Newcastle Inner City Bypass – Rankin Park to Jesmond

Environmental impact statement

Technical Paper 2 – Traffic and Transport Assessment

November 2016

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Transport Roads & Maritime Services NSW

Newcastle Inner City Bypass Rankin Park to Jesmond

Technical Paper 2
Traffic and Transport Assessment

Ref: 245321

PSC No. 14.2533.2117

Prepared for: Roads and Maritime Services

Revision: Rev 0

3 November 2016

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Document control record

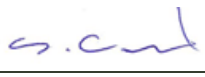
Document prepared by:

Aurecon Australia Pty Ltd

ABN 54 005 139 87

23 Warabrook Boulevard
Warabrook NSW 2304
Australia

T +61 2 4941 5415
E newcastle@aurecongroup.com
W aurecongroup.com

Document control						
Report title		Technical Paper 2 Traffic and Transport Assessment				
Document ID		RP2J-TP2	**Project number**		245321	
File path		pw:\\designshare.au.aurecon.info:PW_PROD_AU\Documents\Projects\24xxxx\245321 - Rankin Park to Jesmond\3 Project Delivery\Environmental\EIS\EIS document\Technical papers\Traffic Technical Assessment\RP2J-EIS Tech Paper 2-Traffic and Transport_Rev 0.docx				
Client		Roads and Maritime Services	**Client contact**		Matthew Mate	
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
Rev 0	3 November 2016	Final	SC, NE	SC	BM, CD, LC	BM
Current revision		**Rev 0**				
Approval						
Author signature			Approver signature			
Name		Steve Crick	Name		Brian Mortimore	
Title		Environmental Approvals Leader Newcastle	Title		Technical Director	

Newcastle Inner City Bypass Rankin Park to Jesmond

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Aurecon Australia Pty Ltd
ABN 54 005 139 87
23 Warabrook Boulevard
Warabrook NSW 2304
Australia

T +61 2 4941 5415
E newcastle@aurecongroup.com
W
newcastle@aurecongroup.com
aurecongroup.com

Executive summary

The Newcastle Inner City Bypass is part of Roads and Maritime Services' long-term strategy to provide an orbital road within Newcastle's road network to connect the Pacific Highway at Bennetts Green and the Pacific Highway at Sandgate.

The project would involve the construction of about 3.4 kilometres of new four-lane dual carriageway highway between Lookout Road, New Lambton Heights and the intersection of Newcastle Road and Main Road at Jesmond. The project is located within the Newcastle local government area (LGA), about 11 kilometres west of the Newcastle Central Business District.

The road network surrounding the project currently suffers from traffic congestion and delays at key intersections. These issues are likely to worsen in the future as traffic volumes increase, with existing traffic volumes along this route currently in the order of 40,000 to 60,000 vehicles per day and predicted to grow by around one per cent per annum. At-grade intersections currently produce conflict points, resulting in safety issues, congestion and traffic delays. The risk of maintaining the current configuration of the network is increased congestion and the costs to the community of that congestion.

Traffic modelling has been carried out to primarily assess the predicted traffic performance of the project and the forecast redistribution of traffic on the road network within the study area. The adopted traffic modelling methodology followed a two-tier structure. The Roads and Maritime Lower Hunter Traffic Model was used to provide forecast traffic demand information as input into a more detailed project specific microsimulation model for operational assessment of options and for providing outputs for economic analysis.

To satisfy the modelling requirements, Roads and Maritime carried out extensive traffic data collection in the study area involving origin-destination surveys, midblock traffic counts and intersections turning counts.

Existing daily traffic volumes and traffic patterns were used to compare and predict the redistribution of traffic on the surrounding road network with the project. This found that the project was predicted to carry between about 23,100 and 31,300 vehicles per day in 2020, reducing traffic volumes on the existing route of Lookout Road, Croudace Street and Newcastle Road by about 25 to 45 per cent depending on location.

Network performance modelling determined that the project is predicted to provide major benefits for motorists using the bypass with substantial improvements in travel time for both northbound and southbound journeys. The project is also predicted to improve travel times for north-south trips on the existing route and for east-west trips on Newcastle Road.

Intersection performance modelling within the surrounding road network showed that the project would generally improve intersection performance at key existing intersections under forecast traffic volumes during peak periods.

The project is expected to improve road safety on the existing route of Lookout Road, Croudace Street and Newcastle Road as a result of reduction in traffic volumes and improved traffic flows. A road safety analysis predicted that the project would reduce annual crash rates for traffic using the project and existing route by about 20 crashes per year which represents a 32 per cent reduction.

A number of modifications to existing roads would also be required for the project such as tie-ins on Lookout Road and Newcastle Road to connect the new section of roadway to these roads, as well as upgrade works on McCaffrey Drive including its intersection with Lookout Road.

The project would also provide improved connectivity and safety for cyclists and pedestrians traveling through the construction of new shared paths, paved footpaths, signalised pedestrian crossings, on and off road cycleways, and shared path bridges.

The project would require the removal of some informal parallel parking spaces and removal or relocation of bus stops on Lookout Road and Newcastle Road in the vicinity of the new interchanges. This is not expected to result in material impacts to motorists or public transport users due to the availability of other parking areas and bus stops in nearby areas.

The project would result in minor works being carried out to the driveways of several residences located on Newcastle Road and Lookout Road. This is not expected to impact these residents and would generally result in improvement to their existing driveways.

The majority of construction activities required for the project would not cause traffic impacts as they would occur in the bushland areas. Construction of the northern and southern interchanges would require temporary traffic restrictions to be implemented. These would result in temporary delays for road users, although works requiring major traffic disruptions would be scheduled to occur outside peak periods where possible, so that delays would be minimised.

A number of management measures would be established for construction of the project to mitigate potential traffic impacts due to construction. These would include development of Construction Traffic Management and Vehicle Movement Plans, and consultation with potentially affected road users and residents with accesses that adjoin construction areas.

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1 Introduction

1.1 Project overview

Roads and Maritime Services (Roads and Maritime) is seeking approval to construct the fifth section of the Newcastle Inner City Bypass between Rankin Park and Jesmond (the project). The approval is sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Newcastle Inner City Bypass is part of Roads and Maritimes' long-term strategy to provide an orbital road within Newcastle's road network to connect the Pacific Highway at Bennetts Green with the Pacific Highway at Sandgate.

Construction of the project would form part of the Newcastle Inner City Bypass. This would provide improved traffic flows across the western suburbs of Newcastle and connect key regional destinations such as Bennetts Green, Charlestown and Jesmond shopping centres, John Hunter Hospital precinct, The University of Newcastle and the Pacific Highway.

The north-south road corridor was first planned in the 1950's and incorporated into the Northumberland County Planning Scheme in 1957.

Sections of the Newcastle Inner City Bypass have opened progressively since the early 1980s as outlined in Table 1-1.

Table 1-1 Newcastle Inner City Bypass section status

Section	Route	Length	Status
A	West Charlestown Bypass	6.0 km	Completed in 2003
B	Kotara Heights to Rankin Park	2.4 km	Completed in 1983
C	Rankin Park to Jesmond	3.4 km	Subject to this planning approval
D	Jesmond to Shortland	3.2 km	Completed in 1993
E	Shortland to Sandgate	2.3 km	Completed in 2014

A strategic design for the Rankin Park to Jesmond project was displayed for community comment in 2007. Community feedback was considered to finalise the preferred route corridor, which was reserved in Newcastle City Council's local environmental plan.

In June 2014 the NSW Government announced it would complete the $280 million Rankin Park to Jesmond section of the bypass, including $150 million from Restart NSW to progress the project. Roads and Maritime has since carried out a comprehensive review of the 2007 strategic design and a refined strategic design was displayed for community feedback in May and June 2016. A concept design has since been developed for the project, which forms the basis of this assessment that has been prepared to support the environmental impact statement (EIS) for the project.

1.2 The project

The project would involve the construction of about 3.4 kilometres of new four lane divided road between Lookout Road at New Lambton Heights and Newcastle Road at Jesmond. The project is located in the Newcastle local government area (LGA), about 11 kilometres west of the Newcastle central business district and about 160 kilometres north of Sydney (Figure 1-1).

Key features of the project (Figure 1-2) include:

- New road with two lanes in each direction, separated by a median
- Three interchanges, consisting of:
  - Northern interchange providing access to Newcastle Road and the existing Jesmond to Shortland section of the Newcastle Inner City Bypass. The full interchange provides all movements to/from the bypass and Newcastle Road
  - Hospital interchange providing access between John Hunter Hospital precinct and the bypass. The half-interchange providing access to/from the north
  - Southern interchange providing access to Lookout Road and the existing Kotara to Rankin Park section of the Newcastle Inner City Bypass. The bypass would travel under McCaffrey Drive. The half interchange provides connection in both directions on Lookout Road
- Structures along the road to allow for drainage, animal and bushwalker access
- Tie in and upgrades to connecting roads, including Lookout Road, McCaffrey Drive and Newcastle Road
- Large cut and fill embankments due to steep and undulating terrain
- Pedestrian and cycling facilities, including a shared path bridge over Newcastle Road
- Noise barriers and/or architectural treatment, as required
- Permanent operational water quality measures.

Ancillary work to facilitate construction of the project (Figure 1-3), including:

- Adjustment, relocation and/or protection of public utilities and services
- Mine subsidence treatment, as required
- Temporary construction facilities, including sedimentation basins, compounds and stockpile sites
- Temporary and permanent access tracks
- Concrete/asphalt batching plant, as required.

LEGEND

- The Project
- Road
- Local government area
- National Parks and Wildlife Service Estate and bushland reserves
- Watercourse area

Paper Size A4

0 270 540 1,080 1,620 2,160

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Rankin Park to Jesmond

Figure 1-1
Project locality

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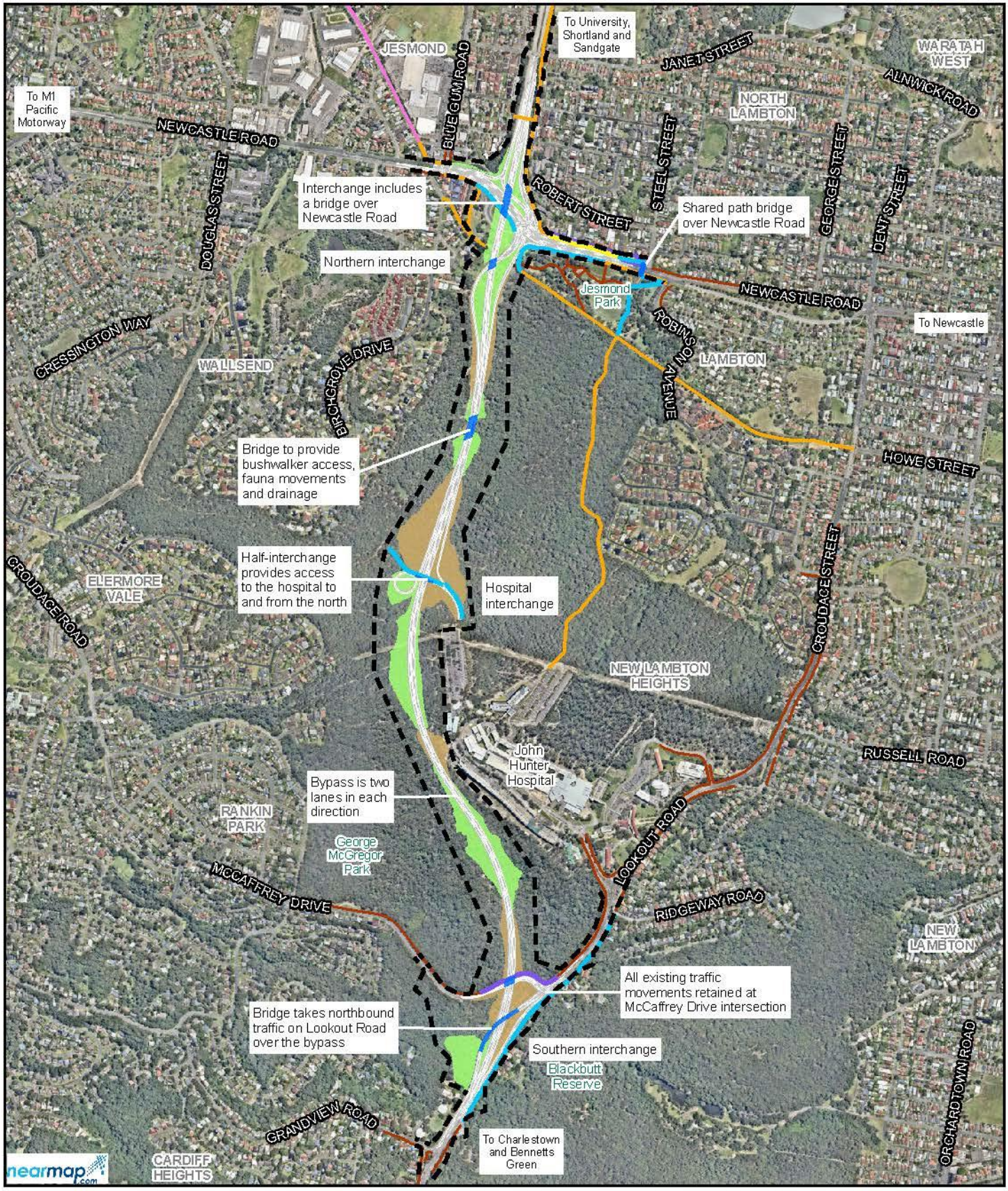
Data source: Aurecon: The Project, 2016 : Geoscience Australia: 250k Topographic Series 3, 2006.



LEGEND

- Design
- Pavement
- Bridge
- Earthworks cut
- Earthworks fill
- Proposed road corridor
- Existing on-road cycleway
- Existing shared path
- Proposed shared path
- Proposed on-road cycleway
- Existing footpath
- Proposed footpath

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Rankin Park to Jesmond

Figure 1-2
Project overview

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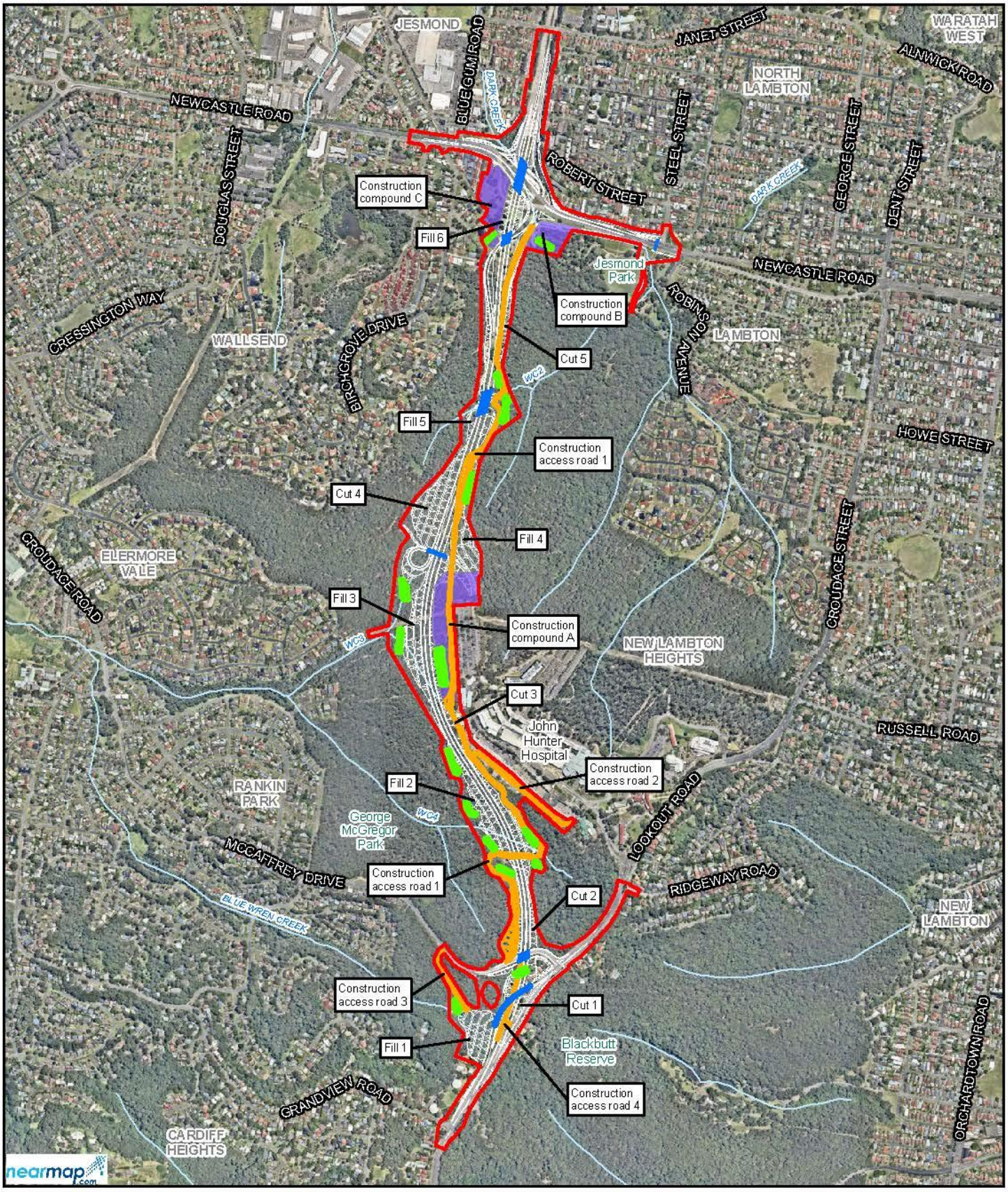
Data source: RMS: Project corridor, 2016; Aurecon: Design / cycleways, 2016; Nearmap: Aerial Imagery, 20160331; LPI: DTDB, 2012



LEGEND

- Construction footprint
- Construction compound
- Construction access tracks
- Construction sedimentation basin
- Design
- Bridge
- Watercourse

Paper Size A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Rankin Park to Jesmond

Figure 1-3
Construction ancillary facilities

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Data source: Nearmap: Aerial Imagery, 20160331; Aurecon: Construction footprint/ Design / Water quality structures, 2016; LPI: DTDB, 2012.

1.3 Project objectives

The key objectives of the project are to:

- Provide continuity of the Newcastle Inner City Bypass between Bennetts Green and Sandgate
- Reduce travel times and congestion on the Newcastle Inner City Bypass
- Provide traffic relief on key parts of the surrounding road network.

In so doing, it is intended to:

- Improve road safety
- Minimise impacts on the natural and built environment
- Provide value for money.

To support the project objectives, the concept design and EIS has been developed by:

- Designing the project to consider the environmental constraints and avoid or minimise impacts to the environment
- Satisfying the technical requirements for the design of the project
- Optimising the concept design to ensure the project can be constructed and maintained both practically and efficiently
- Applying appropriate urban design, landscape and visual principles in the concept design of the project elements
- Carrying out appropriate community and stakeholder consultation
- Designing all connections, modifications and improvements necessary to link the project to the existing road network
- Planning temporary arrangements which minimise disruption to local and through traffic and maintain access to adjacent properties during construction.

The overall project goal is to achieve the best possible result for each of the above tasks, both in isolation and when considered together.

1.4 Purpose of this report

This report has been prepared to provide an assessment of the traffic and transport related impacts and benefits that may result from construction and operation of the project. On 3 March 2015, NSW Department of Planning and Environment (DP&E) issued Secretary's Environmental Assessment Requirements (SEARs) for the project's environmental impact assessment.

Table 1-2 identifies the SEARs which are relevant to this technical assessment.

Table 1-2 Secretary's Environmental Assessment Requirements relevant to this technical assessment

Secretary's Environmental Assessment Requirements (SEARs) relevant to this technical assessment	Where addressed in this technical assessment
The Environmental Impact Statement must include the following specific matters: **Traffic and Transport –** including but not limited to:	
■ Detailed assessment and modelling of operational traffic and transport impacts. This must consider:	■ Chapters 4, 5 and 6
– key intersections and interchanges, and the level of service/performance of intersections upstream and downstream of the project area	■ Section 5.4.2
– impacts on property access and on-street parking provision, including permanent changes to access and parking	■ Section 5.7

Secretary's Environmental Assessment Requirements (SEARs) relevant to this technical assessment	Where addressed in this technical assessment
– impacts on access to and from John Hunter Hospital	■ Sections 5.5.3 and 5.7.2
– maintenance of existing cycle routes and consideration of opportunities to integrate elements within existing and proposed networks, including those identified in the *Newcastle Cycling Strategy and Action Plan* and maintenance of existing pedestrian paths between residential neighbourhoods	■ Section 5.6.3
– operational implications for public transport and opportunities to improve public transport services and patronage	■ Section 5.6.2
– safety and access impacts on road users (including cyclists and pedestrians)	■ Sections 5.6 and 5.7
■ assessment of construction traffic and transport impacts of the proposal (including ancillary facilities) and associated management measures, in particular:	■ Chapters 6 and 7
– impacts to the road network (including safety and level of service, pedestrian and cyclist areas, maintenance of access to John Hunter Hospital, and distribution to public transport services, access to properties and parking)	■ Sections 6.2 to 6.5
– route identification and scheduling of transport movements, including movements to transport spoil	■ Sections 6.1 to 6.4
– the number, frequency and size of construction related vehicles (both passenger, commercial and heavy vehicles)	■ Sections 6.3 to 6.5
– the nature of existing traffic on construction access routes (including consideration of peak traffic times)	■ Sections 6.3 and 6.5
– the need to close, divert or otherwise reconfigure elements of the road network associated with construction of the proposal	■ Section 6.5 and Chapter 7
■ Details of stakeholder consultation regarding access disruption, including John Hunter Hospital and emergency services.	■ Sections 5.8 and 6.5.

This report is primarily based on the findings of the following reports, with additional refinements carried out during the concept design phase:

- Traffic Modelling Report – Lower Hunter Traffic Model prepared by Arcadis Australia Pacific Pty Ltd (Arcadis) (2016), as discussed further in Section 4.1.1.
- Microsimulation Traffic Modelling Report prepared by Aurecon Group Pty Ltd (Aurecon) (2016a), as discussed further in Section 4.1.2.
- Microsimulation Traffic Model Calibration and Validation Report prepared by Aurecon Group Pty Ltd (Aurecon) (2015), as discussed further in Section 4.1.2 and provided in Appendix A.

The study area for this assessment has been defined as all areas within the project's construction and operational footprint and the surrounding road network that connects with the project. This is discussed further in Section 2.

2 Existing traffic and transport environment

This chapter outlines the existing traffic and transport features and conditions relevant to the study area and the significance of the existing road network to regional road traffic movements.

2.1 Regional transport movement

2.1.1 General traffic

Traffic movements within the study area are dominated by the north-south traffic flows on the existing sections of the Newcastle Inner City Bypass, Lookout Road and Croudace Street which form part of route A37, and east-west traffic flows along Newcastle Road which forms part of route A15. The study area and road network surrounding the project are shown on Figure 2-1.

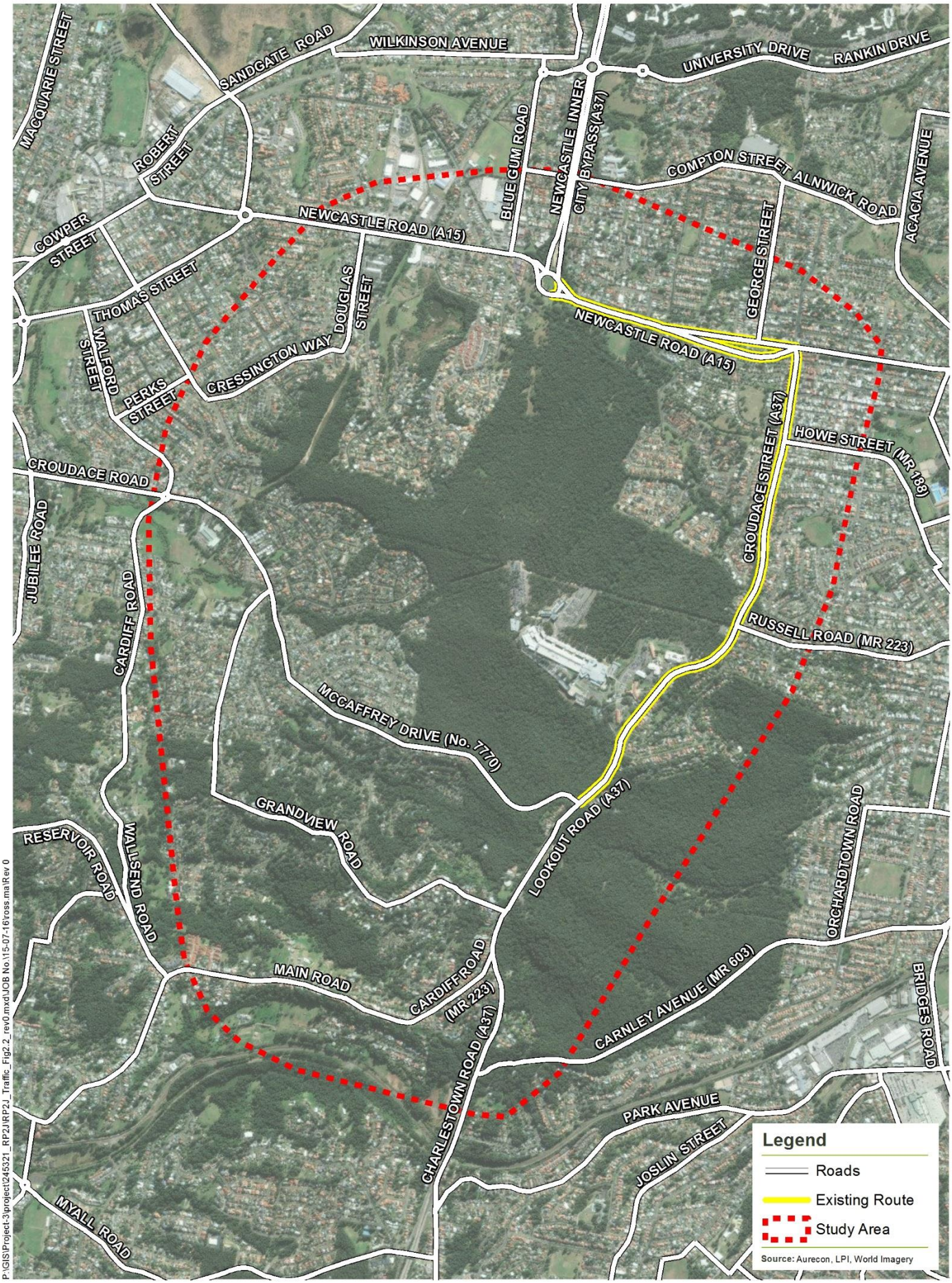
Route A15 is the main east-west road transport route through Newcastle, providing road connection between the city and national and state highways located to the west. The route links the M1 Pacific Motorway and Hunter Expressway (route M15) at West Wallsend, and Stewart Avenue (Pacific Highway route A43) at Newcastle West. Route A15 connects with a number of other arterial roads, including: Lake Road (route B53) which is the main arterial road servicing the western side of Lake Macquarie; and Turton Road (route B63) which links the northern suburbs of Newcastle and the Port of Newcastle with suburbs to the south such as Kotara and Broadmeadow.

Route A37 is a key north-south road transport route through Newcastle, providing an alternate 'bypass' route to the Pacific Highway that avoids the inner suburbs of the city. The route connects the Pacific Highway (route A43) at Bennetts Green in the south and again at Sandgate (route A43) in the north. Route A37 shares a section of Route A15 between the intersection with Newcastle Road (Jesmond Roundabout) and Croudace Street. The section of Route A37, from Charlestown Road to Newcastle Road is located along a major ridge line over the majority of its length. The A37 route is along Charlestown Road, Lookout Road and Croudace Street, and is intersected by a number of regional roads, all of which are signalised intersections.

There are a number of intersections along the length of A37 meaning there are numerous weaving movements as traffic joins A37 at one intersection and exit at another intersection, sometimes in close proximity.

The road network surrounding the project currently suffers from traffic congestion and delays at key intersections, particularly during peak periods. There are a number of constraints along the existing route of Lookout Road, Croudace Street and Newcastle Road (refer to Figure 2-1) which include:

- Eleven sets of existing traffic lights on Lookout Road, Croudace Street and Newcastle Road from the McCaffrey Drive intersection to the existing roundabout on Newcastle Road at Jesmond
- Sixteen uncontrolled intersections with local and regional roads
- A large number of driveways to private properties, which reduce the allowable traffic speed and contribute to traffic congestion
- A public school located on Croudace Street with a 40 kilometre per hour school zone speed limit in place during peak hours.



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Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 2-1: Road network

2.1.2 Heavy and restricted access vehicles

Heavy vehicles are defined under the Heavy Vehicle National Law (which is administered by the National Heavy Vehicle Regulator) as a vehicle with a single, or combined (ie with trailer) mass of more than 4.5 tonnes. This includes many types of trucks and large vehicles such as buses.

Restricted access vehicles are any single or combined vehicle which when either empty or loaded exceed the overall dimensions specified for heavy vehicles under the Heavy Vehicle National Law. These include vehicles such as B-double trucks, road trains, and vehicles over 4.6 metres in height.

Restricted access vehicles are not permitted to travel on a number of roads and these include the existing route of Lookout Road and Croudace Street. A review of restricted access vehicle movements on the road network surrounding the project identified the following key restricted access vehicle routes:

- Newcastle Road (A15) – this route can be used by B-double trucks and vehicles with a height of up to 4.6 metres. This road provides the restricted access vehicle route between the M1 Pacific Motorway and Hunter Expressway (M15) and inner areas of Newcastle
- Newcastle Inner City Bypass (A37): Jesmond to Sandgate – this route connects Newcastle Road (A15) to areas to the north of Newcastle, including Hexham, Kooragang Island and the Port of Newcastle
- Lake Road (B53) – this route connects Newcastle Road with areas to the south of Newcastle such as Lake Macquarie
- Stewart Avenue / Hannell Street / Industrial Drive / Maitland Road (A43): Newcastle West to Hexham – this route connects areas to the north and west of Newcastle, including the Pacific Highway and New England Highway with the Port of Newcastle, inner Newcastle and Lake Macquarie to the south.

Sections of the Newcastle Inner City Bypass route south of Newcastle Road are not approved for use by restricted access vehicles. Volumes of heavy vehicles that use the existing route are currently low at about four per cent of all traffic.

There are no approved routes for road trains within the study area or broader region. Heavy vehicle transport routes relevant to the study area and broader region are shown on Figure 2-2.

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Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 2-2: Heavy vehicle routes

2.2 Road network

The existing State road network relevant to the project comprises the following key routes (refer to Figure 2-1):

- Newcastle Inner City Bypass (A37) – Newcastle Road, Jesmond to Pacific Highway, Sandgate
- Newcastle Inner City Bypass (A37) – Charlestown Road, Lookout Road and Croudace Street
- Newcastle Road (A15) – generally between Wallsend and Broadmeadow, specifically between Blue Gum Road, Jesmond and Croudace Street, Lambton.

Key regional roads within the study area include:

- Howe Street
- Russell Road
- McCaffrey Drive
- Cardiff Road
- Carnley Avenue.

A description of each of these major traffic routes is provided in the following sections.

2.2.1 Charlestown Road/Lookout Road/Croudace Street (section of the A37)

The predominant north-south route through the study area, this section provides a link between Charlestown Road and Newcastle Road. It is intersected by various east-west connector roads and provides an important arterial road function for the western Newcastle road network.

The key features of this road are:

- The route generally varies between an undivided and divided four lane configuration
- Generally good horizontal alignment along the Lookout Road ridge line but major variability in vertical alignment, with steep grades on the Croudace Street section between New Lambton Heights and Lambton
- Main access route to John Hunter Hospital precinct off Lookout Road
- Signalised intersections with Carnley Avenue, Cardiff Road, McCaffrey Drive, Kookaburra Circuit, Jacaranda Close, Russell Road, Mitchell Street/Pride Avenue, Howe Street and Newcastle Road
- Heavily used route with traffic volumes being around 40,000 to 55,000 vehicles per day
- Eight sets of existing traffic lights along the route between McCaffrey Drive and Newcastle Road
- 10 uncontrolled intersections with local roads between McCaffrey Drive and Newcastle Road
- The speed limit of this route varies between 60 kilometres per hour and 70 kilometres per hour
- The route passes New Lambton Heights Infants School and Lambton Public School with associated 40 kilometre per hour school zones
- Numerous private property frontages and residential accesses over the full length.

2.2.2 Newcastle Road (A15)

This route is generally between Wallsend and Broadmeadow, specifically between Blue Gum Road, Jesmond and Croudace Street, Lambton.

Within the immediate study area the key features of this road are:

- Typically dual carriageway with a concrete median and two lanes in each direction
- Provides an east-west link between Newcastle and Wallsend and the M1 Pacific Motorway

- Heavily used route, carrying about 60,000 vehicles per day
- Major intersections with traffic lights with Croudace Street/Dent Street and with Blue Gum Road
- Numerous intersections without traffic lights with streets in North Lambton, the majority of which are left-in/left-out only
- Signalised pedestrian crossing on Newcastle Road around 300 metres east of the roundabout at Jesmond
- A large roundabout at the junction with Newcastle Inner City Bypass (A37) at Jesmond which is partially signalised on the north-west corner
- Typically the road has variable vertical and horizontal alignment, with a major hill immediately west of Croudace Street.

2.2.3 Newcastle Inner City Bypass (A37) Jesmond – Shortland – Sandgate

The existing section of Newcastle Inner City Bypass comprises typically a four lane divided carriageway with an interchange at University Drive about one kilometre north of Newcastle Road. The total length of this section of Newcastle Inner City Bypass is about five kilometres and represents an important component of the State road network in the Newcastle region. It carries about 36,100 vehicles per day.

The existing 3.2 kilometre section of A37 from Jesmond to Shortland was completed and opened to traffic in June 1993. The remaining 1.8 kilometre section of A37 from Shortland to Sandgate was completed and opened to traffic in January 2014.

The key features of this road are:

- High standard divided dual carriageway, generally with two lanes in each direction
- The speed limit of this section is 90 kilometres per hour
- Grade separated interchanges at University Drive and Sandgate Road
- Crosses over the Main Northern Railway Line and Astra Street with overpasses of other streets such as Vale Street and Janet Street to maintain connectivity
- Commences at a large roundabout at its southern junction with Newcastle Road at Jesmond
- A signalised intersection controls access at the northern end where it connects with the Pacific Highway (Maitland Road) at Sandgate.

2.2.4 Howe Street (MR 188)

Howe Street provides a connection between Lambton and New Lambton. The route is popular for travel between the inner western suburbs and the Jesmond / Wallsend area. It is a two way suburban street with numerous residences and property accesses. The road is typically one lane in either direction with a speed limit of 60 kilometres per hour. It carries about 8,500 vehicles per day.

2.2.5 Russell Road (MR 223)

Russell Road provides a major east-west route within the study area, providing a link between the A37 route, John Hunter Hospital, and McCaffrey Drive at New Lambton Heights and New Lambton/Broadmeadow in the east. The route passes through the New Lambton Shopping district and the commercial area of Broadmeadow. With typically one lane in each direction, the road passes through both residential and commercial properties, with speed limit of 60 kilometres per hour. It carries about 16,200 vehicles per day.

2.2.6 McCaffrey Drive/Croudace Road (No. 7770)

McCaffrey Drive provides a connection from Lake Road (route B53) and Thomas Street (route A15) in the north-west to Lookout Road (route A37) through Rankin Park and Elermore Vale, providing a major east-west route together with Russell Road to the east to Lambton, Broadmeadow and Newcastle CBD. It also provides an alternative to the A15 route (Newcastle Road/Croudace Street/Lookout Road) for traffic movements in a south to north-west orientation between the Newcastle Inner City Bypass south of McCaffrey Drive and suburbs to the north-west of the study area such as Fletcher, Maryland and further west. The route also provides access from the west to the John Hunter Hospital precinct. The road is characterised by a two lane single carriageway with fronting residential properties and passes Elermore Vale shopping centre. The road is typically one lane in either direction with a speed limit of 60 kilometres per hour. It carries about 18,600 vehicles per day.

2.2.7 Main Road / Cardiff Road (MR 223)

Main Road / Cardiff Road provides a connection to the suburbs of Cardiff, Glendale and Boolaroo to the west of Lookout Road. The road typically consists of a two lane undivided carriageway with some sections having variable vertical and horizontal alignment. This road services residential and commercial areas, as well as the Cardiff industrial complex. The road is typically one lane in either direction with a speed limit of 60 kilometres per hour. It carries about 14,700 vehicles per day.

2.2.8 Carnley Avenue (MR 603)

Carnley Avenue provides a connection between Charlestown Road at Kotara Heights and Bridges Road at New Lambton. It passes along the southern boundary of Blackbutt Reserve and provides a key link for travel between Newcastle and Lake Macquarie. The road is a single carriageway with typically a single eastbound and two westbound lanes, with a speed limit of 70 kilometres per hour. This road carries about 21,000 vehicles per day.

2.3 Existing land use

2.3.1 Regional land uses

As described in Section 2.2, the road network within the study area includes state road transport routes (A37 and A15) and therefore, the traffic movements within the study area are influenced by broad regional land use.

Traffic movements on the key north-south route within the study area (A37) are influenced by large areas of urban and commercial development to both the north and south of this route. Traffic movements on the key east-west route within the study area (A15) are influenced by connectivity with the M1 Pacific Motorway / Hunter Expressway (M15) and outer suburbs of Newcastle to the west, and the Port of Newcastle and Newcastle Central Business District (CBD) and inner suburbs to the east. The key land use affecting traffic movements through the study area include:

- Residential – the study area is surrounded by residential suburbs. Residents of these suburbs use the arterial roads passing through the study area to access other parts of Newcastle for employment, education, shopping and recreational purposes. Residential growth is also anticipated to the west of Newcastle associated with direct access to the M15/A15 and hence connectivity with Newcastle.
- Commercial, retail and light industrial – a range of commercial and light industrial developments are located in areas surrounding the study area, including major shopping centres at Wallsend, to the west, Jesmond to the north, Kotara and Newcastle to the east and Charlestown to the south. Substantial commercial and light industrial developments are located at Wallsend and Cardiff to the east, Jesmond and Warabrook to the north, Broadmeadow and Newcastle to the east and Charlestown and Gateshead to the south.

- Heavy industrial and port operations – significant heavy industrial operations are located within the Port of Newcastle to the north-east of the study area. These operations supply a range of products to destinations within the Hunter, Central Coast and Sydney Regions and therefore would contribute to restricted access vehicle movements within the study area. Conversely, the Port of Newcastle is a destination for a range of manufacturers, agricultural producers, mines, oil and gas and cargo companies located in these regions. These suppliers would also contribute to restricted access vehicle movements through the study area.
- Social infrastructure – the John Hunter Hospital precinct is located within the study area and is the principal medical referral centre servicing the Lower Hunter, Lake Macquarie and northern regions of NSW. The hospital is a major metropolitan hospital with an emergency department. The University of Newcastle is located about 1.2 kilometres to the north-east of the project and is a major regional university, educating about 20,000 students a year. These facilities are key regional destinations.

2.3.2 Local land use

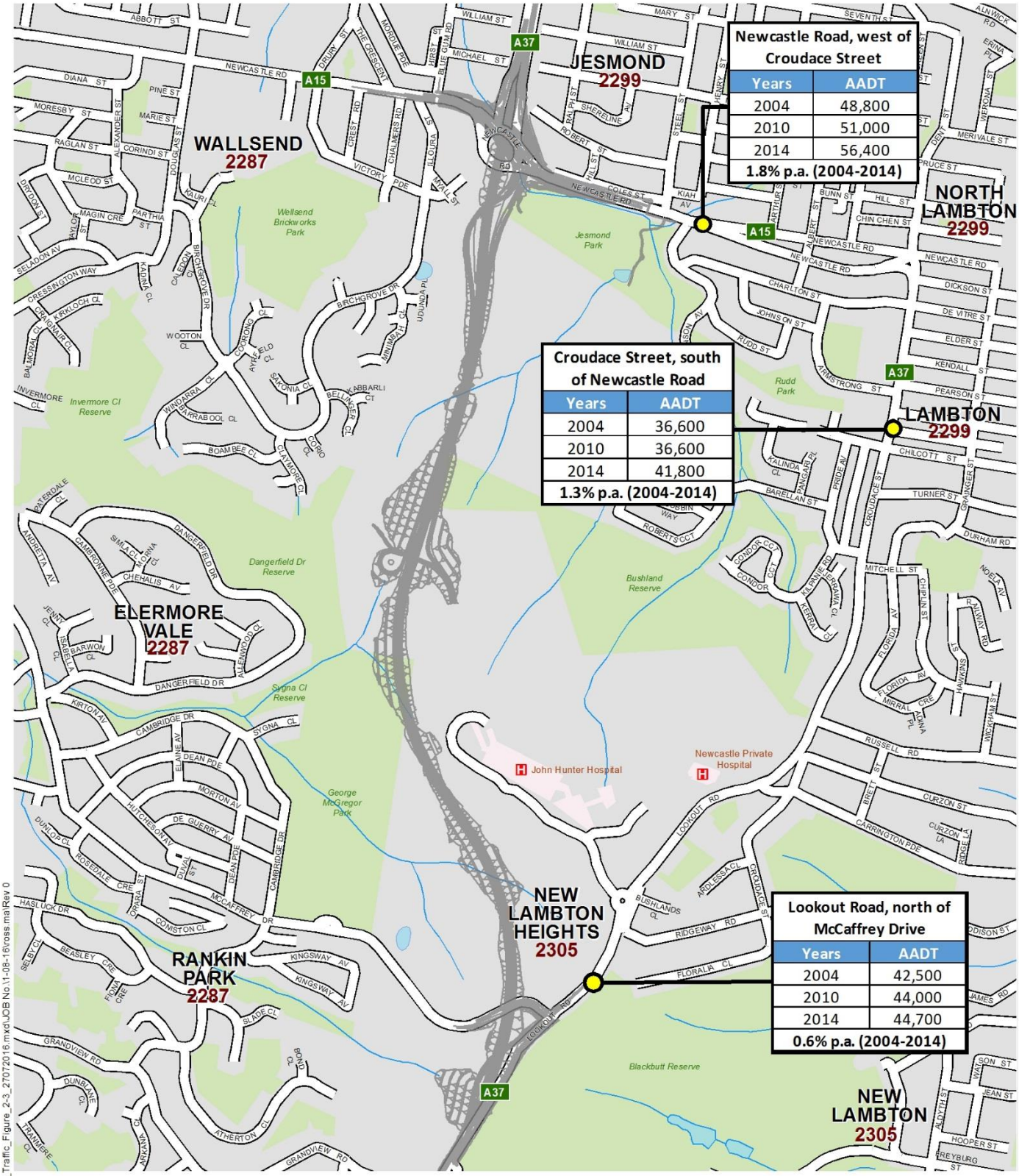
The site of the project generally consists of a large tract of remnant bushland surrounded by residential suburbs and the John Hunter Hospital precinct. These land uses influence travel patterns within the study area in addition to the regional transport routes described in Section 2.3.1.

Key local features that contribute to traffic flows within the study area include:

- The suburbs of Rankin Park, Elermore Vale, Wallsend and Lambton – these suburbs generally consist of low-density residential developments located around local roads and cul-de-sacs. Some medium-density residential developments such as retirement villages and townhouse developments are scattered through these suburbs, along with a small number of local shops and services which are generally located on arterial roads.
- Jesmond retail precinct – this area is located to the north-west of the project's northern interchange and contains a Stockland Shopping Centre, Hotel Jesmond, several fast-food outlets and a range of other retail shops. Access to this area is from Newcastle Road and other local roads to the north of the study area.
- Parks and open spaces – Jesmond Park is located in the northern section of the study area, south of Newcastle Road. This park includes an oval, stand/clubhouse, car park, formal garden areas, public barbeque areas and playing equipment. Access to this area is from Robinson Avenue and Victory Parade with car parking available within Jesmond Park with access from Robinson Avenue, and on-street parking bays on Newcastle Road. There is also a car park within Jesmond Park with access from Robinson Avenue. Other smaller reserves and parks located in the study area include Dangerfield Reserve and George McGregor Park which are bushland reserves to the west of the project. Blackbutt Reserve is located at the southern end of the project on the eastern side of Lookout Road. An access point is located off Lookout Road about 500 metres to the south of McCaffrey Drive. This reserve includes parking and picnic facilities and provides access to walking trails within Blackbutt Reserve.
- John Hunter Hospital precinct– as discussed in Section 2.3.1, the John Hunter Hospital is located immediately to the east of the project. Access to the hospital is currently provided from two signalised intersections located on Lookout Road.
- Lambton Public School – located on Croudace Street to the east of the project, with 380 students enrolled in 2015.
- New Lambton Heights Infants School – located at the southern end of Lookout Road between Grandview Road and Cardiff Road. A total of 82 students were enrolled in 2015. There is a dedicated bus zone located directly adjacent to this school and the northbound carriageway which applies during school start and end times.

2.4 Historical traffic growth

Annual average daily traffic (AADT) data was collected by Roads and Maritime between 2004 and 2014 on Newcastle Road, Croudace Street and Lookout Road within the study area. This data is shown on Figure 2-3 and shows that in the last ten years, traffic on the key traffic routes through the study area has grown by about 0.6 to 1.8 per cent per annum.



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- Annual Average Daily Traffic (AADT) count location
- the Project

Source: BingMaps, Aurecon

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Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 2-3: Historical traffic volumes on key roads between 2004 and 2014

2.5 Crash data

The road network in the study area is subject to a high number of crashes. From 2010 to 2014 there were 315 crashes recorded on the existing route of Lookout Road, Croudace Street and Newcastle Road (refer to Figure 2-4).

A summary of this data is provided in Table 2-1. The key findings from this data include:

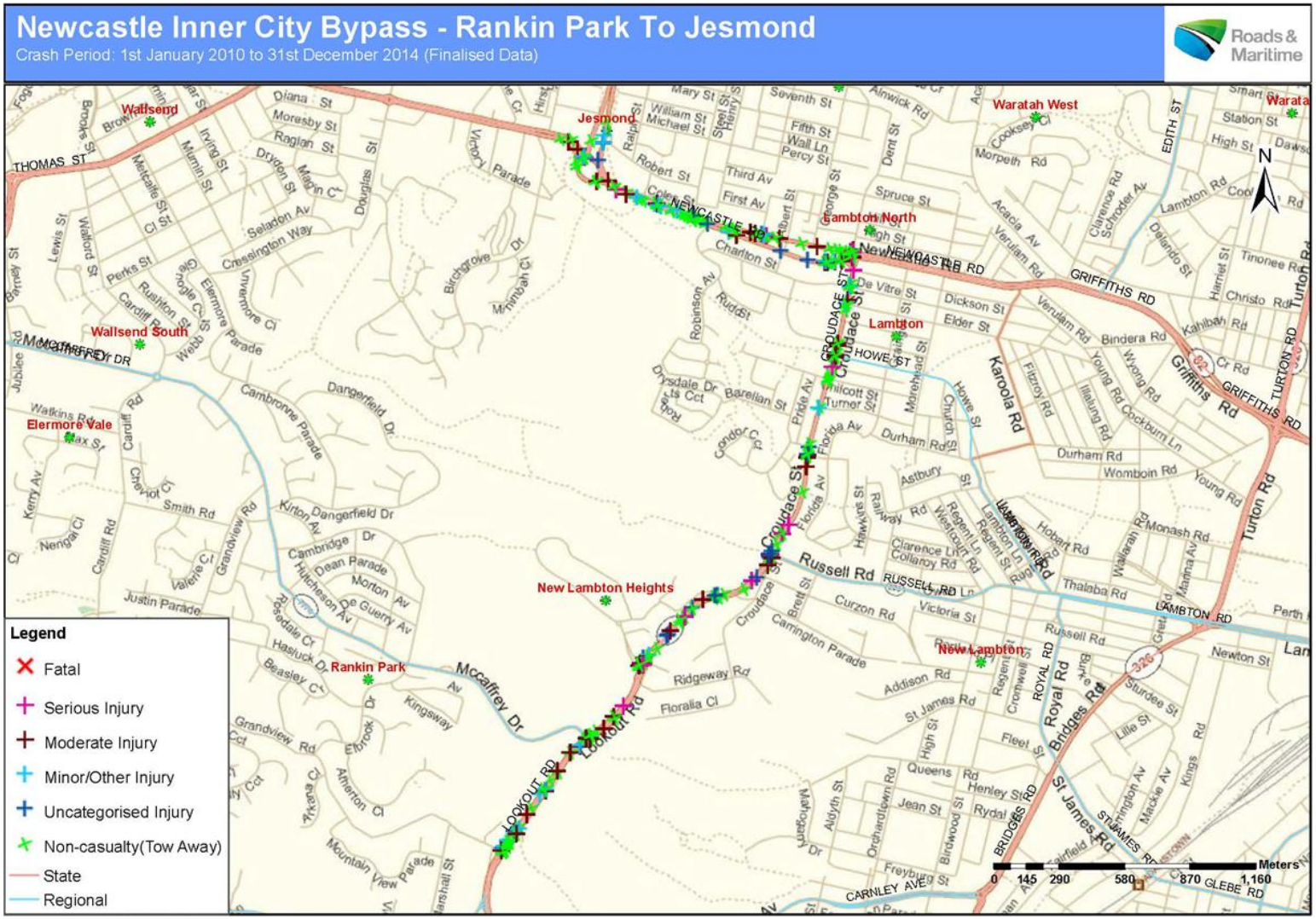
- The majority of crashes occurred in dry weather (78 per cent) and were rear-end (76 per cent), multi-vehicle (90 per cent) which indicate heavy traffic congestion along this route
- Another common type of crash during this period was vehicles leaving the roadway or losing control (13 per cent). These types of crashes typically occur on roads with numerous curves, steep grades and variable road conditions, which occur along the existing route
- 22 per cent of crashes that occurred were during wet conditions, which indicates the variable road conditions on the existing route contributed to a substantial number of the crashes that occurred
- Restricted access vehicles accounted for over 18.5 per cent of crashes, but only make up four per cent of traffic volume. This is considered to be reflective of congested traffic conditions and the variability of road conditions, such as grade, speed limit and curves
- About 43 per cent of crashes occurred at intersections, reflecting the large number of intersections and conflict points for traffic flow along this route.

Table 2-1 Crash history summary (Newcastle Road and Lookout Road/Croudace Street)

Type	Factor	Number of crashes (2010 to 2014)	Proportion of total
Vehicle	Car and light vehicles	298	74%
	Restricted access vehicle[1]	74	18.5%
	Bus	2	0.5%
	Emergency vehicle	3	1%
	Motorcycle	18	4.5%
	Bicycle	2	0.5%
	Pedestrian	4	1%
Number of vehicles	Single vehicle	32	10%
	Multi-vehicle	283	90%
Contributing factors	Speed	22	n/a[2]
	Fatigue	15	n/a[2]
Road surface conditions	Wet	69	22%
	Dry	246	78%
	Snow or ice	0	0%
Location	Intersection	135	43%
	Non-intersection	180	57%
Vehicle movement	Head-on	5	2%
	Rear-end	195	76%
	Lane change	11	4.5%
	Ran off road or out of control	33	13%
	Other	11	4.5%
Injury	Fatal	0	0%

Type	Factor	Number of crashes (2010 to 2014)	Proportion of total
	Injury	133	42%
	Non-injury	182	58%
Totals	Average per year	63	n/a
	Total crashes	315	n/a

Source: Roads and Maritime
1 includes light truck, rigid truck, articulated trucks, heavy trucks, restricted access vehicles, rigid and articulated trucks and heavy buses
2 This data was not reported for most crashes and therefore the actual total for each contributing factors is unknown.



Source: Roads and Maritime, 2016

Figure 2-4 Crash History

2.6 Public transport

2.6.1 Rail services

There are no rail services located within the study area itself, however, there are a number of services that operate within three kilometres, including:

- Main Northern Railway Line (northern line) – located about 2.5 kilometres to the north
- Main Northern Railway Line (southern line) – located about one kilometre to the south.

The closest train stations are Kotara Station on the southern line, and Warabrook Station on the northern line.

2.6.2 Bus services

Roads within the study area are used by the following public bus services:

- Newcastle Buses: Route 100 – this bus service travels between Jesmond and Charlestown, along Newcastle Road and Lookout Road/Croudace Street, and services John Hunter Hospital precinct via its main entrance.
- Newcastle Buses: Route 224 – this service travels between Wallsend and Newcastle by Kotara, and services John Hunter Hospital. This service travels along McCaffrey Drive and Lookout Road to the John Hunter Hospital precinct, then back along Lookout Road to Kotara.
- Newcastle Buses: Route 222, which travels between Wallsend and Newcastle and services John Hunter Hospital. This service travels along Grandview Road and Lookout Road/Croudace Street and services the John Hunter Hospital precinct via its main entrance.
- Newcastle Buses: Routes 226, 230 and 231, which travel between Glendale, Maryland and Wallsend to Newcastle along Newcastle Road and Croudace Street to its intersection with Howe Street.
- Newcastle Buses Route 235 which travels between Wallsend and Newcastle via Jesmond, North Lambton, Waratah and Hamilton. This service departs Newcastle Road at Blue Gum Road Jesmond to service Jesmond and North Lambton before re-joining Newcastle Road at Croudace Street.
- Newcastle Buses: Route 363, which travels between Warners Bay and Newcastle. This service travels along Cardiff Road, Lookout Road and Russell Road and services the John Hunter Hospital precinct via its main entrance.

