The Northern Road Upgrade, Glenmore Parkway, Glenmore Park to Jamison Road, South Penrith

Roads and Maritime Services

Traffic and Transport

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Contents

Glossary of terms and acronyms

Term / acronym	Meaning
100MVKT	100 million vehicle kilometres travelled
AIMSUN	A microsimulation tool for evaluation of road network performance
AADT	Annual average daily traffic
ATC	Automatic Traffic Count
BSA	Bureau of Statistics and Analytics, Transport for NSW
CBD	Central Business District
CEMP	Construction Environmental Management Plan
Crash severity index	An assessment of road safety based on the type and number of crashes occurring on a subject section of road
CTMP	Construction Traffic Management Plan
DEOH	Defence Establishment Orchard Hills
DoS	Degree of saturation
DPE	NSW Department of Planning and Environment
EIS	Environmental Impact Statement
EP&A Act	Environmental Planning and Assessment Act 1979
GEH	It is a standard statistical measure used in the calibration of traffic models to compare the differences between modelled and observed traffic flows
LEP	Local Environment Plan
LGA	Local Government Area
LoS	Level of service
LTTMP	NSW Long Term Transport Master Plan
M4	M4 Western Motorway
M7	M7 Motorway
M12	A proposed motorway planned for Western Sydney Airport access
PCU	Passenger car units
REF	Review of Environmental Factors
RMS	NSW Roads and Maritime Services
Roads and Maritime	NSW Roads and Maritime Services
SAFN	Sydney Area Foundation Model
SEARs	Secretary's environmental assessment requirements
SSI	State Significant Infrastructure
STAM	Strategic Traffic Assignment Model, a static highway assignment traffic model run by NSW Roads and Maritime Services

Term / acronym	Meaning
STM	Sydney Strategic Travel Model, a travel demand forecasting model run by Transport for NSW
TfNSW	Transport for NSW
TMP	Traffic Management Plan
VHT	Vehicle hours travelled
VKT	Vehicle kilometres travelled
VMS	Variable Message Sign
VPH	Vehicles per hour
WSA	Proposed Western Sydney Airport in Badgerys Creek
WSIP	Western Sydney Infrastructure Plan

Executive Summary

Jacobs has been engaged by Roads and Maritime Services (Roads and Maritime) to prepare a Review of Environmental Factors (REF) for The Northern Road Upgrade between Glenmore Parkway, Glenmore Park and Jamison Road, Penrith (the proposal). The proposal comprises about four km of The Northern Road, from Glenmore Parkway, Glenmore Park to Jamison Road, Penrith, upgrading from the existing four-lane to an eight-lane road.

The Northern Road would consist of an eight-lane divided road with three general traffic lanes and a kerbside bus lane in each direction up to Jamison Road. The proposal would include upgrades and changes to some intersections as well as provisions for pedestrians and cyclists.

The assessment provided in this report will be used to inform the REF. The key areas examined as part of this impact assessment include:

- An understanding of the existing traffic and transport conditions in the study area
- Assessing the impacts of future developments and growth in travel demand at completion (2021),10 years (2031) and 20 years (2041) after completion
- Assessing the impacts of the proposed The Northern Road upgrade in 2021, 2031 and 2041
- Assess impacts on pedestrians, cyclists and public transport
- Assess impacts of the construction phase of the proposal
- Identify mitigation measures required to address these impacts.

Existing transport network

Road network

The Northern Road is a major arterial road that extends between Narellan and Richmond. The Northern Road is a four-lane road with sections of divided and undivided road throughout the study area.

The corridor will play an increasingly important role as development increases in the Western Sydney Priority Growth Area. The road will also form a key connection to the planned Western Sydney Airport (WSA) at Badgerys Creek.

The study area includes the following roads which connect with The Northern Road:

- Glenmore Parkway: a collector two-lane divided road. It is 12 m to 35 m wide and has a signposted speed limit of 50 km/h
- Wentworth Road: a local two-lane undivided road. It is six metres wide and has a signposted speed limit of 70 km/h
- The M4 Motorway: a six-lane east-west motorway that connects the Blue Mountains with the greater Sydney metropolitan area. The M4 Motorway interchanges with The Northern Road in the study area and has a signposted speed limit of 110 km/h
- Tukara Road: a collector two-lane undivided road. It is 11 m wide and has a signposted speed limit of 50 km/h
- Frogmore Road: a local two-lane undivided road. It is six metres wide and has a signposted speed limit of 60 km/h
- Maxwell Street: a collector two-lane undivided road that widens to four lanes on approach to The Northern Road. Maxwell Street is 12 m wide and has a signposted speed limit of 50 km/h
- Bringelly Road: a collector two-lane undivided road that widens to four lanes on approach to The Northern Road. Bringelly Road is 11 m wide and has a signposted speed limit of 50 km/h
- Smith Street: a collector four-lane road that is undivided through the study area. Smith Street is 12 m wide and has a signposted speed of 50 km/h

- Jamison Road: a sub-arterial four-lane road that is a divided carriageway to the east of The Northern Road and undivided to the west of The Northern Road. Jamison Road is between 13 m and 20 m wide and has a signposted speed limit of 60 km/h.

Public transport network

There are currently two bus routes that operate through the study area:

- Route 794 operates between Penrith and Glenmore Park, predominantly along The Northern Road. This service operates every 30 minutes in both the morning and evening peak periods and every hour during off-peak and weekend periods
- Route 789 operates between Penrith and Luddenham, along The Northern Road. Only one service in each direction is provided in the morning and evening peak periods.

Active transport network

There is currently limited pedestrian infrastructure provided along The Northern Road. Footpaths along The Northern Road are provided between Maxwell Street and Jamison Road however no formal footpath is provided between Maxwell Street and Glenmore Parkway.

On-road cycle lanes are provided in the shoulder of The Northern Road between Glenmore Parkway and the M4 Motorway. The Northern Road is designated as a 'bicycle friendly road' between Tukara Road and Jamison Road however no formal lanes or infrastructure are provided.

Future traffic and transport impacts

Do Minimum scenario traffic performance

Modelling of the Do Minimum scenario indicates that the performance of intersections along the proposal corridor would be unacceptably low if the proposal was not built. In general, testing of the forecast traffic flows on The Northern Road under the future year scenarios shows that there would be insufficient capacity along The Northern Road under the existing configuration. This level of congestion indicates that the forecast traffic demand cannot be adequately served by the road network under these conditions. Glenmore Parkway and Wentworth Road, the M4 Motorway, Frogmore Road and Tukara Road, and Maxwell Street and Bringelly Road, are the worst performing intersections in the 2021 Do Minimum scenario model. The 2031 and 2041 Do Minimum scenario modelling shows that the majority of intersections perform at Level of Service (LoS) F and worse delays would be likely along the corridor under this scenario.

Proposal scenario traffic performance

The modelling of the 2021, 2031 and 2041 forecast traffic growth scenarios with the proposal indicates that the proposal would relieve the capacity constraints along The Northern Road, particularly at the M4 Motorway, Frogmore Road and Tukara Road, and Maxwell Street and Bringelly Road. Under these future growth scenarios, the intersections along The Northern Road study area are likely to operate acceptably at LoS D or better, with the exception of Maxwell Street and Bringelly Road under 2041 future growth scenario.

Modelled intersection delays also show that the intersections would generally perform with higher delays in 2041 and 2031 than 2021; this is consistent with the increase in traffic forecast between these years as a consequence of additional land use at the proposed Western Sydney Airport and the South West Priority Growth Area.

Impacts on local roads and access

The proposal would have impacts on the following local roads and access in the study area:

- Fairwater Court: residents of Fairwater Court currently use the roundabout at the intersection of The Northern Road and Glenmore Parkway to make a u-turn to travel west along Glenmore Parkway. This will no longer be possible when this intersection is upgraded to traffic signals

- Penrith Golf and Recreation club: the right turn out of the Penrith Golf and Recreation club to The Northern Road is currently permitted. Under the proposal, this turn would no longer be permitted
- Garswood Road: right turns out of and into Garswood Road is currently not permitted from The Northern Road. Traffic travelling south along The Northern Road continue to Glenmore Parkway where drivers may use the existing roundabout to make a u-turn to access to Garswood Road. Under the proposal this movement would no longer be possible
- Homestead Road: right turns into and out of Homestead Road are currently permitted from The Northern Road. The proposal would result in a median through this intersection that would change access at Homestead Road to left in and left out only
- Castle Road and Frogmore Road: properties on the eastern side of The Northern Road are currently able to turn right from the south and right to the north to access their properties. The proposal would result in a median through this intersection that would change access to these properties to left in and left out only
- Castle Road: right turns into and out of Castle Road are currently permitted from The Northern Road. The proposal would result in a median through this intersection that would change access at Castle Road to left in and left out only.
- Smith Street and Bringelly Road: properties on the eastern side of The Northern Road are currently able to turn right across The Northern Road to access their properties. The proposal would result in a median through this intersection that would change access to these properties to left in and left out only.

Impacts on public transport

The proposal includes the provision of a 24 hour kerbside bus lane in each direction between Glenmore Parkway and Jamison Road. This bus lane would allow buses to travel north and south along The Northern Road without being affected by general traffic congestion and delays. These bus lanes would support the operation of a high-frequency, ‘Rapid’ tier bus service between Liverpool and Penrith via the planned Western Sydney Airport, providing the operating conditions required to deliver the travel speed and reliability that customers would expect from a higher-order, centre-to-centre public transport connection. In addition to the bus lanes, relocation of existing bus stops will also be undertaken.

Impacts on freight transport

The proposal would improve reliability, travel times and operating conditions for freight traffic currently travelling on The Northern Road. Increased lane widths and design speed along The Northern Road would make the road better suited to semi-trailer and B-Double vehicles. Although the proposal would not change any existing B-Double or high-mass vehicle routes, the enlargement of intersections along The Northern Road will improve safety and manoeuvrability for freight vehicles. For freight travelling on the M4 Motorway the proposal would also minimise queues onto the main carriageway by providing additional capacity at The Northern Road interchange.

In the future, The Northern Road would become the primary route for construction traffic from the planned Western Sydney Airport and the planned M12 Motorway and would become the primary route from these construction activities to the Sydney Motorway network. The proposal would ensure that this construction traffic would have a safe and reliable route to the M4 Motorway.

Impacts on active transport

The proposal would introduce a number of significant improvements to pedestrians and cyclists along The Northern Road. These improvements include:

- A new three metre shared path along the western side of The Northern Road between Glenmore Parkway and Jamison Road
- A new three metre shared path on the eastern side of the Northern Road between Wentworth Road and Bringelly Road
- An upgraded 1.5 m footpath on the eastern side of The Northern Road between Bringelly Road and Jamison Road

- New pedestrian crossings at the intersection of The Northern Road and Glenmore Parkway (currently a roundabout)
- A new pedestrian crossing across The Northern Road at Frogmore Road
- A new signalised pedestrian crossing on the southern approach of the intersection of The Northern Road and Bringelly Road
- A new signalised pedestrian crossing on the southern approach of the intersection of The Northern Road and Jamison Road.
- Kerbside bus lanes, which would allow on-road cycling and reduce conflicts with the larger general traffic stream.

Impacts on parking

As parking is currently not permitted along the length of The Northern Road between Glenmore Parkway and Jamison Road, the proposal would have a minimal impact on parking opportunities within the proposal area. The construction of an additional eastbound lane on Jamison Road on approach to The Northern Road would require banning parking on both sides of Jamison Road for 200 m, resulting in the loss of up to 15 existing parking spaces. This parking could be accommodated elsewhere on surrounding local streets.

Impacts on Nepean Hospital

Analysis of travel speeds and intersection performance on The Northern Road without the proposal shows that during peak periods emergency vehicles would be required to travel through very congested intersections and experience substantial delays along The Northern Road when approaching Nepean Hospital from the south.

The proposal would substantially reduce these delays and improve access to Nepean Hospital from the south. During peak periods the proposed bus lane would likely be clear for emergency vehicles to travel uninterrupted along The Northern Road between Glenmore Parkway and Jamison Road.

Impacts on road safety

The proposal would result in the following improvements to road safety:

- Removal or alteration of existing uncontrolled right turn movements to signal controlled. This would reduce the incidence of right turn vehicles conflicting with through traffic and increase the safety of these movements
- Upgrade of existing roundabout at the intersection of The Northern Road and Glenmore Parkway to a set of traffic signals. This would reduce delays for traffic during peak periods and decrease the likelihood of vehicles accepting smaller unsafe gaps in traffic on the circulating carriageway of the roundabout
- Provision of formal pedestrian crossings where they currently do not exist at Jamison Road, Maxwell Street and Tukara Road. This would improve pedestrian and cyclist safety by providing more formal crossing opportunities and decreasing the likelihood of pedestrian and cyclists crossing elsewhere along The Northern Road
- Provision of a shared pedestrian and cycle path along the length of the proposal, decreasing the likelihood of cycles travelling in general traffic lanes
- Provision of new crash barriers along parts of the proposed upgrade, particularly in sections of narrowed median and the new M4 Interchange bridge.

Construction traffic impacts

For the purposes of this assessment, construction of the proposal is assumed to take place over three stages:

- Stage One: construction of The Northern Road southbound carriageway between the southern limit of the works and Jamison Road. Between Bringelly Road and Jamison Road, Stage One would be a partial construction (i.e. fewer lanes) due to the narrow road corridor

- Stage Two: construction of The Northern Road northbound carriageway between the southern limit of the works and Jamison Road. Between Maxwell Street and Jamison Road, Stage Two would be a partial construction (i.e. fewer lanes) due to the narrow road corridor
- Stage Three: construction of remaining lanes and median in the northbound and southbound carriageway on The Northern Road.

It is expected that the proposal would be built between 2017 and 2019, subject to weather.

Construction traffic generation

The majority of traffic generated during the construction stages would be from plant equipment and material deliveries including:

- Construction material
- Spoil removal
- Construction plant
- Construction personnel (light vehicles).

During peak traffic period, about 220 additional light vehicles are likely to be generated per day. Assuming that 80 per cent of these light vehicles arrive in the same hour, the likely peak hour volume on the busiest days would be in the order of 176 vehicles per hour with almost all of these vehicles arriving at the worksite in the morning and leaving in the afternoon. The majority of this traffic would likely travel along The Northern Road from the M4, with a small proportion travelling from The Northern Road from the north and south. Furthermore, the average traffic generation for any one worksite would be around one third of the peak volume at 59 two-way vehicle trips per day.

The number of truck movements to any one work site is likely to be in the order of 100 trucks per day based on assessment of similar proposals. This would equate to some 12 to 13 truck movements per hour in the peak hours. This number of trucks is unlikely to have a significant traffic impact on the road network. Typically the type of trucks that construction would generate would be truck-and-dog vehicles, heavy rigid vehicles and concrete trucks.

Impacts on existing developments

Access to some properties may be affected by the construction activities, particularly in areas where construction would be occurring along the existing The Northern Road corridor. This could be either through the loss of or alterations to existing access arrangements. Development of traffic management plans approved by Roads and Maritime Services would ensure continuity of access for properties affected by construction works.

Impacts on road network operation

Construction activities would be staged to ensure that there is no reduction in road capacity through the course of construction. The primary impacts of construction traffic generation would be reduced speeds through construction zones on The Northern Road.

Construction activity is likely to impact traffic operation in the following instances:

- Disruptions to traffic on the M4 Motorway: reduced speeds would be in place on the M4 Motorway during the construction of temporary pavement in the median and during overhead bridge works which would take place over live traffic. Detours may also be in place when works over live traffic are unsafe. In these cases, traffic would be required to detour south to Glenmore Parkway or north to Tukara Road where a temporary u-turn would be provided
- Reduced speed limits at traffic crossovers: traffic crossovers would be established at the northern and southern ends of the existing bridge over the M4 Motorway to permit contra-flow operation during bridge construction activities. Traffic would be required to travel on the opposite side of the road at reduced speed during these periods. Crossover operation should be limited to outside of peak periods
- Temporary traffic calming: the majority of construction activities would likely be occurring adjacent to live traffic and a significant proportion of the construction period would require vehicles to travel on temporary pavement

or temporary ramps. During these periods, traffic would be required to travel at reduced speed and may also be subject to traffic control to allow for the movement of construction vehicles around or between construction sites.

Impacts on bus services

Routes 794 and 789 operate through the study area; these are primarily peak period services, with 789 only operating during weekdays. During construction of the proposal the following impacts to buses and bus passengers are likely:

- Reductions in speed when travelling through construction activity areas including traffic switches and tie in works. When travelling through these zones, bus speeds would be limited to 40 km/h
- Temporary relocation of stops away from construction zones, particularly where works are being undertaken within the existing The Northern Road corridor. This would involve the relocation of stops where construction work would make existing stops inaccessible and may require passengers to walk further distances to reach their stops. Based on the spacing of stops and the staging of construction activities, this is likely to affect up to three stops at any one time during construction and seven stops in total. Between the M4 Motorway and Maxwell Street, stops on the eastern side of The Northern Road would need to be relocated as well as the two bus stops between Maxwell Street and Jamison Road
- Bus stops would be managed through the construction process to ensure that bus would be able to stop outside of general traffic lanes and not delay through traffic
- Alternative access to relocated bus stops may need to be provided depending on where the bus stops are relocated. This may involve the construction of temporary footpaths adjacent to construction zones
- Consultation with bus operators and the community to ensure adequate notification is provided prior to the temporary relocation of a bus stop and any temporary alternative access arrangements.

Impacts on pedestrian and cyclist access

During construction, pedestrian and cyclists may need to use alternative temporary paths where one side of The Northern Road may be inaccessible. In most cases, pedestrians and cyclists would be diverted to alternative routes to ensure full connectivity is maintained.

In cases where there is not an available alternative, the provision of temporary alternative access routes to properties in the study area would be required to ensure that safe pedestrian and cycling access is maintained during the course of construction. Currently proposed temporary footpaths include:

- Maxwell Street, south side west of Aspen Street
- Maxwell Street north side east of Aspen Street.

As construction would take place in stages, these temporary arrangements are likely to be in place for up to two years.

Cumulative impacts

In assessing the effects of the proposal the traffic modelling has taken into account the likely cumulative effects of the proposal with other planned road upgrade projects in place, namely:

- M4 Smart Motorway
- Werrington Arterial Road upgrade
- M12 Motorway
- Planned Western Sydney Airport and associated accesses.

The assessment has also taken into account the traffic generation from the planned land developments in the area through the use of future traffic demand forecasts from Roads and Maritime's Sydney Traffic Assignment Model (STAM). It is assumed that the broader traffic implications of other employment lands in the broader Western

Sydney Employment Area, as well as the Werrington Arterial Road, its associated interchange with the M4 Motorway and the planned Western Sydney Airport at Badgerys Creek, have all been accounted for in future travel demand provided by Roads and Maritime for this proposal.

Analysis of network-wide statistics from the AIMSUN traffic model, including total vehicle kilometres of travelled (VKT) and total hours of travelled (VHT), shows that average network speeds are consistently higher for all scenarios with the proposal.

Environmental management measures

Construction traffic management measures

The majority of long-term impacts of the proposal have been addressed through the concept design and include the following:

- Maintenance of access to existing streets and properties, addressed through the access strategy
- Management of traffic capacity constraints, addressed through the design and operation of traffic signals and other intersection treatments
- Provision of public transport capacity and priority, addressed through the design by provision of bus lanes in both directions along the length of The Northern Road between Glenmore Parkway and Smith Street
- Provision of active transport facilities, addressed through the design by installation of a shared path along the length of The Northern Road.

There would be impacts of the proposal that cannot be removed through the concept design. Environmental management measures would be required to minimise the construction impacts of the proposal on traffic and transport.

The key environmental management measure required to address the impacts of construction on traffic and transport would be Traffic Management Plans (TMPs) prepared as part of the Construction Environmental Management Plan (CEMP). These plans would be prepared by the construction contractor and would be required to outline the guidelines, general requirements and specific procedures to be used for any works that may have an impact on traffic operation. The TMP would be required to:

- Identify individual traffic management requirements at each phase of construction
- Outline the general principles and procedures for the development of specific construction Traffic Management Plans (CTMPs)
- Ensure safe and continuous traffic movement for construction workers and the general public
- Maintain the capacity of existing roads where possible
- Identify the requirements for temporary speed restrictions where traffic may pose a safety risk to workers
- Maintain continuity of access to local roads and properties, particularly along The Northern Road (may require temporary u-turn facilities)
- Provide temporary traffic control where necessary
- Identify requirements and placement of traffic barriers
- Provide appropriate warning and signage for traffic in the vicinity of work areas
- Include methods to minimise road user delays such as undertaking works around live traffic including tie-in and bridge work outside of peak periods
- Undertake construction activities off-line where possible to minimise the requirement to operate temporary traffic control and reduced speed zones
- Develop a communication plan to advise local residents and businesses of any changes to traffic conditions during construction.

Other environmental management measures that would be undertaken include:

- Consultation will be undertaken with property owners between Maxwell Street / Bringelly Road and Smith Street to review front yard storage and vehicle manoeuvrability.
- Requirements for any changes to local traffic and access arrangements will be confirmed during detailed design in consultation with the local road authority and any affected landowners, including any temporary alternative access arrangements as required.
- Consultation will be undertaken with potentially affected residences prior to the commencement of and during work in accordance with Roads and Maritime's Community Involvement and Communications Resource Manual. Consultation will include but not limited to door knocks, newsletters or letterbox drops providing information on the proposed work, working hours and a contact name and number for more information or to register complaints.
- Consultation will be carried out with emergency services to ensure adequate emergency vehicle access is provided and maintained at all times for the duration of construction.
- Pedestrian and cyclist access will be maintained throughout construction. Where that is not feasible or necessary, temporary alternative access arrangements will be provided following consultation with affected landowners and the local road authority.
- Access for public transport services, including school bus services, will be maintained. The requirements for any temporary changes will be confirmed following consultation with local bus operators and the community.

1. Introduction

Roads and Maritime Services (Roads and Maritime) is proposing to upgrade The Northern Road between Glenmore Parkway, Glenmore Park and Jamison Road, Penrith (referred to as 'the proposal' for the purposes of this report). The corridor is located about 47 km west of the Sydney Central Business District (CBD). The proposal would upgrade The Northern Road to an eight-lane divided road, with three general traffic lanes and a kerbside bus lane in each direction, separated by a raised concrete median. The Northern Road continues as a six lane carriageway to the north of Jamison Road.

The Northern Road is classified as a State Road and forms part of the A9 route, which connects Narellan to Richmond. The Northern Road also provides connections between the Western Sydney Priority Growth Area, the Western Sydney Employment Area, the M4 Motorway, and the site for the proposed Western Sydney Airport (WSA) at Badgerys Creek.

This section of The Northern Road is currently a four lane road, largely divided by a median. Between 200 m south of Smith Street and 200 m north of Frogmore Road there is a 1.3 km section that is undivided. There are five signalised, and six unsignalised intersections, as well as various uncontrolled property accesses along this section of The Northern Road. At some unsignalised intersections and property accesses, right turn movements can be made across a painted median.

Roads and Maritime is upgrading The Northern Road as part of the Australian and NSW governments' Western Sydney Infrastructure Plan, which will deliver $3.6 billion in road infrastructure improvements over the next 10 years. The proposal was announced in April 2014 as part of the Western Sydney Infrastructure Plan's program of works to support the proposed Western Sydney Airport at Badgerys Creek.

It is anticipated that construction of the proposal would commence in early 2017 and would be open to traffic by mid-2020.

1.1 Description of the proposal

The proposal involves upgrading about four kilometres of The Northern Road between Glenmore Parkway, Glenmore Park and Jamison Road, Penrith. The proposal comprises the following key features:

- An eight-lane divided road (three general traffic lanes and a kerbside bus lane in each direction) from just south of Glenmore Parkway, Glenmore Park to Jamison Road, South Penrith
- An upgrade to the M4 Motorway interchange, including:
  - Construction of a new two-span bridge over the M4 Motorway, located to the east of the existing bridge alignment
  - Replacement of the existing two sets of traffic lights at the M4 Motorway interchange, with a single set of traffic lights to control all movements at the interchange
  - Widening of ramps to accommodate future Smart Motorway requirements
  - Demolition of the existing bridge over the M4 Motorway
- New traffic lights on The Northern Road at:
  - The Glenmore Parkway and Wentworth Road intersection
  - The Frogmore Road and Tukara Road intersection
- Altered intersection arrangements at:
  - The Northern Road and Homestead Road (left-in, left-out only)
  - The Northern Road and Castle Road (left-in, left-out only)
- Upgrade of The Northern Road and Glenmore Parkway / Wentworth Road intersection, comprising:
  - Traffic lights to replace the existing roundabout, allowing all movements

- Separate left-turn lanes on all approach roads to the intersection
- Additional left-turn and right-turn capacity from both approach roads onto The Northern Road
- A new dedicated access road into the Penrith Golf and Recreation Club, meeting Glenmore Parkway at a new T-intersection about 175 metres west of The Northern Road, with all left and right turn movements allowed
- A new single-lane roundabout on Glenmore Parkway west of the proposed new Golf Club access road, to facilitate U-turn movements for traffic entering or leaving Fairwater Court and Garswood Road

- Changes to local roads, including:
  - Extension of Cross Road to provide a new local connection between Wentworth Road and Homestead Road
  - A new roundabout on Frogmore Road, west of the existing intersection with Simeon Road providing access to Penrith Christian School
  - Removal of the existing roundabout at Maxwell Street and Aspen Street, and replacement with a new four-leg roundabout realigned to include Hilliger Road, with traffic lights on the Aspen Street leg only
- New pedestrian and cyclist facilities, including:
  - A three-metre wide shared path along the western side of The Northern Road between Glenmore Parkway and Jamison Road
  - A three-metre wide shared path along the eastern side of The Northern Road between Wentworth Road and Bringelly Road
  - A 1.5 metre wide footpath on the eastern side of The Northern Road between Bringelly Road and Jamison Road
- New or additional pedestrian crossing signals at:
  - The Northern Road intersection with Glenmore Parkway and Wentworth Road
  - The M4 Motorway interchange
  - The Northern Road intersection with Frogmore Road and Tukara Road
  - The Northern Road intersection with Maxwell Street and Bringelly Road
  - The intersection of The Northern Road and Jamison Road
- New retaining walls along:
  - The eastern side of The Northern Road, south of Homestead Road
  - Both sides of the M4 Motorway beneath the proposed bridge (reinforced soil walls)
  - The northern side of the eastbound M4 on-ramp, towards the eastern end of the ramp
  - The western side of The Northern Road, south of Tukara Road
  - The eastern side of The Northern Road adjacent to the Flower Power Garden Centre, south of Castle Road
  - The eastern side of The Northern Road, south of Bringelly Road
  - The eastern and western side of The Northern Road at numerous locations between Maxwell Street / Bringelly Road and Smith Street
  - The southern side of Smith Street, west of the intersection with The Northern Road
  - The eastern and western side of The Northern Road at numerous locations between Smith Street and Jamison Road
- Upgrade of drainage infrastructure, including:
  - New or upgraded cross-drainage structures to replace existing cross-drainage where required

  - New longitudinal drainage including open concrete or grass-lined catch drains, grassed swales, pits and pipes
- New noise barriers at the following locations:
  - A noise mound along the northern side of the eastbound M4 Motorway off-ramp (the mound would be about 670 metres long and six metres high)
  - A noise wall along the eastbound M4 Motorway off-ramp from the end of the noise mound, continuing north along the western side of The Northern Road to Aspen Street (the wall would be about one kilometre long and up to 4.5 metres high)
  - A noise wall along the eastbound M4 Motorway on-ramp, between the motorway and the buildings at the Penrith Christian School (the wall would be about 325 metres long and up to 4.5 metres high)
- Two permanent variable message signs (VMS) on The Northern Road near the M4 Motorway interchange
- New street lighting
- New landscaping
- Relocation of utility services and construction/installation of new utility services
- Relocation of some bus stops and construction of new bus stops
- Changes to property accesses along The Northern Road to left-in, left-out only
- Adjustments to private properties to accommodate the proposal, including driveways, front yards, retaining walls, utility connections and fencing
- Establishment and use of temporary site compounds during construction.

It is anticipated that construction of the proposal would start during 2017 and is expected to be completed by mid-2020.

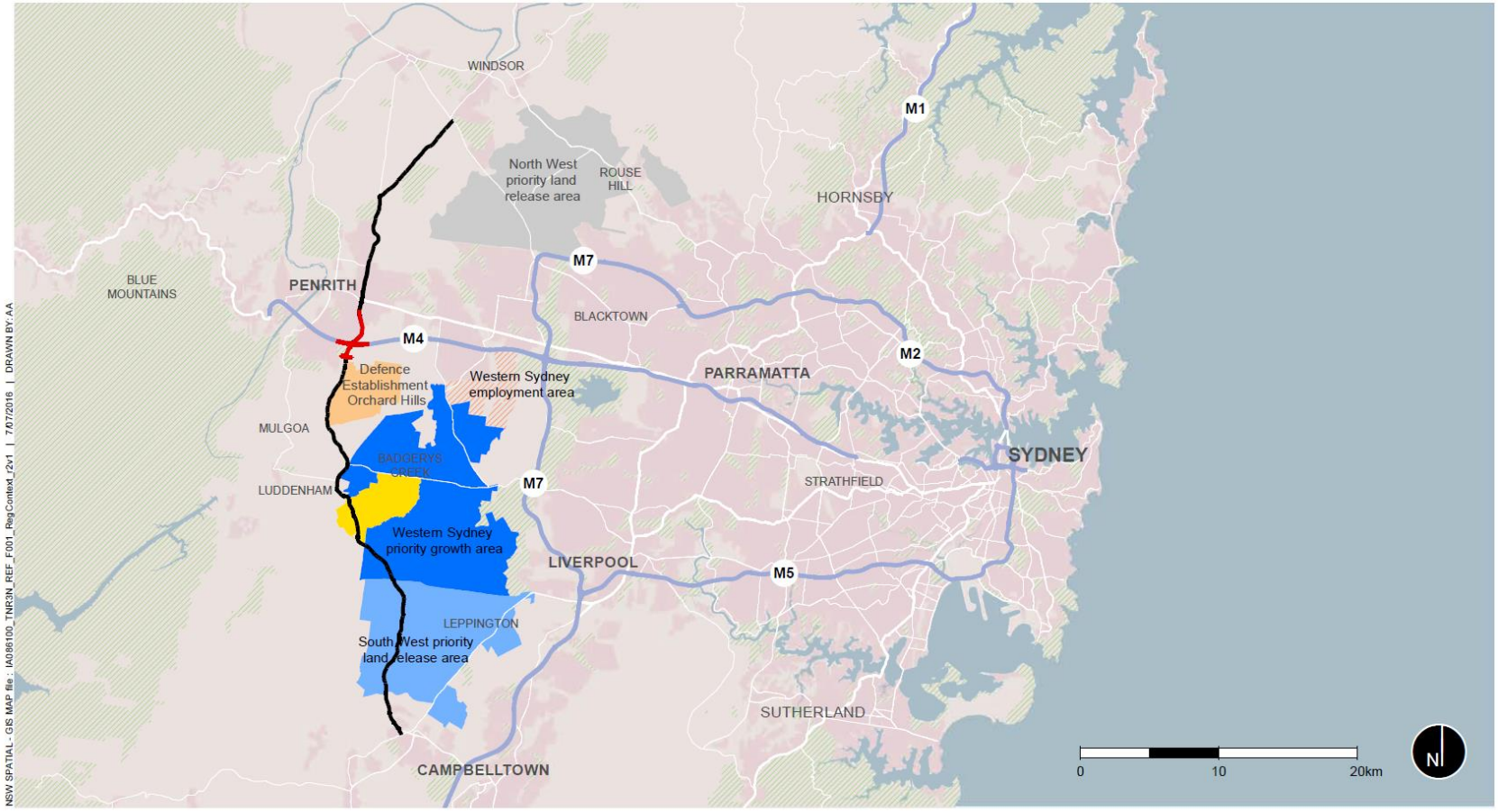
1.2 Location and context

The proposal is located in the Penrith local government area, within the Roads and Maritime Sydney region. The area is mostly flat to undulating in topography.

The proposal area is generally divided into distinct geographies. To the east of The Northern Road and south of Bringelly Road, the proposal area is predominately semi-rural or rural residential in character, the remaining areas to the west of The Northern Road, and north of Bringelly Road are characterised by low density residential development comprising the southern suburbs of the City of Penrith. It also includes some commercial, educational, community and recreational land uses.

The proposal crosses the M4 Motorway roughly equal distance between Mulgoa Road and Mamre Road. The Northern Road is the main collector to and from the M4 Motorway in the region. The regional context of The Northern Road is provided in Figure 1.1.

Figure 1.1 : Regional context of the proposal



1.3 Need for the proposal

The Northern Road is a critical arterial connection between the M4 Motorway and the Great Western Highway. It provides access to and from residential development in South Penrith as well as key traffic generators and attractors including Nepean Hospital, Penrith South Public School and Kingswood and Penrith High Schools. In the longer term, The Northern Road would become the primary north-south route to key developments further to the south of the M4 Motorway, including the planned Western Sydney Airport at Badgerys Creek, and the South West Priority Growth Area.

Preliminary traffic modelling undertaken by Roads and Maritime as well as Penrith Council have identified a need to upgrade The Northern Road to provide sufficient capacity for forecast growth along the corridor and to provide public transport connection to the proposed Western Sydney Airport.

1.4 Scope and purpose of this report

Jacobs Group (Australia) has been commissioned by NSW Roads and Maritime Services (Roads and Maritime) to undertake a traffic and transport assessment for the proposed upgrade of The Northern Road between Jamison Road and Glenmore Parkway. The purpose of this study is to assess the existing conditions, assess the impacts of the proposal and recommend any mitigation measures required to address these impacts.

The assessment provided in this report will be used to inform the Review of Environmental Factors (REF) being undertaken by Roads and Maritime. The key areas examined as part of this impact assessment include:

- An understanding of the existing traffic and transport conditions in the study area
- Assessing the impacts of future developments and growth in travel demand at completion (2021), 10 years (2031) and 20 years (2041) after completion
- Assessing the impacts of the proposed The Northern Road upgrade in 2021, 2031 and 2041
- Assess the changes to existing network routes as a result of the proposed upgrade
- Assess impacts on pedestrian, cyclists and public transport
- Assess impacts of the construction phase of the proposal
- Identify environmental management measures required to mitigate these impacts.

1.5 Traffic modelling process

Traffic modelling is a core component of the appraisal of the proposal and has been used to forecast and evaluate traffic impacts of future land use and planned road network improvements in the vicinity of The Northern Road. The traffic modelling assessment process for the proposal involved the following:

- Development of a micro simulation traffic model of The Northern Road under existing traffic conditions
- Development of future year (2021, 2031 and 2041) forecasts for The Northern Road corridor and testing of the proposed upgrade in the micro simulation AIMSUN model.

1.6 Limitations and assumptions

This assessment has been undertaken for the purpose of assessing the proposal and therefore focuses on the traffic and transport impacts in the study area. This study assumes the following:

- Inclusion of the widened M4 Motorway interchange ramps at the time of opening the proposal to traffic (however excluding any ramp metering operation)
- Construction of Werrington Arterial Road and associated ramps at the M4 Motorway before completion of the proposal
- Construction of the M12 Motorway between M7 Motorway and The Northern Road within 10 years of the proposal being completed
- Opening of the planned Western Sydney Airport within 10 years of the proposal being completed.

Traffic forecasts have been based on:

- Operation of planned Western Sydney Airport within 10 years of the proposal being completed
- 2014 standard Land Use assumptions from Bureau of Transport Statistics and Analytics (BTSA) including South West Priority Growth Area, Western Sydney Priority Growth Area and the proposed Western Sydney Airport.

1.7 Report Structure

This report is comprised of the following sections:

- Section 2 – Planning context: outlines the previous planning work undertaken in the study area and identifies the strategic objectives of the proposal
- Section 3 – Existing conditions: summarises the existing conditions within The Northern Road Study area
- Section 4 – Key feature of the proposal: outlines the key traffic and transport features of the proposal
- Section 5 – Appraisal of Future Traffic and Transport Impacts: outlines the key traffic and transport impacts of the proposal on The Northern Road corridor
- Section 6 – Environmental management measures: outlines the environmental management measures required to mitigate any impacts of the proposal on traffic and transport
- Section 7 – Summary and conclusions: presents a summary of the study findings and sets out the principal conclusions for the study.

2. Planning context

2.1 Overview

This section provides a summary of the key relevant planning, policies and controls affecting the proposal. This review establishes the transport and land use context of the proposal and the objectives that it is supporting.

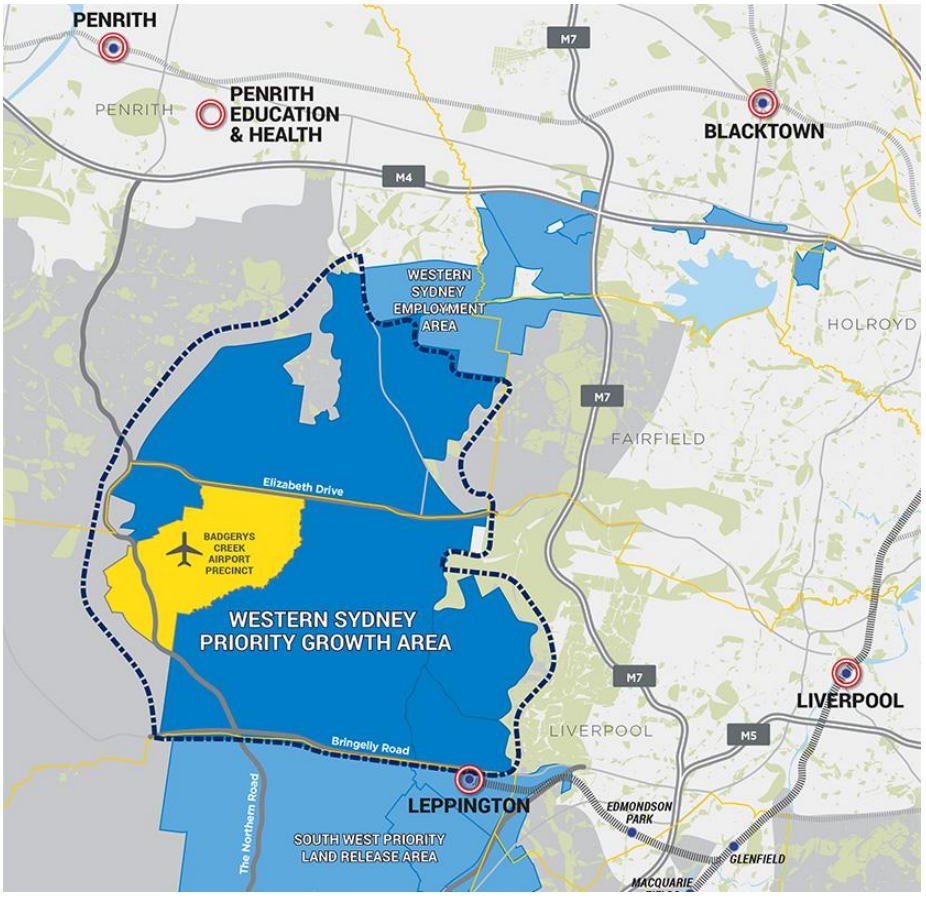
2.2 Regional context

The Northern Road is located in Western Sydney between Penrith and Campbelltown and connects the South West Priority Growth Area with the Regional Centre of Penrith, which both key component of *A Plan for Growing Sydney (2014)*. The Northern Road connects and supports the following key growth areas in Western Sydney:

- Penrith Regional City Centre, the regional city centre for West Subregion
- Planned Western Sydney Airport, Sydney's second airport and a catalyst for significant new investment in infrastructure and employment in the West Subregion
- South West Priority Growth Area, the fastest population growth area in Sydney and the location of the proposed Bringelly Road Enterprise Corridor
- Western Sydney Priority Growth Area, covering some 2450 ha and forecast to provide up to 57,000 jobs by 2031.

The location of The Northern Road along with its context within Western Sydney is shown in Figure 2.1.

Figure 2.1 : The Northern Road location and regional context



Source: NSW Department of Planning and Environment

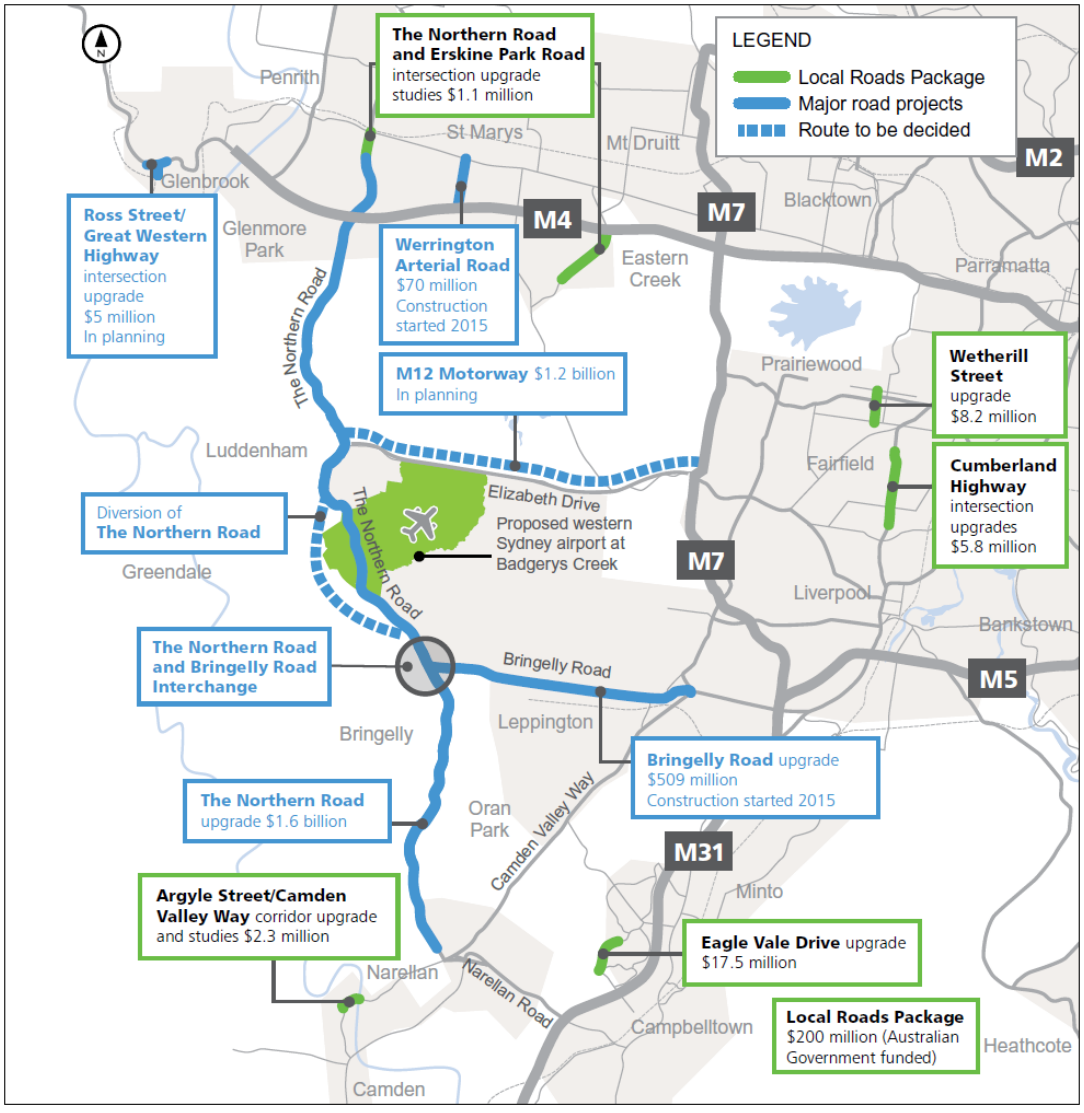
2.3 Transport context

The Western Sydney Infrastructure Plan (WSIP) announced in 2015 committed to a 10 year, $3.6 billion road investment program for Western Sydney. Key features of the Western Sydney Infrastructure plan include:

- Upgrade of The Northern Road to a minimum of four lanes between Narellan Road and Jamison Road
- Construction of the new M12 Motorway with up to six lanes between the M7 Motorway at Cecil Hills and The Northern Road at Luddenham, connecting to the planned Western Sydney Airport site
- Upgrade of Bringelly Road to a minimum of four lanes between The Northern Road and Camden Valley Way
- Building the Werrington Arterial Road by upgrading Kent Road and Gipps Street to four lanes between the Great Western Highway and the M4 Motorway, including two new east facing ramps on the M4 Motorway
- Upgrading the intersection of Ross Street and the Great Western Highway, Glenbrook
- A $200 million Local Roads Package for councils to apply for local road upgrades (Australian Government funded).

