to assist in managing complaints.

6.1 Specific noise mitigation – Noise Catchment Area A

In accordance with the *RMS Construction Noise Guideline*, provided below is a summary of the required noise mitigation and management measures for the most affected sensitive receivers in NCA_A:

- Standard work hours – Notification, verification, phone calls, respite offer.
- Day out of hours work – Verification, individual briefings, notifications, respite period 1, duration respite, phone calls, specific notifications
- Evening out of hours work - Verification, individual briefings, notifications, respite period 1, duration respite, phone calls, specific notifications
- Night-time out of hours work – Alternative accommodation, verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite.

6.2 Specific noise mitigation - Noise Catchment Area B

In accordance with the *RMS Construction Noise Guideline*, provided below is a summary of the required noise mitigation and management measures for the most affected sensitive receivers in NCA_B:

- Standard work hours – Notification, verification
- Day out of hours work – Verification, notifications, respite period 1, duration respite,
- Evening out of hours work - Verification, individual briefings, notifications, respite period 1, duration respite, phone calls, specific notifications
- Night-time out of hours work – Alternative accommodation, verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite.

6.3 Specific noise mitigation - Noise Catchment Area C

The predicted noise levels provided in Section 4.3 identify that noise compliance would achieved for NCA_C. However due to topography and potential unexpected noise propagation paths, minor exceedances of the noise criteria may be experienced. It is recommended that letter box drops for the first row of houses within catchment area NCA_C is undertaken for all out of hours work.

6.4 Specific noise mitigation - Construction compound

- Day out of hours work – Notification, respite period 1, duration respite
- Evening out of hours work - Notification, respite period 1, duration respite
- Night-time out of hours work – Verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite.

6.5 Standard noise mitigation

In addition to the specific noise mitigation, where reasonable and feasible the following noise mitigation should be employed.

6.5.1 Construction noise and vibration management plan

A Construction Noise and Vibration Management Plan (CNVMP) would be prepared. The CNVMP would include the following:

- Identification of nearby residences and other sensitive land uses
- Description of approved hours of work
- Description and identification of all construction activities, including work areas, equipment and duration
- Description of what work practices (generic and specific) would be applied to minimise noise and vibration
- A complaints handling process
- Noise and vibration monitoring procedures
- Overview of community consultation required for identified high impact works.

The CNVMP should include consideration of the following issues:

- Cumulative construction noise impacts
- Construction noise fatigue.

Feasible and reasonable mitigation measures would be detailed within the CNVMP to manage predicted noise levels at sensitive receivers and areas where construction fatigue could occur. Consultation with the affected community would also occur prior to and during construction.

6.5.2 Community consultation and complaints handling

All residents impacted by noise from the proposed works which are expected to exceed the construction noise management levels (NML) should be consulted prior to the commencement of construction. The highest consideration should be given to those that are predicted to be most affected as a result of the works.

The information provided to the residents should include:

- Programmed times and locations of construction work
- The hours of proposed works
- Construction noise and vibration impact predictions
- Construction noise and vibration mitigation measures to be implemented on site.

Community consultation regarding construction noise and vibration would be detailed in the Community Involvement Plan for the construction of the project and would include a 24 hour hotline and complaints management process.

For out-of-hours works, consultation would take place with consideration to Practice Note vii of Roads and Maritime's *Environmental Noise Management Manual* (ENMM) and Strategy 2 of the ICNG.

6.5.3 Work practices

Induction and training would be provided to relevant staff and sub-contractors outlining their responsibilities with regard to noise and vibration.

6.5.4 Construction hours and work scheduling

Details of all out of hours work required would form part of the CNVMP.

Noisy work would be scheduled to be undertaken during the standard hours as far as possible. Noisy activities that cannot be undertaken during standard construction hours are to be scheduled as early as possible during the evening and/or night-time periods.

Particularly noisy activities such as the use of impact piling rigs, road and concrete saws, rock hammers, should be scheduled where feasible and reasonable around times of high background noise to provide masking.

Deliveries would be carried out during standard construction hours where feasible and reasonable.

Consideration would be given to construction timetabling to minimise noise impacts, such as the use of respite periods.

6.5.5 Respite

A protocol would be developed to identify the need for, and provision of, respite measures for residential receivers in accordance with the *ICNG*. Respite measures may include the restriction to the hours of construction activities resulting in impulsive or tonal noise (such as rock hammering, pile driving), or other appropriate measures agreed between the contractor and residential receiver such as temporary alternative accommodation.

The protocol would form part of the CNVMP.

6.6 Construction noise

6.6.1 Construction traffic

The following measures would be implemented to reduce and manage noise and vibration impacts associated with construction traffic:

- Truck drivers would be advised of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (ie minimising/restricting the use of engine compression brakes, and no extended periods of engine idling)
- Site access and egress points would be located away from residences and other sensitive land uses, where feasible and reasonable
- Deliveries and spoil removal would be planned to avoid queuing of trucks on or around the compounds
- Construction sites would be arranged to limit the need for reversing associated with regular/repeatable movements (eg trucks transporting spoil) to minimise the use of reversing alarms
- Where feasible and reasonable, non-tonal reversing alarms would be used, taking into account the requirements of the Workplace Health and Safety legislation
- Spoil would be moved during the day where practical, and feasible and reasonable management strategies would be investigated in consultation with the NSW Environment Protection Authority to minimise the volume of heavy vehicle movements at night.

6.6.2 Plant and equipment selection and location

The selection of plant and equipment can have a significant impact on construction noise levels. Appropriate plant would be selected for each task to minimise the noise contributions.

Alternative works methods such as the use of hydraulic or electric-controlled units in place of diesel units would be considered and implemented where feasible and reasonable. The use of alternative machines that perform the same function, such as rubber wheeled plant, would be considered in place of steel tracked plant.

Equipment would be regularly inspected and maintained to ensure it is in good working order.

Plant should be located on site with as much distance as possible between the plant and noise sensitive receivers. Noisy equipment would be orientated away from residential receivers where feasible and reasonable.

6.6.3 Noise monitoring

A noise monitoring program would be implemented to assist in confirming and controlling the site specific potential for disturbance at particularly sensitive localities at the commencement of activities and periodically during construction. The results would be reviewed to determine if additional mitigation measures are required. All measurements would be undertaken in accordance with *Australian Standard 1055.1-1997 – Acoustics – Description and measurement of environmental noise, Part 1: General procedures*.

A noise monitoring program would be presented in the CNVMP.

If regenerated noise is reported to be a problem during vibration intensive works, attended and/or unattended noise measurements would be undertaken within the relevant building spaces to determine the level of regenerated noise.

6.7 Construction vibration

In some circumstances, construction activity within the safe working distance cannot be avoided based on the type of work required and the prevalent geological site conditions. These conditions may not be fully understood until work has commenced. Provided below is a summary of management measures for vibration intensive activities that occur within safe working distances.

Equipment selection and maintenance

Equipment size would be selected taking into account the safe working distances and the distance between the area of construction and the most affected sensitive receiver.

The use of less vibration intensive methods of construction or equipment would be considered where feasible and reasonable when working in proximity to existing structures.

Equipment would be maintained and operated in an efficient manner, in accordance with manufacturer's specifications, to reduce the potential for adverse vibration impacts.

Scheduling of construction activities

Wherever reasonable and reasonable, vibration intensive works should be limited to the least sensitive times of the day.

Supplementary vibration monitoring

If the use of vibration intensive plant cannot be avoided within the safe working distance for cosmetic damage to existing structures the following procedure would occur as a minimum:

- Notification of the works to the affected residents and community
- Works would not proceed until attended vibration measurements are undertaken.

If ongoing works are required a temporary relocatable vibration monitoring system would be installed to warn operators (via flashing light, audible alarm, short message service (SMS) etc) when vibration levels are approaching the cosmetic damage objective.

7.0 Conclusion

A detailed construction noise and vibration assessment has been undertaken to determine likely impacts to nearby sensitive receivers. Roads and Maritime do not expect a change in traffic volumes as a result of the project. As such as operational noise assessment is not warranted for this project.

The project is divided up into two areas. Zone A is located on Pittwater Road to the south of Hawkesbury Avenue. Zone B is located on Pittwater road between Dee Why Road and Sturdee Parade. Zone C is the noise catchment area located one street back from the main alignment. This catchment area has lower noise levels due to shielding of Pittwater Road. The project also incorporates a construction compound which is located at the site of the Manly Value Commuter Car Park.

Background noise logging has been undertaken at each of the Zones within the Proposal area to quantify the existing noise levels. The background noise logging was used to define the construction noise management levels in accordance with the EPA's *Interim Construction Noise Guideline*.

The degree of potential construction noise has been assessed at the most affected noise sensitive receiver within each Zone of works. The results identify that the community has the potential to be adversely impacted by the proposed works, particularly if out of hours working hours are used. Provided in Section 6.0 are specific noise mitigation measures for each noise catchment area of the proposed works. These recommendations have been made in accordance with the *Roads and Maritime Construction Noise and Vibration Guideline*. Due to small offset distances between the source and receivers, all works are expected to exceed the noise management levels at the most affected receiver. Both generic and project specific noise mitigation measures have been provide for inclusion where found reasonable and feasible. These measures are detailed in Section 6.5.