A number of bus stops and dedicated bus lanes are located along the bus routes, which are identified on Figure 2-5. The John Hunter Hospital is a key bus stop and is identified as a ‘timing point’ by Newcastle Buses.

In addition a number of school bus services travel along existing roads in the study area during morning and afternoon periods from Monday to Friday during school term. These roads include Newcastle Road, Blue Gum Road, Croudace Street, Russell Road, Lookout Road, McCaffrey Drive, Grandview Road and Main Road. School bus services use the existing public bus stops along these roads. Specific school bus stops are located on Croudace Street at Lambton Public School and on Lookout Road at New Lambton Heights Infants School. Newcastle Buses and Ferries also operate late night bus services after midnight on Friday and Saturday nights. These buses take passengers from inner Newcastle to outlying suburbs and some of these buses travel along Newcastle Road through the study area.

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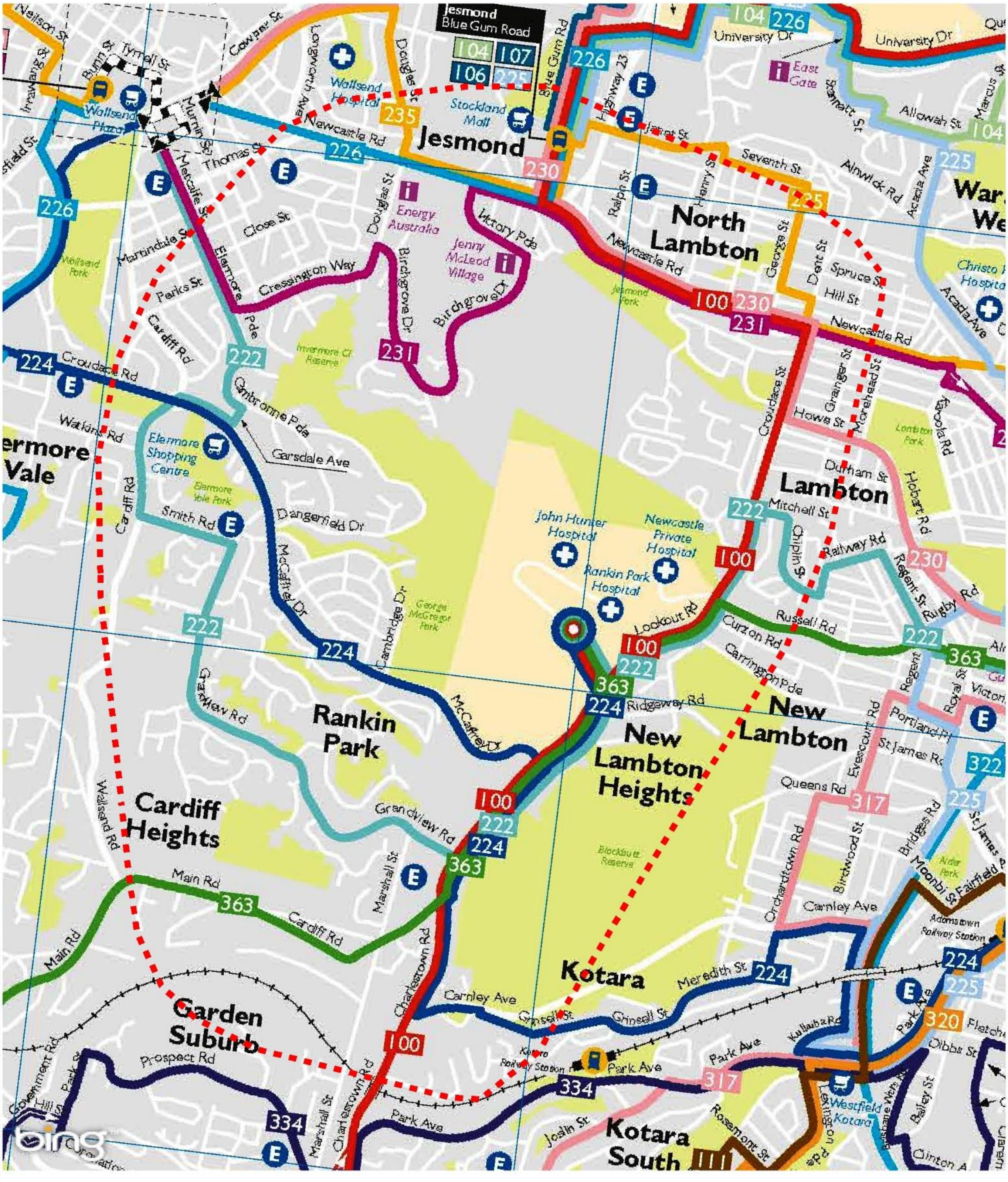

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Legend

Study Area

Source: Newcastle Buses

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Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 2-5: Public transport routes

2.6.3 Taxi and hire car services

Several companies offer taxi services covering the study area. These include Newcastle Taxis, Waratah Hire Cars, Silver Service and Newcastle Hire Cars. Taxi ranks are located within the John Hunter Hospital and Stockland Jesmond Shopping Centre.

2.6.4 Community transport

Community transport services are provided across Newcastle by operators such as: Mercy Services, Newcastle Community Transport Group and Awabakal Newcastle Aboriginal Co-operative. These services generally provide ad-hoc transport for specific groups, such as people with a disability or the elderly. These services regularly travel to the John Hunter Hospital precinct and Stockland Jesmond Shopping Centre.

2.7 Cycling and pedestrian network

2.7.1 Pedestrian

Formal paved paths for pedestrians exist in the study area in the form of shared paths and footpaths.

At the northern end of the project there are a number of existing shared paths and paved pedestrian footpaths. These include:

1) An east-west shared path running along the southern extent of Jesmond Park to the Newcastle Road and Blue Gum Road intersection. This forms part of a pedestrian/cycleway linking Lambton to Jesmond and Wallsend
2) A north-south shared path between Jesmond Park to John Hunter Hospital
3) A shared path on the southern side of Newcastle Road between Robinson Avenue and the mid-block signalised pedestrian crossing near Hill Street
4) Shared path on the eastern side of the Jesmond to Shortland section of the Newcastle Inner City Bypass commencing at the north eastern corner of the existing Jesmond Roundabout on Newcastle Road and extending north to the University of Newcastle
5) A network of paved footpaths exists within Jesmond Park providing connection between Newcastle Road and the east-west shared path.

There is also a network of unpaved tracks, some of which are fire trails that occur throughout the bushland area bounded by Jesmond Park, John Hunter Hospital, Lookout Road, McCaffrey Drive and residential properties associated with Lambton, Wallsend, Elermore Vale and Rankin Park. These tracks are used informally for activities such as bike riding and bush walking, and for pedestrian access to John Hunter Hospital precinct.

At the southern end of the project, there are a number of existing paved pedestrian footpaths along the existing route of Lookout Road and McCaffrey Drive. These include:

6) Paved footpath on both sides of Lookout Road between Kookaburra Circuit and McCaffrey Drive
7) A paved footpath on the northern side of McCaffrey Drive running from the intersection of McCaffrey Drive and Lookout Road, west for about one kilometre where it ends opposite the Elbrook Drive and McCaffrey Drive intersection
8) Paved footpath on the western side of Lookout Road from the intersection at McCaffrey Drive to about 40 metres to the south
9) Paved footpath on the eastern side of Lookout Road from the Blackbutt Reserve entrance to about 160 metres to the south.

There are also a number of signalised pedestrian crossings on the surrounding road network, including:

a) Douglas Street/ Newcastle Road

b) Drury Street/ Newcastle Road/ Victory Parade

c) Blue Gum Road/ Newcastle Road

d) Newcastle Road about 170 metres west of Steel Street adjacent to Jesmond Park

e) Dent Street/ Croudace Street/ Newcastle Road

f) Morehead Street/ Newcastle Road

g) Croudace Street about 40 metres south of Elder Street adjacent to Lambton Public School

h) Howe Street/ Croudace Street

i) Pride Avenue/ Mitchell Street/ Croudace Street

j) Croudace Street/ Russell Road/ Lookout Road

k) Jacaranda Drive/ Lookout Road

l) John Hunter Hospital Access/ Lookout Road

m) McCaffrey Drive/ Lookout Road

n) Cardiff Road/ Charlestown Road/ Lookout Road.

The pedestrian network surrounding the project is shown on Figure 2-6.

2.7.2 Cycling

Newcastle's existing bicycle network is made up of marked on-road routes and off-road shared paths. *Newcastle City Council's Cycling Strategy and Action Plan* (Newcastle City Council 2012) (the action plan) identifies proposed off-road and on-road cycling routes within the study area (refer to Figure 2-7). The overall objective of the action plan is to make cycling a safe and attractive travel option to facilitate more people using bicycles for more of their trips. This objective supports the NSW 2021 target of more than doubling cycling mode share for trips at a local and district level in the Greater Sydney region by 2016.

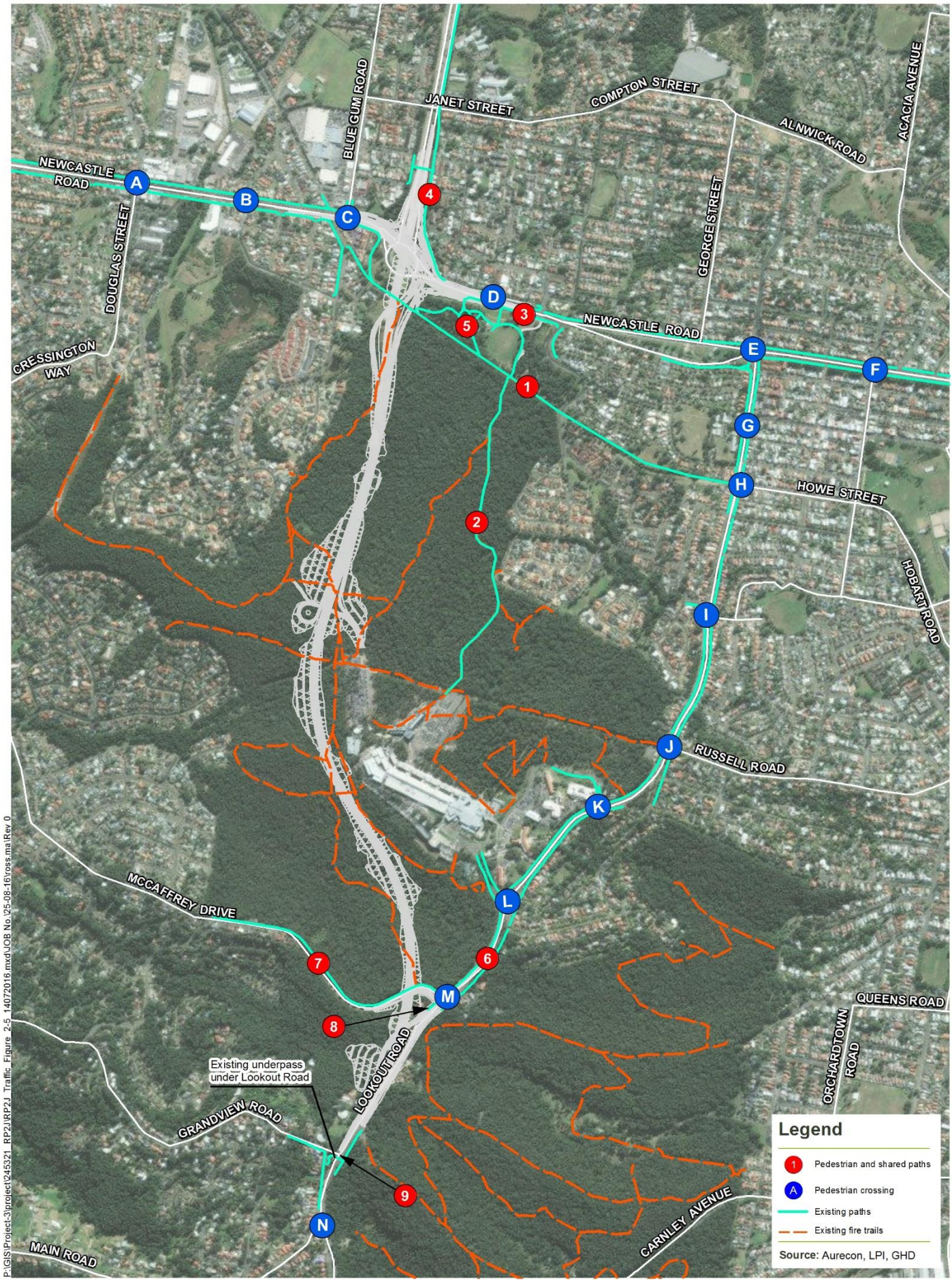
Existing off-road shared paths exist at the northern end of the project, including:

- East-west shared path on the southern side of Jesmond Park, running from Howe Street, Lambton to Newcastle Road, Jesmond, near its intersection with Blue Gum Road. This path forms part of regional cycling route R5 – Newcastle City Centre to Glendale, as defined by the action plan. This route connects a number of key locations in Newcastle, including the city centre, Broadmeadow sports and entertainment precinct, Lambton Park and Glendale TAFE. This route connects to other on-road cycling routes and shared paths, as shown on Figure 2-7
- East-west shared path on the southern side of Newcastle Road, running between Robinson Avenue and the mid-block signalised pedestrian crossing near Hill Street
- North–south shared path running through the bushland area to the south of Jesmond Park, connecting the Jesmond Park path to the John Hunter Hospital. This path forms part of local cycling route L8 – University to John Hunter Hospital under the action plan and connects to route R5 at the eastern end of Jesmond Park
- North-south shared path running along the eastern side of the Jesmond to Shortland section of the Newcastle Inner City Bypass. This path connects the University of Newcastle with Coles Street, Jesmond, providing access to Jesmond Park via an existing traffic light controlled crossing on Newcastle Road. This path forms part of local cycling route L8 – University to John Hunter Hospital as defined by the action plan. This route provides connections to route R5 at Jesmond Park and to regional route R6 (Newcastle City Centre, University, Birmingham Gardens) at University Drive.

On the existing sections of the Newcastle Inner City Bypass, cyclists are currently able to use the predominantly 2-2.5 metre shoulders.

The project footprint also includes the following planned cycling routes:

- R3 (Kotara to Sandgate). This regional cycling route would generally follow the corridor of the overall Newcastle Inner City Bypass, connecting to route R3 (Newcastle to Maitland) at Sandgate and to Bennetts Green in Lake Macquarie LGA. This route relies on the Newcastle Inner City Bypass creating suitable provisions for cyclists and the project would achieve this within the project footprint, and includes proposed on-road provision for the length of the project. Cycling provisions provided by the project are described in more detail in Section 5.6.3
- L31 (John Hunter Hospital to Wallsend). This local cycling route would provide a connection from the John Hunter Hospital precinct to Elermore Parade, Elermore Vale. The route would generally travel through bushland, traversing the project footprint and passing through Invermore Reserve and Dangerfield Drive Reserve to the west. This route would cross route R3 and would require extensive construction of off-road paths.



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Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 2-6: Pedestrian network

Legend

- Study Area
- **Cycling Routes**
- On road - existing route
- On road - proposed route
- Off road - existing route
- Off road - proposed route

Source: BingMaps

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Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 2-7: Cycling routes

2.8 Parking

2.8.1 John Hunter Hospital precinct

Car parking is provided at multiple car parks at the John Hunter Hospital Complex, which includes a series of multilevel and open car parks providing about 3,400 car parking spaces. On-street parking is also available at various locations around the hospital on streets such as Lookout Road, Ridgeway Road and Carrington Parade. Visitor access to the car parks at the hospital is generally timed and charged for.

A number of pick-up and set-up down areas are located within the hospital precinct, typically at the entries to key facilities such as the emergency ward, Royal Newcastle Centre, Newcastle Private Hospital and Rankin Park Centre. Short-term parking (15 minute), bus stops and taxi zones are located at the main entry to the John Hunter Hospital and the Royal Newcastle Centre.

2.8.2 General parking

Two off-street car parking areas associated with Jesmond Park and Blackbutt Reserve are located within the study area. The Jesmond Park car park is accessed from Robinson Avenue and provides informal, untimed parking for visitors of Jesmond Park. A small parking and picnic area associated with Blackbutt Reserve is located to the east of Lookout Road, near Grandview Road.

Untimed, on-street parking is permitted on most of the regional and local roads within the study area, however, some parking restrictions apply on the State road network. Parking restrictions adjacent to the project include:

- On-street parking is generally not permitted along Newcastle Road, although parking is permitted in some areas where a marked shoulder is provided, such as adjacent to Jesmond Park on both the eastbound and westbound carriageways. Parking is not permitted in the shoulder area on the eastbound carriageway between the signalised pedestrian crossing on Newcastle Road and Steel Street
- On-street parking is permitted on parts of Lookout Road where a marked shoulder is provided of sufficient width. Locations include:
  - Eastern side, about 170 metres south of Jacaranda Drive for about 25 metres
  - Eastern side, from around 130 metres south of McCaffrey Drive to the access for Blackbutt Reserve. Within this section, parking is not permitted for around 60 metres due to a bus zone and parking restriction for about 20 metres on approach to a driveway
  - Western side, about 50 metres south of Ridgeway Road for about 75 metres
  - Western side, about 180 metres north of McCaffrey Drive for about 25 metres. Parking is not permitted in this location in the AM and PM peak periods
  - Western side, from about 90 metres south of McCaffrey Drive to Grandview Road. The shoulder narrows opposite the Blackbutt Reserve entrance over a length of about 100 metres. Whilst there are no formal parking restrictions over this section of narrowed shoulder it is considered not suitable for on-street parking.

2.8.3 Stockland Jesmond Shopping Centre

Stockland Jesmond Shopping Centre contains over 900 car parking spaces which are accessed from Blue Gum Road and Mordue Parade. A number of pick up and set down areas are located within the shopping centre car park. Timed on-street parking is permitted on the western side of Blue Gum Road between the shopping centre car park entrance and Newcastle Road.

2.9 Fire trails

The bushland areas associated with the project are defined as bushfire prone in mapping prepared by Newcastle City Council (2014). This bushland contains a network of fire trails that aid with management of bushfire and bushfire hazard reduction. These trails are discussed further in Section 5.8.

3 Existing road performance

This chapter establishes the existing transport network performance in the study area. Results from traffic surveys and assessments of existing traffic performance are summarised in this chapter.

3.1 Traffic surveys

Roads and Maritime has carried out extensive data collection involving origin-destination (OD) surveys (Arcadis 2016), midblock counts and intersections turning counts in the study area. Two traffic survey data sets were collected in October 2014 and May 2015.

3.1.1 Traffic survey data

October 2014

Traffic surveys were carried out between 7 and 13 October 2014 at the locations shown on Figure 3-1. OD surveys were carried out at 10 locations and midblock traffic counts at 13 locations.

Table 3-1 lists survey type and locations. The survey data provided key inputs to the Lower Hunter Traffic Model (LHTM) refinement for the study area (refer to Section 4.1.1 for more detail).

Table 3-1 October 2014 survey types and locations

Survey type	Date/period	Locations (reference number)*
1. Origin-destination (OD) surveys	■ 9th October 2014 (24 hours)	■ Lookout Road - south of McCaffrey Drive (19) ■ McCaffrey Drive - west of Lookout Road (5) ■ Kookaburra Circuit (John Hunter Hospital access) (8) ■ Jacaranda Drive - (John Hunter Hospital access) (14) ■ Russell Road - west of Brett Street (9) ■ Howe Street - west of Grainger Street (15) ■ Newcastle Road - east of Croudace Street (10) ■ Dent Street - north of Newcastle Road (13) ■ Newcastle Road - west of Inner City Bypass (12) ■ Inner City Bypass - north of Newcastle Road (11)
2. Mid-block traffic surveys	■ 7 – 13 October 2014	■ Lookout Road - south of McCaffrey Drive (19) ■ McCaffrey Drive - west of Lookout Road (5) ■ Kookaburra Circuit (John Hunter Hospital access) (8) ■ Jacaranda Drive (John Hunter Hospital access) (14) ■ Russell Road - west of Brett Street (9) ■ Howe Street - west of Grainger Street (15) ■ Newcastle Road - east of Croudace Street (10)

Survey type	Date/period	Locations (reference number)*
		■ Dent Street - north of Newcastle Road (13) ■ Newcastle Road - west of Inner City Bypass (10) ■ Inner City Bypass - north of Newcastle Road (11) ■ Newcastle Road - east of Newcastle Inner City Bypass (16) ■ Croudace Street - north of Elder Street (17) ■ Lookout Road - south of Russell Road (18)

*** Refer to Figure 3-1**

May 2015

Roads and Maritime carried out additional traffic surveys between 5 and 11 May 2015. Three types of survey data were provided; OD surveys, midblock traffic counts and intersection turning movement counts. The OD surveys were recollected to include additional locations in the south including Charlestown Road, Grandview Road, Cardiff Road, Carnley Avenue and Croudace Road west of Grandview Road (refer to Figure 3-1). The intersection movement count data was collected to reinforce 2014 OD survey data for traffic distribution analysis.

Table 3-2 lists survey type and locations. The survey data was used for further model refinement for the southern section of the study area between McCaffrey and Carnley Avenue.

Table 3-2 May 2015 survey types and locations

Survey type	Date/period	Locations (reference number)*
1. Origin-destination (OD) surveys	■ 6th May 2015 ■ AM peak (7:00-10:00) ■ PM peak (15:00-18:00) ■ 15 key locations	■ Charlestown Road - south of Carnley Avenue (1) ■ Carnley Avenue - east of Charlestown Road (2) ■ Cardiff Road - west of Lookout Road (3) ■ Grandview Road - west of Lookout Road (4) ■ McCaffrey Drive - west of Lookout Road (5) ■ Croudace Road - west of Grandview Road (6) ■ Lookout Road - north of McCaffrey Drive(7) ■ Kookaburra Circuit (John Hunter Hospital access) (8) ■ Russell Road - east of Lookout Road (9) ■ Newcastle Road - east of Croudace Street (10) ■ Newcastle Inner City Bypass - north of Newcastle Road (11) ■ Newcastle Road - west of Newcastle Inner City Bypass (12) ■ Dent Street - north of Newcastle Road (13) ■ Jacaranda Drive (John Hunter Hospital access) (14) ■ Howe Street - east of Croudace Street (15)
2. Mid-block traffic surveys	■ 11 May 2015 ■ 6 key locations	■ Charlestown Road - south of Cardiff Road (1) ■ Carnley Avenue - east of Charlestown Road (2) ■ Cardiff Road - west of Lookout Road (3) ■ Grandview Road - west of Lookout Road (4)

Survey type	Date/period	Locations (reference number)*
		■ Croudace Road - west of Grandview Road (6) ■ Lookout Road - north of McCaffrey Drive (7)
3. Intersection turning movement counts	■ AM peak (7:00-10:00) ■ PM peak (15:00-18:00) ■ 10 intersections	■ Cardiff Road / Charlestown Road ■ Grandview Road / Lookout Road ■ Marshall Street / Grandview Road ■ McCaffrey Drive / Elbrook Drive ■ Croudace Road / Grandview Road / McCaffrey Drive ■ Croudace Road / Cardiff Road ■ Croudace Road / Lake Road ■ Walford Street / Thomas Street ■ Cardiff Road / Marshall Street ■ Charlestown Road / Carnley Avenue

*** Refer to Figure 3-1**

Legend

- Study Area
- Mid-block traffic counts
- Origin Destination (OD) surveys and mid-block traffic counts

Source: Aurecon, World Imagery, LPI

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Projection: GDA 1994 MGA Zone 56

Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

FIGURE 3-1: Traffic survey types and locations

3.1.2 Intersection surveys

Surveys of 18 key intersections within the study area were carried out in April and June 2014 (refer to Figure 3-2). These surveys counted vehicles turning at each of the following intersections in 15 minute intervals as follows:

- Counts carried out on 24 June 2014 during the morning peak (07:00am to 09:00am) and afternoon peak (16:00pm to 18:00pm) at the following intersections:
  - Blue Gum Road/Newcastle Road
  - Croudace Street/Howe Street
  - Croudace Street/Lookout Road/Russell Road
  - Lookout Road/Jacaranda Drive
  - Lookout Road/Hospital Access
  - Cardiff Road/Lookout Road/Charlestown Road
  - Morehead Street/Newcastle Road
  - Croudace Street/Mitchell Street/Pride Avenue
  - Lookout Road/Grandview Road
  - Drury Street/Newcastle Road/Victory Parade.
- Counts carried out on a number of days between April and June 2014 at following intersections and times:
  - Newcastle Road/Dent Street/Croudace Street: 3 – 4 April 2014 Friday (07:30am to 09:30am and 15:00pm to 18:00pm)
  - Charlestown Road/Carnley Avenue: Thursday: 2 – 3 April 2014 (07:30am to 09:30am and 15:00pm to 18:00pm)
  - Newcastle Inner City Bypass/Newcastle Road: 9 – 10 April 2014 (07:00am to 10:00am and 15:00pm to 18:00pm)
  - Blue Gum Road/University Drive: Thursday: 9 – 10 April 2014 (07:00am to 10:00am and 15:00pm to 18:00pm)
  - University Drive/Newcastle Bypass: 18 June 2014 (06:30am to 09:00am and 15:00pm to 18:00pm)
  - University Drive/University Access: 18 June 2014 Wednesday (06:30am to 09:00am and 15:00pm to 18:00pm)
  - Douglass Street/Newcastle Road: 21 May 2014 (07:00am to 09:30am and 15:00pm to 18:00pm)
  - Lookout Road/McCaffrey Drive: Wednesday: 21 May 2014 (07:00am to 09:30am and 15:00pm to 18:00pm).

3.2 Traffic volumes

3.2.1 Daily traffic volumes

Daily traffic volumes recorded during the October 2014 and May 2015 traffic surveys are shown in Table 3-3 and shown on Figure 3-3.

Table 3-3 Average daily weekday traffic volumes

ID[(1)]	Road/location	Average weekday daily traffic (two-way in vehicles)
1	Charlestown Road, south of Carnley Avenue[(1)]	55,100
2	Carnley Avenue, east of Charlestown Road[(1)]	21,000

ID[1]	Road/location	Average weekday daily traffic (two-way in vehicles)
3	Cardiff Road, west of Lookout Road[1]	14,700
4	Grandview Road, west of Lookout Road[1]	2,700
5	McCaffrey Drive, west of Lookout Road[2]	18,600
6	Croudace Road, west of Grandview Road[1]	19,900
7	Lookout Road, north of McCaffrey Drive[1]	49,400
8	Kookaburra Circuit (John Hunter Hospital access)[2]	15,300
9	Russell Road, east of Lookout Road[2]	16,200
10	Newcastle Road, east of Croudace Street[2]	46,500
11	Newcastle Inner City Bypass, north of Newcastle Road[2]	36,100
12	Newcastle Road, west of Newcastle Inner City Bypass[2]	44,300
13	Dent Street, north of Newcastle Road[2]	4,900
14	Jacaranda Drive (John Hunter Hospital access)[2]	2,700
15	Howe Street, east of Croudace Street[2]	8,500
16	Newcastle Road, east of Newcastle Inner City Bypass[2]	60,200
17	Croudace Street, north of Elder Street[2]	41,800
18	Lookout Road, south of Russell Road[2]	48,700
19	Lookout Road, south of McCaffrey Drive[2]	47,200

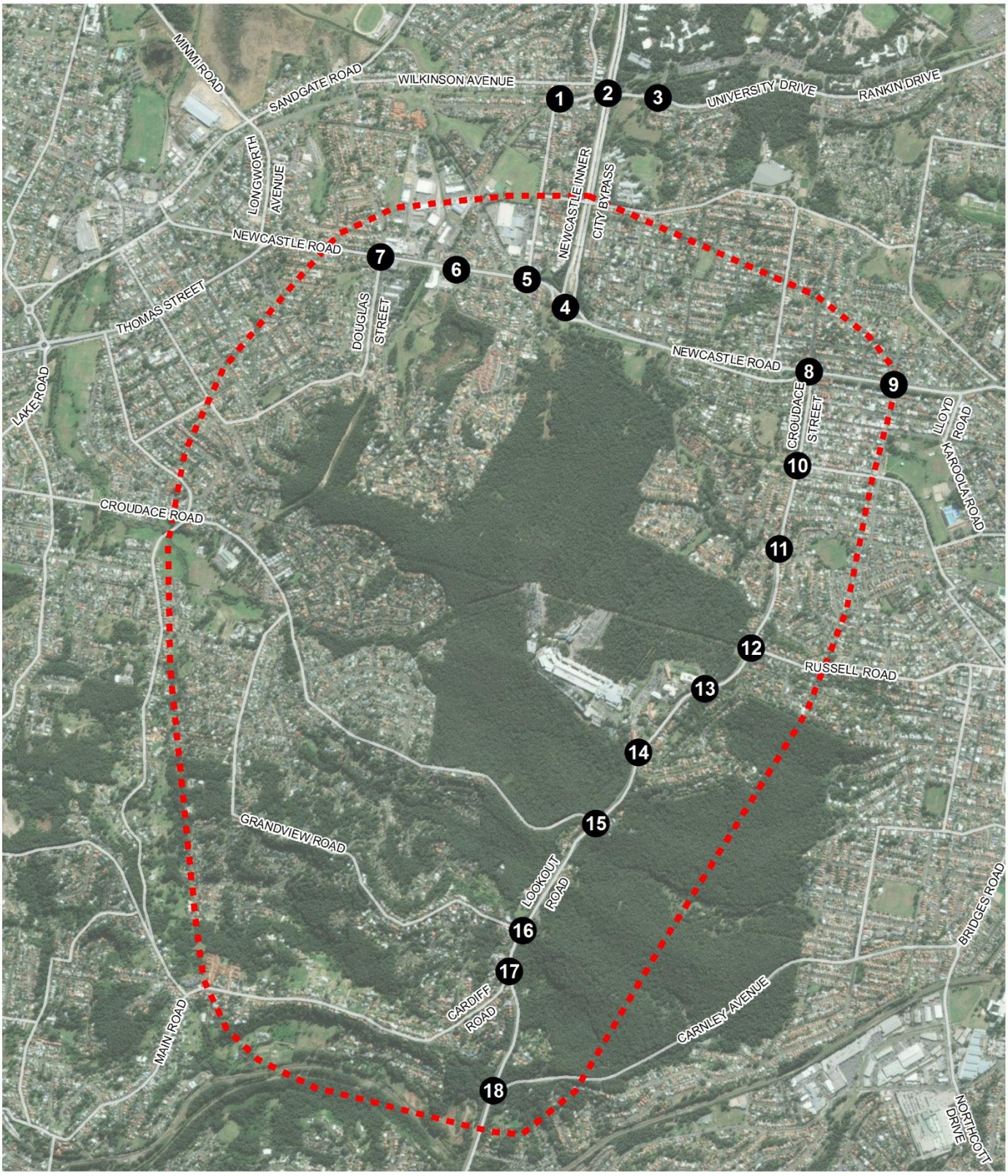
Note: Average Weekday Daily Traffic (two-way in vehicles)

Source: Arcadis 2016

Reference:

(1) May 2015 survey data,

(2) October 2014 survey data.



Legend

- Intersections
- Study Area

Source: Aurecon, World Imagery, LPI

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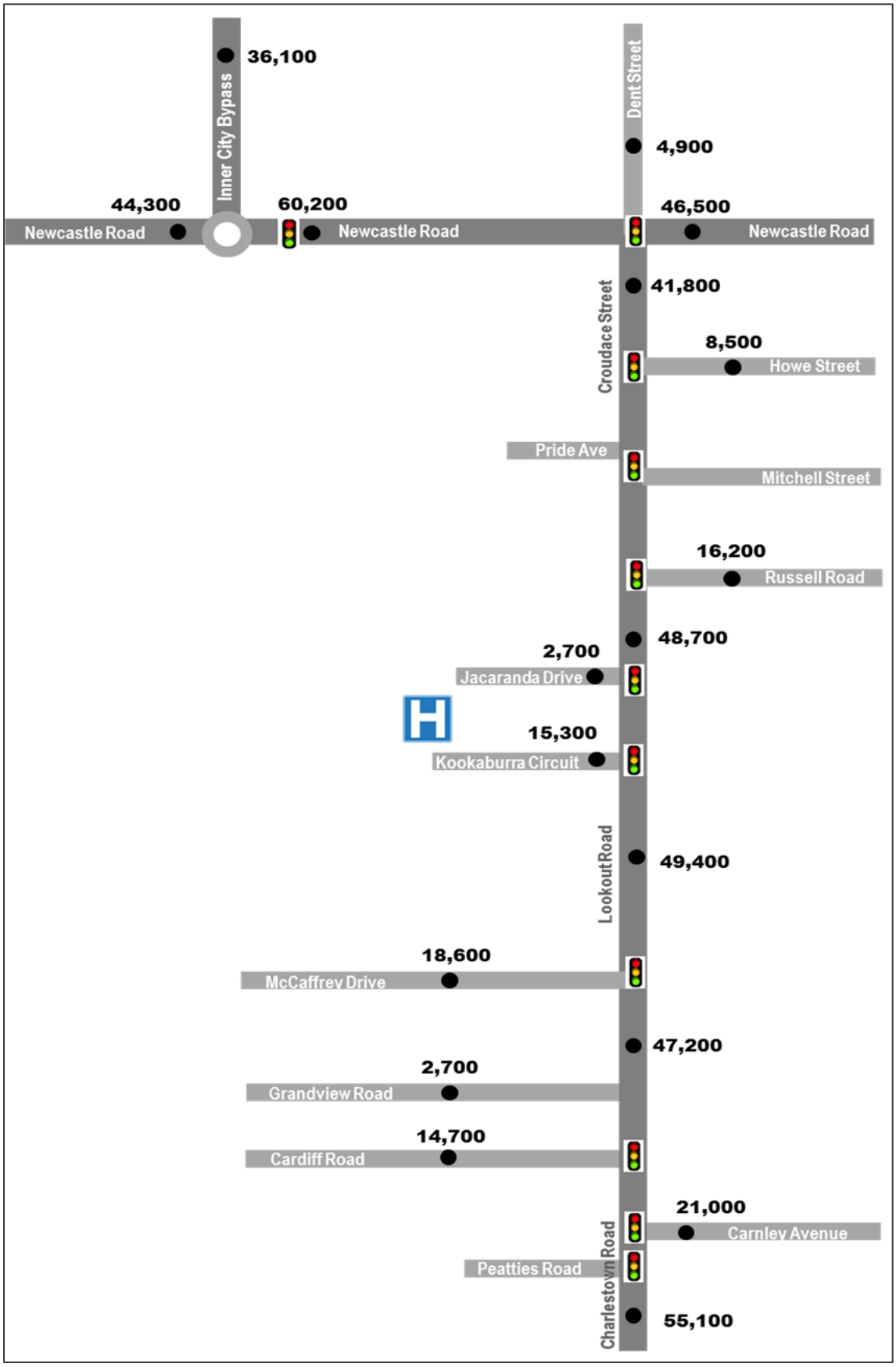
Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 3-2: Intersection survey (RMS 2014)



Source: Arcadis 2016

Figure 3-3 Daily traffic flow diagram for existing 2014/2015

3.3 Origin-destination study

The two OD studies carried out (Arcadis 2016) for the project determined where traffic is travelling for a typical day in the study area. As part of this overall study, two OD surveys were completed in October 2014 and May 2015 (refer to Section 3.1). In this study, trips were defined as one-way movements, from where the trip starts (the origin) to where the trip is going (destination). The surveys were carried out using video cameras and a number-plate recognition system that determined trip patterns by identifying which cars travelled past the OD survey locations.

3.3.1 Origin-destination study results

Analysis of the OD survey data carried out by Arcadis (2016) found that:

- For the key north-south route between Lookout Road and the Newcastle Inner City Bypass (Jesmond to Sandgate section) via Croudace Street and Newcastle Road:
  - Of the total traffic observed at Lookout Road south of McCaffrey Drive, 23 to 24 per cent had an origin or destination at Newcastle Inner City Bypass north of Newcastle Road. Travel to and from areas to the north of the project would be influenced by regional population centres such as Maitland, Raymond Terrace, and The University of Newcastle
  - Of the total traffic observed at the Newcastle Inner City Bypass north of Newcastle Road, 27 to 31 per cent had an origin or destination at Lookout Road south of McCaffrey Drive. Travel to and from areas to the south of the project would be influenced by commercial and retail centres located in suburbs such as Charlestown and Bennetts Green
- Of traffic observed at Lookout Road south of McCaffrey Drive, about 21 to 22 per cent had an origin or destination at McCaffrey Drive. Travel along this route would be influenced by movements between residential areas to the west of the project such as Rankin Park, Elermore Vale and north-west of the study area such as Wallsend, Fletcher and Maryland. Travel would also be associated with commercial and retail areas located at Glendale and Wallsend
- Of the traffic on McCaffrey Drive:
  - About 50 to 53 per cent had an origin or destination south of McCaffrey Drive via Lookout Road
  - About 23 to 27 per cent had an origin or destination at Russell Road to the east of Lookout Road
  - At McCaffrey Drive about 100 vehicles per day had an origin or destination at the Newcastle Inner City Bypass (Jesmond to Sandgate section) or Newcastle Road west of the Newcastle Inner City Bypass
  - Travel on McCaffrey Drive would be influenced by movements between the western suburbs of Newcastle, commercial and retail centres such as Glendale, Wallsend and Charlestown, travel to the John Hunter Hospital precinct and inner city suburbs of Newcastle to the east
- About 44 to 45 per cent of vehicles using the John Hunter Hospital access (Kookaburra Circuit) had an origin and destination at Lookout Road south of McCaffrey Drive, reflecting travel to and from the southern suburbs of Newcastle such as Charlestown and Warners Bay
- At Newcastle Road west of the Newcastle Inner City Bypass, 48 to 52 per cent of vehicles had an origin or destination at Newcastle Road to the east, reflecting travel between the eastern and western suburbs of Newcastle, and the M1 Pacific Motorway and Hunter Expressway
- At Grandview Road more than 80 per cent of vehicles had an origin or destination south at Charlestown Road and Carnley Avenue (13 per cent to and 53 per cent from), and east at Russell and Newcastle roads (64 per cent to and 31 per cent from). A similar pattern was observed at Cardiff Road. This indicates these roads are mostly used for travel between suburbs such as Elermore Vale, Cardiff and locations such as the commercial and retail centres of Newcastle, Charlestown and Bennetts Green, and areas further to the south such as Lake Macquarie.

The study concluded that key travel patterns relevant to the study area include:

- Major north-south route for through and regional traffic between Lookout Road (south of McCaffrey Drive) and the Newcastle Inner City Bypass (Jesmond to Sandgate) via the existing route of Lookout Road, Croudace Street and Newcastle Road
- Major south-west route between Lookout Road (south of McCaffrey) and McCaffrey Drive
- Major east-west movements via Newcastle Road
- Major east-west movement between McCaffrey Drive and Russell Road via Lookout Road.

4 Traffic growth and approach to modelling

This section provides details of the traffic modelling and forecasting approach which was adopted to determine future traffic volumes and operational impacts for the study area.

4.1 Overarching methodology

Traffic modelling has been carried out to assess the predicted traffic performance of the project and the forecast redistribution of traffic on the road network within the study area. This modelling followed a two-tier structure with the Roads and Maritime Lower Hunter Traffic Model being used to provide forecast traffic demand information as input into a more detailed microsimulation model for operational assessment of options and for providing outputs for economic analysis. This approach is illustrated in Figure 4-1.

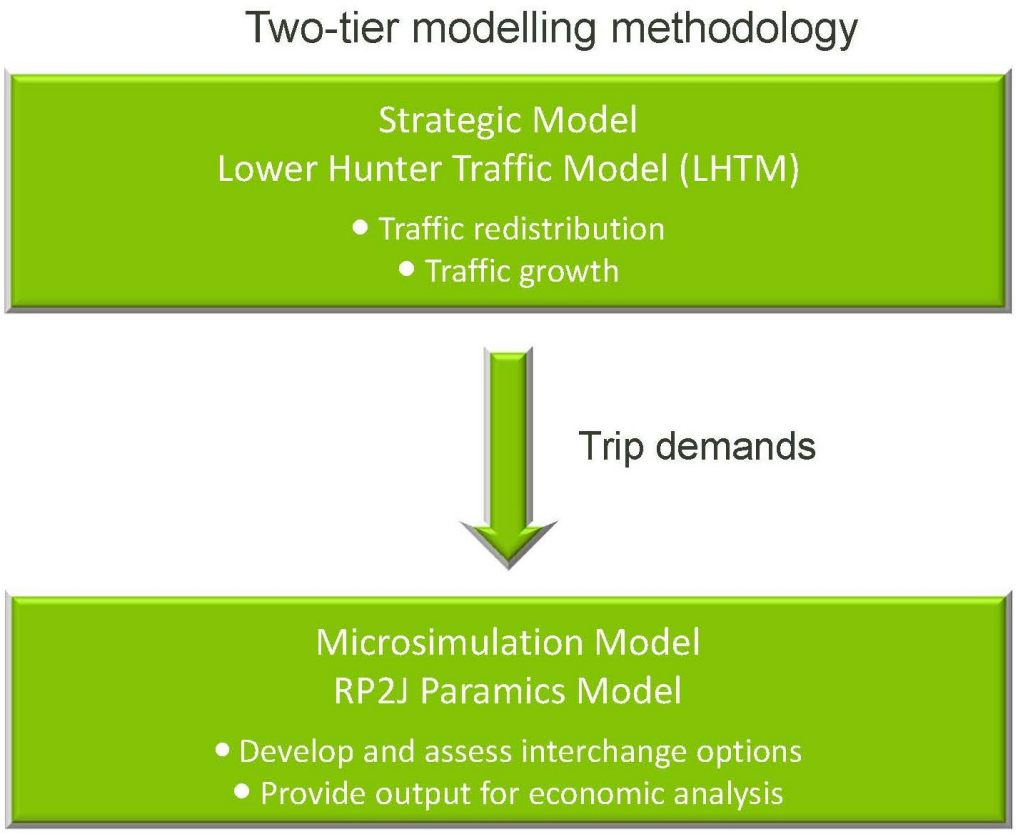


Figure 4-1 Two-tier modelling approach

4.1.1 Strategic model – Lower Hunter Traffic Model

Roads and Maritime engaged Arcadis Australia Pacific Pty Ltd (Arcadis) to carry out strategic traffic modelling for the project using the Roads and Maritime's Lower Hunter Traffic Model (LHTM) to identify future traffic growth and the forecast traffic redistribution on the surrounding road network post implementation of the project.

The LHTM comprises a road network model of the entire Lower Hunter region. It covers the six statistical local areas – inner and outer Newcastle, Lake Macquarie, Cessnock, Maitland and Port Stephens. It also includes a portion of the northern section of Wyong to ensure that the M1 Pacific Motorway is included in the model area.

The LHTM was developed in TransCAD transportation planning software. The LHTM network includes motorways, highways, main roads and key local roads in the Lower Hunter. Travel zones in the model are based on those developed by the Bureau of Transport Statistics. The modelling approach for updating the LHTM follows a conventional four step modelling process by which the number of daily trips is estimated, distributed among origin and destination zones, divided according to mode of travel and assigned to the road network. Under the current form, the LHTM can produce a daily forecast, representing the total 24 hour traffic volumes for an average weekday.

Traffic volume forecasts for the LHTM are based on land use assumptions and forecast population and employment growth as predicted in the Lower Hunter Regional Strategy 2006-31 (Department of Planning 2006). The Lower Hunter Regional Strategy applies to the five local government areas of Newcastle, Lake Macquarie, Port Stephens, Maitland and Cessnock and is one of a number of regional strategies prepared by the NSW Department of Planning. The LHTM has been updated for the study area using actual OD survey data and mid-block traffic counts. The process and methodology of this update is detailed in *Newcastle Inner City Bypass Rankin Park to Jesmond, Traffic Modelling Report – Lower Hunter Traffic Model* (Arcadis 2016).

The LHTM has been used to predict the redistribution of traffic in the study area due to operation of the project. The LHTM was also used to forecast traffic demand for future years with and without the project taking into account forecast traffic growth in the study area, for use in the detailed microsimulation modelling.

The LHTM was calibrated for the study area (Arcadis 2016) using the traffic, intersection and OD survey data discussed in Section 3. This included:

- Refining the road network within the study area to include key arterial and local roads
- Refining travel zones for the study area. The loading points / centroid connectors were reviewed and updated
- Augmenting the LHTM daily trip tables taking into account actual OD traffic distribution and mid-block traffic counts at key locations.

The model was compared to the traffic survey data collected for the project. This comparison (refer to Table 4-1) showed a very close match (Arcadis 2016).

Table 4-1 Comparison of traffic survey results with modelled traffic volumes

ID	Road/Location	Average weekday daily traffic (two-way in vehicles)		% difference
		2014 counts	2014 counts modelled[3]	
1	Charlestown Road, south of Cardiff Road[2]	55,100	54,700	-1%
2	Carnley Avenue, east of Charlestown Road[2]	21,000	22,300	6%
3	Cardiff Road, west of Lookout Road[2]	14,700	15,500	5%
4	Grandview Road, west of Lookout Road[2]	2,700	2,900	7%
5	McCaffrey Drive, west of Lookout Road[1]	18,600	18,300	-2%
6	Croudace Road, west of Grandview Road[2]	19,900	18,900	5%
7	Lookout Road, north of McCaffrey Drive[2]	49,400	47,300	-4%
8	Kookaburra Circuit (John Hunter Hospital access)[1]	15,300	16,300	7%

ID	Road/Location	Average weekday daily traffic (two-way in vehicles)		% difference
		2014 counts	2014 counts modelled(3)	
9	Russell Road, east of Lookout Road(1)	16,200	16,400	1%
10	Newcastle Road, east of Croudace Street(1)	46,500	47,100	1%
11	Newcastle Inner City Bypass, north of Newcastle Road(1)	36,100	35, 700	-1%
12	Newcastle Road, west of Newcastle Inner City Bypass(1)	44,300	47,300	7%
13	Dent Street, north of Newcastle Road(1)	4,900	5,300	8%
14	Jacaranda Drive (John Hunter Hospital access)(1)	2,700	2,700	0%
15	Howe Street, east of Croudace Street(1)	8,500	9,000	6%
16	Newcastle Road, east of Newcastle Inner City Bypass(1)	60,200	58,600	-3%
17	Croudace Street, north of Elder Street(1)	41,800	41,800	0%
18	Lookout Road, south of Russell Road(1)	48,700	47,900	-2%
19	Lookout Road, south of McCaffrey Drive(1)	47,200	45,900	-3%

Note: Average Weekday Daily Traffic (two-way in vehicles)

Source: (1) October 2014 survey data, (2) May 2015 survey data, (3) Lower Hunter Traffic Model (LHTM)

4.1.2 Microsimulation model (Paramics)

A microsimulation traffic model was developed to assess the operational performance of the proposed alignment options for the bypass and associated interchanges using the Quadstone Paramics software platform (Aurecon 2016a). Paramics represents traffic flows within a network, by simulating individual vehicles and their interactions with other vehicles and the surrounding road environment.

The microsimulation traffic modelling has been carried out to meet the following objectives:

- Assess operational performance and identify constraints or issues with design options
- Forecast quantitative traffic statistics for comparison and evaluation of options
- Provide outputs for economic analysis.

An integral element of the traffic assessment relates to the development of a base model representing existing traffic conditions in the two hour morning (7am to 9am) and two hour evening (4pm to 6pm) peak periods. The model was calibrated and validated to 2014/15 traffic survey data.

The development of this base model is detailed in *Traffic Microsimulation Model Calibration and Validation Report*, October 2015 (refer Appendix A).

The base traffic model was then used to develop future year scenarios for the assessment of project options against retention of the existing road network configuration. The results of that process are provided in *Refined Strategic Design Microsimulation Traffic Modelling Report*, (Aurecon 2016a). The overall study methodology for the microsimulation modelling study is shown in Figure 4-2.

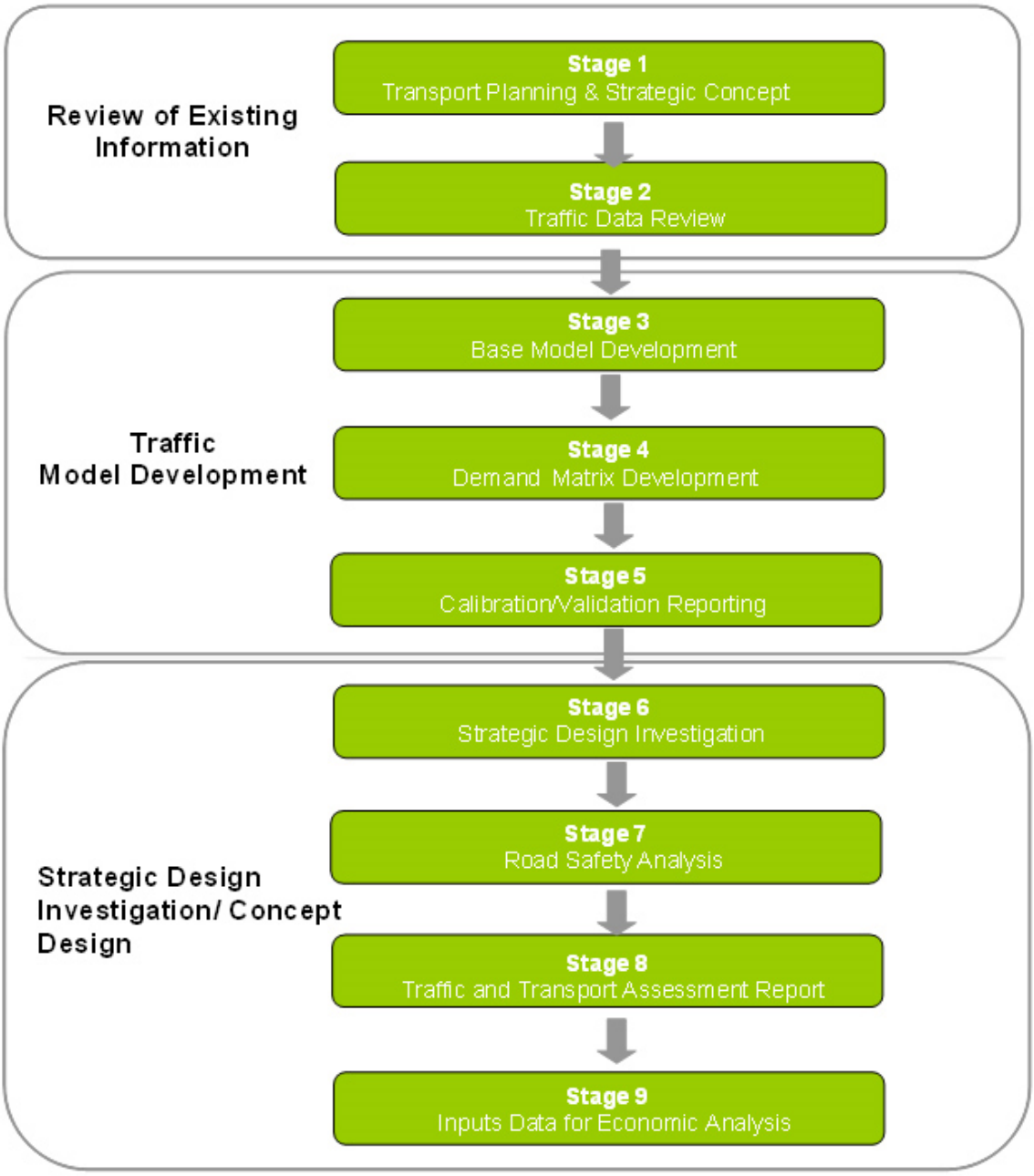


Figure 4-2 Microsimulation study methodology

With the two-tier modelling methodology, the Paramics model uses trip demand forecasts from the LHTM model for modelling of the following scenarios, both with and without the project:

- 2014 current scenario
- 2020 project opening scenario
- 2030 future scenario
- 2040 future scenario.

The results of the microsimulation modelling are discussed further in Section 5.4.

4.2 Traffic forecasting

Future traffic volumes for the study area were forecasted taking into account population and employment increases projected in the Lower Hunter Regional Strategy (DoP 2006).

Table 4-2 shows forecasted daily traffic volumes at the traffic survey locations described in Section 3.2 for 2020, 2030 and 2040 (without the project). Table 4-2 also shows predicted growth rates across the study area between 2014 and 2040 for a period of 26 years.

Table 4-2 shows that:

- Traffic within the study area is expected to grow by about one per cent per annum to 2040 (no predictions were made beyond then)
- Traffic on Lookout Road north of McCaffrey Road (ID7) is expected to grow by about 0.9 per cent per annum from 49,400 vehicles per day in 2014 to 63,100 vehicles per day in 2040
- Traffic on Croudace Street, north of Elder Street (ID17) is predicted to grow by about 0.8 per cent per annum from 41,800 vehicles per day in 2014 to 50,800 vehicles per day in 2040
- Traffic on Newcastle Road east of Newcastle Inner City Bypass (ID16) is predicted to grow by about 1.4 per cent per annum from 60,200 vehicles per day in 2014 to 86,200 vehicles per day in 2040
- Traffic on the Newcastle Inner City Bypass north of Newcastle Road (ID11) is predicted to grow in the order of 2.0 per cent per annum from 36,100 vehicles per day in 2014 to 60,300 vehicles per day in 2040
- Traffic at McCaffrey Drive (ID5), Grandview Road (ID4), Cardiff Road (ID3) and Carnley Avenue (ID2) is expected to grow by between 0.1 per cent to 0.5 per cent between 2014 and 2040
- Traffic on Charlestown Road south of Cardiff Road (ID1) is predicted to grown by about 0.1 per cent per annum between 2014 and 2040.