A summary of the works proposed as part of the WSIP is provided in Figure 2.2.

Figure 2.2 : Summary of Western Sydney Infrastructure Plan program of works



Source: NSW Roads and Maritime Services

Separate from the WSIP, Roads and Maritime committed to the construction and operation of Smart Motorway technology on the M4 Motorway (referred to as M4 Smart Motorways). The concept design for that project was subject to a Review of Environmental Factors (REF) which was approved in October 2015. The concept design assessed as part of that REF did not consider an upgrade of The Northern Road interchange; the proposed civil works at The Northern Road were limited to widening of on and off ramps to provide sufficient storage for ramp metering signals.

2.4 Transport policy context

The Northern Road Upgrade fulfils the strategic policy aims of:

- Providing convenient, reliable access for freight vehicles moving between the planned Western Sydney Airport and Sydney's motorway network to the wider interstate freight network
- Supporting the long-term growth and economic success of the WSEA and the planned Western Sydney Airport
- Supporting the initiatives outlined in the latest Sydney Strategic Plan – *A Plan for Growing Sydney*; in particular improving transport connect ions to provide better access between centres in the West Subregion and centres in other subregions, particularly the South West Priority Growth Area
- Supporting the actions outlined in the *Long Term Transport Master Plan (LTTMP*) including improving public transport and providing essential infrastructure for growth centres.

2.5 New South Wales

NSW Plan 2021

The *NSW 2021: A plan to make NSW number one* ((NSW) Department of Premier and Cabinet 2011) (NSW 2021) was released by the NSW Government in September 2011. The plan provides the NSW Government's direction for the next 10 years to rebuild the economy, provide quality services, renovate infrastructure, restore government accountability, and strengthen local environments and communities.

NSW 2021 identifies 32 goals to meet the five strategies identified in the plan. Goals relevant to the proposal include:

- Improve the performance of the NSW economy
- Increase the competitiveness of doing business in NSW
- Reduce travel times
- Improve road safety
- Invest in critical infrastructure
- Build liveable centres.

The proposal would support long-term economic growth and development and enhanced productivity and competitiveness of business and industry in Western Sydney by improving transport connections from the south, including Campbelltown and the M12 Motorway, and from the Penrith region and M4 Western Motorway, to the proposed Western Sydney Airport and surrounding developments including the South West Priority Growth Area and Western Sydney Priority Growth Area.

The proposal would also support goals relating to travel time and safety and liveability, by relieving road congestion, improving speed, reliability and safety of travel across Western Sydney, the proposed Western Sydney Airport and surrounding developments including the South West Priority Land Release Area and Western Sydney Priority Growth Area.

NSW 2021 is complemented by 19 Regional Action Plans, which identify immediate actions for the NSW Government to respond to priorities raised by communities and improve outcomes for regions across NSW. The two year plans complement the longer-term regional and State strategies.

Western Sydney and Blue Mountains Regional Action Plan

The study area is covered by the *Regional Action Plan for Western Sydney and the Blue Mountains* ((NSW) Department of Premier and Cabinet 2012). The Action Plan focuses on maintaining the region's position as the industrial heart of Sydney's growing economy, while offering better transport and health services for communities and protecting the region's unique natural environment.

Priority actions identified in the Action Plan relevant to the proposal include:

- Delivering road and bridge upgrades to improve traffic flow and enhance motorway capacity
- Improving road safety, including on-going delivery of the Pinch Point Program to improve traffic flow in Metropolitan Sydney
- Improving the movement of freight.

South Western Sydney Regional Action Plan

NSW 2021 is complemented by 19 Regional Action Plans, which identify immediate actions for the NSW Government to respond to priorities raised by communities and improve outcomes for regions across NSW. The two year plans complement the longer-term regional and State strategies.

The study area is covered by the *Regional Action Plan for South Western Sydney* ((NSW) Department of Premier and Cabinet 2012). The Action Plan focuses on supporting one of Australia's largest and fastest growing populations by providing more employment lands and jobs closer to home and improving integrated regional transport.

Priority actions identified in the Action Plan relevant to the proposal include:

- Delivering road and bridge upgrades to improve traffic flow, including enhancing motorway capacity
- Improving road safety, including on-going delivery of the Pinch Point Program to improve traffic flow in Metropolitan Sydney
- Improving the movement of freight.

Draft Metropolitan Strategy for Sydney to 2031

The *Draft Metropolitan Strategy for Sydney to 203*1 ((NSW) Planning and Infrastructure 2013) (Draft Metropolitan Strategy) sets a framework for Sydney's growth and prosperity to 2031 and beyond. It sets out the State Government's vision for Sydney by providing a framework for housing development and job growth over the next 20 years.

The Draft Metropolitan Strategy focuses on the five outcome areas of balanced growth, a liveable city, productivity and prosperity, healthy and resilient environment, and accessibility and connectivity.

The strategy identifies a number of sub-regions, which comprise groups of councils that share similar challenges in delivering the vision for Sydney.

The study area is generally located within the West and South West sub-regions. Priorities identified for the West sub-region relevant to the traffic and transport context of the proposal include:

- Improve transport connections to provide better access between centres in the subregion and centres in other subregions, and with regional NSW (including freight connections)
- Leverage investment and economic development opportunities arising from the development of the planned Western Sydney Airport
- Improve transport connections to eastern Sydney to capitalise on the subregion's increasing role in Sydney's manufacturing, construction and wholesale/ logistics industries in the Western Sydney Employment Area.

Priorities identified for the South West sub-region relevant to traffic and transport context of the proposal include:

- Strengthen the diverse benefits to the economy proposed by the planned Western Sydney Airport at Badgerys Creek
- Recognise and strengthen the subregion's role in Sydney's manufacturing, construction and wholesale/logistics industries by maximising existing employment lands particularly in Fairfield and Liverpool.
- Investigate the long-term potential to locate a major enterprise corridor between Leppington and Bringelly, linked to the extension of the South West Rail Link.

NSW Long Term Transport Master Plan

The *NSW Long Term Transport Master Plan (*Transport for NSW 2012) (LTTMP) sets the framework for the NSW Government to deliver an integrated, modern transport system that puts the customer first. The LTTMP, released in December 2012, is a 20 year plan which responds to key transport challenges and identifies the priorities required to create a transport system that meets a range of needs. The LTTMP will:

- Support Sydney's long term economic growth through improved motorway access and connections linking Sydney's international gateways and Western Sydney and places of business across the city
- Support the growth of new economic centres through investment in the North West Rail Link and the South West Rail Link, new roads in growth corridors, and new bus infrastructure
- Enhance the productivity of commercial and freight generating land uses strategically located near transport infrastructure.

Sydney's Bus Future

Sydney's Bus Future (Transport for NSW 2013) is the NSW Government's long term plan to redesign Sydney's bus network to meet customer needs now and into the future. Sydney's Bus Future sets out step-by-step actions to deliver fast and reliable bus services for customers when and where they are needed. Actions from Sydney's Bus Future that are relevant to the proposal include:

- Adding additional services where they are needed most and creating new routes to enable customers to travel directly to major centres
- Creating faster and more reliable bus services through the implementation of bus priority along roads
- Encourage customers to catch buses by providing convenient, frequent and reliable bus services.

2.6 Local Government strategies

Growing Liverpool 2021

Growing Liverpool 2021 (Liverpool City Council 2011) (Community Strategic Plan) is a 10 year community strategic plan that will guide Liverpool City Council and other organisations in planning for and managing the Liverpool Local

Government Area. *Growing Liverpool 2021* outlines Liverpool City Council's 12 key strategies and delivery program to meet the community's objectives as developed during the council's extensive community engagement process.

Strategy seven of *Growing Liverpool 2021* is to create 'an efficient and a highly connected transport system'. This strategy is relevant to the proposal and includes the following objectives:

- Deliver and maintain a high quality local road system including provision and maintenance of infrastructure and management of traffic issues
- Enhance road safety for all road users
- Promote the provision of a well-functioning regional transport network by State and Federal governments
- Promote an integrated and user friendly public transport service
- Support the delivery of a range of transport options
- Deliver and maintain a range of transport related infrastructure such as footpaths, bus shelters and bikeways.

Penrith Community Plan

The *Penrith Community Plan* (Penrith City Council 2015) (Community Strategic Plan) outlines Penrith City Council's key strategies to meet the community's long term aspirations for Penrith City. The Community Plan focuses on seven outcomes that reflect the community's goals for the region and outlines the strategies Penrith City Council have developed to address these goals.

Outcome three is relevant to the proposal and targets the delivery of effective transport options for passengers and freight in the City and the region by Council and other levels of government. Strategies developed by Penrith City Council to meet outcome three include:

- Secure an effective public transport network
- Provide a safe and efficient road network supported by parking
- Improve the City's footpaths and shared pathway network
- Improve critical cross regional transport connections
- Secure an efficient, integrated and sustainable freight network.

3. Existing conditions

3.1 Overview

This section provides an overview of the existing traffic, transport and land use that influences the development of The Northern Road upgrade (the proposal). This review of existing conditions includes the site context, road network, travel characteristics, road network performance, public transport network, pedestrian and cyclist network and road safety.

3.2 Site context

The study area is centred on The Northern Road between Glenmore Parkway and Jamison Road. The Northern Road is the main north-south collector road in the area, providing access the M4 Motorway. The surrounding land use is mainly residential to the west of The Northern Road. To the east, development is primarily a mix of light industrial and semi-rural.

The Western Sydney Priority Growth Area is located to the south-east of the study area. This area has been identified for new jobs, homes and services around the planned Western Sydney Airport at Badgerys Creek. The upgrade of The Northern Road is a key aspect of planned $3.6 billion infrastructure investment in the region. This is intended to support the expected significant increase in traffic as a result of the planned development activities.

3.3 Existing road network

This section provides a summary of the road network in the surrounding study area.

3.3.1 Motorway network

The M4 Motorway is a six-lane motorway that connects the Blue Mountains with the greater Sydney metropolitan area. Through the study area, the M4 Motorway speed limit is 110km/h. In the study area, the M4 Motorway interchanges with the arterial road network at The Northern Road.

3.3.2 Arterial, sub arterial, collector and local road network

The Northern Road is a major arterial road that runs from Narellan to Richmond. It is a four-lane divided carriageway between Glenmore Parkway and Tukara Road. The road is undivided between Tukara Road and Smith Street. There is a 70km/h signposted speed limit between Glenmore Parkway and Jamison Road.

The corridor will play an increasingly important role as development increases in the Western Sydney Priority Growth Area. The road will also form a key connection to the planned Western Sydney Airport at Badgerys Creek.

The study area includes intersections of The Northern Road with the following roads:

- Glenmore Parkway: a collector two-lane divided road. It is 12 m to 35 m wide and has a signposted speed limit of 50 km/h
- Wentworth Road: a local two-lane undivided road. It is 6 metres wide and has a signposted speed limit of 70 km/h
- Tukara Road: a collector two-lane undivided road. It is 11 m wide and has a signposted speed limit of 50 km/h
- Frogmore Road: a local two-lane undivided road. It is six metres wide and has a signposted speed limit of 60 km/h
- Maxwell Street: a collector two-lane undivided road that widens to four lanes on approach to The Northern Road. Maxwell Street is 12 m wide and has a signposted speed limit of 50 km/h
- Bringelly Road: a collector two-lane undivided road that widens to four lanes on approach to The Northern Road. Bringelly Road is 11 m wide and has a signposted speed limit of 50 km/h

- Smith Street: a collector four-lane road that is undivided through the study area. Smith Street is 12 m wide and has a signposted speed of 50 km/h
- Jamison Road: a sub-arterial four-lane road that is a divided carriageway to the east of The Northern Road and undivided to the west of The Northern Road. Jamison Road is between 13 m and 20 m wide and has a signposted speed limit of 60 km/h.

3.3.3 Existing traffic volumes

Traffic volumes on the road network within the study area were derived from traffic surveys undertaken between November 2014 and July 2015. These volumes are shown in Table 3.1

Table 3.1 : Existing traffic volumes

Road	Between	ADT (vehicles per day)	AM peak (8-9am)	PM peak (4.30pm-5.30pm)
The Northern Road	Glenmore Parkway and Homestead Road	36,930	2671	3216
	M4 Motorway and Maxwell Street	50,991	3721	4020
	Maxwell Street and Smith Street	35,681	2439	2668
	Jamison Road and Stafford Street	34,316	2266	2496
Glenmore Parkway	Windorra Ave and The Northern Road	11,640	1164	521
Wentworth Road	Carolyn Chase and The Northern Road	6395	1063	213
Tukara Road	Kinmont Road and The Northern Road	6015	401	396
Frogmore Road	Simeon Road and The Northern Road	7515	501	236
Maxwell Street	Aspen Street and The Northern Road	11,295	753	1010
Bringelly Road	Oag Crescent and The Northern Road	18,660	1244	1227
Jamison Road	Fragar road and The Northern Road	14,580	972	1086
	Jean Street and The Northern Road	6855	457	520

Hourly traffic volumes over the day were also recorded during July 2015 for the following locations:

- The Northern Road between Glenmore Parkway and Homestead Road
- The Northern Road between M4 Motorway and Maxwell Street
- The Northern Road between Maxwell Street and Smith Street.

Graphs showing traffic volumes over an average weekday at these locations are shown in Figure 3.1, Figure 3.2 and Figure 3.3. Analysis of these traffic flows shows a distinct morning peak hour between 8am and 9am with a longer evening peak period 3pm and 6pm.

Figure 3.1 : 24 hour traffic volumes on The Northern Road between Glenmore Parkway and Homestead Avenue

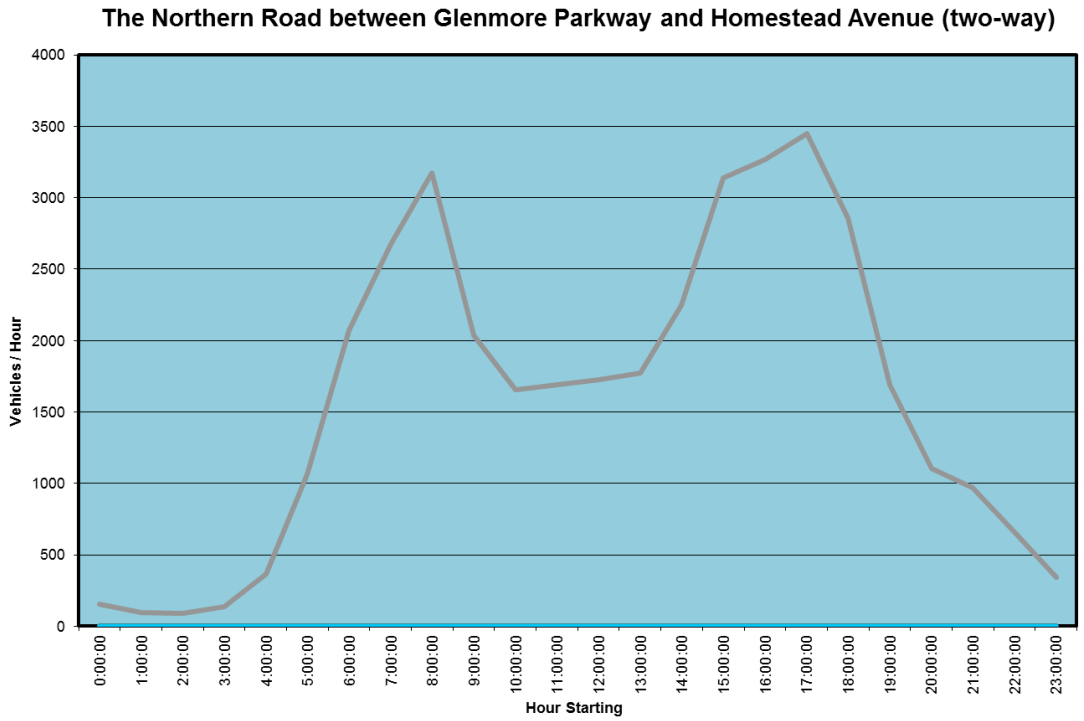


Figure 3.2 : 24 hour traffic volumes on The Northern Road between M4 and Maxwell Street

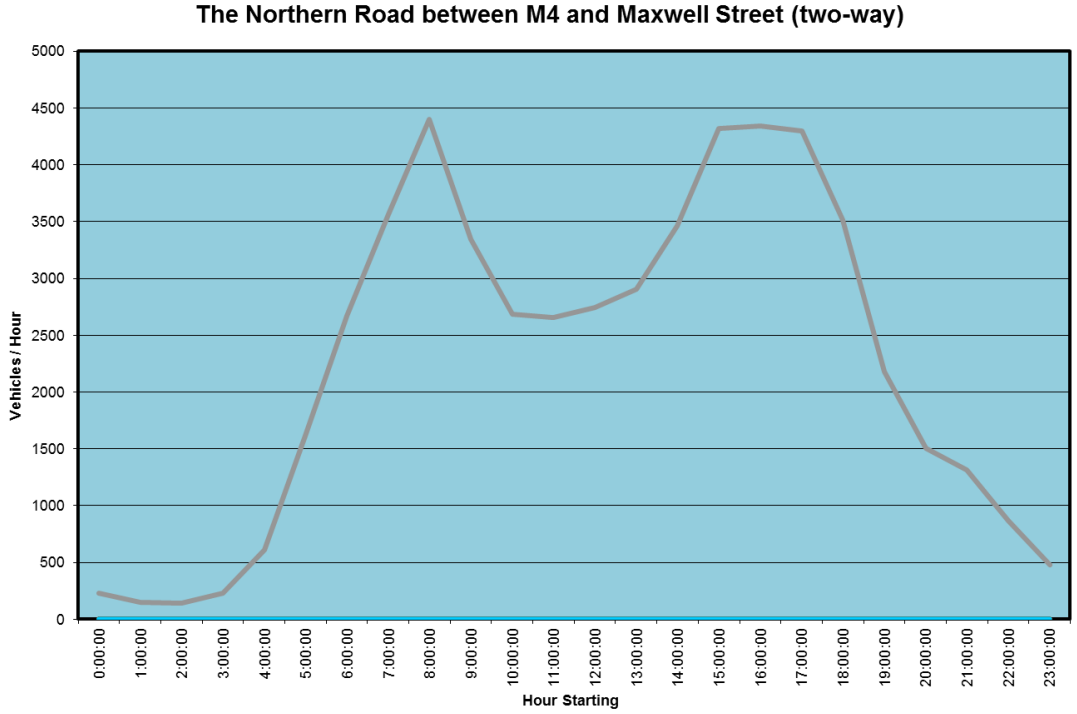
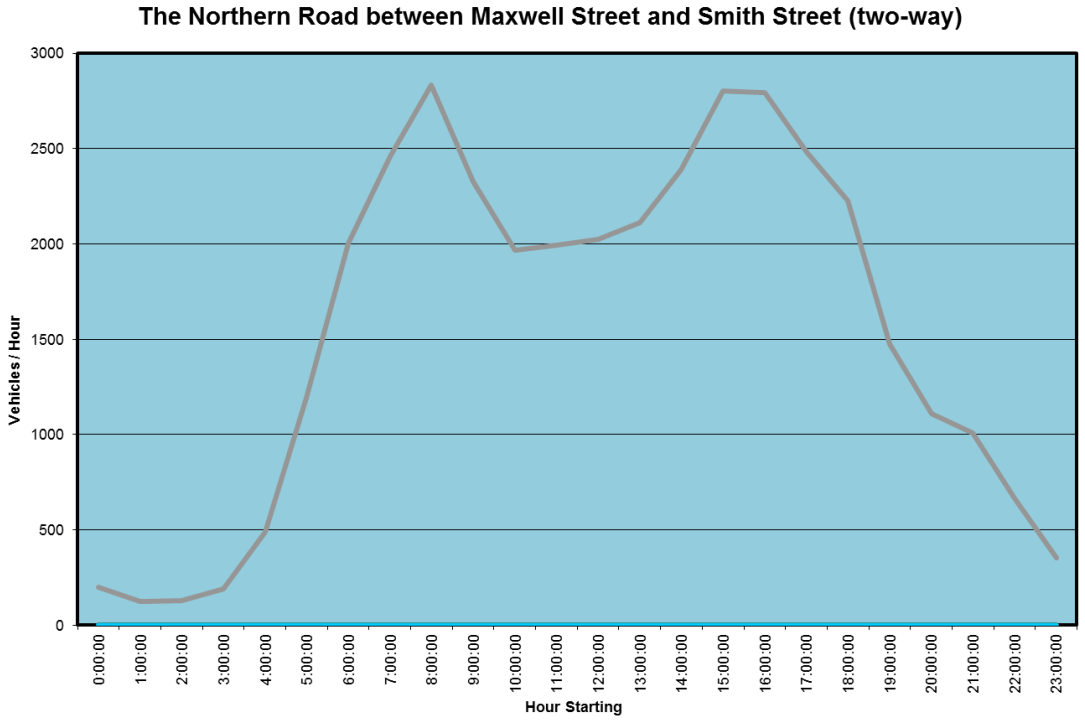


Figure 3.3 : 24 hour traffic volumes on The Northern Road between Maxwell Street and Smith Street



3.4 Existing travel characteristics

An analysis of the Journey to Work data based on the 2011 census data shows that the car driver and car passenger are the predominant mode of travel for people living and working within the study area.

As of 2011 there were 2627 employees within the travel zones adjacent to the proposal and 17,463 residents. The data shown in Table 3.2 indicates that car journeys to work, whether as passenger or driver make up some 94 per cent of the total trips in the study area. Only one percent of trips to work in the area are made by public transport.

Public transport mode share is higher for residents in the study area who work elsewhere. Eleven per cent of these trips use public transport. Car usage however remains dominant with 85 per cent of trips from the study area involving a car.

Table 3.2 : Journey to Work mode share

Mode	Destination (trips to the study area)	Origin (trips from the study area)
Car Driver	89%	79%
Car Passenger	5%	6%
Mode not stated	1%	2%
Train	1%	10%
Bus	0%	1%
Other	4%	2%

Source: BTS Journey to Work 2011 – TZ – 4937,4961,4934,4945,4960,4942,4954

Figure 3.4 and Figure 3.5 present the mode share data by origin and destination respectively.

Figure 3.4 : Study area mode share by origin

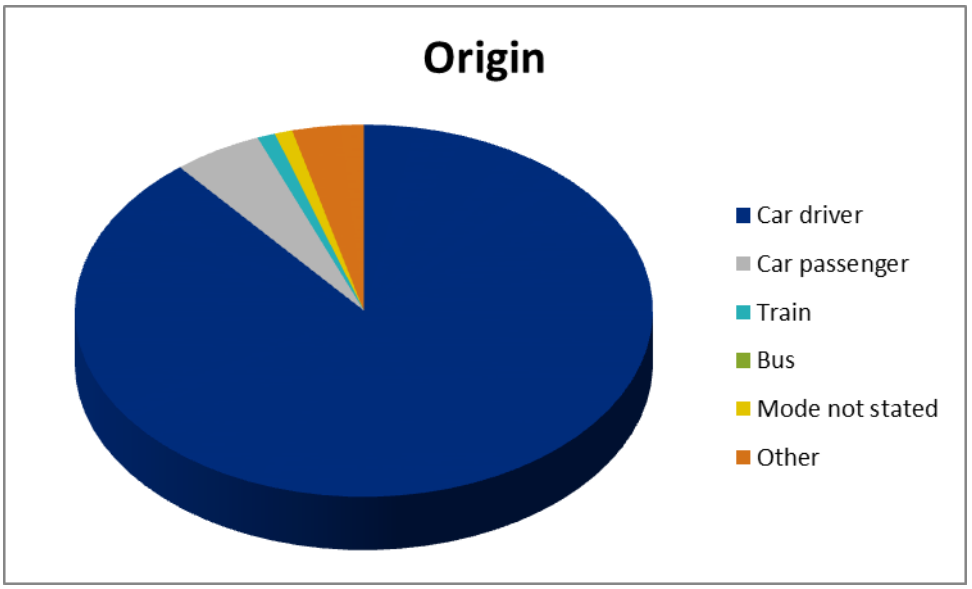
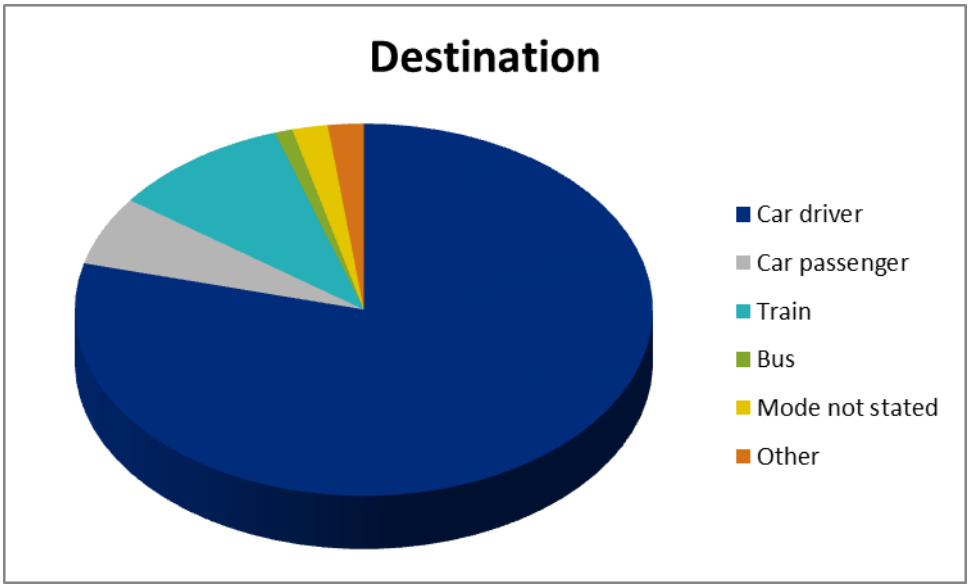


Figure 3.5 : Study area mode share by destination



3.5 Public transport

Public transport in the study area is exclusively provided by Busways Pty Ltd. Kingswood and Penrith train stations are located north of the study area, about one kilometre and two kilometres respectively.

Route 794 operates between Penrith and Glenmore Park, predominantly along The Northern Road. This service operates every 30 minute in both the morning and evening peak periods and every hour during off-peak and weekend periods.

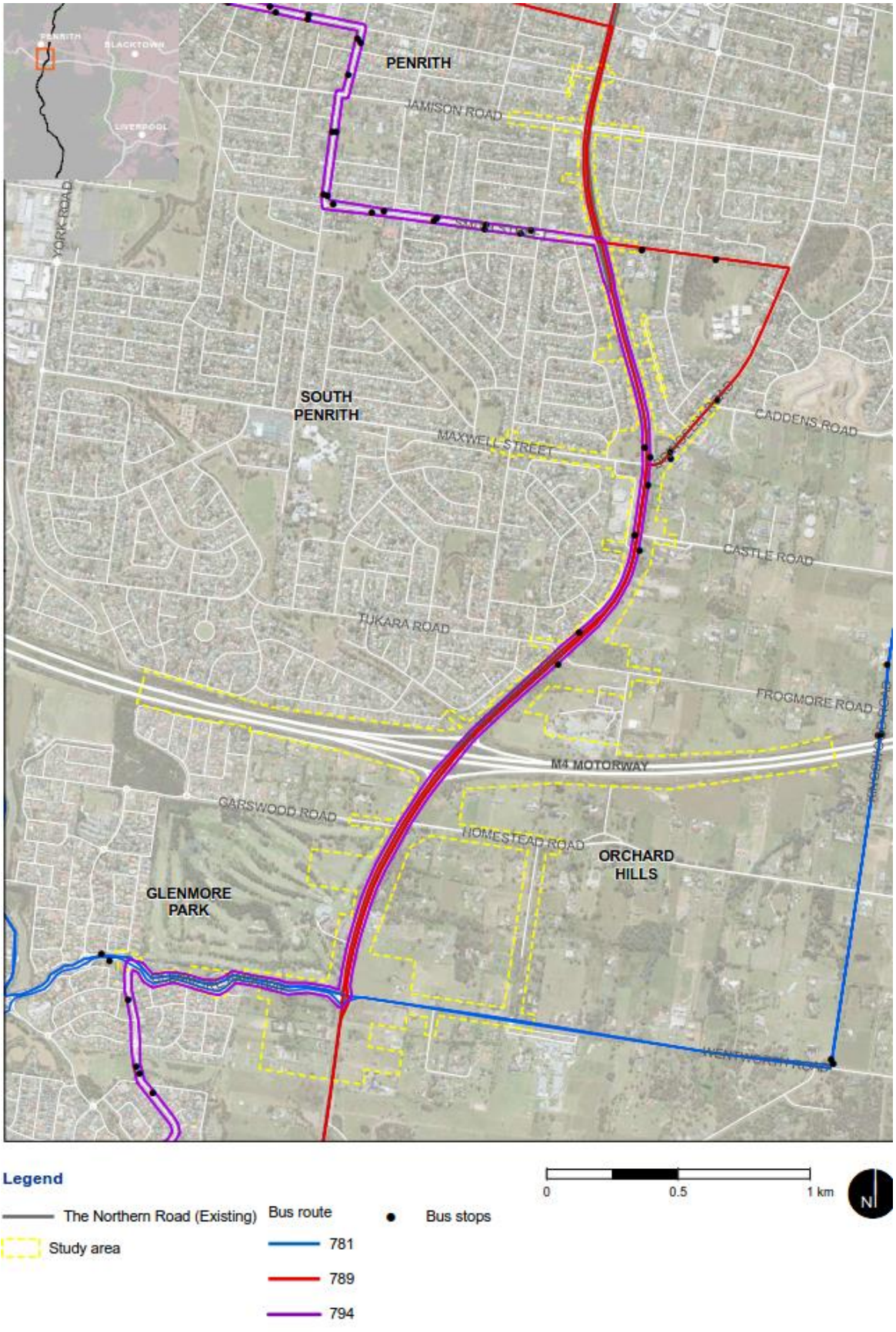
Route 789 operates between Penrith and Luddenham, along The Northern Road. Only one service per hour in each direction is provided in the morning and evening peak periods.

Figure 3.6 shows the existing bus routes and bus stops through the study area. A summary of stops the proposal study area is provided in Table 3.4.

Table 3.3 : Summary of bus stops in the proposal area

Transit Stop	*Location*
2750538	The Northern Road after Maxwell Street (northbound)
2747407	The Northern Road before Bringelly Road (southbound)
274864	The Northern Road after Bringelly Road (southbound)
274820	The Northern Road at John Cootes (northbound)
274813	The Northern Road at Garden Barn (southbound)
2750185	The Northern Road near Flavel Street (northbound)
274814	The Northern Road near Frogmore Street (southbound)

Figure 3.6 : Bus routes in the study area

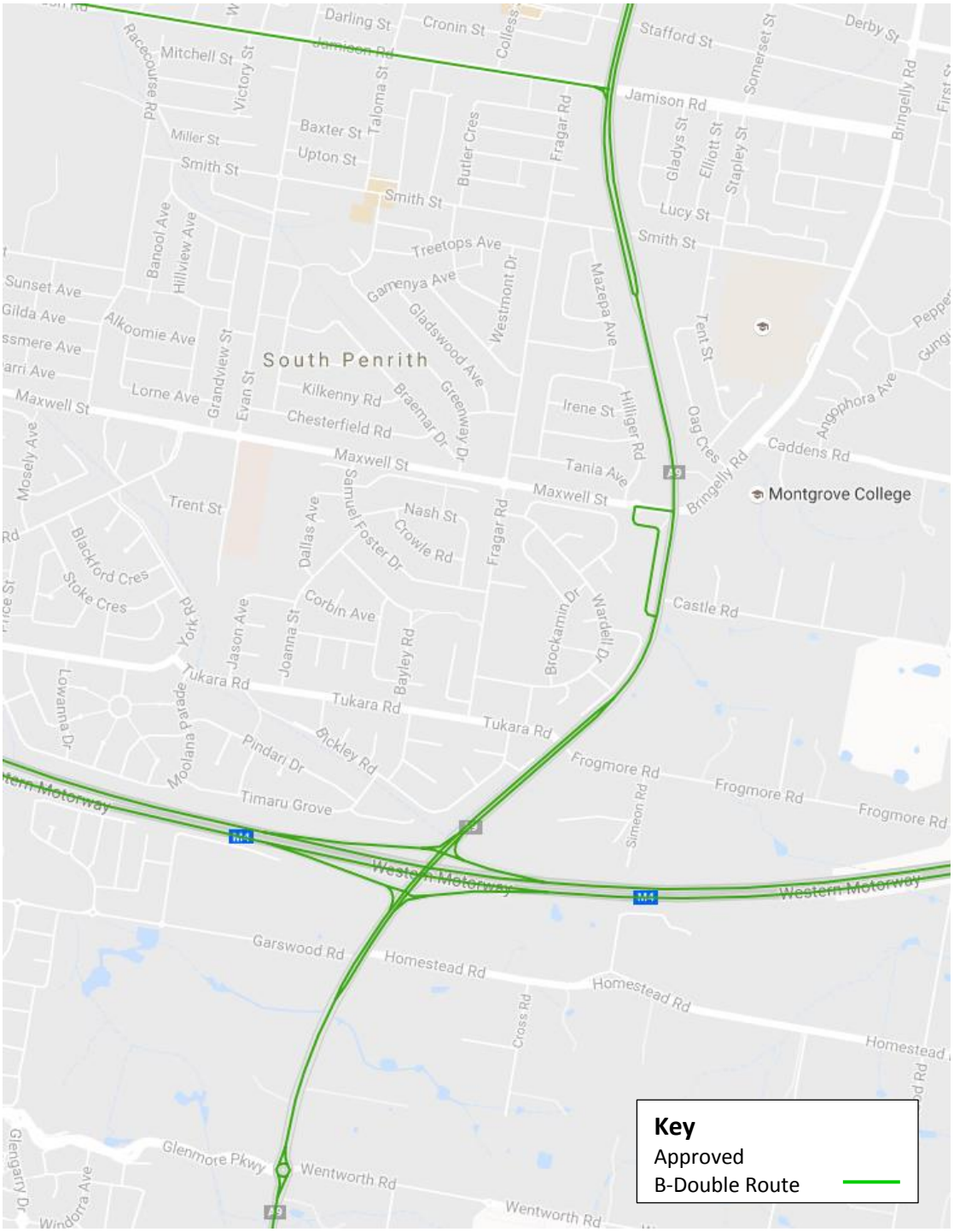


3.6 Freight Routes

The Northern Road forms a significant north-south freight function in the region. The route is approved for the 26 m B-doubles and 4.6 m high vehicles between Jamison Road and Glenmore Parkway. Jamison Road, to the west of the proposal and Aspen Street are also approved routes for 26 m B-doubles.

Higher Mass Limit vehicles are also permitted to use The Northern Road and M4 in the proposal area. Figure 3.7 shows the approved B-Double routes through the proposal area.

Figure 3.7 : Approved B-Double Routes through the study area



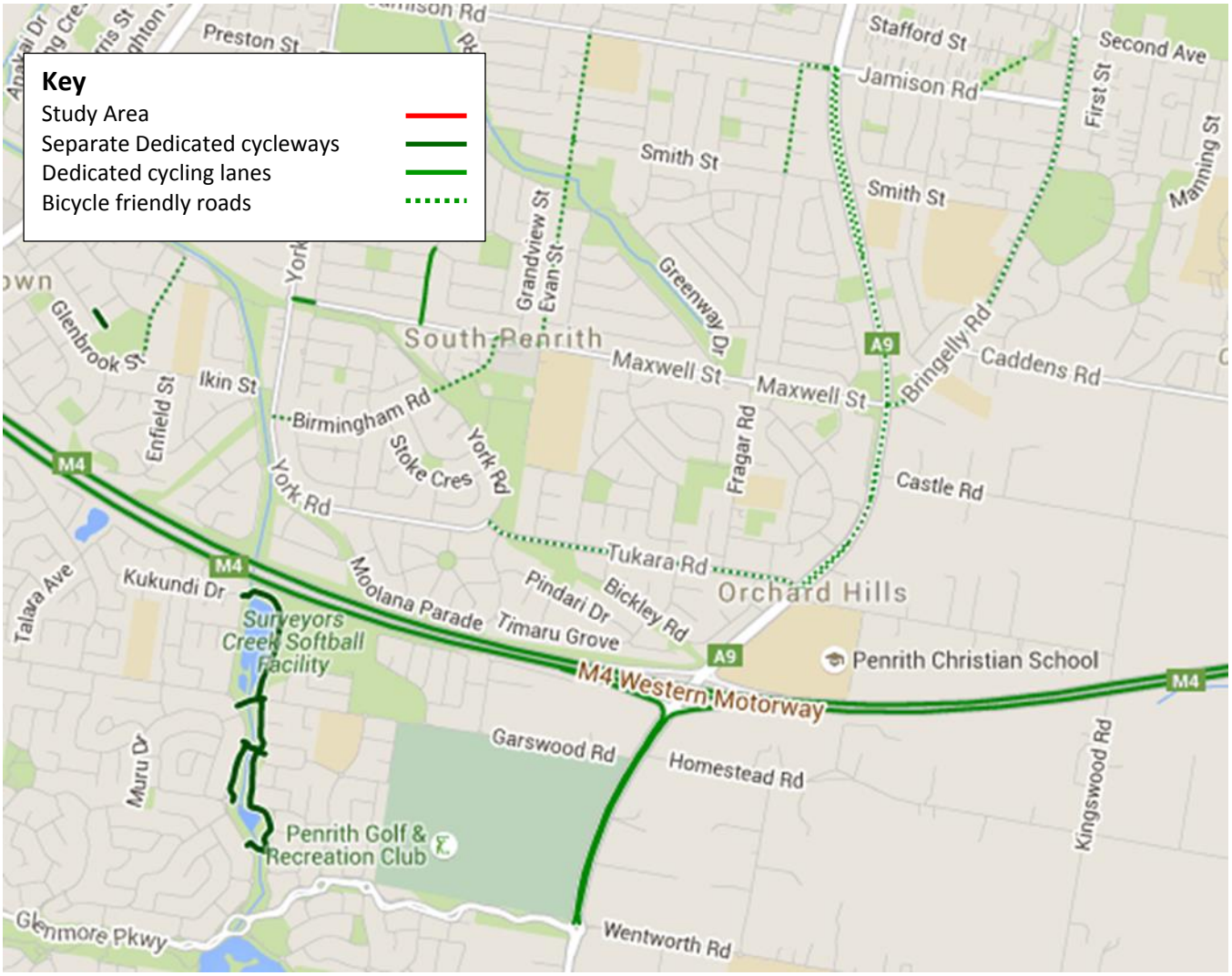
Source: NSW Roads and Maritime Services

3.7 Active transport

There is currently limited pedestrian infrastructure provided along The Northern Road. There are no formal footpaths provided between Maxwell Street and Glenmore Parkway. Footpaths are provided between Maxwell Street and Jamison Road

On-road cycle facilities are provided with the shoulder of The Northern Road between Glenmore Parkway and the M4 Motorway, as shown in Figure 3.8. The Northern Road is designated as a 'bicycle friendly road' between Tukara Road and Jamison Road however no formal lanes or infrastructure are provided.

Figure 3.8 : Cycling routes in the study area



Source: sydneycycleways.net

3.8 Existing road network performance

A traffic model representing the study area has been developed using the AIMSUN modelling platform (version 8.1.0) and has been calibrated and validated according to the principles outlined in the *Roads and Maritime Services Traffic Modelling Guidelines, 2013*.

Micro simulation modelling provides a framework to undertake detailed assessment of the proposed route and any intersections along it, allowing for the assessment and visualisation of the corridor as a whole. The micro simulation traffic modelling work will also assist in the assessment and scoping of proposed intersections along the corridor as well as provide a tool to assist in the development of construction staging and traffic management.

The following section provides an assessment of the existing traffic conditions at key intersections within the study area based on the AIMSUN modelling described above. It includes a description of the assessment criteria and results of the modelling.

3.8.1 Assessment criteria

The performance of the existing road network is largely dependent on the operating performance of intersections which form critical capacity control points. The 'Level of Service' (LoS) is the standard measure used to assess the operational performance of the network and intersections. Level of services is ranked from LoS A to LoS F with LoS A representing the best performance and LoS F the worst. The assessment of intersection operation is based on criteria outlined in Table 3.4, as defined by Roads and Maritime within the RTA guide to Traffic Generating Development 2002.

Table 3.4 : Level of Service criteria for intersections

Level of Service	Average Delay per Vehicle (sec)	Traffic Signals. Roundabouts	Give way & Stop Signs
A	<14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity & accident study required
E	57 to 70	At capacity; incidents would cause excessive delays at signals Roundabouts require other control modes	At capacity, requires other control mode
F	>70	Over Capacity; unstable operation	Over capacity; unstable operation.

Source: RTA Guide to Traffic Generating Developments (2002)

3.8.2 Existing intersection operation

Level of Service for key intersections within the study area, derived from the base (2015) The Northern Road microsimulation traffic model, is shown in Table 3.5.

Table 3.5 : Existing intersection performance along the proposal corridor

Intersection	AM Peak		PM Peak	
	Average delay (sec)	Level of Service	Average delay (sec)	Level of Service
The Northern Road/Glenmore Parkway/Wentworth Road	169	F	118	F
The Northern Road/M4 Motorway*	52	D	30	C
The Northern Road/Maxwell Street/Bringelly Road	43	D	70	F
The Northern Road/Smith Street	20	B	28	B
The Northern Road/Frogmore Road/Tukara Road	35	C	23	B
The Northern Road/Jamison Road	21	B	35	C

*Level of Service is reported as a combination of northern and southern interchange intersection

The micro simulation model shows that the following intersections operate at capacity during peak periods:

- The Northern Road, Glenmore Parkway and Wentworth Road roundabout
- The Northern Road and the M4 Motorway Interchange (both signalised intersections)
- The Northern Road, Maxwell Street and Bringelly Road.

All other intersections within the study area currently operate satisfactorily during peak periods.

3.9 Existing road safety trends

An analysis of crash history data has been carried out in the study area. Crash statistics recorded by RMS are confined to those crashes that conform to the national guidelines for reporting and classifying road vehicle crashes. The main criteria are:

- The crash was reported to the police
- The crash occurred on a road open to the public
- The crash involved at least one moving vehicle
- The crash involved at least one person being killed or injured or at least one motor vehicle being towed away.

Minor crashes where drivers exchange details are not required to be recorded and are not included in the crash data. Crash data for the last available five years (July 2009 to June 2014) has been provided by RMS and is presented below.

Table 3.6 shows the number of crashes in the study area by year. Crashes have gradually declined from 2009 to 2014.

Table 3.6 : Number of crashes

Period	Reported crashes
2009-2010	41
2010-2011	36
2011-2012	35
2012-2013	21
2013-2014	22
Total	*155*

Figure 3.9 shows a plot of reported crashes by crash type along The Northern Road between Glenmore Parkway and Jamison Road for the period between 2010 and 2014. Analysis of the distribution and type of crashes through the study area indicates clustering of crashes at the following locations:

- M4 Interchage: rear-end crashes are concentrated around northern and southern approaches to this interchange. This is indicative of cars travelling at high speeds into queued traffic waiting at traffic lights
- Frogmore Road and Tukara Road: rear-end crashes are concentrated around this intersection. This is indicative of cars travelling at high speeds into slowed traffic entering or exiting the seagull-arrangement at this intersection
- Castle Road: rear-end crashes are concentrated around this location. This is indicative of cars travelling at high speeds into slowed or stopped traffic waiting to make the right turn into Castle Road.