Vibration criteria have been based on the EPA's *Assessing Vibration: A technical guideline*. Dependent on the specific equipment used in the construction process, the vibration generated by the proposed construction works has the potential to impact sensitive receivers. Measures to manage vibration impacts have been recommended primarily in the form of selecting equipment which will comply with the safe working distances identified in Section 5.0. If vibration intensive work is required that would where existing structures would fall within these safe working distances, additional mitigation measures should be implemented as outlined in Section 6.7.

Appendix A

Acoustic Glossary

Appendix A Acoustic Glossary

The following is a brief description of acoustic terminology used in this report.

Term	Definition	
Sound power level	The total sound emitted by a source	
Sound pressure level	The amount of sound at a specified point	
Decibel [dB]	The measurement unit of sound	
A Weighted decibels [dB(A])	The A weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The A-weighting filter emphasises frequencies in the speech range (between 1 kHz and 4 kHz) which the human ear is most sensitive to, and places less emphasis on low frequencies at which the human ear is not so sensitive. When an overall sound level is A-weighted it is expressed in units of dB(A).	
Decibel scale	The decibel scale is logarithmic in order to produce a better representation of the response of the human ear. A 3 dB(A) increase in the sound pressure level corresponds to a doubling in the sound energy. A 10 dB(A) increase in the sound pressure level corresponds to a perceived doubling in volume. Examples of decibel levels of common sounds are as follows:	
	0 dB(A)	Threshold of human hearing
	30 dB(A)	A quiet country park
	40 dB(A)	Whisper in a library
	50 dB(A)	Open office space
	70 dB(A)	Inside a car on a freeway
	80 dB(A)	Outboard motor
	90 dB(A)	Heavy truck pass-by
	100 dB(A)	Jack hammer / subway train
	110 dB(A)	Rock Concert
	115 dB(A)	Limit of sound permitted in industry
	120 dB(A)	747 take off at 250 metres
Frequency [f]	The repetition rate of the cycle measured in Hertz (Hz). The frequency corresponds to the pitch of the sound. A high frequency corresponds to a high pitched sound and a low frequency to a low pitched sound.	
Equivalent continuous sound level [L_{eq}]	The constant sound level which, when occurring over the same period of time, would result in the receiver experiencing the same amount of sound energy.	
Insertion loss	Reduction in noise by inserting a barrier between the source and receiver	
L_{max}	The maximum sound pressure level measured over the measurement period	
L_{min}	The minimum sound pressure level measured over the measurement period	
L_{10}	The sound pressure level exceeded for 10% of the measurement period. For 10% of the measurement period it was louder than the L_{10}.	
L_{90}	The sound pressure level exceeded for 90% of the measurement period. For 90% of the measurement period it was louder than the L_{90}.	

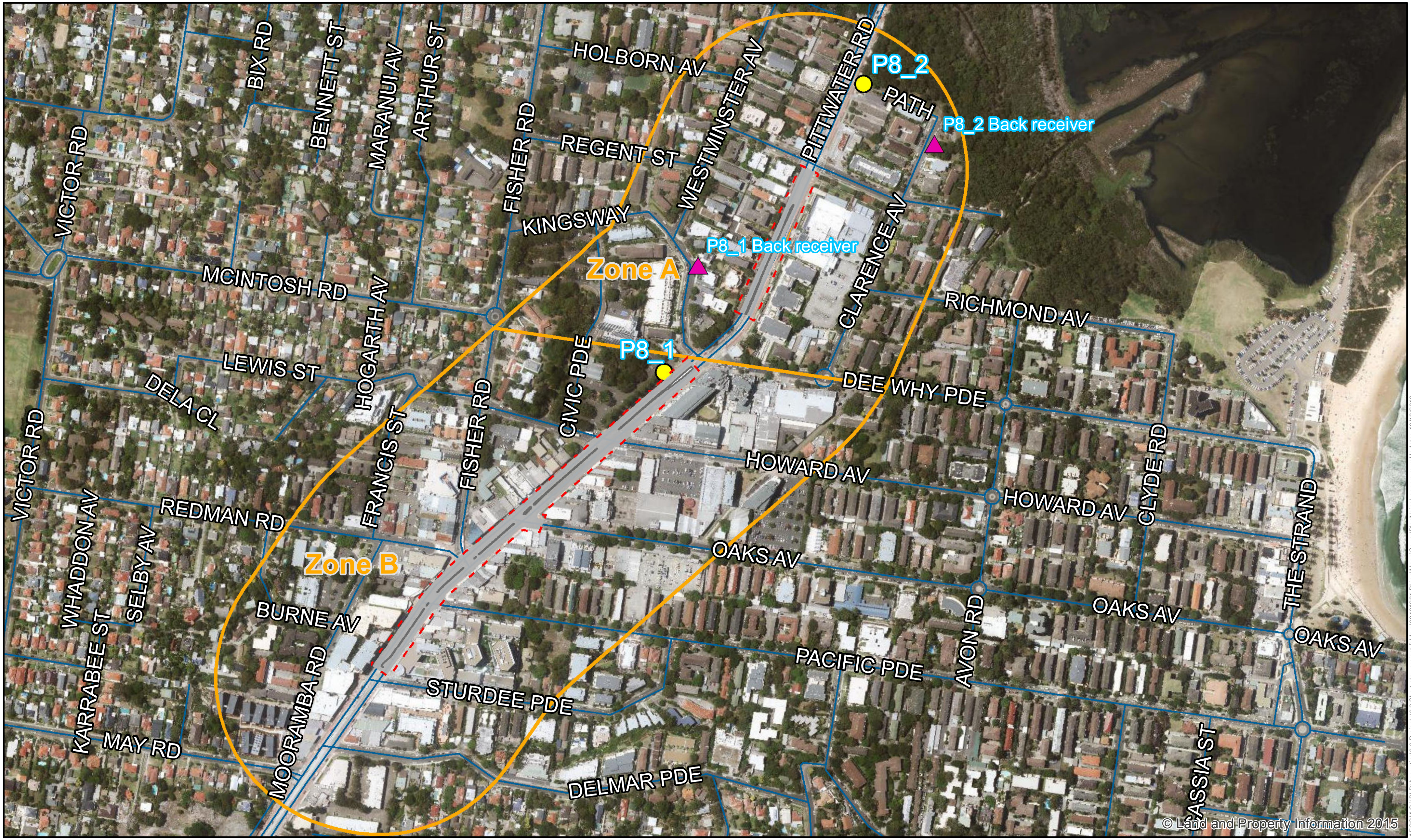
Term	Definition
Ambient noise	The all-encompassing noise at a point composed of sound from all sources near and far.
Background noise	The underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed. The L90 sound pressure level is used to quantify background noise.
Traffic noise	The total noise resulting from road traffic. The L_{eq} sound pressure level is used to quantify traffic noise.
Day	Construction noise The period from 0700 to 1800 h Monday to Saturday and 0800 to 1800 h Sundays and Public Holidays. Road traffic noise The period from 0700 to 2200 h every day of the week.
Evening	Construction noise The period from 1800 to 2200 h Monday to Sunday and Public Holidays. Road traffic noise Not applicable.
Night	Construction noise The period from 2200 to 0700 h Monday to Saturday and 2200 to 0800 h Sundays and Public Holidays. Road traffic noise The period from 2200 to 0700 h every day of the week.
Assessment background level [ABL]	The overall background level for each day, evening and night period for each day of the noise monitoring.
Rating background level [RBL]	The overall background level for each day, evening and night period for the entire length of noise monitoring.

*Definitions of a number of terms have been adapted from Australian Standard AS1633:1985 “Acoustics – Glossary of terms and related symbols”, the EPA’s Industrial Noise Policy and Road Noise Policy.