Table 4-2 Forecast daily traffic volumes without the project

ID	Location	Forecast daily traffic volumes (two-way in vehicles)				Annual growth rate (%) 2014-2040
		2014	2020	2030	2040	
1	Charlestown Road, south of Cardiff Road	55,100	55,500	56,300	57,100	0.1%
2	Carnley Avenue, east of Charlestown Road	21,000	21,100	21,400	21,700	0.1%
3	Cardiff Road, west of Lookout Road	14,700	15,100	15,800	16,600	0.5%
4	Grandview Road, west of Lookout Road	2,700	2,800	3,000	3,100	0.5%
5	McCaffrey Drive, west of Lookout Road	18,600	19,100	20,000	20,900	0.4%
6	Croudace Street, west of Grandview Road	19,900	20,100	20,600	21,000	0.2%
7	Lookout Road, north of McCaffrey Drive	49,400	52,500	57,700	63,100	0.9%
8	Kookaburra Circuit (John Hunter Hospital access)	15,300	16,200	17,900	19,800	1.0%
9	Russell Road, east of Lookout Road	16,200	17,600	20,100	22,600	1.3%
10	Newcastle Road, east of Croudace Street	46,500	51,600	60,100	68,500	1.5%

ID	Location	Forecast daily traffic volumes (two-way in vehicles)				Annual growth rate (%) 2014-2040
		2014	2020	2030	2040	
11	Newcastle Inner City Bypass, north of Newcastle Road	36,100	41,700	51,000	60,300	2.0%
12	Newcastle Road, west of Newcastle Inner City Bypass	44,300	48,200	54,700	61,200	1.3%
13	Dent Street, north of Newcastle Road	4,900	5,400	6,300	7,200	1.5%
14	Jacaranda Drive (John Hunter Hospital access)	2,700	2,700	2,800	2,900	0.3%
15	Howe Street, east of Croudace Street	8,500	9,600	11,400	13,300	1.7%
16	Newcastle Road, east of Newcastle Inner City Bypass	60,200	66,200	76,200	86,200	1.4%
17	Croudace Street, north of Elder Street	41,800	43,900	47,300	50,800	0.8%
18	Lookout Road, south of Russell Road	48,700	51,500	56,400	61,300	0.9%
19	Lookout Road, south of McCaffrey Drive	47,200	48,300	50,200	52,200	0.4%
Study area average						**1.0%**

Note, Average Weekday Daily Traffic (two-way in vehicles).

Source: Lower Hunter Traffic Model (LHTM) and Arcadis (2016).

5 Operational impacts

This section provides an assessment of the resulting traffic, transport and road safety impacts which are anticipated to occur from the operation of the project.

5.1 Strategic traffic modelling

The assessment of the project's operational impacts with respect to the predicted redistribution of traffic demand in the study area was based on modelling of the following features of the project using the LHTM:

- **Southern interchange**: A half interchange with Lookout Road with south facing ramps. This provides a northbound off-ramp to Lookout Road and southbound on-ramp from Lookout Road
- **Hospital interchange**: Via a connection from the bypass to the west of the John Hunter Hospital precinct. A half interchange was modelled in this location, with north facing ramps. This provides hospital access to and from the north
- **Northern interchange**: A full interchange at the northern connection with Newcastle Road and the existing Jesmond to Shortland section of the Newcastle Inner City Bypass.

The results of this modelling are discussed in the following sections.

5.2 Traffic forecasts for the project

Forecast traffic volumes for the project for 2014, 2020, 2030 and 2040, are as shown in Table 5-1 (Arcadis 2016). These volumes reflect the redistribution of traffic demand within the study area's road network that would use the project during its operational phase, with predicted traffic growth rates included for future years.

Table 5-1 Forecast daily traffic volumes on the project

ID	Location	Forecast daily traffic volumes (two-way in vehicles)			
		2014	2020	2030	2040
20	Project northern section, south of Newcastle Road	29,400	31,300	34,500	37,700
21	Project southern section, west of McCaffrey Drive	21,600	23,100	25,600	28,100
22	New Western Hospital access, east of RP2J	7,300	7,800	8,600	9,500

Note, Average Weekday Daily Traffic (two-way in vehicles).

Source: Lower Hunter Traffic Model (LHTM).

Analysis of the traffic forecast data shows:

- Based on 2020 traffic volumes (when the project is expected to be operating), the project is predicted to carry between 23,100 and 31,300 vehicles per day on average weekdays. The northern section between Newcastle Road and the proposed hospital interchange is expected to carry higher traffic. The new western hospital access is predicted to carry about 7,800 vehicles per day
- By 2030, traffic volumes on the project's northern section, south of Newcastle Road are forecast to grow to about 34,500 vehicles per day and by 2040, 37,700 vehicles per day
- By 2030, traffic volumes on the project's southern section, north of McCaffrey Drive are forecast to grow to about 25,600 vehicles per day and by 2040, 28,100 vehicles per day
- Traffic volumes on the proposed hospital interchange are predicted to be about 8,600 vehicles per day in 2030. By 2040, traffic volumes are forecast to grow to about 9,500 vehicles per day.

Overall traffic volumes in the study area are predicted to increase by about one per cent per annum to 2040 and this would place increasing demands on the existing road network if no road improvements are carried out. The forecast increase in traffic volumes would lead to increased crash frequencies and decrease the level of service of the key transport routes in the study area, if current traffic arrangements are maintained.

5.3 Traffic impacts on the existing road network

A comparison of traffic volumes and changes to traffic patterns on existing roads in the study area has been carried out for current and future traffic conditions, both with and without the project and is presented in Table 5-2.

The key findings shown in Table 5-2 for 2020 conditions include:

- The project is expected to increase traffic on Charlestown Road south of Cardiff Road (ID1) by 3,900 vehicles per day (7 per cent) from about 55,500 vehicles per day (without the project) to about 59,400 vehicles per day (with the project)
- Similarly, the project is expected to increase traffic on Lookout Road south of McCaffrey (ID19), where the project joins Lookout Road, by 5,100 vehicles per day (10.5 per cent) from about 48,300 vehicles per day (without the project) to about 53,400 vehicles per day (with the project)
- The project is expected to reduce north-south and west-south through and regional traffic on the existing route of Lookout Road (north of McCaffrey Drive), Croudace Street and Newcastle Road (between Croudace Street and Newcastle Inner City Bypass). The project would reduce traffic on these roads by 25 to 45 per cent depending on location. This would substantially improve traffic flow along this route
- The project is expected to substantially reduce traffic on Lookout Road north of McCaffrey Drive, where the project joins Lookout Road (ID7) by 18,400 vehicles per day (35 per cent) from about 52,500 vehicles per day (without the project) to about 34,100 vehicles per day (with the project)
- The project is expected to reduce traffic on Croudace Street north of Elder Street (ID17) by about 18,800 vehicles per day (43 per cent) from about 43,900 vehicles per day (without the project) to about 25,100 vehicles per day (with the project)
- Traffic on Newcastle Road east of Newcastle Inner City Bypass (ID16) is expected to decrease due to the project by about 16,800 vehicles per day (25 per cent) from about 66,200 vehicles per day (without the project) to about 49,400 vehicles per day (with the project)
- The project is expected to reduce traffic on McCaffrey Drive (ID5) by 3,300 vehicles per day (17 per cent) from about 19,100 vehicles per day (without the project) to about 15,800 vehicles per day (with the project)
- The project is expected to increase traffic on the Newcastle Inner City Bypass north of Newcastle Road (ID11) by about 5,200 vehicles per day (12 per cent) from about 41,700 vehicles per day (without the project) to about 46,900 vehicles per day (with the project)
- The project is expected to reduce traffic on Newcastle Road east of Croudace Street (ID10) by about 3,800 vehicles per day (7 per cent) from 51,600 vehicles per day (without the project) to 47,800 vehicles per day (with the project)
- The project is expected to marginally reduce traffic on Dent Street north of Newcastle Road (ID13) by about 500 vehicles per day
- The project is expected to marginally increase traffic on Grandview Road west of Lookout Road (ID4) by about 200 vehicles per day
- The project is expected to marginally increase traffic on Carnley Avenue east of Lookout Road (ID2) by about 300 vehicles per day

- The proposed hospital interchange is expected to significantly reduce traffic on the existing John Hunter Hospital access (Kookaburra Circuit) (ID8) by about 7,700 vehicles per day (48 per cent) from 16,200 vehicles per day (without the project) to 8,500 vehicles per day (with the project).

Once constructed, the project would redistribute traffic in the study area and surrounding road network for north-south and south-west movements. Figure 5-1 to Figure 5-4 provide a comparison of traffic volumes for key locations in the study area, with and without the project for 2014, 2020, 2030 and 2040.

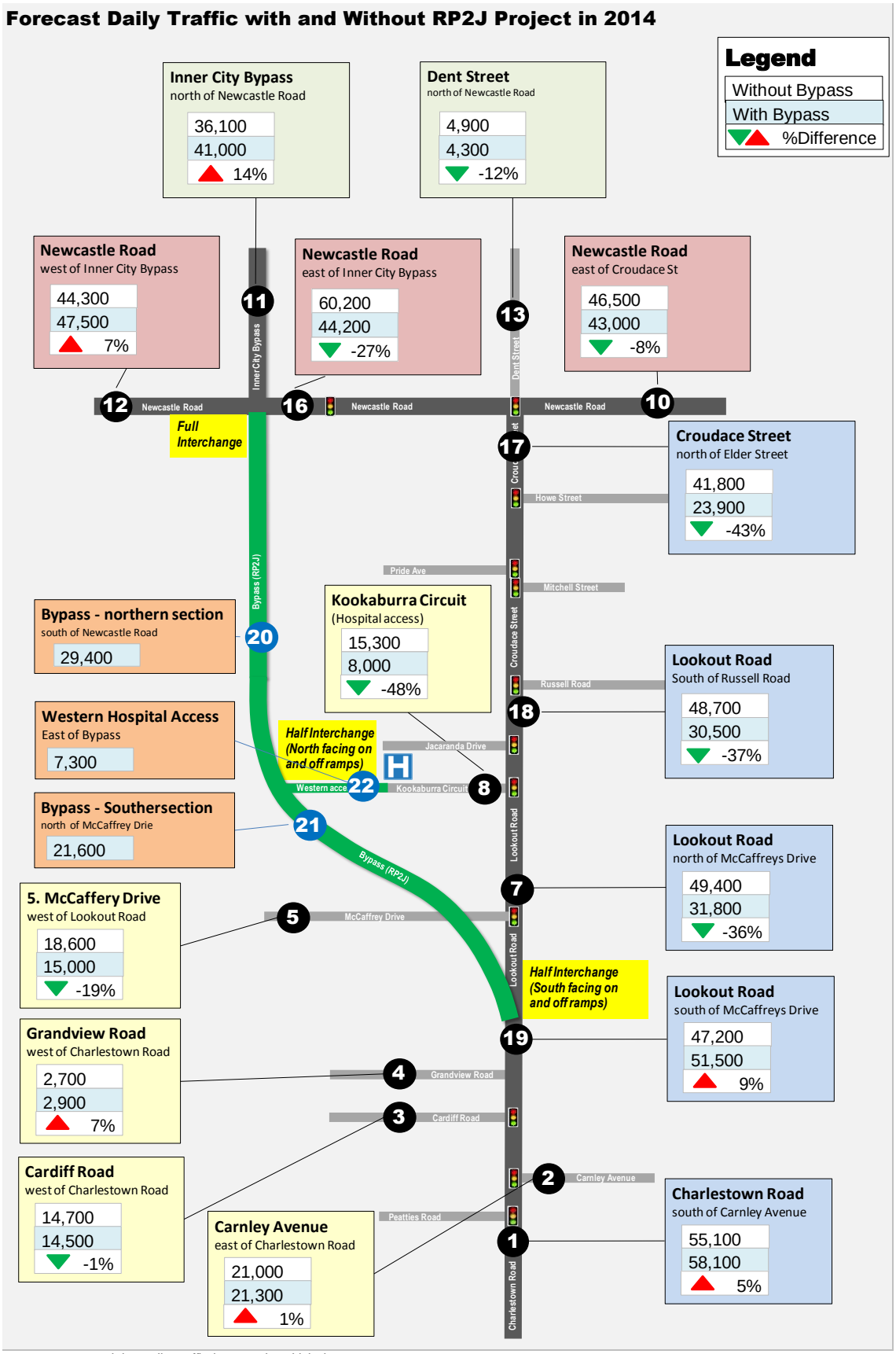
Table 5-2 Forecast daily volumes on key locations with the project

ID	Location	2014			2020			2030			2040		
		No project	With project	Change	No project	With project	Change	No project	With project	Change	No project	With project	Change
1	Charlestown Road, south of Cardiff Road	55,100	58,100	3,000	55,500	59,400	3,900	56,300	61,700	5,400	57,100	64,000	6,900
2	Carnley Avenue, east of Charlestown Road	21,000	21,300	300	21,100	21,400	300	21,400	21,600	200	21,700	21,900	200
3	Cardiff Road, west of Lookout Road	14,700	14,500	-200	15,100	14,700	-400	15,800	15,100	-700	16,600	15,500	-1,100
4	Grandview Road, west of Lookout Road	2,700	2,900	200	2,800	3,000	200	2,900	3,200	300	3,100	3,400	300
5	McCaffrey Drive, west of Lookout Road	18,600	15,000	-3,600	19,100	15,800	-3,300	20,000	17,000	-3,000	20,900	18,200	-2,700
6	Croudace Road, west of Grandview Road	19,900	16,100	-3,800	20,100	16,600	-3,500	20,600	17,500	-3,100	21,000	18,500	-2,500
7	Lookout Road, north of McCaffrey Drive	49,400	31,800	-17,600	52,500	34,100	-18,400	57,700	38,000	-19,700	63,100	42,300	-20,800
8	Kookaburra Circuit (John Hunter Hospital access)	15,300	8,000	-7,300	16,200	8,500	-7,700	17,900	9,300	-8,600	19,800	10,300	-9,500
9	Russell Road, east of Lookout Road	16,200	15,300	-900	17,600	16,800	-800	20,100	19,400	-700	22,600	21,900	-700
10	Newcastle Road, east of Croudace Street	46,500	43,000	-3,500	51,600	47,800	-3,800	60,100	055,900	-4,200	68,500	64,000	-4,500
11	Newcastle Inner City Bypass, north of Newcastle Road	36,100	41,000	4,900	41,700	46,900	5,200	51,000	56,800	5,800	60,300	66,900	6,600
12	Newcastle Road, west of Newcastle Inner City Bypass	44,300	47,500	3,200	48,200	51,600	3,400	54,700	58,500	3,800	61,200	65,300	4,100
13	Dent Street, north of Newcastle Road	4,900	4,300	-600	5,400	4,900	-500	6,300	5,900	-400	7,200	6,800	-400

ID	Location	2014			2020			2030			2040		
		No project	With project	Change	No project	With project	Change	No project	With project	Change	No project	With project	Change
14	Jacaranda Drive (John Hunter Hospital access)	2,700	2,700	0	2,700	2,700	0	2,800	2,800	0	2,900	2,900	0
15	Howe Street, east of Croudace Street	8,500	8,600	100	9,600	9,700	100	11,400	11,700	300	13,300	13,600	300
16	Newcastle Road, east of Newcastle Inner City Bypass	60,200	44,200	-16,000	66,200	49,400	-16,800	76,200	58,200	-18,000	86,200	67,100	-19,100
17	Croudace Street, north of Elder Street	41,800	23,900	-17,900	43,900	25,100	-18,800	47,300	27,100	-20,200	50,800	29,100	-21,700
18	Lookout Road, south of Russell Road	48,700	30,500	-18,200	51,500	32,500	-19,000	56,400	36,000	-20,400	61,300	39,500	-21,800
19	Lookout Road, south of McCaffrey Drive	47,200	51,500	4,300	48,300	53,400	5,100	50,200	56,600	6,400	52,200	59,800	7,600

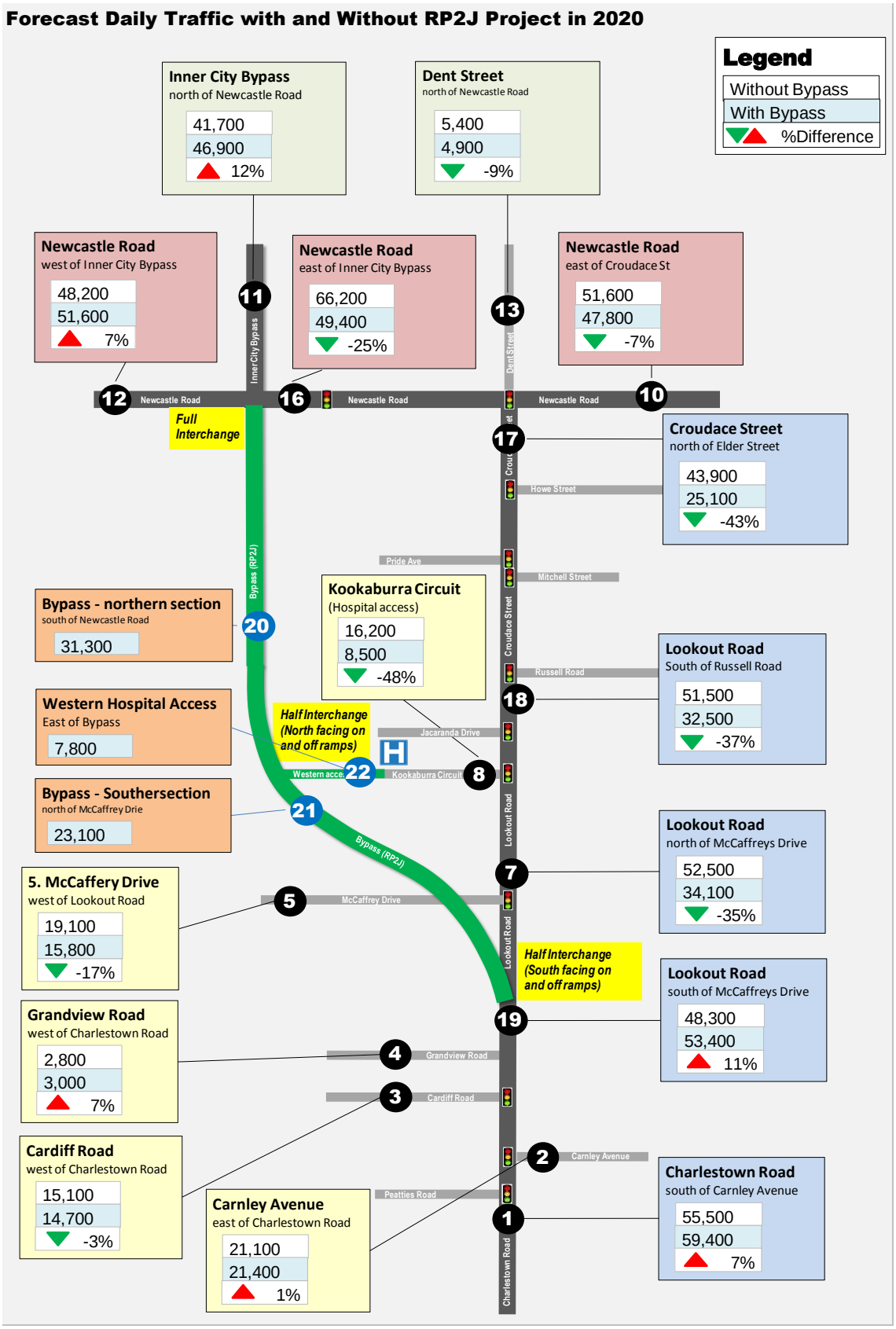
Note, Average Weekday Daily Traffic (two-way in vehicles).

Source: Lower Hunter Traffic Model (LHTM).



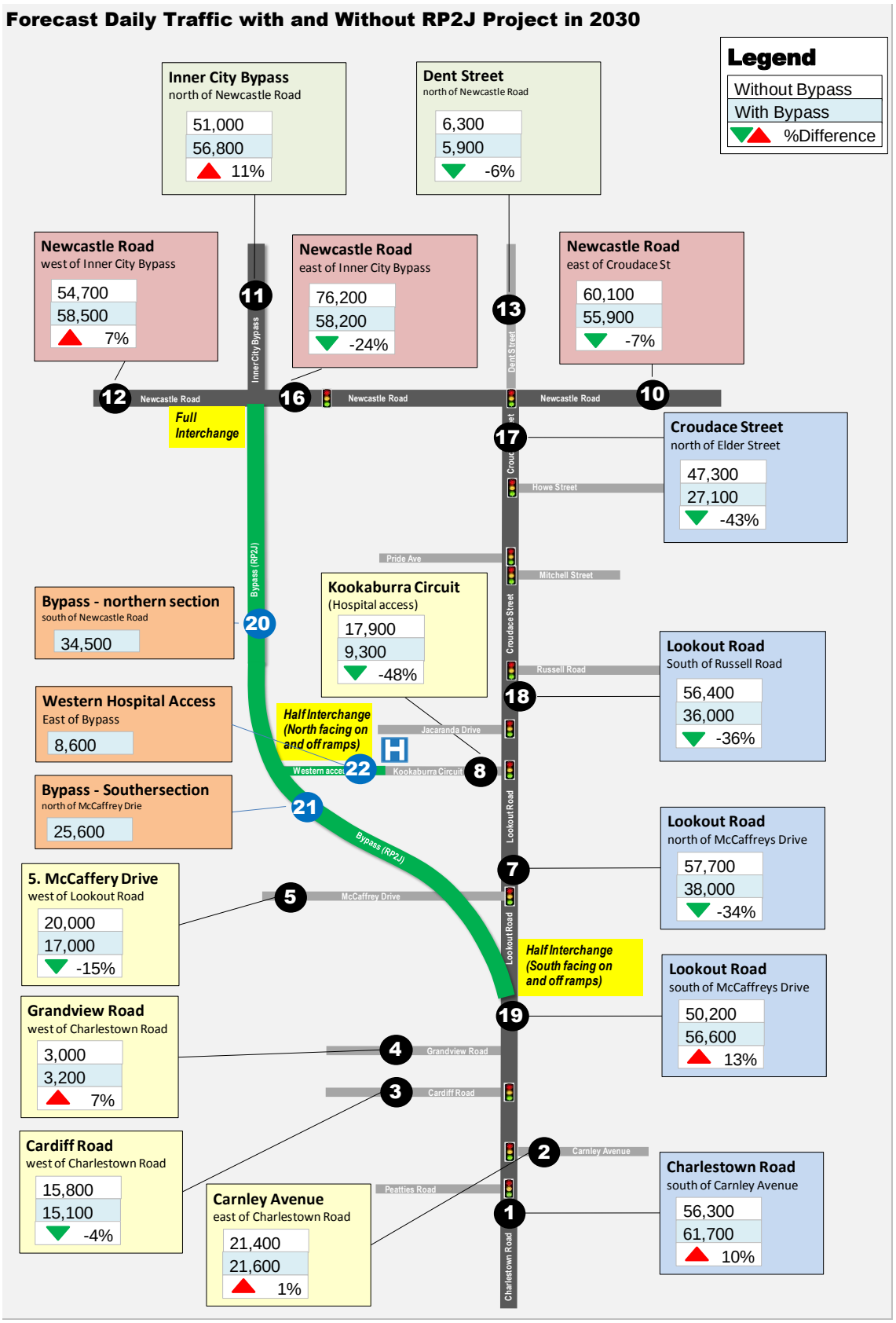
Note, Average Weekday Daily Traffic (two-way in vehicles).
Source: Lower Hunter Traffic Model (LHTM).

Figure 5-1 Forecast daily traffic with and without the project in 2014



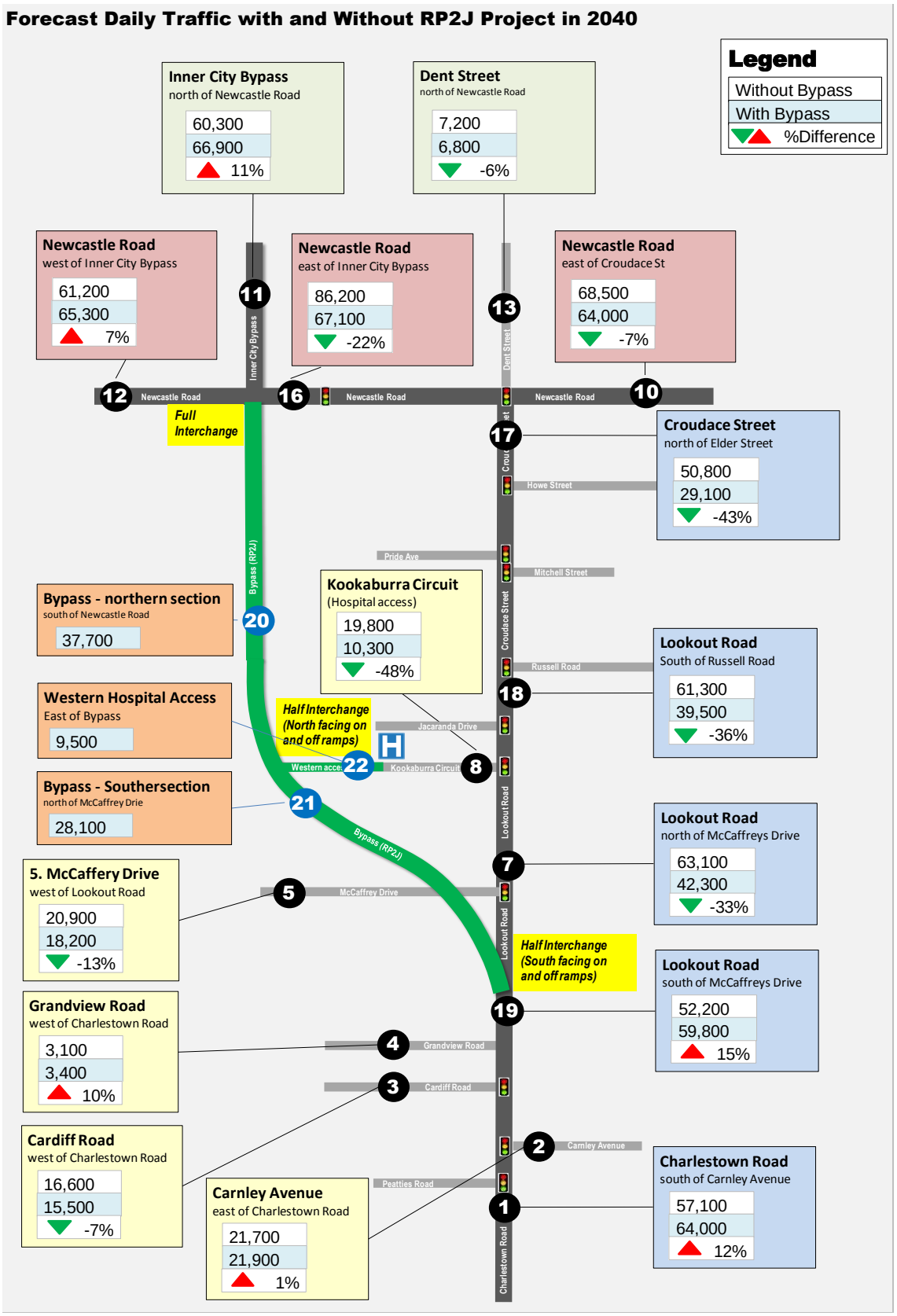
Note, Average Weekday Daily Traffic (two-way in vehicles).
Source: Lower Hunter Traffic Model (LHTM).

Figure 5-2 Forecast daily traffic with and without the project in 2020



Note, Average Weekday Daily Traffic (two-way in vehicles).
Source: Lower Hunter Traffic Model (LHTM).

Figure 5-3 Forecast daily traffic with and without the project in 2030



Note, Average Weekday Daily Traffic (two-way in vehicles).
Source: Lower Hunter Traffic Model (LHTM).

Figure 5-4 Forecast daily traffic with and without the project in 2040

5.4 Operational performance

5.4.1 Network statistics

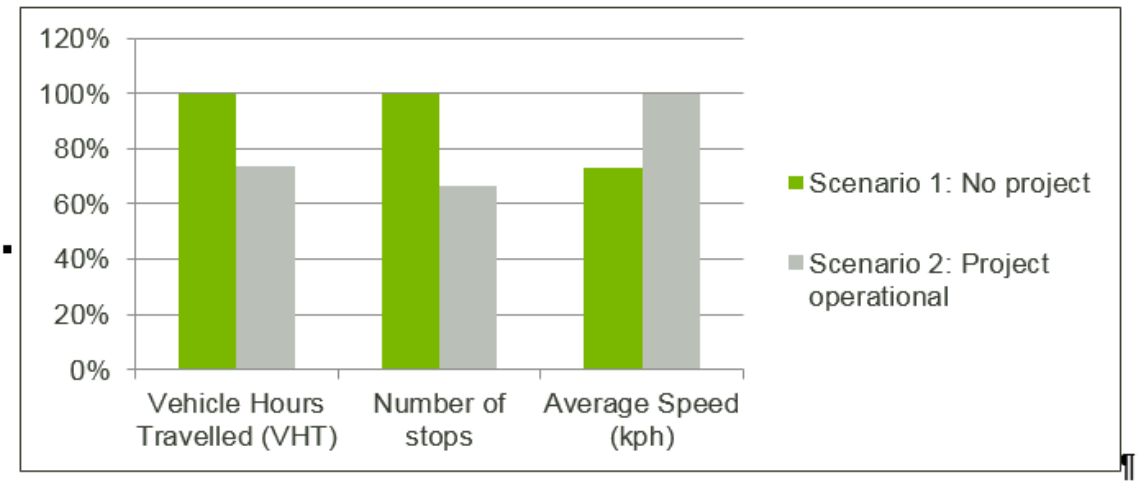
In assessing the network performance levels with and without the project, the following criteria were used based on outputs from the microsimulation traffic modelling described in Section 4:

- Vehicle kilometres travelled (VKT); measures the total distance travelled by all vehicles in the network during the modelled peak period
- Vehicle hours travelled (VHT); measures the total travel time of all vehicles on the network during the modelled peak period. VHT corresponds to the delay and congestion in a network and as such a lower VHT correlates to lower congestion
- Total number of stops; corresponds to congestion, delay and travel time and measures the total stops for all vehicles within the modelled peak period. It is used to calculate the additional vehicle operating costs associated with stopping and accelerating from rest. In an uncongested network, the number of stops is infrequent as higher proportions of vehicles travel at free flow with lower occurrences of stopping behind queued vehicles
- Average Network Speed; is recorded for all traffic in the network over the modelled period. It is calculated by dividing the VKT by the VHT. Average network speed correlates to congestion and delay, higher average network speeds are indicative of a network in which traffic is able to flow more readily.

Table 5-3 provides a summary of network statistics for the study area for the two-hour modelled morning (07:00am to 09:00am) and afternoon (16:00pm to 18:00pm) peak periods for 2020 and 2030 with and without the project. This data is compared graphically on Figure 5-5 to Figure 5-8.

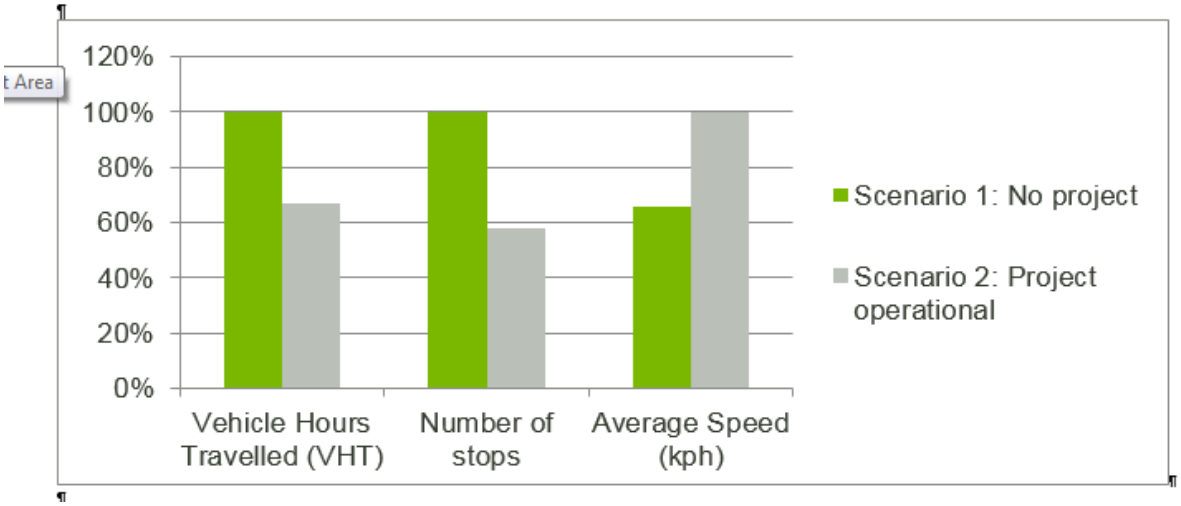
Table 5-3 Summary of peak network performance statistics for 2020 and 2030 with and without the project

Option	VHT	VKT	# of stops	Average speed (kph)
Morning period 2020				
1. No project	3,392	96,453	144,094	28.5
2. Project operational	2,505	97,950	95,991	39.1
Evening period 2020				
1. No project	4,041	105,812	183,175	26.2
2. Project operational	2,691	107,309	106,225	39.9
Morning period 2030				
1. No project	4,830	107,343	185,148	22.2
2. Project operational	3,016	109,157	108,918	36.2
Evening period 2030				
1. No project	6,072	119,195	228,058	19.6
2.				



Source: Aurecon 2016a

Figure 5-5 Network performance – Morning Peak 2020 with and without the project

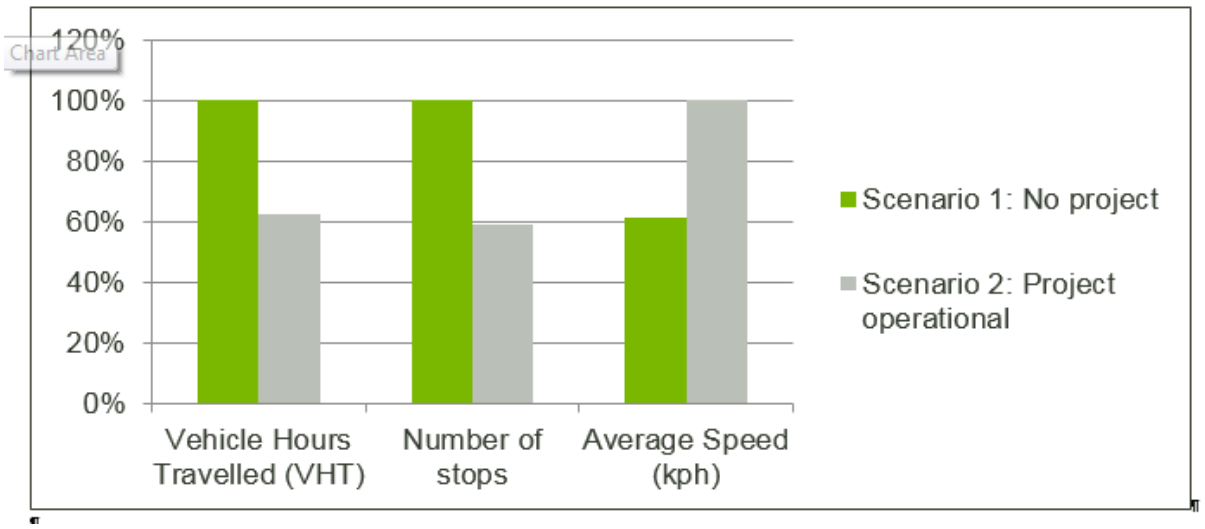


Source: Aurecon 2016a

Figure 5-6 Network performance – Afternoon Peak 2020 with and without the project

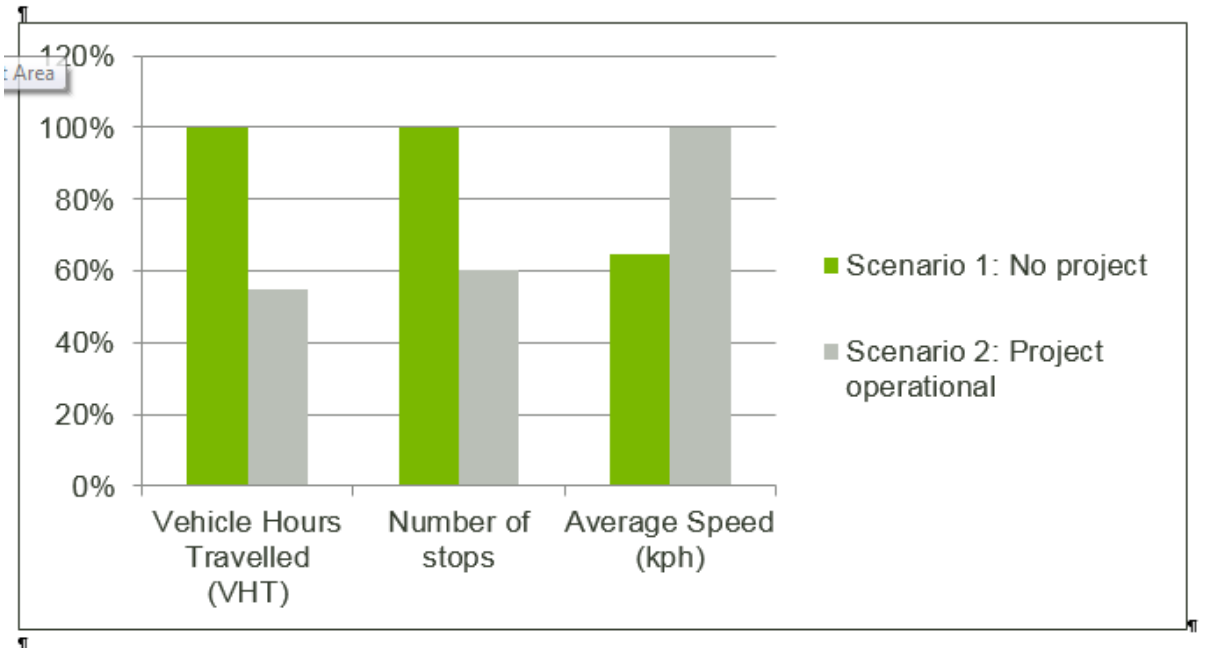
In reviewing the network performance data for 2020 the following conclusions can be derived:

- With the project, congestions levels are predicted to substantially improve with VHT reduced by about 26 per cent in the morning peak and 33 per cent in the afternoon peak
- Similarly, with the project the number of stops are reduced by about 33 per cent in the morning peak and 42 per cent in the afternoon peak
- Travel times are predicted to improve with the project with the average travel speed to increase by about 27 per cent in the morning peak and 34 per cent in the afternoon peak.



Source: Aurecon 2016a

Figure 5-7 Network performance – Morning Peak 2030 with and without the project



Source: Aurecon 2016a

Figure 5-8 Network performance – Afternoon Peak 2030 with and without the project

In reviewing the network performance data for 2030 the following conclusions can be derived:

- With the project, congestion levels are predicted to further reduce (relative to the No project scenario) with VHT reduced by about 38 per cent in the morning peak and 45 per cent in the afternoon peak

- Similarly, with the project the number of stops are reduced by about 41 per cent in the morning peak and 40 per cent in the afternoon peak
- Travel times are predicted to further improve (relative to the No project scenario) with average travel speed to increase by about 39 per cent in the morning peak and 35 per cent in the afternoon peak.

Overall, the project would provide major benefits to road users with substantial reductions in VHT, VKT, and number of stops, as well an increases in average travel speeds across the road network. The No project scenario would not alleviate the forecast congestion and traffic delays due to the predicted increases in VHT, VKT, and number of stops that the road network would face in future years.

5.4.2 Intersection performance

The traffic conditions on major roads and intersections can be quantified in terms of their operating level of service (LoS). Level of service is defined as a qualitative measure of features that include speed, travel time, traffic interruptions, freedom to manoeuvre, safety, driving comfort, convenience and operating costs.

The LoS for each intersection analysed (Aurecon 2016b) has been reported in accordance with the Roads and Maritime's guideline (Guide to Traffic Generating Developments, Issue 2.2, Roads and Traffic Authority, October 2002). Under these guidelines, the performance of an intersection is measured by the intersection average delay per vehicle. For roundabouts and sign-controlled intersections this is critical movement in the intersection with the highest delay and for signalised intersections this is the average intersection delay measured in seconds per vehicle.

LoS criteria are shown in Table 5-4. Table 5-5 shows a summary of LoS for key intersections in the study area which have been calculated for morning and evening peak periods for 2014, 2020 and 2030, with and without the project.

Detailed LoS data for each intersection, including traffic volumes and movements at each intersection and average delays is provided in Appendix B.

Table 5-4 Level of service criteria

Level of service	Average delay (seconds)	Traffic implication
A	<14	Good operation
B	15-28	Good operation with acceptable delays and spare capacity
C	29-42	Satisfactory operation
D	43-56	Operating near capacity
E	57-70	Operating at capacity
F	>70	Extra capacity required

Table 5-5 Intersection performance

Intersection	Level of Service (LoS)									
	2014 AM/PM Peak		2020 AM Peak		2020 PM Peak		2030 AM Peak		2030 PM Peak	
	No project AM	No project PM	No project	With project	No project	With project	No project	With project	No project	With project
University Interchange	B	A	E	B	C	A	F	E	E	C
Blue Gum Road/ Newcastle Road	B	C	B	B	C	B	C	C	B	B
Jesmond Roundabout / Northern Interchange	C	C	D	C	D	C	D	C	D	C
Croudace Street/ Dent Street/ Newcastle Road	D	F	E	D	F	C	E	D	F	D
Croudace Street/ Howe Street	B	B	B	B	B	B	B	B	D	B
Croudace Street/ Lookout Road/ Russell Road	B	E	B	B	D	B	B	B	F	C
Lookout Road/ John Hunter Hospital (Kookaburra Circuit)	C	B	C	B	B	B	C	B	B	B
John Hunter Hospital Interchange				A		A		A		A
Lookout Road/ McCaffrey Drive	D	B	D	B	C	B	E	B	C	B
Lookout Road/Grandview Road	A	A	A	A	A	A	B	A	A	A

Intersection	Level of Service (LoS)									
	2014 AM/PM Peak		2020 AM Peak		2020 PM Peak		2030 AM Peak		2030 PM Peak	
	No project AM	No project PM	No project	With project	No project	With project	No project	With project	No project	With project
Lookout Road/ Cardiff Road	C	B	D	D	D	D	E	C	D	E

Source: Aurecon 2016b

Table 5-5 shows that without the project, the performance at key intersections in the study area varies, with the intersections of Croudace Street / Newcastle Road and Lookout Road /Russell Road having the worst performance in the evening peak period. Other intersections generally function at good levels of service, although as shown in Table 5-5 a number of these intersections are predicted to have reduced performance under forecast traffic volumes. For example, the intersection of Lookout Road and McCaffrey Drive is predicted to reduce in performance from LoS E to F between 2020 and 2030.

Table 5-5 shows that under forecast traffic volumes, the project would generally improve intersection performance at key existing intersections in the study area for 2020 and 2030 scenarios in both the morning and afternoon peak periods. In particular, Table 5-5 shows:

- The project is expected to substantially improve the LoS at the following key intersections in 2020:
  - Croudace Street/Dent Street/Newcastle Road in the afternoon peak period from LoS F to LoS C
  - Croudace Street/Lookout Road/Russell Road in afternoon peak period from LoS E to LoS B
  - Lookout Road/McCaffrey Drive in morning peak from LoS E to LoS A
  - Lookout Road /John Hunter Hospital in the morning peak from LoS C to LoS B, with the proposed Hospital Interchange operating at LoS A in both peak periods.
- The project is expected to substantially improve the level of service at the following key intersections in 2030:
  - Croudace Street/Dent Street/Newcastle Road in the afternoon peak period from LoS F to LoS D
  - Croudace Street/Lookout Road/Russell Road in afternoon peak period from LoS F to LoS C
  - Lookout Road/McCaffrey Drive in morning peak from LoS F to LoS B
  - Lookout Road/Cardiff Road in the morning peak from LoS D to LoS C
  - Lookout Road/John Hunter Hospital in the morning peak from LoS C to LoS B, with the proposed Hospital Interchange operating at LoS A in both peak periods.

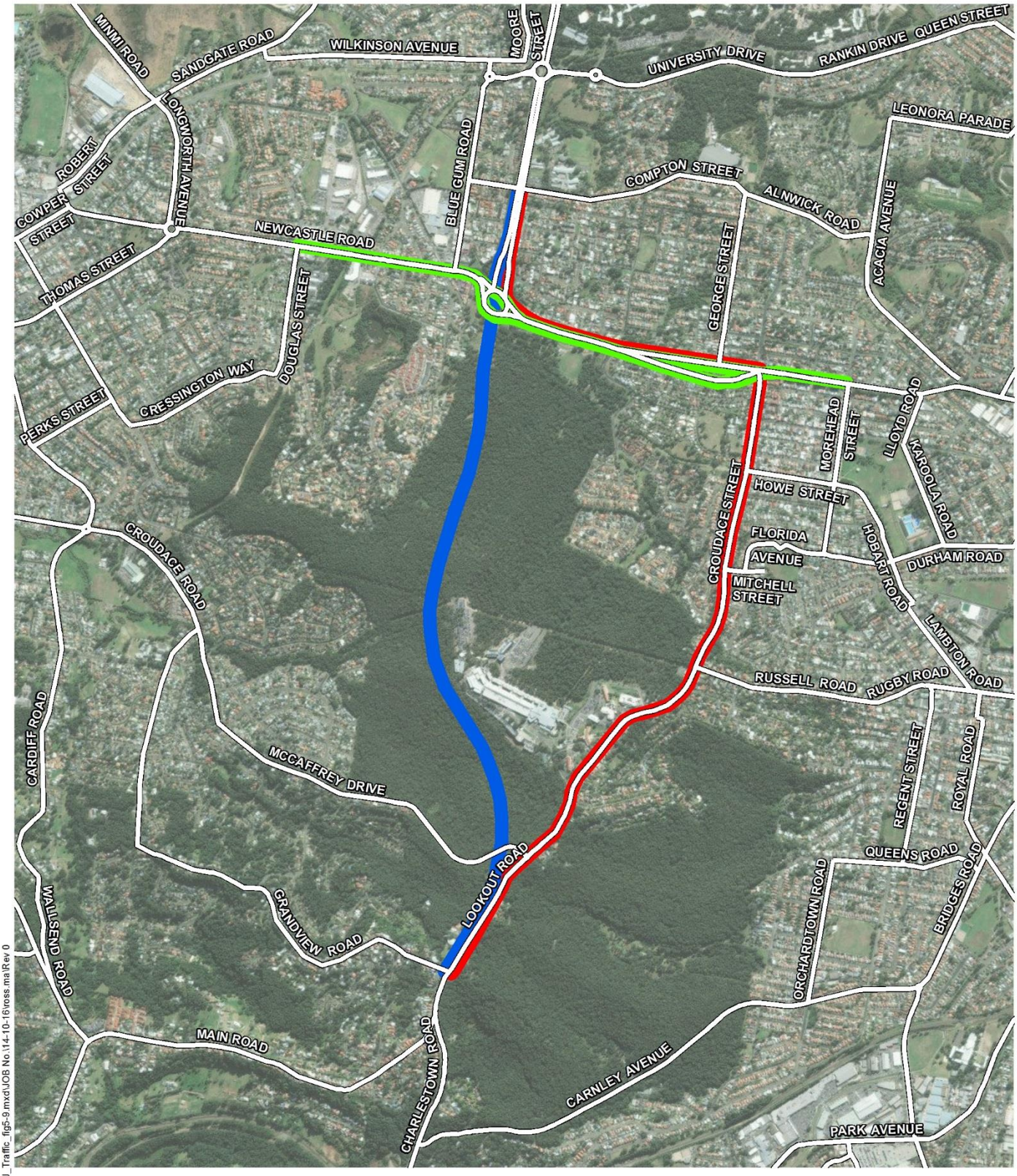
It is noted that as shown in Appendix B, the project caters for higher traffic volumes at the key intersections to the north, west and south of the project. As such the LoS comparison for No project and With project is considered conservative as there are additional benefits associated with the additional throughput of traffic with the project.

5.4.3 Travel times

Travel times for key routes in the study area, including the project, have been determined from the model for the following routes (refer to Figure 5-9):

- **Route A (Green)**: Newcastle Road from Douglas Street to Morehead Street
- **Route B (Red)**: Existing route from Lookout Road (north of Grandview Road), Croudace Street, Newcastle Road and Newcastle Inner City Bypass (north of Newcastle Road)
- **Route C (Blue)**: New route formed by the project, from Lookout Road north of Grandview Road to Newcastle Inner City Bypass (north of Newcastle Road).

For motorists wishing to travel between zones with two route choices, the project's Paramics traffic model takes into account both travel time and travel distance when calculating the most attractive route to take, with travel time weighted higher than travel distance. The concept is that a driver perceives each route to have a total cost based on its travel time and travel distance, and can therefore rank each route from most attractive to least attractive. The traffic modelling predicts all traffic would use the new route formed by the bypass (Route C) for trips between Lookout Road (north of Grandview) and the Newcastle Inner City Bypass (north of Newcastle Road).



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Legend

- Road and Street
- Route A - Newcastle Road - Douglas Street to Morehead Street
- Route B - Existing A37 Route
- Route C - The Project Route

Source: BingMaps, Aurecon

1:25,000

0 200 400m

Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 5-9: Travel time routes

Figure 5-10 to Figure 5-13 show the estimated travel times along these routes for the morning and afternoon peak periods in 2020 and 2030, with and without the project.

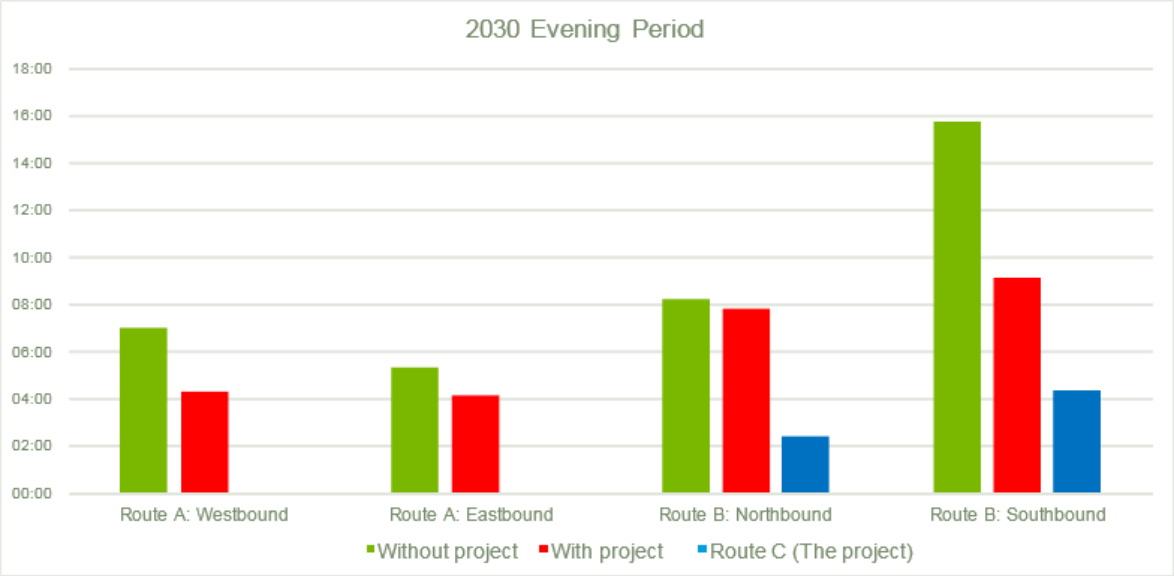


Figure 5-10 Morning peak period travel times 2020

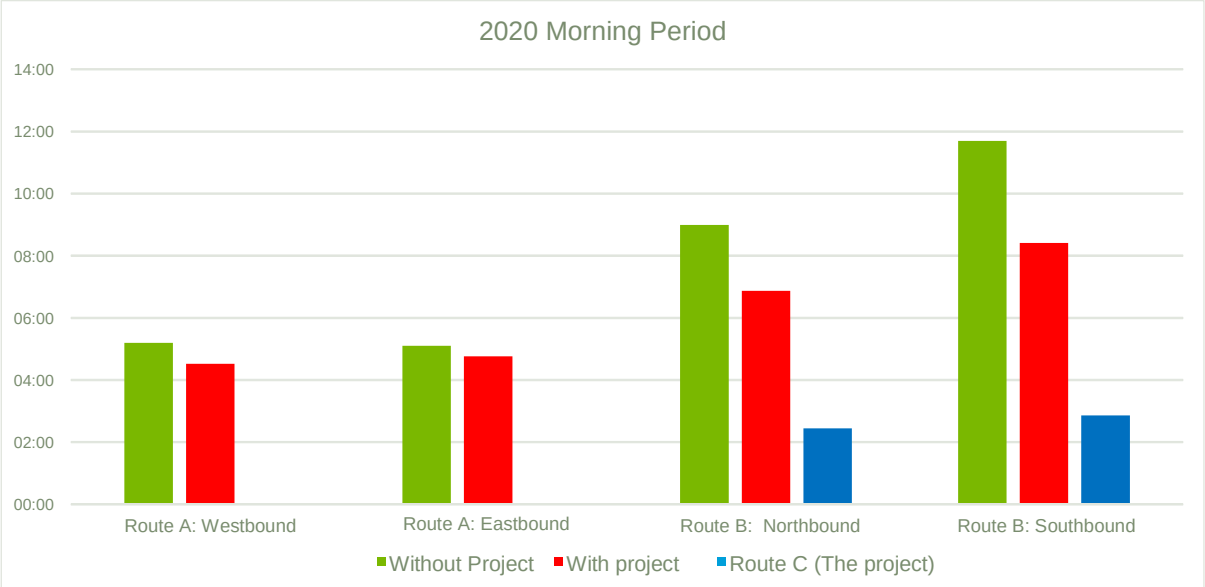


Figure 5-11 Evening peak period travel times 2020

In reviewing the travel time data for 2020 for the bypass route compared to the existing route (Without project scenario), the following conclusions can be derived:

- With the project, northbound travel times for the bypass route are predicted to reduce by about 73 per cent in the morning peak and 71 per cent in the afternoon peak
- With the project, southbound travel times for the bypass route are predicted to reduce by about 76 per cent in the morning peak and 80 per cent in the afternoon peak.