Figure 3.9 : Reported crashes on The Northern Road between Glenmore Parkway and Jamison Road (2010 to 2014)

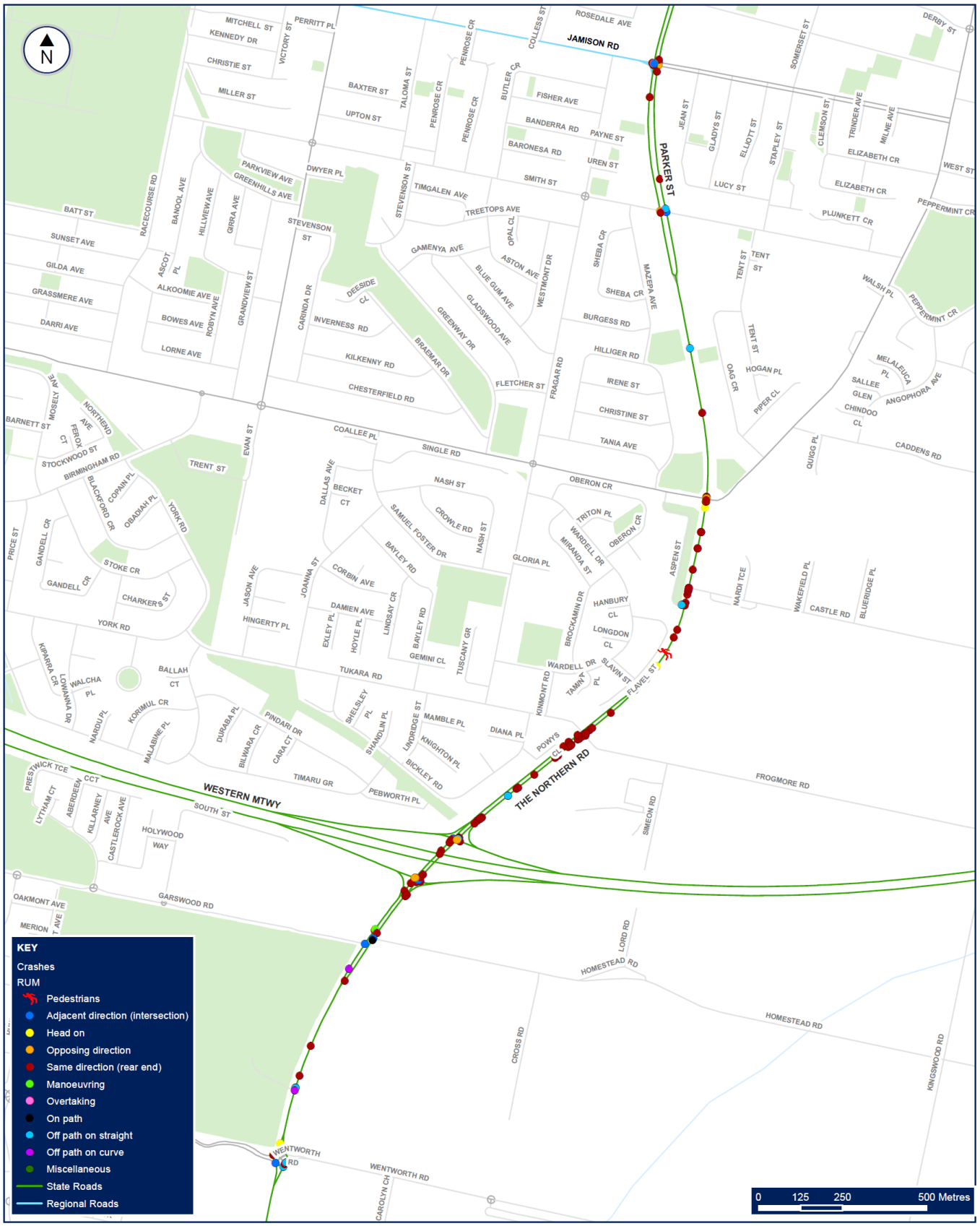


Table 3.7 shows a breakdown the type of crashes that have occurred on The Northern Road between Glenmore Parkway and Jamison Road. Rear end type collisions were the most prevalent reported crashes, accounting for 47 per cent of all crashes.

Table 3.7 : Summary of crash types

Type of crash	Reported crashes
Rear End	75
Turning – Opposing directions	23
Intersection – Adjacent directions - right turn	16
Off to left - Straight	7
Lane Change	4
Off to left - Curve	4
Side Swipe	4
U Turn	4
Intersection - Adjacent directions - cross traffic	3
Intersection - Adjacent directions - left turn	3
Off to right - Straight	3
Broken down vehicle on path	2
Head On - not overtaking	2
Off to right - Curve	2
Out of control on carriageway - Curve	2
Out of control on carriageway - Straight	2
Animal	1
Leaving Parking	1
Pedestrian	1

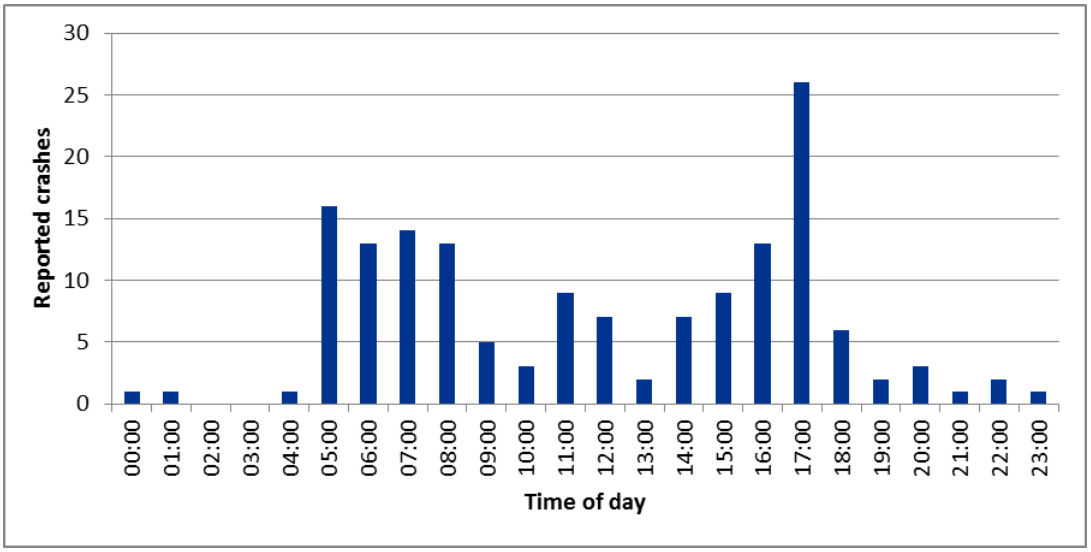
Table 3.8 outlines the severity of crashes on The Northern Road between Glenmore Parkway and Jamison Road. There were no fatal crashes on this section of road between 2009 and 2014 however 67 crashes involved an injury.

Table 3.8 : Summary of crash severity

Severity	Reported crashes
Fatal	0
Injury	67
Non-injury	88

Figure 3.10 shows reported crashes by time of day. Most crashes occur during the day, with more crashes occurring early in the morning and later in the afternoon.

Figure 3.10 : Summary of crashes by time of day



Midblock traffic count data from surveys in July 2015 have been used to calculate average daily traffic numbers for this section of The Northern Road. This has allowed for calculation of a crash rate per 100 million vehicle kilometres travelled (VKT) as well as a crash rate per kilometre per year.

Table 3.9 outlines these crash rates**.** The observed casualty crash rate per km per year for this section of The Northern Road is slightly lower than the average performance of similar roads in NSW.

Table 3.9 : Summary of crash rates

Average daily traffic	Length of section (km)	Crash rate per 100 million VKT	Crash rate per km per year		
			All crashes	Casualty crashes	Average class performance*
39,479	3.7	58.1	8.4	3.6	5.8

Average casualty (fatal and injury) crash rate for this type of road in accordance with Table 4.3 of *Roads and Maritime Network and Corridor Planning Practice Notes*

4. Key features of the proposal

The proposed design for The Northern Road Upgrade between Glenmore Parkway (Glenmore Park) and Jamison Road (South Penrith) is comprised of the following key components:

- Road cross section
- Design speed
- Proposed intersection layouts.

An overview of these key traffic features is presented below.

4.1 Road cross section

The following road cross sections would be provided as part of the proposal:

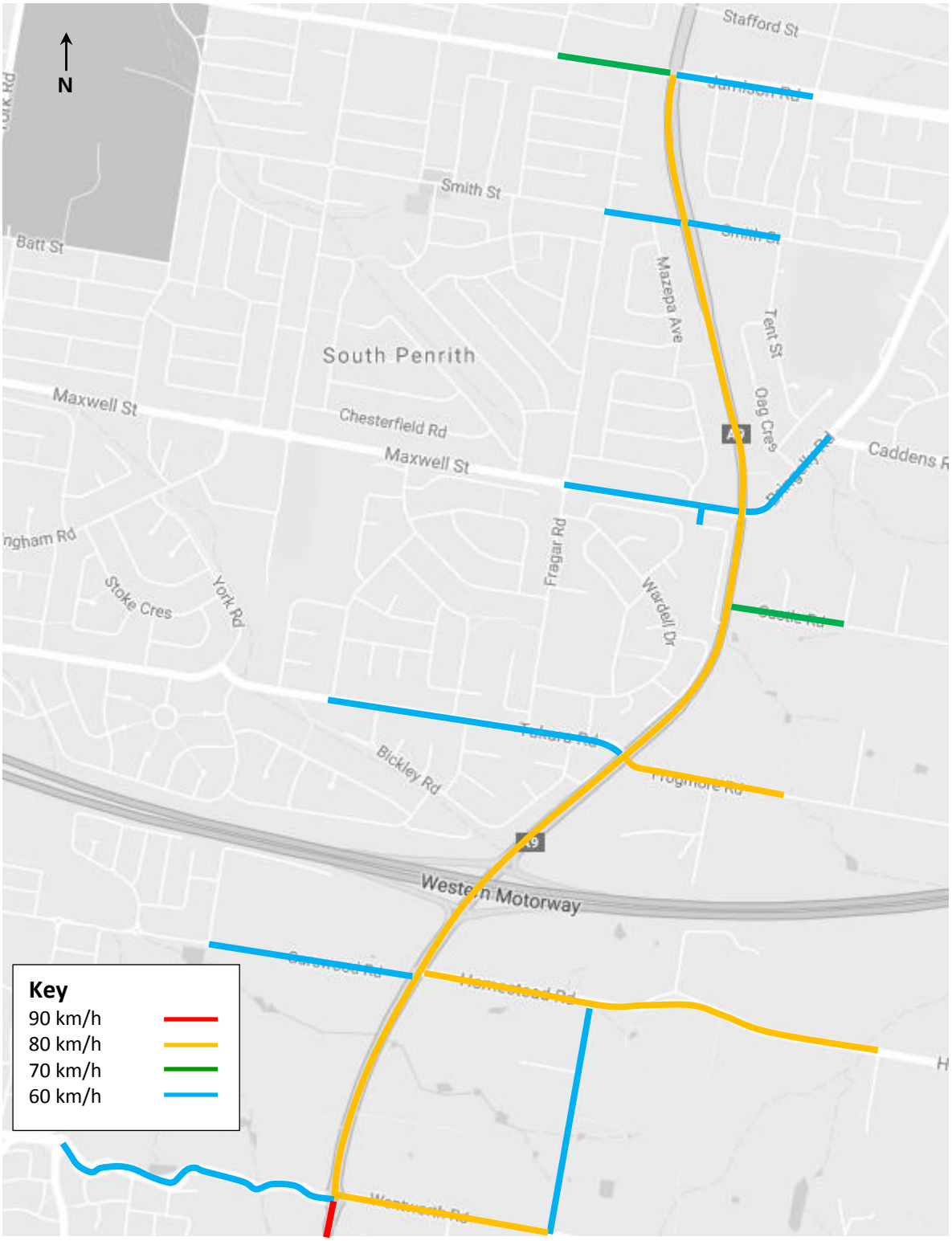
- Four lanes in each direction between Glenmore Parkway and Smith Street with the kerbside lane marked as a bus lane
- Four lanes northbound between Smith Street and Jamison Road northbound with the kerbside lane marked as a bus lane
- Three lanes southbound from Smith Street to 220 m south of Jamison Road with a kerbside bus lane developing 220 m south of Jamison Road.

This cross-section provided three continuous traffic lanes northbound and southbound between Glenmore Parkway and Jamison Road.

4.2 Design speed

A design speed of 90 km/h has been adopted for geometric design of The Northern Road between Glenmore Parkway and the M4 Motorway. A design speed of 80 km/h has been adopted between the M4 Motorway and Jamison Road. Adopted design speeds for other roads within the proposal area are shown in Figure 4.1.

Figure 4.1 : Proposed design speeds



4.3 Intersection layouts

Plots of proposed intersection layouts showing approach configurations for intersections in the proposal are shown in Figure 4.2 to Figure 4.9.

Figure 4.2 : The Northern Road/Glenmore Parkway/Wentworth Road

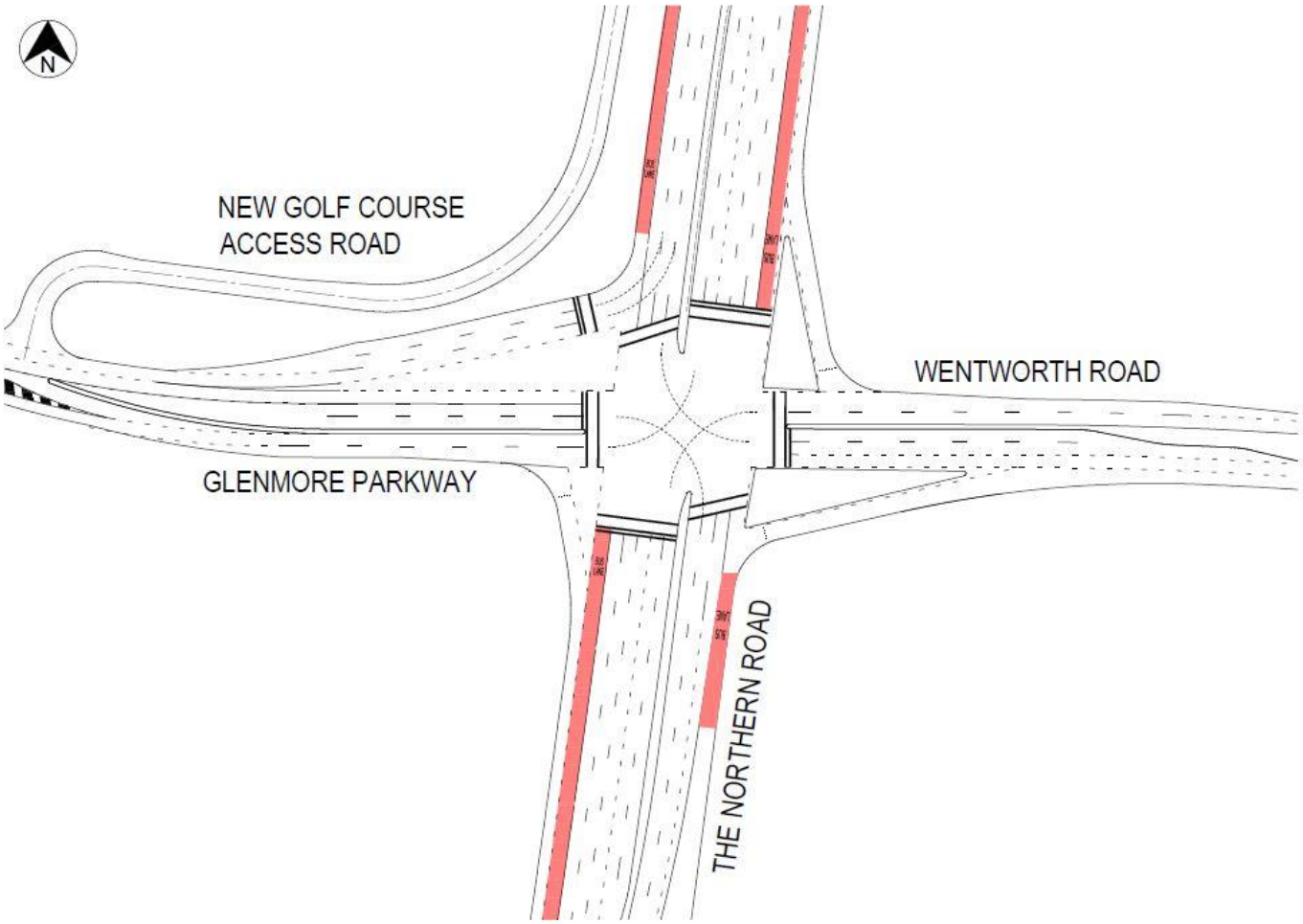


Figure 4.3 : The Northern Road/M4 Motorway

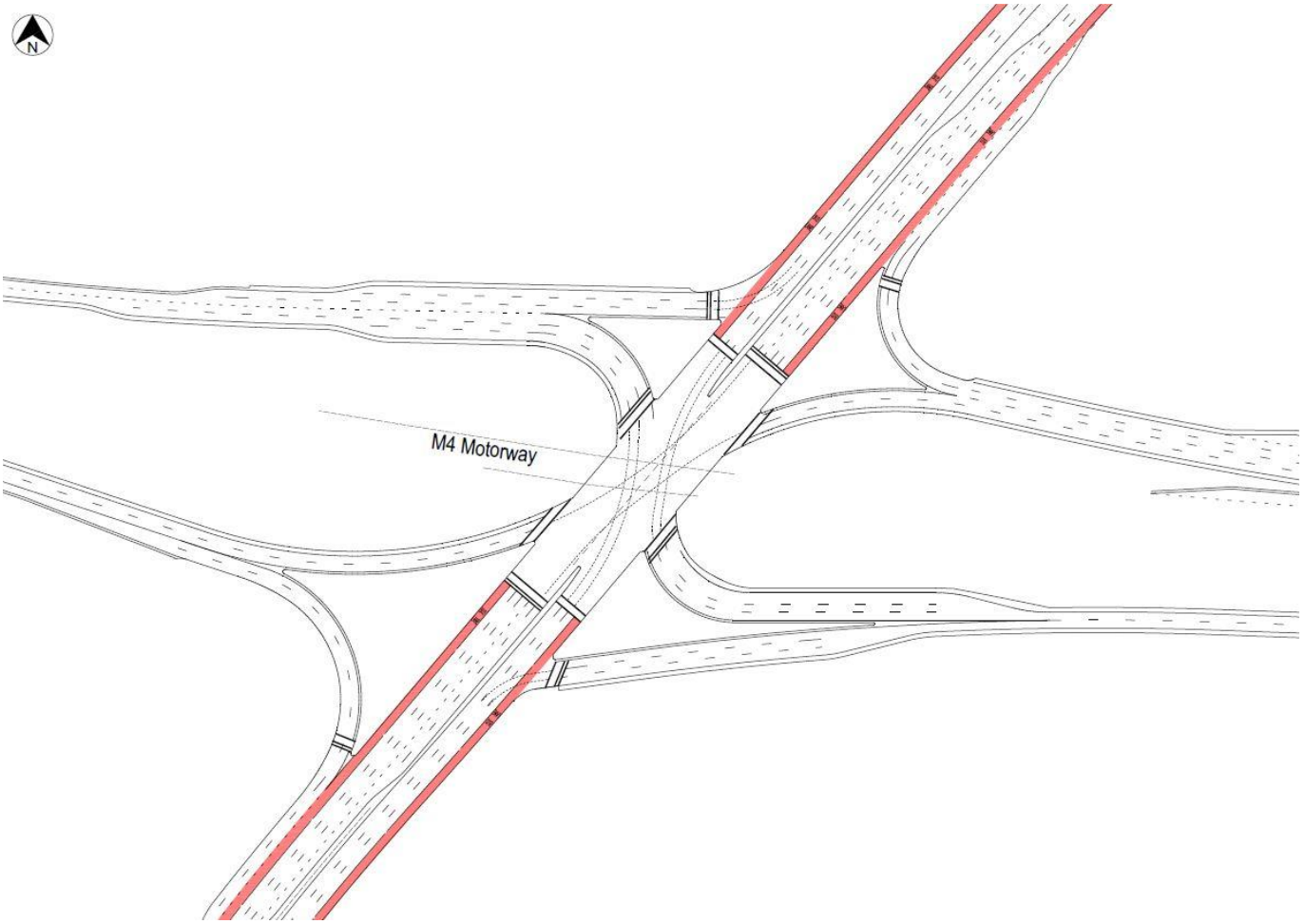


Figure 4.4 : The Northern Road/Frogmore Road/Tukara Road

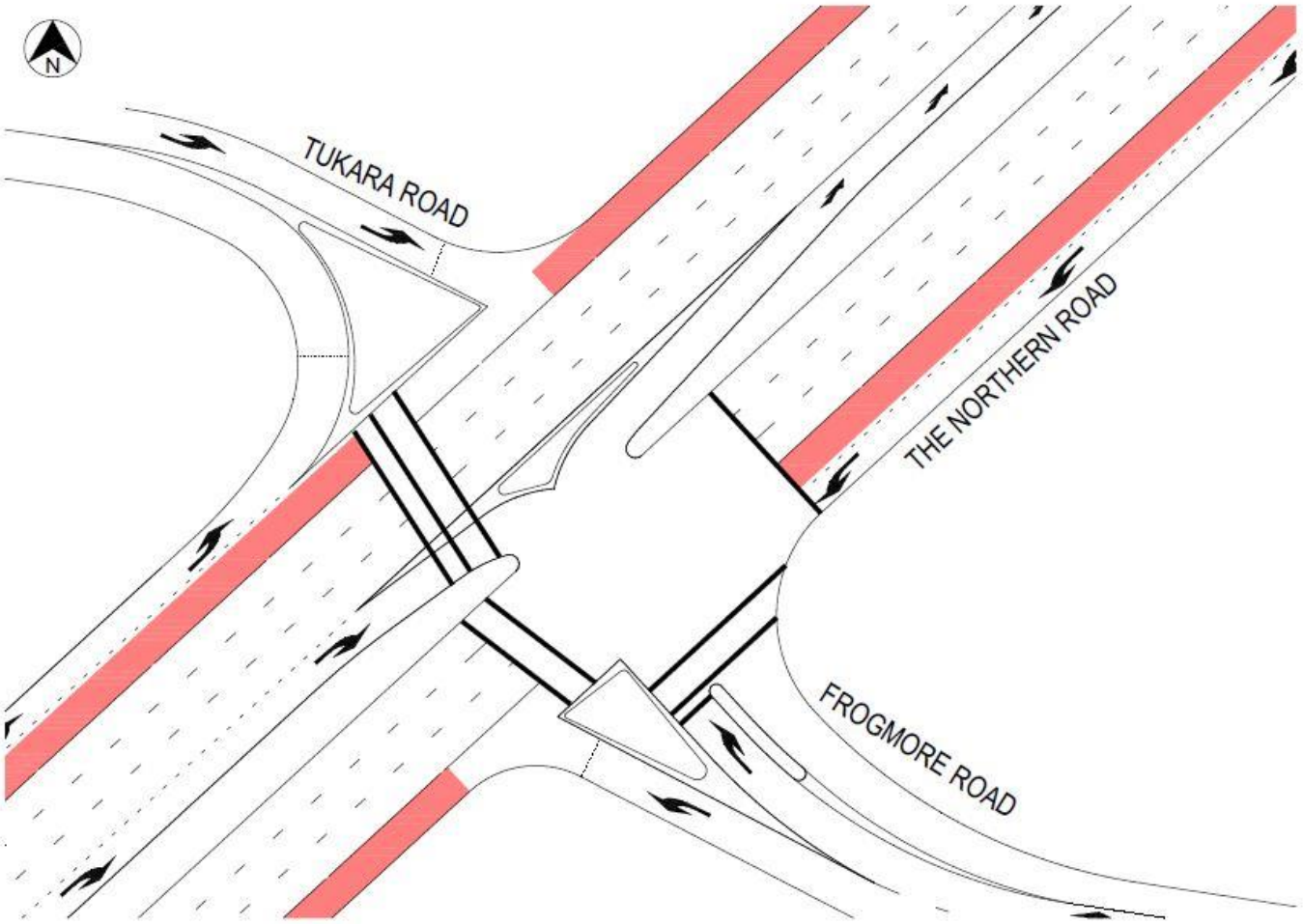


Figure 4.5 : The Northern Road/Aspen Street/Castle Road

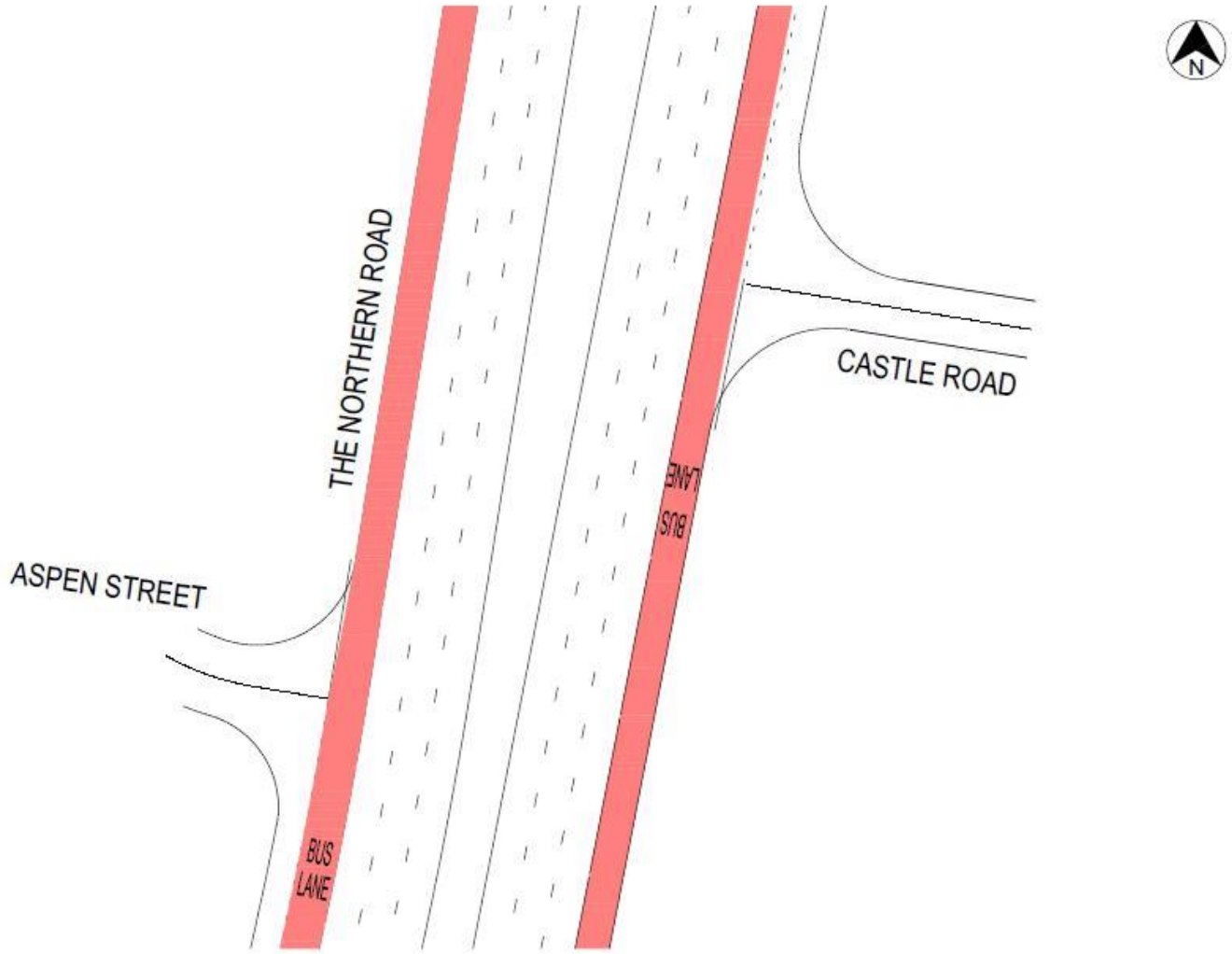


Figure 4.6 : The Northern Road/Maxwell Street/Bringelly Road

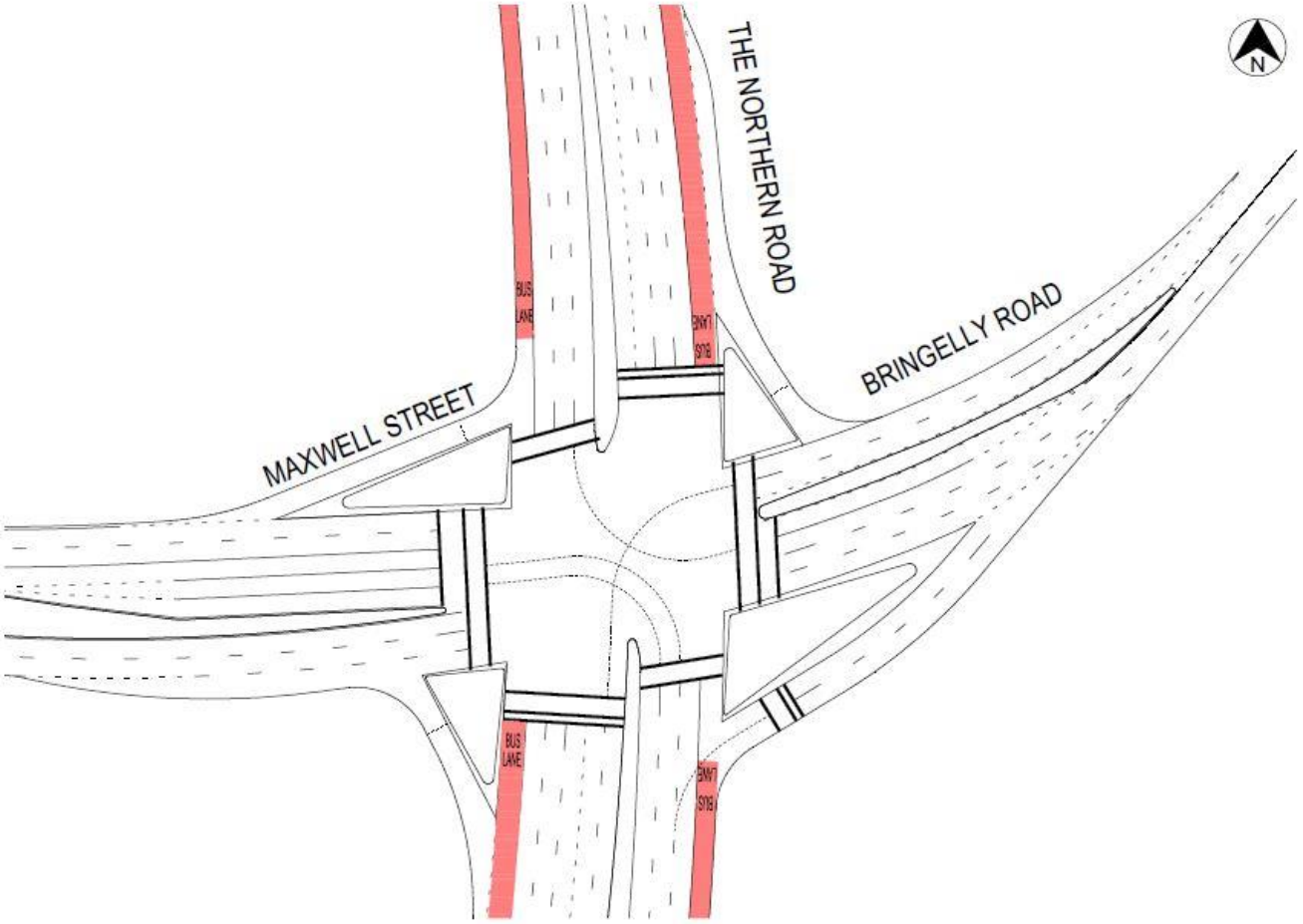


Figure 4.7 : Aspen Street/Maxwell Street/Tania Avenue

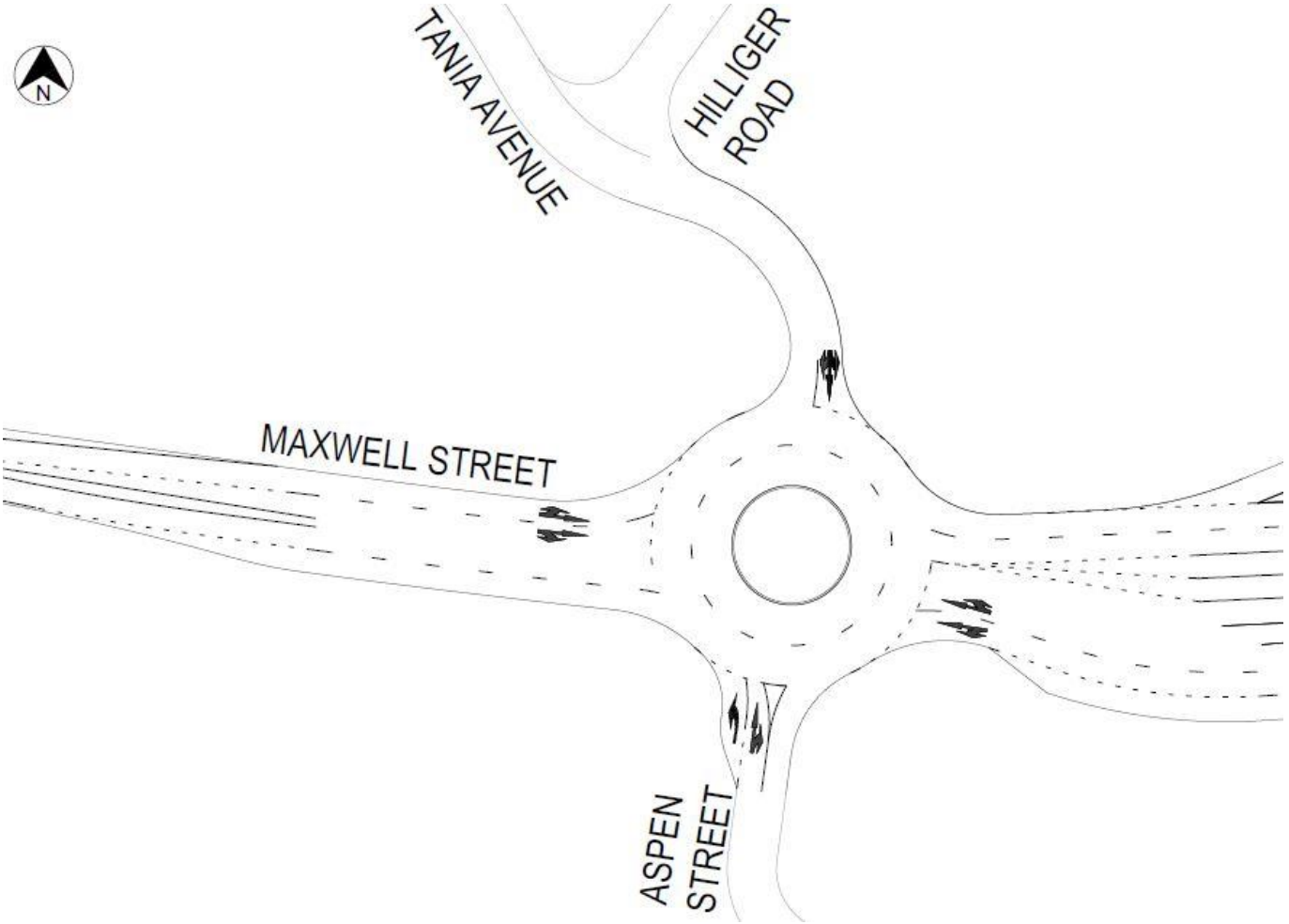


Figure 4.8 : The Northern Road and Smith Street

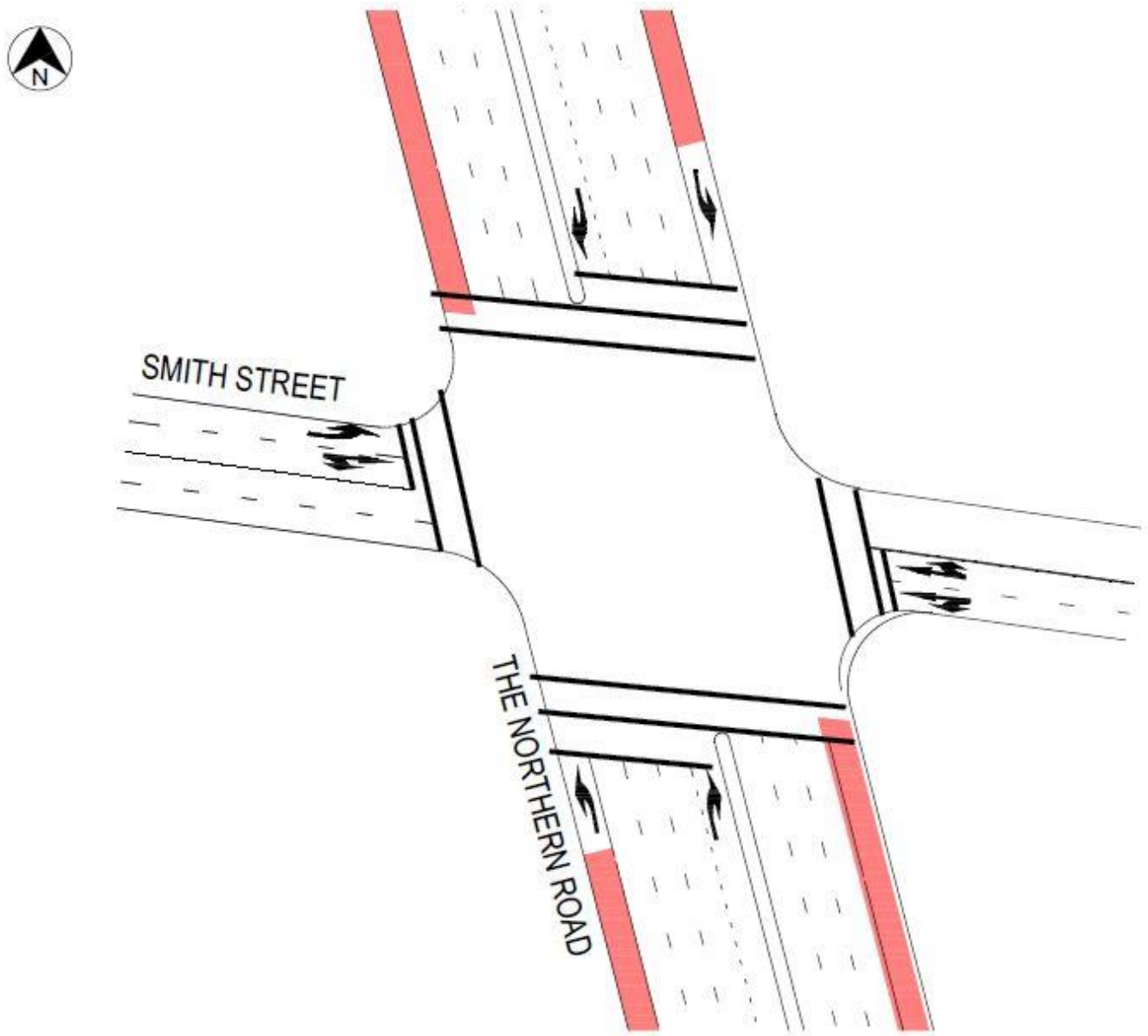
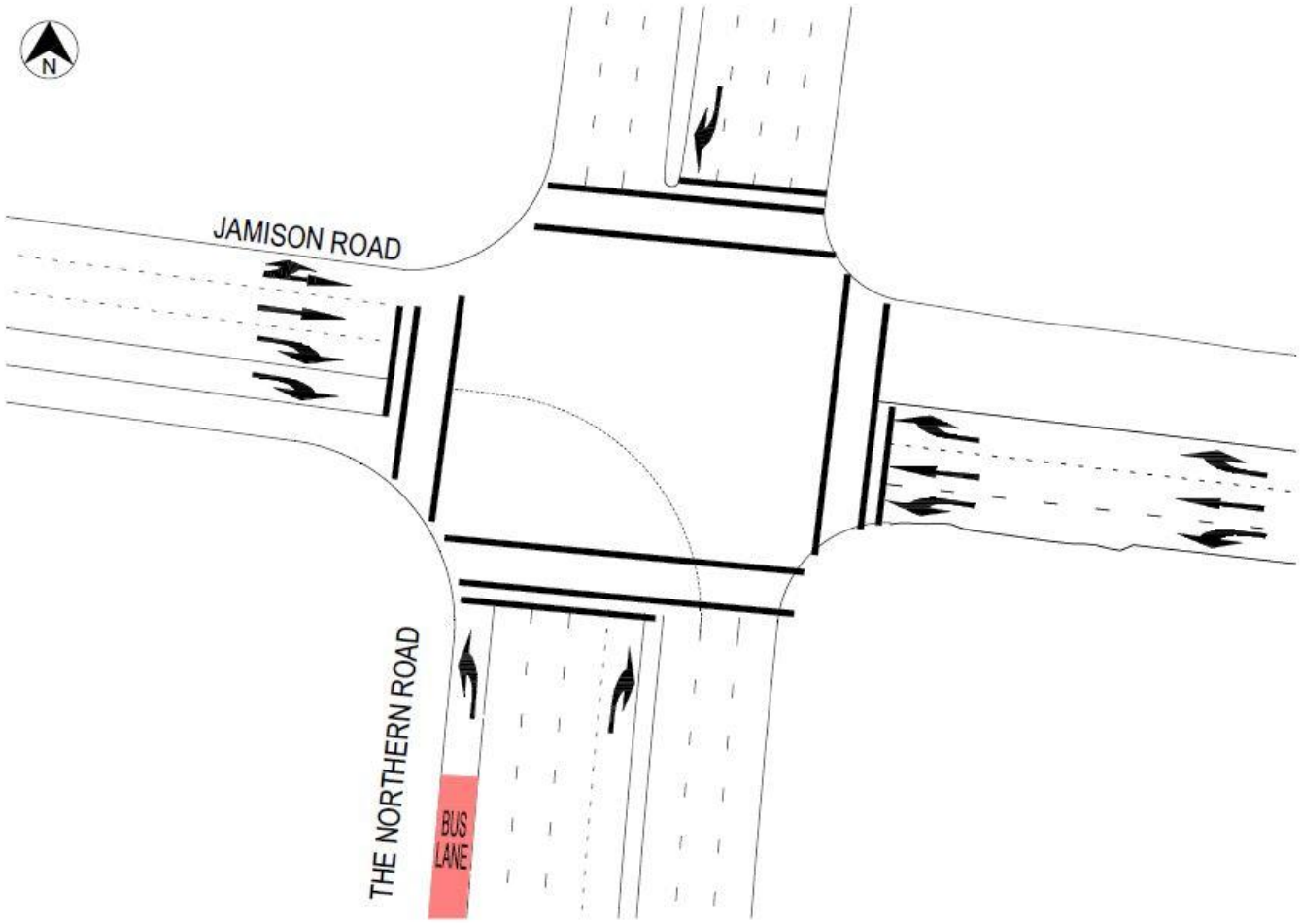


Figure 4.9 : The Northern Road and Jamison Road



4.4 Proposed construction stages

Construction of the proposal is likely to take place within three stages:

- Stage one would involve construction of the kerbside two lanes between Jamison Road and Bringelly Road, as well as construction of the full southbound carriageway between Bringelly Road and Glenmore Parkway
- Stage two would involve construction of the centre lanes and median between Jamison Road and Bringelly Road, and construction of the northbound carriageway between Bringelly Road to Glenmore Parkway
- Stage three, the final stage, would involve completion of the northbound carriageway between Jamison Road to Glenmore Parkway.

Traffic would be switched between the carriageways as required during each stage of construction and onto the existing bridge while the new bridge is being constructed, to preserve traffic flows during construction.

The typical sequence of work during these stages would involve the following tasks:

- Delineate the work area from traffic on The Northern Road
- Traffic management
- Provide gates, and/or a service road or shared area within the work zone to enable access and egress to and from the work areas and access through the work area for residential and commercial properties on both sides of The Northern Road
- Maintain the function, in the current configuration, of all roads leading into The Northern Road with the exception of the closure of Homestead Road at The Northern Road, but only after Cross Road is constructed
- Strip, stockpile and manage topsoil and unsuitable material
- Mill the existing pavement for potential re-use
- Adjust and relocate utilities
- Construct retaining walls and noise walls (where proposed)
- Install culverts
- Construct earthworks for pavement construction
- Carry out bulk earthworks
- Construct the new bridge. This work would be staged to incorporate use of the existing M4 Motorway bridge into the construction sequence, with the eastern portion of the new bridge constructed first, followed by demolition of the existing bridge, then construction of the western portion of the bridge to be stitched with the newly built eastern portion of the bridge. Steps within each stage would include:
    - Forming embankments for the new bridge construction
    - Bridge work including the substructure, abutment and superstructure
    - Building the retaining walls, including foundation work, construction of walls and back filling
- Install drainage (cross-drainage, longitudinal and subsoil drainage)
- Place select material
- Install pavement drainage and subsoil drainage
- Construct road pavement (this would include demolition of existing road pavement where required; and compaction of select fill, sub-base, and the asphalt wearing surface)
- Install kerbs and gutters
- Pave the road surface
- Construct the shared and pedestrian paths
- Rehabilitate topsoil, revegetation and landscaping

- Carry out finishing work (this would include installation of safety barriers, fencing, pavement marking, signposting, road furniture and street lights)
- Commission the built property access such as the golf course access
- Commission the intersections to the final traffic arrangement
- Rehabilitate temporary stockpiles (this would include decommissioning the construction compound and stockpile areas)
- Site clean-up.