Appendix B

Noise logging locations

AECOM



Legend

- Extent of works (approximate)
- Package 8 Zones
- Package 8 Noise loggers and attended location
- Attended - Back Receiver

100 50 0 100 Meters

N

B-Line

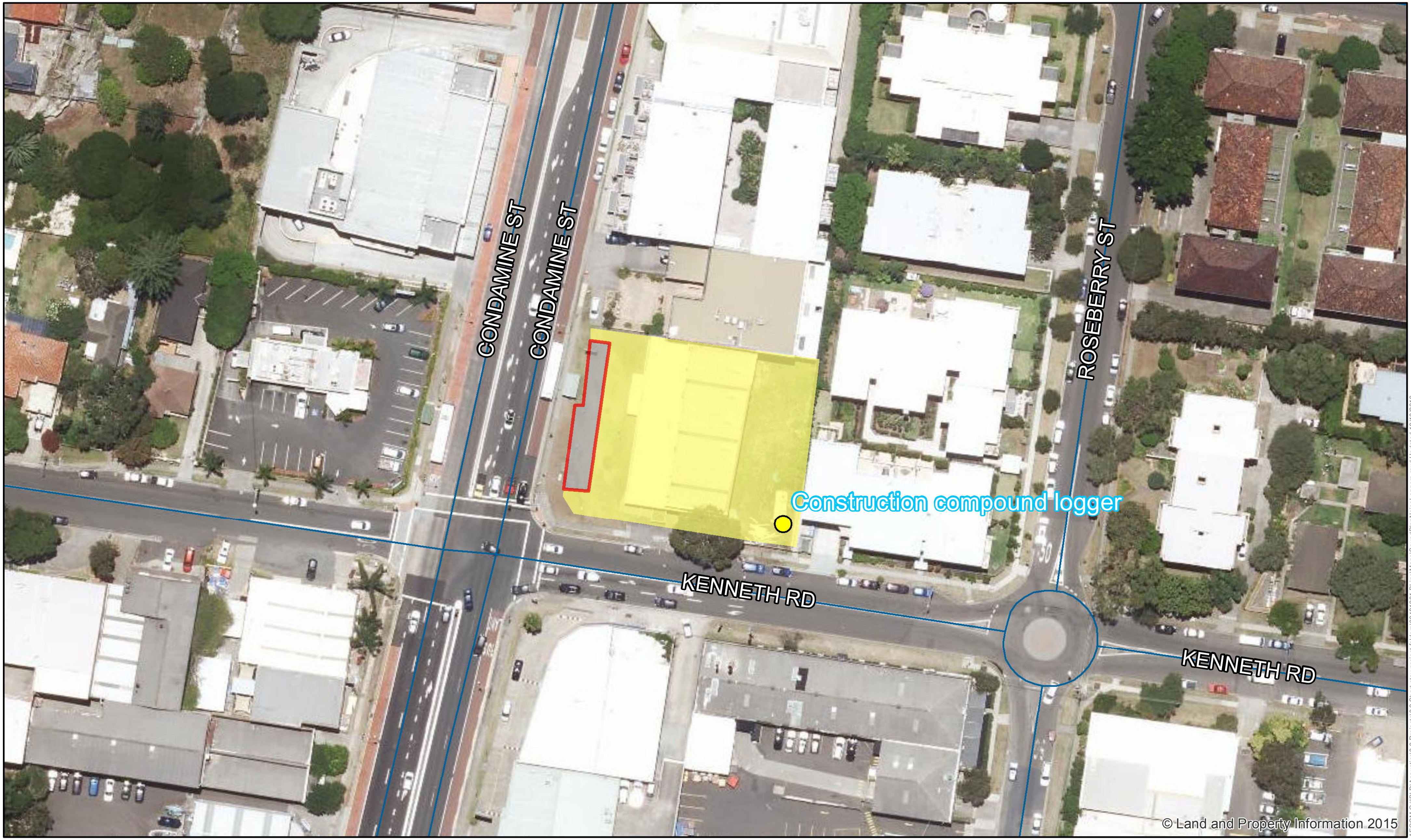
Package 8 Noise Loggers

Source:

OCT 2016

60491201

Fig. **1**



Legend

- Construction compound
- Manly Vale Commuter Car Park

50 25 0 50 Meters

N

B-Line

Package 8, 9 Construction compound

Source:

OCT 2016

60491201

Fig. **1**

Appendix C

Noise logging results

P8_1 - 727 Pittwater Road - 31/08/16 - 11/09/16

Logger Setup

Logger Type: ARL 215

Serial No : 194803

Address: 727 Pittwater Road , Dee Why

Location: On nature strip adjacent carpark, under tree.

Facade / Free Field: Free Field

Environment: Traffic noise is dominant. Logger located elevated above the alignment of Pittwater Road.

Logger Setup Photo

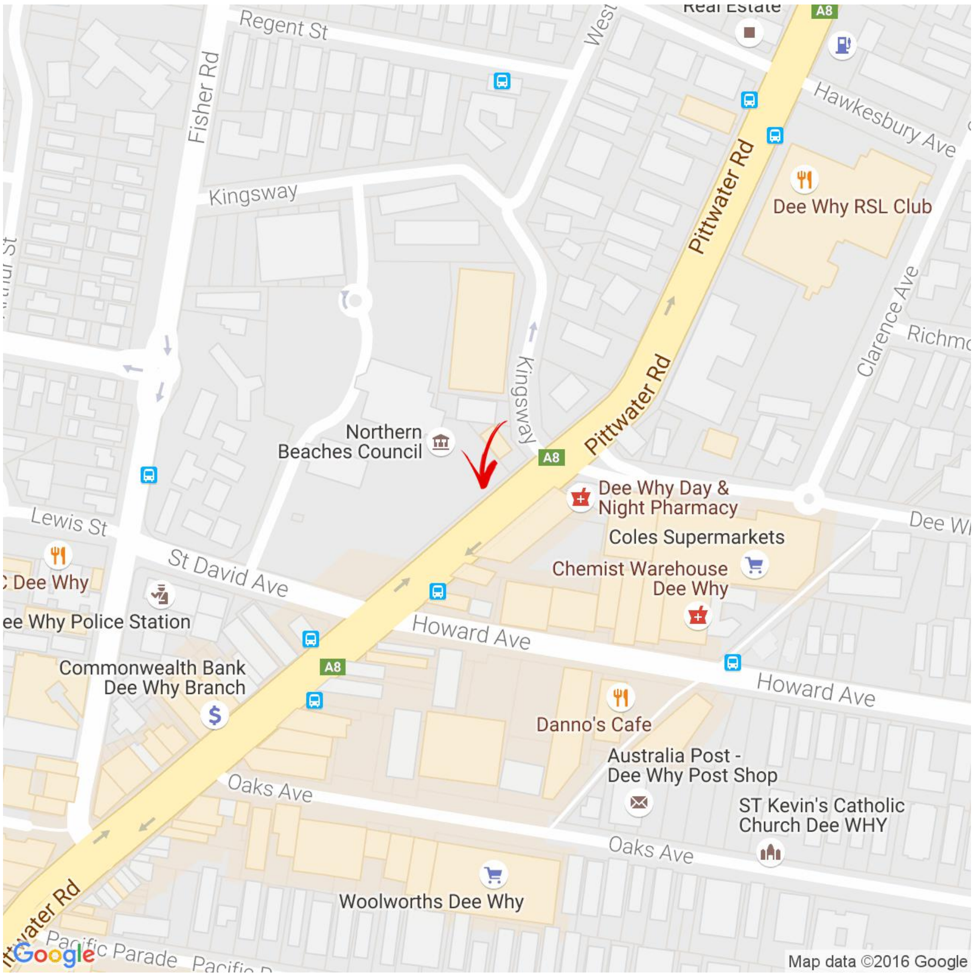
INP Noise Level, dB(A)

	Log Average	RBL
Day	71	58
Evening	70	55
Night	66	42

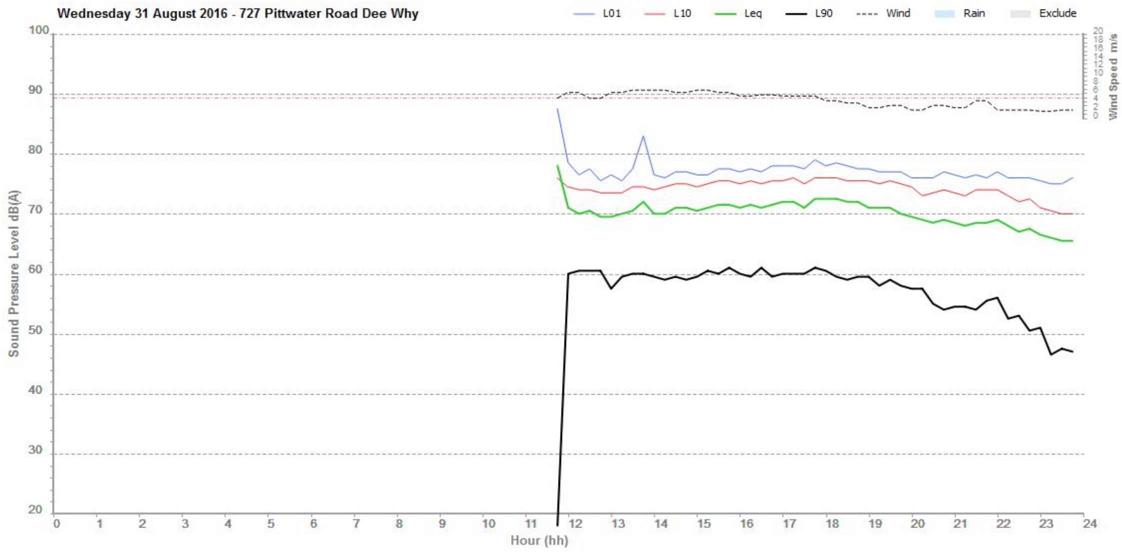
RNP Noise Level, dB(A)