In addition, with the project travel times are also predicted to reduce for both north-south trips on the existing route and east-west trips on Newcastle Road (Douglas Street to Morehead Street).

- With the project, northbound travel times for the existing route are predicted to reduce by about 24 per cent in the morning peak and 12 per cent in the afternoon peak
- With the project, southbound travel times for the existing route are predicted to reduce by about 28 per cent in the morning peak and 48 per cent in the afternoon peak
- With the project, eastbound travel times for Newcastle Road are predicted to reduce by about 7 per cent in the morning peak and 25 per cent in the afternoon peak
- With the project, westbound travel times for the existing route are predicted to reduce by about 13 per cent in the morning peak and 33 per cent in the afternoon peak.

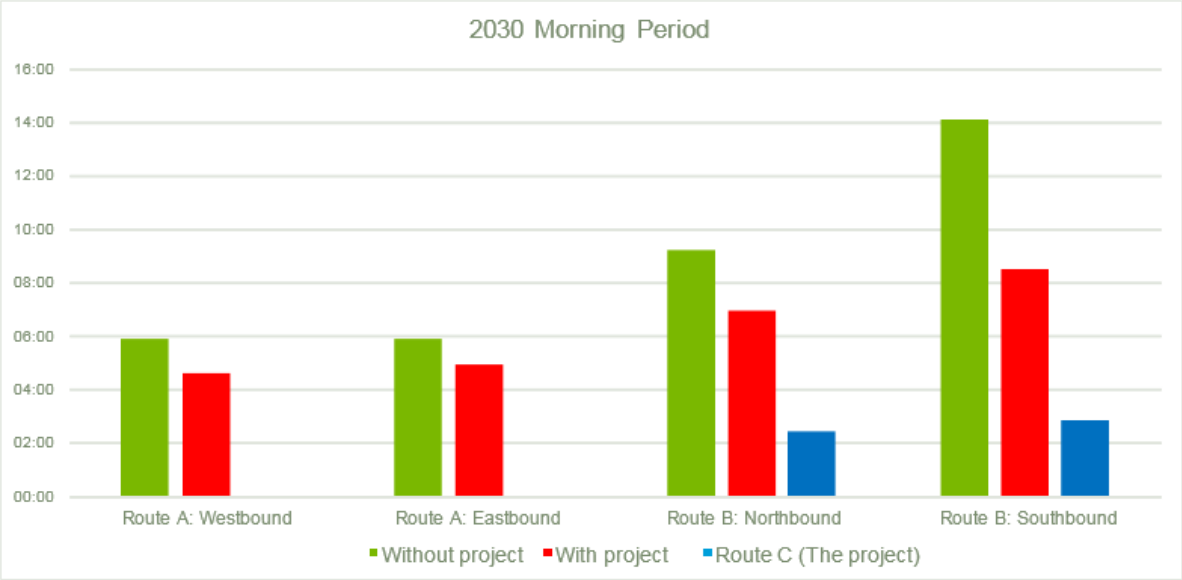


Figure 5-12 Morning peak period travel times 2030

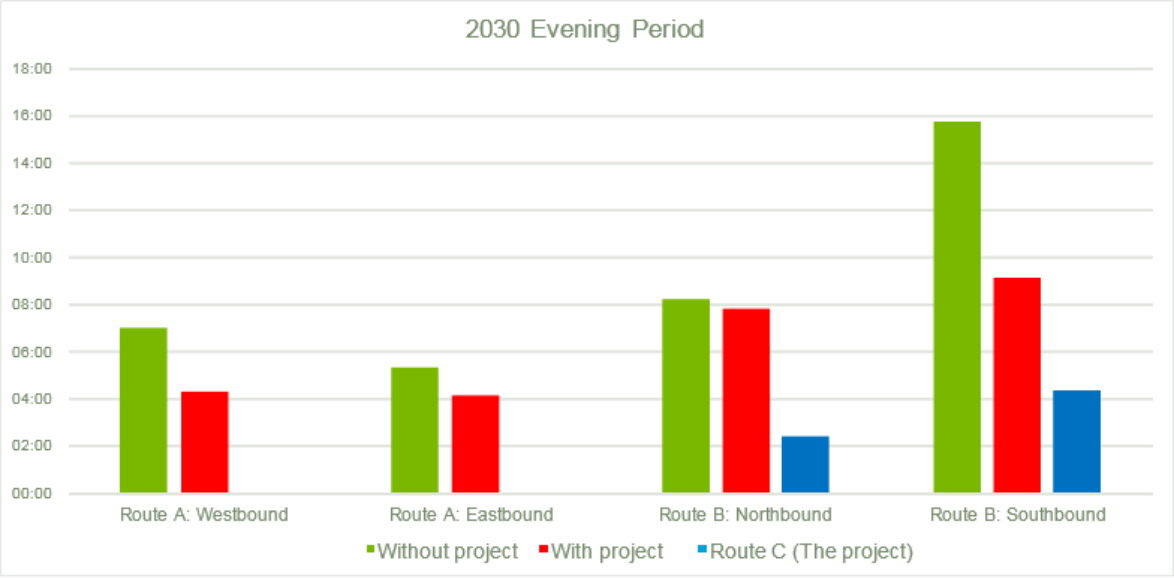


Figure 5-13 Evening peak period travel times 2030

In reviewing the travel time data for 2030 for the bypass route compared to the existing route (Without project scenario), the following conclusions can be derived:

- With the project, northbound travel times for the bypass route are predicted to reduce by about 74 per cent in the morning peak and 71 per cent in the afternoon peak
- With the project, southbound travel times for the bypass are predicted to reduce by about 80 per cent in the morning peak and 74 per cent in the afternoon peak.

In addition, with the project travel times are also predicted to reduce for both north-south trips on the existing route and east-west trips on Newcastle Road (Douglas Street to Morehead Street).

- With the project, northbound travel times for the existing route are predicted to reduce by about 25 per cent in the morning peak and 6 per cent in the afternoon peak
- With the project, southbound travel times for the existing route are predicted to reduce by about 40 per cent in the morning peak and 42 per cent in the afternoon peak
- With the project, eastbound travel times for Newcastle Road are predicted to reduce by about 16 per cent in the morning peak and 22 per cent in the afternoon peak
- With the project, westbound travel times for the existing route are predicted to reduce by about 22 per cent in the morning peak and 38 per cent in the afternoon peak.

In the southbound direction in the 2030 evening peak period, compared to 2020 the predicted travel times on both the existing route and on the bypass route reflect an increase in congestion in the southern sections of the road network due to capacity constraints including the Cardiff Road and Lookout Road intersection.

As part of the Roads and Maritime Inner Newcastle Traffic Study, further investigations are currently being carried out to determine the priorities for future upgrades to the south of the Rankin Park to Jesmond connection with Lookout Road. This study is investigating options to improve traffic flow on this section to the south of the project and other key parts of the inner Newcastle road network.

In reviewing the travel time data for 2020 and 2030, the following conclusions can be derived:

- The project is predicted to provide major benefits for motorists using the Newcastle Inner City Bypass with substantial improvements in traffic flow and travel time for both northbound and southbound journeys, relative to the Without project scenario
- The project is also predicted to improve travel times for north-south trips on the existing route and for east-west trips on Newcastle Road.

5.4.4 Summary of operational performance of the project

In summary, in reviewing the predicted operational performance of the project, the following conclusions can be derived:

- The project is predicted to provide major benefits for motorists using the Newcastle Inner City Bypass with substantial improvements in traffic flow and travel time for both northbound and southbound journeys, relative to the 'No project' scenario
- The project is also predicted to improve travel times for north-south trips on the existing route and for east-west trips on Newcastle Road
- The project is predicted to improve intersection performance at key existing intersections in the study area
- The project is predicted to provide strong economic benefits and high value for money with a benefit-cost ratio of 4.1.

As such, the concept design for the project meets the primary objectives for the project which are to:

- Reduce travel times and improve traffic flow on the Newcastle Inner City Bypass

- Provide traffic relief on key parts of the surrounding road network
- Provide continuity of the Newcastle Inner City Bypass between Bennetts Green and Sandgate.

5.5 Implications for existing traffic movements

5.5.1 Impacts on road safety

As discussed in Section 2.5, the existing route adjacent to the project is subject to a large number of crashes with 315 crashes recorded over a five year period from 2010 to 2014. This equates to about 63 crashes per year. This is reflective of the large number of intersections, variable road conditions and traffic congestion that occurs on these roads.

The project is expected to improve road safety on the existing route (Lookout Road, Croudace Street and Newcastle Road) as a result of reduction in traffic volumes and improved traffic flow. Traffic network performance modelling results indicate that congestion levels and number of stops are predicted to substantially reduce in the morning peak and afternoon peaks whilst travel times are also predicted to improve with increases in the average travel speeds in the morning and afternoon peaks.

Traffic modelling of the existing key intersections indicate improved levels of service (LoS) which is a qualitative measure of features that include speed, travel time, traffic interruptions, freedom to manoeuvre, safety, driving comfort, convenience and operating costs.

The road safety analysis for the project assessed the following key road safety improvements in the study area:

- On the existing route, as rear-end, multi-vehicle crashes are the most common type of crash occurring along the existing route and the frequency of these crashes increases during periods of traffic congestion, the reduction in congestion with the project that occurs along the existing route is anticipated to result in a substantial reduction in rear-end type crashes.
- At the southern interchange, improvements to the existing intersection of McCaffrey Drive and Lookout Road is anticipated to result in a reduction in the number of crashes at this intersection, due to improved traffic flow.
- At the northern interchange, replacement of the existing roundabout at Jesmond with a traffic light controlled intersection is also anticipated to result in a reduction in accidents on Newcastle Road, due to improved management of traffic and improved traffic flow.
- The existing mid-block signalised pedestrian crossing of Newcastle Road located about 300 metres to the east of the existing Jesmond Roundabout would be replaced with a shared path bridge over Newcastle Road. This would improve traffic flows on Newcastle Road and road safety at this intersection as it would require less stopping, give-way and merging movements.

An assessment has been carried out to forecast the potential reduction in crashes resulting from the operation of the project. The assessment included analysis of the existing route and the main project alignment.

The assessment analysed the existing route in two parts:

- Existing route where no new work would be carried out for the project:
  - Lookout Road and Croudace Street: from 200 metres south of McCaffrey Drive (excluding McCaffrey Drive intersection) through to Newcastle Road
  - Newcastle Road: from Croudace Street to 90 metres west of Steel Street (location of existing mid-block signalised pedestrian crossing).
- Existing route where new work would be carried out for the project:
  - McCaffrey Drive intersection with Lookout Road
  - Jesmond Roundabout on Newcastle Road

- Mid-block signalised pedestrian crossing on Newcastle Road, west of Steel Street.

The assessment then examined the potential for additional crashes on the main project alignment and summarised the findings of the overall reduction in predicted crashes.

Existing route sections

The assessment for the predicted reduction in crashes along the existing route with the project is based on traffic volumes and crash rates, with reference to Austroads and Transport for NSW (TfNSW) guidelines.

Table 5-6 summarises the crash data, discussed in Section 2.5, for the existing route of Lookout Road, Croudace Street and Newcastle Road over a five year period, between 2010 and 2014.

Table 5-6 Existing crash numbers on Lookout Road/Croudace Street and Newcastle Road 2010-2014

Location	Fatalities	Injury crashes	Non-casualty crashes	Total
Lookout Road /Croudace Street	0	77	81	158
Newcastle Road	0	41	51	92
Totals	**0**	**118**	**132**	**250**

These crash numbers, together with the traffic volumes were used to calculate the number of crashes per 100 million VKT. Table 5-7 shows the current injury Crash Rate (CR) for these existing sections. Note, as there were no fatalities on the existing route, only Injury and Non-casualty crash numbers were used for comparative purposes.

Table 5-7 Current injury crash rates – Lookout Road/Croudace Street and Newcastle Road

Item	Lookout Road / Croudace Street	Newcastle Road
Length (km)	2.5	1.1
Carriageway	Single	Divided
Surface	Asphaltic concrete	Asphaltic concrete
Existing traffic volumes (weekday daily , 2014)	48,700	60,200
Expansion factor to yearly traffic	300	300
Period of analysis (years)	5	5
Average VKT (5 years)	182,625,000	99,330,000
Injury crashes (5 years, from records)	77	41
Injury CR (per 100 million VKT)	**42**	**41**

Traffic volumes on Newcastle Road and Lookout Road are expected to increase in the coming years prior to opening of the project. Between 2014 and 2020 Lookout Road volumes are predicted to increase from 48,700 to 51,500 vehicles per day and on Newcastle Road volumes are predicted to increase from 60,200 to 66,200 vehicles per day for the same period. In 2020, following completion of the project, weekday traffic volumes are predicted to drop to 32,500 for Lookout Road and 49,400 for Newcastle Road.

Table 5-8 below shows the predicted reduction in Injury Crashes based on the current Injury Crash Rates and the predicted reduction in traffic volumes.

Table 5-8 Predicted reduction in injury crashes – Lookout Road/Croudace Street and Newcastle Road

Item	Lookout Road / Croudace Street	Newcastle Road
Injury Crash Rate	42	41

Item	Lookout Road / Croudace Street	Newcastle Road
2020 volumes – without the project (weekday daily)	51,500	66,200
Number of Injury Crashes (5 year period) without the project	**81**	**45**
2020 volumes – with RP2J (weekday daily)	32,500	49,400
Number of Injury Crashes (5 year period) with the project	**51**	**34**
Reduction in number of Injury Crashes	**30**	**11**

Similarly, for non-casualty crashes, Table 5-9 below shows the current non-casualty Crash Rate (CR) for the existing sections of Newcastle Road and Lookout Road between 2010 and 2014.

Table 5-9 Current non-causality crash rates – Lookout Road/Croudace Street and Newcastle Road

Item	Lookout Road / Croudace Street	Newcastle Road
Length (km)	2.5	1.1
Carriageway	Single	Divided
Surface	Asphaltic concrete	Asphaltic concrete
Existing traffic volumes (weekday daily , 2014)	48,700	60,200
Expansion factor to yearly traffic	300	300
Period of analysis (years)	5	5
Average VKT (5 years)	182,625,000	99,330,000
Non-casualty crashes (5 years, from records)	81	51
Non-casualty CR (per 100 million VKT)	**44**	**51**

Table 5-10 below shows the predicted reduction in non-casualty crashes based on the current crash rate and the predicted reduction in traffic volumes.

Table 5-10 Predicted reduction in non-casualty crashes – Lookout Road/Croudace Street and Newcastle Road

Item	Lookout Road/Croudace Street	Newcastle Road
Non-casualty Crash Rate	44	51
2020 volumes – without the project (weekday daily)	51,500	66,200
Number of Non-casualty Crashes (5 year period) without the project	**86**	**56**
2020 volumes – with RP2J (weekday daily)	32,500	49,400
Number of Non-casualty Crashes (5 year period) with the project	**54**	**42**
Reduction in number of Non-casualty Crashes	**32**	**14**

Existing route sections with new works

To predict reduction in crashes at intersections or sections of road with new works, reference has been made to the TfNSW Centre for Road Safety's publication *Calculating safety outcomes for road projects* (2012). This document provides guidelines to predict reductions in crashes that may be achieved through construction of road safety measures. For example, the related Crash Treatment Reduction Rates Matrix suggests that a 50 per cent reduction in wet weather crashes may be achieved by an "Upgrade seal to high level non-skid surface" treatment. This matrix, together with consideration of predicted change in traffic volumes and LoS traffic modelling results were used to assess overall crash reduction rates anticipated for the areas of new work as described below.

McCaffrey Drive / Lookout Road intersection

Table 5-11 shows a summary of the crashes at the intersection of McCaffrey Drive and Lookout Road between 2010 and 2014. The predominant crash type at this intersection are rear end accidents, along with various other types of accidents including turning and lane change accidents.

Table 5-11 Existing crash numbers McCaffrey Drive intersection between 2010 and 2014

Crash type	Injury crash	Non-casualty crash
Rear end	9	12
Right through	1	1
Lane change	1	1
Other	1	3
Total	**12**	**17**

The proposed upgrades for the intersection include installation of high friction pavement, a raised median at the intersection approach along with introduction of an additional right turn lane and improved signage and line marking. Traffic modelling shows that following completion of the project, the intersection would improve from LoS D to LoS A (as shown in Table 5-5) and result in a substantial reduction in congestion on all approaches to the intersection. This reduction in congestion and related queuing is likely to result in a substantial reduction in rear end crashes on the approaches to the intersection. For the purposes of quantifying these, it has been assessed that in the vicinity of the intersection these type of crashes would reduce by 32 per cent.

Table 5-12 Predicted reduction in crashes at McCaffrey Drive and Lookout Road intersection

Crash type	Injury crash	Non-casualty crash
Reduction	3	4

Jesmond Roundabout

Table 5-13 shows a summary of the crashes at the Jesmond Roundabout between 2010 and 2014. The predominant crash type at this roundabout are rear end, right-through and cross traffic crashes.

Table 5-13 Jesmond Roundabout intersection crashes between 2010 and 2014

Crash type	Injury crash	Non-casualty crash
Rear end	3	5
Right through	2	4
Cross traffic	1	1
Other	1	3
Total	**7**	**13**

The proposed replacement of the existing Jesmond Roundabout with a large multi-lane traffic light controlled intersection (as part of the Northern Interchange) includes installation of high friction pavement, and improved signage and line marking. Traffic modelling shows that following completion of the project, the intersection performance would improve from LoS D to LoS C (as shown in Table 5-5) and result in reduced congestion on all approaches to the intersection. This reduction in congestion and queuing, and improved management of traffic, is likely to result in a reduction in crashes at the intersection. For the purposes of quantifying these, it has been assessed that in the vicinity of the intersection these type of crashes would reduce by 10 per cent.

Table 5-14 Predicted reduction in crashes at Jesmond Roundabout (5 year period)

Crash type	Injury crash	Non-casualty crash
Reduction	1	1

Mid-block signalised pedestrian crossing on Newcastle Road, west of Steel Street

Table 5-15 shows a summary of the crashes at the mid-block pedestrian crossing on Newcastle Road, west of Steel Street between 2010 and 2014. The predominant crash type in the vicinity of this signalised are rear end and pedestrian crashes.

Table 5-15 Existing crash numbers Newcastle Road near Steel Street between 2010 and 2014

Crash type	Injury crash	Non-casualty crash
Rear end	1	10
Pedestrian	2	0
Other	1	2
Total	**4**	**12**

Following completion of the project, the existing crossing would be replaced with a shared path bridge over Newcastle Road, resulting in a substantial reduction in rear end crashes and pedestrian crashes. For the purposes of quantifying this, it is assumed that in the vicinity of the intersection these type of crashes would reduce by 50 per cent.

Table 5-16 Predicted reduction in crashes Newcastle Road near Steel Street (5 year period)

Crash type	Injury crash	Non-casualty crash
Reduction	2	6

Crashes on the main project alignment

An assessment of the potential number of crashes on the new main project alignment, has been carried out. It has been based on crash data and traffic volumes from the existing Jesmond to Shortland section of the Newcastle Inner City Bypass that has a very similar roadway configuration and road environment as the project. The data has been used to calculate the crash rate and apply it to the project based on the forecast traffic volumes.

Table 5-17 shows the crash data for the existing Jesmond to Shortland section of the Newcastle Inner City Bypass, between Janet Street overpass and Sandgate Road exit between 2010 and 2014.

Table 5-17 Crash numbers on Newcastle Inner City Bypass: Jesmond to Shortland 2010-2014

Location	Fatalities	Injury crashes	Non-casualty crashes	Total
Newcastle Inner City Bypass, between Janet Street overpass and Sandgate Road exit.	0	3	7	10

Based on the average weekday daily traffic of 36,100 vehicles, Table 5-18 and Table 5-19 below show the injury and non-casualty crash rates respectively.

Table 5-18 Injury crash rate on existing section of the bypass

Existing section of the bypass north of Janet Street overpass and Sandgate Road exit	
Average weekday daily traffic (2014)	36,100
Section length (km)	2.5
Expansion factor to yearly	300
Period of prediction (years)	5
Average VKT (5 years)	135,375,000
Injury crashes (5 year period)	3
Injury CR (per 100 million VKT)	**2.2**

Table 5-19 below shows the non-casualty crashes for the existing Jesmond to Shortland section of the Newcastle Inner City Bypass, between Janet Street overpass and Sandgate Road exit.

Table 5-19 Non-casualty crash rate on existing section of the bypass

Existing section of the bypass north of Janet Street overpass and Sandgate Road exit	
Average weekday daily traffic (2014)	36,100
Section length (km)	2.5
Expansion factor to yearly	300
Period of prediction (years)	5
Average VKT (5 years)	135,375,000
Non-casualty crashes (5 year period)	7
Non-casualty CR (per 100 million VKT)	**5.2**

It is predicted that the project would have a similar crash rate to existing Jesmond to Shortland section. Based on traffic modelling numbers for the two new sections of the project north and south of the John Hunter Hospital, Table 5-20 and Table 5-21 below show the predicted Injury and non-casualty crash numbers for the main project alignment respectively.

Table 5-20 Predicted main project alignment Injury Crashes

Predicted Injury crashes for the project (2020)	
North of John Hunter Hospital (JHH) average weekday daily traffic	31,300
South of JHH average weekday daily traffic	23,100
North of JHH section length (km)	1.2
South of JHH section length (km)	1.8
Expansion factor to yearly traffic	300
Period of prediction (years)	5
North of JHH average VKT (5 years)	56,340,000
South of JHH average VKT (5 years)	62,370,000
Injury CR (per 100 million VKT)	2.2
Injury crashes (5 year period)	**3**

Table 5-21 Predicted main project alignment Non-casualty crashes

Predicted Non-casualty crashes for the project (2020)	
North of JHH average weekday daily traffic	31,300
South of JHH average weekday daily traffic	23,100
North of JHH section length (km)	1.2
South of JHH section length (km)	1.8
Expansion factor to yearly	300
Period of prediction (years)	5
North of JHH average VKT (5 years)	56,340,000
South of JHH average VKT (5 years)	62,370,000
Non-casualty CR (per 100 million VKT)	5.2
Non-casualty crashes (5 year period)	**6**

Summary

Based on the existing and predicted crash numbers discussed above, there is an overall reduction of predicted crashes on the existing route that is offset by an increase (new) crashes on the main project alignment.

Table 5-22 summarises the changes in crashes that are expected to occur from the project showing a positive reduction in injury and non-casualty crashes. As shown, the road safety analysis predicts that the project would reduce annual crash rates in the study area by about 20 crashes per year (95 crashes over a 5 year period). This represents a predicted 32 per cent reduction in crashes with the project.

Table 5-22 Predicted net change in crashes (5 year period)

Crash type	Existing route (no new works) - Lookout Road and Newcastle Road	Existing route with new works (McCaffrey, Jesmond and mid-block pedestrian crossing)	Main project alignment (new crashes)	Total predicted change in crashes with the project
Injury crashes	- 41	- 6	3	**-44**
Non-casualty crashes	- 46	- 11	6	**-51**

5.5.2 Southern interchange

The project would construct a new half-interchange with Lookout Road. The key features of this interchange would include:

- A two-lane bridge on Lookout Road that would take northbound traffic over the main project alignment and connect to the existing traffic lights at McCaffrey Drive. This would occur via a two-lane off ramp from the northbound lanes of the project, so that traffic proceeding north on Lookout Road can continue unimpeded to the McCaffrey Drive intersection
- Traffic travelling south on Lookout Road would continue to use the existing two southbound lanes and connect with the two southbound lanes from the bypass, north of Grandview Road
- Southbound traffic arrangements on Lookout Road would remain essentially the same, with the addition of traffic lights to assist with the connection with southbound bypass traffic. This would allow traffic to safely connect at this location and safely access right turn lanes at both Grandview Road and Cardiff Road
- All existing traffic movements would be maintained at and in the vicinity of the southern interchange.

To the south of the southern interchange:

- Existing connections to and from Grandview Road would be retained
- Existing connections to and from Blackbutt Reserve would be retained
- Existing left-in and left-out movements for a group of five residences on the eastern side of Lookout Road would be maintained. The existing service road would be upgraded from gravel to pavement. A second access point at the southern end of the gravel service road would be closed for road safety reasons and users of this driveway would be required to use another existing driveway located about 60 metres to the east. This is discussed further in Section 5.7.1
- Existing left-in and left-out movements for two residences on the western side of Lookout Road would be maintained. The two driveways servicing these two residences would also require adjustment to allow for the widened road corridor. This is discussed further in Section 5.7.1.

The southern interchange would retain all current traffic movements and therefore no impacts are expected to occur for travellers using Lookout Road or the project.

5.5.3 Hospital interchange

The project would construct a new half-interchange providing access to the western side of John Hunter Hospital. This interchange would cater for access to and from the north for use by all hospital users including public, staff and emergency services.

The key features of this interchange would include:

- Access to/from the north which includes a southbound off-ramp to exit the bypass to the hospital and a northbound on-ramp with a reverse loop to exit the hospital to enter the bypass
- Motorists from the north would use the proposed new western connection off the bypass to get to the hospital which would reduce travel time and distance
- Motorists from the south would continue using the existing hospital access off Lookout Road at Kookaburra Circuit which would be a more direct route
- A bridge over the bypass would include a shared path for pedestrians and cyclists, providing a connection between the hospital and residential areas to the west.

The Hospital interchange is located less than one kilometre from the northern interchange and the on- and off-ramps have been designed to minimise issues with traffic merging from two interchanges in close proximity. The northbound on-ramp has been designed to move its merge point as far south as possible via a reverse loop to maximise the distance between on and off-ramps. A third southbound lane has been added by extending the southbound on-ramp from the northern interchange past the southbound off-ramp at the hospital interchange. This would alleviate issues with traffic being required to merge at two locations in close proximity. The southbound off-ramp has also been moved as far as possible to the south to address this issue.

As discussed in Sections 5.3 and 5.4.2, the provision of a new western access road to the hospital precinct would benefit the hospital's operation as it would reduce traffic volumes at the existing hospital accesses off Lookout Road. A rearrangement of car-parking spaces in the carpark near the hospital interchange may be required as part of any upgrade of the hospital's road network, to connect with the new access road that would be built for the project. This is not expected to result in a net loss of overall car parks within the hospital precinct. NSW Health Infrastructure would carry out any required road works within the hospital internal road system to accommodate traffic movements to and from the interchange.

Roads and Maritime have carried out extensive consultation with John Hunter Hospital (NSW Health Infrastructure and Hunter New England Local Health District) regarding the project. NSW Health Infrastructure would carry out road works within the hospital internal road system and car parking areas as required to accommodate traffic movements to and from the new western access.

Based on the options assessment process for the project it was determined that the option of developing the hospital as a half-interchange provided the best value for money, with major benefits for the surrounding road network. This is described further in Section 4 of the EIS.

5.5.4 Northern interchange

The project would result in changes to the existing intersection of Newcastle Road and the Newcastle Inner City Bypass: Shortland to Sandgate (the northern interchange) to include the project. This interchange would be upgraded to be a single point signalised interchange.

The key features of this interchange would include:

- Replacement of the existing Jesmond Roundabout with a grade separated interchange including a bridge over Newcastle Road for northbound and southbound movements on the Newcastle Inner City Bypass

- Intersection below the Newcastle Inner City Bypass to the east on Newcastle Road controlled by traffic lights to regulate traffic movements along, on and off Newcastle Road. Turn-lanes would be provided to enter and exit the bypass in all directions
- Newcastle Road would be upgraded through the interchange to three lanes in each direction
- Modification of the shared path through Jesmond Park where it crosses the new section of the bypass. New sections of shared path would be constructed to provide access to signalised pedestrian crossings across the southbound on-ramp from Newcastle Road to the bypass and the northbound off-ramp from the bypass to Newcastle Road. The path would continue to the west travelling underneath the bypass where it bridges over Newcastle Road and connect into the existing path at the intersection of Newcastle Road and Blue Gum Road
- Replacement of the existing mid-block traffic controlled pedestrian crossing on Newcastle Road, to the east of Hill Street, with a new shared path bridge over Newcastle Road to the west of Steel Street. The shared path bridge would be linked to the existing off-road facilities on either side of Newcastle Road.

Construction of the northern interchange would require the removal of a short section of bus lane located on Newcastle Road at its intersection with Blue Gum Road, Jesmond. This is not expected to cause delays for bus services as the Blue Gum Road intersection is predicted to function at a higher level of service during operation of the project (refer to Section 5.4.2). Further details of impacts to bus services are provided in Section 5.6.2.

Construction of the northern interchange would require adjustments to be made to four driveways on Newcastle Road. This is discussed further in Section 5.7.1.

The interchange would allow more efficient movements of traffic on Newcastle Road and the Newcastle Inner City Bypass at this location and therefore would provide benefits for road users at this location.

5.5.5 McCaffrey Drive / Lookout Road Intersection

The project would include upgrades for the existing intersection of McCaffrey Drive and Lookout Road to improve traffic flow.

Key features of the intersection upgrade include:

- Provision of a second right turn lane out of McCaffrey Drive
- Extension of the right and left turn lanes on McCaffrey Drive to Lookout Road
- Extension of then left turn merge lane out of McCaffrey Drive onto Lookout Road
- All other existing traffic movements retained at the McCaffrey Drive and Lookout Road intersection.

As described in Section 5.2, the project would improve the functioning of the intersection of Lookout Road and McCaffrey Drive. Under forecast traffic volumes for 2020 and 2030, without the project the intersection's operational capacity would be exceeded during the morning peak period and significant delays would occur for traffic passing through (over 70 seconds average). With the implementation of the project, this intersection is predicted to operate at a good level of service during the morning peak, with average delays being reduced to a maximum of about 28 seconds.

5.6 Impacts on other travel modes

5.6.1 Heavy vehicles and restricted access vehicles

The project would provide improved travel times and freight efficiency for heavy and restricted access vehicles. The reduction of through trips of these vehicles along the existing Croudace Street / Lookout Road section of the A37 associated with re-routing onto the new section of the Newcastle Inner City

Bypass would also result in an improvement in amenity through a reduction in noise, vibration and emissions associated with heavy and restricted access vehicle travel.

The project has been designed to accommodate larger restricted access vehicles, including the following categories:

- 4.6 metre high vehicles
- 19 metre B-doubles, 23 metre B-doubles and 25/26 metre B-doubles.

As detailed in Section 2.1.2, the sections of the Newcastle Inner City Bypass to the south of the project are currently not approved for restricted access vehicle use. However, the project would open up the potential for these sections to be approved for restricted access vehicle use, which would provide efficiency and safety improvements for freight on the surrounding road network.

Heavy vehicles (not including restricted access vehicles) would be able to continue to use the existing route along Croudace Street and Lookout Road.

5.6.2 Public transport

The project is not expected to require the alteration of any existing public bus routes, rather it would provide an opportunity for bus routes to be reconfigured to take advantage of the hospital interchange access and reduced travel times on the new section of bypass.

Bus services and potential increase in patronage in the area would benefit from the improved traffic conditions due to the project, including reduced congestion on the existing route of Newcastle Road, Croudace Street and Lookout Road.

Table 5-23 identifies bus stops located on the key travel routes of A15 and A37 within the study area. Table 5-23 also identifies bus stops that would require removal or relocation to an adjacent area due to new elements of the project. These include two bus stops along Newcastle Road currently located within close proximity to the existing mid-block signalised pedestrian crossing adjacent to Jesmond Park. The project would replace the existing mid-block signalised pedestrian crossing with a shared path bridge over Newcastle Road west of Steel Street. This would require the removal of two bus stops (Numbers 2299 27 and 2299 20) adjacent to the west of the mid-block crossing. These two bus stops would not be replaced as two existing bus stops located about 150 metres to the east near Steel Street would be retained and serviced by the proposed shared path bridge over Newcastle Road.

Table 5-23 Bus stop locations surrounding the project

ID	Bus stop no.	Location	Direction	Impacted by the project?
1	2289 272	Charlestown Road, south of Peatties Road intersection	Northbound	N
2	2305 172	Lookout Road, south of Jacaranda Drive and adjacent to John Hunter Hospital	Northbound	N
3	2305 170	Lookout Road, south of McCaffrey Drive intersection	Northbound	To be removed
4	2305 169	Lookout Road, south of Grandview Road intersection	Northbound	N
5	2305 167	Charlestown Road, north of Hurn Street intersection	Southbound	N
6	2305 160	Charlestown Road, south of Cardiff Road intersection	Northbound	N
7	2305 151	Lookout Road, adjacent Blackbutt Reserve entrance	Southbound	N

ID	Bus stop no.	Location	Direction	Impacted by the project?
8	2305 150	Lookout Road, adjacent to properties between McCaffrey Drive and Grandview Road	Southbound	To be relocated about 140 metres north
9	2305 149	Kookaburra Circuit, opposite John Hunter Hospital	Westbound	N
10	2305 148	Lookout Road, opposite John Hunter Hospital	Southbound	N
11	2305 145	Lookout Road, south of Carrington Parade	Southbound	N
12	2305 144	Lookout Road, south of Russell Road	Southbound	N
13	2305 81	Croudace Street, north of Russell Road intersection	Northbound	N
14	2305 64	Croudace Street, north of Russell Road intersection	Southbound	N
15	2305 171	Lookout Road, north of McCaffrey Drive	Northbound	To be relocated about 50 metres north
16	2299 106	Newcastle Road, west of Albert Street	Westbound	N
17	2299 104	Croudace Street, south of Charlton Road intersection	Northbound	N
18	2299 103	Croudace Street, south of Armstrong Street intersection	Northbound	N
19	2299 102	Croudace Street, south of Chilcott Street intersection	Northbound	N
20	2299 101	Croudace Street, north of Pride Avenue intersection	Northbound	N
21	2299 100	Croudace Street, south of Mitchell Street intersection	Southbound	N
22	2299 99	Croudace Street, south of Chilcott Street intersection	Southbound	N
23	2299 95	Croudace Street, south of Pearson Street	Southbound	N
24	2299 94	Croudace Street, south of De Vitre Street intersection (adjacent to the 7-Eleven)	Southbound	N
25	2299 27	Newcastle Road, west of existing mid-block signalised pedestrian crossing near Hill Street, and adjacent to Jesmond Park	Westbound	To be removed
26	2299 26	Newcastle Road, west of Steel Street and adjacent to Jesmond Park. Location of proposed shared path bridge over Newcastle Road	Westbound	N
27	2299 21	Newcastle Road, west of Steel Street and adjacent to Jesmond Park. Location of proposed shared path bridge over Newcastle Road	Eastbound	N
28	2299 20	Newcastle Road, west of existing midblock signalised pedestrian crossing near Hill Street	Eastbound	To be removed
29	2287 140	Newcastle Road, between Drury Street and The Crescent	Eastbound	N
30	2288 17	Newcastle Road, west of Illoura Street and the Jesmond Roundabout	Westbound	N
31	2299 19	Newcastle Road, east of Blue Gum Road, west of Jesmond Roundabout	Eastbound	N

As discussed in Section 5.5.4, the existing westbound bus lane and bus signal on Newcastle Road at the Blue Gum Road intersection would require removal to allow for three lanes of through traffic.

The relocation of two existing bus stops on Lookout Road (Numbers 2305 171 and 2305 150) would be required to allow the construction of the southern interchange. Due to the short distances that these bus stops would be moved (50 metres and 140 metres respectively), this is not expected to cause impacts to any users.

The existing northbound bus stop located where the bypass would join Lookout Road (No. 2305 170) would be removed. This bus stop mainly services properties which would be removed for the project and therefore not expected to significantly impact bus users.

The State Transit Authority of NSW (State Transit) are responsible for the operations of Newcastle Buses and Ferries, who manage bus services within Newcastle. State Transit has been consulted regarding the proposed changes to bus stops associated with the project discussed above. The exact location of the bus stop relocation and new bus stops would be determined during the detailed design phase of the project in consultation with State Transit.

5.6.3 Cyclists

The project would require the alteration of shared paths near the northern interchange, including those in Jesmond Park and adjacent to Newcastle Road. This would include truncation of the east-west shared path on the southern side of Jesmond Park, running from Howe Street, Lambton, to Newcastle Road, Jesmond, at the proposed northern interchange (refer to Section 2.7.2 for more details). Cyclists would be able to cross the proposed northern interchange at this location via a series of three traffic light controlled crossings, which cross the on and off-ramps and main alignment of the bypass at the interchange. This would cause delays for cyclists crossing east-west at the northern interchange, however these delays are not expected to be significant as the green time for the signalised crossings would be relatively high due to the dominant traffic movements on Newcastle road being east-west.

Mountain bike riders who use trails located between the John Hunter Hospital and residential areas to the west would also be impacted by the project as some of these trails would be dissected by the project. However with the exception of fire trails, these mountain bike trails are informal and not part of an approved off-road network.

The project would contribute to the Newcastle Cycling Strategy and Action Plan's (NCC 2012) "strategy direction" of providing "a safe, continuous and convenient bicycle network" by providing improved connectivity and safety for cyclists traveling through the study area. Provision for cyclists to cross on- and off-ramps in order to safely access and leave the bypass would be provided for in accordance with the NSW Bicycle Guidelines (RTA 2005).

Cyclist provisions proposed as part of the project which would improve connectivity and safety include:

- A 2.5 to 3.0 metre shoulder on the main project alignment to allow for on-road cyclists to use the bypass. This is as per Council's cyclist strategy (R3 cycleway)
- A connection to the northern interchange at the point where regional cycling route R5 is truncated by the project. Traffic lights would control pedestrian and cyclist movements at the northern interchange to provide for safe pedestrian and cyclist access at the interchange
- Replacement of the existing mid-block traffic light controlled pedestrian crossing on Newcastle Road with a shared path bridge. This would provide a continuous link between the sections of local cycling route L8 located north and south of Newcastle Road, and the northern section of this route with regional cycling route R5
- At the John Hunter Hospital interchange a bridge over the bypass would include a shared path for pedestrians and cyclists, providing a connection between the hospital and bushland / residential areas to the west.

The project would establish part of planned regional cycling route R3 (Kotara to Sandgate) as it would complete the Jesmond to Rankin Park section of this route.

The shared path provided on the bridge crossing the bypass at the Hospital Interchange would establish part of proposed local cycling route L31 (John Hunter Hospital to Wallsend).

5.6.4 Pedestrians and shared paths

Existing footpaths in the vicinity of Jesmond Park, Newcastle Road and McCaffrey Drive would be modified for the project. As discussed in Section 5.6.3, the northern interchange would truncate the east-west shared path passing through Jesmond Park at the northern interchange. An existing pedestrian crossing on the southern side of the intersection of McCaffrey Drive and Lookout Road would also be removed, as this mainly services properties on the south-west side of the intersection which would be removed for the project.

The project would not provide for pedestrian access directly along the bypass. As shown on Figure 5-14a-d the project would maintain and improve existing pedestrian connectivity and safety through provisions including:

- Lookout Road (eastern side) – proposed shared path from the Blackbutt Reserve area car park opposite Grandview Road to Ridgeway Road, opposite the main entrance to the John Hunter Hospital (Kookaburra Circuit)
- Proposed hospital interchange (eastern side) – shared path adjacent to new hospital access road from John Hunter Hospital Car Park No. 4 to the hospital interchange, crossing the bypass via Bridge 3. This path would cross the hospital interchange southbound off-ramp and provide access to existing off-road tracks to the west of the bypass. This would provide pedestrian connectivity to John Hunter Hospital precinct from suburbs to the west of the bypass
- Jesmond Park (R5 cycleway) (eastern side of northern interchange) – a new section of shared path would be constructed adjacent to the southbound on-ramp to the bypass from Newcastle Road to connect to new pedestrian/cyclist crossings of the northern interchange. This path would connect to an existing path on the southern side of Newcastle Road at Jesmond Park
- Jesmond Park (R5 cycleway) (western side of northern interchange) – a new section of shared path would be constructed from the northbound off-ramp from the bypass to Newcastle Road, to the intersection of Newcastle Road and Blue Gum Road. This path would pass beneath the bypass and provide access to new traffic lights for pedestrian cyclist crossing of the northern interchange
- Newcastle Road (northern side) – a new section of footpath between the intersection of Blue Gum Road and Newcastle Road and bus stop no. 229919 (Newcastle Road near Blue Gum Road)
- Coles Street (L8 cycleway) – a new section of on-road cycleway and a pedestrian footpath would be constructed along northern side of Coles Street to connect to the proposed shared path bridge over Newcastle Road with Cole Street and Newcastle University (L8 cycleway)
- Jesmond Park (eastern end) – a new section of shared path between the proposed shared path bridge over Newcastle Road and the R5 cycleway, running through Jesmond Park.

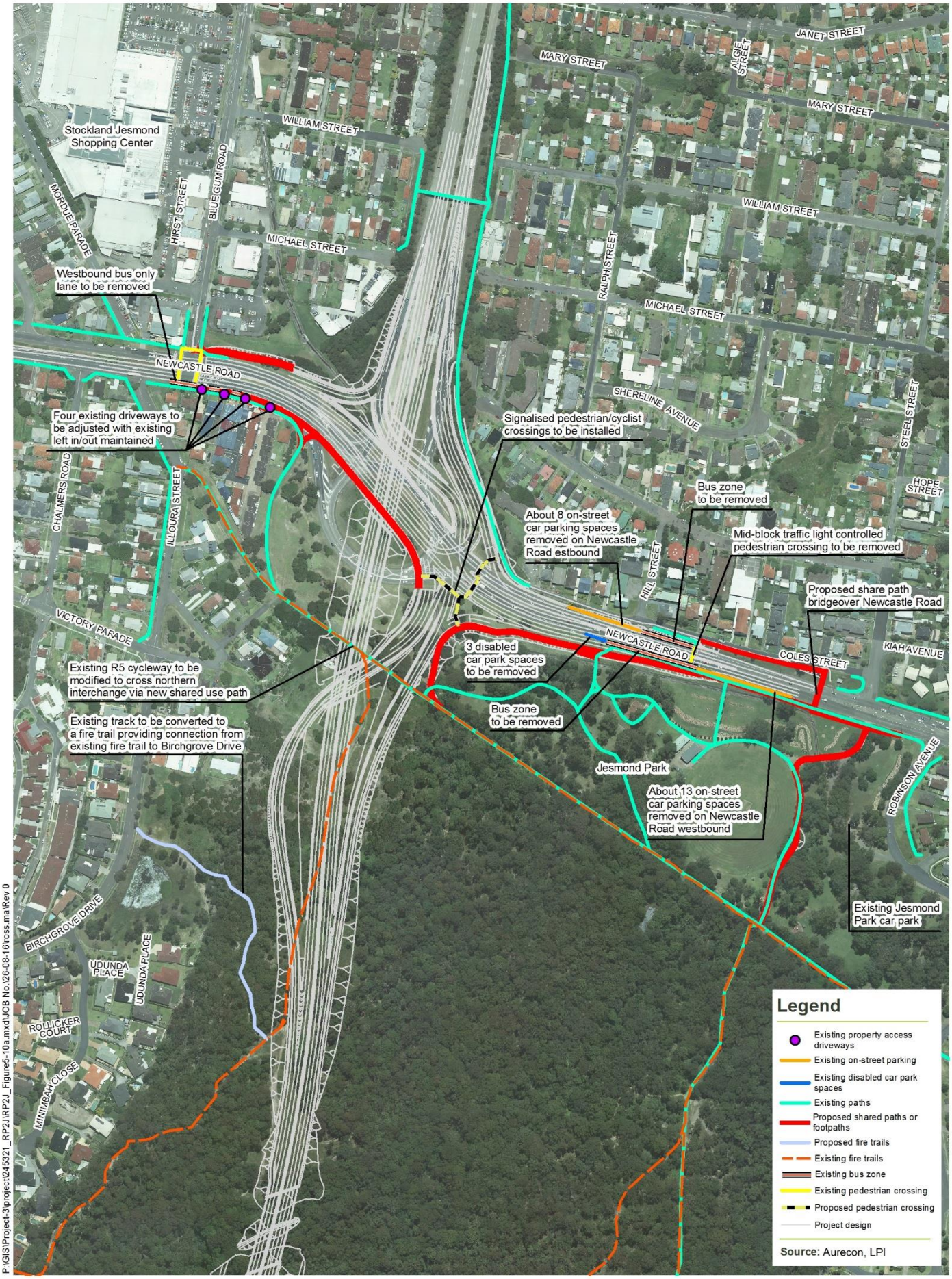
Pedestrian and cyclists crossing from east to west on the southern side of Newcastle Road at the northern interchange would be provided for with three traffic light controlled crossings of the southbound on-ramp from Newcastle Road and northbound off-ramp from the bypass. Pedestrians and cyclists would be able to cross beneath the bypass bridge, which provides a grade separation between the bypass and Newcastle Road.

Pedestrian and cyclists crossing Newcastle Road north to south at the northern interchange would be provided for on the eastern side of the intersection with traffic light controlled crossings of Newcastle Road and the southbound off-ramp providing connection to existing shared path L8.

At the northern interchange, east-west crossings on the northern side of Newcastle Road by pedestrians would not be provided for, as is the current situation. In lieu of this, an existing shared

path route is available for this movement via the footbridge across the Newcastle Inner City Bypass: Jesmond to Sandgate about 300 metres to the north of the interchange. Alternatively pedestrians can use the east-west crossings on the southern side of Newcastle Road and cross to the northern side of Newcastle Road at the existing Blue Gum Road and Newcastle Road signalised pedestrian crossings.

Construction of the proposed shared path bridge over Newcastle Road adjacent to Jesmond Park would provide a safer crossing for pedestrians compared to the existing mid-block pedestrian crossing which has recorded pedestrian/vehicle crashes (refer Section 2.5).



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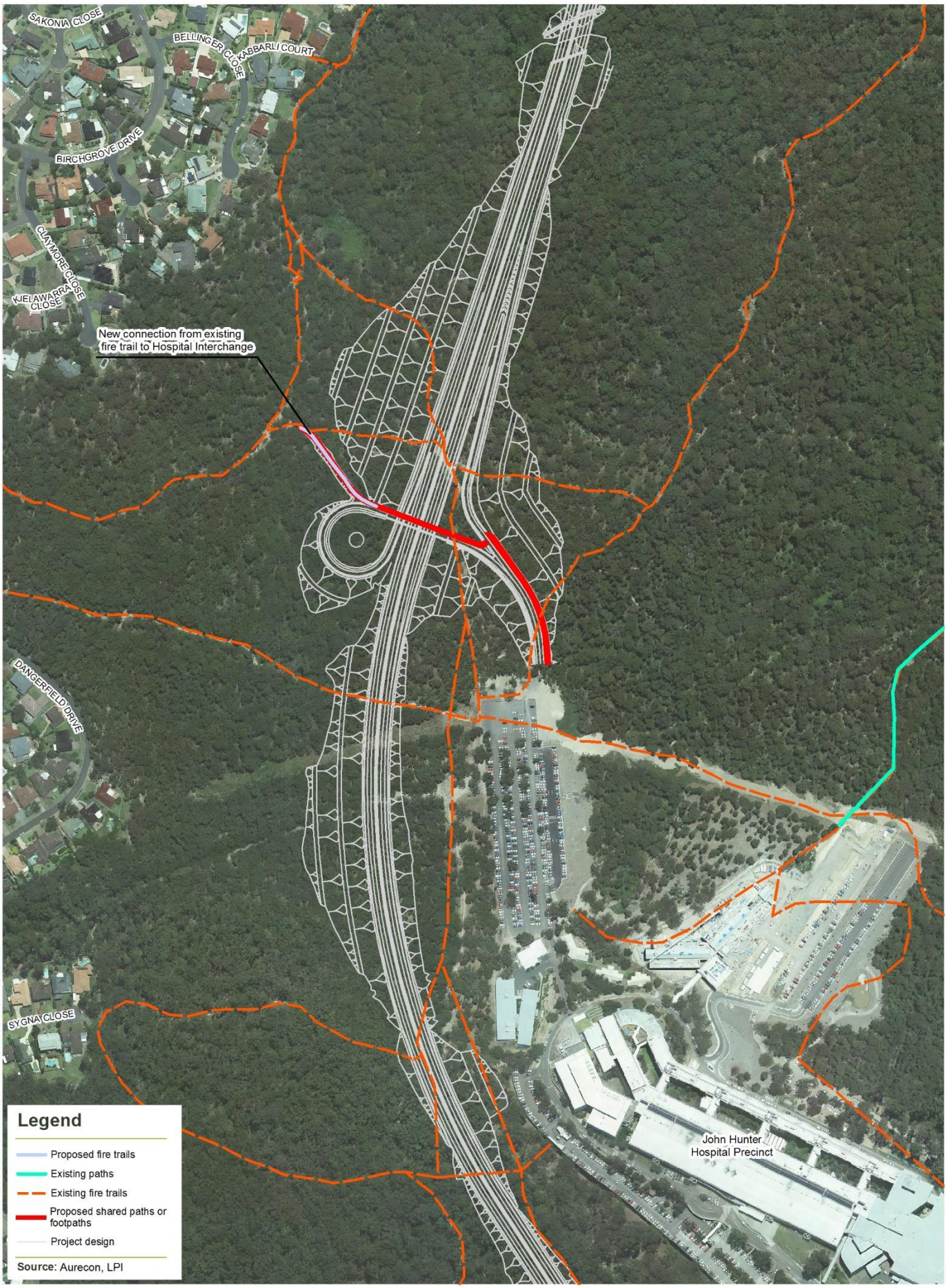
Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 5-14a: Existing and proposed property access provisions, on-street parking and paths



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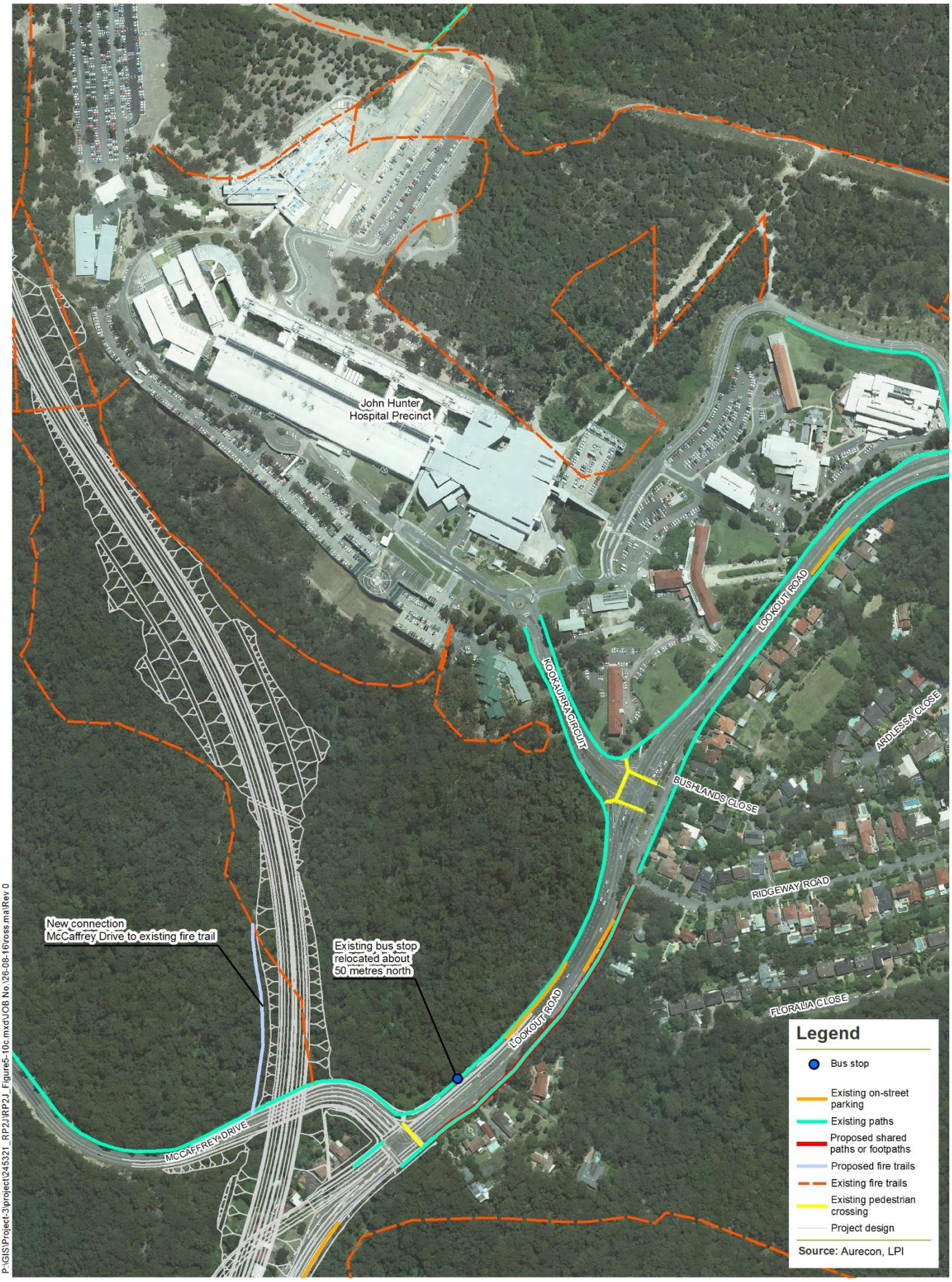
Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 5-14b: Existing and proposed property access provisions, on-street parking and paths



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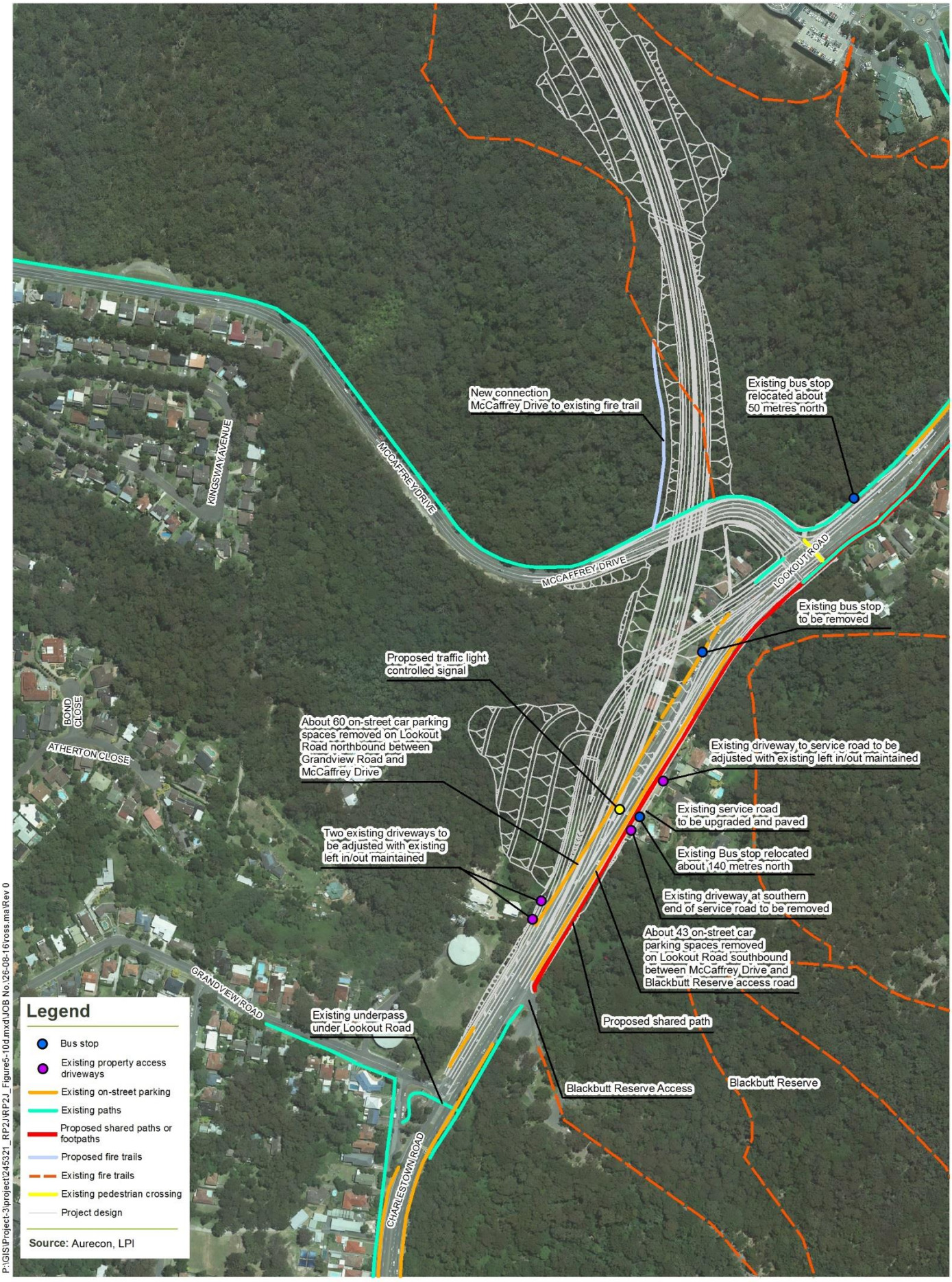
Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 5-14c: Existing and proposed property access provisions, on-street parking and paths



Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 5-14d: Existing and proposed property access provisions, on-street parking and paths

5.7 Property access and on-street parking

5.7.1 Property access

During operation, the existing access to all properties would be reinstated, with adjustments as required to suit the new road infrastructure.