A final stage of construction would comprise construction of The Northern Road medians between Glenmore Parkway and Jamison Road. Northbound traffic would be relocated to the newly constructed northbound carriageway and southbound traffic would remain on the previously constructed southbound carriageway.

Construction staging for the work on adjoining roads would generally be concurrent with the construction work on the main alignment of The Northern Road.

Construction of the proposed M4 Motorway bridge and interchange on- and off-ramps would also be carried out concurrent with the main carriageway upgrade work.

Construction of the proposal will generally be undertaken on each direction in series. Due to the limited road width along The Northern Road between Bringelly Road and Jamison Road, full construction cannot be undertaken in either direction in this section. A final additional stage will required to complete the remaining lanes that cannot be constructed in Stages One or Two.

5. Traffic and transport appraisal

5.1 Overview

The following section provides an assessment of the traffic and transport impacts of the proposal. The study has assessed the traffic and transport impacts for three design years for the weekday peak periods; 2021, 2031 and 2041.

Traffic impacts have been assessed based on traffic modelling undertaken using AIMSUN. Further detail on the development of the traffic model and the assumptions underpinning future year scenarios is provided in Appendix A. The cumulative impacts of the increase in background traffic as well as the impacts of road upgrades and the forecast levels of development within the study area have been included in the assessment.

The assessment considers the impacts on all road users including freight movements, public transport, pedestrians and cyclists.

5.2 Modelled scenarios

The traffic and transport assessment considered the following scenarios:

- Existing 2015 Base Case
- 2021, 2031 and 2041 'without the proposal'
- 2021, 2031 and 2041 'with the proposal'.

The "without the proposal" scenario includes the following road upgrades:

- M4 Smart Motorway civil works (by 2021)
- Werrington Arterial Road upgrade (by 2021)
- M12 Motorway (by 2031)
- Planned Western Sydney Airport (by 2031) including realignment of The Northern Road around the western Sydney airport site.

The 'with the proposal' scenario assumes all the 'Do Minimum' upgrades as well as the completion of The Northern Road upgrade between Mersey Road and Glenmore Parkway. As construction activities are required to ensure that existing traffic capacity on the Northern Road must be maintained through the course of construction, traffic modelling of the construction period has not been undertaken.

A summary of options included in each scenario are presented in Table 5.1

Table 5.1 : Summary of options tested as part of the assessment

	2015 Base	2021 without the proposal	2021 with the proposal	2031 without the proposal	2031 with the proposal	2041 without the proposal	2041 with the proposal
M4 Smart Motorway civil works	×	✓	✓	✓	✓	✓	✓
Werrington Arterial Road upgrade	×	✓	✓	✓	✓	✓	✓
M12 Motorway	×	×	×	✓	✓	✓	✓
Planned Western Sydney Airport	×	×	×	✓	✓	✓	✓
The Northern Road Upgrade between Mersey Road and Glenmore Parkway	×	×	✓	×	✓	×	✓

5.3 Desired Traffic Assessment Criteria

The assessment criteria for road network planning for the proposal relate to:

- Provision of adequate capacity on the higher order road network to cater for forecast traffic based on a minimum intersection Level of Service D for morning and evening peak period operation
- Avoiding impact on the operation of the M4 Motorway by ensuring that queueing of traffic from The Northern Road interchange does not extend beyond the ramp storage and impede flow on the M4 Motorway
- Minimising queue length and avoiding turn bay overflow along The Northern Road
- Minimising travel times along The Northern Road during peak periods
- Provision of optimum intersection configurations that are sensitive to physical constraints and land ownership
- Providing improvements for other road users such as public transport, pedestrian and cyclists.

5.4 Impacts of construction

It is expected that the proposal would be built between 2017 and 2019, subject to weather. The majority of the work would take place during daytime in accordance with the recommended standard hours for construction work set by the *NSW Interim Construction Noise Guidelines 2009*, which are:

- Monday to Friday 7am to 6pm, excluding public holidays
- Saturday 8am to 1pm.

Throughout the course of construction, the existing traffic capacity would need to be maintained. This would be achieved by maintaining the existing lane count on The Northern Road during peak periods. Outside of peak periods, works may need to be undertaken with localised lane closures and traffic disruptions. These works would be planned outside of peak periods to minimise traffic disruptions. Potential work activities which would be undertaken outside standard construction hours would generally include:

- Pavement construction, including asphalting
- Intersection tie ins with side roads
- Lifting and erection of bridge elements
- Line marking
- Any emergency works.

Completion of these works would ensure that there would be minimal disruption to road users, including businesses and landowners in the study area. Potential impacts related to construction traffic are discussed in the following section.

5.4.1 Construction compounds and heavy vehicle routes

The majority of construction would take place within the road corridor and would require the establishment of multiple construction sites adjacent to The Northern Road. Access and egress to these sites, which would be active for the duration of works within that area, would be through static gates that may be controlled by a traffic controller in cases where construction vehicles cannot enter and exit via left turn movements.

For the majority of these gates, access and egress would be via The Northern Road. A plot of proposed heavy vehicles routes is shown in Figure 5.1.

Figure 5.1 : Proposed heavy vehicle routes

Source: Google Maps

The majority of traffic generated during the construction stages would be from plant equipment and material deliveries including:

- Construction material
- Spoil removal
- Construction plant
- Construction personnel (light vehicles).

During peak traffic period, approximately 220 additional light vehicles are likely generated per day. Assuming that 80 per cent of these light vehicles arrive in the same hour, the likely peak hour volume on the busiest days would be in the order of 176 vehicles per hour with almost all of these vehicles arriving at the worksite in the morning and leaving in the afternoon. The majority of this traffic would likely travel along The Northern Road from the M4, with a small proportion travelling from The Northern Road from the north and south. Furthermore, the average traffic generation for any one worksite would be around one third of the peak volume at 59 two-way vehicle trips per day.

The number of truck movements to any one work site is likely to be in the order of 100 trucks per day. This would equate to some 12 to 13 truck movements per hour in the peak hours. This number of trucks is unlikely to have a significant traffic impact on the road network given there are currently about 4,400 heavy vehicles using The Northern Road on an average day. Typically the type of trucks that construction would generate would be truck-and-dog vehicles, heavy rigid vehicles and concrete trucks.

5.4.2 Impacts on existing developments

Access to some properties may be affected by the construction activities, particularly in areas where construction would be occurring in the existing The Northern Road corridor. This could be either though the loss of or changes to existing access arrangements. All existing access should be maintained at all times during the construction period. The development of traffic management plans approved by Roads and Maritime Services would ensure continuity of access for properties affected by construction works.

Through the course of construction, temporary closures and changes to access arrangements affecting individual properties would be negotiated and agreed with individual land owners through consultation to ensure continuity of access and minimise the disruption to business and residences.

To facilitate alternative temporary access to businesses and residences, temporary signposting to local roads affected by construction activities would considered during relevant stages of construction to minimise confusion to motorists.

5.4.3 Impacts on road network operation

As outlined in Section 4.4, construction activities would be staged to ensure that there is no reduction in road capacity through the course of construction. The primary impacts of construction activities would be reductions in speed through areas where construction is taking place.

By ensuring that existing road network capacity is maintained, the likelihood of traffic using alternative local routes will be minimised. Although the opening of the Werrington Arterial Road will present an alternative route to access the M4 for vehicles travelling from Glenmore Park, using local roads to make this journey would still be longer as the route via Homestead Road and Lansdowne Road to Kent Road is circuitous and slower than using the more direct route via The Northern Road and the M4. A comparison of the two routes is provided in Table 5.2.

Table 5.2 : Travel time estimates for alternative routes to M4

Route	Distance (km)	Travel Time (mm:ss)
The Northern Road and M4	5.4	4:10
Homestead Road, Lansdowne Road and Kent Road	6.5	5:30

Construction activity is likely to impact traffic operation in the following instances:

- Disruptions to traffic on the M4 Motorway: reduced speeds would be in place on the M4 Motorway during the construction of temporary pavement in the median and during overhead bridge works which would take place over live traffic. Detours may also be in place when works over live traffic are unsafe or when work is undertaken on ramps. In these cases, traffic may be required to detour using part of the surrounding road network, over The Northern Road or switched the opposite side of the M4 Motorway. These arrangements would be temporary and planned outside of peak periods to minimise impacts to traffic flow
- Reduced speed limits at traffic crossovers: traffic crossovers would be established at the northern and southern ends of the existing bridge over the M4 Motorway to permit contra-flow operation during bridge

construction activities. Traffic would be required to travel on the opposite side of the road at reduced speed during these periods. Crossover operation would generally be limited to outside of peak periods.

- A temporary roundabout would be constructed at the intersection of The Northern Road and Glenmore Parkway and be in operation for the duration of the construction of traffic signals at the same location. This temporary roundabout would have a smaller diameter than the existing roundabout and would operate at a lower speed. Half-road or full road closures and temporary traffic control would be in place along Glenmore Parkway and The Northern Road for short durations during the construction of this temporary roundabout.
- Temporary road closures on local roads and accesses, particularly south of the M4, would be in place for short durations. Temporary road closures would require vehicles to take detours along alternative route for the duration of the closure, while access closures would require temporary alternative driveways to be constructed prior to closures to provide continuity of access to affected properties.
- Temporary traffic calming: the majority of construction activities would likely be occurring adjacent to live traffic and a significant proportion of the construction period would require vehicles to travel on temporary pavement or temporary ramps. During these periods, traffic would be required to travel at reduced speed and may also be subject to traffic control to allow for the movement of construction vehicles around or between construction sites.

5.4.4 Impacts on bus services

Route 794 and 789 operate through the study area; these are primarily peak period services, with 789 only operating during weekdays. During construction of the proposal the following impacts to buses and bus passengers are likely:

- Reductions in speed when travelling through construction activity areas including traffic switches and tie-in works
- Temporary relocation of stops away from construction zones, particularly where works are being undertaken within the existing The Northern Road corridor. This would involve the relocation of stops where construction work would make existing stops inaccessible and may require passengers to walk further distances to reach their stops. Based on the spacing of stops and the staging of construction activities, this is likely to affect up to three stops at any one time during construction and seven bus stops in total. Between the M4 Motorway and Maxwell Street, stops on the eastern side of The Northern Road would need to be relocated as well as the two bus stops between Maxwell Street and Jamison Road
- Bus stops would be managed through the construction process to ensure that bus would be able to stop outside of general traffic lanes and would not delay through traffic
- Alternative access to relocated bus stops may need to be provided depending of where the bus stops are relocated. This may involve the construction of temporary footpaths adjacent to construction zones
- Consultation with bus operators and the community to ensure that adequate notification is provided prior to the temporary relocation of a bus stop and any temporary alternative arrangements.

5.4.5 Impacts on pedestrian and cycle access

During construction, pedestrian and cyclists may need to use alternative temporary paths where one side of The Northern Road may be inaccessible. In most cases, pedestrians and cyclists would be diverted to use alternative routes to ensure that full connectivity is maintained.

In cases where there is not an available alternative, the provision of temporary alternative access routes to properties in the study area would be required to ensure that safe pedestrian and cycling access is maintained during the course of construction. Currently proposed temporary footpaths include:

- Maxwell Street, south side west of Aspen Street
- Maxwell Street north side east of Aspen Street.

As construction would take place in stages, these temporary arrangements are likely to be in place for up to two years.

5.4.6 Impacts on parking

Construction activities are likely to affect up to 10 parking spaces on either side of The Northern Road between Jamison Road and Stafford Street.

5.5 Impacts on road network performance

The criteria outlined in Section 5.3 have been used to assess the performance of intersections along the proposal. Assessment of the intersections has been undertaken based on outputs from The Northern Road micro simulation traffic model, with average delays for intersections extracted from the model for the morning (7.30am to 8.30am) and evening (4.30pm to 5.30pm) peak periods. Modelled peak queue lengths for the same periods have also been reported for each approach to these intersections.

5.5.1 Without the proposal

Table 5.3 summarises the intersection operation along the existing The Northern Road corridor if the proposal was not built. In general, testing of the forecast traffic flows on The Northern Road under the future year scenarios shows that there would be insufficient capacity along The Northern Road under the existing arrangement.

Further qualitative analysis of the future year scenarios under existing arrangements shows that The Northern Road and M4 Motorway interchange would generate delays that would extend along The Northern Road and M4 Motorway resulting in restricted traffic flows on the main carriageways. Table 5.2 confirms there would be insufficient capacity along The Northern Road under the existing arrangement.

Table 5.3 : Intersection performance summary without the proposal

Intersection	2015		2021		2031		2041	
	Av. Delay	LoS	Av. Delay	LoS	Av. Delay	LoS	Av. Delay	LoS
Morning peak								
The Northern Road/Glenmore Parkway/Wentworth Road	>140	F	>140	F	>140	F	>140	F
The Northern Road/M4 Motorway	57	E	102	F	>140	F	>140	F
The Northern Road/Frogmore Road/Tukara Road	35	C	>140	F	>140	F	>140	F
The Northern Road/Maxwell Street/Bringelly Road	43	D	70	E	>140	F	>140	F
The Northern Road/Smith Street	20	B	23	B	83	F	>140	F
The Northern Road/Jamison Road	21	B	25	B	63	E	>140	F
Evening peak								
The Northern Road/Glenmore Parkway/Wentworth Road	118	F	>140	F	>140	F	>140	F
The Northern Road/M4 Motorway	33	C	111	F	>140	F	>140	F
The Northern Road/Frogmore Road/Tukara Road	23	B	132	F	>140	F	>140	F
The Northern Road/Maxwell Street/Bringelly Road	70	F	62	E	>140	F	>140	F
The Northern Road/Smith Street	28	B	25	B	>140	F	>140	F
The Northern Road/Jamison Road	35	C	25	B	>140	F	>140	F

Table 5.4 summarises the modelled peak queue lengths for the morning and evening peak at key intersections along The Northern Road without the proposal. Analysis of these modelled peak queue lengths shows that by 2031, forecast queue lengths are likely to extend beyond adjacent intersections for the M4 interchange and the intersection of The Northern Road, Bringelly Road and Maxwell Street, with queues likely to extend beyond the M4 off-ramps and onto the main line of the M4. Queues on the northern and western approaches of the intersection of The Northern Road and Glenmore Parkway are also likely by 2031. Queues on the southern approach to the intersection of The Northern Road, Frogmore Road and Tukara Road are likely due to delays for vehicles turning right from The Northern Road into Castle Road.

By 2041, queue lengths are likely to extend along the length of The Northern Road between Glenmore Parkway and Jamison Road. Modelled queues will likely block traffic flows and reduce speeds to unacceptable levels.

Table 5.4 : Intersection queue summary without the proposal

Intersection	Morning Peak queue (m)				Evening Peak queue (m)			
	North	East	South	West	North	East	South	West
2021								
The Northern Road/Glenmore Parkway/Wentworth Road	35	19	25	820*	898*	91	558	40
The Northern Road/M4 Motorway	451*	31	439	459*	451*	372*	96	457*
The Northern Road/Frogmore Road/Tukara Road	497*	251	451*†	78	796*	64	0	6
The Northern Road/Maxwell Street/Bringelly Road	103	247*	193	102*	829*	247*	367	102*
The Northern Road/Smith Street	55	12	32	61	37	18	38	138
The Northern Road/Jamison Road	28	28	60	25	55	13	54	21
2031								
The Northern Road/Glenmore Parkway/Wentworth Road	35	24	30	820*	898*	600*	43	46
The Northern Road/M4 Motorway	451*	26	77	457*	451*	372*	108	457*
The Northern Road/Frogmore Road/Tukara Road	796*	251*	0	6	796*	251*	451*†	6
The Northern Road/Maxwell Street/Bringelly Road	829*	247*	247	102*	829	247	108	102
The Northern Road/Smith Street	413*	45	95	193*	413*	180*	42	102*
The Northern Road/Jamison Road	75	30	67	85	178*	13	60	106*
2041								
The Northern Road/Glenmore Parkway/Wentworth Road	638	600	48	820*	898	600*	48	820*
The Northern Road/M4 Motorway	451*	31	96	457*	451*	372*	598	457*
The Northern Road/Frogmore Road/Tukara Road	796*	251*	451*†	6	796*	251*	451*†	24
The Northern Road/Maxwell Street/Bringelly Road	829*	247*	118	102*	829*	247*	789*	102*
The Northern Road/Smith Street	413	50	101	193	413*	180*	48	102*
The Northern Road/Jamison Road	178*	36	72	106*	178*	104*	66	106*

*Intersection queued beyond adjacent upstream intersection
†Intersection was blocked by downstream intersection

Travel times along The Northern Road between Glenmore Parkway and Jamison Road without the proposal are shown in Table 5.5. Analysis of the modelled travel times without the proposal shows that travel times for traffic travelling northbound and southbound along The Northern Road between Glenmore Parkway and Jamison Road are likely to increase substantially, particularly in the southbound direction, when delays from the M4 interchange would result in extensive queuing along The Northern Road. Under the 2031 scenario northbound travel times would peak around the 2031 forecast year. This is due to the large volumes of traffic that would be held back at key locations in the surrounding network, some of which are outside of the study area, including:

- Jamison Road and The Northern Road
- M4 Motorway Interchange
- Glenmore Parkway and The Northern Road
- Park Road and The Northern Road

Table 5.5 : Travel time summary (Glenmore Parkway to Jamison Road) without the proposal

	2015 (mm:ss)	2021 (mm:ss)	2031 (mm:ss)	2041 (mm:ss)
Morning peak				
Northbound	05:24	05:59	10:40	09:38
Southbound	05:38	11:39	26:25	34:46
Evening Peak				
Northbound	05:59	05:50	19:59	11:31
Southbound	07:41	11:55	48:10	26:41

5.5.2 With the proposal

Table 5.6 summarises intersection performance with the proposal. Analysis of the intersection performance along The Northern Road with the proposal shows that all of the intersections within the study area would operate satisfactorily in 2021, 2031 and 2041.

Table 5.6 : Intersection performance summary with the proposal

Intersection	2021		2031		2041	
	Av. Delay	LoS	Av. Delay	LoS	Av. Delay	LoS
Morning Peak						
The Northern Road/Glenmore Parkway/Wentworth Road	44	D	45	D	48	D
The Northern Road/M4 Motorway	34	C	38	C	40	C
The Northern Road/Frogmore Road/Tukara Road	18	B	19	B	21	B
The Northern Road/Maxwell Street/Bringelly Road	38	C	38	C	46	D
The Northern Road/Smith Street	26	B	26	B	29	B
The Northern Road/Jamison Road	36	C	41	C	48	D
Evening Peak						
The Northern Road/Glenmore Parkway/Wentworth Road	35	C	44	D	56	D
The Northern Road/M4 Motorway	37	C	41	C	44	D
The Northern Road/Frogmore Road/Tukara Road	15	B	18	B	24	B
The Northern Road/Maxwell Street/Bringelly Road	38	C	40	C	40	C
The Northern Road/Smith Street	26	B	27	B	22	B
The Northern Road/Jamison Road	35	C	38	C	46	D

Table 5.7 summarises the modelled peak queue lengths for the morning and evening peak at key intersections along The Northern Road with the proposal. Analysis of the modelled queue lengths with the proposal shows that for the majority of intersections along the proposal, queue lengths will be shorter than without the proposal. The main exception to this is at the intersection of The Northern Road with Frogmore Road and Tukara Road. At this intersection, northbound traffic will interrupted by the proposed pedestrian crossing over The Northern Road at this location. As this crossing does not currently exist, queue lengths for this approach are likely to increase as a result of the project. Similarly, due to the removal of the existing right turn into Castle Road from The Northern Road, this right turn would no longer be likely to cause queues that may extend past Tukara Road.

Analysis of M4 off-ramp queue lengths shows that the proposal has sufficient storage to ensure that traffic will not queue back onto the M4 during peak periods.

Table 5.7 : Intersection queue summary with the proposal

Intersection	Morning Peak queue (m)				Evening Peak queue (m)			
	North	East	South	West	North	East	South	West
2021								
The Northern Road/Glenmore Parkway/Wentworth Road	80	20	138	20	73	17	99	21
The Northern Road/M4 Motorway	60	38*	81	40*	61	76*	93	43*
The Northern Road/Frogmore Road/Tukara Road	60	5	91	13	117	18	38	11
The Northern Road/Maxwell Street/Bringelly Road	141	56	90	36	110	29	90	51
The Northern Road/Smith Street	78	30	50	50	67	38	99	60
The Northern Road/Jamison Road	32	22	82	55	47	48	103	45
2031								
The Northern Road/Glenmore Parkway/Wentworth Road	108	38	235	76	173	21	204	11
The Northern Road/M4 Motorway	105	42*	140	53*	100	77*	117	68*
The Northern Road/Frogmore Road/Tukara Road	120	30	140	5	185	17	37	50
The Northern Road/Maxwell Street/Bringelly Road	150	62	147	62	135	27	110	60
The Northern Road/Smith Street	78	39	75	53	90	39	114	62
The Northern Road/Jamison Road	36	25	117	65	78	49	112	74
2041								
The Northern Road/Glenmore Parkway/Wentworth Road	152	33	270	86	177	28	288	30
The Northern Road/M4 Motorway	118	71*	134	75*	130	88*	94	53*
The Northern Road/Frogmore Road/Tukara Road	180	55	155	10	340	25	35	55
The Northern Road/Maxwell Street/Bringelly Road	151	36	290	68	190	27	195	82
The Northern Road/Smith Street	74	25	100	108	151	41	158	62
The Northern Road/Jamison Road	79	55	165	179	80	75	125	123

*Maximum of right and left turn lanes reported as approach queue length

Travel times along The Northern Road between Glenmore Parkway and Jamison Road with the proposal are shown in Table 5.8. Analysis of the modelled travel times shows that the proposal would result in morning peak travel time that would be comparable to today and evening peak travel times that would be lower than those experienced today. The majority of the likely reductions in travel time through the corridor would be due to improved operating conditions at the M4 interchange and the intersection of The Northern Road and Glenmore Parkway.

Table 5.8 : Travel time summary (Glenmore Parkway to Jamison Road) with the proposal

	2015 (mm:ss)	2021 (mm:ss)	2031 (mm:ss)	2041 (mm:ss)
Morning peak				
Northbound	5:24	4:48	4:58	5:13
Southbound	5:38	5:17	5:18	5:35
Evening Peak				
Northbound	5:24	4:48	4:58	5:13
Southbound	5:38	5:17	5:18	5:35

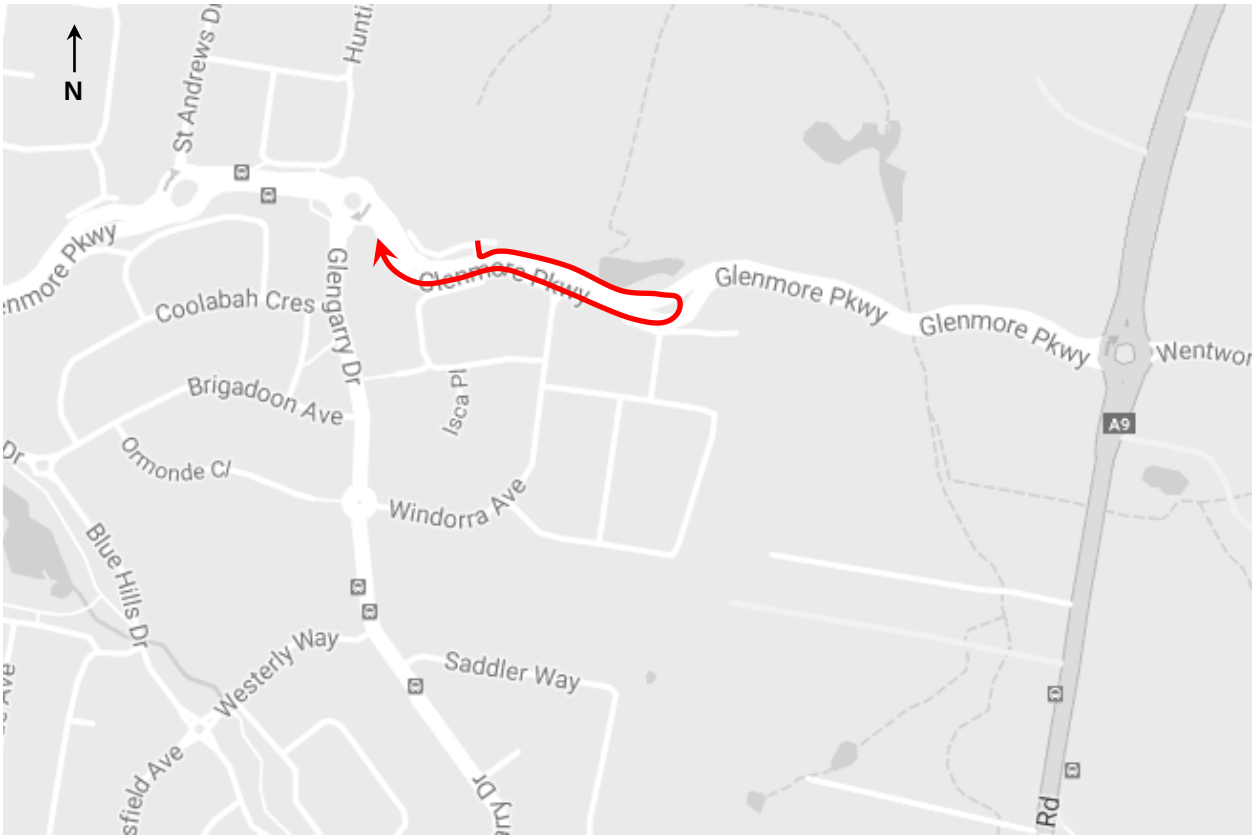
5.6 Impacts on local roads and access

The proposal would have a number of impacts on local roads and access in the study area. These impacts are summarized below.

5.6.1 Fairwater Court

Residents of Fairwater Court are not able to turn right onto Glenmore Parkway and currently use the roundabout at the intersection of The Northern Road and Glenmore Parkway to make a u-turn to travel west along Glenmore Parkway. This will no longer be possible when this intersection is upgraded to traffic signals. The proposed alternative route for this movement is shown in Figure 5.2. As the proposed U-turn facility on Glenmore Parkway is closer to Fairwater Court this would be a reduction in travel time of up to one minute.

Figure 5.2 : Proposed alternative route from Fairwater Court to Glenmore Parkway west



Source: Google Maps

5.6.2 Penrith Golf and Recreation club

The right turn out of the Penrith Golf and Recreation club is currently permitted on to The Northern Road. Under the proposal, this turn would no longer be permitted. Traffic accessing the Penrith Golf and Recreation club would do so from the proposed new service road on Glenmore Parkway as shown in Figure 5.3. The changes in travel times to and from the Penrith Gold and Recreation Club would be:

- Right turn into Penrith Golf and Recreation Club from The Northern Road: maximum detour 0.3 km (<1 minute)
- Right turn out of Penrith Golf and Recreation Club to The Northern Road: maximum detour 0.6 km (1.4 minutes).

Figure 5.3 : Proposed alternative route To Penrith Golf and Recreation Club from The Northern Road

Source: Google Maps

5.6.3 Garswood Road

Garswood Road currently allows only left turn on to and off The Northern Road. Traffic from north of Garswood Road currently continues south to Glenmore Parkway, where drivers may use the existing roundabout to make a u-turn and access Garswood Road from the south. Under the proposal, the intersection of Glenmore Parkway and the Northern Road would become signal controlled and this movement would no longer be possible. Traffic that currently perform this manoeuvre would turn right into Glenmore Parkway and use the proposed u-turn facility on Glenmore Parkway to travel north along The Northern Road, as shown in Figure 5.4. Travel via the u-turn facility on Glenmore Parkway would be a maximum detour of 0.3 km (1 minute).

Figure 5.4 : Proposed alternative route to Garswood Road from The Northern Road

Source: Google Maps

5.6.4 Homestead Road

Right turns into and out of Homestead Road are currently permitted from The Northern Road. The proposal would result in a median through this intersection that would change access to Homestead Road to left in and left out only. Traffic that currently turns right into Homestead Road from The Northern Road would be required turn right into Wentworth Road and travel north via Cross Road which would connect Wentworth Road and Homestead Road as part of the proposal. Traffic currently turning right out of Homestead Road would be required to travel south to Glenmore Parkway to use the u-turn facility to turn right or alternatively return to Wentworth Road before turning right onto The Northern Road. Both movements are shown in Figure 5.5.

The changes in travel times to and from Homestead Road would be:

- Right turn into Homestead Road from The Northern Road: maximum detour 1.1 km (two minutes)
- Right turn out of Homestead Road to The Northern Road: maximum detour 1.6 km (3.2 minutes).

Figure 5.5 : Proposed alternative route to Homestead Road from The Northern Road

Source: Google Maps

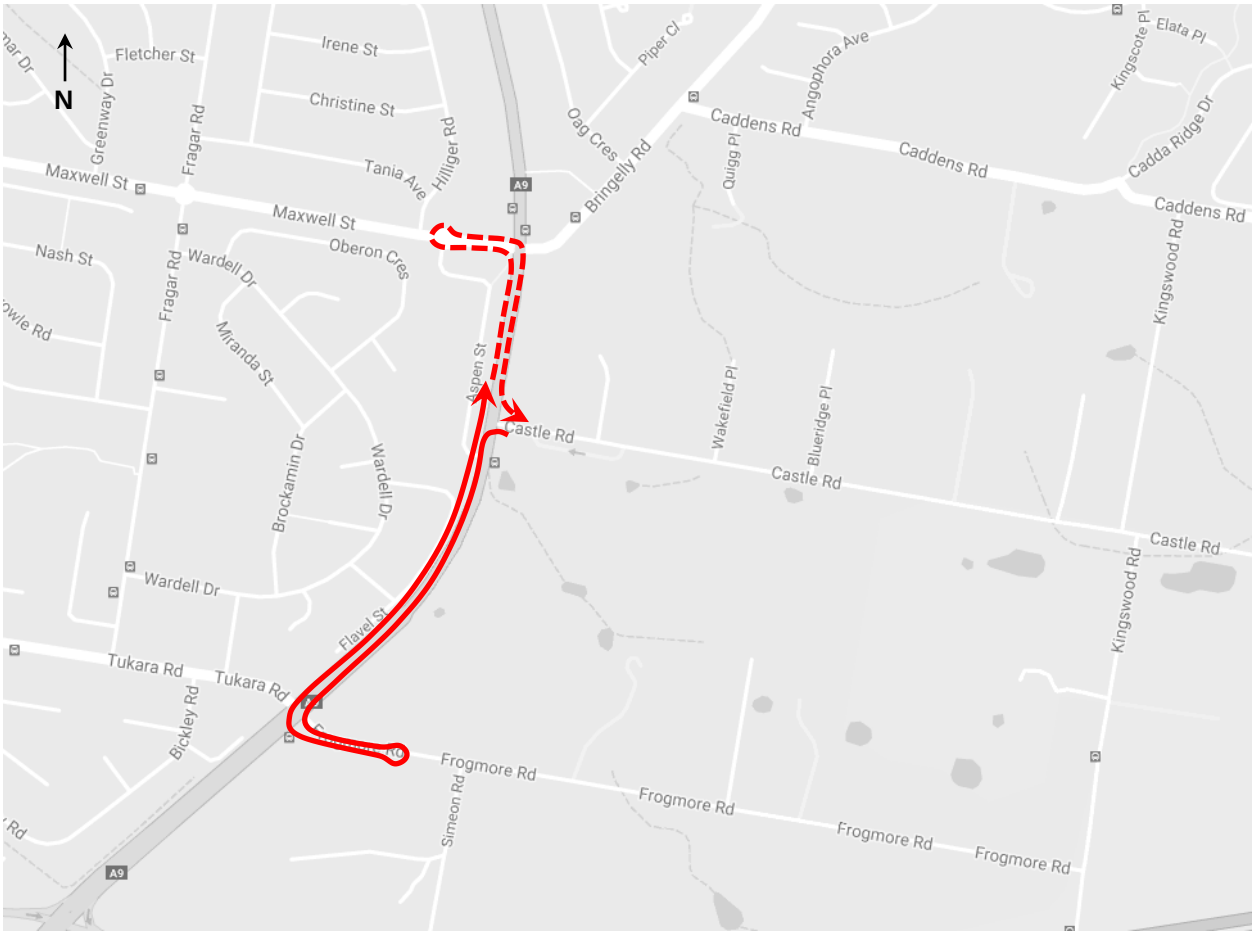
5.6.5 Castle Road to Frogmore Road

Properties on the eastern side of The Northern Road between Castle Road and Frogmore Road are currently able to turn right in and out of their properties. The proposal would result in a median through this section that would change access to these properties to left in and left out only. Traffic that currently turns right out of these properties would be required to turn left into The Northern Road, left into Frogmore Road and make a u-turn at the proposed roundabout on Frogmore Road. They would then be able to travel west along Frogmore Road and turn right into The Northern Road. Traffic that currently turns right into these properties from the south would be required to continue north to Maxwell Street and make a u-turn at the Aspen Street roundabout then turn right back on to The Northern Road. Both movements are shown in Figure 5.6.

The changes in travel times to and from these properties would be:

- Right turn into eastern properties between Castle Road and Frogmore Road: maximum detour 0.8 km (2.3 minutes)
- Right turn out of eastern properties between Castle Road and Frogmore Road: maximum detour 1.7 km (3.4 minutes).

Figure 5.6 : Proposed alternative route to eastern properties between Castle Road and Frogmore Road



Source: Google Maps

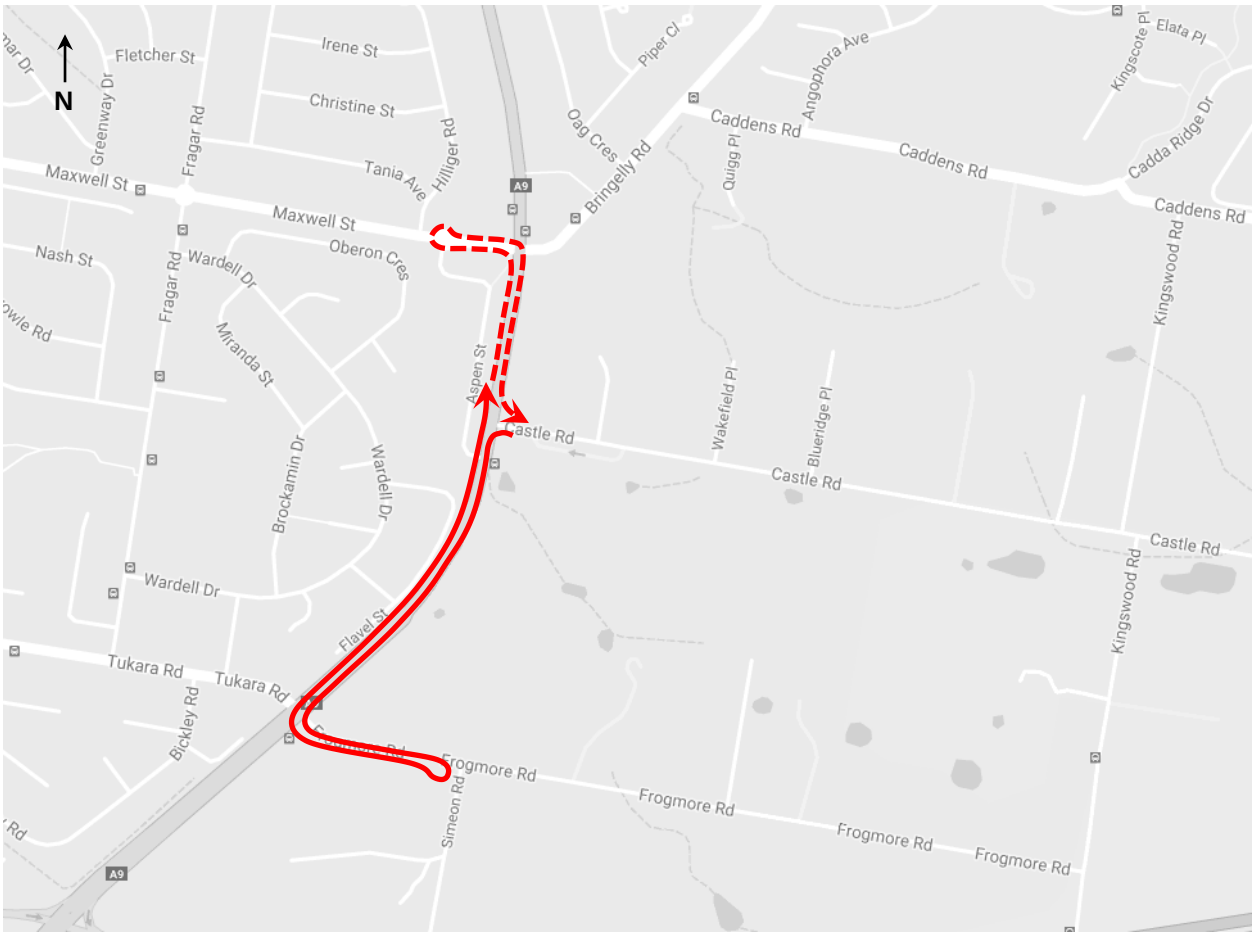
5.6.6 Castle Road

Right turns into and out of Castle Road are currently permitted from The Northern Road. The proposal would result in a median through this intersection that would change access to Castle Road to left in and left out only. Traffic that currently turns right into Castle Road from The Northern Road would be required to turn left into Maxwell Street and make a u-turn or turn right into Frogmore Road and travel north via Kingswood Road. Traffic currently turning right out of Castle Road would be required to travel to Frogmore Road and make a u-turn at the proposed roundabout on Frogmore Road. These routes are shown in Figure 5.7.

The changes in travel times to and from these properties would be:

- Right turn into Castle Road and Frogmore Road: maximum detour 0.8 km (2.3 minutes)
- Right turn out of Castle Road and Frogmore Road: maximum detour 1.7 km (3.4 minutes).

Figure 5.7 : Proposed alternative route to Castle Road



Source: Google Maps

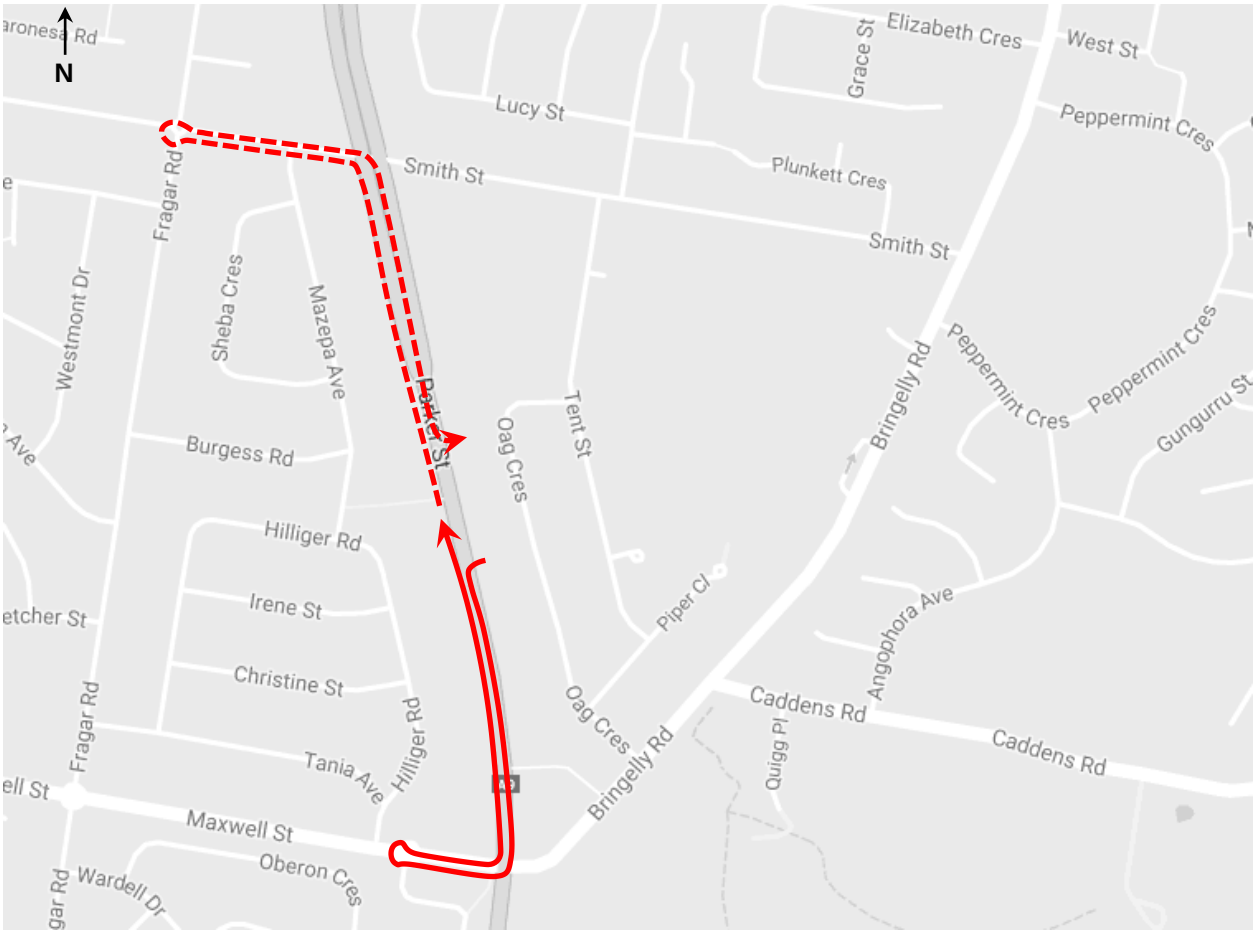
5.6.7 Smith Street to Bringelly Road

Properties on the eastern and western side of The Northern Road between Smith Street and Bringelly Road are currently able to turn right across The Northern Road to access their properties. The proposal would result in a median through this section that would change access to these properties to left in and left out only. Traffic that currently turns right into these properties would be required to travel to Smith Street to make a u-turn at Fragar Road or Maxwell Street to make a u-turn at Aspen Street. They would then return to The Northern Road and turn left into their properties. Residents would make the reverse movement to exit their properties. These alternative routes are shown in Figure 5.8 and Figure 5.9.

The changes in travel times to and from these properties would be:

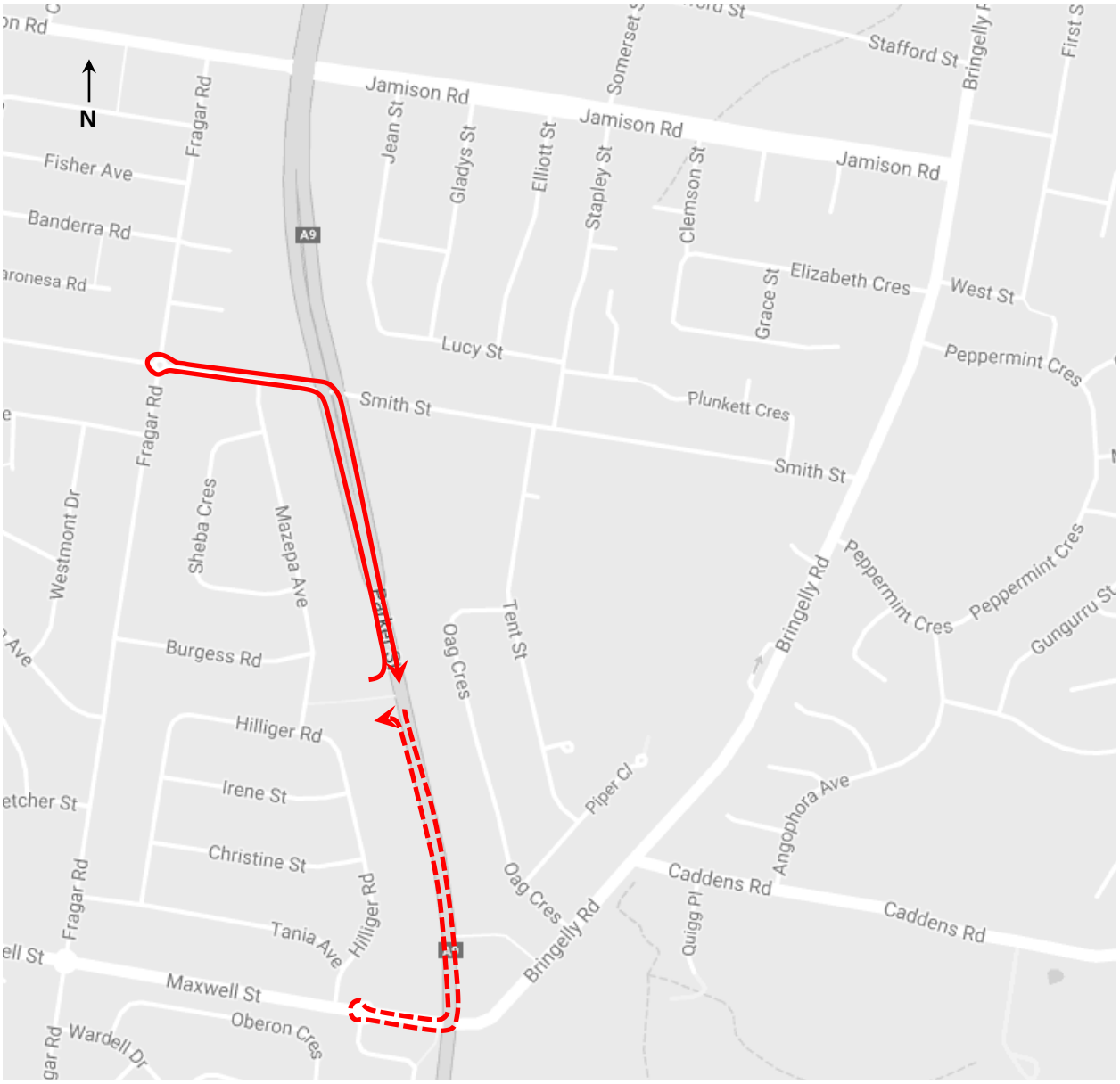
- Right turn into eastern properties between Smith Street and Bringelly Road: maximum detour 1.6k m (3.3 minutes)
- Right turn out of eastern properties between Smith Street and Bringelly Road: maximum detour 0.8 km (2.3 minutes)
- Right turn into western properties between Smith Street and Maxwell Street: maximum detour 1.3k m (2.9 minutes)
- Right turn out of western properties between Smith Street and Maxwell Street: maximum detour 1.7 km (3.4 minutes).