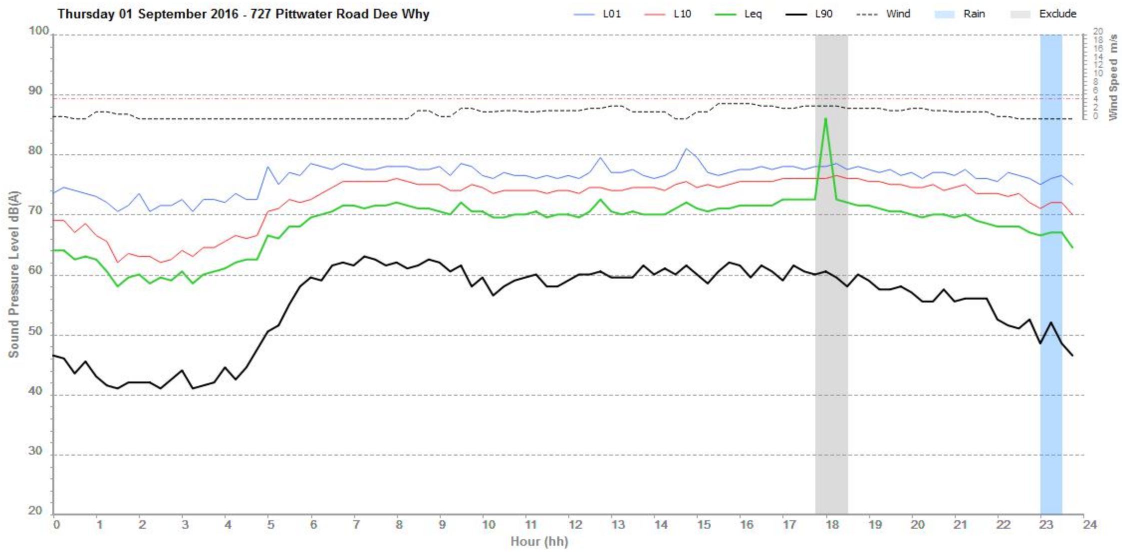
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