Safe access for all impacted properties would be provided during operation of the project, which would include:

- Existing speed limits on Newcastle Road (70 kilometres per hour) and Lookout Road (70 kilometres per hour) would be unchanged by the project at property accesses as listed in the following section
- A shoulder would be provided on Lookout Road and Newcastle Road with driveways widened (where feasible) between the road and property boundary to improve access
- On-street parking would not be available on Lookout Road and Newcastle Road near the accesses. This would remove potential obstructions to visibility created by parked vehicles in the shoulder when leaving an access and enable vehicles when entering an access to use the shoulder without negotiating parked vehicles
- Sight distance to/from property accesses meets design standards as outlined in Chapter 5.

The following areas have direct property access that would be affected by the project (refer to Figure 5-14a-d).

- Lookout Road northbound, about 200 metres north of Grandview Road – two residential properties in this location directly access Lookout Road via two driveways. The project would widen the carriageway of Lookout Road in this location to the west by about six and eight metres at each respective driveway. All works would be contained within the road reserve and the level of these driveways would remain the same at the property boundary. This is not expected to impact on access for these properties during the operational phase of the project, as their existing left-in and left-out movements would be maintained
- Lookout Road southbound, about 230 to 300 metres south-east of McCaffrey Drive – five residential properties access Lookout Road via a service road in this area. The service road is accessed via two driveways that connect to Lookout Road, located about 50 metres apart. The service road would be upgraded from gravel to pavement. The southernmost driveway of this road is located where a new traffic light would be installed for the project. As such, this driveway would be removed to ensure safe functioning of the traffic lights. Residents of these properties would be able to use the other existing driveway to the service road, located a short distance to the north which would be retained and widened to improve access. This is not expected to impact on the residents of these properties during the operational phase of the project, as their existing left-in and left-out movements would be maintained
- Newcastle Road westbound, between the Blue Gum Road intersection and the northern interchange – four properties are located in this area: a detached residence with no driveway, a motel (Jesmond Executive Villas) with two driveways and two blocks of residential units with one driveway each. Adjustments would be carried out at these properties to allow for minor raising of the kerb height on Newcastle Road for the project, including new driveways, footpaths and kerbs. This is not expected to impact on the residents and users of these properties during the operational phase of the project, as their access would be improved by reducing the steepness of their existing driveways.

Roads and Maritime will carry out consultation with all affected property owners regarding changes to access arrangements during detailed design.

5.7.2 Parking

No on-street parking would be allowed for along the new bypass including on-ramps and off-ramps. On other roads adjacent to the project changes to on-street parking would occur. Existing parking and proposed changes that would occur to parking as part of the project are shown on Figure 5-14a-d and include:

- Lookout Road northbound/southbound, to the south of McCaffrey Drive – informal, untimed, on-street parking is available at this location within the roadside shoulder on both the north and southbound carriageways. No on-street parking would be available between McCaffrey Drive and Grandview Road on both sides of Lookout Road, with the exception of a 90 metre section adjacent to the Lookout Road southbound carriageway between the Blackbutt Reserve Access road and Grandview Drive, which provides about 13 on-street car parking spaces. The project would remove about 43 on-street car parking spaces from the southbound carriageway and about 60 from the northbound carriageway, between McCaffrey Drive and Grandview Drive. Parking in this area of Lookout Road is generally used for parking by patrons and staff of John Hunter Hospital and represents only a very small proportion of available parking for the hospital. The hospital itself has over 3,400 car parking spaces and more parking spaces are available on adjacent roads, such as sections of Lookout Road. Given the available parking in the hospital (over 3400 car parking spaces) and on surrounding streets, the loss of these spaces is not expected to result in any significant impacts in the study area. The removal of 60 parking spaces from the northbound carriageway of Lookout Road would remove informal on-street parking in front of 136 Lookout Road, where a music teaching and recording business operates from a private residence. Any vehicles accessing this residence during or after construction of the project would be required to park within the property, or in other nearby streets such as Grandview Road.
- John Hunter Hospital – a rearrangement of car-parking spaces within the carpark adjacent to the hospital interchange (Carpark 4) may be required as part of the upgrade of the hospital's road network, to allow for the new access road that would be built for the project. This is not expected to result in a net loss of overall car parks within the hospital, with road works within the hospital to accommodate the new access road to be managed by NSW Health Infrastructure.
- Newcastle Road eastbound, to the east of the northern interchange – informal, untimed on-street parking is available in two sections of the roadside shoulder at this location. These parking areas would be removed to allow for widening of Newcastle Road. This area is generally used for parking by visitors of Jesmond Park and is estimated to include about eight car parking spaces. As parking in this area requires users of the park to cross Newcastle Road, it is not expected to be heavily used. As Jesmond Park has a dedicated car park located about 350 metres to the south (accessed from Robinson Avenue) and other available on-street parking, removal of these parking spaces is not expected to create noticeable impacts to users of Jesmond Park.
- Newcastle Road, westbound, to the east of the northern interchange – informal, timed, on-street parking adjacent to Jesmond Park is available in this location, including a bay for disabled parking. This parking area would be removed to allow for widening of Newcastle Road at this location. This parking area is generally used for parking by visitors of Jesmond Park and is estimated to include about 16 car parking spaces, including three disabled car parking spaces. Removal of this parking is not expected to cause impacts to users of Jesmond Park as on-street parking is available further to the south on Newcastle Road and Robinson Avenue and the park has a dedicated car park which is accessed from Robinson Avenue. However, the removal of a disabled car parking area may cause impacts for disabled users of the park and provisions for establishing a new disabled car parking area within the park's existing dedicated carpark would be investigated as part of the detailed design for the project in consultation with Newcastle City Council.

The overall impacts of the project on parking in the study area are expected to be minor. Small, generally isolated areas of road shoulder on State roads would be removed on Lookout Road and Newcastle Road, where informal parking is currently available. These areas are not located adjacent to any businesses or community centres and their removal is not expected to cause impacts to any

frequent users of the area. There is no expected loss of parking for any surrounding regional or local roads.

5.8 Bushfire and emergency services

As discussed in Section 2.9, the bushland area that the project traverses is identified as bushfire prone by Newcastle Council's Draft Bush Fire Prone Land Map 2014. A number of existing fire trails are located within the study area which are used by the landowner and fire authorities for bushfire management and bushfire hazard reduction activities.

Construction of the project would create a substantial bushfire break between residential areas and the John Hunter Hospital precinct. This would reduce bushfire risk to these areas. The project would also improve access to bushland areas adjacent to the main project alignment and improved access to the John Hunter Hospital precinct via the proposed hospital interchange.

The project would intersect several fire trails that cross the main project alignment in an east-west direction (indicative location of these trails are shown on Figure 5-14a-d). Consultation was carried out with Fire and Rescue NSW, Newcastle City Council and Hunter New England Local Health District during development of the project to identify measures to mitigate issues associated with this. Ensuring that adequate provisions are provided for bushfire and emergency services was an important consideration in the development of the project. To mitigate impacts on the network of fire trails, additional fire trails have been proposed to be constructed. The proposed additional fire trails were developed in consultation with the relevant fire authorities discussed above and include:

- At the southern end of the project, a new fire trail would be constructed off McCaffrey Drive. This trail would be about 200 metres in length and would connect to an existing fire trail on the western side of the bypass. Due to the steep topography in this location, the fire trail would have a steep vertical grade and its design would only be suitable for off-road and bushfire management vehicles
- In the central section of the project, a new fire trail would be constructed off the north-west corner of the hospital interchange. This fire trail would be about 100 metres in length and would connect to an existing fire trail on the western side of the bypass
- At the northern end of the project, an existing informal track off Birchgrove Drive would be reclassified as a fire trail. The fire trail would be about 300 metres in length and would connect to an existing fire trail on the western side of the bypass.

The proposed works would ensure bushfire access during operation is maintained within the bushland corridor. The construction phase of the project would also be carried out and planned to ensure adequate access to the existing fire trails are maintained (refer to Section 6.5.5).

Further consultation will be carried out with the relevant fire authorities during the detailed design of the project.

6 Construction impacts

This section provides an assessment of the resulting traffic, transport and road safety impacts which are anticipated to occur during construction of the project.

6.1 Assessment methodology

The assessment of potential construction traffic impacts discussed in this section considers the:

- Construction processes, staging and timeframes
- Estimates of construction materials
- Locations of construction access routes (on site)
- Locations of ancillary areas.

This assessment is based on potential construction methodologies developed during the concept design. Further development of these aspects would occur as the project progress through detailed design stage and construction.

6.2 Overview of construction activities

6.2.1 Construction process

Detailed construction methodologies would be developed by the selected contractor(s) for the project. Construction works would be carried out in accordance with Roads and Maritime's Standard Specifications and a project specific Construction Environmental Management Plan (CEMP) and associated Construction Traffic Management Plan (CTMP). These plans would incorporate the management measures developed for the project as part of the Environmental Impact Statement (EIS).

Construction of the project is described in detail in the EIS and would generally involve the activities described in Table 6-1.

Table 6-1 Construction activities

Type	Typical Activities
Enabling works	■ Community notification of construction commencement ■ Relocation of flora and fauna species, if required ■ Road and intersection modifications at the existing Jesmond Roundabout to facilitate construction access ■ Minor clearing works ■ Minor topsoil stripping ■ Construction of minor access roads ■ Construction access from Kookaburra Circuit roundabout to construction area ■ Investigative drilling ■ Installation of environmental controls ■ Property demolition works at the southern interchange ■ Installation of temporary construction signage and lighting ■ Fencing of construction areas and site compounds ■ Construction of temporary side track adjacent to proposed McCaffrey Drive Bridge

Type	Typical Activities
Site establishment	■ Construction of temporary access tracks (including creek crossings) ■ Establishment of on-site compounds ■ Clearing of vegetation and stockpiling of mulch materials ■ Progressive construction of sedimentation and erosion controls as required, including construction of diversion and catch drains along the project formation ■ Progressive installation of temporary fencing ■ Temporary traffic management arrangements ■ Mine grouting operations
Bulk Earthworks	■ Stripping topsoil and stockpiling for reuse in embankment stabilisation ■ Progressive construction of sedimentation and erosion controls as required ■ Excavation of cuttings (including sorting and processing of materials) ■ Construction of fill embankments ■ Placement and compaction of selected material
Drainage and Structures	■ Construction of retaining walls ■ Construction of drainage structures within cuttings and roadways ■ Construction of catch drains including scour protection work ■ Realignment of watercourse beneath Bridge 4
Bridge construction	■ Establishment of bridge satellite work compounds ■ Construct access to foundations as well as piling/crane platforms ■ Construction of bridge foundations ■ Construction of bridge abutments and piers ■ Construction of bridge deck superstructures
Pavement Works	■ Construction of base and sub-base pavement layers ■ Construction of pavement drainage including kerb and gutters as required ■ Construction of medians and barriers ■ Construction of pavement wearing course
Finishing works	■ Final pavement line marking ■ Signposting ■ Street lighting ■ Landscaping and tree planting ■ Installation of fauna furniture ■ Demobilisation ■ Restoration of on-site compounds
Other	■ Relocation of Utilities ■ Construction of noise walls ■ Construction of footpaths/bike tracks

6.2.2 Construction timing

Subject to planning approval and availability of funding, the project would be expected to start construction in about 2018 and take about 30 months to complete, weather permitting. The timing and duration of construction activities may also be influenced by, but not limited to, the following:

- Inclement weather
- Final design and construction methodology required
- Different site conditions (for example more rock to be excavated than expected)
- Extent of mine remediation work required.

Final construction staging and programing would be determined by the construction contractor in coordination with Roads and Maritime.

6.2.3 Workforce and work hours

The size and arrangement of the construction workforce is expected to fluctuate throughout the construction period. The workforce is expected to peak at about 100 personnel per day. This would be highly influenced on the staging of construction and activities within that stage. The final number of construction personnel would be determined by the construction contractor.

The standard construction working hours as noted in the NSW Interim Construction Noise Guideline (Department of Environment and Climate Change 2008) are shown in Table 6-2.

Table 6-2 Standard construction hours

Work Type	NSW Interim Construction Noise Guideline Recommended standard hours of work
Normal Construction	Monday to Friday: 7.00 am to 6.00 pm Saturday: 8.00 am to 1.00 pm Sunday and Public Holidays: No Work

The NSW Interim Construction Noise Guideline also states the following activities could be carried out outside the recommended standard construction hours, assuming all feasible and reasonable mitigation measures are implemented to minimise the impacts to any surrounding sensitive land uses:

- Delivery of oversized plant or structures
- Emergency work
- Maintenance and repair of public infrastructure where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
- Public infrastructure works that shorten the length of the project
- Works where a proponent demonstrates and justifies a need to operate outside the recommended standard construction hours
- Works which maintain noise levels at receivers below the night time noise management levels.

The NSW Interim Construction Noise Guideline indicates works permitted outside standard construction hours includes works on public infrastructure works where extended construction work hours would shorten the length of the project and are supported by the affected community.

The work hours for the project are proposed to be extended by 2 hours from Monday to Friday and by 5 hours on Saturdays as shown in Table 6-3.

Table 6-3 Proposed construction hours

Work Type	Normal construction + extended hours of work
Normal Construction	Monday to Friday: 6.00 am to 7.00 pm Saturday: 7.00 am to 5.00 pm Sunday and Public Holidays: No Work

When work outside of the proposed construction hours is required the ICNG acknowledges that negotiation agreements with the community may be required. The consultation and procedural requirements of Roads and Maritime's *Noise Mitigation Guideline* (2015) may be implemented for any out of hours works.

The contractor would work together with Roads and Maritime to minimise works outside the proposed construction hours. Where work is required outside of the proposed construction hours, measures would be implemented in accordance with an approved project specific Construction Environmental

Management Plan (CEMP) to minimise noise and other types of disturbances to surrounding residents, businesses and road users.

6.2.4 Ancillary sites

Three main areas have been identified within the construction boundary of the project for potential use as site compounds and other ancillary uses needed to construct the project. The locations of these are shown on Figure 6-1. These sites have been located based on:

- Topography and accessibility to construction areas
- Minimising impacts on native vegetation and residential areas where possible
- Location above the 20-year average recurrence interval (ARI) flood level where possible.

The proposed uses of the ancillary sites are provided in Table 6-4. It should be noted that these are indicative only and would require further refinement based on the needs of the construction contractor. Construction staging would influence the staging and use requirements of these sites.

Table 6-4 Indicative on-site compound use

Site Compound	Proposed use							
	Main Site Compound	Materials Handling	Crushing Plant	Stockpile Site	Bridge Girders	Site offices	Deliveries	Parking
A	x	x	x	x	x	x	x	x
B					x	x	x	x
C					x	x	x	x

These ancillary sites would be accessed from the proposed construction access roads and access points discussed in Section 6.3.

It is estimated that about 10,000 square metres would be required for stockpiling within the compound areas and along the length of the construction footprint (if required). Final stockpiling locations would be determined by the construction contractor. A concrete batch plant may be established within site compound A to produce concrete during construction of the project, although large concrete suppliers are located in adjacent areas which may remove the need for this.

Asphalt batch plants may also be established in one or more of the site compounds, although it is likely to be more cost-effective for asphalt to be supplied from external sources.

The need for on-site concrete and asphalt batch plants would be determined during the construction stage by the contractor, in consultation with Roads and Maritime.

6.3 Construction traffic

Construction related traffic would use the surrounding road network to:

- Haul material from quarries / borrow source to work site areas
- Carry equipment and materials from one section of the construction area to another (where required)
- Provide access for the delivery of construction materials and the removal of waste
- Provide access for the workforce to the various locations along the construction boundary, in particular site compounds.

The most significant contributions to additional vehicle movements on the existing road network would occur at access points to the proposed construction access roads and on the roads linking to sources of key construction materials such as asphalt and concrete products.

The majority of construction traffic movements are expected to be contained within the project's construction boundary with the exception of deliveries to site, disposal of waste and staff travel. Construction access routes have been located with consideration of potential noise and vibration impacts on sensitive receivers.

Haulage of material to the site would generally occur via the restricted access vehicle network described in Section 2.1.2. Use of local roads is not expected to occur for haulage of bulk materials, although haulage of material on sections of McCaffrey Drive, Lookout Road and Kookaburra Circuit (John Hunter Hospital access) may be required during some stages of construction. This is discussed further in Section 6.4.

6.3.1 On-site construction access roads

The project would require construction of temporary roads within the project boundary to provide access during construction. The main project alignment has a number of constraints that limit access options, including: steep terrain, access and egress from local road network, proximity to John Hunter Hospital and local residents, and environmental impacts.

The proposed construction access roads have been developed and assessed as shown in Figure 6-1. These access roads provide options for accessing the project's construction areas. The selected construction contractor(s) may use some or all of these roads during the construction period.

- **Construction access road 1 (CAR1) –** would be the main access road for the northern section of the project. It would extend along the main project alignment between Newcastle Road and McCaffrey Drive.

  Northern access to CAR1 would be provided with connection(s) off Newcastle Road near, or from, the Jesmond Roundabout. Temporary traffic light controls may be used for the roundabout on Newcastle Road to allow construction traffic to access the construction site from all directions.

  Southern access to CAR1 would be provided with a connection off McCaffrey Drive to the west of the main project alignment.

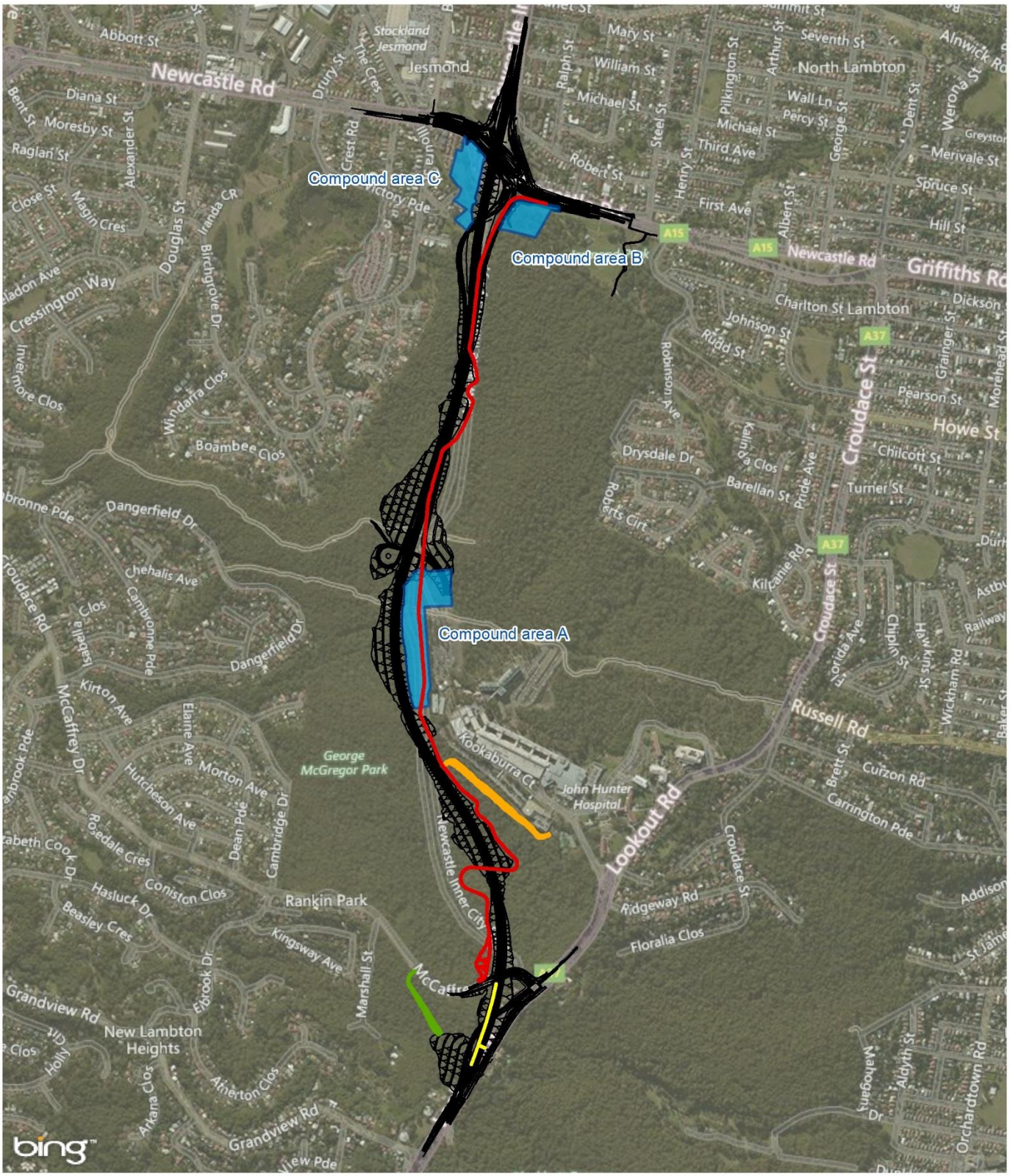
  The access point at Jesmond Roundabout is expected to be the main access point for delivery of bulk materials to the site, such as concrete and asphalt.

- **Construction access road 2 (CAR2) –** would provide access off the existing John Hunter Hospital access road (Kookaburra Circuit) and along the southern boundary of John Hunter Hospital. This option would provide a secondary access to CAR1 at cut area 3 (shown on Figure 6-2). CAR2 would be used by light vehicles and may be used for the haulage of excavated material from the section south of McCaffrey Drive. This is discussed further in Section 6.4.

  This route would require partial use of the hospital's road network and construction traffic would pass in close proximity to Ronald McDonald House Newcastle (located within the hospital grounds). Use of this access road would be managed to minimise impacts to the hospital's road network and Ronald McDonald House Newcastle, particularly during peak periods. Consultation would be carried out with the John Hunter Hospital and Hunter New England Local Health District to establish a set of rules for use of this access road during peak periods, prior to the commencement of construction.

- **Construction access road 3 (CAR3) –** would provide access from McCaffrey Drive to the southern section of the project. This access road may be used to haul material to and from cut 1 and fill 1 (shown on Figure 6-2).

- **Construction access road 4 (CAR4) –** Would provide access from Lookout Road to the southern section of the project. This access road may be used to haul material to and from cut 1 and fill 1 as well as the construction of Bridge 1 (shown on Figure 6-2). Once McCaffrey Drive bridge is sufficiently completed CAR4 may be continued along the alignment and connect to CAR1.



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Legend

- Design
- Site compounds
- Construction Access Road 1 - Northern Access
- Construction Access Road 2 - South Eastern Access
- Construction Access Road 3 - Southern Access
- Construction Access Road 4 - Southern Access

Source: BingMaps, Aurecon

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Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 6-1: Site compounds and access roads

6.3.2 Construction traffic travel routes

Transport of key construction materials to construction sites is anticipated to typically occur from the sources described in Table 6-5 along the restricted access vehicle routes described in Section 6.3.2.

This would involve use of the following main routes:

- **Access to the northern end of CAR1** – construction traffic would gain access from an access point at or near Jesmond Roundabout. Vehicles travelling from the east and west would be expected to use Newcastle Road to get to this point. From the south, access to the construction area entrance point would typically occur via the existing A37 route (Charlestown Road, Lookout Road, Croudace Street, Newcastle Road).

  Vehicles travelling from the north would be expected to access the northern construction areas from the Newcastle Inner City Bypass: Jesmond to Sandgate section.

  Construction traffic accessing the northern sections of the project from the eastbound lanes of Newcastle Road or the southbound lanes of the Newcastle Inner City Bypass: Jesmond to Sandgate would need to make a right-turn or straight-through movement on Jesmond Roundabout to access CAR1. This may require traffic controls and/or changes to existing lane configurations at the roundabout. If vehicles travelling from these directions are not permitted to make these traffic movements, they would be expected to either:

  - Travel further east on Newcastle Road and make use of the local road network to turn around and return back along Newcastle Road from the west
  - Use the University Drive interchange and local road network to turn right from Dent Street onto Newcastle Road
  - Use CAR2 via Lookout Road.

  All of these option result in increased travel distances and a greater impact of construction vehicles on local roads. For example, vehicles travelling to CAR2 would travel an additional distance of about 5.5 kilometres to access the construction area.

  Traffic control measures for construction vehicular access to the northern construction areas would be investigated during the detailed design stage and developed as part of the project's CTMP (refer to Section 6.5).

- **Access to the southern end of CAR1 –** construction traffic would gain access from McCaffrey Drive. Restricted access use of McCaffrey Drive from the west is not expected as McCaffrey Drive is not a designated restricted access route. However; some construction traffic may use McCaffrey Drive to access the construction areas from the west. Vehicles (including heavy vehicles) travelling from the east may use this access.

  Traffic control measures for construction vehicular access from the east/to the west turning right across McCaffrey Drive would be investigated during the detailed design stage and developed as part of the project's CTMP.

- **Access to CAR2 –** construction traffic would gain access from the John Hunter Hospital access road (Kookaburra Circuit). Vehicles travelling from the north, south, east or west would enter via the signalised intersection at Lookout Road and Kookaburra Circuit.

- **Access to CAR3 –** construction traffic would gain access from McCaffrey Drive. Restricted access vehicle use of McCaffrey Drive from the west is not expected as McCaffrey Drive is not a designated restricted access vehicle route. However; some construction traffic may use McCaffrey Drive to access the southern construction areas from the west. Vehicles (including heavy vehicles) travelling from the east may use this access.

  Traffic control measures for construction vehicular access to the east turning right across McCaffrey Drive would be investigated during the detailed design stage and developed as part of the project's CTMP.

- **Access to CAR4 –** construction traffic would gain access from Lookout Road. Vehicles travelling from the south would be expected to use the existing A37 route (Charlestown Road, Lookout Road,). Vehicles travelling from the north via the existing A37 route (Newcastle Road Croudace Street Lookout Road). As a raised median separates carriageways of Lookout Road at CAR4 and no turning provisions exist for southbound traffic to turn into to CAR4, changes to traffic lanes and traffic controls may be established to provide access for southbound traffic.

  Measures to ensure heavy and restricted access vehicles associated with construction of the project do not use local roads to access construction areas would be developed as part of the project's CTMP (refer to Section 6.4).

6.4 Material haulage

6.4.1 General construction materials

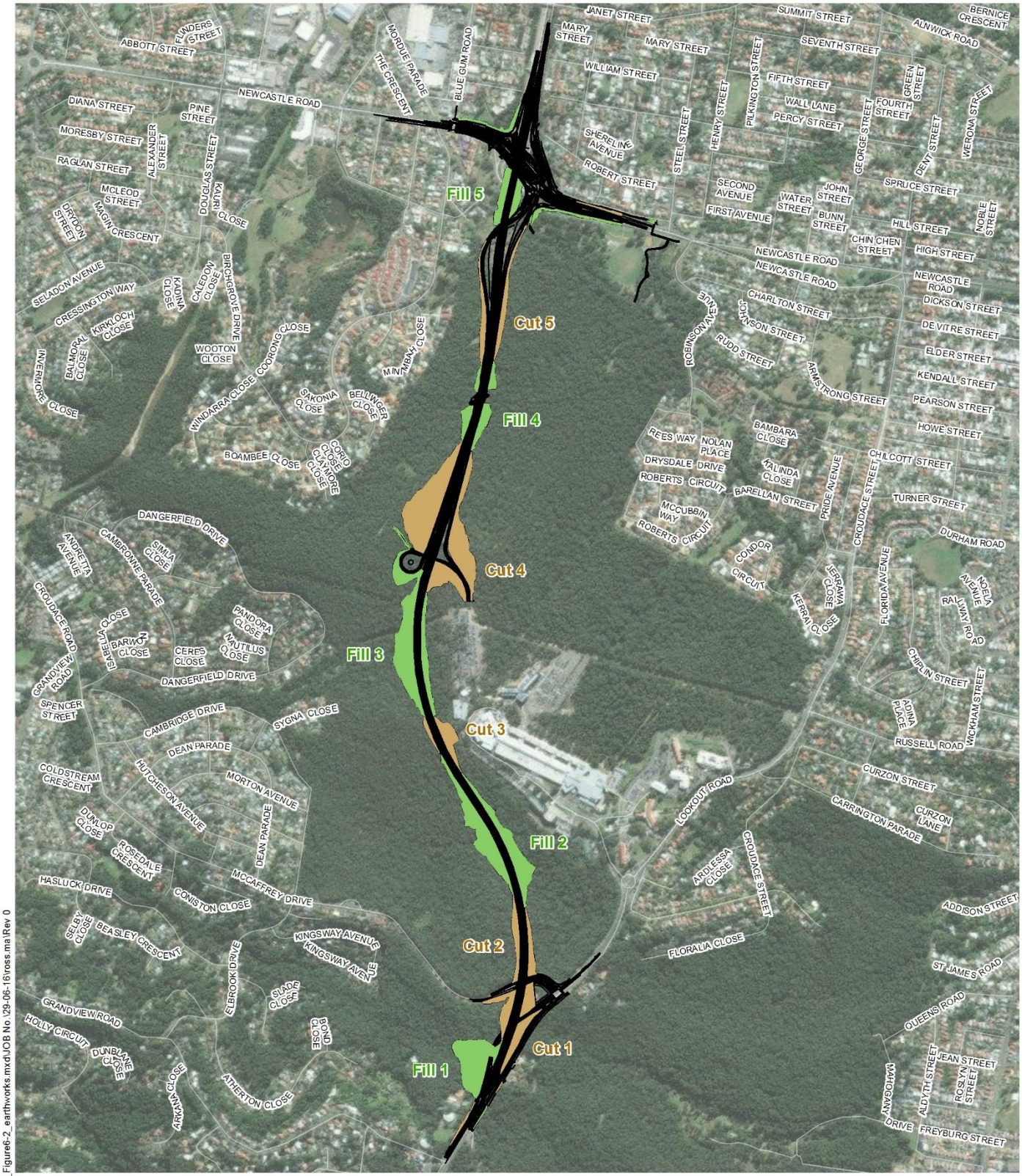
Construction of the project would require a range of materials to be transported to and within the construction site and compound/stockpile areas. The key materials that would be transported as part of the construction process are outlined in Table 6-5. Table 6-5 provides estimates of distances between the materials source and CAR1, as this road is anticipated to be the main access point for a majority of material deliveries.

Table 6-5 Potential sources of construction materials

Material	Potential source	Location	Distance to CAR1
Concrete, cement	Boral Concrete	47 Mordue Parade, Wallsend, NSW	<1 km
	Boral Concrete	Frith Avenue, Boolaroo, NSW	11 km
	Hunter Ready-mixed Concrete	8 Nevin Close, Gateshead, NSW	12.5 km
Asphalt	Fulton Hogan	40 Gardiner Street, Rutherford, NSW	37 km
	Boral Asphalt	1 Gross Street, Carrington, NSW	9 km
Quarry products (sand, aggregates, road bases)	Martins Creek Quarry	Station Street, Martins Creek, NSW	50 km
	Seaham Quarry	Italia Road, Seaham, NSW	34 km
	SCE	Ingall Street, Mayfield, NSW	6 km
Water	Hunter Water Corporation reticulated water supply	On-site	n/a

6.4.2 On-site earthworks

The project involves various earthworks operations such as excavations for cuts and placement of fill for embankments. The project involves major fill and cut operations to the north and south of the John Hunter Hospital interchange in the central section of the main project alignment. A series of lesser but still significant cuts and fills occur throughout the remainder of the main project alignment. Areas of cut and fill are shown on Figure 6-2 and outlined in Table 6-6.



Legend

- Earthworks cut
- Earthworks fill
- Design

Source: BingMaps, Aurecon

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Newcastle Inner City Bypass Rankin Park to Jesmond **Traffic and Transport Assessment**

Projection: GDA 1994 MGA Zone 56

FIGURE 6-2: Earthworks locations

Table 6-6 Major earthworks cut/fill volumes

Cut/ Fill No.	Ch Start (m)	Ch Finish (m)	Cut (m^3)	Fill (m^3)
Fill 1	7265.0	7485.0		122,000
Cut 1	7487.5	7700.0	175,000	
Cut 2	7702.5	7950.0	88,000	
Fill 2	7952.5	8415.0		283,000
Cut 3	8417.5	8582.5	39,000	
Fill 3	8585.0	8967.5		251,000
Cut 4	8970.0	9445.0	588,000	
Fill 4	9447.5	9580.0		43,000
Fill 5	9612.5	9700.0		14,000
Cut 5	9702.5	10040.0	90,000	
Fill 6	10042.5	10607.5		90,000
Total			**980,000**	**803,000**

Earthworks haulage within the site is expected to be carried out by a range of earthmoving vehicles including trucks, truck and trailer and scrappers.

Main haulage movements between the cut and fill areas shown on Figure 6-2 are expected to be contained within the construction boundary with the exception of any off-site disposal.

Use of CAR 2 may be required for haulage or excavated material from cut 1 to the areas north of McCaffrey Drive. This would involve haulage of material through the John Hunter Hospital Road network and the existing hospital access intersection on Lookout Road. If required, these haulage activities would be carried out either by truck or truck and trailer. If only using trucks, it is estimated that about 144 vehicle movements (two way) per day would be required for an 85 day period. If truck and trailer were to be used it is estimated that about 84 trips per day would be required for a 76 day period.

It is predicted that about 38,000m^3 of excavated material that is unsuitable for use in fill may have to be disposed of off-site. This material would be transported via designated restricted access vehicle routes A37 (Lookout Drive, Croudace Street, Charlestown Road) or Newcastle Road and would require about 4,100 vehicle movements.

6.4.3 Bridge construction

The project would require a total of 19 Bridge Spans of varying lengths using Super T precast concrete bridge girders to be delivered to construction areas. These girders would be delivered to site on an oversized semi-trailer which would require an Oversize Overmass Permit from Roads and Maritime. Transport of the Super T girders to the construction area would occur along designated restricted access vehicle routes A37 (Jesmond to Sandgate, Lookout Drive, Croudace Street, Charlestown Road) or A15 (Newcastle Road) and would be carried out outside of peak traffic periods.

Access to each bridge site would occur through the following routes:

- Bridge 1 (southern interchange): direct access via Lookout Road with a left-in/left-out arrangement
- Bridge 2 (southern interchange): direct access via McCaffrey Drive initially, with staged access via Lookout Road
- Bridge 3 (hospital interchange): access via CAR1 (entry via Jesmond Roundabout)
- Bridge 4 (bridge over watercourse on main project alignment): access via CAR1 (entry via Jesmond Roundabout)

- Bridge 5 (northern interchange, northbound off-ramp): access via CAR1 (entry via Jesmond Roundabout)
- Bridge 6 (northern interchange): direct access via Jesmond Roundabout or via the Newcastle Inner City Bypass
- Bridge 7 (shared path bridge over Newcastle Road): access directly from Newcastle Road and CAR1.

It is not known at this stage where the girders would be sourced from.

6.5 Construction traffic impacts

6.5.1 General traffic impacts

Construction of the project is planned to occur over a 30 month period and would result in some traffic and transportation impacts to the surrounding road network during this time. These impacts would mostly relate to:

- Speed limit restrictions, traffic diversions and traffic lane or road closures on existing roads adjacent to work sites
- Increased localised traffic due to construction activities, particularly from heavy vehicle movements during earthworks
- Temporary changes to property access during the construction period
- Impacts to travel times, including public transport timetables, due to traffic controls being implemented
- Detours to pedestrian and cyclist movements due to construction works blocking existing shared paths
- Restrictions to, or additional use of on-street parking on local roads near construction areas.

6.5.2 Staging of construction works

Construction of the project would be staged to enable resource usage efficiency, minimise environmental impacts, minimise disruptions to surrounding vehicular traffic and achieve desired program delivery dates. The final construction staging of the project would be determined by the construction contractor.

Conceptual construction staging plans have been developed for the three main components of the project, as outlined below.

Main project alignment

A conceptual construction staging plan has been developed for the main project alignment, consisting of five main stages:

- Stage 1:
  - Install erosion and sediment controls, including sediment basins
  - Establish site compounds
  - Establish construction access roads
  - Install temporary gully crossing at Bridge 4 location.
- Stage 2:
  - Carry out mine grouting operations and commence bulk earthworks.
- Stage 3:
  - Complete bulk earthworks

- Commence installation of utilities and drainage
- Construct abutments and foundations for bridges 3, 4 and 5
- Install roadbase materials.

- Stage 4:
  - Install deck of bridges 3, 4 and 5
  - Complete installation of utilities and drainage
  - Carry out construction of road pavement and kerbs and medians.
- Stage 5:
  - Complete roadway construction including pavement surfacing
  - Install lighting, signage and linemarking.

Northern interchange

A conceptual construction staging plan has been developed for the northern interchange consisting of four main stages, which would require several traffic switches, and possible night works to facilitate the construction of the proposed bridge structure, traffic lights and road pavements. The main stages for the northern interchange are:

- Stage 1:
  - Install drainage
  - Carry out earthworks
  - Relocate utilities and install traffic lights in areas adjacent to existing roadways where traffic disruptions would not be required for construction activities.
- Stage 2:
  - Install temporary traffic lights and/or traffic controls at Jesmond Roundabout (eastern and northern approaches)
  - Construct bridge foundations and piers (including the northern abutment), and roadworks within the northern, eastern and western sides of the roundabout
  - In this stage, traffic would be diverted onto the new on-ramp to the existing Newcastle Inner City Bypass: Jesmond to Sandgate and a new alignment would be established for eastbound traffic on Newcastle Road through the roundabout.
- Stage 3:
  - Relocate or install temporary traffic lights and/or traffic controls at Jesmond Roundabout (eastern approach to Newcastle Road) to allow road works in western side of the roundabout
  - In this stage, east and westbound traffic on Newcastle Road would use new alignments through Jesmond Roundabout.
- Stage 4:
  - Construct southern bridge abutment
  - Install Super T bridge girders
  - Complete final pavement installation
  - Install roadside furniture and complete road markings
  - In this stage, traffic on Newcastle Road and the existing Newcastle Inner City Bypass: Jesmond to Sandgate would use the final traffic routes through the northern intersection.

Southern interchange

A conceptual construction staging plan has been developed for the Southern Interchange consisting of five main stages, which would require several traffic switches, and possible night works to facilitate the construction of the proposed bridge structures, intersection works and road pavements. The main stages for the southern interchange are:

- Stage 1:
  - Demolish existing dwellings at intersection of McCaffrey Drive and Lookout Road
  - Carry out preliminary utility relocations and works within areas that do not require traffic controls or disruptions to occur.
- Stage 2:
  - Establish temporary new traffic route (side track) for traffic on McCaffrey Drive for bridge construction
  - Carry out utility relocations and drainage works.
- Stage 3:
  - Switch traffic on McCaffrey Drive to temporary side track
  - Carry out major earthwork activities
  - Construct McCaffrey Drive bridge (Bridge 2).
- Stage 4:
  - Switch traffic on McCaffrey Drive to new section of roadway (using Bridge 2)
  - Construct Lookout Road bridge over the bypass (Bridge 1) (no disruption to existing traffic movements on Lookout Road).
- Stage 5:
  - Switch northbound traffic on Lookout Road to new alignment (using Bridge 1)
  - Construct sections of bypass connecting to southern interchange
  - Complete final utility relocations and drainage works
  - Install roadside furniture and complete line markings.

6.5.3 Construction traffic volumes

An estimate of the number of construction vehicles that would access the project construction site via the public road network has been made based on estimates of materials required for the project, typical capacities of construction vehicles and anticipated staff numbers. This estimate is provided in Table 6-7.

Table 6-7 Estimate of construction traffic movements

Task	Activity	Quantity	Rate per day	Vehicle capacity	Trips/day per activity	No. of sites with activity	Trips/day (two way)	Total trips (two way)	Duration (days)	Worst-case vehicle movements per day
Bridge construction	Concrete delivery	2,500m^3	100	8	13	2	50	625	13	50
Earthworks	Unsuitable removal	38,000m^3	200	19	11	3	63	4,074	65	65
Pavements	Imported heavily bound base	35,000m^3	500	19	26	2	105	3,684	35	105
	Asphalt - intermediate courses	11,000 T	400	25	16	1	32	880	28	30
	Drainage layer delivery	11,500m^3	500	19	26	1	53	1211	23	55
Drainage installation	Concrete delivery	488m^3	50	8	6	2	25	122	15	10
Kerbs and barriers	Concrete delivery	8,330m^3	100	8	13	2	50	2,083	15	40
Workforce	Staff vehicles	100			100		200		Peak per day	200
Total vehicle movements per day									**Heavy**	**355**
									Light	**200**

Light vehicles used for construction of the project would typically be used to transport staff to construction areas and for minor construction activities such as inspections and movement of light equipment. As shown in Table 6-7, construction of the project is expected to involve up to 200 light (including passenger) vehicle movements per day. The majority of these movements would occur along main roads such as Newcastle Road and Lookout Road, although small numbers of light vehicles may use local roads during the construction period.

To provide an indication of the worst-case impacts of construction traffic on the current network, the estimated volume (including both light and heavy vehicles) that would use the existing road network has been expressed as a percentage of the existing average weekday traffic flow (two way) at a range of locations in the vicinity of the construction site. This was also calculated for AM and PM peak periods.

This analysis indicates that in comparison to total vehicle trips on the existing road network, the volume generated by the proposed construction would not exceed 1.5 per cent of average weekday daily traffic volumes and 1.8 per cent of traffic volumes during peak periods. Due to the low predicted increase in traffic volumes, this worst-case scenario is considered unlikely to affect the level of service at the intersections servicing these roads.

The estimated weekday traffic volumes and predicted construction traffic impacts are indicated in Table 6-8. Estimated weekday peak hour traffic volumes and predicted construction traffic impacts are indicated in Table 6-9 and Table 6-10. All sites indicated are located on designated restricted access vehicle routes suitable for use by construction traffic associated with the project.

Table 6-8 Impact of estimated worst-case construction traffic on current (2014) traffic volumes

ID	Road/location	Average weekday daily traffic (two-way in vehicles)	Indicative predictive construction traffic impact (% increase)
1	Charlestown Road, south of Carnley Avenue	55,100	1.0%
7	Lookout Road, north of McCaffrey Drive	49,400	1.1%
10	Newcastle Road, east of Croudace Street	46,500	1.2%
11	Newcastle Inner City Bypass, north of Newcastle Road	36,100	1.5%
12	Newcastle Road, west of Newcastle Inner City Bypass	44,300	1.3%
16	Newcastle Road, east of Newcastle Inner City Bypass	60,200	0.9%
17	Croudace Street, north of Elder Street	41,800	1.3%
18	Lookout Road, south of Russell Road	48,700	1.1%
19	Lookout Road, south of McCaffrey Drive	47,200	1.2%

Table 6-9 Impact of estimated worst-case construction traffic on current (2014) AM peak traffic volumes

ID	Road/location	Average weekday AM peak hour traffic (two-way in vehicles)	Indicative predictive construction traffic impact (% increase)
1	Charlestown Road, south of Carnley Avenue	4,209	1.2%
7	Lookout Road, north of McCaffrey Drive	3,942	1.3%
10	Newcastle Road, east of Croudace Street	3,801	1.3%
11	Newcastle Inner City Bypass, north of Newcastle Road	3,149	1.6%
12	Newcastle Road, west of Newcastle Inner City Bypass	4,001	1.3%

ID	Road/location	Average weekday AM peak hour traffic (two-way in vehicles)	Indicative predictive construction traffic impact (% increase)
16	Newcastle Road, east of Newcastle Inner City Bypass	4,498	1.1%
17	Croudace Street, north of Elder Street	2,774	1.8%
18	Lookout Road, south of Russell Road	3,728	1.4%
19	Lookout Road, south of McCaffrey Drive	3,606	1.4%

Table 6-10 Impact of estimated worst-case construction traffic on current (2014) PM peak traffic volumes

ID	Road/location	Average weekday PM peak hour traffic (two-way in vehicles)	Indicative predictive construction traffic impact (% increase)
1	Charlestown Road, south of Carnley Avenue	4,638	1.1%
7	Lookout Road, north of McCaffrey Drive	3,986	1.3%
10	Newcastle Road, east of Croudace Street	3,998	1.3%
11	Newcastle Inner City Bypass, north of Newcastle Road	2,767	1.8%
12	Newcastle Road, west of Newcastle Inner City Bypass	3,599	1.4%
16	Newcastle Road, east of Newcastle Inner City Bypass	4,387	1.1%
17	Croudace Street, north of Elder Street	3,114	1.6%
18	Lookout Road, south of Russell Road	3,618	1.4%
19	Lookout Road, south of McCaffrey Drive	3,917	1.3%

John Hunter Hospital

As described in Section 6.3.2, CAR2 would have access from the John Hunter Hospital road network, with construction traffic passing in close proximity to Ronald McDonald House. CAR2 would be predominantly used for light vehicle access, although haulage of excavated material from cut 1 to site compound A may occur during construction of the southern interchange. As described in Section 6.4.2, this is predicted to result in up to 144 vehicle movements (two way) per day over a period of 85 days as a worst case scenario if trucks only are used. If truck and trailer were to be used it is estimated that about 84 trips per day would be required for a 76 day period.

Use of the John Hunter Hospital road network for haulage activities would increase traffic volumes passing through the intersection of Kookaburra Circuit and Lookout Road. Table 3-3 shows that an average of about 15,300 vehicles use Kookaburra Circuit each day. If CAR2 was used by 144 heavy vehicles for haulage as described above and 200 light vehicle movements occurred for staff travel (as described in Table 6-7), this would represent a 2.2 per cent increase in vehicle movements on Kookaburra Circuit (the John Hunter Hospital access road). This is not expected to result in material impacts to traffic movements within the John Hunter Hospital road network.

Construction traffic accessing the entry point for CAR2 would use the road used to access the lower levels of the hospitals' Car Park No.1 and Ronald McDonald House. This road is a two lane road running downhill from Kookaburra Circuit to Car Park No. 1 which includes a pedestrian crossing between Ronald McDonald House the car park. The road ends at boom gates at the entrance to Car Park No. 1. Construction vehicles using this road would typically travel at low speeds on this road to maintain a safe entrance or exit speed from CAR2. This may cause impacts for pedestrians and delays for vehicles travelling to or from Car Park No. 1 or Ronald McDonald House. Traffic and

pedestrian controls would be established to minimise these impacts.CAR2 mostly follows an existing fire trail and an access track used for the recently completed extension of Car Park No. 1. Use of this access road for construction traffic has recently occurred without significant impacts occurring to Ronald McDonald House and Car Park No. 1.

As described in Section 6.3.1, consultation would be carried out with the John Hunter Hospital and Hunter New England Local Health District, and Ronald McDonald House to establish a set of rules for use of this road during peak periods, prior to the commencement of construction. Traffic and pedestrian controls would be established in accordance with a construction traffic management plan to minimise potential pedestrian and local traffic impacts.

6.5.4 Temporary traffic management

All construction activities are expected to be completed while maintaining through traffic on existing roads. No requirements for diversions of traffic along other road routes have been identified for the project. Temporary traffic management measures would be implemented at various stages of the project in accordance with the Traffic Control at Worksites (Roads and Traffic Authority 2010) document. This includes:

- Modification to lane widths to facilitate the safe entry, exit and movement of plant and materials and allow for construction staging of proposed works in close proximity to existing roads
- Placement of separation barriers to protect live traffic from the worksites
- Reducing speed zones where existing road conditions are adversely modified by the construction effort
- Reducing shoulder widths to allow for tie in works to be completed
- Traffic detours
- Stop/go controls
- The use of temporary directional and advisory signage as well as Variable Message Signs would be used throughout the surrounding road network where necessary.

As described in Section 6.2.1, the construction contractor would prepare and implement a CEMP and associated CTMP to define traffic controls required for specific construction activities. These documents would be prepared in accordance with Roads and Maritime's standard specifications, the contract for constructing the project, the EIS and approval conditions.

6.5.5 Impacts on other travel modes

Heavy and restricted access vehicles and public transport

Temporary delays may occur for heavy and restricted access vehicles and buses travelling through the study area due to increased traffic levels and the implementation of the temporary traffic management measures described in Section 6.4. Due to the high existing traffic volumes passing through the area and the low levels of additional traffic that would be generated by the project, impacts from a temporary increase in traffic volume during construction is expected to have very minor impacts.

Section 5.6.2 describes the changes that would be required to bus stops as part of the project. No additional alterations or relocations of bus stops are expected to be required for construction of the project.