Figure 5.8 : Proposed alternative route to eastern properties between Smith Street and Bringelly Road



Source: Google Maps

Figure 5.9 : Proposed alternative route to western properties between Smith Street and Maxwell Street

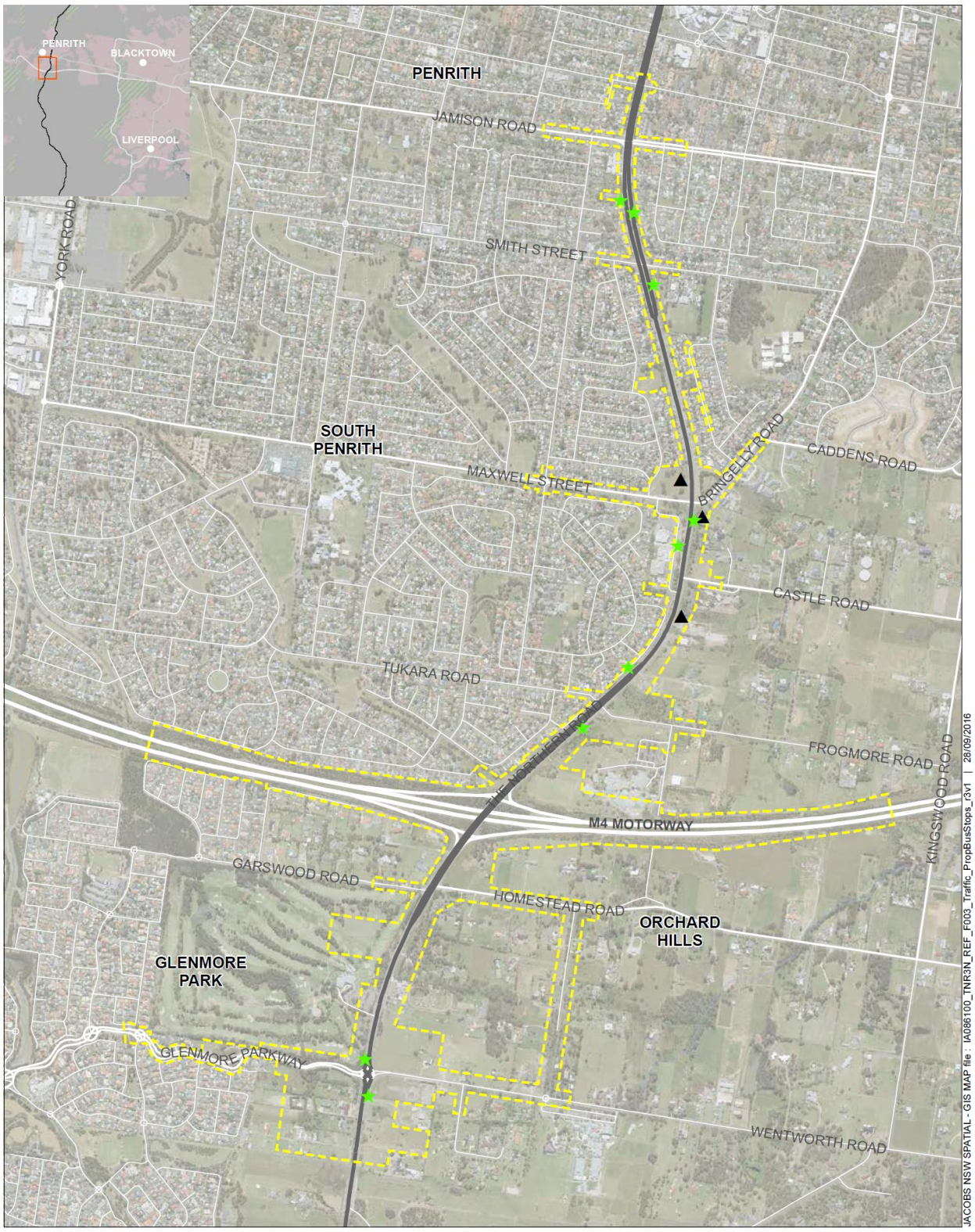


Source: Google Maps

5.7 Impacts on public transport

The proposal includes the provision of a 24 hour kerbside bus lane in each direction between Glenmore Parkway and Jamison Road. This bus lane would allow buses to travel north and south along The Northern Road without being affected by general traffic congestion and delays. These bus lanes would support the operation of a high-frequency, 'Rapid' bus service between Liverpool and Penrith via the western Sydney airport, providing operating conditions required to deliver travel speed and reliability that customers would expect from a higher-order, centre-to-centre public transport connection. In addition to the bus lanes, relocation of existing bus stops will also be undertaken. The relocation and construction of additional bus stops along The Northern Road will improve access to public transport by expanding the catchment of existing bus services and locating the stops closer to businesses and other key destinations within the study area. A plot of the proposed bus stop relocations is shown in Figure 5.10.

Figure 5.10 : Proposed relocation of bus stops



5.8 Impacts on freight transport

The proposal would improve reliability and travel times for freight on The Northern Road by providing additional traffic capacity. The proposal would also reduce travel time and improve reliability for freight travelling on the M4 Motorway by providing additional capacity at The Northern Road interchange and minimising queues on the main carriageway. Increased lane widths, reduced longitudinal grades and higher design speed along The Northern Road will improve operating conditions for freight vehicles making the road better suited to semi-trailer and B-Double vehicles. The proposal would not change any existing B-Double or high-mass vehicle routes however the enlargement of intersections along The Northern Road will improve safety and manoeuvrability for freight vehicles.

In the future, The Northern Road would become the primary route for construction traffic from the planned Western Sydney Airport and M12 Motorway and would become the primary route from these construction activities to the Sydney Motorway network. The proposal would ensure that this construction traffic would have a safe and reliable route to the M4 Motorway.

5.9 Impacts on active transport

The proposal would introduce a number of significant improvements to pedestrians and cyclists along The Northern Road. These improvements include:

- A new three metre wide shared path along the western side of The Northern Road between Glenmore Parkway and Jamison Road
- An upgraded 1.5 m wide footpath on the eastern side of The Northern Road between Bringelly Road and Jamison Road
- A new three metre wide shared path on the eastern side of the Northern Road between Bringelly Road and Wentworth Road
- New pedestrian crossings at the intersection of The Northern Road and Glenmore Parkway (currently a roundabout)
- A new signalised pedestrian crossing across The Northern Road at Frogmore Road
- A new signalised pedestrian crossing on the southern approach of the intersection of The Northern Road and Bringelly Road
- A new signalised pedestrian crossing on the southern approach of the intersection of The Northern Road and Jamison Road
- Kerbside bus lanes which allow on-road cycling and a reduction in the conflicts with the larger general traffic stream.

The proposal would improve the accessibility and safety for pedestrians and cyclists along The Northern Road.

5.10 Impacts on parking

Signposted parking is not currently permitted along the length of The Northern Road between Glenmore Parkway and Jamison Road. The proposal would have a minimal impact on parking opportunities within the proposal area. The following parking areas within the proposal area will be affected by the proposed upgrade:

- Construction of an additional eastbound lane on Jamison Road west on approach to The Northern Road would require removal of parking on both sides of Jamison Road for about 200 m west of The Northern Road. This results in the loss of up to 15 existing parking spaces. This parking is currently underutilised and is not linked to commercial land use. Additional parking is currently available in the surrounding local streets within 200 m as shown in Figure 5.11.
- Widening of Jamison Road east on approach to The Northern Road would result in the removal of parking on either side of Jamison Road up to Jean Street. This would result in a loss of up to 15 existing parking spaces. This parking is currently underutilised and is not associated with nearby commercial land use. Additional parking is currently available on existing local streets within 200 m as shown in Figure 5.11.
- Construction of an additional eastbound lane on Maxwell Street on approach to The Northern Road would require removal of parking on the northern side of Maxwell Street for about 170 m west of Hilliger Road. This would result in the loss of up to 17 existing parking spaces. This parking is currently underutilised and is not linked to commercial land use. Additional parking is currently available in the surrounding local streets and on the westbound side of Maxwell Street within 200 m as shown in Figure 5.12.
- The realignment of Aspen Street and the introduction of a traffic signal on approach to Maxwell Street would require the removal of parking for up to 160 m south of Maxwell Street on either side of Aspen Street. This would result in the loss of up to 32 parking spaces. This parking is generally used for overnight parking and not by patrons of businesses along Aspen Street. Businesses on Aspen Street currently provide sufficient parking space in accordance with Penrith Council Development Control Plans.
- Widening of The Northern Road between Smith Street and Bringelly Road will also result in the narrowing of the existing verge in this section, which is currently used by property owners as informal parking space. Informal parking in the verge through this section of The Northern Road will no longer be possible and works within these properties will be considered through the detailed design process to identify any opportunities to provide augmented vehicle storage space where reasonable and feasible.

Figure 5.11 : Proposed removal of parking on Jamison Road

Source: Google Maps

Figure 5.12 : Proposed removal of parking on Maxwell Street

Source: Google Maps

5.11 Impacts on Nepean Hospital Access

Nepean Hospital is located on The Northern Road with direct access to The Northern Road about 600 m north of the proposal and access from side roads to the east of The Northern Road. Although it is situated outside of the study area, the proposal would improve emergency vehicle access to the Hospital. Analysis of travel speeds and intersection performance on The Northern Road without the proposal shows that during peak periods emergency vehicles would be required to travel through very congested intersections and would experience substantial delays along The Northern Road when approaching Nepean Hospital from the south.

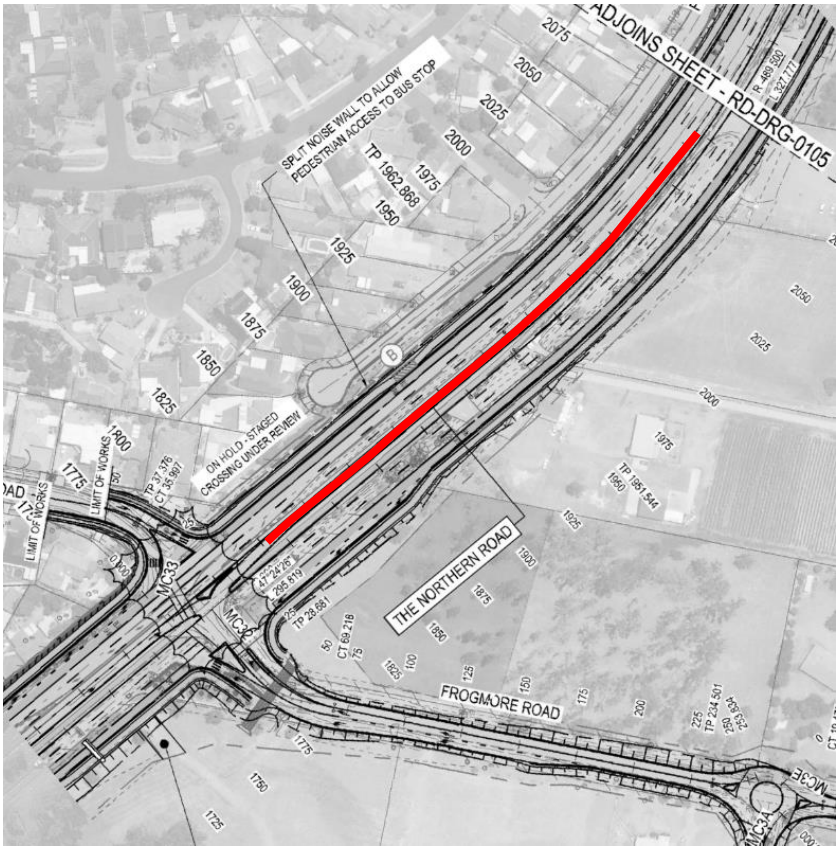
The proposal would substantially reduce these delays and improve access to Nepean Hospital from the south. During peak periods the proposed bus lane would likely be clear for emergency vehicles to travel uninterrupted along The Northern Road between Glenmore Parkway and Jamison Road.

5.12 Impacts on road safety

The proposal would result in the following improvements to road safety:

- Improved design standard of the proposed road to improve the safety impacts of grades, lane widths and design speeds.
- Extension of the existing central median to provide carriageway separation along the full length of The Northern Road between Glenmore Parkway and Jamison Road.
- Improved safety for vehicles travelling along the M4 due to increased capacity for off-ramps and reduced likelihood for off-ramp queues to extend to the main carriageway of the M4.
- Inclusion of dedicated bus lanes to reduce conflicts between stopped buses and cars travelling along The Northern Road in the kerbside lane. This would also decrease conflicts for traffic entering and exiting properties along The Northern Road.
- A number of existing uncontrolled right turn movements would either be removed or would become signal controlled. This would reduce the incidence of right turn vehicles conflicting with through traffic and increase the safety of these movements. Improvements in the existing crash rate is expected at the following locations:
    - Castle Road
    - Frogmore Road/Tukara Road
    - Homestead Road
    - Undivided sections of the corridor where properties are accessed via informal right turns across The Northern Road
- The existing roundabout at the intersection of The Northern Road and Glenmore Parkway would be upgraded to a set of traffic signals. This would reduce delays for traffic during peak periods and decrease the likelihood of vehicles accepting smaller unsafe gaps in traffic on the circulating carriageway of the roundabout.
- The existing seagull intersection at The Northern Road/Frogmore Road/Tukara Road would be upgraded and signalised. Road safety benefits associated with this upgrade would include:
    - The upgrade would control all movements at the intersection and reduce the likelihood of unsafe gap acceptance and merge selection
    - Improved delineation and islands to prevent vehicles making illegal movements through the intersection
    - Longer merge length for vehicles turning right from Frogmore Road heading northbound on The Northern Road to provide vehicles with more time to merge with northbound traffic, as shown in Figure 5.13. This merge length would increase from 25 m to 280 m.
- Formal pedestrian crossings would be provided where they currently do not exist at Glenmore Parkway, Tukara Road, Maxwell Street and Jamison Road. This would improve pedestrian and cyclist safety by providing more formal crossing opportunities and decreasing the likelihood of pedestrian and cyclists crossing elsewhere along The Northern Road.
- A shared pedestrian and cycle path would be provided along the length of the proposal, decreasing the likelihood of cycles travelling in general traffic lanes.
- New crash barriers would be provided along sections of the proposed upgrade, particularly in sections of narrowed median and the new M4 Interchange bridge.

Figure 5.13 : Proposed extension of Frogmore Road seagull merge length



5.13 Cumulative impacts

In assessing the effects of the proposal the traffic modelling has taken into account the likely cumulative effects of the proposal with other planned road upgrade projects in place, namely:

- M4 Smart Motorway
- Werrington Arterial Road upgrade
- M12 Motorway
- Planned Western Sydney Airport and associated accesses.

The assessment has also taken into account the traffic generation from the planned land developments in the area through the use of future traffic demand forecasts from Roads and Maritime's Strategic Traffic Assignment Model (STAM). It is assumed that the broader traffic implications of other employment lands in the broader Western Sydney Employment Area, as well as the Werrington Arterial Road, its associated interchange with the M4 Motorway and the planned Western Sydney Airport at Badgerys Creek, have all been accounted for in future travel demand provided by Roads and Maritime for this proposal. STAM also accounts for the redistribution of traffic around changes to road network capacity including the proposal or other road upgrade projects occurring within the same time period.

A summary of the network-wide statistics from the AIMSUN traffic model, showing total vehicle kilometres of travel (VKT), total hours of travel (VHT) and average network speed with and without the proposal is shown in Table 5.9. Analysis of these network statistics shows that average network speeds are consistently higher for all scenarios with the proposal.

Table 5.9 : Summary of network statistics

Scenario	VHT[1]	VKT[2]	Average Speed (km/h)[3]
Without the proposal			
2021 AM	5,591	192,709	34.5
2021 PM	8,583	228,984	26.7
2031 AM	8,949	166,664	18.6
2031 PM	16,141	190,316	11.8
2041 AM	10,804	177,667	16.4
2041 PM	19,975	182,261	9.1
With the proposal			
2021 AM	3,766	216,598	57.5
2021 PM	4,502	243,778	54.1
2031 AM	4,178	234,663	56.2
2031 AM	5,180	270,726	52.3
2031 AM	4,687	256,019	54.6
2031 PM	5,786	293,250	50.7

1 Vehicle hours of Travel, the total travel time incurred by all vehicles in the network

2 Vehicle Kilometres of Travel, the total travel distance incurred by all vehicles in the network

3 Average network speed is calculated as VHT/VKT

As a result of all these cumulative impacts, the proposal and associated interchange with the M4 Motorway would improve the overall road network performance in the study area, reducing overall delays and travel distances and increasing the average network speeds.

6. Environmental management measures

The majority of long-term impacts of the proposal have been addressed through the concept design and include the following:

- Maintenance of access to existing streets and properties, addressed through the access strategy
- Management of traffic capacity constraints, addressed through the design and operation of traffic signals and other intersection treatments
- Provision of public transport capacity and priority, addressed through the design by provision of bus lanes in both directions along the length of The Northern Road between Glenmore Parkway and Smith Street
- Provision of active transport facilities, addressed through the design by provision of a shared path along the length of The Northern Road.

There would be impacts of the proposal that cannot be removed through the concept design and are primarily impacts of construction. Environmental management measures would be required to minimise the impacts of construction of the proposal on traffic and transport.

The key environmental management measure required to address the impacts of construction on traffic and transport would be Traffic Management Plans (TMPs) prepared as part of the Construction Environmental Management Plan (CEMP). These plans would be prepared by the construction contractor and would be required to outline the guidelines, general requirements and specific procedures to be used for any works that may have an impact on traffic operation. The TMP would be required to:

- Identify individual traffic management requirements at each phase of construction
- Outline the general principles and procedures for the development of specific construction Traffic Management Plans (CTMPs)
- Ensure safe and continuous traffic movement for construction workers and the general public
- Maintain the capacity of existing roads where possible
- Identify the requirements for temporary speed restrictions where traffic may pose a safety risk to workers
- Maintain continuity of access to local roads and properties, particularly along The Northern Road (may require temporary u-turn facilities)
- Provide temporary traffic control where necessary
- Identify requirements and placement of traffic barriers
- Provide appropriate warning and signage for traffic in the vicinity of work areas
- Include methods to minimise road user delays such as undertaking works around live traffic including tie-in and bridge work outside of peak periods
- Undertake construction activities off-line where possible to minimise the requirement to operate temporary traffic control and reduced speed zones
- Develop a communication plan to advise local residents and businesses of any changes to traffic conditions during construction.

Other environmental management measures that would be undertaken include:

- Consultation will be undertaken with property owners between Maxwell Street / Bringelly Road and Smith Street to review front yard storage and vehicle manoeuvrability.
- Requirements for any changes to local traffic and access arrangements will be confirmed during detailed design in consultation with the local road authority and any affected landowners, including any temporary alternative access arrangements as required.
- Consultation will be undertaken with potentially affected residences prior to the commencement of and during work in accordance with Roads and Maritime's Community Involvement and Communications Resource

Manual. Consultation will include but not limited to door knocks, newsletters or letterbox drops providing information on the proposed work, working hours and a contact name and number for more information or to register complaints.

- Consultation will be carried out with emergency services to ensure adequate emergency vehicle access is provided and maintained at all times for the duration of construction.
- Pedestrian and cyclist access will be maintained throughout construction. Where that is not feasible or necessary, temporary alternative access arrangements will be provided following consultation with affected landowners and the local road authority.
- Access for public transport services, including school bus services, will be maintained. The requirements for any temporary changes will be confirmed following consultation with local bus operators and the community.

7. Summary and conclusions

Roads and Maritime is proposing to upgrade The Northern Road between Glenmore Parkway, Glenmore Park and Jamison Road, Penrith (referred to as 'the proposal' for the purposes of this report). The corridor is located about 47 km west of the Sydney Central Business District (CBD). The proposal would upgrade The Northern Road to an eight-lane divided road, with three general traffic lanes and a kerbside bus lane in each direction, separated by a median.

7.1 Overview

Traffic modelling of the proposal has been undertaken using the AIMSUN micro simulation modelling platform. The micro simulation model allows for detailed interactions between vehicles and is part of a wider model of The Northern Road corridor that is being used for assessing the functional performance of The Northern Road Upgrade between Mersey Road and Jamison Road.

7.2 Key findings

Overall, analysis of the road network performance under the 2021, 2031 and 2041 future horizon years shows that the proposal is required to ensure that The Northern Road continues to operate at an acceptable level of service into the future. Upgrading The Northern Road between Glenmore Parkway and Mersey Road would improve access and travel times through the corridor ensure the interchange with the M4 Western Motorway would operate within a reasonable level of service.

The potential impacts to traffic and transport from the proposal would include the following:

Positive Impacts

- Reduced delays and higher travel speeds for vehicles travelling along The Northern Road as well as improved safety for vehicles using current priority-controlled intersections
- Reduced road crashes along the corridor
- Improved pedestrian / cyclist safety due to the provision of formal crossings and shared paths
- Reduced impacts to the operation of the M4 Motorway from vehicles queued from The Northern Road onto the M4.

Potential negative Impacts

- Changes to access arrangements for properties that currently rely on right turns into and out of Castle Road, Garswood Road and Homestead Road
- Reduced speeds and increased delays for vehicles travelling along The Northern Road during construction
- Interruptions to bus operations during construction including temporary relocation of bus stops
- Restrictions on access to properties along The Northern Road for pedestrian and cyclists during construction.

7.3 Recommendations

Traffic and transport impacts associated with construction of the proposal would need to be mitigated through environmental management measures. These measures would include the development and implementation of be Traffic Management Plans (TMPs) prepared as part of the Construction Environmental Management Plan (CEMP). These plans would be prepared by the construction contractor and would be required to outline the guidelines, general requirements and specific procedures to be used for any works that may have an impact on traffic operation.

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Appendix A. AIMSUN traffic model development

Modelling overview

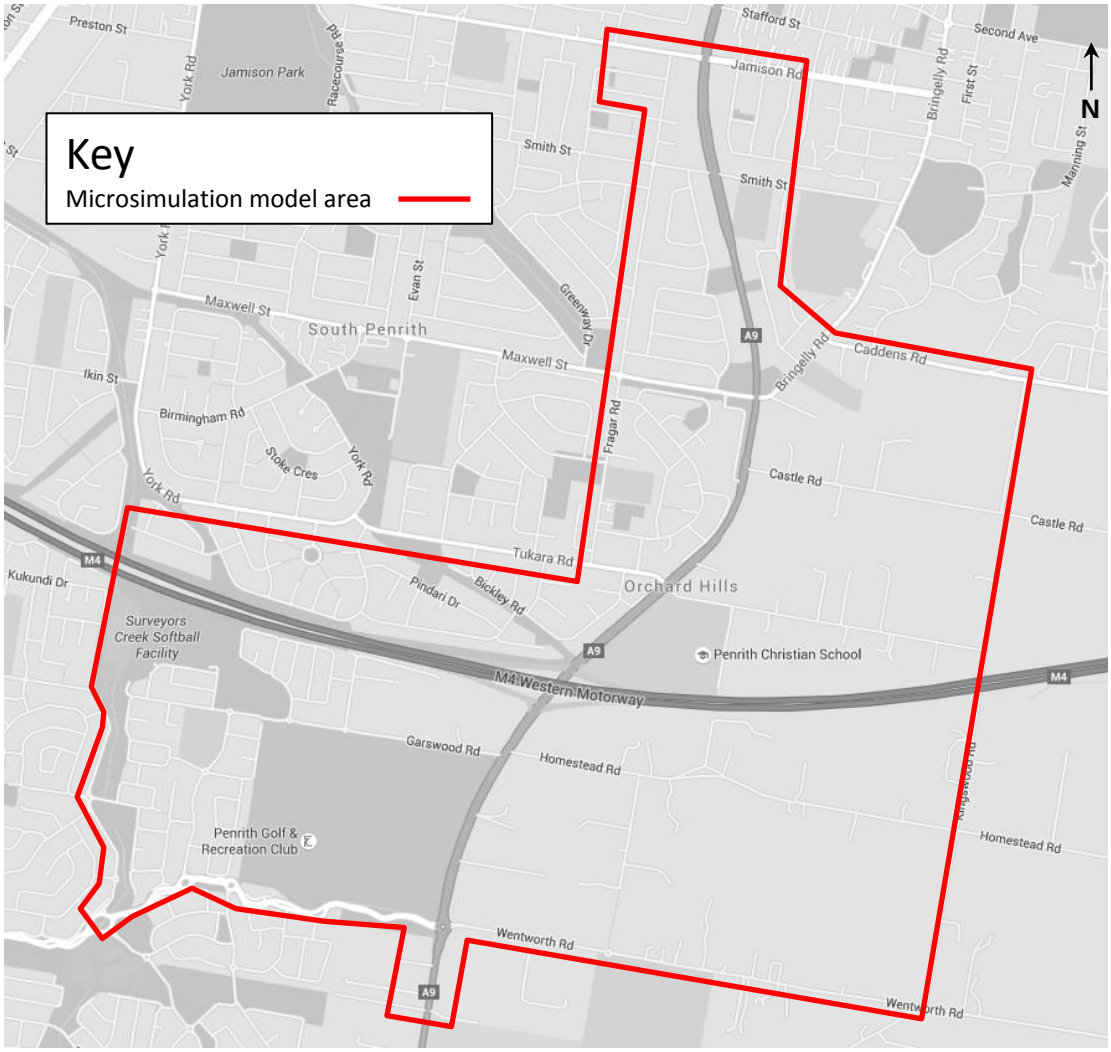
To inform the impact assessment of the proposed upgrade of The Northern Road from Glenmore Parkway, Glenmore Park to Jamison Road, Penrith (the proposal) an AIMSUN microsimulation traffic model was developed. The micro simulation model allows the simulation detailed interactions between vehicles and is described briefly below. The model is part of a wider model of The Northern Road corridor that is being used for assessing the functional performance of the proposal.

This section summarises the calibration and validation of The Northern Road micro simulation model. Further detail regarding the development, calibration and validation of this model is detailed in *The Northern Road Upgrade Jamison Road, Penrith to Mersey Road, Bringelly (Stage 3 and 4) Traffic Model Calibration and Validation Report (Jacobs, 2015),* provided in Appendix A.

Geographic model extents

The micro simulation traffic model used for the proposal extends along The Northern Road between Glenmore Parkway and Jamison Road. A plot of the model extents is provided in Figure 8.1.

Figure 8.1 : Micro simulation model extents



Source: Google Maps

Data sources

Data sources used to calibrate the model consisted of the following:

- Intersection turning movement surveys collected in November 2014 and July 2015
- Automatic traffic counts (ATC) collected in July 2015
- SCATS detector counts collected in July 2015
- Floating-car travel time surveys undertaken in October 2015

These data sources were reviewed and validated to determine the consistency of the data between intersections and between different survey days. The analysis indicated that there was some variability in the observed traffic flows, particularly in the morning peak period where traffic flows varied by more than 10 per cent between survey days. However, this is typical for turning movements with low flows.

Model development

Development of the base micro simulation traffic model involved the following steps:

- Create a corridor model based on a sub-area traversal from the Transport for NSW Sydney Area Foundation Model (SAFN)
- Disaggregate the travel zone system from the STM TZ06 system to include greater detail around The Northern Road
- Undertake a departure adjustment process to refine the 4 hour matrices to 15 minute time slices
- Calibrate the mesoscopic assignment to a suitable level and in accordance with *Traffic Modelling Guidelines* (Roads and Maritime, 2013)
- Calibrate the hybrid assignment to the final calibration standards
- Generate future year demand matrices for 2021, 2031 and 2041 based on forecast traffic volumes from Roads and Maritime Sydney Traffic Assignment Model (STAM)
- Develop Do Minimum scenario models based on approved projects only
- Develop The Northern Road Upgrade scenario models based on the proposed concept design
- Run and optimise The Northern Road Upgrade scenario under micro simulation

Traffic assignment was based on micro simulation of static model paths. This is consistent with the current pattern of traffic demand and reflects the routes that drivers currently take through the corridor.

Calibration and validation

Model calibration

Calibration is the process of adjusting the model to meet observed traffic data. This model has been calibrated to turning movement counts based on the criteria set out by Roads and Maritime for microsimulation models and adapted for mesoscopic models.

The GEH statistic is a standard statistical measure used in the calibration of traffic models to compare the differences between modelled and observed traffic flows. The GEH statistic is defined as follows:

$$GEH = \sqrt{\frac{(V_{observed} - V_{modelled})^2}{(0.5 \times (V_{observed} + V_{modelled}))}}$$

Where *v* represents the traffic flow (modelled or observed) in vehicles per hour.

- In accordance with the calibration requirements provided in the *Traffic Modelling Guidelines (*Roads and Maritime, 2013). The target requirements that were adopted for the calibration of the model were:
- No flow comparisons with GEH values greater than 10.
- At least 85 per cent of flow comparisons with GEH less than 5.

In addition to GEH comparisons, regression analysis of observed versus modelled flows was also undertaken. The following criteria for regression analysis were adopted:

- R^2 greater than 0.95
- Slope between 1.05 and 0.95

The R^2 generally represents the closeness of fit of the observed data points to modelled data points and the slope of the trend line gives an indication of whether the model is general over-assigning (greater than 1) or under-assigning (less than 1) traffic across the network.

For The Northern Road between Glenmore Parkway and Jamison Road model, the core area is assumed to be the whole model extents.

A summary of intersection turning movement comparisons by GEH and R^2 is provided in Table 8.1. The same comparisons are shown by vehicle type in Table 8.2.

Table 8.1 : Summary of microsimulation turning movement comparisons – Total vehicles

Period	GEH less than 5	GEH greater than 5	R^2	Slope
6am to 7am	181 (98%)	3 (2%)	0.998	0.977
7am to 8am	183 (99%)	1 (1%)	0.998	0.983
8am to 9am	181 (98%)	3 (2%)	0.999	1.005
9am to 10am	149 (99%)	1 (1%)	0.997	0.982
6am to 10am (Aggregate)	*694 (99%)*	*8 (1%)*	*0.998*	*0.989*
3pm to 4pm	181 (98%)	3 (2%)	0.997	0.983
4pm to 5pm	180 (98%)	4 (2%)	0.998	1.010
5pm to 6pm	181 (98%)	3 (2%)	0.998	0.995
6pm to 7pm	148 (99%)	2 (2%)	0.998	0.992
3pm to 7pm (Aggregate)	*690 (98%)*	*12 (2%)*	*0.998*	*0.992*

Table 8.2 : Summary of microsimulation turning movement comparisons – Classified vehicles, 'network-wide' criteria

Period	Light vehicles (cars)		Heavy vehicles (trucks + heavy trucks)	
	R^2	Slope	R^2	Slope
6am to 7am	0.998	0.982	0.959	0.906
7am to 8am	0.998	0.985	0.942	0.938
8am to 9am	0.999	1.007	0.953	0.990
9am to 10am	0.997	0.994	0.977	0.878
6am to 10am (Aggregate)	*0.998*	*0.993*	*0.956*	*0.925*
3pm to 4pm	0.997	0.993	0.968	0.838
4pm to 5pm	0.998	1.016	0.971	0.885
5pm to 6pm	0.998	0.992	0.955	1.061
6pm to 7pm	0.998	0.990	0.930	1.008
3pm to 7pm (Aggregate)	*0.997*	*1.000*	*0.954*	*0.896*

Analysis of the GEH and regression statistics show that the model conforms to the Roads and Maritime standards for microsimulation models for both total and light vehicle traffic, with:

- At least 98 per cent of total vehicle turning movement volumes showing GEH of 5 or less in each hour, exceeding the target of 85 per cent
- R^2 greater than 0.99 in each hour, exceeding the target of 0.95
- Slope between 0.975 and 1.02 in each hour, exceeding the target of 0.95 to 1.05

Regression statistics for the much lower heavy vehicle volumes are not as accurate, with slight overall underestimation of approximately 5 per cent compared to the (conservatively high) targets, but do indicate a reasonable degree of calibration for the intended use. Given the forecast growth in traffic through the study area in future years, this underestimation of base year heavy vehicle flows does not substantially impact the operational assessment of the proposal.

Based on these comparison statistics, the model meets the requirements of the *Traffic Modelling Guidelines* (Roads and Maritime, 2013) and can be considered adequately calibrated.

Model validation

Model validation is the process of comparing a model data set to a data set independent to that used in the calibration and assessing whether the model is correctly replicating the observed volume-delay behaviour. The base models for The Northern Road between Glenmore Parkway and Jamison Road have been validated against travel times recorded during the same period as the turning movement surveys. Detailed comparisons of modelled travel times and observed travel times are presented in Appendix A of this report.

As recommended by the Roads and Maritime *Traffic Modelling Guidelines*, the target for validation of each route in each hour is for the modelled average travel time for each route to be within 1 minute, or 15 % (whichever is higher) of observed.

The performance of the model against these targets is summarised in Table 8.3.

Table 8.3 : Summary of travel time validation results

Direction of travel	Time (hour starting)							
	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00
Northbound								
Observed Ave	18:33	18:01	22:43	19:09	19:30	21:53	20:34	19:07
Target Min	15:46	15:19	19:19	16:17	16:35	18:36	17:29	16:15
Target Max	21:10	20:41	25:39	21:48	22:26	25:06	23:21	21:50
Modelled Ave	19:27	21:13	22:08	20:33	21:38	22:09	22:58	20:58
Difference	5%	18%	-3%	7%	11%	1%	12%	10%
Southbound								
Observed Ave	20:06	20:35	20:35	19:10	23:05	20:19	24:11	23:12
Target Min	17:05	17:30	17:30	16:18	19:37	17:16	20:33	19:43
Target Max	23:06	23:37	23:36	21:56	26:17	23:19	27:29	26:02
Modelled Ave	20:27	21:29	23:24	20:41	22:49	23:00	23:01	20:57
Difference	2%	4%	14%	8%	-1%	13%	-5%	-10%

Analysis of travel time and modelled congestion along the Northern Road indicates that the model generally meets the requirements for travel time comparisons, with modelled peak direction travel times being within the required 15 per cent of observed in all cases except one. This result is close to the target and is not considered a substantial difference from the observed travel time that would affect the model's suitability for this study.

Based on these calibration and validation results, the models are considered adequately validated for the purposes of assessing the proposal.

Future demand development

Future traffic demand used as a part of the assessment has been developed based on data provided by Roads and Maritime from the Sydney Traffic Assignment Model (STAM) for the whole of The Northern Road Upgrade (between Mersey Road and Glenmore Parkway). Link flows from STAM were provided for base and future horizon years and used to develop the following future horizon year models:

- Year of opening: 2021
- Year of opening plus 10 years: 2031
- Year of opening plus 20 years: 2041.

Although the 2021 has been adopted as the year of opening, the actual year of opening is more likely to be 2019. It is noted that Roads and Maritime forecasts are only produced in 5 year increments from the 2011 census; adopting the 2021 forecast year as the year of opening is a conservative assumption and acceptable for the purposes of modelling the proposal.

A summary of the total traffic demand at each of the horizon years is provided in Table 8.4. The reduction in traffic growth under the 2021 horizon year is a result of the opening the Werrington Arterial Road which would allow westbound M4 Motorway traffic to exit prior to The Northern Road to access the Caddens and Orchard Hills areas.

Table 8.4 : Traffic demand summary (5 hour peak period)

Peak Period	2015 trips	2021 trips	2031 trips	2041 trips
Morning	52,030	51,812 (-0.4%)	64,701 (24.4%)	81,467 (56.6%)
Evening	62,070	62,404 (0.5%)	76,986 (24.0%)	95,981 (54.6%)

A summary of modelled traffic volumes in the morning and evening peak hour on The Northern Road for the 2015, 2021, 2031 and 2041 forecast years is provided in Table 8.5.

Table 8.5 : Modelled traffic flows on The Northern Road (morning and evening peak hour) with the proposal

Section	Direction	2015 (veh/hr)		2021 (veh/hr)		2031 (veh/hr)		2041 (veh/hr)	
		AM	PM	AM	PM	AM	PM	AM	PM
South of Glenmore Parkway	NB	1,507	1,108	1,991	1,844	2,474	2,372	2,822	2,815
	SB	909	1,159	1,387	1,799	2,077	2,643	2,416	2,859
North of Glenmore Parkway	NB	2,143	1,434	2,456	2,042	2,786	2,536	2,965	2,820
	SB	1,241	1,952	1,376	2,485	1,932	3,288	2,115	3,456
North of M4	NB	2,767	2,180	3,028	2,593	3,360	2,950	3,626	3,084
	SB	1,656	2,370	2,031	2,826	2,423	3,315	2,662	3,640
South of Maxwell Street	NB	2,171	1,606	2,510	2,107	2,754	2,470	3,033	2,805
	SB	1,524	2,357	1,813	2,557	2,162	3,051	2,415	3,300
North of Maxwell Street	NB	1,681	1,263	1,733	1,588	2,035	1,868	2,157	2,087
	SB	1,097	1,704	1,395	1,913	1,656	2,255	1,889	2,346
North of Smith Street	NB	1,652	1,238	1,690	1,537	2,004	1,805	2,102	2,054
	SB	1132	1845	1,362	1,823	1,675	2,251	1,904	2,226
North of Jamison Road	NB	1,659	1,332	1,652	1,513	1,901	1,750	2,029	1,937
	SB	1,138	1,789	1,303	1,764	1,599	2,086	1,826	2,089

Planned future network improvements

A number of road network upgrades are planned or under construction near the proposal. These include:

- M4 Smart Motorway project
- Werrington Arterial Road upgrade
- M12 Motorway
- Western Sydney airport and associated accesses

These upgrades have been included as part of the analysis of the future road network operation and are described in further detail below.

M4 Smart Motorway

The Smart Motorways project or 'Managed Motorways' will introduce ramp metering and other intelligent transport systems to improve the improve flow of traffic on the M4 Motorway and is expected to be complete by 2021. Two key elements of that project that affect the assessment of the proposal are:

- Widening of The Northern Road/M4 Motorway entry ramps
- Widening of The Northern Road/M4 Motorway exit ramps

The M4 Smart Motorways project did not include any additional capacity along The Northern Road at the M4 Motorway. Assessment of the proposal has assumed that any upgrade of this intersection would provide entry ramp storage and ramp length at least equivalent to that provided in the M4 Smart Motorway project.

Werrington Arterial Road upgrade

The Kent Road/Gipps Street corridor in Claremont Meadows is being upgraded to form the Werrington Arterial Road. The Werrington Arterial Road will be open to traffic by late 2016. It will include two new east facing ramps at a new interchange with the M4 Motorway.

M12 Motorway

The planned M12 Motorway would provide direct access to the planned western Sydney airport at Badgerys Creek and connect to Sydney's motorway network. The plan is for an east-west motorway of about 15 - 17km between the M7 Motorway and The Northern Road which would provide increased road capacity and reduce congestion and travel times in the future. It would also improve the movement of freight in and through western Sydney and is expected to serve the Western Sydney Priority Land Release Area and the Western Sydney Employment Area. For the purposes of this assessment, the M12 is assumed to be open within 10 years of opening the proposal to traffic and would connect with The Northern Road at a grade-separated interchange.

Western Sydney airport

The planned Western Sydney Airport (WSA) is proposed at Badgerys Creek on the existing Commonwealth land between Elizabeth Drive and The Northern Road. On opening in the mid-2020s, the airport would operate from one runway with approximately 5 million passengers per annum. As passenger numbers increase over time, so too would job opportunities both at the airport and in surrounding business districts. A second parallel runway would be required in around 2050. The second runway would provide the capacity to meet growth in demand for air travel. The proposed airport is still in the concept planning stage. However, current plans propose two accesses to the proposed airport site. A main passenger access would connect directly to the (planned) M12 Motorway on the northern border of the site, while a service access would connect to The Northern Road on the south-western boundary of the site. A rail corridor and station are also being planned, with a passenger rail corridor currently under investigation by Transport for NSW.

Appendix B. Model calibration and validation report

The Northern Road Upgrade Jamison Road between Mersey Road, Bringelly and Jamison Road, Penrith

Roads and Maritime Services

Traffic Model Calibration and Validation Report

IA086100-RP-TM-0055 | 00 (WIP)

November 2015

Contract No: 14.2166.0494-0007

The Northern Road Upgrade between Mersey Road, Bringelly and Jamison Road Penrith

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Project manager:	E. D'Angola
Author:	J. Patterson
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1	23/11/2015	Draft for submission	JP	IS	IS

Contents

1. Introduction

1.1 The project

Jacobs have been commissioned by the Transport for NSW to develop a microsimulation traffic model of The Northern Road between Mersey Road, Bringelly and Jamison Road, Penrith. The Northern Road microsimulation traffic model will provide a tool for the assessment the impacts of the proposed The Northern Road Upgrade between Mersey road and Jamison road (Hereafter referred to as The Northern Road Upgrade).

Microsimulation modelling provides a framework to undertake detailed assessment of the proposed route and any intersections along it, allowing for the assessment and visualisation of the corridor as a whole. The microsimulation traffic modelling work will also assist in the assessment and scoping of proposed intersections along the corridor as well as provide a tool to assist in the development of construction staging and traffic management

1.2 Modelling process

The microsimulation traffic model developed by Jacobs forms the last two steps in a three-tiered modelling approach. High-level land use forecasting and mode split has been undertaken using the Transport for NSW Sydney Strategic Transport Model (STM) which has been used to provide initial network structure and to generate future growth scenarios.

The Northern Road Upgrade model has been developed using the Aimsun modelling platform (version 8.1.0) and has been calibrated and validated according to the principles outlined in the Roads and Maritime Services *Traffic Modelling Guidelines, 2013*.

Following development of the microsimulation model, further assessment of intersection treatments will be undertaken using SIDRA intersection modelling, which will assist in developing optimised layouts and signal phasing for intersections along the corridor.

1.3 Purpose of this report

This report is intended to document the development, calibration and validation of the Northern Road Upgrade. It details the process undertaken to calibrate and validated the models and specifies the conformance of the models to relevant standards for calibration and validation.

1.4 Assumptions and limitations

The calibration and validation of the Parramatta Road Reconfiguration hybrid simulation traffic model is based on a number of assumptions:

- Peak period trip tables supplied by Transport for NSW are an accurate representation of peak period travel demand.
- Traffic count data supplied by Roads and Maritime are a true and accurate representation of existing traffic conditions.
- Public Transport data supplied by Transport for NSW are a true and accurate representation of existing traffic conditions.
- Signal timing data provided by Roads and Maritime is correct.

The calibration and validation of the model documented in this report is subject to the following limitations:

- Traffic model development has been limited to microsimulation modelling of the study corridor, focusing on The Northern Road between Mersey Road and Jamison Road with side roads modelled as approaches.
- The zoning system within the model is limited to some subdivision of the Sydney Strategic Transport Model zone system, and includes detailed zone disaggregation down to the level of local or collector roads where appropriate to match observed traffic counts.
- Traffic data, including counts, speed and flow profiles and travel time surveys were gathered from a number of sources, some of which were not consistent with one another. While every effort has been made to ensure continuity in these sources, some inconsistency in count data is expected, though is not considered likely to distort the basis of the result presented and conclusions drawn.