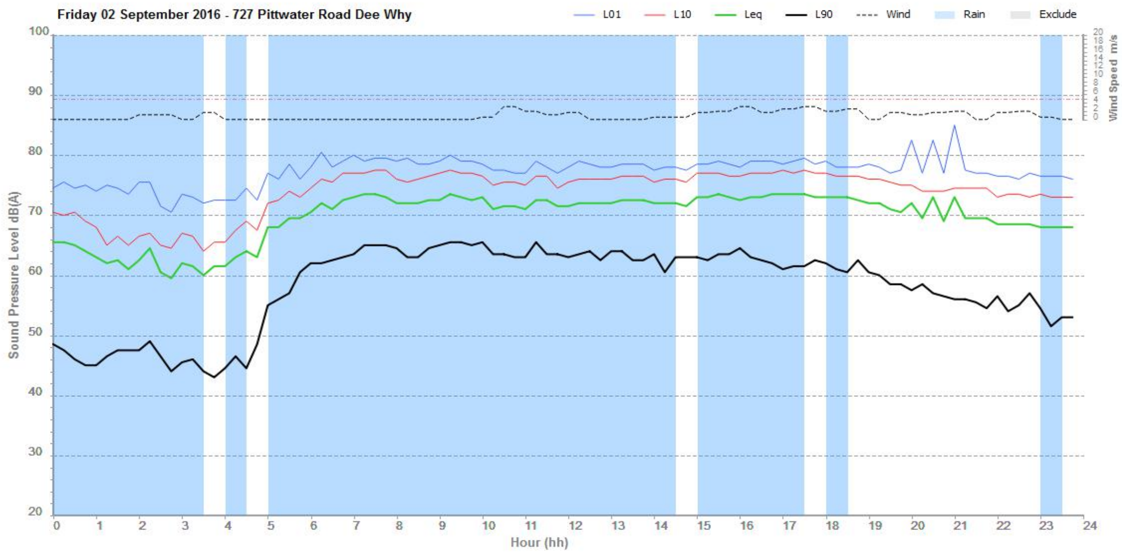
Logger Location Map



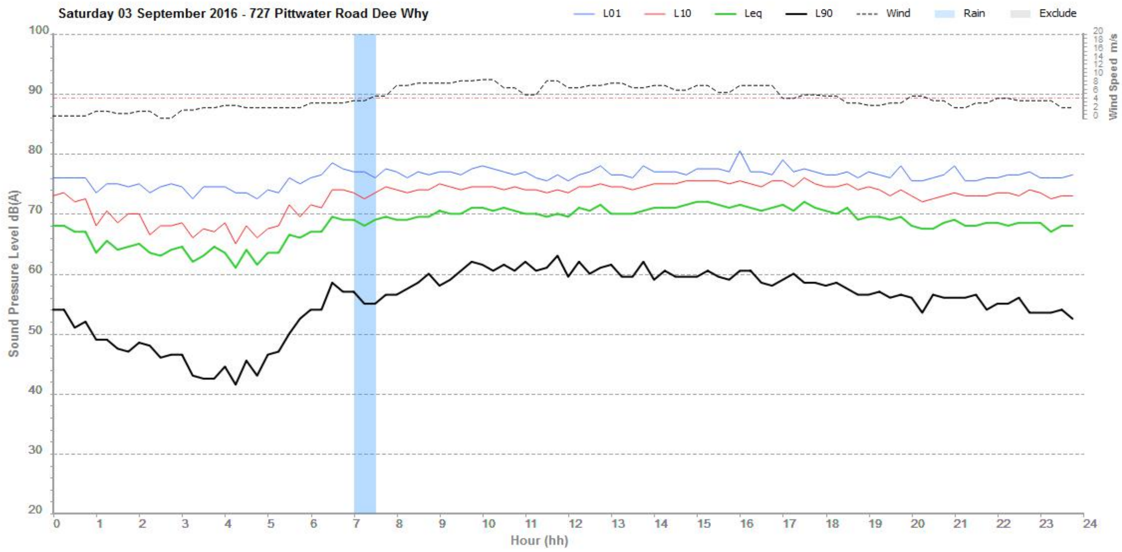
Logger Graphs

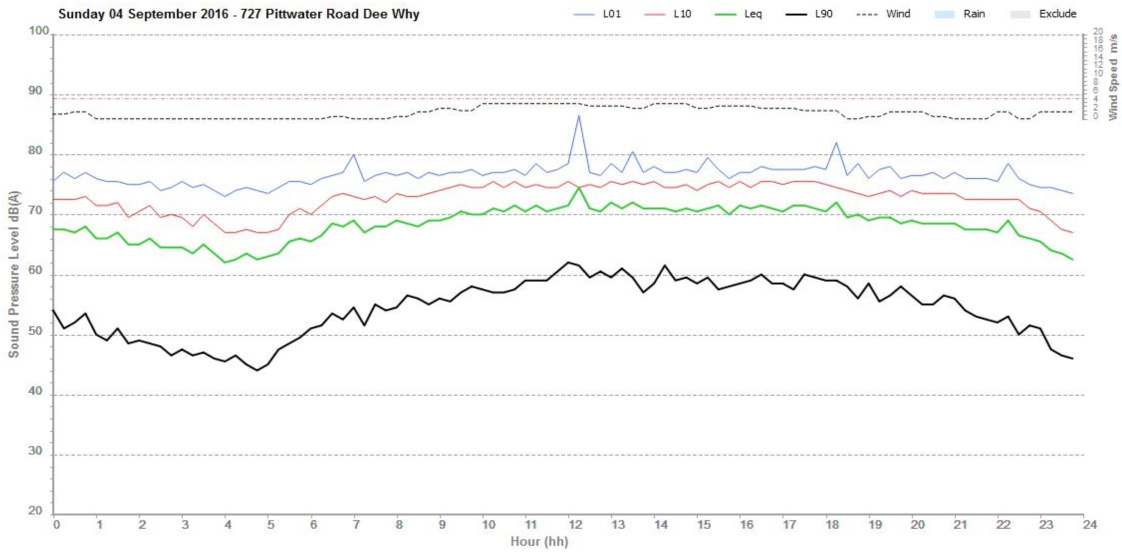


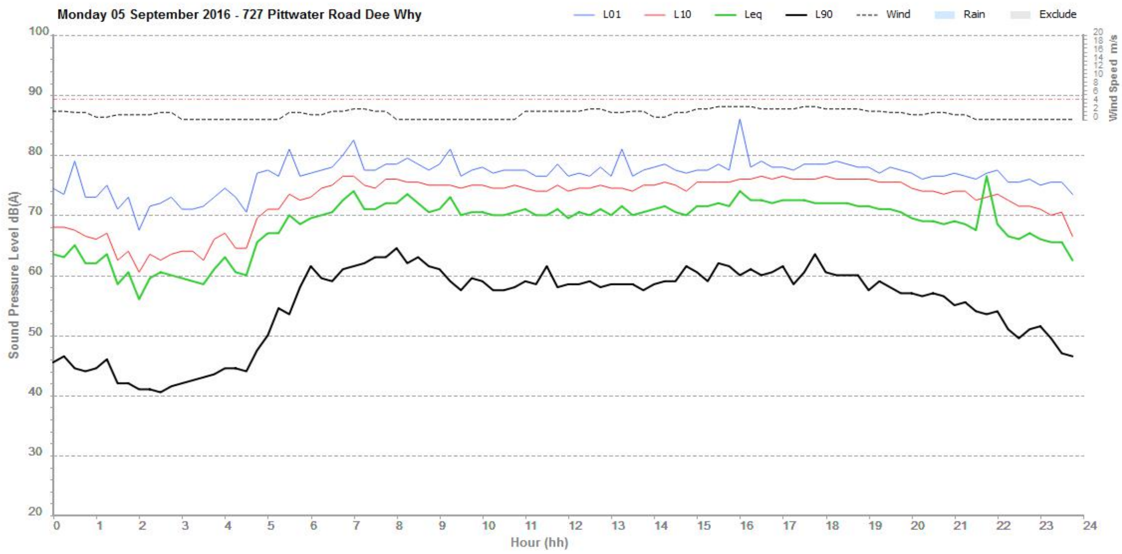




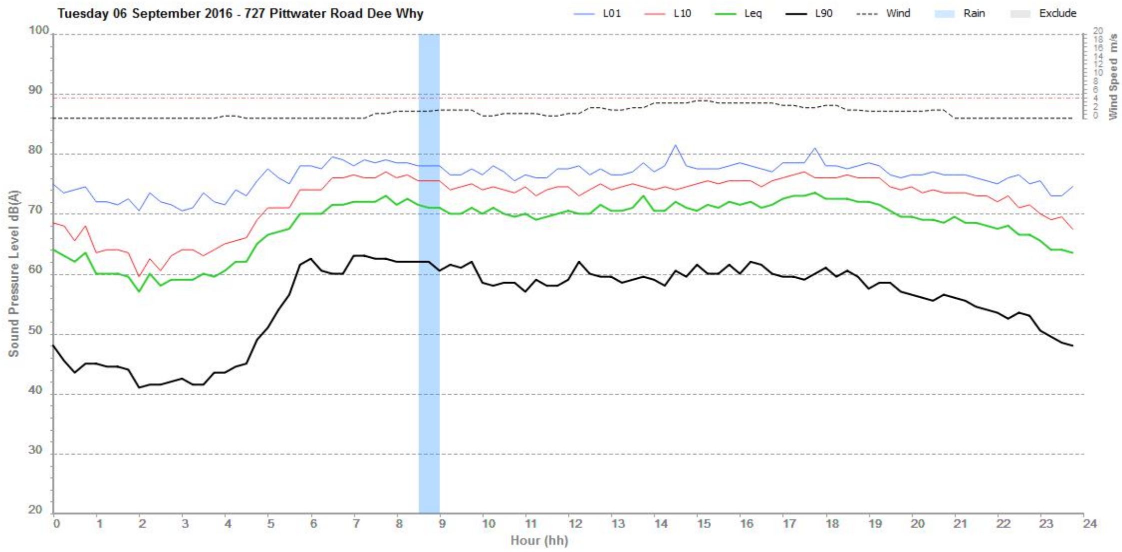
Logger Graphs

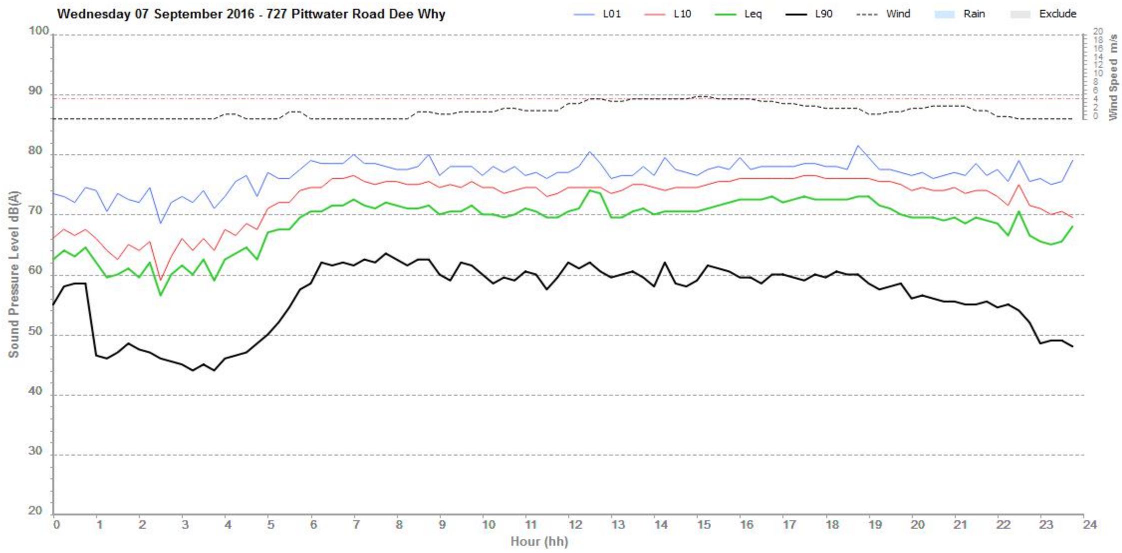


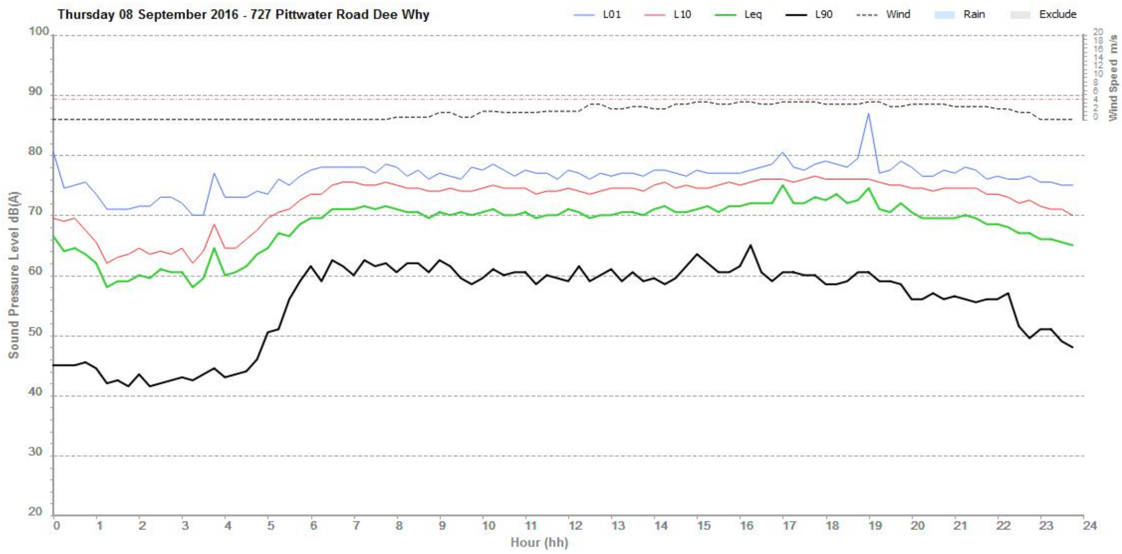




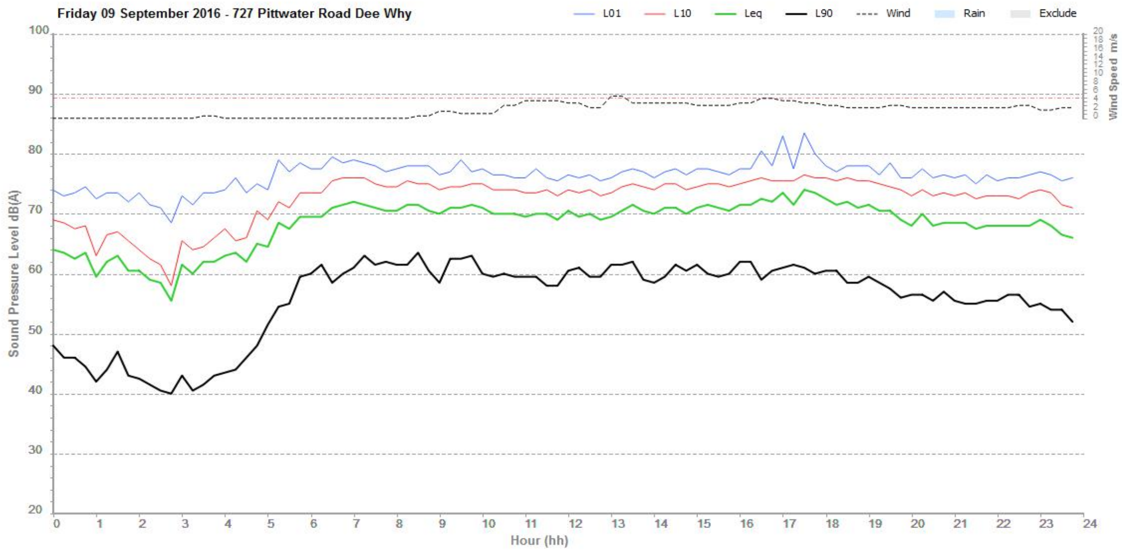
Logger Graphs

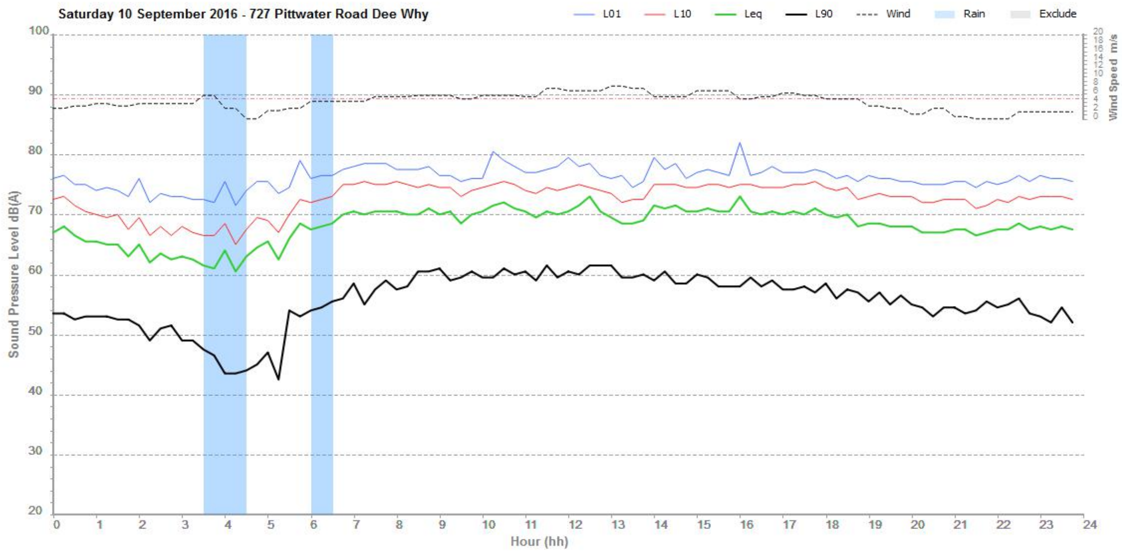


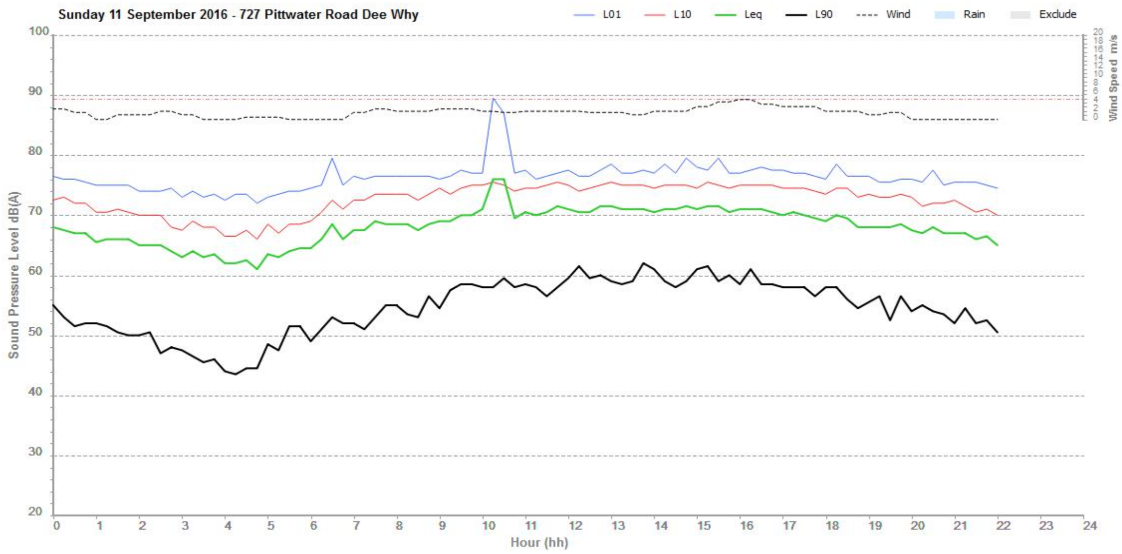




Logger Graphs