Bus passengers would be impacted if they intend to use the bus stops that are to be removed or relocated for the project. Consultation would be carried out with bus operators during the detailed design phase to finalise bus stop closures and relocations prior to construction and to ensure changes to bus stops are communicated to bus users prior to commencement of construction.

Bushfire and emergency services

Construction of the project would impact on several fire trails that cross the main project alignment in an east-west direction (indicative location of these trails are shown on Figure 5-14a-d). The construction phase of the project would be planned and to ensure adequate access to the existing fire trails are maintained. Further consultation will be carried out with the relevant fire authorities during the detailed design of the project.

Changes to traffic arrangements and temporary traffic management measures established on existing roads during construction may disrupt the passage of emergency services that need to use these roads. Emergency services would be notified in advance of any changes to traffic conditions (ie partial or total road closures).

Cyclists and pedestrians

Temporary delays and/or detours may be required where construction activities occur across existing cycling routes and shared paths, such as the R5 – Newcastle City Centre to Glendale cycleway running through Jesmond Park. Alternative cycling and pedestrian routes would be developed during the detailed design phase and detours established as required during the construction period.

Property access and parking

Section 5.7 describes the permanent property access and parking changes that would result from construction of the project. It is not currently anticipated that any additional property access and parking restrictions would be required during the construction period. Incidental additional use of existing parking areas may occur during the construction period by construction staff, however; construction staff would be expected to park within the site compound areas described in Section 6.2.4.

7 Management of traffic and transport impacts

The following management and mitigation measures would be implemented to mitigate construction and operational traffic impacts from the project:

- Development of a Construction Traffic Management Plan (CTMP) for the project, prior to commencement of construction. The plan will be developed in consultation with landholders affected by the construction works, such as: Newcastle City Council; Hunter Medical Research Institute; NSW Health Infrastructure; Hunter New England Local Health District and Ronald McDonald House.

  The CTMP will detail how the traffic associated with construction of the project would be managed in accordance with Roads and Maritime's *Traffic Control at Work Sites* (Roads and Traffic Authority 2010) and relevant Australian Standards (AS) such as AS1742 Manual of Uniform Traffic Controls Devices (Standards Australia 2011) and the work site manual *Roads and Maritime Specification G10* (Roads and Maritime 2015).

  This plan will include, but not be limited to, the following:

  - Confirmation of the location of areas ancillary sites, and how these would be accessed
  - Scheduling of construction works, particularly deliveries, to be completed outside of peak periods where possible
  - Requirements for notification of road users where traffic controls, detours or road closures are to be implemented
  - Requirements for notification of emergency services prior to any changes to traffic conditions occurring such as detours, partial or full road closures
  - Requirements for notification of local residents and land users where temporary property access restrictions or parking is required
  - Specific traffic controls to be implemented to manage and regulate traffic movements during construction
  - Measures to assess damage to any local roads used for construction access and requirements for these to be repaired where required and maintained in a serviceable condition.
- A Vehicle Movement Plan (VMP) will be prepared as part of the CTMP which will assess construction related heavy and restricted access vehicle movements in to, and out of construction sites and outline:
  - Details of haulage routes and confirmation of vehicle movements
  - Traffic rules for vehicles travelling to construction areas, such as restriction of heavy and restricted access vehicles to designated routes and limitation of U-turn movements on Newcastle Road
  - Measure to minimise the occupation of existing roads
  - Measures to manage and mitigate traffic impacts to John Hunter Hospital, in particular, impacts to Ronald McDonald House
  - Requirements for condition surveys or local roads prior to construction.
- The contractor will be required to obtain any required licences and permits, such as a Road Occupancy Licence, which would be required for any works or traffic controls within a public roadway

- Consultation will be carried out with any potentially affected receivers and approval would be obtained from Roads and Maritime and the NSW Environmental Protection Authority, prior to any works being carried out outside proposed construction hours
- During detailed design, Roads and Maritime will carry out consultation with affected landowners about changes to property access
- Consultation will be carried out with Newcastle City Council regarding the relocation of three existing disabled car parks located on Newcastle Road adjacent to Jesmond Park
- Consultation with Newcastle Buses will be carried out regarding the relocation of a number of existing bus stops along Newcastle Road and Lookout Road/Croudace Street, during detailed design

Consultation with relevant fire authorities will be carried out during the detailed design phase regarding the construction of additional fire trails and to ensure access is maintained to fire trails maintained during construction.

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9 Glossary

Table 9-1 Glossary of Terms

Term	Definition
%	Per cent
A37	Route of National Significance A37
AADT	Annual Average Daily Traffic
ARI	Average Recurrence Interval
AS	Australian Standard
CBD	Central Business District
CEMP	Construction Environment Management Plan
CH	Chainage
CTMP	Construction Traffic Management Plan
DP&E	Department of Planning and Environment
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning & Assessment Act 1979*
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
HW23	State Highway 23
km	Kilometres
LGA	Local Government Area
LHTM	Lower Hunter Traffic Model
LoS	Level of Service
m	Metres
m^3	Cubic metres
MR	Main Road
OD	Origin-destination
Roads and Maritime	Roads and Maritime Services
RTA	Roads and Traffic Authority
SEARS	Secretary's Environmental Assessment Requirements
The project	Newcastle Inner City Bypass – Rankin Park to Jesmond
VHT	Vehicle Hours Travelled
VKT	Vehicle Kilometres Travelled
VMP	Vehicle Movement Plan

Appendices

Appendix A Microsimulation Traffic Model Calibration and Validation Report, October 2015

aurecon

NSW Transport Roads & Maritime Services

Newcastle Inner City Bypass Rankin Park to Jesmond Microsimulation Traffic Model Calibration and Validation Report

Ref: 245321

PSC No. 14.2533.2117

Prepared for: Roads and Maritime Services

November 2015

Document control record

Document prepared by:

Aurecon Australia Pty Ltd

ABN 54 005 139 873

23 Warabrook Boulevard
Warabrook NSW 2304
Australia

T +61 2 4941 5415
E newcastle@aurecongroup.com
W aurecongroup.com

Document control							aurecon
Report title		Traffic Microsimulation Model Calibration and Validation Report					
Document ID		RP2J-TMCVR	**Project number**		245321		
File path		pw:\\DESIGNSHARE.AU.AURECON.INFO:PW_PROD_AU\Documents\Projects\24xxxx\245321 - Rankin Park to Jesmond\3 Project Delivery\Engineering\Traffic\RP2J-Traffic Modelling Calibration and Validation Report.docx					
Client		Roads and Maritime Services	**Client contact**		Matthew Mate		
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**	
0	9 February 2015	Draft for Client review	LMB	LMB	CRB	CSM	
1	24 February 2015	Incorporated client comments	LMB	LMB	CRB	BM	
2	15 September 2015	Final draft for SDI Report	LMB	LMB	CRB	BM	
3	1 November 2015	Final for RSD Report	LMB	LMB	CRB	BM	
Current revision		3					

Approval			
Author signature		Approver signature	
Name	L Beban	Name	B Mortimore
Title	Transport Engineer	Title	Project Manager

Newcastle Inner City Bypass Rankin Park to Jesmond

Microsimulation Traffic Model Calibration and Validation Report

Date November 2015
Reference 245321

Aurecon Australia Pty Ltd
ABN 54 005 139 873
23 Warabrook Boulevard
Warabrook NSW 2304
Australia

T +61 2 4941 5415
E newcastle@aurecongroup.com
W aurecongroup.com

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1 Introduction

This report documents the development of microsimulation base traffic models associated with the Newcastle Inner City Bypass – Rankin Park to Jesmond project (RP2J). This report focuses on the base model development, operation, and summarises the results of the model calibration / validation against relevant modelling guidelines.

1.1 Background

The Newcastle Inner City Bypass is part of Roads and Maritime Services' long-term strategy to provide an orbital road within Newcastle's road network to connect the Pacific Highway at Bennetts Green and the Pacific Highway at Sandgate, see Figure 1-1.

Figure 1-1: Overall Newcastle Inner City Bypass

Aurecon was appointed by Roads and Maritime Services (Roads and Maritime), in a letter of acceptance dated 27 November 2014, as the Professional Services Contractor (PSC) to provide the project development services for the concept design and environmental assessment for the Newcastle Inner City Bypass – Rankin Park to Jesmond (RP2J).

The scope of work includes determining the existing traffic and transportation patterns within the study area, assessing interchange/intersection options, investigating potential impacts of the project during construction and operation, and producing a traffic and transportation assessment report as part of the environmental assessment.

An integral element of this traffic assessment relates to the development of base traffic models representing existing traffic conditions. The base traffic model will then be used to develop future year scenarios for the assessment of bypass options against retention of the existing road network configuration.

Aurecon has developed a staged approach to track progress with each element of the model and reporting development. The staged approach starts with the development of a base model with which all option testing will be undertaken.

The overall study methodology is shown in Figure 1-2.

This model calibration / validation report documents model development through Stages 3 to 5 of this methodology.

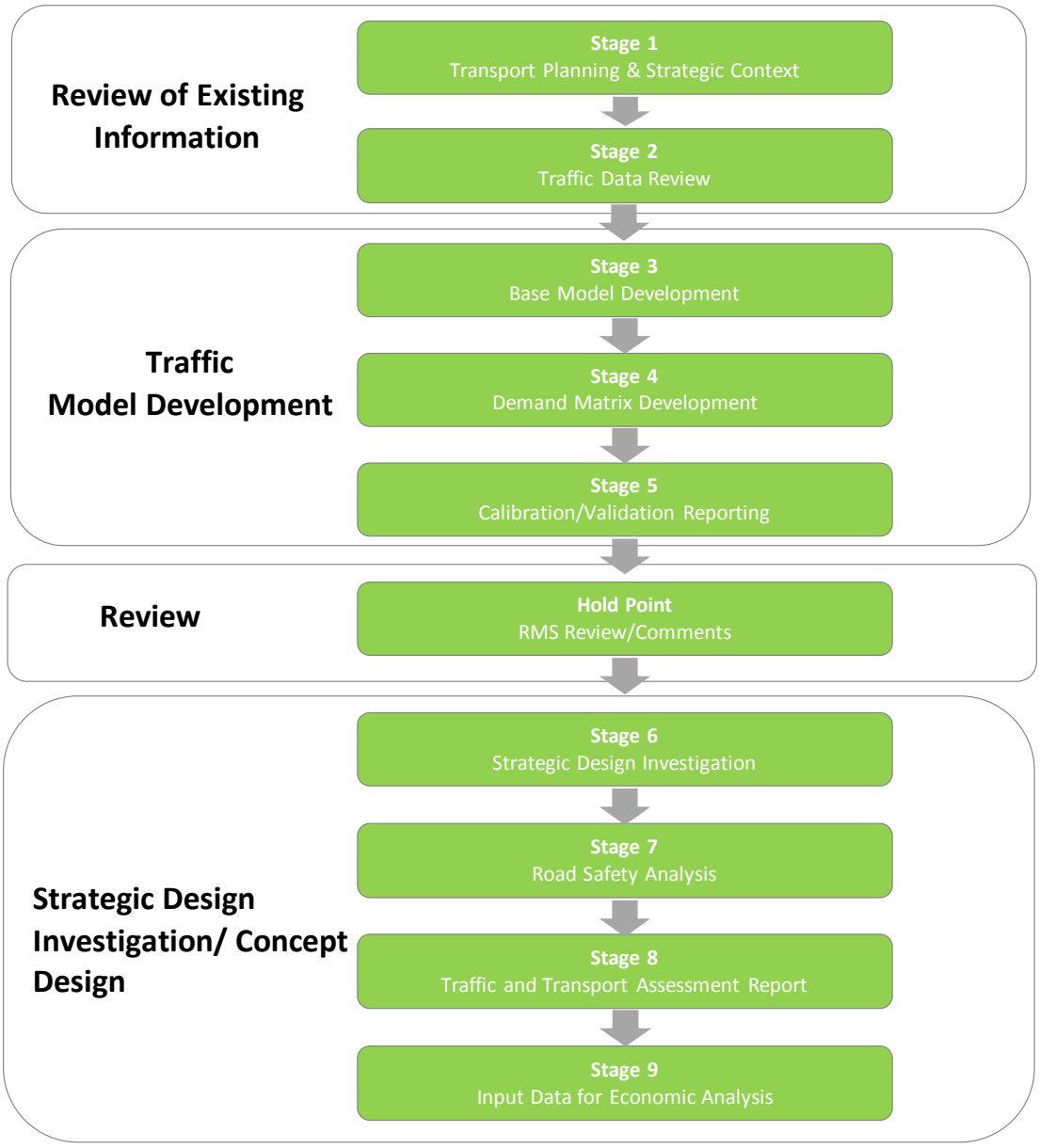


Figure 1-2: Study Methodology

2 Model Form

2.1 Paramics

The traffic model software package used for the project is Quadstone Paramics (Paramics).

Paramics represents traffic flows within a network, by simulating individual vehicles and their interactions with other vehicles and the surrounding road environment. As with real traffic conditions, these interactions can vary for each model run, resulting in unique results.

Paramics version 6.9.3 has been used in the development of this base model. All subsequent option testing should be undertaken using the same version of the software.

To obtain statistically meaningful results the average network performance is taken from multiple simulation runs. Roads and Maritime guidelines recommend a minimum of five model runs to be undertaken to obtain statistically meaningful results, and specify seed values to be used for these runs as detailed further in Section 6.2.

2.2 Base Model Network

The base model network, as shown in Figure 2-1, primarily covers the A37 route from the south via Charlestown Road, Lookout Road, Croudace Street, Newcastle Road and the existing section of the Newcastle Inner City Bypass north of Newcastle Road.

All major roads within this area have been integrated in the model. Roads carrying relatively low traffic volumes that are considered to not substantially influence traffic flow within the modelled area have not been included.

The base model was compiled using available digital aerial photography, with site visits to confirm the accuracy and operation of the modelled network. The model was constructed to a 1:1 scale, ensuring correct vehicle operation and accurate reaction to the road geometry and interaction with other vehicles.

2.3 Model Periods

The Paramics model has been developed for a morning and evening traffic periods:

- Morning period (AM) – 07:00 to 09:00
- Evening period (PM) – 16:00 to 18:00

The following peak hours have been calculated for each of the above model periods, based on observed traffic survey data.

- Morning peak hour – 07:30 to 08:30
- Evening peak hour – 16:30 to 17:30

Model durations of greater than one hour ensure the periods either side of the peak hour are adequately modelled. This allows the model to adequately accommodate peak hour spreading which could result with future growth within the study area.

2.4 Site Visits

Site visits were undertaken by Aurecon staff to assess current traffic conditions during both peak periods, confirm the model form and ensure realistic vehicle behaviour is replicated within the model.

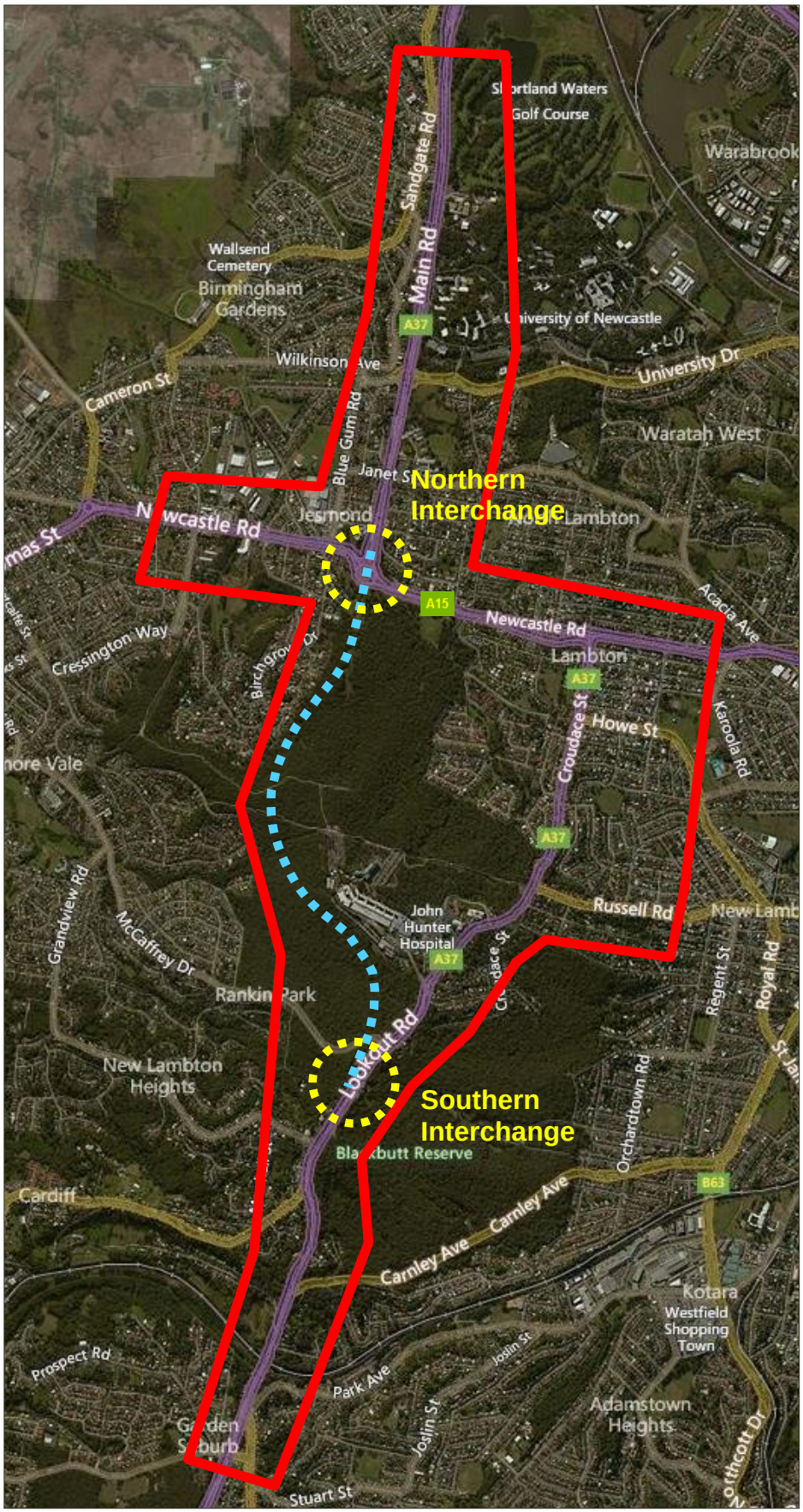


Figure 2-1: Modelled study area

3 Traffic Data Collection

3.1 Survey Data

An extensive range of traffic survey data of existing traffic conditions has been provided by Roads and Maritime to assist with the base traffic model development.

The traffic survey data provided consisted of:

- Intersection turning movement counts
- Travel time data along two routes within the study area as detailed in Section 3.1.2.
- Origin-Destination (OD) surveys to ascertain trip distribution within the study area
- Classified link counts

More information on the traffic survey data provided for the development of the Paramics traffic modelling study can be found in the related traffic modelling report titled *Newcastle Inner City Bypass, Rankin Park to Jesmond Traffic Modelling Report – Lower Hunter Traffic Model (Hyder, 2015)*

3.1.1 Intersection Turning Movements Counts

Intersection turning movement count surveys were undertaken in morning and evening peak periods.

Data has come from two sources:

- Counts undertaken on behalf of AECOM on Tuesday 24th of June 2014
- Counts undertaken on behalf of Roads and Maritime on a number of days between April and June 2014

In total 18 intersections were surveyed by vehicle type in 15 minute intervals as shown below:

- Blue Gum Road/ University Drive
- Newcastle Inner City Bypass (NICB)/ University Drive
- University Access/ University Drive
- Newcastle Inner City Bypass (NICB)/ Newcastle Road
- Blue Gum Road/ Newcastle Road
- Drury Street/ Newcastle Road/ Victory Parade
- Douglas Street/ Newcastle Road
- Croudace Street/ Dent Street/ Newcastle Road
- Morehead Street/ Newcastle Road
- Croudace Street/ Howe Street
- Croudace Street/ Mitchell Street/ Pride Avenue
- Croudace Street/ Lookout Road/ Russell Road
- Lookout Road/ Jacaranda Drive
- Lookout Road/ Hospital Access
- Lookout Road/ McCaffrey Drive
- Grandview Road/ Lookout Road
- Cardiff Road/ Lookout Road/ Charlestown Road
- Carnley Avenue/ Charlestown Road

3.1.2 Journey Time Data

Roads and Maritime have supplied travel time data collected for the following two routes for 2013 and 2014 for use in validating the base model.

Travel time data has been provided for the peak direction in each of the peak periods.

- **Route 4:** Newcastle Road from Douglas St to Morehead Street
- **Route 7:** A37 Route Charlestown Road – Lookout Road – Croudace Street – Newcastle Road – ICB – University Drive

The observed routes are illustrated Figure 3-1:

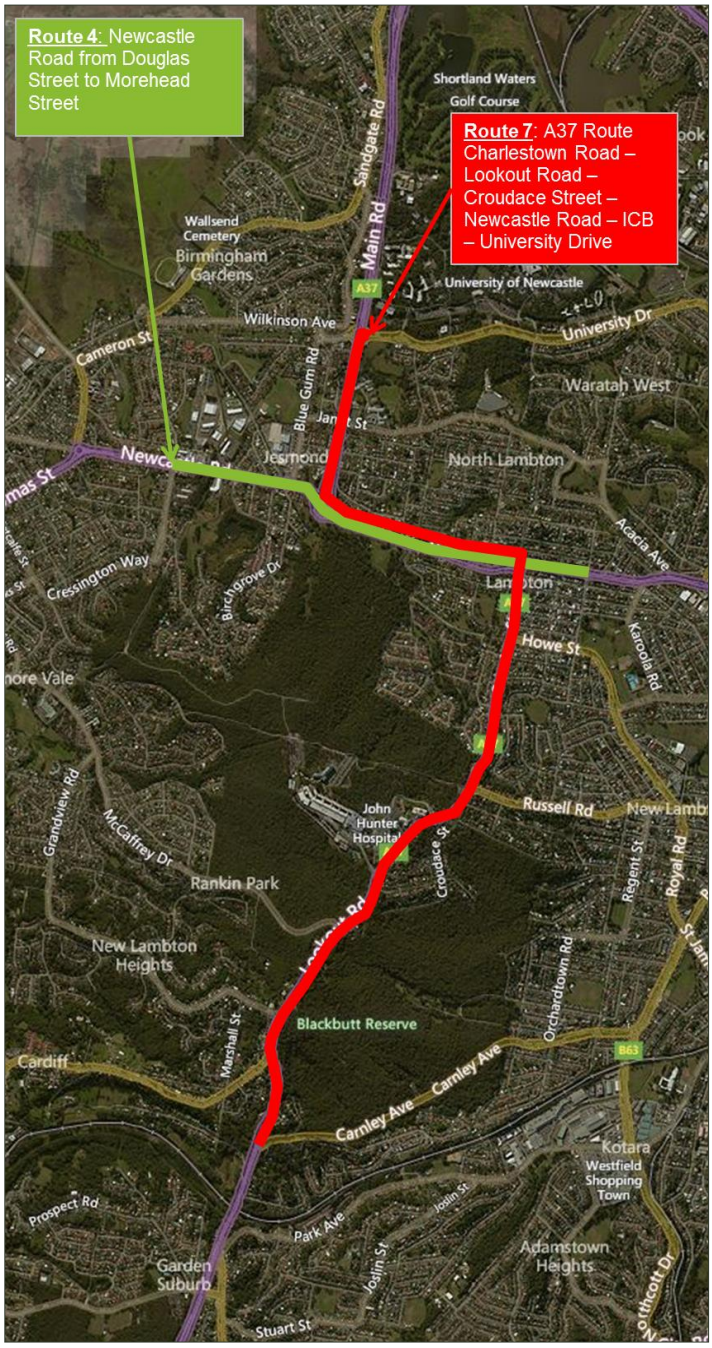


Figure 3-1: Observed journey time routes

3.1.3 Origin-Destination Surveys

Roads and Maritime commissioned two origin-destination surveys to ascertain the distribution of existing trip demand within the study area.

Stations were located at a number of points within and / or adjacent to the modelled area as shown in Figure 3-2. Video units were used to detect and match number plates over a 24 hour period in October 2014 and for a 3-hour period in the morning and evening peaks in May 2015.

Further details and analysis of the two origin-destination surveys are provided in the Hyder report *"Newcastle Inner City Bypass Rankin Park to Jesmond, Traffic Modelling Report – Lower Hunter Traffic Model, October 2015"*.

Figure 3-2: Origin-Destination and classified link count survey station locations

Outputs from these origin-destination surveys have been used in determining and reviewing the trip demand matrices for the model as further detailed in Section 4.2.

3.1.4 Classified Midblock Traffic Count Surveys

Classified midblock traffic count surveys have been undertaken at a number of locations within the study area.

The surveys were undertaken over two seven day periods, namely 7 October to 13 October 2014 and 5th May to 11th May 2015.

The locations are of the surveys are listed below and are also illustrated in Figure 3-2:

- 1 Charlestown Road, south of Carnley Avenue
- 2 Carnley Avenue, east of Charlestown Road
- 3 Cardiff Road, west of Lookout Road
- 4 Grandview Road, west of Lookout Road
- 5 McCaffrey Drive, west of Lookout Road
- 6 Croudace Road, west of Grandview Road
- 7 Lookout Road, north of McCaffrey Drive
- 8 Kookaburra Circuit (John Hunter Hospital access)
- 9 Russell Road, east of Lookout Road
- 10 Newcastle Road, east of Croudace Street
- 11 Newcastle Inner City Bypass, north of Newcastle Road
- 12 Newcastle Road, west of Newcastle Inner City Bypass
- 13 Dent Street, north of Newcastle Road
- 14 Jacaranda Drive (John Hunter Hospital access)
- 15 Howe Street, east of Croudace Street
- 16 Newcastle Road, east of Newcastle Inner City Bypass
- 17 Croudace Street, north of Elder Street
- 18 Lookout Road, south of Russell Road
- 19 Lookout Road, south of McCaffrey Drive

3.1.5 Traffic Signal Data

SCATS traffic signal operation data from Intersection Diagnostic Monitor (IDM) outputs provided was obtained for 16 traffic signal installations within the study area. This data was used to develop fixed signal timings for each of the signalised intersections in the two modelled periods. Outputs from the History (HIST) file were also used to supplement this information.

The signalised intersections and pedestrian crossings are listed below:

- Douglas Street/ Newcastle Road
- Drury Street/ Newcastle Road/ Victory Parade
- Blue Gum Road/ Newcastle Road
- Main Road/ Newcastle Road
- Dent Street/ Croudace Street/ Newcastle Road
- Morehead Street/ Newcastle Road
- Howe Street/ Croudace Street
- Pride Avenue/ Mitchell Street/ Croudace Street
- Croudace Street/ Russell Road/ Lookout Road
- Jacaranda Drive/ Lookout Road
- Hospital Access/ Lookout Road
- McCaffrey Drive/ Lookout Road

- Cardiff Road/ Charlestown Road/ Lookout Road
- Carnley Avenue/ Charlestown Road
- Jesmond Park Signalised Pedestrian Crossing
- Lambton Primary School Signalised Pedestrian Crossing.

In addition, offsets between intersections (signal coordination) were determined for input to the models from the LX regional configuration file also provided by Roads and Maritime.

Roads and Maritime also provided SCATS Volume Store (VS) traffic loop count data as a further source to supplement traffic surveys.

3.1.6 Public Transport Information

Existing bus stops and services have been added to the model. Bus stop locations were derived from aerial photography, Google Transit Feed and on-site confirmation. Bus routes and timetabling have been provided by Newcastle Buses.

4 Traffic Demand and Assignment

4.1 Zone Structure

Zones are defined as areas in the model from which traffic is generated or attracted. In total 26 zones have been applied to the model.

The zone layout is shown in Figure 4-1 and Table 4-1.

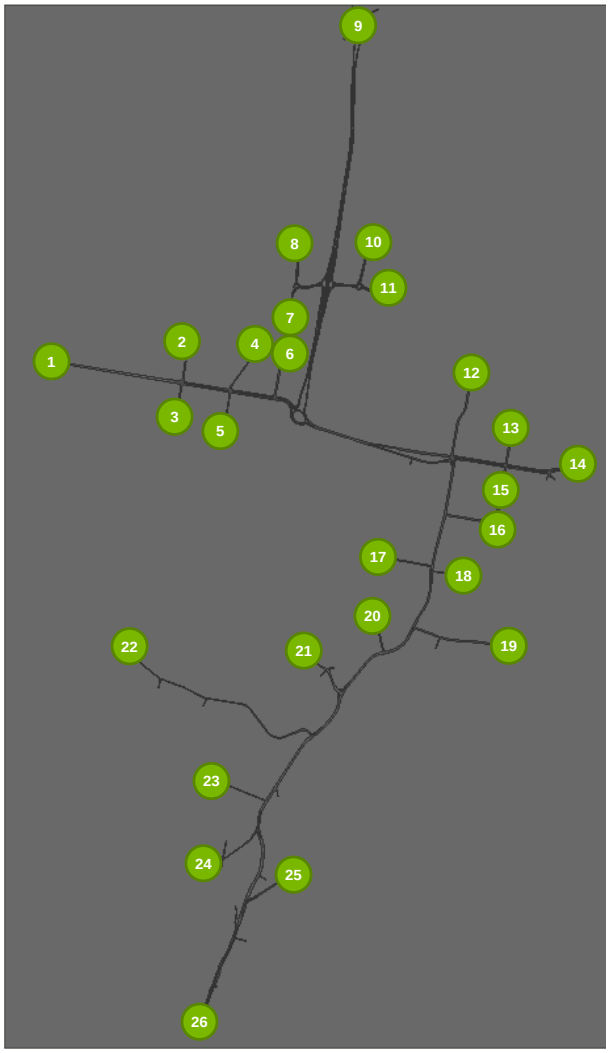


Figure 4-1: Network zone configuration

Table 4-1: Model zone system

Zone Number	Location
Zone 1	Newcastle Road (west)
Zone 2	Douglas Street (north)
Zone 3	Douglas Street (south)
Zone 4	Drury Street
Zone 5	Victory Parade
Zone 6	Blue Gum Road
Zone 7	Blue Gum Road
Zone 8	Wilkinson Avenue
Zone 9	Newcastle Inner City Bypass
Zone 10	Newcastle University Access Road
Zone 11	University Drive
Zone 12	Dent Street
Zone 13	Morehead Street (north)
Zone 14	Newcastle Road (east)
Zone 15	Morehead Street (south)
Zone 16	Howe Street
Zone 17	Pride Avenue
Zone 18	Mitchell Street
Zone 19	Russell Road
Zone 20	Jacaranda Drive
Zone 21	Kookaburra Circuit
Zone 22	McCaffrey Drive
Zone 23	Grandview Road
Zone 24	Cardiff Road
Zone 25	Carnley Avenue
Zone 26	Charlestown Road

4.2 Demand Matrix Development

The available origin-destination survey data (refer section 3.1.3) in combination with the turning movement count data has been used to develop a set of trip demand matrices for both morning and evening peak periods. This has been prepared so that the distribution of trip demand in the base model adequately replicates existing conditions.

To provide a more refined representation of the split of vehicle types and movements within the study area, separate trip demand matrices have been developed for light (cars) and heavy vehicles.

4.2.1 Paramics Matrix Development

The methodology for the development of the trip demand matrices for each of the modelled periods is detailed below.

1. Analysis of turning movement counts was undertaken on a network wide basis. Link totals between surveyed intersections were compared and where necessary minor adjustments made to balance trips totals between intersections. Classified link counts and SCATS VS data were referenced in this adjustment process.

2. Origin-destination (OD) survey data was analysed to determine the distribution of trips throughout the network for application to the Paramics model zone structure and to develop a Prior Matrix. Where possible, data from stations in the OD survey was mapped directly to a zone within the Paramics model. In some instances OD survey stations represented a number of zones within the Paramics model and some disaggregation of this data was required. Turning movement counts were used to assist this process.

3. The Prior Matrix two hour matrices were adjusted to collected survey data using the Furness method. Trip end totals for each Paramics zone were formed from turning movement survey data. Known OD movements such as trips from one external zone to another external zone were “frozen” to remain unadjusted through the Furnessing process.

4. The resulting trip demand matrices from this process were applied to the model and an iterative loop of testing and matrix refinement undertaken to achieve an appropriate level of model calibration.

4.3 Traffic demand release profiles

Traffic demand release profiles have been applied to dispense traffic demands in defined time intervals over the model periods. These profiles were developed based on the traffic survey data which was collated in 15 minute intervals.

The traffic demand release profiles, labelled as traffic flow factors, are displayed in Table 4-2 and are a percentage of the two hour trip demand matrices.

In the evening peak, an additional profile has been developed for Newcastle East (Zone 14) to better represent the release of traffic from this area of the road network.

Time	Profile		Time	General	Newcastle East
07:00	8.16%		16:00	12.18%	11.91%
07:15	9.40%		16:15	12.60%	12.91%
07:30	12.96%		16:30	12.77%	13.13%
07:45	13.80%		16:45	12.78%	13.32%
08:00	13.96%		17:00	12.86%	13.40%
08:15	14.33%		17:15	12.61%	12.79%
08:30	14.00%		17:30	12.42%	11.59%
08:45	13.39%		17:45	11.78%	10.74%

Table 4-2: Traffic Demand release profiles

4.4 Traffic assignment

The base model network being a linear network does not contain any route choice elements. However consideration of the effects of route choice forms part of option testing with the bypass route in place.

For option assessment modelling, route choice parameters were established through evaluation of parameters and outputs from the Lower Hunter Traffic Model (LTHM). Comparison was made of predicted flows on the existing and new bypass routes from the LHTM with those assigned in the Paramics model, along with observation of model operation to inform the development of appropriate values for these parameters.

4.5 Vehicle characteristics

Parameters for vehicle behaviour from the previous model have been reviewed for suitability to take forward with this model. The parameters are to be consistent with those outlined in the Roads and Maritime manual, Roads and Traffic Authority (2009) *Paramics Microsimulation Modelling – RMS Manual v1.0.* These parameters were considered suitable for application in this modelling and through observation of model operation have not been adjusted as part of the calibration process.

5 Model Coding

Through the calibration process adjustments have been made to the modelling parameters to ensure the model replicates the existing observed traffic conditions. This is considered standard traffic modelling practice and forms part of the calibration process.

5.1 Behaviour

Paramics represents the behavioural characteristics of drivers by assuming a normally distributed range of values for aggression and awareness attributes. These influence aspects of model operation such as gap acceptance, lane changing and vehicle following. It is not common practice to alter these values from the software defaults unless there is a strong case for modification. Default values have been retained in the development of this model.

5.2 Configuration

The standard Roads and Maritime Paramics configuration settings as detailed in Roads and Maritime manual, Roads and Traffic Authority (2009) *Paramics Microsimulation Modelling – RMS Manual v1.0* have been applied.

5.3 Road types

Road categories have been applied in accordance with Roads and Maritime standard categories based on speed environment and number of lanes.

5.4 Version

The model has been developed in Version 6.9.3 of Paramics. This was the current version at the time of model development.

5.5 Elevation

Node heights have been applied to the model to ensure the effects of gradient on traffic speed and acceleration/ deceleration are accounted for in the modelling. The TWOPAS gradient model feature of Paramics has been enabled, consistent with the guidelines described in the Roads and Maritime manual, Roads and Traffic Authority (2009) *Paramics Microsimulation Modelling – RMS Manual v1.0.*

5.6 Visibility

Visibility settings have been adjusted on links on the approaches to the Jesmond roundabout to reflect the high level of visibility available to vehicles at this roundabout and to assist with calibration of throughput and observed queues on these approaches. Similarly, visibility settings have been adjusted on the slip lane left turns from McCaffrey Drive into Lookout Road and from Croudace Street into Newcastle Road.

5.7 Gap settings

Gap settings have been adjusted for movements at the Jesmond Roundabout to improve replication of observed operation and vehicle throughput. This consisted of reducing gap acceptance parameters for the southbound movement from the stop line at Main Road (Newcastle Inner City Bypass) to circulating flow to make a subsequent right turn to Newcastle Road and the westbound movement from the stop line at Newcastle Road to circulating flow to make a subsequent right turn to Main Road.

5.8 Headway factors

Headway factors have been applied to eastbound links in advance of the Croudace Street/ Dent Street/ Newcastle Road intersection. These were applied to assist in the replication of observed queuing on this approach. This measure has been used in conjunction with adjustments to the release profile and lane choice on this approach to match observed driver behaviour.

5.9 Lane choice

Where necessary, lane choice rules have been used to make sure vehicles are in the appropriate lane in advance of decision points. Where lane choice rules have not been sufficient to adequately replicate lane choice, restrictions have been added to the model.

6 Model Calibration

6.1 Calibration/ Validation criteria

Model calibration/ validation is necessary to ensure that a model accurately represents an existing traffic situation within predetermined limits and can be used with confidence to test alternatives.

Calibration for this model has been based on the following:

- **Vehicle Behaviour:** Undertaking a visual check to confirm the observed on-street vehicle behaviour is consistent with that observed in the model
- **Turn Counts:** Comparing observed and modelled turning movements for general traffic over the modelled peak hour periods
- **Link Counts:** Comparing observed and modelled link counts for general traffic over the modelled peak hour periods
- **Journey Times:** Comparing observed and modelled journey travel times for general traffic over the modelled peak hour periods

The model has been calibrated/ validated with reference to the criteria as outlined in the Roads and Maritime document *Traffic Modelling Guidelines, Version 1.0, February 2013.* Section 11.5 details suggested calibration and validation criteria for microsimulation models and these have been applied in this assessment, as outlined in Table 6-1 and Table 6-2.

For the purposes of the calibration reporting, the core area criteria has also been applied to outputs for the modelled study area as a whole. The application of the core area criteria to the entire model network is considered very conservative and has been used for the purposes of refining the model further to ensure it provides a thorough and robust base model for options assessment.

Table 6-1 Roads and Maritime calibration and validation criteria

Topic	Network Wide	Core Area
Link or Turn	Tolerance limits for network-wide area: *GEH < 5 Minimum 85 per cent of observations to be within tolerance limits* *Turn or link flows with GEH > 10 require explanation in reporting*	Tolerance limits for core area: *Flows < 99 – to be within 10 vehicles of observed value* *Flows 100 to 999 – to be within 10 per cent of observed value* *Flows 1000 to 1999 – to be within 100 vehicles of observed value* *Flows > 2000 – to be within 5 per cent of observed value* *100 per cent of observations to be within tolerance limits*
Link or Turn	Plots of observed vs modelled hourly flows required for all observations *Plots to include lines showing GEH = 5 tolerance limits* *R^2 value to be included with plots and to be > 0.9* *Slope equation to be included with plots (intercept to be set to zero)*	Plots of observed vs modelled hourly flows required for all observations *Plots to include lines showing core tolerance limits* *R2 value to be included with plots and to be > 0.95* *Slope equation to be included with plots (intercept to be set to zero)*

Table 6-2 Journey time criteria

Journey times	Criteria	
	Journey time average	Average modelled journey time to be within 15 per cent or one minute (whichever is greater) of average observed journey time for full length of route.
	Section time average	Average modelled journey time to be within 15 per cent of average observed journey time for individual sections.
	Journey time variability	Average and 95 per cent confidence intervals to be plotted for observed and modelled travel times for each journey time route. Comparison to be to modeller and Roads and Maritime satisfaction.

All data listed in Section 3.1 was used to calibrate the model. Detailed comparisons between observed and modelled calibration statistics are presented in the following sections for the peak hours. Where applicable the results reference the criteria as set out in the above tables.

6.2 Model runs

Five runs of each model have been undertaken. In accordance with Roads and Maritime requirements seed values 28, 560, 2849, 7771 and 86524 have been utilised throughout the calibration process.

6.3 Model stability

The coefficient of variation (COV) has been used to assess the variability between each run on the network statistics. The COV is a measure of the variation between model runs. Typically 5% is considered a good level of correlation. The coefficient of variance is calculated by dividing the mean by the standard deviation as follows:

$$COV = \frac{SD}{\mu} \times 100$$ Where: SD = Standard Deviation, μ = Mean

Table 6-3: Morning period, network statistics (5 model runs)

Statistic	Total travel time (hr)	Total vehicle km travelled	Total number of Vehicles	Mean speed (kph)
Mean	2,359	90,347	28,515	38
Std Dev	44	818	221	1
Min	2,314	88,917	28,168	37
Max	2,419	90,886	28,766	39
Range	105	1,969	598	2
CoV	1.9%	0.9%	0.8%	2.1%

Table 6-4: Evening period, network statistics (5 model runs)

Statistic	Total travel time (hr)	Total vehicle km travelled	Total number of Vehicles	Mean speed (kph)
Mean	2,758	99,119	31,964	36
Std Dev	57	219	84	1
Min	2,702	98,893	31,903	35
Max	2,825	99,467	32,104	37
Range	124	574	201	2
CoV	2.1%	0.2%	0.3%	1.9%

The general network statistics for both periods predict a CoV of less than 4%. It is considered the model is stable.

6.4 Turn count calibration

The following sections make comparisons between observed and modelled turn counts for each peak hour period, by organising the observed counts into volume ranges. This allows the data to be assessed with more emphasis placed on the higher volume movements. The comparison includes averaged modelled results from all five runs. Graphical comparisons are also presented for each period.

Tables of observed and modelled turn count values for individual movements are provided in Appendix A.

6.4.1 Morning peak hour turn count comparisons

Table 6-5 provides the results comparing the observed and modelled count data for each individual link with a survey target during the morning peak hour period. The links have been organised into ranges by their observed count volume.

Table 6-5: Morning peak hour observed versus modelled turn counts

Criteria and Measures	Calibration Targets	Result	Number meeting criteria	Total number of counts
Network Wide				
GEH Statistic < 5 for Individual Turn Flows	>85% of cases	99%		
R^2 value for modelled vs observed flows for all individual turns	>0.9	0.99		
Core Area				
Individual Turn Volumes				
Within 10 veh/h, for Flow<99	100% of cases	76%	35	46
Within 10%, for 100<Flow<999 veh/h	100% of cases	83%	48	58
Within 100 veh/h, for 1000 veh/h<Flow<1999 veh/h	100% of cases	72%	18	25
Within 5%, for >2000 veh/h	100% of cases	86%	6	7
R^2 value for modelled vs observed flows for all individual turns	>0.95	0.99		

The model shows a good level of calibration to the Roads and Maritime network wide performance criteria.

To provide further confidence in the suitability of the model for the testing of options for the Rankin Park to Jesmond project, further comparison has been undertaken against other calibration criteria as discussed in Section 6.5.3.

The following graph presents a plot of observed counts against modelled counts for the morning peak period with core area calibration tolerances.

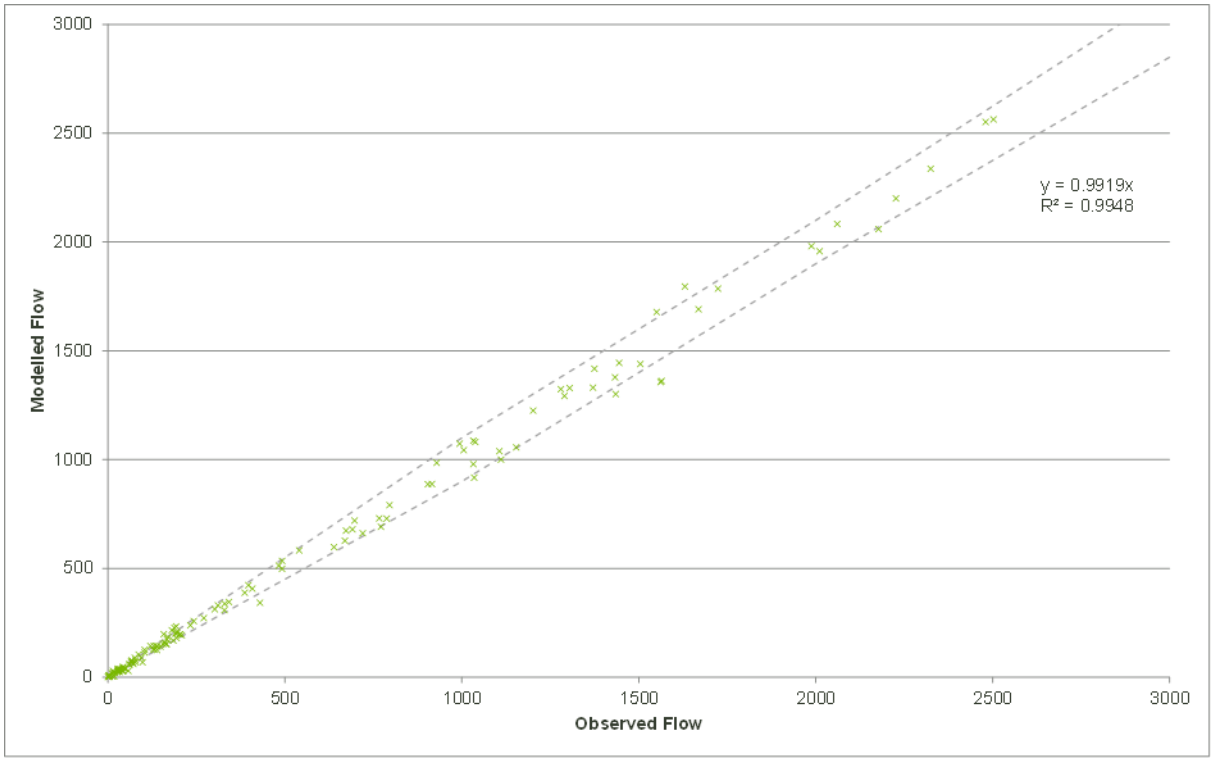


Figure 6-1 - Morning peak hour observed versus modelled turn count plot

The graph illustrates the majority of counts fall within the core calibration criteria, while those that don't meet criteria are generally on the cusp of compliance.

6.4.2 Evening peak hour turn count comparisons

Table 6-6 presents a comparison between observed and modelled count data for each individual turn with a survey target during the evening peak hour period. The turns have been organised into ranges by their observed count.

Table 6-6: Evening peak hour observed versus modelled turn counts

Criteria and Measures	Calibration Targets	Result	Number meeting criteria	Total number of counts
Network Wide				
GEH Statistic < 5 for Individual Turn Flows	>85% of cases	99%		
R^2 value for modelled vs observed flows for all individual turns	>0.9	0.99		
Core Area				
Individual Turn Volumes				
Within 10 veh/h, for Flow<99	100% of cases	71%	32	45
Within 10%, for 100<Flow<999 veh/h	100% of cases	79%	44	56
Within 100 veh/h, for 1000 veh/h<Flow<1999 veh/h	100% of cases	81%	25	31
Within 5%, for >2000 veh/h	100% of cases	100%	4	4
R^2 value for modelled vs observed flows for all individual turns	>0.95	0.99		

The model shows a good level of calibration to the Roads and Maritime network wide performance criteria.

The following graph shows a plot of observed counts against modelled counts for the evening peak hour period with core area calibration criteria.

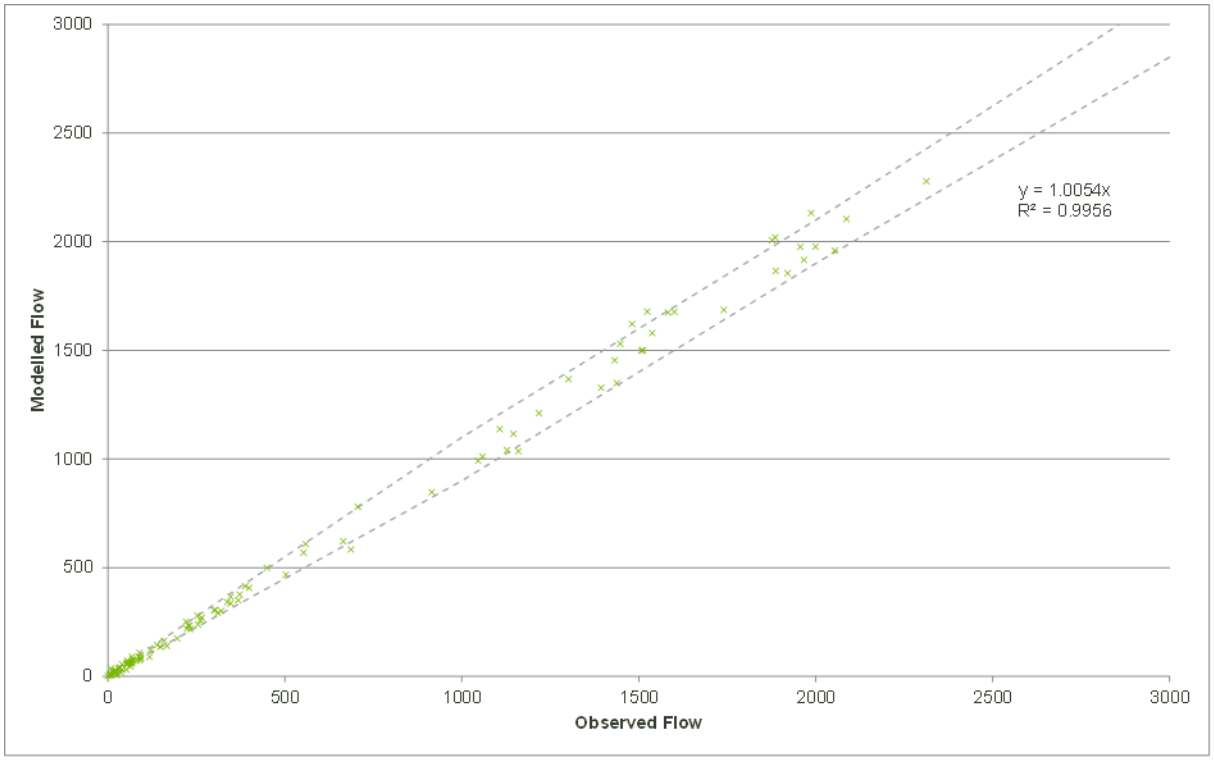


Figure 6-2: Evening peak hour observed versus modelled turn counts

The graph illustrates a strong correlation between observed and modelled counts, reinforced by the R^2 value of 0.99.

6.5 Link count calibration

Link counts have been compared based on approach and exit link flows at intersections, comprised from the same set of data used for turn count comparisons.

The following sections compare the observed and modelled link counts for each peak hour period, by organising the observed counts into volume ranges. This allows the data to be assessed with more emphasis placed on the higher volume movements. The comparison includes averaged modelled results from all five runs. Graphical comparisons are also presented for each period.

Roads and Maritime guidelines recommend modelled link flows to have a minimum R^2 of 0.9. The minimum R^2 value is increased to 0.95 for core areas. The network wide area needs at least 85% of cases to have a GEH < 5. For the core area all cases should fall within calibration criteria for specified flow ranges.

Tables of observed and modelled link count values for individual movements are provided in Appendix B.

6.5.1 Morning peak hour link count comparisons

Table 6-7 presents the results comparing observed and modelled count data for each individual link with a survey target during the morning peak hour period. The links have been organised into ranges by their observed count.

Table 6-7: Morning peak hour observed versus modelled link counts

Criteria and Measures	Calibration Targets	Result	Number meeting criteria	Total number of counts
Network Wide				
GEH Statistic < 5 for Individual Link Flows	>85% of cases	98%		
R^2 value for modelled versus observed flows for all individual links	>0.9	0.99		
Core Area				
Individual Link Volumes				
Within 10 veh/h, for Flow<99	100% of cases	73%	8	11
Within 10%, for 100<Flow<999 veh/h	100% of cases	85%	33	39
Within 100 veh/h, for 1000 veh/h<Flow<1999 veh/h	100% of cases	69%	34	49
Within 5%, for >2000 veh/h	100% of cases	79%	19	24
R^2 value for modelled versus observed flows for all individual links	>0.95	0.99		

The model shows a good level of calibration to the Roads and Maritime network wide performance criteria. The following graph presents a plot of observed counts against modelled counts for the morning peak period with core area calibration criteria.

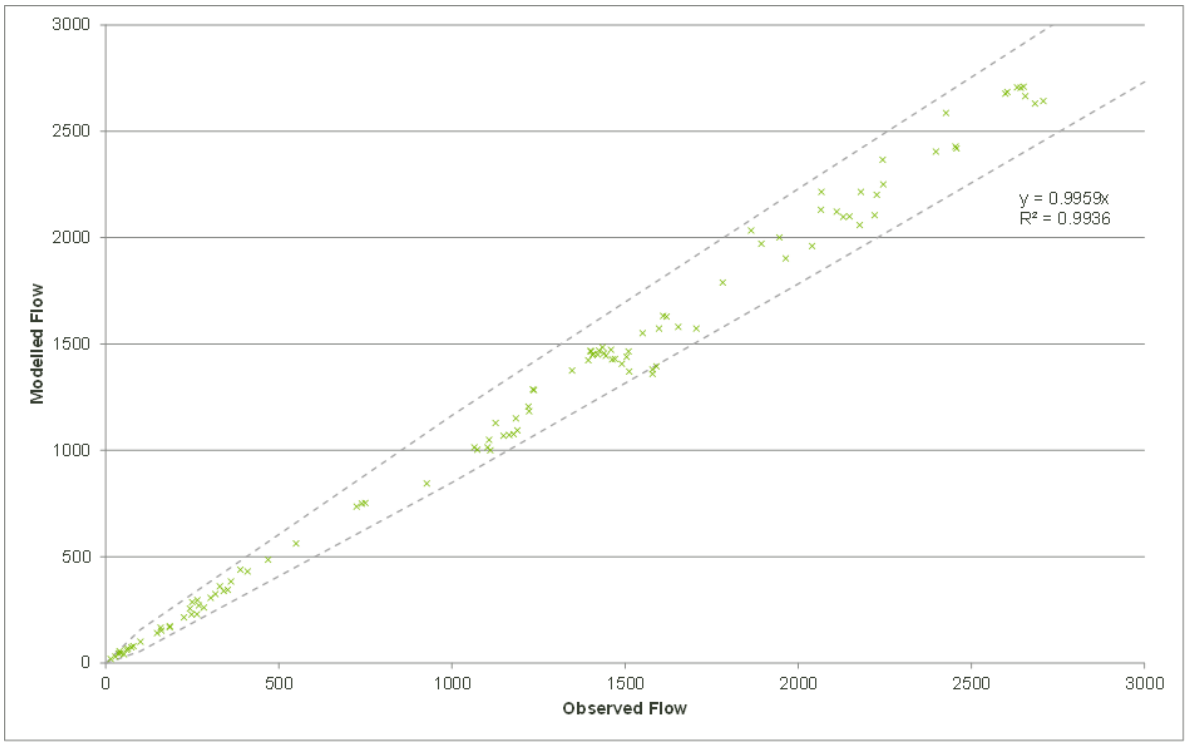


Figure 6-3: Morning peak hour observed versus modelled link counts

The graph illustrates a good correlation between observed and modelled counts, reinforced by the R2 value of 0.99.