1.5 Report structure

This report details has been structured as follows:

- Section 2: *Study Area* – Describes the study area extents and existing conditions.
- Section 3: *Model Development* – Outlines the methodology used in the development of the model.
- Section 4: *Demand Matrix Development* – Outlines the methodology used to prepare the model demands.
- Section 5: *Model Calibration* – Details the Calibration procedures and results.
- Section 6: *Model Validation* – Details validation procedures and results.
- Section 7: *Summary and Conclusions* – Outlines the conclusions of the calibration and validation process.

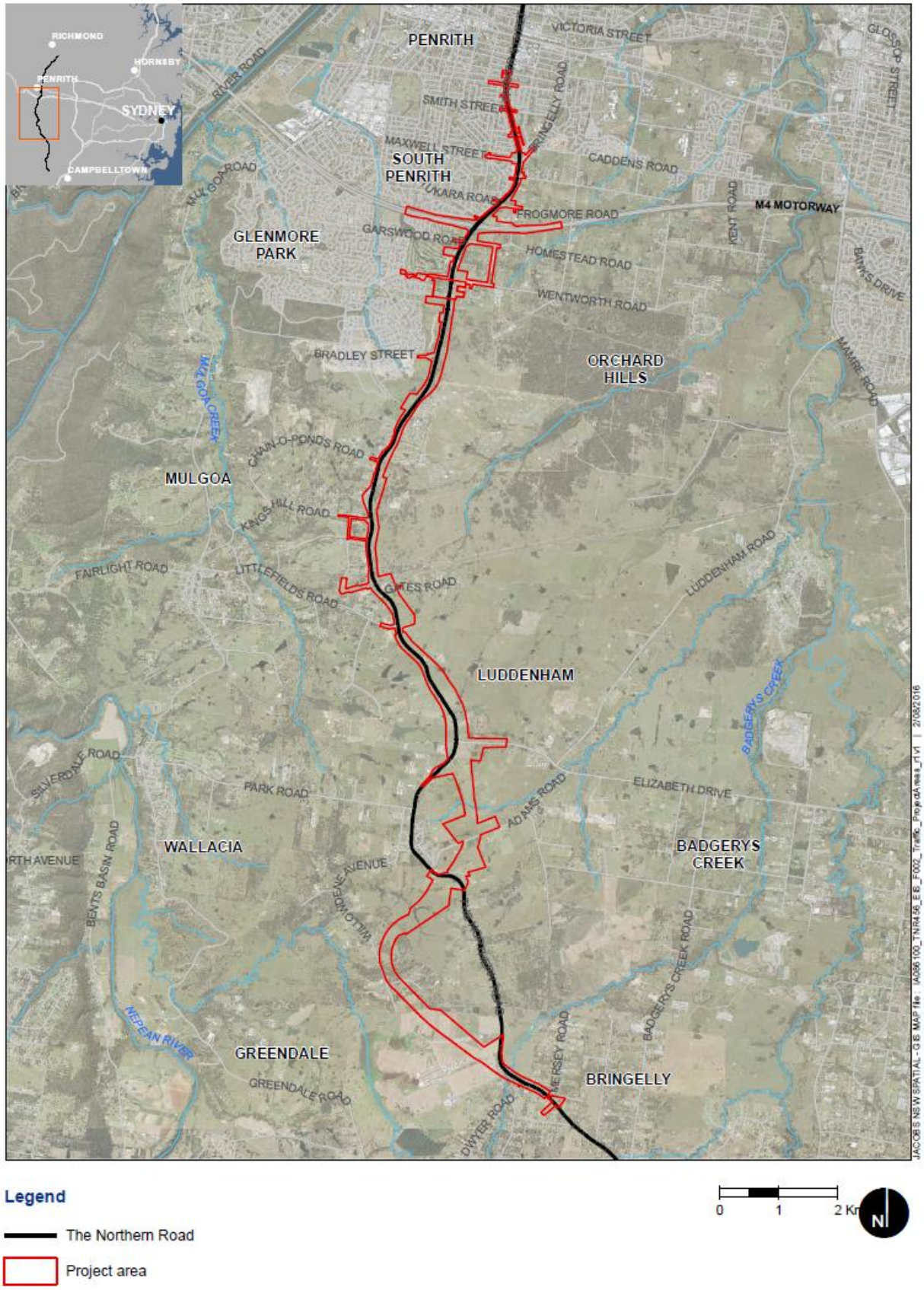
2. Study Area

2.1 Background

The Northern Road is an arterial road in Sydney's west that connects Narellan, in Sydney's South West with Penrith, in Sydney's North West. Primarily a two lane rural undivided road for the majority of its length, The Northern Road passes through the localities of Oran Park, Bringelly, Luddenham, Orchard Hills and Penrith. It is bordered by two large commonwealth land reservations, including the proposed Western Sydney Airport (WSA) site, which it crosses through, and the Defence Establishment, Orchard Hill (DEOH), passing along its western boundary.

This report focuses on The Northern Road Stage upgrade between Mersey Road, Bringelly and Jamison Road, Penrith. A map of the study area is provided in Figure 2.1.

Figure 2.1 : The Northern Road Upgrade, Bringelly to Penrith study area



2.2 Road network

For the majority of its length through the study area, The Northern Road is a two-lane rural road on a single carriageway. It provides a link between Narellan in the south, and Penrith in the north. Between Glenmore Parkway and Jamison Road The Northern Road widens to two lanes in each direction and it becomes an urban arterial road with divided carriageways between Smith Street and Jamison Road.

The majority of intersections along the project length are unsignalised. The signalised intersections along the project length are:

- M4 Western Motorway
- Maxwell Street and Bringelly Road
- Smith Street
- Jamison Road

There are also roundabouts, at Elizabeth Road and Glenmore Parkway. Both of these have two circulating lanes.

The Northern Road is generally 80 km/h between Mersey Road and Glenmore Parkway, with reduction to 60 km/h through Luddenham town centre. Between Glenmore Parkway and Jamison Road, The Northern Road is 70 km/h.

2.3 Existing traffic conditions

South of Glenmore Parkway, The Northern Road is generally uncongested and free-flowing during peak periods. Between the M4 Western Motorway and Jamison Road, congestion is usually observed on approach to the following intersections:

- M4 Western Motorway
- Bringelly Road and Maxwell Street
- Jamison Road

Congestion is also observed on some side roads along the Northern Road including:

- Glenmore Parkway
- Maxwell Street
- Jamison Road
- Bradley Street

3. Model development

3.1 Overview

The Northern Road Upgrade microsimulation model has been developed using the Aimsun traffic modelling platform. Aimsun allows for the development of static and dynamic traffic models within a unified platform, performing traditional static macroscopic modelling using volume delay functions as well as more detailed dynamic mesoscopic and microscopic simulation modelling. Dynamic traffic models are useful in modelling congested or capacity-constrained conditions where traffic demand exceeds available capacity and traffic diverts to seek less congested routes. These conditions result in queuing that builds up and dissipates over time and dynamic routing of traffic that is responsive to this build-up of delays.

The Northern Road Upgrade model has been developed using Aimsun version 8.1.0 and is based on an initial road network and traffic demand supplied by Transport for NSW, converted from the Roads and Maritime Strategic Traffic Assignment Model(STAM). This model has been built within Jacob's Greater Metropolitan Sydney network, which includes detail in coding from other projects within Sydney including the M4 Motorway and a large area of Western Sydney, and has used many of the existing volume delay functions and node delay functions that have been developed as a result of this work.

3.2 Model scope

3.2.1 Geographical coverage

A plot of the model extents is provided in Figure 3.1. The model covers the length of The Northern Road between the following roads:

- Mersey Road, Bringelly
- Jamison Road, Penrith

In addition to The Northern Road, the following sections of road were also modelled as side areas, including:

- Adams Road
- Littlefields Road
- Kings Hill Road
- Chain-O-Ponds Road
- Kingswood Road

3.2.2 Temporal coverage

The Northern Road Upgrade model covers the following time periods:

- Morning peak: 6am to 10am
- Evening peak: 3pm to 7pm

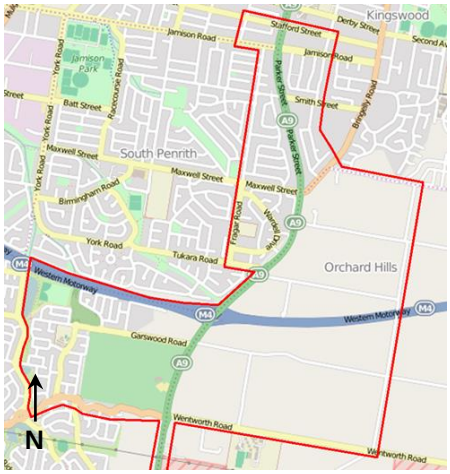
3.2.3 Vehicle classes

The Northern Road Upgrade model uses the following vehicle classes:

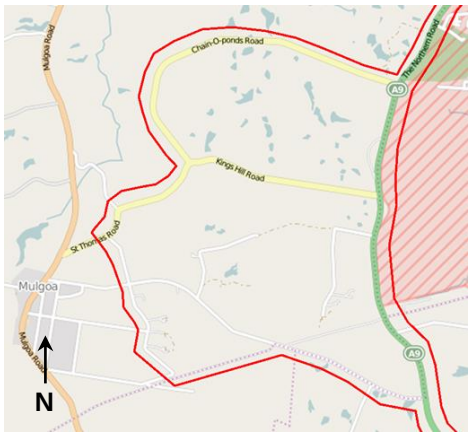
- Car, including cars and light commercial vehicles
- Rigid trucks
- Articulated trucks

Figure 3.1 : The Northern Road Upgrade model extents

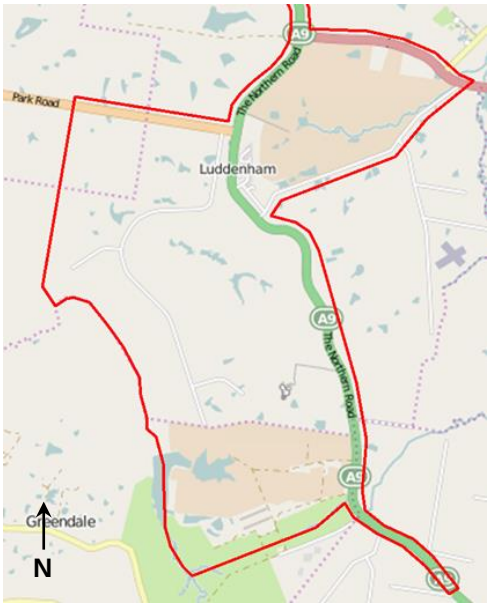
Overall model area



Orchard Hill area



Mulgoa area



Luddenham Area

3.3 Zoning system

The travel zone system for The Northern Road Stage Upgrade model has been developed based on Transport for NSW's TZ06 zoning system. Internal zones covered by the model area have been subdivided based on existing land use and external travel zones have been created based on the external cut points along the model cordon.

A plot of the internal travel zones used in the model is provided in Figure 3.2. External zones are shown in Figure 3.3.

Figure 3.2 : Aimsun model internal travel zones

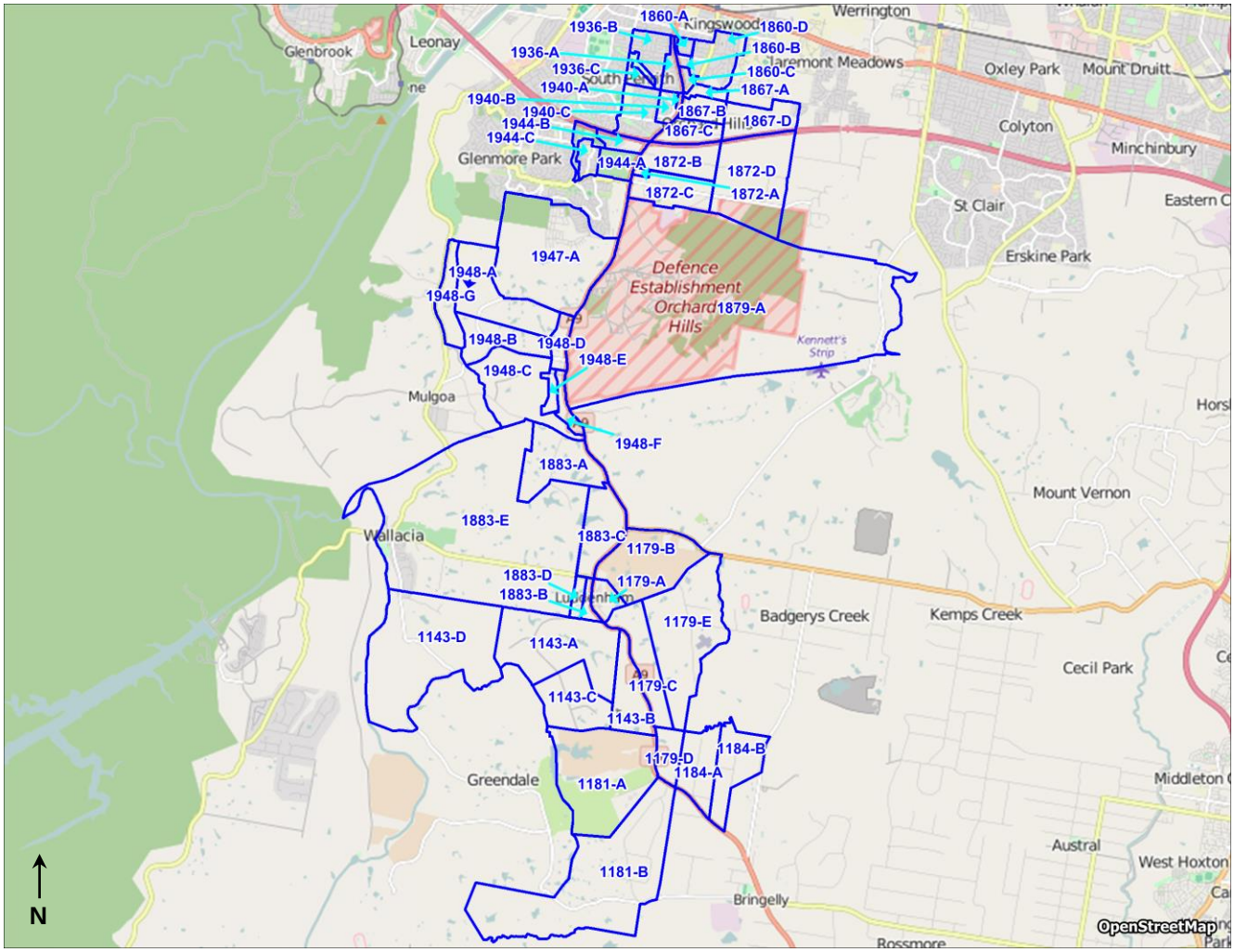
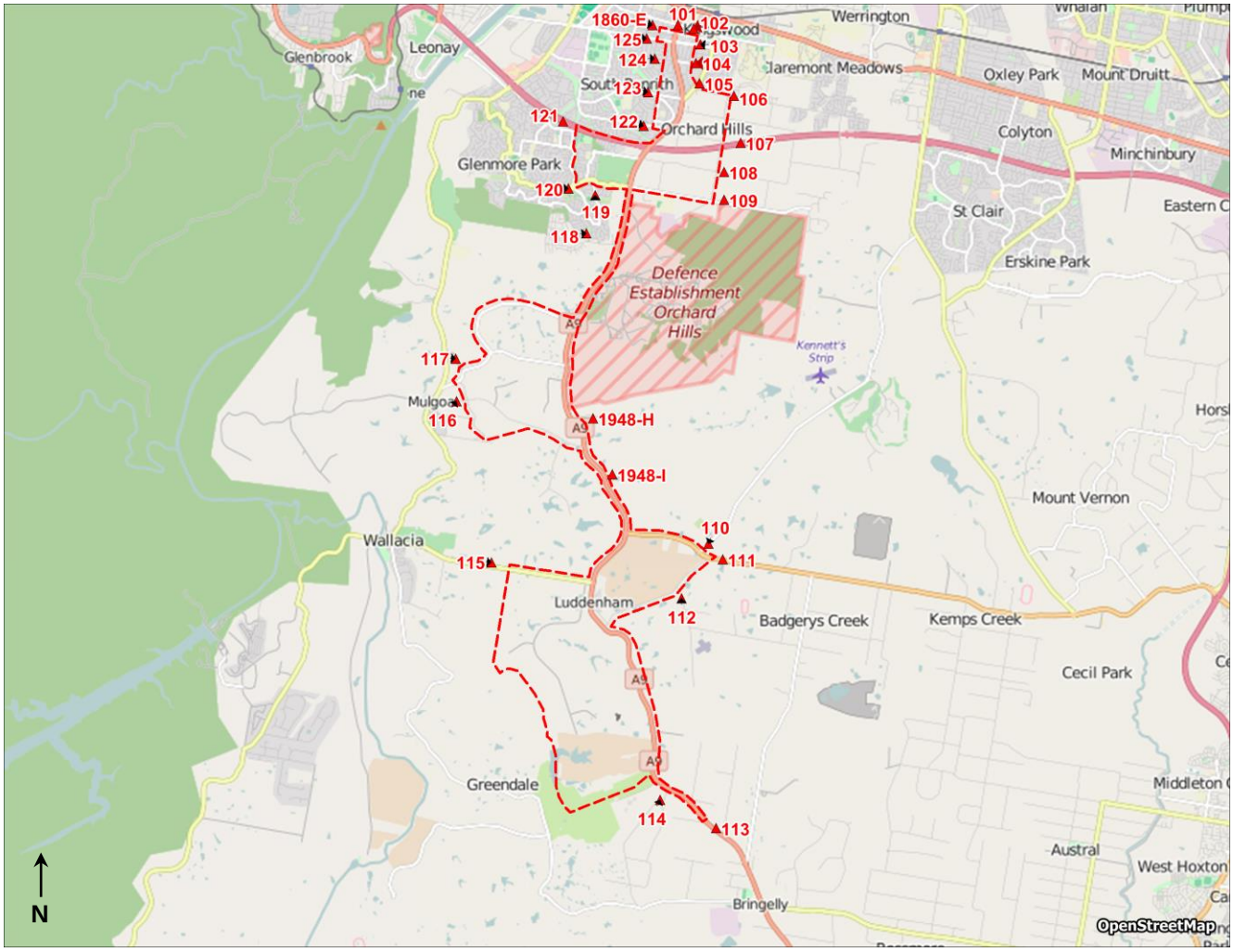


Figure 3.3 : Aimsun model external travel zones



The nominal external zones at Stafford Street West ("1860-E"), Gates Road ("1948-H") and a representative driveway at approximately 2787 The Northern Road, between Littlefields Road and Elizabeth Drive ("1948-I"), represent very small fractions of strategic model zones which do not appropriately connect in the Aimsun model area. These have been seeded based on the nearest comparable internal zones (1860 and 1948 respectively).

3.4 Model data

Traffic data used in the development of the Northern Road Upgrade was supplied by various agencies. These data sources included:

- Intersection turning movement surveys
- Automatic traffic counts
- SCATS detector counts
- Floating-car travel time surveys

3.4.1 Intersection turning movement counts

Intersection turning movement counts were undertaken by Roads and Maritime on 21 and 23 July, 2015 at the following locations:

- The Northern Road and Smith Street
- The Northern Road, Castle Street and Aspen Street
- The Northern Road and M4 Western Motorway
- The Northern Road, Hampstead Road and Garswood Road
- The Northern Road, Glenmore Parkway and Wentworth Road
- The Northern Road and Bradley Street
- The Northern Road and Defence Establishment Gates
- The Northern Road and Chain-O-Ponds Road
- The Northern Road and Kings Hill Road
- The Northern Road and Longview Road
- The Northern Road and Gates Road
- The Northern Road and Littlefields Road
- The Northern Road and Elizabeth Drive
- The Northern Road and Park Road
- The Northern Road and Blaxland Avenue
- The northern Road and Roots Avenue
- The Northern Road and Adams Road
- The Northern Road and Dwyer Road
- Elizabeth Drive and Luddenham Road

The following additional intersection turning movement counts were undertaken by Penrith Council between 15 and 21 November 2014:

- The Northern Road, Maxwell Street and Bringelly Road
- The Northern Road, Tukara Road and Frogmore Road
- The Northern Road and Jamison Road
- The Northern Road and Derby Street
- The Northern Road and Great Western Highway

A plot of the intersection count locations used in the development of the model is provided in Figure 3.4.

Figure 3.4 : Intersection count locations

3.4.2 Automatic traffic count data

Automatic traffic count data (ATC) was provided for the period between 22 and 29 July 2015. This count data covered the following locations along The Northern Road:

- Between Stafford Street and Jamison Road
- Between Smith Street and Maxwell Street
- Between Maxwell Street and M4 Motorway
- Between Homestead Road and Glenmore Parkway
- Between Glenmore Parkway and Bradley Street
- Between Chain-O-Pond Road and Kings Hill Road
- Between Littlefields Road and Elizabeth Drive
- Between Elizabeth Drive and Park Road
- Between Park Road and Blaxland Avenue
- Between Eaton Road and Dwyer Road
- Between Dwyer Rod and Mersey Road

3.4.3 SCATS detector counts

SCATS detector counts were collected for the following signalised intersections:

- TCS 2306: The Northern Road and Westbound Ramps
- TCS 3669: The Northern Road and Eastbound Ramps

3.4.4 Floating-car travel time surveys

Floating-car travel time surveys were undertaken on 13 and 20 October 2015 during the morning and evening peak periods. Surveys were undertaken along the length of The Northern Road between Mersey Road, Bringelly and Stafford Street, Penrith. A total of 10 travel time observations were made in each direction during the morning and evening peak period. Analysis of the surveyed travel times showed that there was some localised variability in observed travel times, which is to be expected from the generally small sample sizes achievable using the floating-car survey method.

3.5 Development of Real Data Sets

Real Data Sets (RDS) of target volumes have been used for two purposes in The Northern Road Upgrade base model development:

1) Target volumes against which model calibration is measured

2) Target volumes to guide the matrix adjustment processes

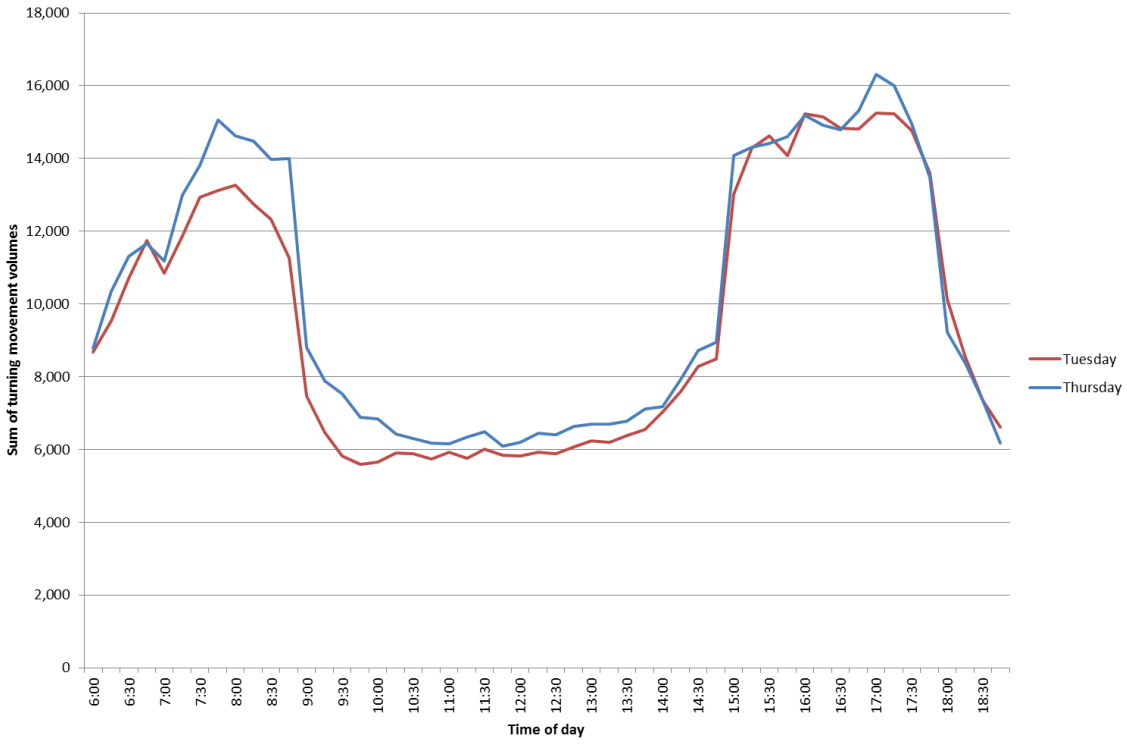
These two RDSs are not the same because the Aimsun adjustment processes require target volumes for every time interval in the modelled period, warm up and cool down, while the count data available covers different time periods in different locations. The available count data has been extrapolated to provide estimated targets for missing time periods in order to guide the adjustments, but only time periods with actual count data have been used as calibration targets.

SCATS detector data for the M4 interchange for the intersection survey day has been used to help guide the balancing of the intersection counts for consistency, but has not been used directly for calibration targets due to the level of uncertainty inherent in induction loop counts.

3.5.1 Count processing

As multiple days' worth of turning movement count data were supplied over a number of different time periods, analysis of the various surveys days was undertaken to determine which day had the highest overall traffic flow. A plot of the sum of turning movement flows for the Tuesday and Thursday surveys is shown in Figure 3.5.

Figure 3.5 : Analysis of traffic flow on survey days



Analysis of the Tuesday and Thursday surveys showed that there is variability in observed traffic flows through the study area, particularly in the morning peak where flows can vary in excess of 10 percent from day to day. Thursday was selected as the survey day for use in calibration of The Northern Road Upgrade traffic model, based on the higher observed traffic flows.

Real Data Sets were developed independently for light vehicles (cars) and heavy vehicles (trucks and articulated trucks), then added together to calculate the Real Data Set for total vehicles.

3.5.2 Infill of missing intervals

For the demand adjustment process, Aimsun requires that all the locations covered by the real data set have target volumes specified for each time interval. For the older (November 2014) intersection counts, which did not cover the full four hour peak periods to be modelled, the missing periods were filled in the following way:

- All turning movements were identified as northbound, southbound, or neutral (crossing The Northern Road).
- Average profiles for each direction of travel were calculated using the sum of directional movements across all of the 13 hour intersection surveys (those from July 2015). These were used to calculate the ratio of the 15 minute volume in each interval outside the November 2014 count period compared to closest interval in the November 2014 count period.
- A 'neutral' profile and corresponding ratios were calculated from the sum of northbound and southbound movements in the 13 hour surveys.
- These profiles were used to calculate missing intervals for the incomplete surveys.

3.5.3 Expansion to shoulder periods

The 13 hour surveys covered the cool down hour after the morning peak model period and the warm up hour for the evening peak model. Targets for these time periods could therefore be based directly on these counts, in the case of the 2015 surveys, or using the process described in Section 3.5 Development of Real Data Sets in the case of the 2014 surveys.

To synthesise the adjustment targets required for the hours before the morning peak period and after the evening period, the automatic traffic count data listed in Section 3.4.2 Automatic traffic count data was used. This was provided in one hour intervals. The ratio between the hour to be calculated and the nearest peak period hour, for each direction of travel and for the sum of both directions, was calculated. For each 15 minute interval in the hour to be extrapolated, this ratio was applied to the target volume for the corresponding interval in the adjacent hour.

3.5.4 Consistency checks and balancing

To provide a sound basis for calibration and demand adjustment, especially in view of the range of types and dates covered by the surveys, the counts have been adjusted for consistency. This also provides an additional check that the counts have been processed and imported into the model correctly.

The counts were found to have poor consistency between adjacent intersections in some cases, notably across the M4 interchange (between the eastbound and westbound ramp terminal intersections). The scale and pattern of the differences indicated that they could not be wholly related to the build-up or discharge of queues between intersections. The target volumes were therefore adjusted to enforce consistency between adjacent intersections unless adjacent land uses with access to The Northern Road, represented by a zone, were present.

Initially the targets were adjusted to achieve consistency without reducing any of the counted volumes. This yielded demands higher than the intersection capacity in some cases, especially at the M4 interchange and Bringelly Road / Maxwell Road.

The M4 interchange SCATS detector counts for the same day as the intersection surveys were therefore used as a guide. This data was checked and no detector problems or missing data was identified

The heavy vehicle targets calculated without reducing any surveyed volumes were retained.

At the M4 interchange, the light vehicle targets in each 15 minute interval were then capped so that the total volume for each signalised movement in each interval would not be more than 10% higher than the SCATS count.

Any inconsistency between the M4 intersections remaining after applying these caps was removed by reducing the contributing turns at the higher end of the section.

Finally, northbound and southbound light vehicle through volumes at intersections north of the M4 were propagated from the M4 targets. Turning movements at these intersections remained as surveyed.

South of the M4, the more conservative light vehicle targets calculated without reducing any surveyed volumes were used.

Balancing was applied in the same way to all time intervals, after deriving initial infill and shoulder period volumes as described in sections 3.5.2 Infill of missing intervals and 3.5.3 Expansion to shoulder periods.

3.5.5 Final calibration targets

The final calibration targets are the balanced volumes for each time interval for which survey data was included in the original data set.

3.6 Road network coding

3.6.1 Initial network coding

Coding of the road network was undertaken on the basis of updating Transport for NSW's latest Sydney GMA Aimsun network. Infilling of detail within the study area was undertaken on the basis of 2015 aerial photography provided by Roads and Maritime along with additional road network data from GIS, intersection layout plans and Google Street View. Intersections, interchanges and minor streets were added to the study area as part of the network coding process.

Additional time-dependent traffic management policies were coded in the network to reflect the following time-dependent features:

- School speed zones
- Time-dependent lane controls (including parking restrictions)

Parking restrictions were checked using roadside signage in Google Street View. This identified traffic lanes with parking prohibited in one or both peak periods. No time dependant parking lane coding was required for this model

The network coding was carried out to a high level of detail, including:

- Modelling of road gradients: In order to better reflect the impacts of steep grades on heavy vehicles, spot heights have been coded at nodes and at high and low points along The Northern Road and on the M4 Western Motorway ramps. These gradients affect the acceleration and deceleration profiles of heavy vehicles along the corridor
- Opposing lane overtaking: As The Northern Road is a two-lane rural road through much of the study area and due to the limited opportunities for overtaking, opposite-lane overtaking occurs through some sections of the corridor. This behaviour can be modelled in Aimsun using the two-way overtaking model, which has been enabled for sections of The Northern Road separated by a broken median line.

3.6.2 Network coding adjustments during calibration

During the calibration and validation process, a number of adjustments have been made to the network coding to better represent traffic behaviour and routing. These adjustments included:

- Adjustments to sight distances and look ahead distances at intersections to reflect realistic vehicle behaviour
- Increased acceleration and reduced reaction time to reflect more alert and impatient driver behaviour at:
  - Southern approach to Glenmore Parkway roundabout (high acceleration, reaction time -0.2 sec)
  - Western approach to Glenmore Parkway roundabout (medium acceleration, reaction time -0.15 sec)
  - Right turn into Castle Street (medium acceleration)
  - Stafford Street eastbound approach to The Northern Road (medium acceleration)
- Reduced initial gap (from 3.0 to 2.5 seconds) and reduced final give way time factor (from 2.0 to 1.5) to reflect more impatient driver behaviour at:
  - Southern approach to Glenmore Parkway roundabout (high acceleration)
  - Western approach to Glenmore Parkway roundabout (medium acceleration)
  - Right turn into Castle Street

3.7 Public transport network coding

Coding of the public transport network was undertaken based on bus stop, bus route and bus timetable data from the Transport for NSW Operational Spatial Database (OSD). This database provides the location of bus stops, bus routes and stopping patterns as well as timetables arrival times at each stop along each route.

A subset of the OSD was extracted that detailed the stops and routes for all public and school buses passing through the study area during the morning and evening peak periods. These bus stops were imported and the regular (non-school) bus routes created based on linking stops according to the shortest path between stops. Review and correction of imported routes was also undertaken to ensure that stops were imported in the correct locations and that routes operated along the correct roads.

As public transport performance is not a focus of this model and Opal data for the study area was not available, a standard dwell time of 20 seconds has been applied to all bus stops and routes, as agreed with Roads and Maritime.

3.8 Traffic signal settings

SCATS timing statistics and LX signal data for September 2015, provided by Roads and Maritime, was used as the basis for fixed-time traffic signal phase and cycle times and offsets for each modelled 15 interval.

A review of the timing statistics indicated significant differences between consecutive 15 minute intervals, reflecting the responsiveness of the SCATS system to variations in traffic volume. As the timing data available was not for the survey day, it has been used a starting point, and the phase times have been adjusted to suit the target volumes in each 15 minute interval.

Where possible, offsets were identified from the LX files. Maximum cycle times for each subsystem were also identified from the LX files. Cycle times were calculated from this information and the highest average cycle time in each subsystem, rounded up to the nearest 10 seconds, was used as the common subsystem cycle time.

3.9 Behavioural settings

The following behavioural settings were used in the development of The Northern Road Upgrade base model:

- Look-ahead distance variability: 40 per cent
- Simulation step: 0.8 seconds
- Mesoscopic reaction time (all vehicles): 1.2 seconds
- Mesoscopic reaction time at traffic lights (all vehicles): 1.3 seconds

- Microscopic reaction time: same as simulation step
- Microscopic reaction time (all vehicles): 0.85 seconds
- Microscopic reaction time at traffic lights (all vehicles): 0.95 seconds
- Global arrivals: exponential distribution

Based on advice from TSS (developers of Aimsun) as a general rule of thumb, reaction times used in mesoscopic simulation are generally 1.3 to 1.5 times those used in micro-simulation to account for simplifications of vehicle behaviour made by the mesoscopic simulator including instantaneous acceleration and limited lane choice opportunities. The reaction time for mesoscopic simulation has been selected based on this advice.

3.10 Traffic assignment and simulation

Unlike micro-simulation and static traffic models, Aimsun allows for a combination of assignment types in combination with different vehicle simulation methods. As route choice in the study area is very limited, and traffic volumes and travel patterns on competing routes can only be nominal due to a lack of count data, the Northern Road Upgrade base model has initially been developed using a two stage process:

1) Static equilibrium assignment using static traffic model

2) Stochastic assignment (one-shot assignment using converged static model paths) using microscopic simulator

In stage 1, travel paths were reviewed and adjusted using turn penalties where necessary to overcome the limits of the strategic volume delay functions and ensure travel paths were realistic. Demand estimation and departure adjustment was then undertaken using static equilibrium assignment. When a good match to target time interval volumes was achieved, and a profile of 15 minute demand matrices for each vehicle class had been developed, stage 2 microsimulation assignment was used to model dynamic effects on traffic conditions.

A standard seed value of 560 (the first seed value specified in the Roads and Maritime *Traffic Modelling Guideline, 2013*) has been used for all dynamic model runs.

As a next step, to improve the responsiveness of the model to potential new route choices in future option construction scenarios, Dynamic User Equilibrium will be introduced. The dynamic network will then be adjusted (for example by controlling the attractiveness of lower order competing routes) so that the base year route choice is a good match to the vetted static model routing upon which the demand matrices are based.

4. Demand matrix development

4.1 Traffic demand estimation methodology

Traffic demand estimation was undertaken using the Departure Adjustment method available in Aimsun. The following stages were used in the development of base traffic demand:

- Assignment of The Northern Road Upgrade base model and generation of morning and evening peak hour sub-area traversal matrices using static assignment.
- Expansion of the single hour traversal matrices in the strategic model zone system to four hour total matrices, plus one hour warm up and cool down period matrices, in the higher-resolution The Northern Road Upgrade zone system.
- Static adjustment using departure adjustment methodology within Aimsun to create 15-minute matrices based on modelled static assignment travel times and paths.

Each of these stages is described in further detail below.

4.1.1 Source demand matrices

The starting point for demand matrix development for The Northern Road Upgrade model was the morning and evening peak hour matrices derived from the Transport for NSW Sydney Strategic Transport Model (STM) which were included in the foundation Sydney Greater Metropolitan Area (GMA) model.

These initial strategic model demands were supplied by the WestConnex Delivery Authority (WDA) and consist of a combination of the WestConnex toll forecasting model base 2012 demands within the Sydney region and the STM 2011 demands for the remainder of the GMA. These in turn incorporated the then-current Freight Movement Model (FMM) heavy vehicle demands.

These initial strategic model demands were supplied as two-hour morning peak and three-hour evening peak matrices.

Traversal matrices for The Northern Road Upgrade model area were extracted from static assignments of these demands across the full GMA network.

4.1.2 Expansion of traversal matrices

The traversal matrices were first expanded to The Northern Road Upgrade model zone system using zone split factors based on land use areas.

The traversal matrices were then scaled up to a four hour total, using the average profile from all the target volumes for the relevant vehicle class (light or heavy) to calculate ratios between the four hour Aimsun period total flows and the relevant strategic model periods. The total target volume profiles were also used to calculate the ratios between peak hour and the hours before and after the Aimsun periods, in order to construct the six hour demand input to the departure adjustment process.

4.1.3 Static demand adjustment

The four-hour flat traffic demand for the sub-area traversal was refined to The Northern Road Upgrade zone system and adjusted to meet observed traffic flows throughout the network according to the 15 minute targets for each period using static departure adjustment. The departure adjustment procedure is an iterative matrix adjustment procedure that uses the paths and modelled travel time results from a static assignment to adjust the demand matrix and distribute trips in time so that their arrival profiles match observed flow profiles at count locations across the network. Trips between zones which were originally part of the same TZ06 source zones, or otherwise had no demand in the cordon matrices but were possible trips, were allowed for by introducing small seed values to empty cells at the start of the adjustment process. The demand adjustment was

undertaken on the basis of the target volumes in the Real Data Set described in Section 3.5 Development of Real Data Sets.

4.1.4 Departure adjustment and slicing

The aim of this process is to adjust and slice an origin-destination matrix that considers static model travel times to allocate trips to the correct departure matrix in order to reach the each count location at the correct time when running dynamic simulations. This allows for the time shifting of longer trips by considering static travel times in the adjustment. It should be emphasized that this process uses static travel times and hence dynamic factors such as congestion at signalised intersections are not considered.

The following are the parameters used in this project:

- Warm-up: 1 hour
- Matrix elasticity: (unbounded)
- Deviation matrix: none (no maximum deviation set)

The interval duration is the general time duration used for the slicing calculation. The cost multiplier is a conversion factor of the cost unit in macro functions. The matrix weight of 1 is used to maintain the total trip numbers of a particular matrix. In other words, a matrix weight of 0 would give complete freedom to the adjustment to change as much as required.

4.2 Demand adjustment results

Statistics showing the change in total traffic demand before and after this adjustment process are detailed in the figures below.

4.2.1 Trip length distribution

Frequency histograms of the morning and evening peak trip length distribution (6am to 10am and 3pm and 7pm respectively) are shown in Figure 4.1 and Figure 4.2.

Analysis of the car trip length distribution shows that the distribution profile has remained broadly similar before and after adjustment. The peak frequency locations remain the same, though the intensity of some peaks is modified:

- The seed matrix peaks between 6000m and 7000m are increased
- The 1000m, 9000m and 10000m peaks are reduced.

The lower frequency trips between 3000m and 4500m are also increased. These changes generally reflect the requirement to introduce longer trips where the original static model traffic demand did not assign trips to the study area as a consequence of the coarseness of zones in this part of the network.

Importantly, there is no increase in very short trips which could suggest unrealistic increases to specific local trips to match problematic counts.

Figure 4.1 : Trip length distribution comparison – AM peak

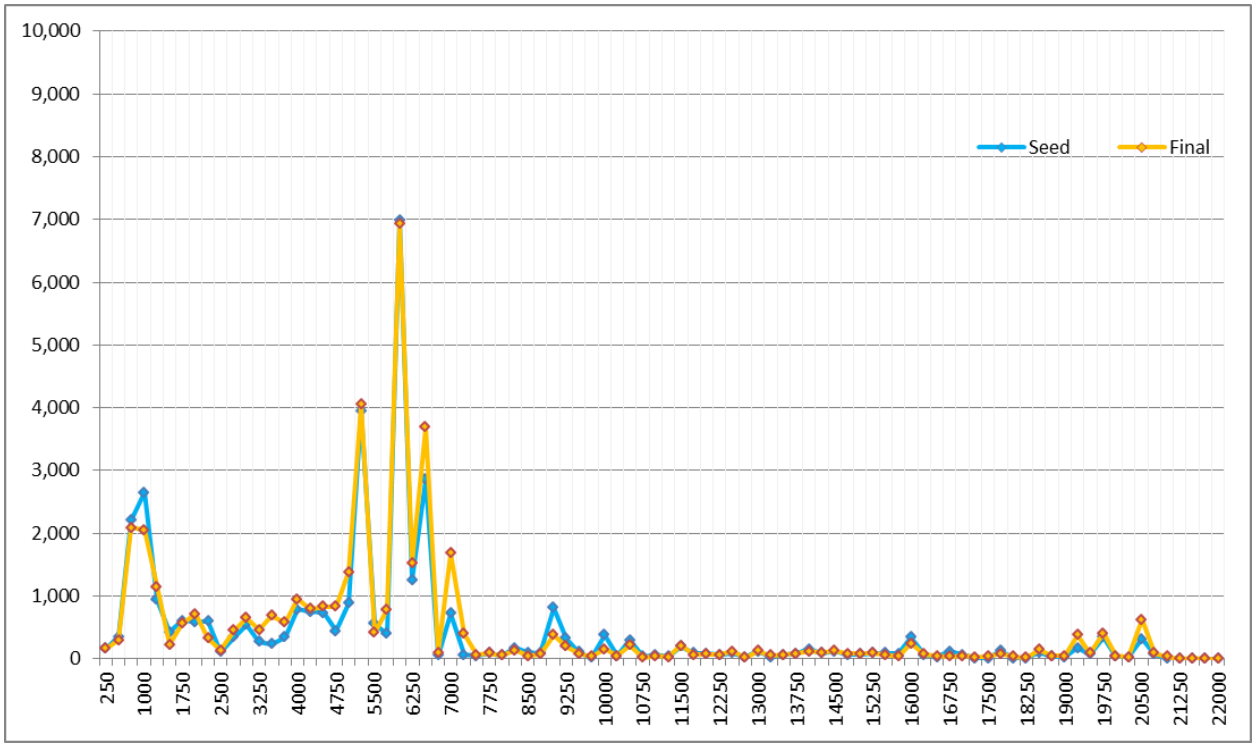
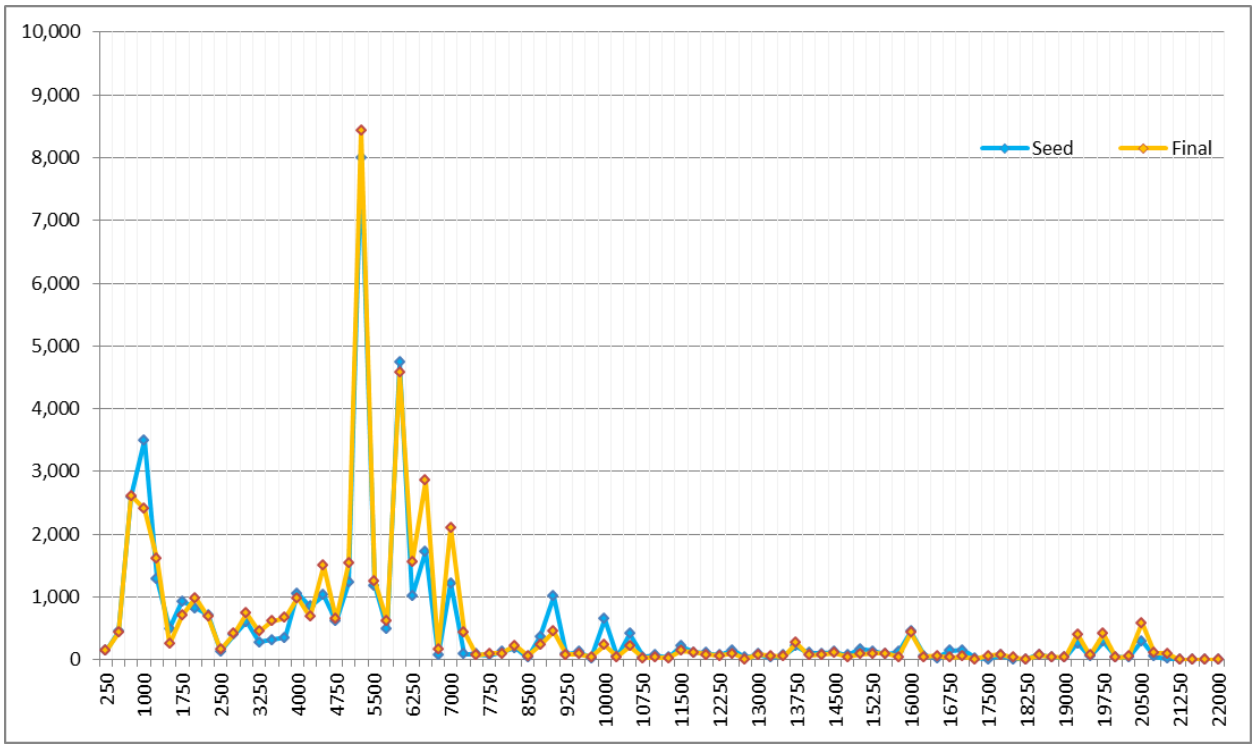


Figure 4.2 : Trip length distribution comparison – PM peak



5. Model calibration

5.1 Overview

The initial calibration of The Northern Road Upgrade base model has been undertaken with a view to meeting the targets for calibration provided in the Roads and Maritime *Traffic Modelling Guidelines, 2013* adapted for microsimulation where possible. The calibration has been undertaken based on hourly turning movement counts over the four-hour morning and evening peak periods.