P8_2 - 946 Pittwater Road - 31/08/16 - 12/09/16

Logger Setup

Logger Type: ARL 215

Serial No : 194528

Address: 946 Pittwater Road , Dee Why

Location: Reserve walkway to the north near telegraph pole

Facade / Free Field: Free Field

Environment: Traffic noise is dominant. Logger located by public walkway in reserve.

Logger Setup Photo

INP Noise Level, dB(A)

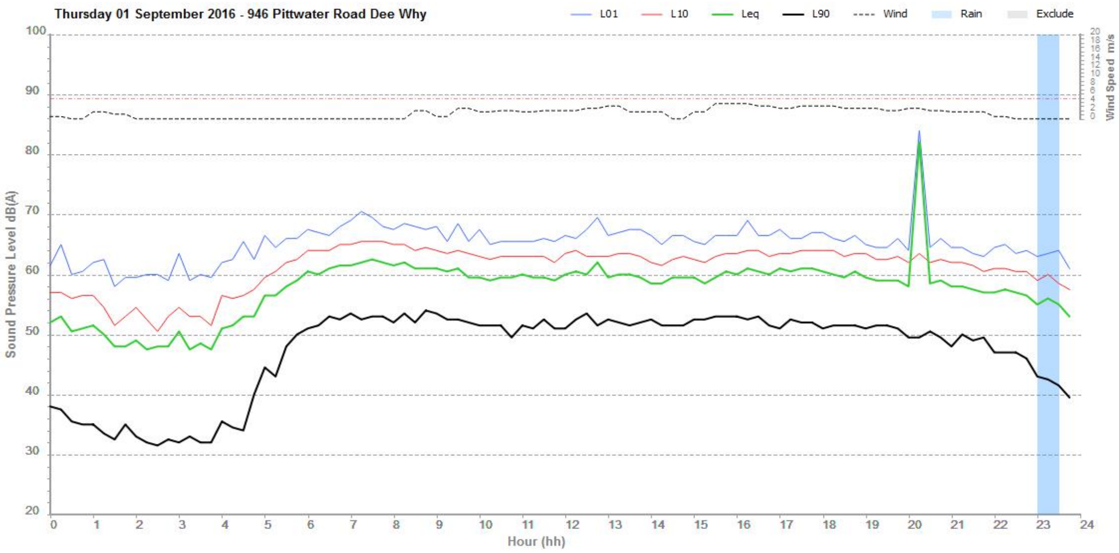
	Log Average	RBL
Day	62	51
Evening	62	48
Night	55	37

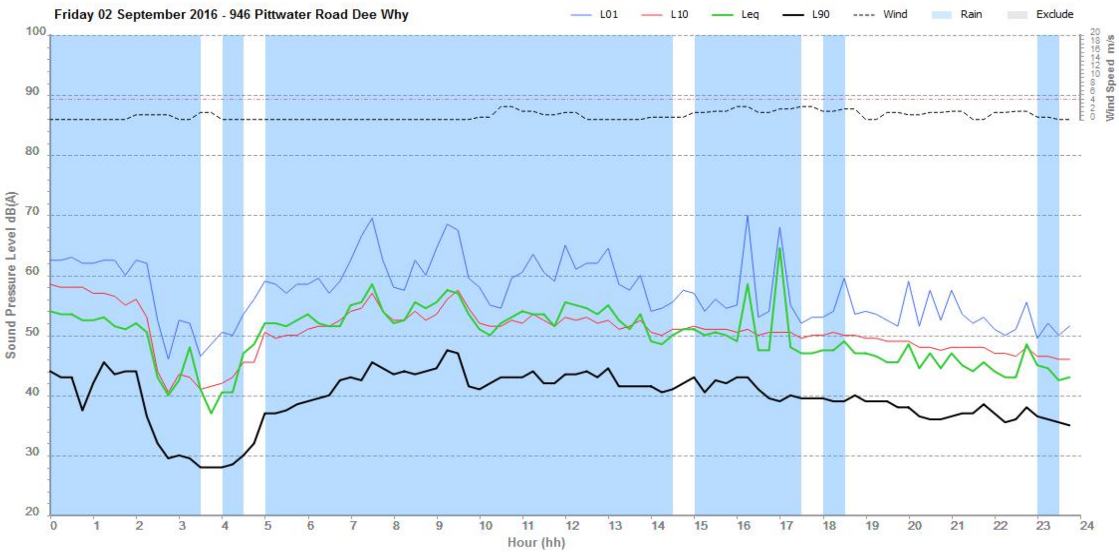
RNP Noise Level, dB(A)