6.5.2 Evening peak hour link count comparisons

The following table presents the results achieved comparing the observed and modelled count data for each individual link with a survey target during the Evening peak hour period. The links have been organised into ranges by their observed count.

Table 6-8: Evening Peak Hour Observed Versus Modelled Link Counts

Criteria and Measures	Calibration Targets	Result	Number meeting criteria	Total number of counts
Network Wide				
GEH Statistic < 5 for Individual Link Flows	>85% of cases	100%		
R^2 value for modelled versus observed flows for all individual links	>0.9	0.99		
Core Area				
Individual Link Volumes				
Within 10 veh/h, for Flow<99	100% of cases	80%	8	10
Within 10%, for 100<Flow<999 veh/h	100% of cases	92%	34	37
Within 100 veh/h, for 1000 veh/h<Flow<1999 veh/h	100% of cases	74%	39	53
Within 5%, for >2000 veh/h	100% of cases	83%	19	23
R^2 value for modelled versus observed flows for all individual links	>0.95	0.99		

The model shows a good level of calibration to the Roads and Maritime network wide performance criteria. The following graph shows a plot of observed counts against modelled counts for the Evening peak period with core area calibration criteria.

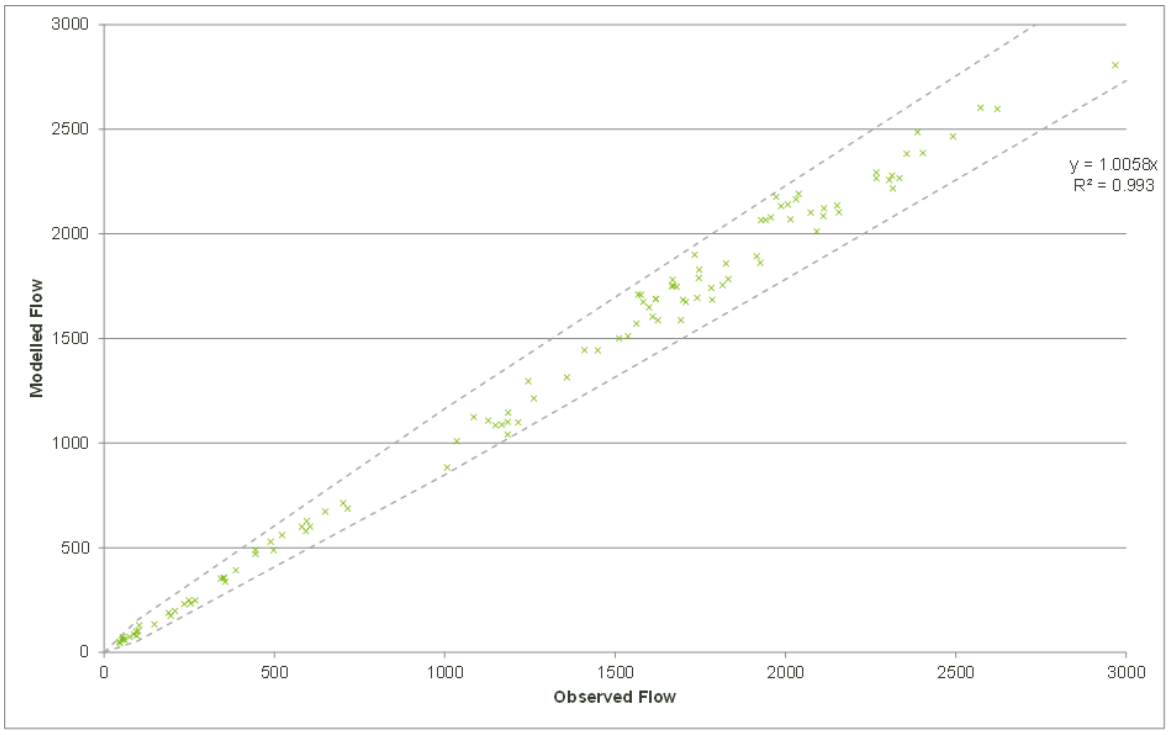


Figure 6-4: Evening peak hour observed versus modelled link counts

The graph illustrates a strong correlation between observed and modelled counts, reinforced by the R2 value of 0.99.

6.5.3 Comments on turn and link flow calibration

To provide Roads and Maritime with further confidence in the suitability of the model for undertaking the assessment of options for the Rankin Park to Jesmond project, guidelines for models of a similar size and nature from other jurisdictions have been referenced.

The two sources are the *UK Design Manual for Roads and Bridges (DMRB)* and *New Zealand Transport Agency (NZTA) Transport Model Development Guidelines*.

6.5.3.1 DRMB

DMRB Vol 12a, Chapter 4 sets out the criteria for the calibration of transport models in the UK. These are outlined in Table 6-9 along with the level of adherence achieved by the RP2J model for turn movement counts in both peak periods.

Table 6-9: DMRB, Calibration Criteria for turn movements

Criteria	Calibration Target	AM Turns	PM Turns
Within 100 veh/h, for Flow<700 veh/h	>85% of cases	100%	100%
Within 15%, for 400 veh/h<Flow<2700 veh/h	>85% of cases	98%	98%
Sum of all link flows difference	<5%	1%	0%
GEH for all individual link flows <5	>85% of cases	99%	99%

6.5.3.2 NZTA Transport Model Development Guidelines

These guidelines were developed by the New Zealand Modelling User Group (NZMUGS) and have recently been adopted by NZTA. For small corridor models, the following criteria are detailed for turn movement counts.

Table 6-10 outlines the criteria and the level of calibration achieved in both periods.

Table 6-10: NZTA Transport Model Development Guidelines, calibration criteria for turn movements

Criteria	Calibration Target	AM Turns	PM Turns
Within 50 veh/h, for Flow<400 veh/h	>85% of cases	100%	100%
Within 12.5%, for 400 veh/h<Flow<2000 veh/h	>85% of cases	93%	98%
Within 250 veh/h, for Flow>2000 veh/h	>85% of cases	100%	100%

Against both sources the model shows a high level of adherence to calibration criteria in both model periods for turning movement counts.

6.6 Journey time calibration

Journey time comparisons have been undertaken for the peak modelled hours for the routes described earlier in this report in Section 3.1.2. The comparison includes the average of the model results from all five runs.

Roads and Maritime modelling guidelines specify the average modelled journey time for the full route length and individual sections are to be within 15 per cent or one minute (whichever is greater) of average observed journey time for full length of route.

6.6.1 Morning peak hour travel time comparisons

Table 6-11 presents a comparison of observed journey times against those achieved in the model for the morning peak period. The applicable calibration criteria, either within 15% or 1 minute is highlighted in bold.

Table 6-11: Morning peak hour journey time comparison

Route Name	Observed			Modelled	Diff	Diff
	Minimum	Maximum	Average	Average		
Route 4: Newcastle EBD	00:03:00	00:08:14	00:05:09	00:04:21	**00:00:48**	-16%
Route 7: Lookout- Croudace NBD	00:08:43	00:18:19	00:12:48	00:10:57	00:01:51	**-14%**

The table illustrates a good correlation between observed and modelled journey times with the Route 4 and Route 7 routes having a difference that is within 15% or 1 minute of the observed.

Graphs of journey time against travel distance for all routes are provided in Appendix C.

6.6.2 Evening peak hour travel time comparisons

The observed and modelled journey times in minutes are presented in the following table with difference and percentages for the PM peak hour period.

Table 6-12: Evening peak hour journey time comparison

Route Name	Observed			Modelled	Diff	% Diff
	Minimum	Maximum	Average	Average		
Route 4: Newcastle WBD	00:03:32	00:10:06	00:07:08	00:06:16	00:00:53	**-12%**
Route 7: Lookout – Croudace SBD	00:09:15	00:23:31	00:13:49	00:12:32	00:01:17	**-9%**

In the evening peak period all journey times meet required calibration criteria.

6.7 Calibration results summary

The calibration summary in the table below presents the level of calibration achieved in the model against the Roads and Maritime criteria as specified in the *Traffic Modelling Guidelines, Version 1.0, February 2013*.

Table 6-13 – Calibration summary

Type	Criteria and Measures (Observed vs. Modelled)	Calibration Target	AM	PM
Model Stability	The overall network statistics such as mean flow, density, mean speed, mean travel time, mean delay, total travel distance and total travel time.	The coefficient of variation (CoV) within 5% (max)	2.1% max	2.1% max
Network Wide				
Turn counts	GEH statistic < 5.0 for individual link flows	>85% of cases	99%	99%
	R^2 value for modelled versus observed flows for all individual links	0.90	0.99	0.99
Link counts	GEH statistic < 5.0 for individual link flows	>85% of cases		
	R^2 value for modelled versus observed flows for all individual links	0.90		
Journey Times		Within 15% (or 1 min)	All	All
Core area				
Turn Counts	Within 10 veh/h, for Flow<99	100%	76%	71%
	Within 10%, for 100<Flow<999 veh/h		83%	79%
	Within 100 veh/h, for 1000 veh/h<Flow<1999 veh/h		72%	81%
	Within 5%, for >2000 veh/h		86%	100%
Link Counts	Within 10 veh/h, for Flow<99	100%	73%	80%
	Within 10%, for 100<Flow<999 veh/h		85%	92%
	Within 100 veh/h, for 1000 veh/h<Flow<1999 veh/h		69%	74%
	Within 5%, for >2000 veh/h		79%	83%
	R^2 value for modelled versus observed flows for all individual links	>0.95	0.99	0.99

The above table demonstrates the model adheres to the calibration/ validation criteria. Both morning and evening peak models have good adherence to network wide criteria.

As demonstrated in Section 6.5.3, the model also shows good adherence to calibration guidelines of other jurisdictions (United Kingdom and New Zealand) for turn counts for models of a similar size.

With respect to journey times the model demonstrates a good level of adherence, with all journey times within calibration criteria.

7 Conclusion

A traffic simulation model for the Rankin Park to Jesmond (RP2J) project has been developed using Quadstone Paramics simulation software version 6.9.3 to replicate existing traffic conditions observed for a 2014 base year.

Statistical analysis of model runs demonstrates the modelled network and output results are stable.

Comparisons have been made between the following modelled and observed measures:

- Turn count
- Link counts
- Journey times.

Comparison results illustrate the model provides good replication of existing traffic conditions against network calibration criteria and observed journey times.

It is considered that the Paramics RP2J microsimulation base model is fit for purpose and provides a robust model for undertaking the following investigations for the project:

- Undertaking traffic analysis of interchange options
- Assessing the construction and operational impacts of the project within the study area
- Providing outputs for economic analysis.

Appendix A
Observed vs Modelled Turn Counts

Morning Peak Period

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
Douglas/ Newcastle	Douglas Street (N)	Left	139	125	-14	-10%	1.3
	Douglas Street (N)	Thru	39	35	-4	-10%	0.7
	Douglas Street (N)	Right	70	68	-2	-3%	0.2
	Newcastle Road (E)	Left	78	77	-1	-1%	0.1
	Newcastle Road (E)	Thru	1,371	1,330	-41	-3%	1.1
	Newcastle Road (E)	Right	61	57	-4	-7%	0.5
	Douglas Street (S)	Left	30	31	1	3%	0.2
	Douglas Street (S)	Thru	95	89	-6	-7%	0.6
	Douglas Street (S)	Right	192	204	12	6%	0.8
	Newcastle Road (W)	Left	29	27	-2	-6%	0.3
	Newcastle Road (W)	Thru	2,325	2,336	11	0%	0.2
	Newcastle Road (W)	Right	44	40	-4	-9%	0.6
Drury/ Newcastle/ Victory	Drury Street (N)	Left	5	5	0	0%	0.0
	Drury Street (N)	Thru	4	3	-1	-15%	0.3
	Drury Street (N)	Right	28	36	8	27%	1.3
	Newcastle Road (E)	Left	4	7	3	75%	1.3
	Newcastle Road (E)	Thru	1,375	1,418	43	3%	1.1
	Newcastle Road (E)	Right	27	23	-4	-16%	0.8
	Victory Parade (S)	Left	32	32	0	-1%	0.1
	Victory Parade (S)	Thru	28	30	2	7%	0.4
	Victory Parade (S)	Right	166	152	-14	-8%	1.1
	Newcastle Road (W)	Left	104	113	9	9%	0.9
	Newcastle Road (W)	Thru	2,480	2,551	71	3%	1.4
	Newcastle Road (W)	Right	20	20	0	-2%	0.1
Blue Gum/ Newcastle	Blue Gum Road (N)	Left	140	141	1	1%	0.1
	Blue Gum Road (N)	Right	129	129	0	0%	0.0
	Newcastle Road (E)	Thru	1,280	1,324	44	3%	1.2
	Newcastle Road (E)	Right	120	143	23	19%	2.0
	Newcastle Road (W)	Left	130	143	13	10%	1.1
	Newcastle Road (W)	Thru	2,503	2,563	60	2%	1.2
Croudace/ Dent/ Newcastle	Dent Street (N)	Left	33	24	-9	-27%	1.6
	Dent Street (N)	Thru	203	196	-7	-3%	0.5
	Dent Street (N)	Right	48	40	-8	-16%	1.1
	Newcastle Road (E)	Left	329	308	-21	-6%	1.2
	Newcastle Road (E)	Thru	994	1,073	79	8%	2.5
	Newcastle Road (E)	Right	98	69	-29	-30%	3.2

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Croudace Street (S)	Left	904	886	-18	-2%	0.6
	Croudace Street (S)	Thru	164	152	-12	-7%	0.9
	Croudace Street (S)	Right	483	512	29	6%	1.3
	Newcastle Road (W)	Left	2	9	7	330%	2.9
	Newcastle Road (W)	Thru	1,551	1,678	127	8%	3.2
	Newcastle Road (W)	Right	691	679	-12	-2%	0.5
Morehead/ Newcastle	Morehead Street (N)	Left	66	70	4	6%	0.5
	Morehead Street (N)	Thru	32	29	-3	-11%	0.6
	Morehead Street (N)	Right	3	1	-2	-60%	1.2
	Newcastle Road (E)	Left	42	46	4	9%	0.6
	Newcastle Road (E)	Thru	1,305	1,329	24	2%	0.7
	Morehead Street (S)	Left	131	126	-5	-4%	0.5
	Morehead Street (S)	Thru	61	60	-1	-1%	0.1
	Morehead Street (S)	Right	161	158	-3	-2%	0.3
	Newcastle Road (W)	Left	0	1	1	0%	1.1
	Newcastle Road (W)	Thru	2,227	2,200	-27	-1%	0.6
Croudace/ Howe	Croudace Street (N)	Left	188	226	38	20%	2.7
	Croudace Street (N)	Thru	1,033	979	-54	-5%	1.7
	Howe Street (E)	Left	32	35	3	8%	0.5
	Howe Street (E)	Right	271	271	0	0%	0.0
	Croudace Street (S)	Thru	1,435	1,301	-134	-9%	3.6
	Croudace Street (S)	Right	77	69	-8	-11%	1.0
Croudace/ Pride	Croudace Street (N)	Thru	1,111	1,000	-111	-10%	3.4
	Croudace Street (S)	Thru	1,565	1,361	-204	-13%	5.3
	Croudace Street (S)	Left	15	19	4	27%	1.0
	Pride Avenue (W)	Left	13	3	-10	-77%	3.5
	Pride Avenue (W)	Right	67	76	9	13%	1.0
Croudace/ Mitchell	Croudace Street (N)	Left	11	16	5	49%	1.5
	Croudace Street (N)	Thru	1,154	1,056	-98	-9%	3.0
	Mitchell Street (E)	Left	35	37	2	7%	0.4
	Mitchell Street (E)	Right	18	3	-15	-84%	4.7
	Croudace Street (S)	Thru	1,562	1,356	-205	-13%	5.4
	Croudace Street (S)	Right	29	39	10	33%	1.7
Croudace/ Lookout/ Russell	Croudace Street (N)	Left	43	30	-13	-31%	2.2
	Croudace Street (N)	Thru	1,106	1,039	-67	-6%	2.1
	Russell Street (E)	Right	58	28	-30	-51%	4.5
	Russell Street (E)	Left	492	534	42	8%	1.8

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Croudace Street (S)	Thru	1,433	1,378	-55	-4%	1.5
	Croudace Street (S)	Right	697	719	22	3%	0.8
Jacaranda/ Lookout	Jacaranda Street (N)	Left	43	46	3	8%	0.5
	Lookout Road (E)	Right	149	141	-8	-6%	0.7
	Lookout Road (E)	Thru	1,505	1,439	-66	-4%	1.7
	Lookout Road (W)	Thru	2,178	2,059	-119	-5%	2.6
Hospital/ Lookout	Lookout Road (N)	Thru	1,033	1,086	53	5%	1.6
	Lookout Road (N)	Right	430	341	-89	-21%	4.5
	Lookout Road (S)	Left	673	673	0	0%	0.0
	Lookout Road (S)	Thru	2,011	1,957	-54	-3%	1.2
	Hospital Road (W)	Left	137	142	5	4%	0.4
	Hospital Road (W)	Right	204	196	-8	-4%	0.5
Lookout/ McCaffrey	Lookout Road (N)	Thru	1,038	1,081	43	4%	1.3
	Lookout Road (N)	Right	196	205	9	4%	0.6
	Lookout Road (S)	Left	193	233	40	21%	2.8
	Lookout Road (S)	Thru	1,988	1,981	-7	0%	0.2
	McCaffrey (W)	Left	720	661	-59	-8%	2.2
	McCaffrey (W)	Right	387	388	1	0%	0.0
Grandview/ Lookout	Lookout Road (N)	Thru	1,445	1,444	-1	0%	0.0
	Lookout Road (N)	Right	14	29	15	104%	3.2
	Lookout Road (S)	Left	50	40	-10	-20%	1.5
	Lookout Road (S)	Thru	2,061	2,082	21	1%	0.5
	Grandview Road (W)	Left	185	168	-17	-9%	1.3
Cardiff/ Charlestown/ Lookout	Charlestown Road (N)	Thru	1,202	1,225	23	2%	0.7
	Charlestown Road (N)	Right	192	198	6	3%	0.5
	Charlestown Road (S)	Left	170	185	15	9%	1.1
	Charlestown Road (S)	Thru	1,724	1,786	62	4%	1.5
	Cardiff Road (W)	Left	342	345	3	1%	0.2
	Cardiff Road (W)	Right	408	407	-1	0%	0.1
Carnley/ Charlestown	Charlestown Road (N)	Left	330	337	7	2%	0.4
	Charlestown Road (N)	Thru	1,290	1,291	1	0%	0.0
	Carnley Avenue (E)	Left	492	497	5	1%	0.2
	Carnley Avenue (E)	Right	233	238	5	2%	0.3
	Charlestown Road (S)	Thru	1,631	1,795	164	10%	4.0
	Charlestown Road (S)	Right	796	791	-5	-1%	0.2
Newcastle/ NICB	Main Road (N)	Left	788	728	-60	-8%	2.2

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Main Road (N)	Right	397	422	25	6%	1.2
	Newcastle Road (E)	Thru	1,006	1,044	38	4%	1.2
	Newcastle Road (E)	Right	1,035	917	-118	-11%	3.8
	Newcastle Road (W)	Left	929	985	56	6%	1.8
	Newcastle Road (W)	Thru	1,669	1,691	22	1%	0.5
Blue Gum/ University	Blue Gum Street (N)	Left	771	691	-80	-10%	3.0
	Blue Gum Street (N)	Thru	302	312	10	3%	0.6
	University Street (E)	Left	167	173	6	4%	0.5
	University Street (E)	Right	243	257	15	6%	0.9
	Blue Gum Street (S)	Thru	87	103	16	19%	1.7
	Blue Gum Street (S)	Right	156	153	-3	-2%	0.3
NICB/ University	NICB Street (N)	Left	209	193	-16	-8%	1.1
	NICB Street (N)	Right	68	75	7	10%	0.8
	University Road (E)	Left	181	215	34	19%	2.4
	University Road (E)	Thru	311	330	19	6%	1.0
	University Road (E)	Right	104	125	21	20%	2.0
	NICB Street (S)	Left	42	27	-15	-36%	2.6
	NICB Street (S)	Right	767	729	-38	-5%	1.4
	University Road (W)	Left	72	60	-12	-16%	1.5
	University Road (W)	Thru	639	597	-42	-7%	1.7
	University Road (W)	Right	194	180	-14	-7%	1.1
University/ University Access	University Access (N)	Left	17	23	6	34%	1.3
	University Access (N)	Right	76	88	12	16%	1.4
	University Road (E)	Thru	541	582	41	8%	1.7
	University Road (E)	Right	158	197	39	25%	2.9
	University Road (W)	Left	670	627	-43	-6%	1.7
	University Road (W)	Thru	916	887	-29	-3%	1.0

Evening Peak Period

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
Douglas/ Newcastle	Douglas Street (N)	Left	69	66	-3	-5%	0.4
	Douglas Street (N)	Thru	93	87	-6	-6%	0.6
	Douglas Street (N)	Right	93	80	-13	-14%	1.4
	Newcastle Road (E)	Left	227	233	6	2%	0.4
	Newcastle Road (E)	Thru	2,000	1,977	-23	-1%	0.5
	Newcastle Road (E)	Right	40	55	15	39%	2.2
	Douglas Street (S)	Left	64	45	-19	-30%	2.6
	Douglas Street (S)	Thru	33	41	8	25%	1.3
	Douglas Street (S)	Right	139	144	5	3%	0.4
	Newcastle Road (W)	Left	30	32	2	6%	0.3
	Newcastle Road (W)	Thru	1,538	1,579	41	3%	1.0
	Newcastle Road (W)	Right	32	38	6	18%	0.9
Drury/ Newcastle/ Victory	Drury Street (N)	Left	11	7	-4	-33%	1.2
	Drury Street (N)	Thru	20	18	-2	-11%	0.5
	Drury Street (N)	Right	159	163	4	3%	0.3
	Newcastle Road (E)	Left	5	4	-1	-20%	0.5
	Newcastle Road (E)	Thru	2,087	2,104	17	1%	0.4
	Newcastle Road (E)	Right	21	14	-7	-31%	1.6
	Victory Parade (S)	Left	21	26	5	22%	1.0
	Victory Parade (S)	Thru	9	11	2	20%	0.6
	Victory Parade (S)	Right	64	62	-2	-3%	0.3
	Newcastle Road (W)	Left	70	77	7	10%	0.8
	Newcastle Road (W)	Thru	1,741	1,685	-55	-3%	1.3
	Newcastle Road (W)	Right	22	21	-1	-5%	0.3
Blue Gum/ Newcastle	Blue Gum Road (N)	Left	233	218	-15	-7%	1.0
	Blue Gum Road (N)	Right	265	270	5	2%	0.3
	Newcastle Road (E)	Thru	1,887	1,865	-22	-1%	0.5
	Newcastle Road (E)	Right	224	219	-5	-2%	0.3
	Newcastle Road (W)	Left	221	251	30	13%	1.9
	Newcastle Road (W)	Thru	1,448	1,529	81	6%	2.1
Croudace/ Dent/ Newcastle	Dent Street (N)	Left	22	27	5	25%	1.1
	Dent Street (N)	Thru	311	291	-20	-6%	1.1
	Dent Street (N)	Right	23	18	-5	-23%	1.2
	Newcastle Road (E)	Left	559	608	49	9%	2.0
	Newcastle Road (E)	Thru	1,302	1,367	65	5%	1.8
	Newcastle Road (E)	Right	68	90	22	32%	2.4

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Croudace Street (S)	Left	706	780	74	10%	2.7
	Croudace Street (S)	Thru	167	139	-28	-17%	2.2
	Croudace Street (S)	Right	372	376	4	1%	0.2
	Newcastle Road (W)	Left	14	19	5	37%	1.3
	Newcastle Road (W)	Thru	1,432	1,454	22	2%	0.6
	Newcastle Road (W)	Right	1,046	992	-54	-5%	1.7
Morehead/ Newcastle	Morehead Street (N)	Left	22	22	0	1%	0.0
	Morehead Street (N)	Thru	67	61	-6	-9%	0.7
	Morehead Street (N)	Right	0	1	1	0%	1.7
	Newcastle Road (E)	Left	81	72	-9	-11%	1.0
	Newcastle Road (E)	Thru	1,877	2,006	129	7%	2.9
	Morehead Street (S)	Left	65	59	-6	-10%	0.8
	Morehead Street (S)	Thru	54	55	1	1%	0.1
	Morehead Street (S)	Right	149	135	-14	-10%	1.2
	Newcastle Road (W)	Left	6	6	0	7%	0.2
	Newcastle Road (W)	Thru	1,921	1,855	-66	-3%	1.5
Croudace/ Howe	Croudace Street (N)	Left	253	279	26	10%	1.6
	Croudace Street (N)	Thru	1,481	1,620	139	9%	3.5
	Howe Street (E)	Left	87	89	2	2%	0.2
	Howe Street (E)	Right	300	303	3	1%	0.2
	Croudace Street (S)	Thru	1,059	1,011	-48	-5%	1.5
	Croudace Street (S)	Right	90	73	-17	-18%	1.8
Croudace/ Pride	Croudace Street (N)	Thru	1,583	1,674	91	6%	2.2
	Croudace Street (S)	Thru	1,128	1,040	-88	-8%	2.7
	Croudace Street (S)	Left	57	61	4	6%	0.5
	Pride Avenue (W)	Left	8	35	27	340%	5.9
	Pride Avenue (W)	Right	37	15	-22	-58%	4.2
Croudace/ Mitchell	Croudace Street (N)	Left	19	11	-8	-43%	2.1
	Croudace Street (N)	Thru	1,601	1,677	76	5%	1.9
	Mitchell Street (E)	Left	71	75	4	5%	0.4
	Mitchell Street (E)	Right	25	5	-20	-82%	5.3
	Croudace Street (S)	Thru	1,160	1,036	-124	-11%	3.8
	Croudace Street (S)	Right	56	63	7	12%	0.9
Croudace/ Lookout/ Russell	Croudace Street (N)	Left	52	31	-21	-40%	3.3
	Croudace Street (N)	Thru	1,524	1,678	154	10%	3.8
	Russell Street (E)	Right	40	29	-11	-27%	1.8
	Russell Street (E)	Left	449	498	49	11%	2.3

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Croudace Street (S)	Thru	1,146	1,115	-31	-3%	0.9
	Croudace Street (S)	Right	553	569	16	3%	0.7
Jacaranda/ Lookout	Jacaranda Street (N)	Left	196	174	-22	-11%	1.6
	Lookout Road (E)	Right	52	59	7	14%	1.0
	Lookout Road (E)	Thru	1,987	2,132	145	7%	3.2
	Lookout Road (W)	Thru	1,512	1,500	-12	-1%	0.3
Hospital/ Lookout	Lookout Road (N)	Thru	1,886	2,019	133	7%	3.0
	Lookout Road (N)	Right	121	120	-1	0%	0.1
	Lookout Road (S)	Left	231	233	2	1%	0.1
	Lookout Road (S)	Thru	1,218	1,210	-8	-1%	0.2
	Hospital Road (W)	Left	320	300	-20	-6%	1.1
	Hospital Road (W)	Right	687	584	-103	-15%	4.1
Lookout/ McCaffrey	Lookout Road (N)	Thru	1,957	1,976	19	1%	0.4
	Lookout Road (N)	Right	665	621	-44	-7%	1.7
	Lookout Road (S)	Left	503	467	-36	-7%	1.7
	Lookout Road (S)	Thru	1,107	1,137	30	3%	0.9
	McCaffrey (W)	Left	303	306	3	1%	0.2
	McCaffrey (W)	Right	399	406	7	2%	0.4
Grandview/ Lookout	Lookout Road (N)	Thru	2,313	2,278	-35	-2%	0.7
	Lookout Road (N)	Right	90	109	19	21%	1.9
	Lookout Road (S)	Left	118	89	-29	-25%	2.9
	Lookout Road (S)	Thru	1,508	1,498	-10	-1%	0.3
	Grandview Road (W)	Left	55	72	17	32%	2.2
Cardiff/ Charlestown/ Lookout	Charlestown Road (N)	Thru	1,967	1,916	-51	-3%	1.2
	Charlestown Road (N)	Right	368	350	-18	-5%	1.0
	Charlestown Road (S)	Left	347	336	-11	-3%	0.6
	Charlestown Road (S)	Thru	1,438	1,349	-89	-6%	2.4
	Cardiff Road (W)	Left	255	238	-17	-7%	1.1
	Cardiff Road (W)	Right	338	341	3	1%	0.2
Carnley/ Charlestown	Charlestown Road (N)	Left	262	258	-4	-2%	0.3
	Charlestown Road (N)	Thru	2,054	1,959	-95	-5%	2.1
	Carnley Avenue (E)	Left	915	847	-68	-7%	2.3
	Carnley Avenue (E)	Right	347	366	19	6%	1.0
	Charlestown Road (S)	Thru	1,394	1,327	-67	-5%	1.8
	Charlestown Road (S)	Right	388	414	26	7%	1.3
Newcastle/ NICB	Main Road (N)	Left	1,094	1,122	28	3%	0.8

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Main Road (N)	Right	653	706	53	8%	2.0
	Newcastle Road (E)	Thru	1,362	1,363	1	0%	0.0
	Newcastle Road (E)	Right	712	738	26	4%	1.0
	Newcastle Road (W)	Left	373	386	12	3%	0.6
	Newcastle Road (W)	Thru	1,293	1,364	71	5%	1.9
Blue Gum/ University	Blue Gum Street (N)	Left	367	376	9	3%	0.5
	Blue Gum Street (N)	Thru	214	224	10	5%	0.7
	University Street (E)	Left	381	403	22	6%	1.1
	University Street (E)	Right	747	705	-42	-6%	1.6
	Blue Gum Street (S)	Thru	289	304	15	5%	0.9
	Blue Gum Street (S)	Right	156	183	28	18%	2.1
NICB/ University	NICB Street (N)	Left	74	65	-9	-12%	1.1
	NICB Street (N)	Right	144	136	-8	-5%	0.6
	University Road (E)	Left	550	538	-12	-2%	0.5
	University Road (E)	Thru	876	835	-41	-5%	1.4
	University Road (E)	Right	225	224	-1	0%	0.1
	NICB Street (S)	Left	104	140	36	35%	3.3
	NICB Street (S)	Right	279	258	-21	-8%	1.3
	University Road (W)	Left	55	66	11	21%	1.5
	University Road (W)	Thru	354	345	-9	-2%	0.5
	University Road (W)	Right	144	146	2	1%	0.2
University/ University Access	University Access (N)	Left	138	121	-17	-12%	1.5
	University Access (N)	Right	578	557	-21	-4%	0.9
	University Road (E)	Thru	1,079	1,041	-37	-3%	1.1
	University Road (E)	Right	48	49	1	1%	0.1
	University Road (W)	Left	226	202	-24	-10%	1.6
	University Road (W)	Thru	490	467	-23	-5%	1.1

Appendix B
Observed vs Modelled Link Counts

Morning Peak Period

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
Douglas/ Newcastle	Douglas Street (N)	Arrival	248	228	-20	8%	1.3
	Douglas Street (N)	Departure	185	173	-12	7%	0.9
	Newcastle Road (E)	Arrival	1,510	1,464	-46	3%	1.2
	Newcastle Road (E)	Departure	2,656	2,665	9	0%	0.2
	Douglas Street (S)	Arrival	317	324	7	2%	0.4
	Douglas Street (S)	Departure	161	152	-9	5%	0.7
	Newcastle Road (W)	Arrival	2,398	2,404	6	0%	0.1
	Newcastle Road (W)	Departure	1,471	1,429	-42	3%	1.1
Drury/ Newcastle/ Victory	Drury Street (N)	Arrival	37	44	7	19%	1.1
	Drury Street (N)	Departure	159	166	7	4%	0.5
	Newcastle Road (E)	Arrival	1,406	1,447	41	3%	1.1
	Newcastle Road (E)	Departure	2,651	2,709	58	2%	1.1
	Victory Parade (S)	Arrival	226	214	-12	5%	0.8
	Victory Parade (S)	Departure	28	30	2	7%	0.4
	Newcastle Road (W)	Arrival	2,604	2,684	80	3%	1.6
	Newcastle Road (W)	Departure	1,435	1,485	50	3%	1.3
Blue Gum/ Newcastle	Blue Gum Road (N)	Arrival	269	270	1	0%	0.1
	Blue Gum Road (N)	Departure	250	286	36	15%	2.2
	Newcastle Road (E)	Arrival	1,400	1,467	67	5%	1.8
	Newcastle Road (E)	Departure	2,643	2,704	61	2%	1.2
	Newcastle Road (W)	Arrival	2,633	2,706	74	3%	1.4
	Newcastle Road (W)	Departure	1,409	1,453	44	3%	1.2
Croudace/ Dent/ Newcastle	Dent Street (N)	Arrival	284	261	-23	8%	1.4
	Dent Street (N)	Departure	264	229	-35	13%	2.2
	Newcastle Road (E)	Arrival	1,421	1,450	29	2%	0.8
	Newcastle Road (E)	Departure	2,067	2,214	147	7%	3.2
	Croudace Street (S)	Arrival	1,551	1,551	0	0%	0.0
	Croudace Street (S)	Departure	1,223	1,183	-40	3%	1.1
	Newcastle Road (W)	Arrival	2,244	2,365	121	5%	2.5
	Newcastle Road (W)	Departure	1,946	2,000	54	3%	1.2
Morehead/ Newcastle	Morehead Street (N)	Arrival	101	100	-1	1%	0.1
	Morehead Street (N)	Departure	61	61	0	0%	0.0
	Newcastle Road (E)	Arrival	1,347	1,374	27	2%	0.7
	Newcastle Road (E)	Departure	2,454	2,428	-26	1%	0.5
	Morehead Street (S)	Arrival	353	344	-9	3%	0.5

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Morehead Street (S)	Departure	74	74	0	1%	0.0
	Newcastle Road (W)	Arrival	2,227	2,200	-27	1%	0.6
	Newcastle Road (W)	Departure	1,439	1,456	17	1%	0.4
Croudace/ Howe	Croudace Street (N)	Arrival	1,221	1,205	-16	1%	0.5
	Croudace Street (N)	Departure	1,706	1,572	-134	8%	3.3
	Howe Street (E)	Arrival	303	306	3	1%	0.2
	Howe Street (E)	Departure	265	295	30	11%	1.8
	Croudace Street (S)	Arrival	1,512	1,370	-142	9%	3.8
	Croudace Street (S)	Departure	1,065	1,013	-52	5%	1.6
Croudace/ Pride	Croudace Street (N)	Arrival	1,111	1,000	-111	10%	3.4
	Croudace Street (S)	Departure	1,178	1,076	-102	9%	3.0
	Croudace Street (S)	Arrival	1,580	1,380	-200	13%	5.2
	Pride Avenue (W)	Departure	15	19	4	27%	1.0
	Pride Avenue (W)	Arrival	80	79	-1	2%	0.1
Croudace/ Mitchell	Croudace Street (N)	Departure	1,580	1,359	-220	14%	5.7
	Croudace Street (N)	Arrival	1,165	1,072	-93	8%	2.8
	Mitchell Street (E)	Departure	40	55	15	38%	2.2
	Mitchell Street (E)	Arrival	53	40	-13	24%	1.9
	Croudace Street (S)	Departure	1,189	1,093	-96	8%	2.8
	Croudace Street (S)	Arrival	1,591	1,395	-196	12%	5.1
Croudace/ Lookout/ Russell	Croudace Street (N)	Departure	1,491	1,407	-84	6%	2.2
	Croudace Street (N)	Arrival	1,149	1,068	-81	7%	2.4
	Russell Street (E)	Departure	740	749	9	1%	0.3
	Russell Street (E)	Arrival	550	562	12	2%	0.5
	Croudace Street (S)	Departure	1,598	1,572	-26	2%	0.6
	Croudace Street (S)	Arrival	2,130	2,097	-33	2%	0.7
Jacaranda/ Lookout	Jacaranda Street (N)	Departure	149	141	-8	6%	0.7
	Jacaranda Street (N)	Arrival	43	46	3	8%	0.5
	Lookout Road (E)	Departure	2,221	2,105	-116	5%	2.5
	Lookout Road (E)	Arrival	1,654	1,580	-74	4%	1.9
	Lookout Road (W)	Departure	1,505	1,439	-66	4%	1.7
	Lookout Road (W)	Arrival	2,178	2,059	-119	5%	2.6
Hospital/ Lookout	Lookout Road (N)	Departure	2,148	2,099	-49	2%	1.1
	Lookout Road (N)	Arrival	1,463	1,427	-36	2%	0.9
	Lookout Road (S)	Departure	1,237	1,283	46	4%	1.3
	Lookout Road (S)	Arrival	2,684	2,630	-54	2%	1.1

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Hospital Road (W)	Departure	1,103	1,014	-89	8%	2.7
	Hospital Road (W)	Arrival	341	338	-3	1%	0.1
Lookout/ McCaffrey	Lookout Road (N)	Departure	2,708	2,642	-66	2%	1.3
	Lookout Road (N)	Arrival	1,234	1,286	52	4%	1.5
	Lookout Road (S)	Departure	1,425	1,469	44	3%	1.1
	Lookout Road (S)	Arrival	2,181	2,214	33	2%	0.7
	McCaffrey (W)	Departure	389	438	49	13%	2.4
	McCaffrey (W)	Arrival	1,107	1,049	-58	5%	1.8
Grandview/ Lookout	Lookout Road (N)	Departure	2,246	2,250	4	0%	0.1
	Lookout Road (N)	Arrival	1,459	1,473	14	1%	0.4
	Lookout Road (S)	Departure	1,445	1,444	-1	0%	0.0
	Lookout Road (S)	Arrival	2,111	2,122	11	1%	0.2
	Grandview Road (W)	Departure	64	69	5	7%	0.6
	Grandview Road (W)	Arrival	185	168	-17	9%	1.3
Cardiff/ Charlestown/ Lookout	Charlestown Road (N)	Departure	2,066	2,131	65	3%	1.4
	Charlestown Road (N)	Arrival	1,394	1,423	29	2%	0.8
	Charlestown Road (S)	Departure	1,610	1,632	22	1%	0.5
	Charlestown Road (S)	Arrival	1,894	1,970	76	4%	1.7
	Cardiff Road (W)	Departure	362	383	21	6%	1.1
	Cardiff Road (W)	Arrival	750	752	2	0%	0.1
Carnley/ Charlestown	Charlestown Road (N)	Departure	1,864	2,033	169	9%	3.8
	Charlestown Road (N)	Arrival	1,620	1,629	9	1%	0.2
	Carnley Avenue (E)	Departure	1,126	1,128	2	0%	0.1
	Carnley Avenue (E)	Arrival	725	735	10	1%	0.4
	Charlestown Road (S)	Departure	1,782	1,788	6	0%	0.2
	Charlestown Road (S)	Arrival	2,427	2,586	159	7%	3.2
Newcastle/ NICB	Main Road (N)	Departure	1,964	1,902	-62	3%	1.4
	Main Road (N)	Arrival	1,185	1,150	-35	3%	1.0
	Newcastle Road (E)	Departure	2,457	2,419	-38	2%	0.8
	Newcastle Road (E)	Arrival	2,041	1,960	-80	4%	1.8
	Newcastle Road (W)	Departure	1,403	1,466	63	4%	1.7
	Newcastle Road (W)	Arrival	2,598	2,676	78	3%	1.5
Blue Gum/ University	Blue Gum Street (N)	Departure	330	360	31	9%	1.7
	Blue Gum Street (N)	Arrival	1,073	1,003	-70	7%	2.2
	University Street (E)	Departure	928	844	-84	9%	2.8
	University Street (E)	Arrival	410	431	21	5%	1.0

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Blue Gum Street (S)	Departure	469	485	16	3%	0.7
	Blue Gum Street (S)	Arrival	243	256	13	5%	0.8
NICB/ University	NICB Street (N)	Arrival	277	268	-9	3%	0.6
	NICB Street (N)	Departure	176	185	9	5%	0.7
	University Road (E)	Arrival	596	670	74	12%	2.9
	University Road (E)	Departure	1,615	1,519	-96	6%	2.4
	NICB Street (S)	Arrival	809	756	-53	7%	1.9
	NICB Street (S)	Departure	375	395	20	5%	1.0
	University Road (W)	Arrival	905	837	-68	8%	2.3
	University Road (W)	Departure	421	431	10	2%	0.5
University/ University Access	University Access (N)	Departure	828	824	-4	0%	0.1
	University Access (N)	Arrival	93	111	18	20%	1.8
	University Road (E)	Departure	933	910	-23	2%	0.8
	University Road (E)	Arrival	699	779	80	12%	3.0
	University Road (W)	Departure	617	671	54	9%	2.1
	University Road (W)	Arrival	1,586	1,514	-72	5%	1.8

Evening Peak Period

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
Douglas/ Newcastle	Douglas Street (N)	Arrival	255	233	-22	9%	1.4
	Douglas Street (N)	Departure	103	128	25	25%	2.4
	Newcastle Road (E)	Arrival	2,267	2,265	-2	0%	0.0
	Newcastle Road (E)	Departure	1,746	1,789	43	2%	1.0
	Douglas Street (S)	Arrival	236	230	-6	3%	0.4
	Douglas Street (S)	Departure	352	357	5	2%	0.3
	Newcastle Road (W)	Arrival	1,600	1,649	49	3%	1.2
	Newcastle Road (W)	Departure	2,157	2,102	-55	3%	1.2
Drury/ Newcastle/ Victory	Drury Street (N)	Arrival	190	188	-2	1%	0.1
	Drury Street (N)	Departure	100	102	2	2%	0.2
	Newcastle Road (E)	Arrival	2,113	2,122	9	0%	0.2
	Newcastle Road (E)	Departure	1,816	1,755	-61	3%	1.4
	Victory Parade (S)	Arrival	94	98	4	5%	0.4
	Victory Parade (S)	Departure	47	43	-4	9%	0.7
	Newcastle Road (W)	Arrival	1,833	1,783	-49	3%	1.2
	Newcastle Road (W)	Departure	2,267	2,293	26	1%	0.5
Blue Gum/ Newcastle	Blue Gum Road (N)	Arrival	498	487	-11	2%	0.5

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Blue Gum Road (N)	Departure	445	470	25	6%	1.2
	Newcastle Road (E)	Arrival	2,111	2,084	-27	1%	0.6
	Newcastle Road (E)	Departure	1,681	1,747	66	4%	1.6
	Newcastle Road (W)	Arrival	1,669	1,780	111	7%	2.7
	Newcastle Road (W)	Departure	2,152	2,135	-17	1%	0.4
Croudace/ Dent/ Newcastle	Dent Street (N)	Arrival	356	336	-20	6%	1.1
	Dent Street (N)	Departure	249	248	-1	0%	0.1
	Newcastle Road (E)	Arrival	1,929	2,065	136	7%	3.0
	Newcastle Road (E)	Departure	1,826	1,857	31	2%	0.7
	Croudace Street (S)	Arrival	1,245	1,295	50	4%	1.4
	Croudace Street (S)	Departure	1,916	1,892	-24	1%	0.6
	Newcastle Road (W)	Arrival	2,492	2,465	-27	1%	0.5
	Newcastle Road (W)	Departure	2,031	2,164	133	7%	2.9
Morehead/ Newcastle	Morehead Street (N)	Arrival	89	85	-4	5%	0.5
	Morehead Street (N)	Departure	60	61	1	2%	0.2
	Newcastle Road (E)	Arrival	1,958	2,078	120	6%	2.7
	Newcastle Road (E)	Departure	2,092	2,012	-80	4%	1.8
	Morehead Street (S)	Arrival	268	248	-20	7%	1.2
	Morehead Street (S)	Departure	148	133	-15	10%	1.2
	Newcastle Road (W)	Arrival	1,927	1,861	-66	3%	1.5
	Newcastle Road (W)	Departure	1,942	2,066	124	6%	2.8
Croudace/ Howe	Croudace Street (N)	Arrival	1,734	1,899	165	10%	3.9
	Croudace Street (N)	Departure	1,359	1,314	-45	3%	1.2
	Howe Street (E)	Arrival	387	391	4	1%	0.2
	Howe Street (E)	Departure	343	352	9	3%	0.5
	Croudace Street (S)	Arrival	1,149	1,084	-65	6%	1.9
	Croudace Street (S)	Departure	1,568	1,709	141	9%	3.5
Croudace/ Pride	Croudace Street (N)	Arrival	1,583	1,674	91	6%	2.2
	Croudace Street (S)	Departure	1,620	1,689	69	4%	1.7
	Croudace Street (S)	Arrival	1,185	1,100	-85	7%	2.5
	Pride Avenue (W)	Departure	57	61	4	6%	0.5
	Pride Avenue (W)	Arrival	45	51	6	12%	0.8
Croudace/ Mitchell	Croudace Street (N)	Departure	1,185	1,040	-145	12%	4.3
	Croudace Street (N)	Arrival	1,620	1,687	67	4%	1.7
	Mitchell Street (E)	Departure	75	73	-2	2%	0.2
	Mitchell Street (E)	Arrival	96	79	-17	18%	1.8
	Croudace Street (S)	Departure	1,672	1,751	79	5%	1.9

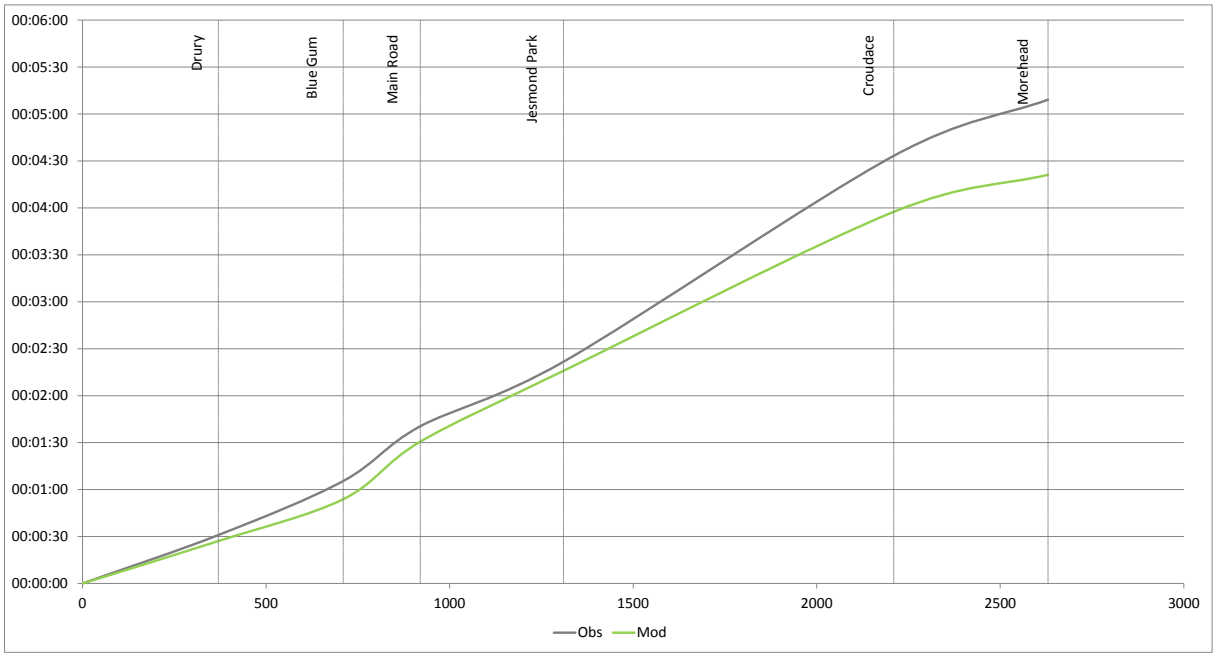
Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Croudace Street (S)	Arrival	1,216	1,098	-118	10%	3.5
Croudace/ Lookout/ Russell	Croudace Street (N)	Departure	1,186	1,145	-41	3%	1.2
	Croudace Street (N)	Arrival	1,576	1,709	133	8%	3.3
	Russell Street (E)	Departure	605	600	-5	1%	0.2
	Russell Street (E)	Arrival	489	528	39	8%	1.7
	Croudace Street (S)	Departure	1,973	2,176	203	10%	4.5
	Croudace Street (S)	Arrival	1,699	1,684	-15	1%	0.4
Jacaranda/ Lookout	Jacaranda Street (N)	Departure	52	59	7	14%	1.0
	Jacaranda Street (N)	Arrival	196	174	-22	11%	1.6
	Lookout Road (E)	Departure	1,708	1,674	-34	2%	0.8
	Lookout Road (E)	Arrival	2,039	2,191	152	7%	3.3
	Lookout Road (W)	Departure	1,987	2,132	145	7%	3.2
	Lookout Road (W)	Arrival	1,512	1,500	-12	1%	0.3
Hospital/ Lookout	Lookout Road (N)	Departure	1,538	1,510	-28	2%	0.7
	Lookout Road (N)	Arrival	2,007	2,139	132	7%	2.9
	Lookout Road (S)	Departure	2,573	2,603	30	1%	0.6
	Lookout Road (S)	Arrival	1,449	1,443	-6	0%	0.2
	Hospital Road (W)	Departure	352	354	2	0%	0.1
	Hospital Road (W)	Arrival	1,007	884	-123	12%	4.0
Lookout/ McCaffrey	Lookout Road (N)	Departure	1,410	1,444	34	2%	0.9
	Lookout Road (N)	Arrival	2,622	2,597	-25	1%	0.5
	Lookout Road (S)	Departure	2,356	2,382	26	1%	0.5
	Lookout Road (S)	Arrival	1,610	1,604	-6	0%	0.2
	McCaffrey (W)	Departure	1,168	1,088	-80	7%	2.4
	McCaffrey (W)	Arrival	702	713	11	2%	0.4
Grandview/ Lookout	Lookout Road (N)	Departure	1,563	1,570	7	0%	0.2
	Lookout Road (N)	Arrival	2,403	2,387	-16	1%	0.3
	Lookout Road (S)	Departure	2,313	2,278	-35	2%	0.7
	Lookout Road (S)	Arrival	1,626	1,587	-39	2%	1.0
	Grandview Road (W)	Departure	208	198	-10	5%	0.7
	Grandview Road (W)	Arrival	55	72	17	32%	2.2
Cardiff/ Charlestown/ Lookout	Charlestown Road (N)	Departure	1,693	1,587	-106	6%	2.6
	Charlestown Road (N)	Arrival	2,335	2,266	-69	3%	1.4
	Charlestown Road (S)	Departure	2,305	2,257	-48	2%	1.0
	Charlestown Road (S)	Arrival	1,785	1,685	-100	6%	2.4
	Cardiff Road (W)	Departure	715	686	-29	4%	1.1

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Cardiff Road (W)	Arrival	593	579	-14	2%	0.6
Carnley/ Charlestown	Charlestown Road (N)	Departure	1,741	1,693	-48	3%	1.2
	Charlestown Road (N)	Arrival	2,316	2,217	-99	4%	2.1
	Carnley Avenue (E)	Departure	650	672	22	3%	0.9
	Carnley Avenue (E)	Arrival	1,262	1,213	-49	4%	1.4
	Charlestown Road (S)	Departure	2,969	2,806	-163	5%	3.0
	Charlestown Road (S)	Arrival	1,782	1,741	-41	2%	1.0
Newcastle/ NICB	Main Road (N)	Departure	1,085	1,124	39	4%	1.2
	Main Road (N)	Arrival	1,747	1,828	81	5%	1.9
	Newcastle Road (E)	Departure	2,387	2,486	99	4%	2.0
	Newcastle Road (E)	Arrival	2,074	2,101	27	1%	0.6
	Newcastle Road (W)	Departure	2,015	2,069	54	3%	1.2
	Newcastle Road (W)	Arrival	1,667	1,750	83	5%	2.0
Blue Gum/ University	Blue Gum Street (N)	Departure	1,036	1,009	-27	3%	0.8
	Blue Gum Street (N)	Arrival	581	600	19	3%	0.8
	University Street (E)	Departure	522	560	37	7%	1.6
	University Street (E)	Arrival	1,128	1,108	-20	2%	0.6
	Blue Gum Street (S)	Departure	595	627	32	5%	1.3
	Blue Gum Street (S)	Arrival	445	488	43	10%	2.0
NICB/ University	NICB Street (N)	Arrival	218	201	-17	8%	1.2
	NICB Street (N)	Departure	280	291	11	4%	0.6
	University Road (E)	Arrival	1,651	1,597	-54	3%	1.3
	University Road (E)	Departure	707	668	-39	6%	1.5
	NICB Street (S)	Arrival	383	398	15	4%	0.8
	NICB Street (S)	Departure	694	684	-10	1%	0.4
	University Road (W)	Arrival	553	558	5	1%	0.2
	University Road (W)	Departure	1,124	1,112	-12	1%	0.4
University/ University Access	University Access (N)	Departure	274	251	-23	8%	1.4
	University Access (N)	Arrival	716	678	-38	5%	1.4
	University Road (E)	Departure	628	588	-40	6%	1.6
	University Road (E)	Arrival	1,127	1,090	-37	3%	1.1
	University Road (W)	Departure	1,657	1,598	-58	4%	1.4
	University Road (W)	Arrival	716	669	-47	7%	1.8