Base model calibration has been undertaken in two stages:

- Calibration of the static assignment parameters iteratively alongside demand adjustment to ensure that the adjustment is undertaken using valid static assignment routing.
- Calibration of the traffic signals and microscopic simulation parameters were undertaken after static adjustment was completed.

Although the static assignment and adjustment processes uses separate network parameters to the microscopic simulation, some additional parameters accounting for model delay were also calibrated in the static assignment model on the basis of signal timings derived from the mesoscopic simulation.

5.2 Calibration targets

The GEH statistic is used in the calibration of traffic models to compare the differences between modelled and observed traffic flows. The GEH statistic is defines as follows:

$$GEH = \sqrt{\frac{(V_{observed} - V_{modelled})^2}{(0.5 \times (V_{observed} + V_{modelled}))}}$$

Based on the calibration and validation requirements presented in the Roads and Maritime *Traffic Modelling Guidelines, 2013*, a calibrated model should conform to the following 'network-wide' standard:

- No flow comparisons with GEH values greater than 10.
- At least 85 per cent of flow comparisons with GEH less than 5.

In addition to GEH comparisons, regression analysis of observed versus modelled flows was also undertaken. The following criteria for regression analysis were adopted:

- R^2 greater than 0.95
- Slope between 1.05 and 0.95

The R^2 generally represents the closeness of fit of the observed data points to modelled data points and the slope of the trend line gives an indication of whether the model is general over-assigning (greater than 1) or under-assigning (less than 1) traffic across the network.

In addition to these criteria, following criteria should also be met for the model "core area":

- Flows < 99 – to be within 10 vehicles of the 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.

For The Northern Road Upgrade model, there is no specific 'core area' – the data is of equal quality and density along the full corridor. The variability between counts on different days and between adjacent intersections also shows significantly more variation from day to day and from site to site than the 'core area' targets. While the model calibration has aimed to get as close to these targets as possible; in some locations where observed traffic volumes vary more than calibration tolerances, or where adjustments to counts have been made in excess of these tolerances, it is expected that modelled flows may not be within these tolerance bands and still reflect on-site traffic conditions.

5.3 Calibration results

A summary of the target network-wide count comparison statistics for the microsimulation assignment, for all vehicles, is presented in Table 5.1. Detailed results for each turning movement are presented in Appendix A.

Table 5.2 shows the classified network-wide calibration results in the form of regression statistics for light and heavy vehicles.

Regression plots for each hour, for total, light and heavy vehicles respectively, are provided in Appendix B.

These results show that the network achieves a high degree of calibration, at a network-wide level, for total vehicles and for light vehicles. Each hour is well within the targets identified in section 5.2 Calibration targets with respect to GEH values and regression statistics.

The results for heavy vehicles are less accurate. Although the R^2 statistics are good, the results show a slight underestimation of heavy vehicles overall across each peak. This is to be expected, as heavy vehicle volumes are generally much lower than car volumes throughout the study area.

Table 5.1 : Summary of microsimulation turning movement comparisons – Total vehicles, 'network-wide' criteria

Period	GEH less than 5	GEH greater than 5	R^2	Slope
6am to 7am	181 (98%)	3 (2%)	0.998	0.977
7am to 8am	183 (99%)	1 (1%)	0.998	0.983
8am to 9am	181 (98%)	3 (2%)	0.999	1.005
9am to 10am	149 (99%)	1 (1%)	0.997	0.982
6am to 10am (Aggregate)	694 (99%)	8 (1%)	0.998	0.989
3pm to 4pm	181 (98%)	3 (2%)	0.997	0.983
4pm to 5pm	180 (98%)	4 (2%)	0.998	1.010
5pm to 6pm	181 (98%)	3 (2%)	0.998	0.995
6pm to 7pm	148 (99%)	2 (2%)	0.998	0.992
3pm to 7pm (Aggregate)	690 (98%)	12 (2%)	0.998	0.992

Table 5.2 : Summary of microsimulation turning movement comparisons – Classified vehicles, 'network-wide' criteria

Period	Light vehicles (cars)		Heavy vehicles (trucks + heavy trucks)	
	R^2	Slope	R^2	Slope
6am to 7am	0.998	0.982	0.959	0.906
7am to 8am	0.998	0.985	0.942	0.938
8am to 9am	0.999	1.007	0.953	0.990
9am to 10am	0.997	0.994	0.977	0.878
6am to 10am (Aggregate)	0.998	0.993	0.956	0.925
3pm to 4pm	0.997	0.993	0.968	0.838
4pm to 5pm	0.998	1.016	0.971	0.885
5pm to 6pm	0.998	0.992	0.955	1.061
6pm to 7pm	0.998	0.990	0.930	1.008
3pm to 7pm (Aggregate)	0.997	1.000	0.954	0.896

The turns with GEH greater than 5 in any hour are summarised in Table 5.3. For context, Table 5.4 shows the target volumes for these turns, and Table 5.5 shows the modelled volumes. As these tables show, all of these turns are in non-critical locations and involve small volumes.

No turning movements had a GEH of greater than 10 in any hour.

Table 5.3 : Summary of microsimulation turning movements with GEH > 5 in any hour - GEH

Intersection	Approach	Direction	GEH : hour starting							
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00
The Northern Rd / Jamison Rd	East	Right	6.6	0.8	2.3		2.3	7.1	0.3	
The Northern Rd / Maxwell St / Bringelly Rd	West	Left	5.2	1.9	0.0		0.3	1.7	0.1	
The Northern Rd / Castle Rd / Aspen St	W to N+E		8.3	4.9	4.7	6.3	6.2	5.0	5.4	5.9
The Northern Rd / Homestead Rd / Garswood Rd	South	Right	0.8	0.6	5.7	0.2	2.6	2.3	2.6	1.8
The Northern Rd / Chain-O-Ponds Rd	West	Left	1.8	1.8	1.0	1.1	0.3	1.3	5.1	2.0
The Northern Rd / Kings Hill Rd	West	Left	3.7	0.2	3.4	1.5	2.5	1.1	2.0	5.1
The Northern Rd / Blaxland Ave	East	Right	1.3	5.3	2.1	2.1	1.6	0.3	0.3	1.5
The Northern Rd / Dwyer Rd	North	Right	1.4	0.0	3.9	0.5	0.2	0.6	5.4	0.8
Park Rd / Campbell St	East	Left	2.0	2.8	6.3	3.2	4.9	5.7	4.2	3.5
Park Rd / Campbell St	South	Right	1.4	2.4	5.1	2.8	5.3	2.4	2.8	2.0
Park Rd / Campbell St	West	Right	2.7	4.9	4.0	0.3	5.8	7.1	4.4	4.7

Table 5.4 : Summary of microsimulation turning movements with GEH > 5 in any hour – Target volumes

Intersection	Approach	Direction	Target volume							
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00
The Northern Rd / Jamison Rd	East	Right	12	14	20		18	18	13	
The Northern Rd / Maxwell St / Bringelly Rd	West	Left	26	19	31		50	38	45	
The Northern Rd / Castle Rd / Aspen St	W to N+E		45	12	11	30	45	40	46	41
The Northern Rd / Homestead Rd / Garswood Rd	South	Right	58	148	70	25	51	29	22	18
The Northern Rd / Chain-O-Ponds Rd	West	Left	3	19	13	9	15	8	2	6
The Northern Rd / Kings Hill Rd	West	Left	104	150	119	58	62	60	47	37
The Northern Rd / Blaxland Ave	East	Right	7	15	23	11	7	13	11	5
The Northern Rd / Dwyer Rd	North	Right	11	16	14	16	34	29	24	26
Park Rd / Campbell St	East	Left	2	4	20	5	12	16	9	6
Park Rd / Campbell St	South	Right	0	3	13	4	14	3	4	2
Park Rd / Campbell St	West	Right	34	53	81	13	31	31	17	11

Table 5.5 : Summary of microsimulation turning movements with GEH > 5 in any hour – Modelled volumes

Intersection	Approach	Direction	Modelled volume							
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00
The Northern Rd / Jamison Rd	East	Right	48	17	11		29	63	14	
The Northern Rd / Maxwell St / Bringelly Rd	West	Left	60	28	31		48	49	44	
The Northern Rd / Castle Rd / Aspen St	W to N+E		4	0	0	4	12	14	16	11
The Northern Rd / Homestead Rd / Garswood Rd	South	Right	52	156	127	24	34	18	36	11
The Northern Rd / Chain-O-Ponds Rd	West	Left	7	12	17	6	14	12	18	12
The Northern Rd / Kings Hill Rd	West	Left	145	148	85	70	83	52	62	75
The Northern Rd / Blaxland Ave	East	Right	11	44	34	5	12	14	10	9
The Northern Rd / Dwyer Rd	North	Right	16	16	33	14	35	26	59	30
Park Rd / Campbell St	East	Left	0	0	0	0	0	0	0	0
Park Rd / Campbell St	South	Right	0	0	0	0	0	0	0	0
Park Rd / Campbell St	West	Right	20	23	49	12	6	2	3	0

Table 5.6 shows the performance of the model against the more stringent 'core area' criteria. Most of the turning movements in each hour meet the desirable targets, with only one movement over 2000 vph outside this range. Over 85% of all counts above 100 vph are within the desirable limits.

Table 5.6 : Summary of microsimulation turning movement comparisons – Total vehicles, 'core area' criteria

Period	Percentage of turns within target				
	Total	< 99 vph	100 – 999 vph	1000 – 1999 vph	> 2000 vph
6am to 7am	81%	73%	89%	100%	n/a
7am to 8am	83%	73%	88%	100%	100%
8am to 9am	77%	66%	83%	100%	100%
9am to 10am	81%	80%	80%	86%	n/a
6am to 10am (Aggregate)	80%	73%	85%	98%	100%
3pm to 4pm	80%	71%	88%	91%	50%
4pm to 5pm	82%	74%	84%	100%	100%
5pm to 6pm	80%	73%	81%	100%	100%
6pm to 7pm	83%	80%	87%	100%	n/a
3pm to 7pm (Aggregate)	81%	74%	85%	97%	83%

The main reason for the differences between the target and modelled volumes are the differences in travel speed between the static and dynamic models, affecting the arrival time for longer trips, and the build-up of queues between intersections, which is not allowed for in the balancing of target volumes. Given the variability and inconsistency in observed traffic flows outlined in Section 3.5 Development of Real Data Sets, this is considered acceptable.

5.4 Calibration key findings

Analysis of the GEH and regression statistics show that the model conforms to the Roads and Maritime standards for microsimulation models for both total and light vehicle traffic, with:

- At least 98 per cent of total vehicle turning movement volumes showing GEH of 5 or less in each hour, exceeding the target of 85 per cent
- R^2 greater than 0.99 in each hour, exceeding the target of 0.95
- Slope between 0.975 and 1.02 in each hour, exceeding the target of 0.95 to 1.05

Regression statistics for the much lower heavy vehicle volumes are not as accurate, with slight overall underestimation of approximately 5 per cent compared to the (conservatively high) targets, but do indicate a reasonable degree of calibration for the intended use.

Based on these comparison statistics, the model can be considered adequately calibrated.

6. Model validation

6.1 Overview

Validation of The Northern Road Upgrade microsimulation model has been undertaken on the basis of travel times. Private vehicle travel time comparisons have been undertaken along The Northern Road between Mersey Road and Jamison Road based on floating-car travel time surveys as detailed in Section 3.4.4 Floating-car travel time surveys. In addition to this quantitative validation, qualitative validation of congestion along the corridor has also been undertaken based on inspection of modelled vehicle density.

6.2 Travel time validation

Travel time validation has been undertaken on the basis of floating car travel time surveys along The Northern Road. As recommended by Roads and Maritime *Traffic Modelling Guidelines, 2013* the target for validation of each route in each hour is for the modelled average travel time for the route to be within one minute, or 15 per cent (whichever is higher).

The performance of the model against these targets is summarised in Table 6.1.

Table 6.1 : Summary of travel time validation results

Direction of travel	Time (hour starting)							
	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00
Northbound								
Observed Ave	18:33	18:01	22:43	19:09	19:30	21:53	20:34	19:07
Target Min	15:46	15:19	19:19	16:17	16:35	18:36	17:29	16:15
Target Max	21:10	20:41	25:39	21:48	22:26	25:06	23:21	21:50
Modelled Ave	19:27	21:13	22:08	20:33	21:38	22:09	22:58	20:58
Southbound								
Observed Ave	20:06	20:35	20:35	19:10	23:05	20:19	24:11	23:12
Target Min	17:05	17:30	17:30	16:18	19:37	17:16	20:33	19:43
Target Max	23:06	23:37	23:36	21:56	26:17	23:19	27:29	26:02
Modelled Ave	20:27	21:29	23:24	20:41	22:49	23:00	23:01	20:57

Graphs of modelled and observed cumulative travel time in the peak direction along The Northern Road are provided in Figure 6.1 to Figure 6.8. Additional travel time comparisons for the counter-peak direction are provided in Appendix C.

In these graphs, the modelled average time is shown in red. The heavy black line shows the observed average, while the lighter grey lines show individual observed times. The dashed green lines show an indicative target envelope, based on the one minute/15 per cent criteria.

These results show that the validation target is met in all cases except northbound between 7:00 and 8:00 AM, where the modelled average is 32 seconds above the target range. The profile for this result is shown in Figure 6.2. This shows that the difference is mainly due to a slightly but consistently lower speed in the model south of Glenmore Parkway, compared to the survey. This may be due to more aggressive overtaking in reality, reduced overtaking opportunities in the model due to conservatively high target volumes, or higher maximum speeds on some parts of the corridor than in the model (which assumes the posted speeds are not exceeded). This profile suggests that delays at the key intersections are close to the observed. This result is therefore not expected to affect the model's suitability for the development and assessment of upgrading options.

Figure 6.1 : Cumulative travel time, model vs observed – northbound, 6am to 7am

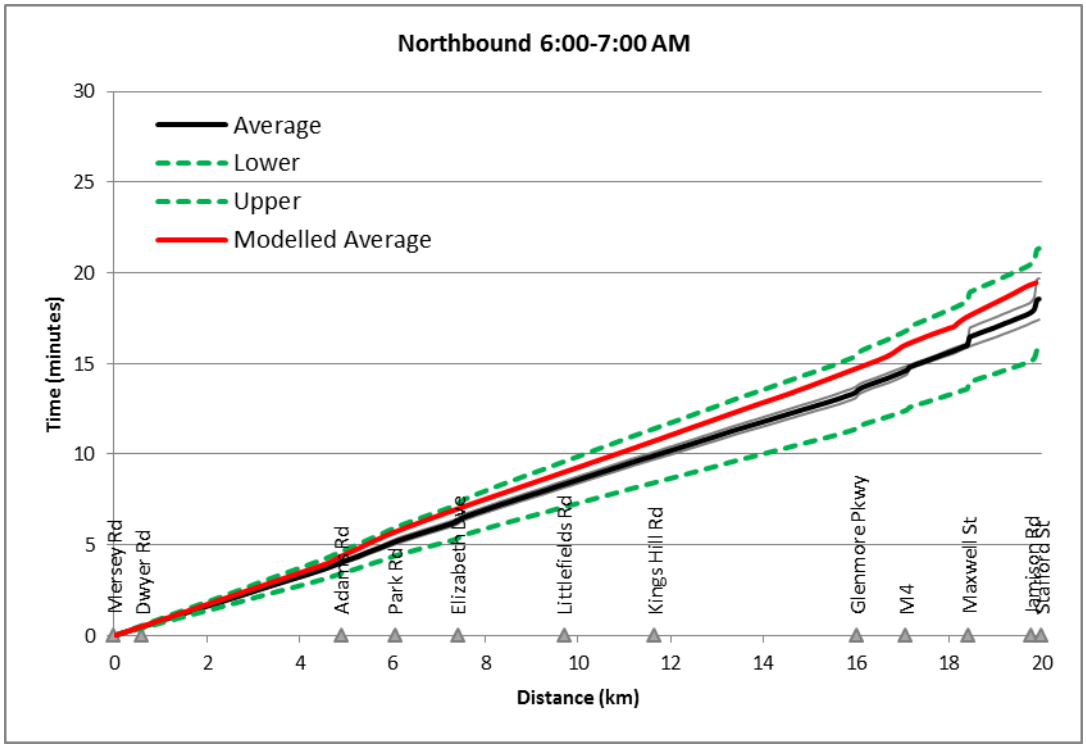


Figure 6.2 : Cumulative travel time, model vs observed – northbound, 7am to 8am

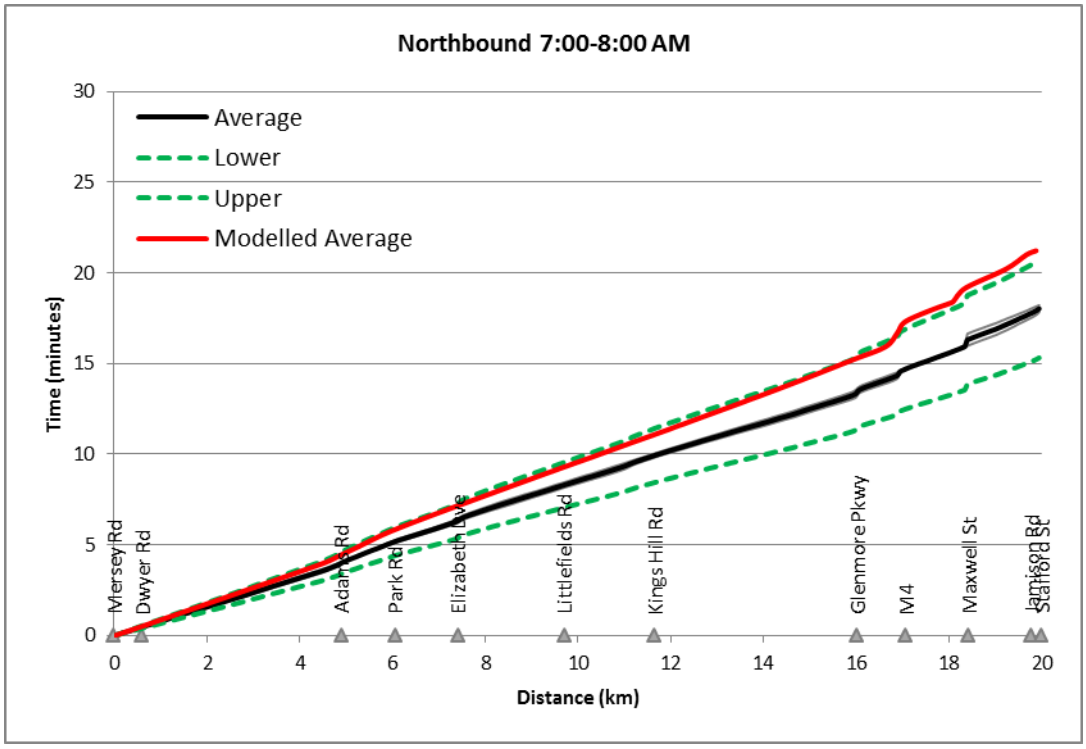


Figure 6.3 : Cumulative travel time, model vs observed – northbound, 8am to 9am

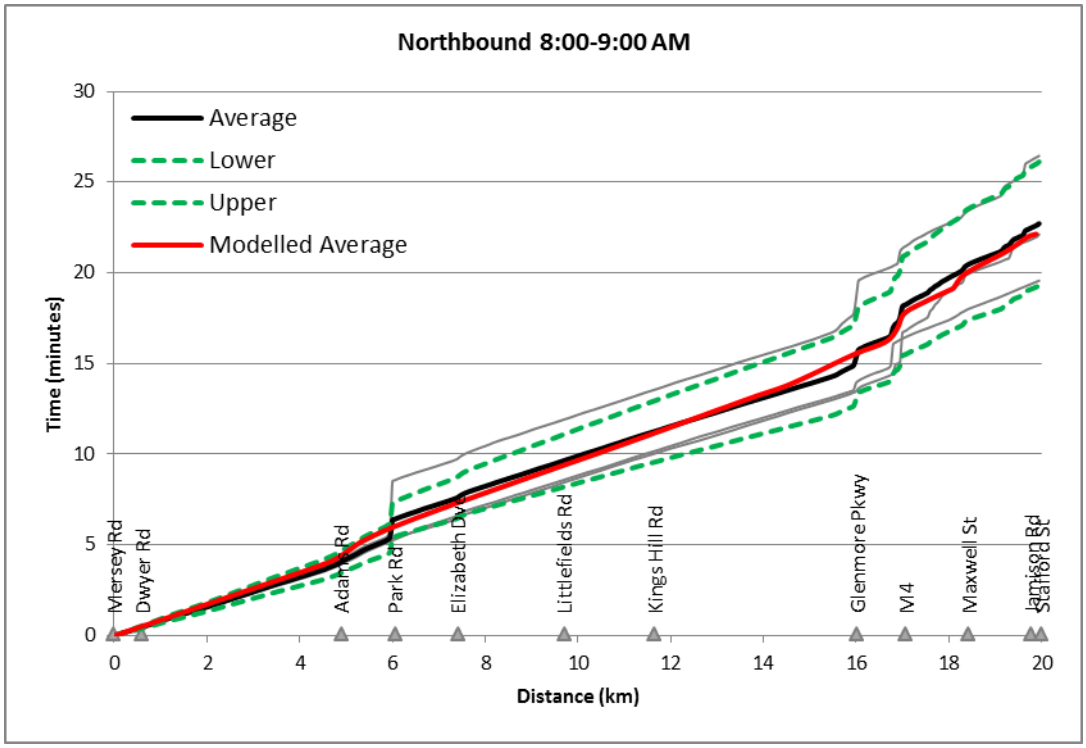


Figure 6.4 : Cumulative travel time, model vs observed – northbound, 9am to 10am

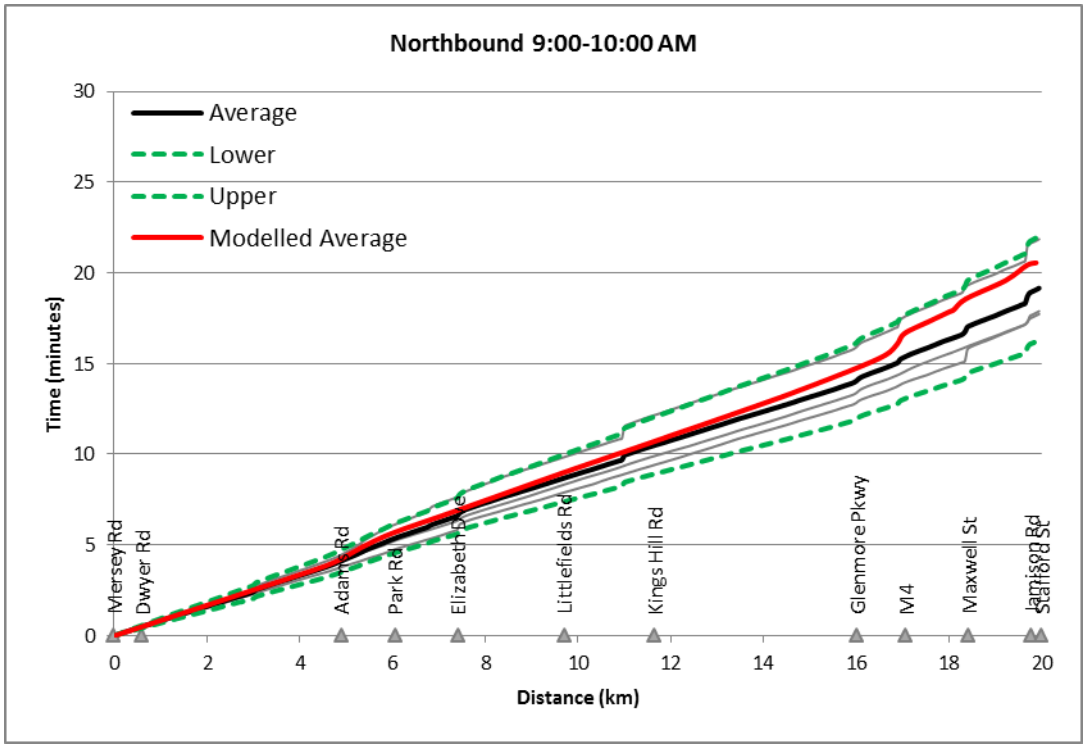


Figure 6.5 : Cumulative travel time, model vs observed – southbound, 3pm to 4pm

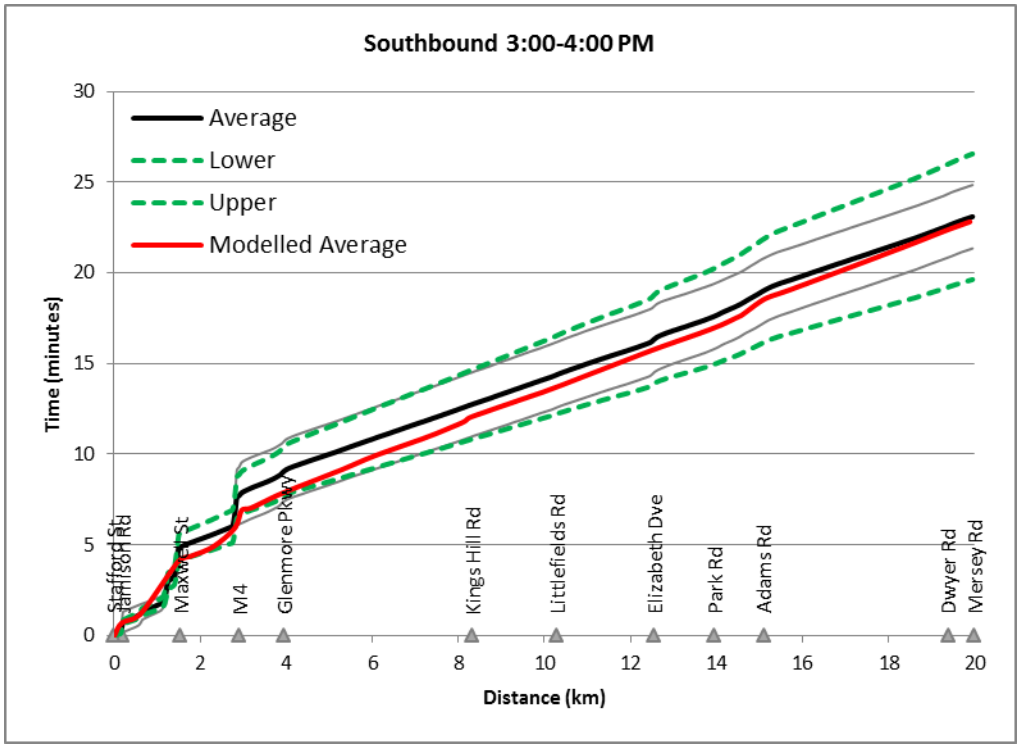


Figure 6.6 : Cumulative travel time, model vs observed – southbound, 4pm to 5pm

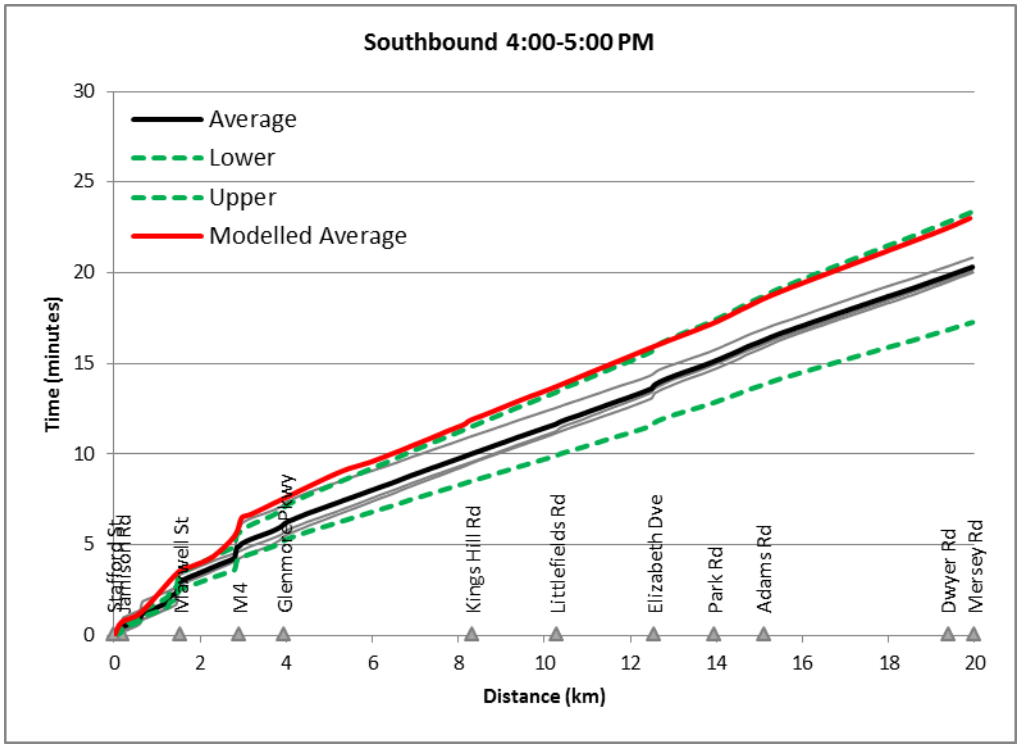


Figure 6.7 : Cumulative travel time, model vs observed – southbound, 5pm to 6pm

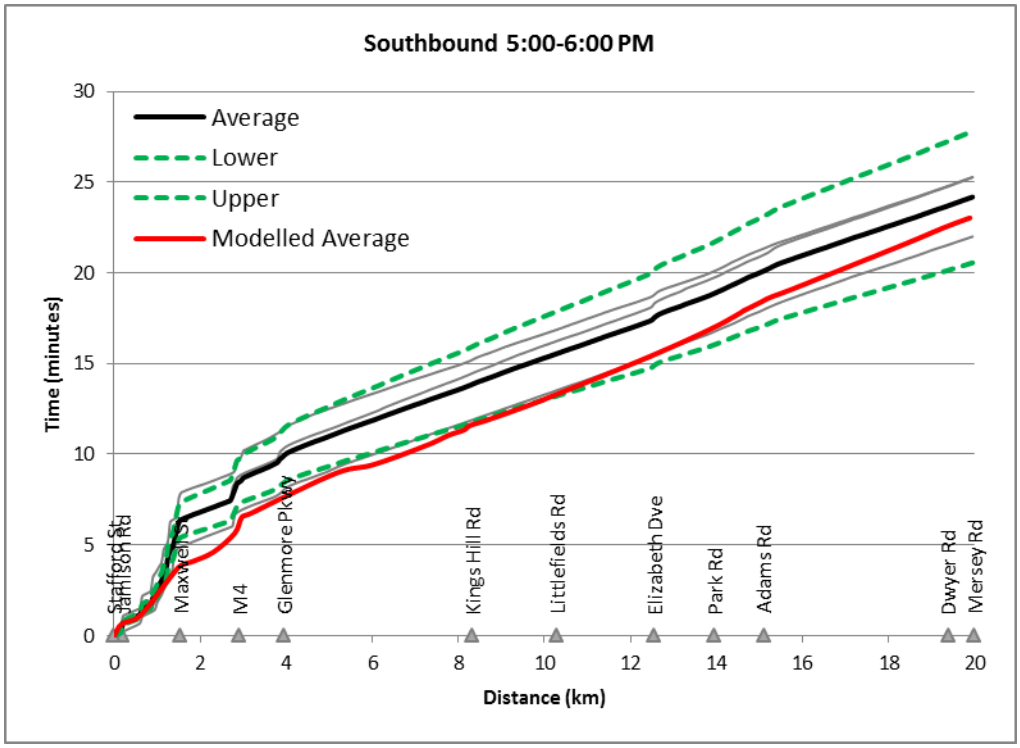
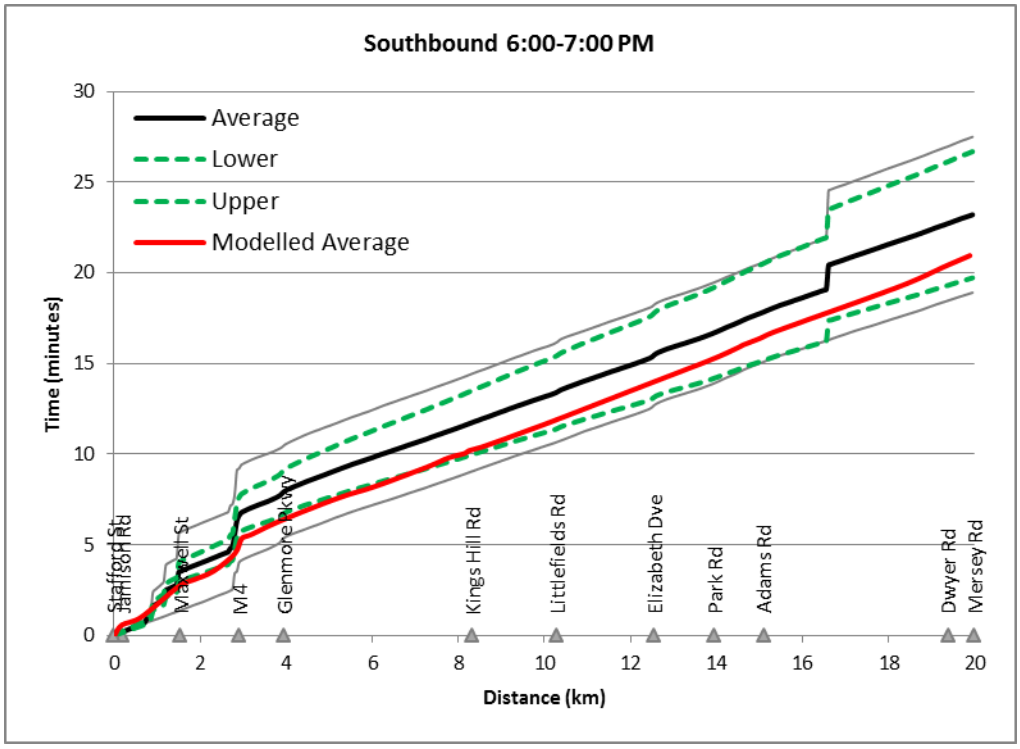


Figure 6.8 : Cumulative travel time, model vs observed – southbound, 6pm to 7pm



6.3 Congestion validation

Plots of the key congestion areas along The Northern Road are shown in Figure 6.9 and Figure 6.10. These plots show the modelled congestion in key areas including:

- The M4 Western Motorway interchange
- On the approaches to Bringelly Road / Maxwell Street
- The Glenmore Parkway roundabout
- Jamison Street

Figure 6.9 : Key congestion areas, AM peak (8:30am)

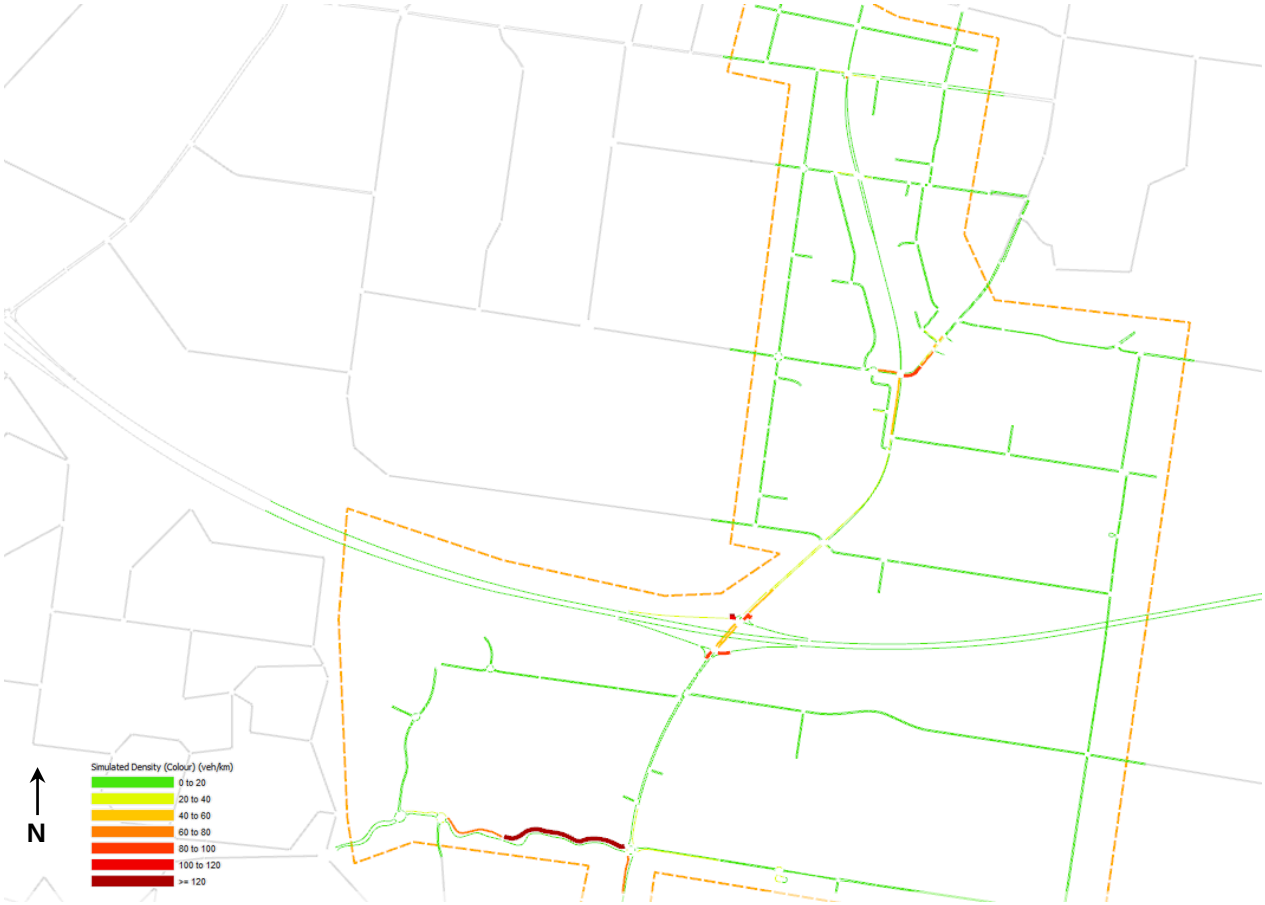


Figure 6.10 : Key congestion areas, PM peak (4:45pm)

6.4 Validation key findings

Analysis of travel time and modelled congestion along The Northern Road indicates that the model generally meets the requirements for travel time comparisons, with modelled peak direction travel times being within the required 15 per cent of observed in all cases except one. This result is close to the target and is not considered substantial difference from the observed travel time that would affect the model's suitability for this study (as discussed in Section 6.2 Travel time validation).

Furthermore, the model replicates congestion that is observed in the field, particularly around the M4 Western Motorway interchange, Bringelly Road / Maxwell Street, and the Glenmore Parkway roundabout. This indicates that the model is well-validated and suitable for use in the testing of future options.

7. Summary and conclusions

7.1 Overview

This report covers the calibration and validation results of The Northern Road Upgrade base model as part of The Northern Road Upgrade between Mersey Road, Bringelly and Jamison Road, Penrith. This model has been prepared to assist in the assessment of design options and construction staging of the Northern Road Upgrade.

7.2 Calibration findings

The results presented in this report indicate that the Northern Road Upgrade model is adequately calibrated on the basis of turning movement comparisons and meets the standards for microsimulation model calibration outlined in the Roads and Maritime *Traffic Modelling Guidelines, 2013.*

7.3 Validation findings

Comparison of modelled travel times with observed data shows that the model is generally replicating the pattern of delays observed along The Northern Road. Analysis of observed and modelled travel times shows that the model generally meets the standards for microsimulation model validation outlined in the Roads and Maritime *Traffic Modelling Guidelines, 2013,* and the single exception is close to the target and not substantial enough to affect the model's suitability. Analysis of modelled congestion and vehicle density across the network also shows that the model is replicating congestion that is observed in the field.

Based on the calibration and validation statistics presented in this report, The Northern Road Upgrade model is suitable for use in assessing future upgrade options and construction staging.