	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

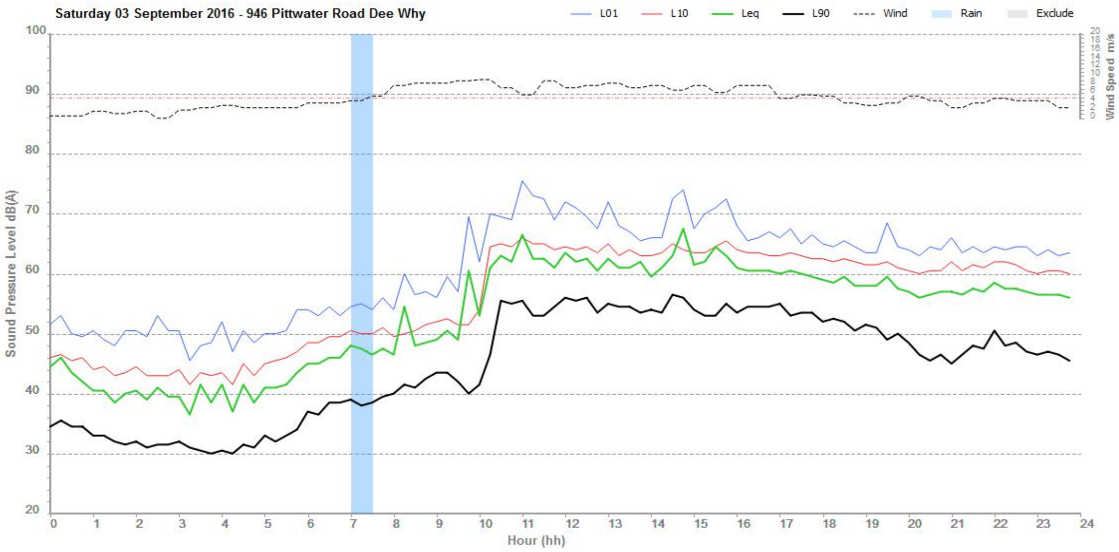
Logger Location Map

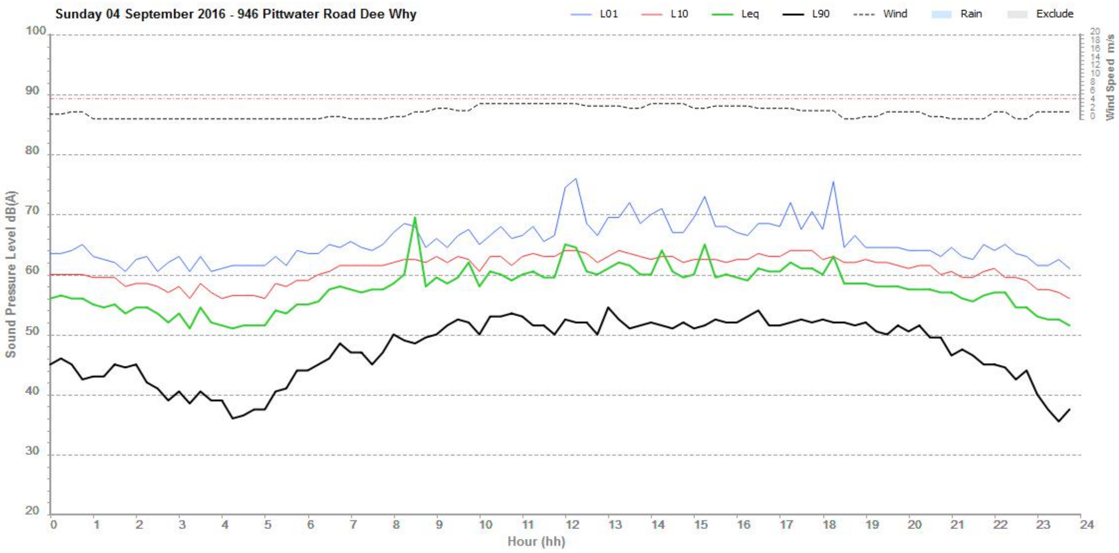
Logger Graphs

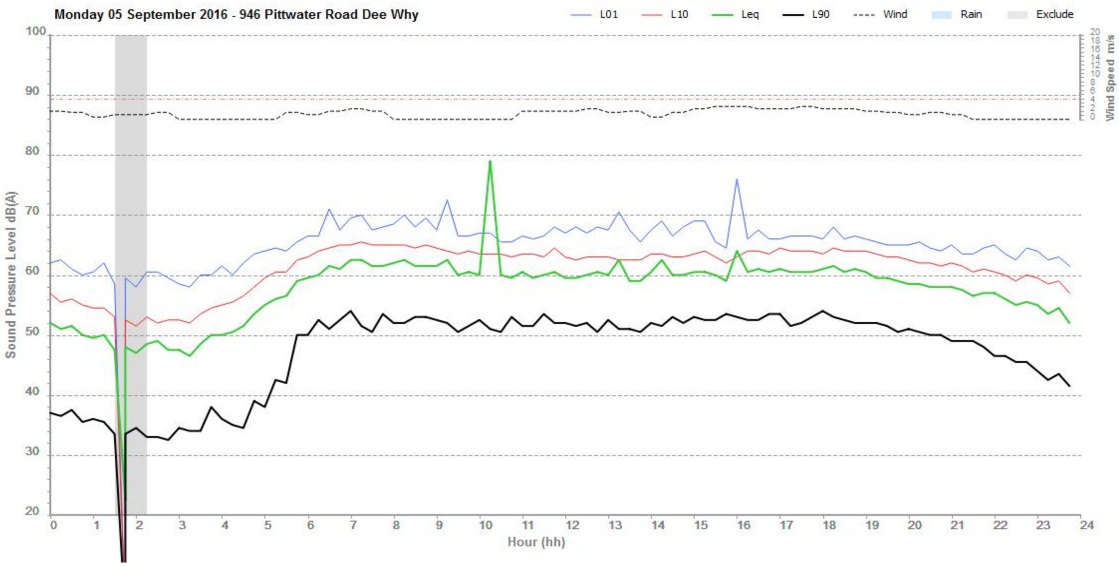




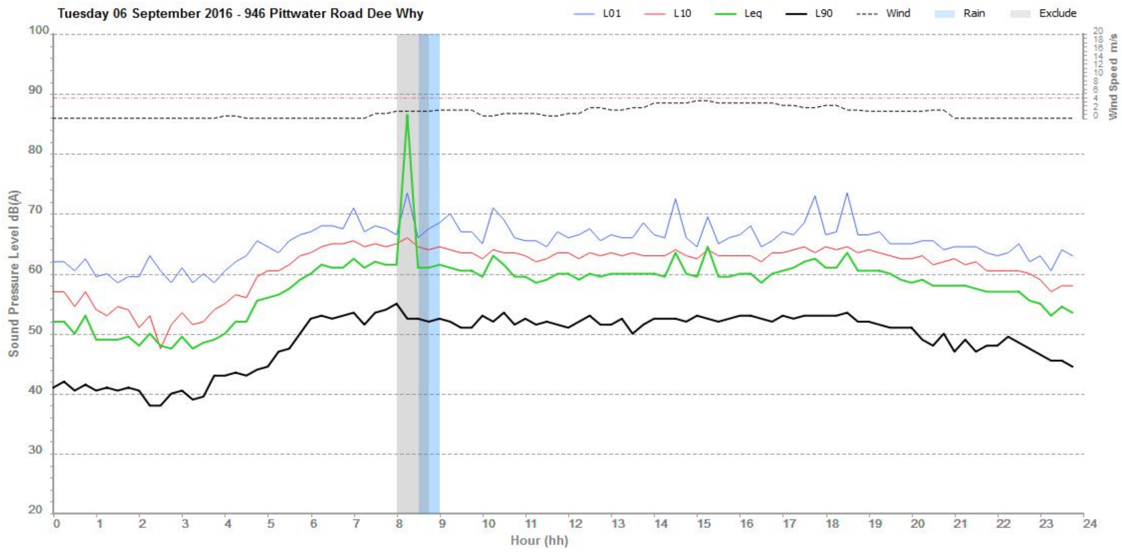
Logger Graphs

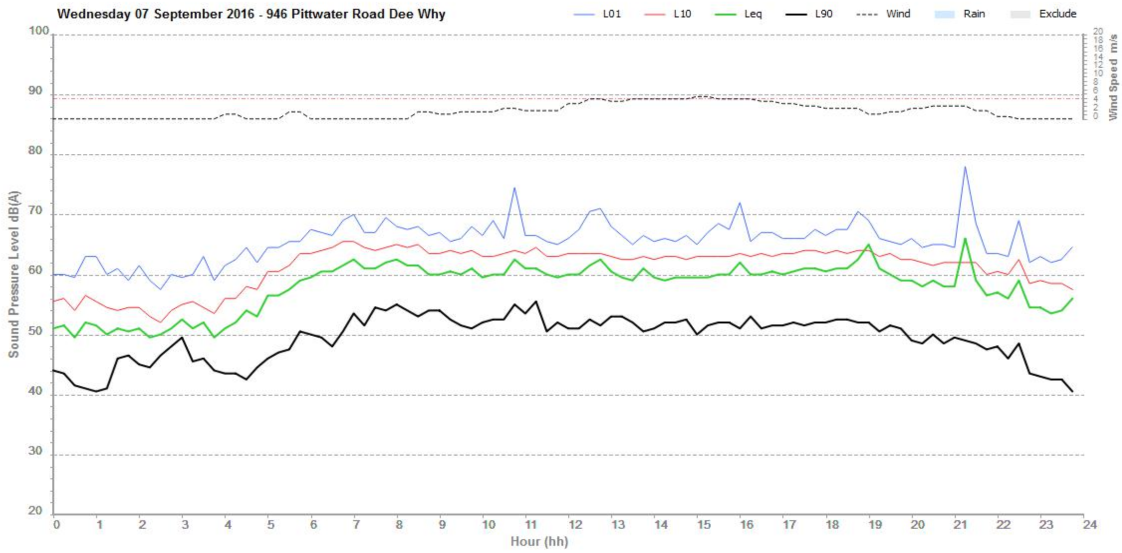


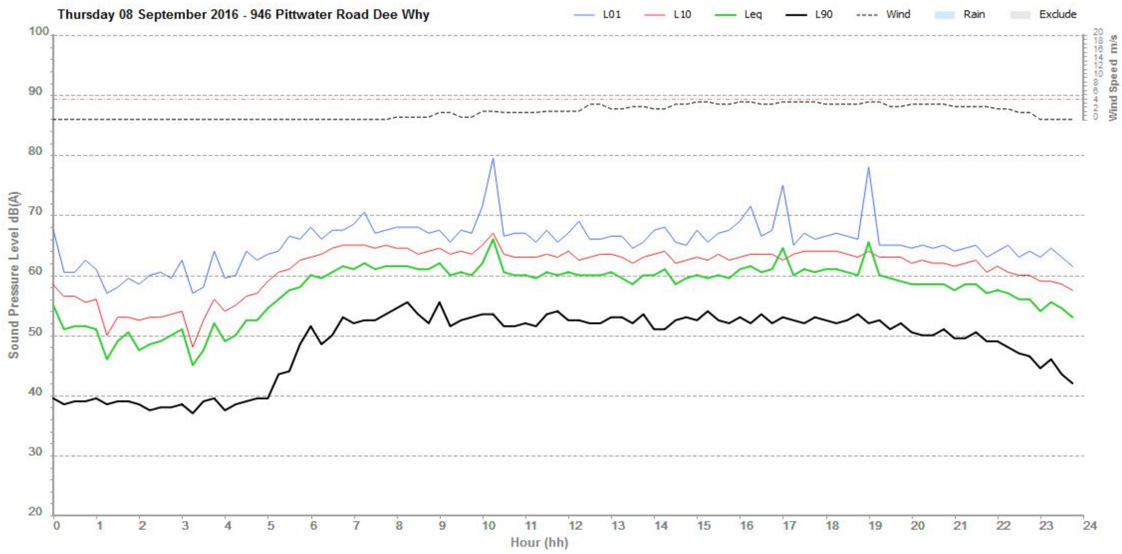




Logger Graphs







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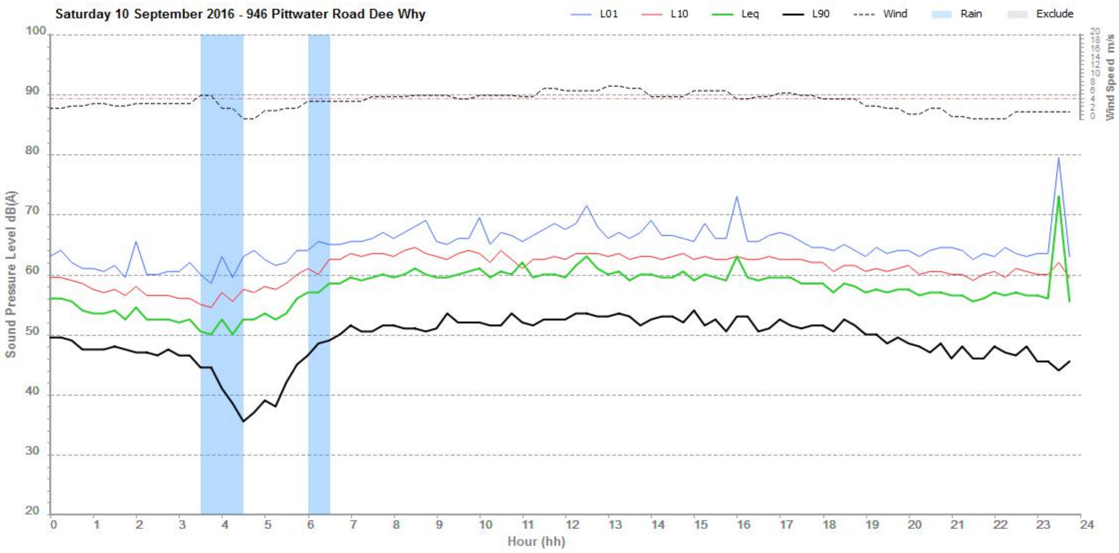
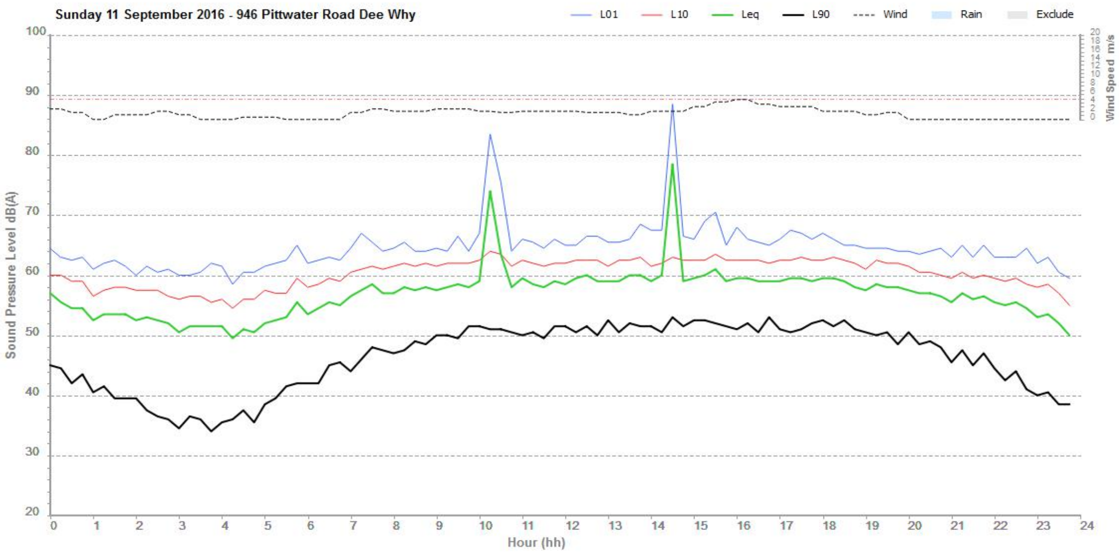