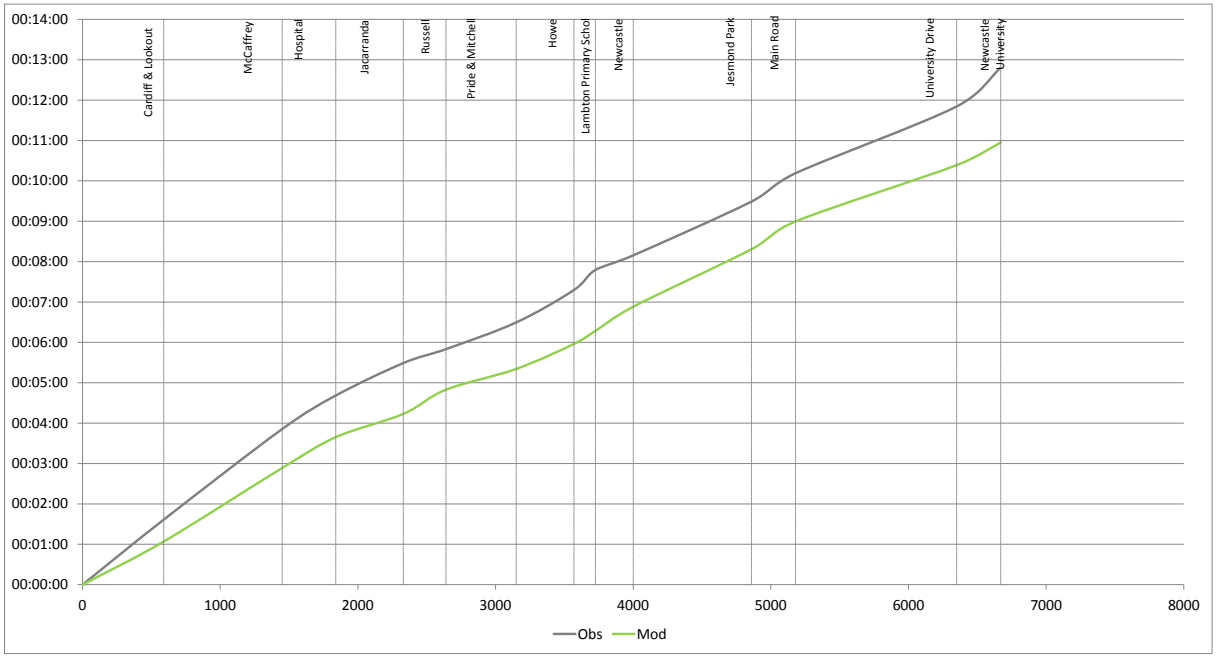
Appendix C
Journey Time Graphs

Morning Peak

Route 4: Newcastle EBD

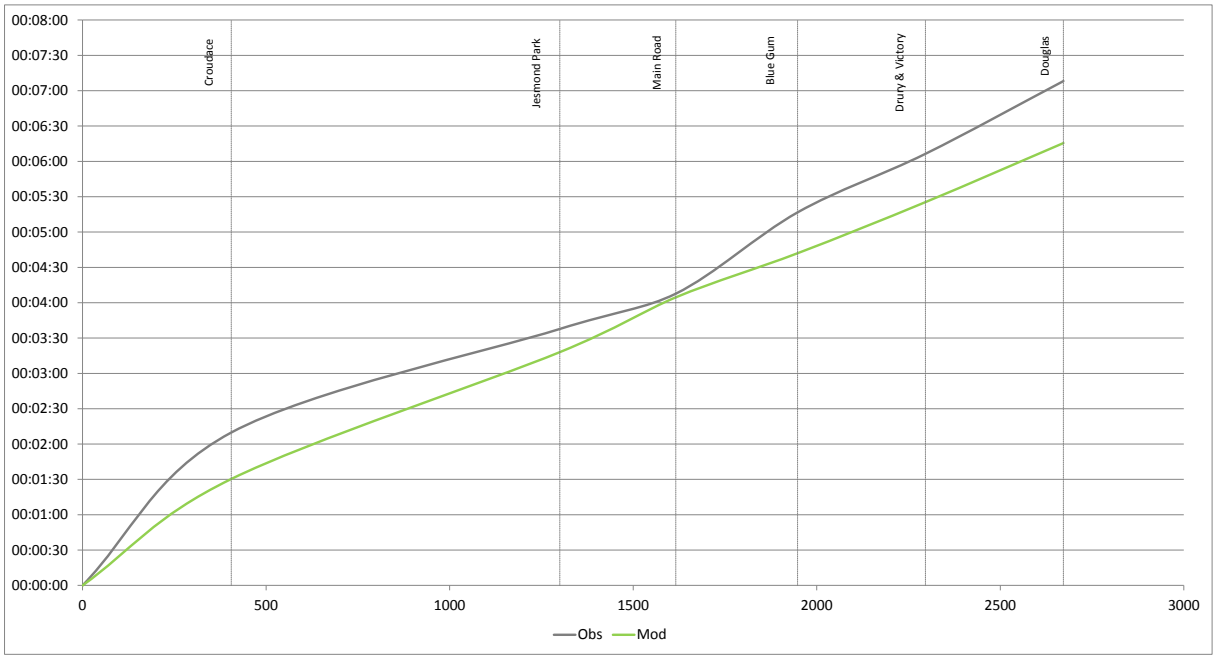


Route 7: Lookout- Croudace NBD

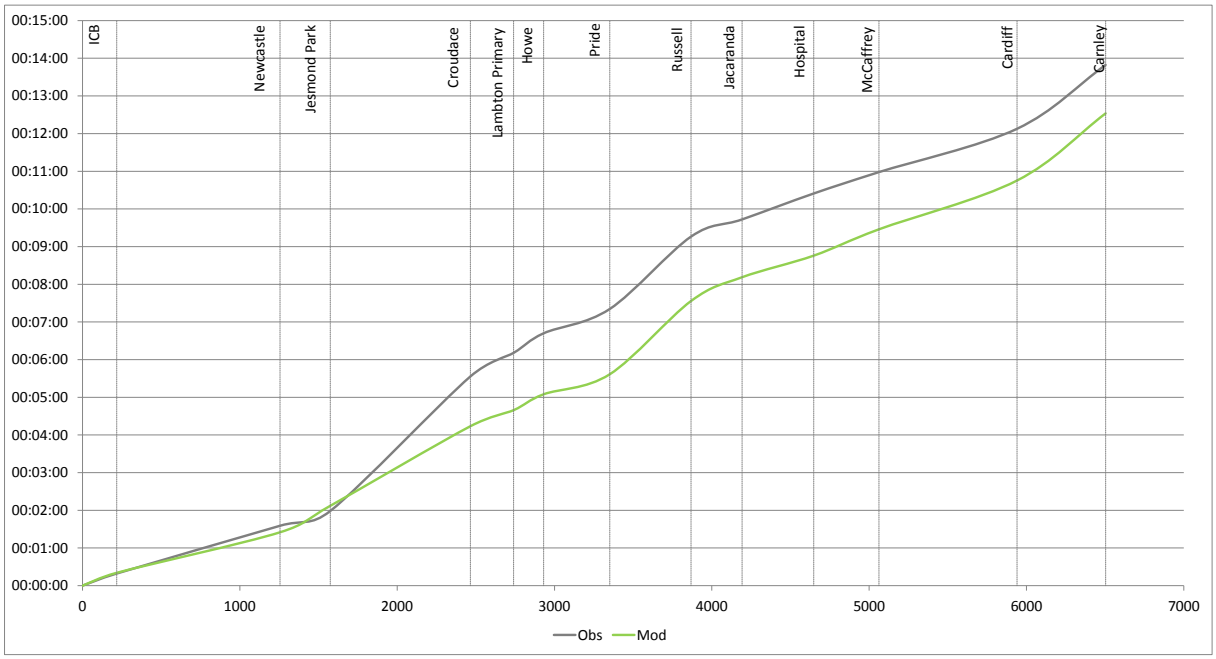


Evening Peak

Route 4: Newcastle WBD



Route 7: Lookout – Croudace SBD



Aurecon Australia Pty Ltd
ABN 54 005 139 873
23 Warabrook Boulevard
Warabrook NSW 2304
Australia
O Box 19
The University of Newcastle
Callaghan NSW 230

T +61 2 4941 5415
F +61 2 4941 5489
E newcastle@aurecongroup.com
W aurecongroup.com

Appendix B
Level of service data

Intersection	Approach	Mvt	2014 Existing AM								
			Movement			Approach			Intersection		
			Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS
University Interchange	ICB North	Left	191	10	A	265	16	B	2517	19	B
		Right	74	34	C						
	University East	Left	217	1	A	669	5	A			
		Thru	326	6	A						
		Right	126	6	A						
	ICB South	Left	28	4	A	749	6	A			
		Right	721	6	A						
	University West	Left	61	28	B	834	44	D			
		Thru	595	47	D						
		Right	179	41	C						
Jesmond Roundabout	ICB	Left	725	55	D	1139	69	E	4793	34	C
		Right	414	93	F						
	Newcastle East	Thru	1036	20	B	2678	23	B			
		Right	903	32	C						
	Newcastle West	Left	977	18	B	977	29	C			
		Thru	1671	36	C						
Croudace/ Dent/ Newcastle	Dent	Left	24	45	D	259	54	D	5739	50	D
		Thru	195	57	E						
		Right	40	46	D						
	Newcastle East	Left	308	9	A	1439	45	D			
		Thru	1064	53	D						
		Right	68	95	F						
	Croudace	Left	880	16	B	1697	39	C			
		Thru	302	68	E						
		Right	514	63	E						
	Newcastle West	Left	9	52	D	2344	59	E			
		Thru	1661	53	D						
		Right	675	74	F						
Croudace/ Howe	Croudace North	Left	225	8	A	1200	10	A	2937	14	B
		Thru	975	11	A						
	Howe	Left	35	32	C	302	49	D			
		Right	267	51	D						
	Croudace South	Thru	1301	4	A	1435	9	A			
		Right	134	60	E						
Croudace/ Lookout/ Russell	Croudace	Left	28	19	B	1062	27	B	3738	19	B
		Thru	1033	27	B						
	Russell	Left	537	9	A	565	11	A			
		Right	29	50	D						
	Lookout	Thru	1390	10	A	2111	17	B			
		Right	721	31	C						
Lookout/ Hospital	Lookout North	Thru	1088	12	A	1769	42	D	4745	29	C
		Right	681	89	F						
	Lookout South	Left	672	17	B	2634	20	B			
		Thru	1962	21	B						
	Hospital	Left	144	7	A	342	31	C			
		Right	197	48	D						
Lookout/ McCaffrey	Lookout North East	Thru	1077	2	A	1281	11	A	4550	52	D
		Right	204	55	D						
	Lookout South West	Left	234	58	E	2220	63	E			
		Thru	1986	64	E						
	McCaffrey North West	Left	662	68	E	1049	78	F			
		Right	387	96	F						
Lookout/ Cardiff	Lookout North	Thru	1224	16	B	1422	29	C	4146	34	C
		Right	198	111	F						
	Lookout South	Left	186	24	B	1972	35	C			
		Thru	1786	36	C						
	Cardiff	Left	344	24	B	751	41	C			
		Right	407	55	D						
Carnley/ Charlestown/ Lookout	Lookout	Left	341	26	B	1633	38	C	4928	25	B
		Thru	1291	41	C						
	Carnley	Left	499	1	A	736	19	B			
		Right	237	58	E						
	Charlestown	Thru	1783	8	A	2559	19	B			
		Right	776	44	D						

Douglas/ Newcastle	Douglas North	Left	125	44	D	228	54	D	4412	20	B
		Thru	35	50	D						
		Right	68	74	F						
	Newcastle East	Left	78	19	B	1457	21	B			
		Thru	1322	20	B						
		Right	57	45	D						
	Douglas South	Left	31	24	B	325	49	D			
		Thru	88	36	C						
		Right	206	57	E						
	Newcastle West	Left	26	16	B	2403	13	A			
		Thru	2336	12	A						
		Right	40	57	E						
Blue Gum/ Newcastle	Blue Gum North	Left	140	22	B	271	30	C	4420	24	B
		Thru	131	39	C						
	Newcastle East	Thru	1315	5	A	1456	10	A			
		Right	141	63	E						
	Newcastle West	Left	143	31	C	2693	30	C			
		Thru	2550	30	C						
Grandview/ Lookout	Lookout North	Thru	1438	3	A	1467	4	A	3758	13	A
		Right	28	64	E						
	Lookout South	Left	40	18	B	2125	19	B			
		Thru	2085	19	B						
	Lookout West	Left	166	11	A	166	11	A			
		Right	0	0	A						

Intersection	Approach	Mvt	2014 Existing PM								
			Movement			Approach			Intersection		
			Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS
University Interchange	ICB North	Left	65	2	A	201	6	A	2749	9	A
		Right	136	7	A						
	University East	Left	537	3	A	1596	7	A			
		Thru	835	9	A						
		Right	224	8	A						
	ICB South	Left	140	14	A	395	17	B			
		Right	255	19	B						
	University West	Left	66	2	A	556	10	A			
		Thru	345	12	A						
		Right	145	9	A						
Jesmond Roundabout	ICB	Left	1122	28	B	1833	40	C	5211	34	C
		Right	711	58	E						
	Newcastle East	Thru	1338	41	C	2994	43	D			
		Right	729	63	E						
	Newcastle West	Left	385	7	A	385	14	B			
		Thru	1355	16	B						
Croudace/ Dent/ Newcastle	Dent	Left	27	57	E	336	64	E	6264	82	F
		Thru	291	67	E						
		Right	18	34	C						
	Newcastle East	Left	609	30	C	2060	65	E			
		Thru	1361	77	F						
		Right	89	109	F						
	Croudace	Left	771	7	A	1423	26	B			
		Thru	277	48	D						
		Right	374	48	D						
	Newcastle West	Left	19	89	F	2445	132	F			
		Thru	1440	90	F						
		Right	986	196	F						
Croudace/ Howe	Croudace North	Left	277	14	A	1892	18	B	3433	21	B
		Thru	1615	18	B						
	Howe	Left	87	31	C	384	59	E			
		Right	297	67	E						
	Croudace South	Thru	1009	7	A	1157	12	A			
		Right	148	46	D						
Croudace/ Lookout/ Russell	Croudace	Left	32	110	F	1699	106	F	3906	56	E
		Thru	1668	106	F						
	Russell	Left	498	15	B	527	18	B			
		Right	29	68	E						
	Lookout	Thru	1112	8	A	1680	17	B			
		Right	568	34	C						
Lookout/ Hospital	Lookout North	Thru	2021	3	A	2262	7	A	4587	19	B
		Right	241	38	C						
	Lookout South	Left	233	4	A	1441	25	B			
		Thru	1208	29	C						
	Hospital	Left	299	22	B	884	40	C			
		Right	585	49	D						
Lookout/ McCaffrey	Lookout North East	Thru	1973	11	A	2594	26	B	4908	27	B
		Right	621	73	F						
	Lookout South West	Left	465	18	B	1602	23	B			
		Thru	1137	25	B						
	McCaffrey North West	Left	306	5	A	713	39	C			
		Right	406	64	E						
Lookout/ Cardiff	Lookout North	Thru	1910	10	A	2258	21	B	4520	28	B
		Right	348	78	F						
	Lookout South	Left	336	16	B	1683	31	C			
		Thru	1347	35	C						
	Cardiff	Left	237	14	B	579	44	D			
		Right	342	65	E						
Carnley/ Charlestown/ Lookout	Lookout	Left	259	32	C	2226	47	D	5159	30	C
		Thru	1967	49	D						
	Carnley	Left	835	3	A	1197	16	B			
		Right	362	47	D						
	Charlestown	Thru	1327	6	A	1736	18	B			
		Right	409	55	D						

Douglas/ Newcastle	Douglas North	Left	66	58	E	233	61	E	4360	34	
		Thru	87	58	E						
		Right	80	67	E						
	Newcastle East	Left	231	45	D	2248	47	D			
		Thru	1962	46	D						
		Right	55	92	F						
	Douglas South	Left	45	35	C	230	42	D			
		Thru	41	32	C						
		Right	144	48	D						
	Newcastle West	Left	32	14	B	1649	12	A			
		Thru	1579	10	A						
		Right	38	72	F						
Blue Gum/ Newcastle	Blue Gum North	Left	218	21	B	487	33	C	4324	29	
		Thru	270	42	D						
	Newcastle East	Thru	1841	19	B	2057	25	B			
		Right	216	79	F						
	Newcastle West	Left	251	32	C	1780	33	C			
		Thru	1529	33	C						
Grandview/ Lookout	Lookout North	Thru	2269	5	A	2378	6	A	4035	4	A
		Right	109	22	B						
	Lookout South	Left	88	1	A	1585	1	A			
		Thru	1496	1	A						
	Lookout West	Left	72	2	A	72	2	A			
		Right	0	0	A						

Intersection	Approach	Mvt	2020 No Project AM								
			Movement			Approach			Intersection		
			Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS
University Interchange	ICB North	Left	193	120	F	257	145	F	2709	56	E
		Right	64	220	F						
	University East	Left	238	30	C	740	27	B			
		Thru	373	25	B						
		Right	129	24	B						
	ICB South	Left	35	6	A	837	7	A			
		Right	802	7	A						
	University West	Left	66	83	F	876	102	F			
		Thru	625	102	F						
		Right	185	107	F						
Jesmond Roundabout	ICB	Left	702	93	F	1065	111	F	5059	42	D
		Right	363	147	F						
	Newcastle East	Thru	1123	19	B	2947	21	B			
		Right	1012	29	B						
	Newcastle West	Left	1046	21	B	1046	38	C			
		Thru	1793	48	D						
Croudace/ Dent/ Newcastle	Dent	Left	31	51	D	281	59	E	6089	58	E
		Thru	206	60	E						
		Right	45	62	E						
	Newcastle East	Left	332	8	A	1599	47	D			
		Thru	1193	55	D						
		Right	74	95	F						
	Croudace	Left	946	26	B	1768	58	E			
		Thru	313	96	F						
		Right	509	96	F						
	Newcastle West	Left	9	45	D	2441	65	E			
		Thru	1752	58	E						
		Right	680	83	F						
Croudace/ Howe	Croudace North	Left	226	9	A	1240	11	A	3045	18	B
		Thru	1015	12	A						
	Howe	Left	41	23	B	316	58	E			
		Right	275	63	E						
	Croudace South	Thru	1357	12	A	1489	16	B			
		Right	132	60	E						
Croudace/ Lookout/ Russell	Croudace	Left	31	31	C	1130	30	C	3901	21	B
		Thru	1099	30	C						
	Russell	Left	577	11	A	604	13	A			
		Right	28	56	D						
	Lookout	Thru	1431	10	A	2166	18	B			
		Right	735	33	C						
Lookout/ Hospital	Lookout North	Thru	1154	16	B	1879	45	D	4920	31	C
		Right	725	91	F						
	Lookout South	Left	675	18	B	2679	21	B			
		Thru	2004	22	B						
	Hospital	Left	146	9	A	362	32	C			
		Right	216	48	D						
Lookout/ McCaffrey	Lookout North East	Thru	1162	3	A	1370	10	A	4679	54	D
		Right	208	48	D						
	Lookout South West	Left	235	61	E	2289	67	E			
		Thru	2054	68	E						
	McCaffrey North West	Left	644	79	F	1020	85	F			
		Right	377	94	F						
Lookout/ Cardiff	Lookout North	Thru	1285	15	B	1484	21	B	4300	45	D
		Right	199	59	E						
	Lookout South	Left	178	54	D	2040	65	E			
		Thru	1862	66	E						
	Cardiff	Left	376	22	B	777	38	C			
		Right	401	52	D						
Carnley/ Charlestown/ Lookout	Lookout	Left	340	30	C	1688	44	D	5100	37	C
		Thru	1348	47	D						
	Carnley	Left	485	1	A	714	44	D			
		Right	229	136	F						
	Charlestown	Thru	1895	23	B	2698	31	C			
		Right	803	50	D						

Douglas/ Newcastle	Douglas North	Left	140	78	F	249	80	F	4726	22	B
		Thru	38	116	F						
		Right	71	64	E						
	Newcastle East	Left	72	19	B	1522	20	B			
		Thru	1396	19	B						
		Right	54	51	D						
	Douglas South	Left	34	29	C	351	47	D			
		Thru	103	35	C						
		Right	214	55	D						
	Newcastle West	Left	26	17	B	2605	14	B			
		Thru	2532	13	A						
		Right	46	65	E						
Blue Gum/ Newcastle	Blue Gum North	Left	153	34	C	309	40	C	4682	26	B
		Thru	156	46	D						
	Newcastle East	Thru	1345	7	A	1489	16	B			
		Right	144	104	F						
	Newcastle West	Left	151	29	B	2884	30	C			
		Thru	2733	30	C						
Grandview/ Lookout	Lookout North	Thru	1505	2	A	1537	3	A	3915	9	A
		Right	32	81	F						
	Lookout South	Left	43	9	A	2218	10	A			
		Thru	2175	10	A						
	Lookout West	Left	160	41	C	160	41	C			
		Right	0	0	A						

Intersection	Approach	Mvt	2020 With Project AM								
			Movement			Approach			Intersection		
			Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS
University Interchange	ICB North	Left	212	67	E	266	82	F	3104	26	
		Right	55	137	F						
	University East	Left	313	2	A	820	5	A			
		Thru	385	7	A						
		Right	122	8	A						
	ICB South	Left	34	6	A	1120	11	A			
		Right	1086	11	A						
	University West	Left	65	30	C	898	48	D			
		Thru	622	52	D						
		Right	211	44	D						
Northern Interchange C7	ICB North	Left	388	24	B	864	23	B	5853	35	
		Right	476	22	B						
	Newcastle East	Left	141	8	A	1676	42	D			
		Thru	1030	47	D						
		Right	504	42	D						
	ICB South	Left	223	44	D	229	46	D			
		Right	6	96	F						
	Newcastle West	Left	1055	26	B	3083	34	C			
		Thru	1689	38	C						
		Right	340	41	C						
Croudace/ Dent/ Newcastle	Dent	Left	45	29	C	280	51	D	4696	47	
		Thru	143	51	D						
		Right	92	61	E						
	Newcastle East	Left	183	7	A	1552	34	C			
		Thru	1286	33	C						
		Right	83	101	F						
	Croudace	Left	331	8	A	784	36	C			
		Thru	120	52	D						
		Right	333	57	E						
	Newcastle West	Left	14	48	D	2081	60	E			
		Thru	1819	58	E						
		Right	248	79	F						
Croudace/ Howe	Croudace North	Left	244	7	A	579	19	B	1501	21	
		Thru	335	28	B						
	Howe	Left	44	12	A	335	20	B			
		Right	291	22	B						
	Croudace South	Thru	508	15	B	587	24	B			
		Right	79	84	F						
Croudace/ Lookout/ Russell	Croudace	Left	31	45	D	453	51	D	2370	18	
		Thru	422	51	D						
	Russell	Left	533	4	A	557	6	A			
		Right	25	42	D						
	Lookout	Thru	608	6	A	1360	11	A			
		Right	753	16	B						
Lookout/ Hospital	Lookout North	Thru	570	8	A	808	19	B	2870	15	
		Right	238	44	D						
	Lookout South	Left	555	8	A	1803	11	A			
		Thru	1248	12	A						
	Hospital	Left	100	7	A	258	31	C			
		Right	158	46	D						
Lookout/ McCaffrey	Lookout North East	Thru	581	3	A	722	16	B	3062	14	
		Right	141	70	F						
	Lookout South West	Left	196	2	A	1435	10	A			
		Thru	1238	11	A						
	McCaffrey North West	Left	565	3	A	905	18	B			
		Right	340	44	D						
Lookout/ Cardiff	Lookout North	Thru	1433	8	A	1657	20	B	4639	52	
		Right	224	93	F						
	Lookout South	Left	174	60	E	2112	70	F			
		Thru	1939	71	F						
	Cardiff	Left	441	55	D	869	69	E			
		Right	428	84	F						
Carnley/ Charlestown/ Lookout	Lookout	Left	378	26	B	1848	38	C			
		Thru	1469	41	C						

	Carnley	Left	507	5	A	742	52	D	5379	43	D
		Right	235	152	F						
	Charlestown	Thru	1966	29	C	2789	43	D			
		Right	823	76	F						
Hospital Interchange	SBD Off Ramp	Left	327	2	A	327	2	A	437	1	A
	Hospital	Left	0	0	A	110	0	A			
		Right	110	0	A						
	NBD Off Ramp	Right	0	0	A	0	0	A			
Douglas/ Newcastle	Douglas North	Left	135	49	D	246	57	E	5168	18	B
		Thru	39	84	F						
		Right	72	58	E						
	Newcastle East	Left	89	16	B	1743	19	B			
		Thru	1592	17	B						
		Right	62	70	F						
	Douglas South	Left	35	29	C	342	54	D			
		Thru	88	38	C						
		Right	219	65	E						
	Newcastle West	Left	29	12	A	2837	11	A			
		Thru	2759	10	A						
		Right	50	73	F						
Blue Gum/ Newcastle	Blue Gum North	Left	169	34	C	325	36	C	5161	19	B
		Right	155	38	C						
	Newcastle East	Thru	1590	15	B	1738	24	B			
		Right	148	112	F						
	Newcastle West	Left	147	16	B	3098	14	B			
		Thru	2951	14	A						
Grandview/ Lookout	Lookout North	Thru	1667	0	A	1706	1	A	4270	4	A
		Right	39	42	C						
	Lookout South	Left	38	6	A	2382	5	A			
		Thru	2344	5	A						
	Lookout West	Left	182	19	B	182	19	B			
		Right	0	0	A						

Intersection	Approach	Mvt	2020 No Project PM								
			Movement			Approach			Intersection		
			Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS
University Interchange	ICB North	Left	77	2	A	229	7	A	2785	34	C
		Right	151	10	A						
	University East	Left	491	48	D	1490	53	D			
		Thru	774	55	D						
		Right	225	55	D						
	ICB South	Left	143	12	A	423	17	B			
		Right	280	19	B						
	University West	Left	75	6	A	644	13	A			
		Thru	402	15	B						
		Right	166	12	A						
Jesmond Roundabout	ICB	Left	1075	92	F	1752	97	F	5348	46	D
		Right	677	107	F						
	Newcastle East	Thru	1407	34	C	3156	36	C			
		Right	756	55	D						
	Newcastle West	Left	439	6	A	439	14	B			
		Thru	1490	16	B						
Croudace/ Dent/ Newcastle	Dent	Left	28	72	F	370	88	F	6496	89	F
		Thru	323	89	F						
		Right	19	97	F						
	Newcastle East	Left	614	55	D	2089	96	F			
		Thru	1379	110	F						
		Right	96	151	F						
	Croudace	Left	797	7	A	1462	27	B			
		Thru	286	52	D						
		Right	379	50	D						
	Newcastle West	Left	22	84	F	2575	118	F			
		Thru	1559	77	F						
		Right	994	183	F						
Croudace/ Howe	Croudace North	Left	288	15	B	1930	20	B	3499	24	B
		Thru	1642	21	B						
	Howe	Left	87	26	B	398	57	E			
		Right	311	66	E						
	Croudace South	Thru	1018	9	A	1171	17	B			
		Right	153	73	F						
Croudace/ Lookout/ Russell	Croudace	Left	32	94	F	1719	93	F	3981	55	D
		Thru	1688	93	F						
	Russell	Left	533	24	B	562	25	B			
		Right	29	58	E						
	Lookout	Thru	1112	14	A	1700	25	B			
		Right	588	47	D						
Lookout/ Hospital	Lookout North	Thru	2079	6	A	2330	9	A	4672	22	B
		Right	251	34	C						
	Lookout South	Left	225	5	A	1435	29	C			
		Thru	1210	34	C						
	Hospital	Left	307	26	B	907	43	D			
		Right	600	51	D						
Lookout/ McCaffrey	Lookout North East	Thru	2039	14	A	2668	28	B	5019	32	C
		Right	629	74	F						
	Lookout South West	Left	504	23	B	1641	28	B			
		Thru	1136	30	C						
	McCaffrey North West	Left	308	17	B	710	56	E			
		Right	401	86	F						
Lookout/ Cardiff	Lookout North	Thru	1966	12	A	2323	19	B	4628	46	D
		Right	357	57	E						
	Lookout South	Left	348	19	B	1750	34	C			
		Thru	1403	37	C						
						554	195	F			
		Right	328	224	F						
Carnley/ Charlestown/ Lookout	Lookout	Left	276	95	F	2264	109	F	5291	60	E
		Thru	1987	111	F						
	Carnley	Left	866	6	A	1233	31	C			
		Right	366	91	F						

	Charlestown	Thru	1388	7	A	1794	18	B			
		Right	406	55	D						
Douglas/ Newcastle	Douglas North	Left	78	46	D	265	50	D	4603	32	C
		Thru	91	64	E						
		Right	96	39	C						
	Newcastle East	Left	234	46	D	2292	45	D			
		Thru	2004	44	D						
		Right	53	77	F						
	Douglas South	Left	56	27	B	265	40	C			
		Thru	43	42	D						
		Right	167	44	D						
	Newcastle West	Left	32	7	A	1781	12	A			
		Thru	1711	11	A						
		Right	38	53	D						
Blue Gum/ Newcastle	Blue Gum North	Left	242	25	B	519	40	C	4563	31	C
		Thru	276	53	D						
	Newcastle East	Thru	1866	19	B	2099	27	B			
		Right	233	83	F						
	Newcastle West	Left	254	35	C	1946	33	C			
		Thru	1692	33	C						
Grandview/ Lookout	Lookout North	Thru	2332	5	A	2444	6	A	4151	4	A
		Right	112	21	B						
	Lookout South	Left	96	1	A	1629	1	A			
		Thru	1533	1	A						
	Lookout West	Left	77	4	A	77	4	A			
		Right	0	0	A						

Intersection	Approach	Mvt	2020 With Project PM								
			Movement			Approach			Intersection		
			Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS
University Interchange	ICB North	Left	76	2	A	223	5	A	3330	12	A
		Right	146	7	A						
	University East	Left	704	6	A	1849	11	A			
		Thru	891	13	A						
		Right	255	13	A						
	ICB South	Left	174	19	B	624	23	B			
		Right	450	25	B						
	University West	Left	73	3	A	634	10	A			
		Thru	384	12	A						
		Right	177	9	A						
Northern Interchange C7	ICB North	Left	572	18	B	1361	15	B	5688	30	C
		Right	789	13	A						
	Newcastle East	Left	37	9	A	1955	36	C			
		Thru	1378	34	C						
		Right	540	44	D						
	ICB South	Left	354	47	D	391	48	D			
		Right	38	54	D						
	Newcastle West	Left	433	21	B	1981	31	C			
		Thru	1262	33	C						
		Right	285	40	C						
Croudace/ Dent/ Newcastle	Dent	Left	42	75	F	357	77	F	5182	31	C
		Thru	269	72	F						
		Right	46	104	F						
	Newcastle East	Left	555	6	A	2144	19	B			
		Thru	1498	21	B						
		Right	91	68	E						
	Croudace	Left	425	5	A	776	28	B			
		Thru	112	54	D						
		Right	240	57	E						
	Newcastle West	Left	31	37	C	1905	38	C			
		Thru	1589	33	C						
		Right	285	65	E						
Croudace/ Howe	Croudace North	Left	310	9	A	1114	20	B	2056	21	B
		Thru	804	25	B						
	Howe	Left	79	26	B	396	31	C			
		Right	317	33	C						
	Croudace South	Thru	464	10	A	545	15	B			
		Right	82	42	C						
Croudace/ Lookout/ Russell	Croudace	Left	31	13	A	935	10	A	2666	16	B
		Thru	904	10	A						
	Russell	Left	562	6	A	590	7	A			
		Right	28	31	C						
	Lookout	Thru	562	12	A	1142	25	B			
		Right	580	38	C						
Lookout/ Hospital	Lookout North	Thru	1364	3	A	1429	5	A	3062	15	B
		Right	65	47	D						
	Lookout South	Left	193	2	A	962	19	B			
		Thru	769	23	B						
	Hospital	Left	197	12	A	671	32	C			
		Right	474	40	C						
Lookout/ McCaffrey	Lookout North East	Thru	1325	7	A	1819	18	B	3543	16	B
		Right	494	47	D						
	Lookout South West	Left	413	4	A	1110	9	A			
		Thru	697	12	A						
	McCaffrey North West	Left	265	2	A	613	24	B			
		Right	348	41	C						
Lookout/ Cardiff	Lookout North	Thru	2196	9	A	2645	15	B	5077	43	D
		Right	449	46	D						
	Lookout South	Left	351	48	D	1856	59	E			
		Thru	1506	61	E						
	Cardiff	Left	256	84	F	575	119	F			
		Right	319	147	F						
Carnley/ Charlestown/ Lookout	Lookout	Left	290	108	F	2468	120	F			
		Thru	2178	121	F						

	Carnley	Left	897	4	A	1306	30	C	5683	66	E
		Right	409	86	F						
	Charlestown	Thru	1485	8	A	1909	21	B			
		Right	424	68	E						
Hospital Interchange	SBD Off Ramp	Left	125	0	A	125	0	A	427	0	A
	Hospital	Left	0	0	A	302	0	A			
		Right	302	0	A						
	NBD Off Ramp	Right	0	0	A	0	0	A			
Douglas/ Newcastle	Douglas North	Left	82	54	D	251	71	F	5163	19	B
		Thru	84	77	F						
		Right	85	82	F						
	Newcastle East	Left	265	17	B	2750	16	B			
		Thru	2431	15	B						
		Right	54	68	E						
	Douglas South	Left	50	26	B	253	65	E			
		Thru	42	35	C						
		Right	162	85	F						
	Newcastle West	Left	33	8	A	1908	9	A			
		Thru	1836	8	A						
		Right	39	70	F						
Blue Gum/ Newcastle	Blue Gum North	Left	247	24	B	535	36	C	5134	24	B
		Right	288	46	D						
	Newcastle East	Thru	2294	22	B	2559	27	B			
		Right	265	69	E						
	Newcastle West	Left	257	16	B	2040	17	B			
		Thru	1783	17	B						
Grandview/ Lookout	Lookout North	Thru	2661	2	A	2787	2	A	4641	3	A
		Right	126	21	B						
	Lookout South	Left	73	3	A	1770	3	A			
		Thru	1697	3	A						
	Lookout West	Left	84	7	A	84	7	A			
		Right	0	0	A						

Intersection	Approach	Mvt	2030 No Project AM								
			Movement			Approach			Intersection		
			Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS
University Interchange	ICB North	Left	185	212	F	247	249	F	2717	85	F
		Right	63	358	F						
	University East	Left	231	66	E	735	59	E			
		Thru	376	56	E						
		Right	128	56	D						
	ICB South	Left	34	9	A	881	14	B			
		Right	847	14	A						
	University West	Left	62	112	F	853	135	F			
		Thru	602	137	F						
		Right	189	133	F						
Jesmond Roundabout	ICB	Left	662	103	F	990	131	F	5253	44	D
		Right	328	187	F						
	Newcastle East	Thru	1205	23	B	3109	25	B			
		Right	1048	34	C						
	Newcastle West	Left	1153	21	B	1153	35	C			
		Thru	1874	43	D						
Croudace/ Dent/ Newcastle	Dent	Left	37	42	C	316	52	D	6319	69	E
		Thru	230	52	D						
		Right	49	63	E						
	Newcastle East	Left	343	53	D	1687	106	F			
		Thru	1256	118	F						
		Right	88	150	F						
	Croudace	Left	966	20	B	1822	46	D			
		Thru	333	81	F						
		Right	523	74	F						
	Newcastle West	Left	7	37	C	2493	63	E			
		Thru	1816	55	D						
		Right	670	84	F						
Croudace/ Howe	Croudace North	Left	243	9	A	1266	11	A	3103	17	B
		Thru	1024	12	A						
	Howe	Left	42	28	B	339	65	E			
		Right	297	70	E						
	Croudace South	Thru	1370	3	A	1498	10	A			
		Right	128	81	F						
Croudace/ Lookout/ Russell	Croudace	Left	31	23	B	1139	30	C	3962	22	B
		Thru	1108	31	C						
	Russell	Left	630	12	A	659	14	B			
		Right	29	52	D						
	Lookout	Thru	1448	12	A	2165	20	B			
		Right	717	36	C						
Lookout/ Hospital	Lookout North	Thru	1164	27	B	1926	53	D	4961	35	C
		Right	762	94	F						
	Lookout South	Left	675	19	B	2680	23	B			
		Thru	2005	24	B						
	Hospital	Left	150	9	A	356	31	C			
		Right	206	47	D						
Lookout/ McCaffrey	Lookout North East	Thru	1157	3	A	1363	11	A	4663	62	E
		Right	206	59	E						
	Lookout South West	Left	239	89	F	2294	96	F			
		Thru	2055	96	F						
	McCaffrey North West	Left	644	47	D	1006	55	D			
		Right	362	69	E						
Lookout/ Cardiff	Lookout North	Thru	1261	15	B	1448	25	B	4281	63	E
		Right	188	99	F						
	Lookout South	Left	180	74	F	2043	86	F			
		Thru	1863	88	F						
	Cardiff	Left	371	56	E	789	73	F			
		Right	418	88	F						
Carnley/ Charlestown/ Lookout	Lookout	Left	353	25	B	1688	39	C	5141	54	D
		Thru	1334	42	D						
	Carnley	Left	512	3	A	732	56	E			
		Right	220	178	F						
	Charlestown	Thru	1912	59	E	2721	63	E			
		Right	809	73	F						

Douglas/ Newcastle	Douglas North	Left	162	51	D	277	52	D	4958	22	B
		Thru	40	37	C						
		Right	76	61	E						
	Newcastle East	Left	84	21	B	1575	21	B			
		Thru	1429	19	B						
		Right	62	77	F						
	Douglas South	Left	38	41	C	378	47	D			
		Thru	101	44	D						
		Right	238	49	D						
	Newcastle West	Left	30	12	A	2727	16	B			
		Thru	2652	15	B						
		Right	45	64	E						
Blue Gum/ Newcastle	Blue Gum North	Left	184	48	D	348	48	D	4931	33	C
		Thru	165	48	D						
	Newcastle East	Thru	1390	20	B	1540	32	C			
		Right	150	146	F						
	Newcastle West	Left	159	33	C	3043	32	C			
		Thru	2884	32	C						
Grandview/ Lookout	Lookout North	Thru	1474	4	A	1502	5	A	3884	15	B
		Right	29	90	F						
	Lookout South	Left	43	21	B	2214	19	B			
		Thru	2171	19	B						
	Lookout West	Left	167	49	D	167	49	D			
		Right	0	0	A						

Intersection	Approach	Mvt	2030 With Project AM								
			Movement			Approach			Intersection		
			Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS
University Interchange	ICB North	Left	214	222	F	268	242	F	3465	59	E
		Right	54	323	F						
	University East	Left	360	2	A	952	5	A			
		Thru	452	7	A						
		Right	140	7	A						
	ICB South	Left	46	22	B	1312	22	B			
		Right	1266	22	B						
	University West	Left	61	88	F	933	113	F			
		Thru	652	117	F						
		Right	220	108	F						
Northern Interchange C7	ICB North	Left	452	23	B	904	23	B	6313	35	C
		Right	452	23	B						
	Newcastle East	Left	80	7	A	1791	43	D			
		Thru	1104	47	D						
		Right	606	40	C						
	ICB South	Left	254	37	C	260	38	C			
		Right	6	92	F						
	Newcastle West	Left	1213	22	B	3359	34	C			
		Thru	1777	41	C						
		Right	368	42	D						
Croudace/ Dent/ Newcastle	Dent	Left	78	50	D	343	61	E	5138	50	D
		Thru	174	59	E						
		Right	91	74	F						
	Newcastle East	Left	235	11	A	1708	43	D			
		Thru	1380	45	D						
		Right	92	101	F						
	Croudace	Left	365	9	A	866	41	C			
		Thru	144	60	E						
		Right	357	65	E						
	Newcastle West	Left	16	47	D	2221	57	E			
		Thru	1959	54	D						
		Right	245	84	F						
Croudace/ Howe	Croudace North	Left	269	7	A	659	19	B	1679	21	B
		Thru	390	26	B						
	Howe	Left	47	16	B	371	21	B			
		Right	325	22	B						
	Croudace South	Thru	559	14	B	648	23	B			
		Right	89	79	F						
Croudace/ Lookout/ Russell	Croudace	Left	27	62	E	507	60	E	2591	19	B
		Thru	481	59	E						
	Russell	Left	595	6	A	618	9	A			
		Right	23	73	F						
	Lookout	Thru	672	4	A	1466	10	A			
		Right	793	15	B						
Lookout/ Hospital	Lookout North	Thru	692	6	A	931	17	B	3208	19	B
		Right	239	51	D						
	Lookout South	Left	634	12	A	1984	17	B			
		Thru	1350	20	B						
	Hospital	Left	101	7	A	293	30	C			
		Right	192	43	D						
Lookout/ McCaffrey	Lookout North East	Thru	705	3	A	878	16	B	3393	14	B
		Right	173	70	F						
	Lookout South West	Left	181	4	A	1536	12	A			
		Thru	1355	13	A						
	McCaffrey North West	Left	632	2	A	979	15	B			
		Right	347	39	C						
Lookout/ Cardiff	Lookout North	Thru	1469	7	A	1751	13	A	5039	34	C
		Right	282	47	D						
	Lookout South	Left	216	21	B	2318	29	C			
		Thru	2102	29	C						
	Cardiff	Left	516	69	E	970	83	F			
		Right	454	100	F						
Carnley/ Charlestown/ Lookout	Lookout	Left	387	18	B	1909	26	B			
		Thru	1521	29	B						

	Carnley	Left	579	1	A	863	49	D	5747	47	D
		Right	284	146	F						
	Charlestown	Thru	2078	45	D	2975	60	E			
		Right	898	94	F						
Hospital Interchange	SBD Off Ramp	Left	428	2	A	428	2	A	562	1	A
	Hospital	Left	0	0	A	134	0	A			
		Right	134	0	A						
	NBD Off Ramp	Right	0	0	A	0	0	A			
Douglas/ Newcastle	Douglas North	Left	154	67	E	275.4	85	F	5630	23	B
		Thru	44	111	F						
		Right	78	106	F						
	Newcastle East	Left	108	14	A	1923.8	15	B			
		Thru	1747	14	B						
		Right	69	36	C						
	Douglas South	Left	44	39	C	381.6	105	F			
		Thru	106	48	D						
		Right	232	143	F						
	Newcastle West	Left	34	8	A	3049.6	13	A			
		Thru	2964	12	A						
		Right	52	73	F						
Blue Gum/ Newcastle	Blue Gum North	Left	189	28	B	370	41	C	5641	30	C
		Right	181	54	D						
	Newcastle East	Thru	1742	31	C	1904	44	D			
		Right	162	185	F						
	Newcastle West	Left	167	20	B	3367	21	B			
		Thru	3201	21	B						
Grandview/ Lookout	Lookout North	Thru	1760	6	A	1811	7	A	4614	7	A
		Right	51	50	D						
	Lookout South	Left	34	5	A	2621	4	A			
		Thru	2587	4	A						
	Lookout West	Left	182	49	D	182	49	D			
		Right	0	0	A						

Intersection	Approach	Mvt	2030 No Project PM								
			Movement			Approach			Intersection		
			Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS
University Interchange	ICB North	Left	59	12	A	171	27	B	2419	58	E
		Right	111	36	C						
	University East	Left	337	119	F	1010	117	F			
		Thru	522	116	F						
		Right	151	116	F						
	ICB South	Left	155	9	A	460	13	A			
		Right	305	15	B						
	University West	Left	86	6	A	778	15	B			
		Thru	489	16	B						
		Right	204	16	B						
Jesmond Roundabout	ICB	Left	945	110	F	1541	126	F	5242	44	D
		Right	596	151	F						
	Newcastle East	Thru	1423	22	B	3211	23	B			
		Right	777	37	C						
	Newcastle West	Left	490	7	A	490	15	B			
		Thru	1631	17	B						
Croudace/ Dent/ Newcastle	Dent	Left	30	412	F	398	427	F	6620	102	F
		Thru	343	430	F						
		Right	24	412	F						
	Newcastle East	Left	633	74	F	2112	98	F			
		Thru	1391	107	F						
		Right	88	126	F						
	Croudace	Left	833	9	A	1527	28	B			
		Thru	289	49	D						
		Right	404	54	D						
	Newcastle West	Left	23	69	E	2584	98	F			
		Thru	1629	68	E						
		Right	931	150	F						
Croudace/ Howe	Croudace North	Left	280	56	E	1882	58	E	3517	43	D
		Thru	1603	58	E						
	Howe	Left	84	23	B	399	58	E			
		Right	315	67	E						
	Croudace South	Thru	1080	9	A	1236	16	B			
		Right	156	64	E						
Croudace/ Lookout/ Russell	Croudace	Left	36	149	F	1676	139	F	4096	75	F
		Thru	1640	138	F						
	Russell	Left	615	28	B	654	30	C			
		Right	39	57	E						
	Lookout	Thru	1163	19	B	1766	31	C			
		Right	603	54	D						
Lookout/ Hospital	Lookout North	Thru	2094	5	A	2358	8	A	4800	27	B
		Right	264	32	C						
	Lookout South	Left	247	7	A	1528	30	C			
		Thru	1280	34	C						
	Hospital	Left	308	48	D	915	72	F			
		Right	607	84	F						
Lookout/ McCaffrey	Lookout North East	Thru	1983	21	B	2660	38	C	5104	34	C
		Right	677	90	F						
	Lookout South West	Left	508	21	B	1698	26	B			
		Thru	1190	28	B						
	McCaffrey North West	Left	330	6	A	746	39	C			
		Right	416	65	E						
Lookout/ Cardiff	Lookout North	Thru	1924	12	A	2291	21	B	4639	48	D
		Right	366	66	E						
	Lookout South	Left	350	17	B	1782	31	C			
		Thru	1432	35	C						
	Cardiff	Left	233	166	F	566	207	F			
		Right	334	236	F						
Carnley/ Charlestown/ Lookout	Lookout	Left	276	88	F	2229	103	F	5315	60	E
		Thru	1953	106	F						
	Carnley	Left	850	11	A	1226	45	D			
		Right	376	121	F						
	Charlestown	Thru	1416	7	A	1860	19	B			
		Right	443	57	E						

Douglas/ Newcastle	Douglas North	Left	89	59	E	284	71	F	4836	28	
		Thru	101	97	F						
		Right	93	56	D						
	Newcastle East	Left	222	34	C	2280	35	C			
		Thru	2006	34	C						
		Right	52	66	E						
	Douglas South	Left	57	26	B	278	49	D			
		Thru	44	35	C						
		Right	177	59	E						
	Newcastle West	Left	41	8	A	1994	12	A			
		Thru	1912	11	A						
		Right	40	77	F						
Blue Gum/ Newcastle	Blue Gum North	Left	267	26	B	580	36	C	4759	27	
		Thru	313	44	D						
	Newcastle East	Thru	1803	12	A	2027	19	B			
		Right	224	74	F						
	Newcastle West	Left	285	30	C	2152	32	C			
		Thru	1867	33	C						
Grandview/ Lookout	Lookout North	Thru	2290	6	A	2398	7	A	4157	5	
		Right	108	22	B						
	Lookout South	Left	100	2	A	1669	2	A			
		Thru	1569	2	A						
	Lookout West	Left	90	4	A	90	4	A			
		Right	0	0	A						

Intersection	Approach	Mvt	2030 With Project PM								
			Movement			Approach			Intersection		
			Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS
University Interchange	ICB North	Left	84	3	A	256	7	A	3787	29	C
		Right	172	10	A						
	University East	Left	827	17	B	2100	22	B			
		Thru	1004	26	B						
		Right	269	25	B						
	ICB South	Left	203	58	E	733	75	F			
		Right	530	81	F						
	University West	Left	82	3	A	699	11	A			
		Thru	429	13	A						
		Right	188	9	A						
Northern Interchange C7	ICB North	Left	648	18	B	1295	18	B	6216	31	C
		Right	648	18	B						
	Newcastle East	Left	156	8	A	2299	39	C			
		Thru	1472	30	C						
		Right	671	66	E						
	ICB South	Left	387	37	C	472	39	C			
		Right	85	46	D						
	Newcastle West	Left	475	8	A	2150	30	C			
		Thru	1354	33	C						
		Right	321	47	D						
Croudace/ Dent/ Newcastle	Dent	Left	61	82	F	401	94	F	5690	43	D
		Thru	250	103	F						
		Right	90	80	F						
	Newcastle East	Left	510	16	B	2370	41	C			
		Thru	1762	45	D						
		Right	98	108	F						
	Croudace	Left	465	5	A	796	28	B			
		Thru	110	58	E						
		Right	221	60	E						
	Newcastle West	Left	56	34	C	2123	41	C			
		Thru	1763	36	C						
		Right	304	69	E						
Croudace/ Howe	Croudace North	Left	343	5	A	1070	18	B	2052	20	B
		Thru	727	24	B						
	Howe	Left	87	24	B	441	28	B			
		Right	354	29	C						
	Croudace South	Thru	442	6	A	541	16	B			
		Right	99	63	E						
Croudace/ Lookout/ Russell	Croudace	Left	38	84	F	851	72	F	2720	39	C
		Thru	813	71	F						
	Russell	Left	674	9	A	697	10	A			
		Right	23	41	C						
	Lookout	Thru	551	22	B	1171	34	C			
		Right	620	44	D						
Lookout/ Hospital	Lookout North	Thru	1378	5	A	1437	6	A	3152	19	B
		Right	59	33	C						
	Lookout South	Left	196	4	A	977	25	B			
		Thru	782	30	C						
	Hospital	Left	211	17	B	738	37	C			
		Right	528	45	D						
Lookout/ McCaffrey	Lookout North East	Thru	1333	16	B	1884	27	B	3627	21	B
		Right	551	53	D						
	Lookout South West	Left	400	3	A	1072	9	A			
		Thru	672	12	A						
	McCaffrey North West	Left	308	3	A	671	25	B			
		Right	363	44	D						
Lookout/ Cardiff	Lookout North	Thru	2280	34	C	2813	38	C	5333	56	E
		Right	533	57	E						
	Lookout South	Left	379	11	A	1911	16	B			
		Thru	1533	18	B						
	Cardiff	Left	277	186	F	609	265	F			
		Right	332	331	F						
Carnley/ Charlestown/ Lookout	Lookout	Left	301	98	F	2566	108	F			
		Thru	2266	109	F						

	Carnley	Left	795	10	A	1137	48	D	5777	67	E
		Right	342	137	F						
	Charlestown	Thru	1574	6	A	2074	25	B			
		Right	500	86	F						
Hospital Interchange	SBD Off Ramp	Left	160	1	A	160	1	A	547	0	A
	Hospital	Left	0	0	A	387	0	A			
		Right	387	0	A						
	NBD Off Ramp	Right	0	0	A	0	0	A			
Douglas/ Newcastle	Douglas North	Left	89	119	F	281.2	133	F	5667	20	B
		Thru	91	154	F						
		Right	102	126	F						
	Newcastle East	Left	296	10	A	3033.8	11	A			
		Thru	2672	10	A						
		Right	65	66	E						
	Douglas South	Left	54	27	B	273.8	84	F			
		Thru	45	37	C						
		Right	175	114	F						
	Newcastle West	Left	32	10	A	2078.2	10	A			
		Thru	2010	9	A						
		Right	36	70	E						
Blue Gum/ Newcastle	Blue Gum North	Left	256	23	B	574	34	C	5576	19	B
		Right	318	44	D						
	Newcastle East	Thru	2511	13	A	2770	16	B			
		Right	259	50	D						
	Newcastle West	Left	288	16	B	2232	20	B			
		Thru	1944	20	B						
Grandview/ Lookout	Lookout North	Thru	2839	20	B	2989	21	B	4873	13	A
		Right	150	41	C						
	Lookout South	Left	69	1	A	1808	1	A			
		Thru	1739	1	A						
	Lookout West	Left	76	7	A	76	7	A			
		Right	0	0	A						

Aurecon Australia Pty Ltd
ABN 54 005 139 87
23 Warabrook Boulevard
Warabrook NSW 2304
Australia

T +61 2 4941 5415
F +61 2 4941 5489
E newcastle@aurecongroup.com
W aurecongroup.com