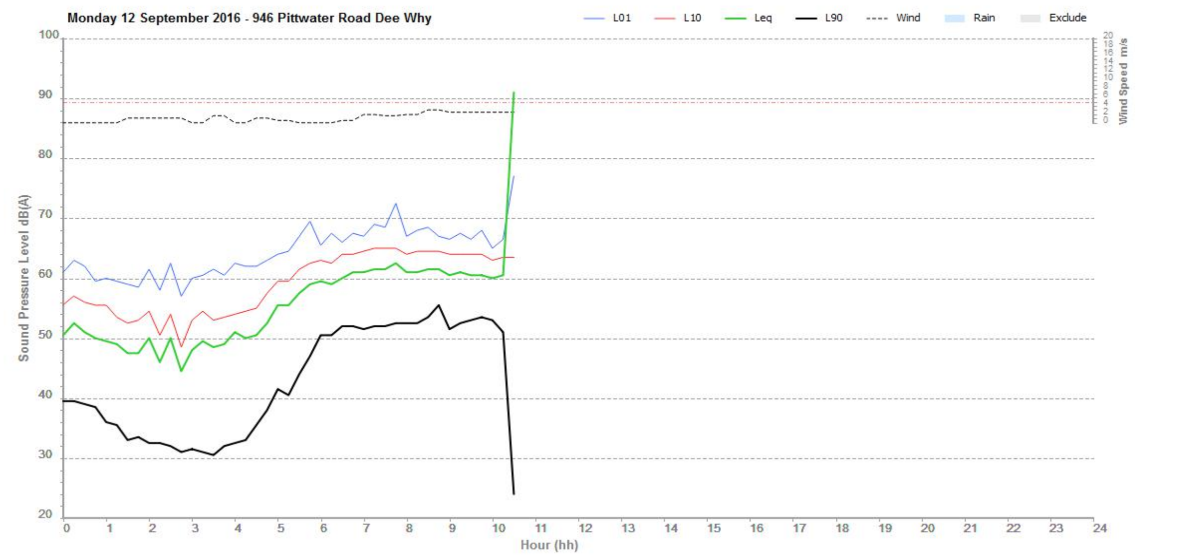




Logger Graphs



Appendix D

Noise catchment areas

AECOM

Legend

WorkZone

- Noise Catchment Area A
- Noise Catchment Area B
- Noise Catchment Area C
- Unattended noise logging locations
- Attended noise logging locations, shielded location
- Extent of works (approximate)

N

250 125 0 250 Meters

B-Line

Package 8 Noise Catchment Areas

Source:

OCT 2016

60491201

Fig. **1**

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