Appendix A. Detailed calibration results

THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL v03 Micro OS1

Traffic Volume Calibration Results : Total Vehicles

Intersection	Approac	Direction	Target volume								Modelled volume								Modelled vs target volume								Meets 'core area' target?								GEH : hour starting								Ave Target (vph)		Ave Modelled (vph)	
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	AM	PM	AM	PM
The Northern Rd S of Derby St	Northbound		1,265	1,495	1,526		1,190	1,320	1,166		1,213	1,447	1,564		1,226	1,247	1,204		-52	-48	38		36	-73	38		1	1	1		1	1	1		1.5	1.3	1.0		1.0	2.0	1.1		1,429	1,225	1,408	1,226
The Northern Rd S of Derby St	Southbound		882	1,030	1,002		1,343	1,470	1,424		872	1,022	1,020		1,360	1,480	1,395		-10	-8	18		17	10	-29		1	1	1		1	1	1		0.3	0.2	0.6		0.5	0.3	0.8		971	1,412	971	1,412
The Northern Rd / Jamison Rd	North	Right	80	130	173		185	240	233		99	134	173		220	239	256		19	4	0		35	-1	23		0	1	1		0	1	1		2.0	0.3	0.0		2.5	0.1	1.5		128	219	135	238
The Northern Rd / Jamison Rd	North	Through	820	946	1,016		1,573	1,479	1,411		822	972	1,037		1,553	1,513	1,349		2	26	21		-20	34	-62		1	1	1		1	1	1		0.1	0.8	0.7		0.5	0.9	1.7		927	1,488	944	1,472
The Northern Rd / Jamison Rd	North	Left	2	5	9		12	10	22		10	14	15		4	15	25		8	9	6		-8	5	3		1	1	1		1	1	1		3.3	2.9	1.7		2.8	1.4	0.6		5	15	13	15
The Northern Rd / Jamison Rd	East	Right	12	14	20		18	18	13		48	17	11		29	63	14		36	3	-9		11	45	1		0	1	1		0	0	1		6.6	0.8	2.3		2.3	7.1	0.3		15	16	25	35
The Northern Rd / Jamison Rd	East	Through	77	118	181		161	210	186		72	133	193		159	197	167		-5	15	12		-2	-13	-19		1	0	1		1	1	0		0.6	1.3	0.9		0.2	0.9	1.4		125	186	133	174
The Northern Rd / Jamison Rd	East	Left	21	28	42		66	75	38		34	42	32		90	101	53		13	14	-10		24	26	15		0	0	1		0	0	0		2.5	2.4	1.6		2.7	2.8	2.2		30	60	36	81
The Northern Rd / Jamison Rd	South	Right	20	27	36		12	9	16		22	22	36		19	15	13		2	-5	0		7	6	-3		1	1	1		1	1	1		0.4	1.0	0.0		1.8	1.7	0.8		28	12	27	16
The Northern Rd / Jamison Rd	South	Through	1,016	1,418	1,551		1,160	1,070	1,116		1,018	1,375	1,547		1,169	1,047	1,127		2	-43	-4		9	-23	11		1	1	1		1	1	1		0.1	1.2	0.1		0.3	0.7	0.3		1,328	1,115	1,313	1,114
The Northern Rd / Jamison Rd	South	Left	52	113	218		169	169	139		42	100	209		206	153	131		-10	-13	-9		37	-16	-8		1	0	1		0	1	1		1.5	1.3	0.6		2.7	1.3	0.7		128	159	117	163
The Northern Rd / Jamison Rd	West	Right	81	115	110		171	237	187		82	115	95		163	240	166		1	0	-15		-8	3	-21		1	1	0		1	1	0		0.1	0.0	1.5		0.6	0.2	1.6		102	198	97	190
The Northern Rd / Jamison Rd	West	Through	74	126	123		134	169	147		67	143	111		146	189	148		-7	17	-12		12	20	1		1	0	1		1	0	1		0.8	1.5	1.1		1.0	1.5	0.1		108	150	107	161
The Northern Rd / Jamison Rd	West	Left	115	126	139		120	169	105		155	115	128		125	205	108		40	-11	-11		5	36	3		0	1	1		1	0	1		3.4	1.0	1.0		0.5	2.6	0.3		127	131	133	146
The Northern Rd / Smith St	North	Right	31	58	81	74	107	91	135	90	35	65	75	64	116	108	122	97	4	7	-6	-10	9	17	-13	7	1	1	1	1	1	0	1	1	0.7	0.9	0.7	1.2	0.9	1.7	1.1	0.7	61	106	60	111
The Northern Rd / Smith St	North	Through	887	1,021	1,064	920	1,695	1,682	1,494	998	880	1,043	1,083	860	1,650	1,730	1,434	1,000	-7	22	19	-60	-45	48	-60	2	1	1	1	1	1	1	1	1	0.2	0.7	0.6	2.0	1.1	1.2	1.6	0.1	973	1,467	967	1,454
The Northern Rd / Smith St	North	Left	4	10	23	6	8	18	7	15	21	20	9	4	25	17	17	8	17	10	-14	-2	17	-1	10	-7	0	1	0	1	0	1	1	1	4.8	2.6	3.5	0.9	4.2	0.2	2.9	2.1	11	12	14	17
The Northern Rd / Smith St	East	Right	11	11	34	14	15	10	12	10	22	21	33	11	18	19	14	4	11	10	-1	-3	3	9	2	-6	0	1	1	1	1	1	1	1	2.7	2.5	0.2	0.8	0.7	2.4	0.6	2.3	18	12	22	14
The Northern Rd / Smith St	East	Through	18	29	90	37	81	56	72	45	25	45	87	31	72	56	72	34	7	16	-3	-6	-9	0	0	-11	1	0	1	1	1	1	1	0	1.5	2.6	0.3	1.0	1.0	0.0	0.0	1.8	44	64	47	59
The Northern Rd / Smith St	East	Left	5	16	19	10	20	20	8	4	10	14	17	10	13	21	13	5	5	-2	-2	0	-7	1	5	1	1	1	1	1	1	1	1	1	1.8	0.5	0.5	0.0	1.7	0.2	1.5	0.5	13	13	13	13
The Northern Rd / Smith St	South	Right	10	25	58	20	22	18	21	8	21	29	42	24	29	13	25	15	11	4	-16	4	7	-5	4	7	0	1	0	1	1	1	1	1	2.8	0.8	2.3	0.9	1.4	1.3	0.8	2.1	28	17	29	21
The Northern Rd / Smith St	South	Through	1,043	1,494	1,706	1,128	1,263	1,186	1,217	857	1,030	1,442	1,673	1,152	1,294	1,157	1,222	868	-13	-52	-33	24	31	-29	5	11	1	1	1	1	1	1	1	1	0.4	1.4	0.8	0.7	0.9	0.8	0.1	0.4	1,343	1,131	1,324	1,135
The Northern Rd / Smith St	South	Left	25	27	53	46	65	59	61	33	30	45	46	33	66	59	80	45	5	18	-7	-13	1	0	19	12	1	0	1	0	1	1	0	0	1.0	3.0	1.0	2.1	0.1	0.0	2.3	1.9	38	55	39	63
The Northern Rd / Smith St	West	Right	44	62	65	43	92	106	86	39	37	51	78	37	97	86	88	36	-7	-11	13	-6	5	-20	2	-3	1	0	0	1	1	0	1	1	1.1	1.5	1.5	0.9	0.5	2.0	0.2	0.5	54	81	51	77
The Northern Rd / Smith St	West	Through	35	76	147	55	74	85	78	63	45	87	154	77	81	91	92	67	10	11	7	22	7	6	14	4	1	0	1	0	1	1	0	1	1.6	1.2	0.6	2.7	0.8	0.6	1.5	0.5	78	75	91	83
The Northern Rd / Smith St	West	Left	34	53	65	52	64	52	43	33	29	48	71	52	57	61	41	26	-5	-5	6	0	-7	9	-2	-7	1	1	1	1	1	1	1	1	0.9	0.7	0.7	0.0	0.9	1.2	0.3	1.3	51	48	50	46
The Northern Rd / Maxwell St / Bringelly Rd	North	Right	22	30	63		111	94	92		22	35	42		91	81	96		0	5	-21		-20	-13	4		1	1	0		0	0	1		0.0	0.9	2.9		2.0	1.4	0.4		38	99	33	89
The Northern Rd / Maxwell St / Bringelly Rd	North	Through	897	1,043	1,064		1,673	1,701	1,480		895	1,052	1,116		1,628	1,735	1,432		-2	9	52		-45	34	-48		1	1	1		1	1	1		0.1	0.3	1.6		1.1	0.8	1.3		1,001	1,618	1,021	1,598
The Northern Rd / Maxwell St / Bringelly Rd	North	Left	18	26	22		22	13	18		16	19	22		22	19	17		-2	-7	0		0	6	-1		1	1	1		1	1	1		0.5	1.5	0.0		0.0	1.5	0.2		22	18	19	19
The Northern Rd / Maxwell St / Bringelly Rd	East	Right	8	37	64		51	38	15		16	37	46		58	54	18		8	0	-18		7	16	3		1	1	0		1	0	1		2.3	0.0	2.4		0.9	2.4	0.7		36	35	33	43
The Northern Rd / Maxwell St / Bringelly Rd	East	Through	50	103	175		215	188	228		39	107	184		201	201	237		-11	4	9		-14	13	9		0	1	1		1	1	1		1.6	0.4	0.7		1.0	0.9	0.6		109	210	110	213
The Northern Rd / Maxwell St / Bringelly Rd	East	Left	182	204	258		370	418	333		200	212	257		333	440	309		18	8	-1		-37	22	-24		1	1	1		1	1	1		1.3	0.6	0.1		2.0	1.1	1.3		215	374	223	361
The Northern Rd / Maxwell St / Bringelly Rd	South	Right	278	447	498		259	245	265		278	412	506		246	238	277		0	-35	8		-13	-7	12		1	1	1		1	1	1		0.0	1.7	0.4		0.8	0.5	0.7		408	256	399	254
The Northern Rd / Maxwell St / Bringelly Rd	South	Through	1,044	1,490	1,724		1,249	1,188	1,239		1,002	1,463	1,710		1,299	1,127	1,257		-42	-27	-14		50	-61	18		1	1	1		1	1	1		1.3	0.7	0.3		1.4	1.8	0.5		1,419	1,225	1,392	1,228
The Northern Rd / Maxwell St / Bringelly Rd	South	Left	44	80	68		128	159	127		52	81	65		126	163	122		8	1	-3		-2	4	-5		1	1	1		1	1	1		1.2	0.1	0.4		0.2	0.3	0.4		64	138	66	137
The Northern Rd / Maxwell St / Bringelly Rd	West	Right	277	298	236		237	272	254		295	272	215		245	278	261		18	-26	-21		8	6	7		1	1	1		1	1	1		1.1	1.5	1.4		0.5	0.4	0.4		270	254	261	261
The Northern Rd / Maxwell St / Bringelly Rd	West	Through	57	120	112		107	113	88		54	117	121		126	133	106		-3	-3	9		19	20	18		1	1	1		0	0	0		0.4	0.3	0.8		1.8	1.8	1.8		96	103	97	122
The Northern Rd / Maxwell St / Bringelly Rd	West	Left	26	19	31		50	38	45		60	28	31		48	49	44		34	9	0		-2	11	-1		0	1	1		1	0	1		5.2	1.9	0.0		0.3	1.7	0.1		25	44	40	47
The Northern Rd / Castle Rd / Aspen St	North	Through	1,345	1,501	1,487	1,228	2,218	2,351	2,045	1,329	1,356	1,462	1,513	1,197	2,120	2,411	1,975	1,321	11	-39	26	-31	-98	60	-70	-8	1	1	1	1	1	1	1	1	0.3	1.0	0.7	0.9	2.1	1.2	1.6	0.2	1,390	1,986	1,382	1,957
The Northern Rd / Castle Rd / Aspen St	North	Left	11	44	71	41	62	40	22	13	34	71	70	40	66	54	37	24	23	27	-1	-1	4	14	15	11	0	0	1	1	1	0	0	0	4.8	3.6	0.1	0.2	0.5	2.0	2.8	2.6	42	34	54	45
The Northern Rd / Castle Rd / Aspen St	East	Right	21	13	5	26	9	8	7	11	26	28	11	28	28	18	17	9	5	15	6	2	19	10	10	-2	1	0	1	1	0	1	1	1	1.0	3.3	2.1	0.4	4.4	2.8	2.9	0.6	16	9	23	18
The Northern Rd / Castle Rd / Aspen St	East	Left	50	95	82	46	90	74	48	41	40	80	96	42	81	72	54	34	-10	-15	14	-4	-9	-2	6	-7	1	0	0	1	1	1	1	1	1.5	1.6	1.5	0.6	1.0	0.2	0.8	1.1	68	63	65	60
The Northern Rd / Castle Rd / Aspen St	S+W to E		50	52	53	47	45	44	43	35	31	58	47	29	43	38	51	34	-19	6	-6	-18	-2	-6	8	-1	0	1	1	0	1	1	1	1	3.0	0.8	0.8	2.9	0.3	0.9	1.2	0.2	51	42	41	42
The Northern Rd / Castle Rd / Aspen St	S to N+E		1,351	2,044	2,326	1,515	1,628	1,590	1,619	1,076	1,313	2,003	2,290	1,557	1,663	1,535	1,710	1,073	-38	-41	-36	42	35	-55	91	-3	1	1	1	1	1	1	1	1	1.0	0.9	0.7	1.1	0.9	1.4	2.2	0.1	1,809	1,478	1,791	1,495
The Northern Rd / Castle Rd / Aspen St	South	Left	110	135	206	120	212	202	204	129	112	112	255	128	216	209	227	140	2	-23	49	8	4	7	23	11	1	0	0	1	1	1	0	1	0.2	2.1	3.2	0.7	0.3	0.5	1.6	0.9	143	187	152	198
The Northern Rd / Castle Rd / Aspen St	W to N+E		45	12	11	30	45	40	46	41	4	0	0	4	12	14	16	11	-41	-12	-11	-26	-33	-26	-30	-30	0	0	0	0	0	0	0	0	8.3	4.9	4.7	6.3	6.2	5.0	5.4	5.9	25	43	2	13
The Northern Rd / Castle Rd / Aspen St	S+W to N		1,346	2,004	2,284	1,498	1,628	1,586	1,622	1,082	1,288	1,938	2,251	1,531	1,638	1,511	1,677	1,049	-58	-66	-33	33	10	-75	55	-33	1	1	1	1	1	1	1	1	1.6	1.5	0.7	0.8	0.2	1.9	1.4	1.0	1,783	1,480	1,752	1,469
The Northern Rd / Tukara Rd / Frogmore Rd	North	Through	1,381	1,515	1,485		2,282	2,388	2,069		1,364	1,477	1,504		2,159	2,472	2,003		-17	-38	19		-123	84	-66		1	1	1		0	1	1		0.5	1.0	0.5		2.6	1.7	1.5		1,460	2,246	1,448	2,211
The Northern Rd / Tukara Rd / Frogmore Rd	North	Left	15	81	85		27	37	24		27	69	87		19	36	26		12	-12	2		-8	-1	2		0	0	1		1	1	1		2.6	1.4	0.2		1.7	0.2	0.4		60	29	61	27
The Northern Rd / Tukara Rd / Frogmore Rd	East	Right	3	19	45		23	20	18		14	30	34		29	24	30		11	11	-11		6	4	12		0	0	0		1	1	0		3.8	2.2	1.8		1.2	0.9	2.4		22	20	26	28
The Northern Rd / Tukara Rd / Frogmore Rd	East	Left	36	91	110		74	28	55		44	86	98		84	35	43		8	-5	-12		10	7	-12		1	1	0		1	1	0		1.3	0.5	1.2		1.1	1.2	1.7		79	52	76	54
The Northern Rd / Tukara Rd / Frogmore Rd	South	Right	16	107	82		25	21	23		24	99	97		27	31	29		8	-8	15		2	10	6		1	1	0		1	1	1		1.8	0.8	1.6		0.4	2.0	1.2		68	23	73	29
The Northern Rd / Tukara Rd / Frogmore Rd	South	Through	1,391	2,080	2,393		1,767	1,703	1,745		1,347	1,995	2,404		1,782	1,672	1,819		-44	-85	11		15	-31	74		1	1	1		1	1	1		1.2	1.9	0.2		0.4	0.8	1.8		1,955	1,738	1,915	1,758
The Northern Rd / Tukara Rd / Frogmore Rd	South	Left	93	241	319		372	395	416		100	249	329		384	389	425		7	8	10		12	-6	9		1	1	1		1	1	1		0.7	0.5	0.6		0.6	0.3	0.4		218	394	226	399
The Northern Rd / Tukara Rd / Frogmore Rd	West	Left	66	79	97		49	69	61		72	91	119		70	61	68		6	12	22		21	-8	7		1	0	0		0	1	1		0.7	1.3	2.1		2.7	1.0	0.9		81	60	94	66
The Northern Rd / M4 WB ramps	North	Through	520	735	732	551	1,348	1,384	1,263	878	520	689	791	559	1,248	1,462	1,163	868	0	-46	59	8	-100	78	-100	-10	1	1	1	1	1	1	1	1	0.0	1.7	2.1	0.3	2.8	2.1	2.9	0.3	635	1,218	640	1,185
The Northern Rd / M4 WB ramps	North	Left	897	872	863	729	1,008	1,032	861	515	919	831	859	698	1,004	1,040	866	550	22	-41	-4	-31	-4	8	5	35	1	1	1	1	1	1	1	1	0.7	1.4	0.1	1.2	0.1	0.2	0.2	1.5	840	854	827	865
The Northern Rd / M4 WB ramps	South	Right	676	609	518	311	314	255	263	159	707	564	511	321	351	243	280	165	31	-45	-7	10	37	-12	17	6	1	1	1	1	0	1	1	1	1.2	1.9	0.3	0.6	2.0	0.8	1.0	0.5	529	248	526	260
The Northern Rd / M4 WB ramps	South	Through	1,305	2,019	2,270	1,464	1,916	1,884	1,951	1,281	1,282	1,972	2,282	1,463	1,949	1,879	1,979	1,255	-23	-47	12	-1	33	-5	28	-26	1	1	1	1	1	1	1	1	0.6	1.1	0.3	0.0	0.8	0.1	0.6	0.7	1,765	1,758	1,750	1,766
The Northern Rd / M4 WB ramps	West	Right	222	373	355	183	288	317	279	201	196	363	347	186	261	301	291	205	-26	-10	-8	3	-27	-16	12	4	0	1	1	1	1	1	1	1	1.8	0.5	0.4	0.2	1.6	0.9	0.7	0.3	283	271	273	265
The Northern Rd / M4 WB ramps	West	Left	195	409	524	300	248	235	233	145	188	386	553	307	246	231	270	160	-7	-23	29	7	-2	-4	37	15	1	1	1	1	1	1	0	0	0.5	1.2	1.2	0.4	0.1	0.3	2.3	1.2	357	215	359	227
The Northern Rd / M4 EB ramps	North	Right	51	143	178	137	337	377	306	203	54	128	180	129	340	392	294	194	3	-15	2	-8	3	15	-12	-9	1	0	1	1	1	1	1	1	0.4	1.3	0.1	0.7	0.2	0.8	0.7	0.6	127	306	123	305
The Northern Rd / M4 EB ramps	North	Through	691	965	909	597	1,299	1,324	1,236	876	653	926	941	632	1,179	1,359	1,193	878	-38	-39	32	35	-120	35	-43	2	1	1	1	1	0	1	1	1	1.5	1.3	1.1	1.4	3.4	1.0	1.2	0.1	791	1,184	788	1,152
The Northern Rd / M4 EB ramps	East	Right	514	849	930	764	1,058	1,089	1,153	742	530	882	947	787	1,113	1,089	1,134	740	16	33	17	23	55	0	-19	-2	1	1	1	1	1	1	1	1	0.7	1.1	0.6	0.8	1.7	0.0	0.6	0.1	764	1,011	787	1,019
The Northern Rd / M4 EB ramps	East	Left	150	205	195	178	529	649	696	478	170	219	209	168	570	680	708	474	20	14	14	-10	41	31	12	-4	0	1	1	1	1	1	1	1	1.6	1.0	1.0	0.8	1.7	1.2	0.5	0.2	182	588	192	608
The Northern Rd / M4 EB ramps	South	Through	1,467	1,779	1,858	1,011	1,172	1,050	1,061	698	1,456	1,680	1,833	981	1,179	1,027	1,119	681	-11	-99	-25	-30	7	-23	58	-17	1	1	1	1	1	1	1	1	0.3	2.4	0.6	1.0	0.2	0.7	1.8	0.6	1,529	995	1,488	1,002
The Northern Rd / M4 EB ramps	South	Left	151	242	333	339	393	440	360	319	144	244	347	322	419	449	403	349	-7	2	14	-17	26	9	43	30	1	1	1	1	1	1	0	1	0.6	0.1	0.8	0.9	1.3	0.4	2.2	1.6	266	378	264	405
The Northern Rd / Homestead Rd / Garswood Rd	North	Through	815	1,121	1,025	743	1,745	1,918	1,851	1,300	792	1,095	1,084	767	1,631	1,988	1,816	1,280	-23	-26	59	24	-114	70	-35	-20	1	1	1	1	0	1	1	1	0.8	0.8	1.8	0.9	2.8	1.6	0.8	0.6	926	1,704	935	1,679
The Northern Rd / Homestead Rd / Garswood Rd	North	Left	25	48	79	32	83	55	80	55	30	51	66	33	99	67	86	70	5	3	-13	1	16	12	6	15	1	1	0	1	0	0	1	0	1.0	0.4	1.5	0.2	1.7	1.5	0.7	1.9	46	68	45	81
The Northern Rd / Homestead Rd / Garswood Rd	East	Right	27	20	23	25	64	46	45	31	28	29	25	23	75	53	61	28	1	9	2	-2	11	7	16	-3	1	1	1	1	0	1	0	1	0.2	1.8	0.4	0.4	1.3	1.0	2.2	0.6	24	47	26	54
The Northern Rd / Homestead Rd / Garswood Rd	East	Left	17	33	37	29	134	113	87	45	25	53	42	49	137	104	88	53	8	20	5	20	3	-9	1	8	1	0	1	0	1	1	1	1	1.7	3.0	0.8	3.2	0.3	0.9	0.1	1.1	29	95	42	96
The Northern Rd / Homestead Rd / Garswood Rd	South	Right	58	148	70	25	51	29	22	18	52	156	127	24	34	18	36	11	-6	8	57	-1	-17	-11	14	-7	1	1	0	1	0	0	0	1	0.8	0.6	5.7	0.2	2.6	2.3	2.6	1.8	75	30	90	25
The Northern Rd / Homestead Rd / Garswood Rd	South	Through	1,376	1,764	1,900	1,153	1,322	1,315	1,240	856	1,358	1,678	1,920	1,051	1,350	1,301	1,305	848	-18	-86	20	-102	28	-14	65	-8	1	1	1	0	1	1	1	1	0.5	2.1	0.5	3.1	0.8	0.4	1.8	0.3	1,548	1,183	1,502	1,201
The Northern Rd / Homestead Rd / Garswood Rd	South	Left	38	49	57	38	153	147	115	91	33	51	57	22	133	138	109	71	-5	2	0	-16	-20	-9	-6	-20	1	1	1	0	0	1	1	0	0.8	0.3	0.0	2.9	1.7	0.8	0.6	2.2	46	127	41	113
The Northern Rd / Homestead Rd / Garswood Rd	West	Left	214	236	268	172	179	129	135	129	219	214	259	197	179	129	147	140	5	-22	-9	25	0	0	12	11	1	1	1	0	1	1	1	1	0.3	1.5	0.6	1.8	0.0	0.0	1.0	0.9	223	143	222	149
The Northern Rd / Glenmore Pkwy / Wentworth Rd	N to S,W,N		881	1,001	884	783	1,520	1,796	1,764	1,148	804	963	947	778	1,436	1,885	1,669	1,134	-77	-38	63	-5	-84	89	-95	-14	1	1	1	1	1	1	1	1	2.7	1.2	2.1	0.2	2.2	2.1	2.3	0.4	887	1,557	873	1,531
The Northern Rd / Glenmore Pkwy / Wentworth Rd	S,E,N to N		841	1,294	1,519	762	1,128	1,071	1,076	574	821	1,263	1,516	732	1,172	1,103	1,063	570	-20	-31	-3	-30	44	32	-13	-4	1	1	1	1	1	1	1	1	0.7	0.9	0.1	1.1	1.3	1.0	0.4	0.2	1,104	962	1,083	977
The Northern Rd / Glenmore Pkwy / Wentworth Rd	Circ past N		25	109	93	16	45	26	29	11	38	129	83	32	33	24	56	22	13	20	-10	16	-12	-2	27	11	0	0	1	0	0	1	0	0	2.3	1.8	1.1	3.3	1.9	0.4	4.1	2.7	61	28	71	34
The Northern Rd / Glenmore Pkwy / Wentworth Rd	W to N		619	656	597	303	317	331	381	312	615	629	598	345	357	344	362	356	-4	-27	1	42	40	13	-19	44	1	1	1	0	0	1	1	0	0.2	1.1	0.0	2.3	2.2	0.7	1.0	2.4	544	335	547	355
The Northern Rd / Glenmore Pkwy / Wentworth Rd	E to W,N,E		32	229	338	60	264	121	119	48	30	243	306	85	276	109	123	42	-2	14	-32	25	12	-12	4	-6	1	1	1	0	1	1	1	1	0.4	0.9	1.8	2.9	0.7	1.1	0.4	0.9	165	138	166	138
The Northern Rd / Glenmore Pkwy / Wentworth Rd	W,S,E to E		59	295	204	33	99	52	55	25	81	283	205	47	79	43	74	37	22	-12	1	14	-20	-9	19	12	0	1	1	0	0	1	0	0	2.6	0.7	0.1	2.2	2.1	1.3	2.4	2.2	148	58	154	58
The Northern Rd / Glenmore Pkwy / Wentworth Rd	Circ past E		119	136	114	36	44	37	38	23	118	141	121	33	28	39	54	19	-1	5	7	-3	-16	2	16	-4	1	1	1	1	0	1	0	1	0.1	0.4	0.6	0.5	2.7	0.3	2.4	0.9	101	36	103	35
The Northern Rd / Glenmore Pkwy / Wentworth Rd	N to E		55	207	197	43	195	60	27	34	44	190	237	52	204	64	38	50	-11	-17	40	9	9	4	11	16	0	1	0	1	1	1	0	0	1.6	1.2	2.7	1.3	0.6	0.5	1.9	2.5	126	79	131	89
The Northern Rd / Glenmore Pkwy / Wentworth Rd	S to N,E,S		815	1,188	1,315	684	922	927	946	481	799	1,167	1,322	655	935	946	971	499	-16	-21	7	-29	13	19	25	18	1	1	1	1	1	1	1	1	0.6	0.6	0.2	1.1	0.4	0.6	0.8	0.8	1,001	819	986	838
The Northern Rd / Glenmore Pkwy / Wentworth Rd	N,W,S to S		848	983	802	618	1,152	1,199	1,054	629	775	962	827	601	1,061	1,266	1,018	591	-73	-21	25	-17	-91	67	-36	-38	1	1	1	1	1	1	1	1	2.6	0.7	0.9	0.7	2.7	1.9	1.1	1.5	813	1,009	791	984
The Northern Rd / Glenmore Pkwy / Wentworth Rd	Circ past S		152	154	196	201	412	634	748	542	148	142	240	211	405	657	703	566	-4	-12	44	10	-7	23	-45	24	1	1	0	1	1	1	1	1	0.3	1.0	3.0	0.7	0.3	0.9	1.7	1.0	176	584	185	583
The Northern Rd / Glenmore Pkwy / Wentworth Rd	E to S		14	43	24	18	42	19	17	15	32	23	30	11	28	25	20	18	18	-20	6	-7	-14	6	3	3	0	0	1	1	0	1	1	1	3.8	3.5	1.2	1.8	2.4	1.3	0.7	0.7	25	23	24	23
The Northern Rd / Glenmore Pkwy / Wentworth Rd	W to E,S,W		153	322	225	53	98	63	64	37	161	294	243	48	74	58	72	34	8	-28	18	-5	-24	-5	8	-3	1	1	1	1	0	1	1	1	0.6	1.6	1.2	0.7	2.6	0.6	1.0	0.5	188	66	187	60
The Northern Rd / Glenmore Pkwy / Wentworth Rd	E,N,W to W		133	168	237	167	425	585	708	486	118	157	270	188	410	586	678	516	-15	-11	33	21	-15	1	-30	30	0	1	0	0	1	1	1	1	1.3	0.9	2.1	1.6	0.7	0.0	1.1	1.3	176	551	183	548
The Northern Rd / Glenmore Pkwy / Wentworth Rd	Circ past W		51	215	297	94	251	170	159	104	60	226	277	109	271	180	147	93	9	11	-20	15	20	10	-12	-11	1	1	1	0	1	1	1	0	1.2	0.7	1.2	1.5	1.2	0.8	1.0	1.1	164	171	168	173
The Northern Rd / Glenmore Pkwy / Wentworth Rd	S to W		90	116	112	130	165	229	171	120	89	130	104	120	174	214	204	138	-1	14	-8	-10	9	-15	33	18	1	0	1	1	1	1	0	0	0.1	1.3	0.8	0.9	0.7	1.0	2.4	1.6	112	171	111	183
The Northern Rd / Bradley St	North	Right	119	275	294	208	373	431	412	276	124	268	293	210	339	462	385	276	5	-7	-1	2	-34	31	-27	0	1	1	1	1	1	1	1	1	0.5	0.4	0.1	0.1	1.8	1.5	1.4	0.0	224	373	224	366
The Northern Rd / Bradley St	North	Through	745	752	532	428	824	787	663	368	685	728	558	400	743	832	673	333	-60	-24	26	-28	-81	45	10	-35	1	1	1	1	1	1	1	1	2.2	0.9	1.1	1.4	2.9	1.6	0.4	1.9	614	661	593	645
The Northern Rd / Bradley St	South	Through	637	878	819	563	852	859	776	470	646	894	824	520	895	847	797	475	9	16	5	-43	43	-12	21	5	1	1	1	1	1	1	1	1	0.4	0.5	0.2	1.8	1.5	0.4	0.7	0.2	724	739	721	754
The Northern Rd / Bradley St	South	Left	20	20	37	20	65	78	115	47	25	27	33	19	61	75	131	46	5	7	-4	-1	-4	-3	16	-1	1	1	1	1	1	1	0	1	1.1	1.4	0.7	0.2	0.5	0.3	1.4	0.1	24	76	26	78
The Northern Rd / Bradley St	West	Right	106	96	82	48	70	46	125	175	113	114	90	47	93	60	122	150	7	18	8	-1	23	14	-3	-25	1	0	1	1	0	0	1	0	0.7	1.8	0.9	0.1	2.5	1.9	0.3	2.0	83	104	91	106
The Northern Rd / Bradley St	West	Left	268	426	608	251	235	297	341	131	257	427	568	259	221	330	350	146	-11	1	-40	8	-14	33	9	15	1	1	1	1	1	0	1	0	0.7	0.0	1.6	0.5	0.9	1.9	0.5	1.3	388	251	378	262

THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL

Traffic Volume Calibration Results : Total Vehicles

Intersection	Approach	Direction	Target volume								Modelled volume								Modelled vs target volume							
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00
The Northern Rd / Defense Establishments Gates	North	Through	736	752	547	451	884	824	778	540	688	753	558	424	818	878	774	479	-48	1	11	-27	-66	54	-4	-61
The Northern Rd / Defense Establishments Gates	North	Left	115	96	67	25	11	9	10	3	115	84	92	30	19	8	25	11	0	-12	25	5	8	-1	15	8
The Northern Rd / Defense Establishments Gates	East	Right	7	17	93	16	102	85	39	20	26	22	96	23	120	75	36	17	19	5	3	7	18	-10	-3	-3
The Northern Rd / Defense Establishments Gates	East	Left	8	3	6	7	13	16	12	2	4	7	6	4	12	12	7	3	-4	4	0	-3	-1	-4	-5	1
The Northern Rd / Defense Establishments Gates	South	Right	34	29	17	9	0	0	0	0	22	17	38	12	1	2	3	1	-12	-12	21	3	1	2	3	1
The Northern Rd / Defense Establishments Gates	South	Through	650	881	763	567	816	852	852	496	645	906	756	519	841	839	894	503	-5	25	-7	-48	25	-13	42	7
The Northern Rd / Chain-O-Ponds Rd	North	Right	2	4	9	13	11	6	11	13	6	14	6	2	12	19	11	8	4	10	-3	-11	1	13	0	-5
The Northern Rd / Chain-O-Ponds Rd	North	Through	742	751	544	445	886	832	779	528	687	751	558	423	820	868	778	479	-55	0	14	-22	-66	36	-1	-49
The Northern Rd / Chain-O-Ponds Rd	South	Through	681	891	767	567	801	842	850	490	663	908	767	524	833	838	864	483	-18	17	0	-43	32	-4	14	-7
The Northern Rd / Chain-O-Ponds Rd	South	Left	0	1	2	2	2	1	2	1	1	3	0	0	1	0	0	8	1	2	-2	-2	-1	-1	-2	7
The Northern Rd / Chain-O-Ponds Rd	West	Right	0	3	2	0	3	1	1	2	1	3	6	0	4	0	0	1	1	0	4	0	1	-1	-1	-1
The Northern Rd / Chain-O-Ponds Rd	West	Left	3	19	13	9	15	8	2	6	7	12	17	6	14	12	18	12	4	-7	4	-3	-1	4	16	6
The Northern Rd / Kings Hill Rd	North	Right	31	39	49	56	132	122	121	64	55	54	57	51	116	110	141	93	24	15	8	-5	-16	-12	20	29
The Northern Rd / Kings Hill Rd	North	Through	675	707	480	383	711	704	570	326	638	689	489	369	670	740	543	313	-37	-18	9	-14	-41	36	-27	-13
The Northern Rd / Kings Hill Rd	South	Through	530	714	644	485	697	764	770	350	508	745	651	434	722	763	764	382	-22	31	7	-51	25	-1	-6	32
The Northern Rd / Kings Hill Rd	South	Left	2	2	3	4	5	6	3	2	6	2	0	2	2	0	0	0	4	0	-3	-2	-3	-6	-3	-2
The Northern Rd / Kings Hill Rd	West	Right	2	1	5	4	2	6	3	4	4	1	4	0	0	1	3	0	2	0	-1	-4	-2	-5	0	-4
The Northern Rd / Kings Hill Rd	West	Left	104	150	119	58	62	60	47	37	145	148	85	70	83	52	62	75	41	-2	-34	12	21	-8	15	38
The Northern Rd / Longview Rd	North	Right	2	2	1	2	3	2	6	2	1	7	8	3	12	8	10	7	-1	5	7	1	9	6	4	5
The Northern Rd / Longview Rd	North	Through	675	705	484	385	710	708	567	329	645	682	480	376	661	727	542	303	-30	-23	-4	-9	-49	19	-25	-26
The Northern Rd / Longview Rd	South	Through	530	713	640	489	700	766	768	350	510	749	643	434	713	755	757	364	-20	36	3	-55	13	-11	-11	14
The Northern Rd / Longview Rd	South	Left	0	1	0	1	3	2	7	1	2	0	1	1	2	0	1	0	2	-1	1	0	-1	-2	-6	-1
The Northern Rd / Longview Rd	West	Right	1	0	3	3	3	3	2	0	3	4	0	4	6	1	0	0	2	4	-3	1	3	-2	-2	0
The Northern Rd / Longview Rd	West	Left	2	2	7	0	2	4	5	2	5	3	2	2	10	4	12	9	3	1	-5	2	8	0	7	7
The Northern Rd / Gates Rd	North	Through	663	692	474	376	701	684	548	314	639	669	476	362	644	718	535	284	-24	-23	2	-14	-57	34	-13	-30
The Northern Rd / Gates Rd	North	Left	7	4	2	2	12	8	6	5	1	4	5	2	12	4	13	7	-6	0	3	0	0	-4	7	2
The Northern Rd / Gates Rd	East	Right	7	5	9	8	5	11	5	5	9	8	6	1	11	8	6	3	2	3	-3	-7	6	-3	1	-2
The Northern Rd / Gates Rd	East	Left	8	9	6	2	5	3	1	0	2	1	3	2	5	0	7	3	-6	-8	-3	0	0	-3	6	3
The Northern Rd / Gates Rd	South	Right	4	1	3	2	9	3	6	3	4	2	0	5	2	4	1	3	0	1	-3	3	-7	1	-5	0
The Northern Rd / Gates Rd	South	Through	527	739	603	469	684	755	726	339	490	746	629	434	691	753	730	356	-37	7	26	-35	7	-2	4	17
The Northern Rd / Littlefields Rd	North	Right	12	9	21	20	32	27	26	18	20	12	17	17	27	44	25	17	8	3	-4	-3	-5	17	-1	-1
The Northern Rd / Littlefields Rd	North	Through	659	692	459	358	674	660	523	296	618	656	464	349	629	666	520	274	-41	-36	5	-9	-45	6	-3	-22
The Northern Rd / Littlefields Rd	South	Through	509	706	587	452	664	750	717	330	465	716	594	421	662	736	718	334	-44	10	7	-31	-2	-14	1	4
The Northern Rd / Littlefields Rd	South	Left	24	24	38	19	42	54	52	19	23	21	31	23	42	63	53	28	-1	-3	-7	4	0	9	1	9
The Northern Rd / Littlefields Rd	West	Right	40	64	43	21	24	33	19	14	38	61	39	22	27	26	27	18	-2	-3	-4	1	3	-7	8	4
The Northern Rd / Littlefields Rd	West	Left	22	34	19	19	29	8	15	12	30	33	34	25	36	27	12	15	8	-1	15	6	7	19	-3	3
The Northern Rd / Elizabeth Dr	In from N		682	739	514	400	676	680	544	311	656	731	512	357	639	688	553	295	-26	-8	-2	-43	-37	8	9	-16
The Northern Rd / Elizabeth Dr	Out to N		497	690	630	479	694	799	729	334	503	744	600	422	692	803	750	349	6	54	-30	-57	-2	4	21	15
The Northern Rd / Elizabeth Dr	Circ past N		325	376	208	112	141	109	114	42	341	409	199	121	133	131	144	40	16	33	-9	9	-8	22	30	-2
The Northern Rd / Elizabeth Dr	In from E		213	204	244	205	463	512	520	250	227	209	237	177	454	486	519	246	14	5	-7	-28	-9	-26	-1	-4
The Northern Rd / Elizabeth Dr	Out to E		570	669	393	221	263	243	232	100	592	711	363	224	243	261	266	98	22	42	-30	3	-20	18	34	-2
The Northern Rd / Elizabeth Dr	Circ past E		437	446	329	291	554	546	426	253	405	430	347	254	528	557	432	237	-32	-16	18	-37	-26	11	6	-16
The Northern Rd / Elizabeth Dr	In from S		705	950	701	474	639	676	605	288	722	1,024	685	447	623	696	634	304	17	74	-16	-27	-16	20	29	16
The Northern Rd / Elizabeth Dr	Out to S		533	534	436	379	821	826	708	415	512	508	473	331	781	804	689	403	-21	-26	37	-48	-40	-22	-19	-12
The Northern Rd / Elizabeth Dr	Circ past S		117	116	137	117	196	232	238	88	120	131	112	97	201	238	263	81	3	15	-25	-20	5	6	25	-7
The Northern Rd / Park Rd	North	Right	70	63	88	74	223	227	238	131	57	69	95	72	226	195	230	135	-13	6	7	-2	3	-32	-8	4
The Northern Rd / Park Rd	North	Through	469	462	342	298	571	579	471	279	445	430	383	266	557	580	479	271	-24	-32	41	-32	-14	1	8	-8
The Northern Rd / Park Rd	South	Through	446	643	511	370	517	576	522	252	414	695	516	360	501	619	520	266	-32	52	5	-10	-16	43	-2	14
The Northern Rd / Park Rd	South	Left	35	46	48	48	78	113	103	45	33	49	38	40	85	100	91	44	-2	3	-10	-8	7	-13	-12	-1
The Northern Rd / Park Rd	West	Right	73	57	62	57	46	37	33	31	68	53	49	65	37	38	26	31	-5	-4	-13	8	-9	1	-7	0
The Northern Rd / Park Rd	West	Left	253	304	189	97	124	89	77	35	300	324	162	90	118	97	89	35	47	20	-27	-7	-6	8	12	0
The Northern Rd / Blaxland Ave	North	Through	526	492	374	341	587	593	484	292	506	476	401	332	562	582	487	280	-20	-16	27	-9	-25	-11	3	-12
The Northern Rd / Blaxland Ave	North	Left	1	6	15	6	20	6	8	7	7	12	18	3	23	19	10	20	6	6	3	-3	3	13	2	13
The Northern Rd / Blaxland Ave	East	Right	7	15	23	11	7	13	11	5	11	44	34	5	12	14	10	9	4	29	11	-6	5	1	-1	4
The Northern Rd / Blaxland Ave	East	Left	8	8	12	4	11	9	3	2	9	10	6	6	12	10	11	6	1	2	-6	2	1	1	8	4
The Northern Rd / Blaxland Ave	South	Right	1	3	9	2	17	16	11	5	6	11	15	8	12	13	15	13	5	8	6	6	-5	-3	4	8
The Northern Rd / Blaxland Ave	South	Through	453	639	517	390	574	679	587	270	424	694	510	388	570	693	585	297	-29	55	-7	-2	-4	14	-2	27
The Northern Rd / Roots Ave	North	Right	9	16	25	5	24	7	10	3	15	14	25	10	17	27	21	15	6	-2	0	5	-7	20	11	12
The Northern Rd / Roots Ave	North	Through	525	484	361	341	574	593	477	291	498	473	383	328	557	563	479	271	-27	-11	22	-13	-17	-30	2	-20
The Northern Rd / Roots Ave	South	Through	429	606	472	379	549	674	578	267	400	661	493	374	558	681	573	285	-29	55	21	-5	9	7	-5	18
The Northern Rd / Roots Ave	South	Left	14	30	37	13	34	19	43	34	19	22	25	25	41	32	43	41	5	-8	-12	12	7	13	0	7
The Northern Rd / Roots Ave	West	Right	40	65	62	13	61	32	37	24	49	56	67	30	65	52	31	23	9	-9	5	17	4	20	-6	-1
The Northern Rd / Roots Ave	West	Left	25	36	54	13	42	22	20	8	30	44	34	21	25	26	25	25	5	8	-20	8	-17	4	5	17
The Northern Rd / Adams Rd	North	Through	559	529	409	347	620	615	508	312	525	516	416	344	601	603	500	289	-34	-13	7	-3	-19	-12	-8	-23
The Northern Rd / Adams Rd	North	Left	6	20	14	7	15	10	6	4	19	15	28	18	17	16	8	7	13	-5	14	11	2	6	2	3
The Northern Rd / Adams Rd	East	Right	4	13	5	5	12	9	9	2	8	9	8	6	9	15	9	14	4	-4	3	1	-3	6	0	12
The Northern Rd / Adams Rd	East	Left	35	31	34	42	72	85	73	35	17	29	22	27	55	66	75	40	-18	-2	-12	-15	-17	-19	2	5
The Northern Rd / Adams Rd	South	Right	50	70	51	35	58	64	35	21	47	52	21	25	55	56	41	22	-3	-18	-30	-10	-3	-8	6	1
The Northern Rd / Adams Rd	South	Through	439	623	504	387	571	684	612	299	412	673	511	392	586	703	599	311	-27	50	7	5	15	19	-13	12
The Northern Rd / Dwyer Rd	North	Right	11	16	14	16	34	29	24	26	16	16	33	14	35	26	59	30	5	0	19	-2	1	-3	35	4
The Northern Rd / Dwyer Rd	North	Through	580	496	393	328	569	636	505	292	555	508	414	336	565	608	523	287	-25	12	21	8	-4	-28	18	-5
The Northern Rd / Dwyer Rd	South	Through	481	617	459	365	568	672	525	245	461	671	435	369	594	677	545	267	-20	54	-24	4	26	5	20	22
The Northern Rd / Dwyer Rd	South	Left	2	5	8	14	9	8	11	3	3	10	15	8	8	8	11	3	1	5	7	-6	-1	0	0	0
The Northern Rd / Dwyer Rd	West	Right	12	11	4	10	9	8	5	4	19	19	7	11	16	14	9	5	7	8	3	1	7	6	4	1
The Northern Rd / Dwyer Rd	West	Left	31	39	24	18	14	20	15	18	16	46	32	21	20	40	25	22	-15	7	8	3	6	20	10	4
Elizabeth Dr / Luddenham R	North	Right	41	48	60	33	125	140	120	80	51	37	67	34	126	124	104	75	10	-11	7	1	1	-16	-16	-5
Elizabeth Dr / Luddenham R	North	Left	45	59	48	40	110	113	94	40	40	49	37	47	106	104	113	41	-5	-10	-11	7	-4	-9	19	1
Elizabeth Dr / Luddenham R	East	Right	86	111	76	56	86	110	84	40	59	85	52	57	72	98	78	40	-27	-26	-24	1	-14	-12	-6	0
Elizabeth Dr / Luddenham R	East	Through	186	181	196	169	340	538	434	208	178	176	169	153	337	513	447	178	-8	-5	-27	-16	-3	-25	13	-30
Elizabeth Dr / Luddenham R	West	Through	520	552	302	198	205	175	145	69	529	572	261	190	189	194	181	64	9	20	-41	-8	-16	19	36	-5
Elizabeth Dr / Luddenham R	West	Left	85	157	113	43	70	63	62	56	105	171	117	42	36	72	90	29	20	14	4	-1	-34	9	28	-27
Park Rd / Campbell St	East	Through	102	105	116	117	289	324	331	170	90	116	134	113	309	296	320	181	-12	11	18	-4	20	-28	-11	11
Park Rd / Campbell St	East	Left	2	4	20	5	12	16	9	6	0	0	0	0	0	0	0	0	-2	-4	-20	-5	-12	-16	-9	-6
Park Rd / Campbell St	South	Right	0	3	13	4	14	3	4	2	0	0	0	0	0	0	0	0	0	-3	-13	-4	-14	-3	-4	-2
Park Rd / Campbell St	South	Left	3	11	23	8	47	16	13	8	5	5	9	0	19	19	20	10	2	-6	-14	-8	-28	3	7	2
Park Rd / Campbell St	West	Right	34	53	81	13	31	31	17	11	20	23	49	12	6	2	3	0	-14	-30	-32	-1	-25	-29	-14	-11
Park Rd / Campbell St	West	Through	326	358	238	150	156	123	106	64	368	377	211	155	156	136	113	66	42	19	-27	5	0	13	7	2

Intersection	Approach	Direction	Meets 'core area' target?								GEH : hour starting								Ave Target (vph)		Ave Modelled (vph)	
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	AM	PM	AM	PM
The Northern Rd / Defense Establishments Gates	North	Through	1	1	1	1	1	1	1	0	1.8	0.0	0.5	1.3	2.3	1.9	0.1	2.7	622	757	606	737
The Northern Rd / Defense Establishments Gates	North	Left	1	0	0	1	1	1	0	1	0.0	1.3	2.8	1.0	2.1	0.3	3.6	3.0	76	8	80	16
The Northern Rd / Defense Establishments Gates	East	Right	0	1	1	1	0	1	1	1	4.7	1.1	0.3	1.6	1.7	1.1	0.5	0.7	33	62	42	62
The Northern Rd / Defense Establishments Gates	East	Left	1	1	1	1	1	1	1	1	1.6	1.8	0.0	1.3	0.3	1.1	1.6	0.6	6	11	5	9
The Northern Rd / Defense Establishments Gates	South	Right	0	0	0	1	1	1	1	1	2.3	2.5	4.0	0.9	0.0	0.8	1.4	0.0	22	0	22	2
The Northern Rd / Defense Establishments Gates	South	Through	1	1	1	1	1	1	1	1	0.2	0.8	0.3	2.1	0.9	0.4	1.4	0.3	715	754	707	769
The Northern Rd / Chain-O-Ponds Rd	North	Right	1	1	1	0	1	0	1	1	2.0	3.3	1.1	4.0	0.3	3.7	0.0	1.5	7	10	7	13
The Northern Rd / Chain-O-Ponds Rd	North	Through	1	1	1	1	1	1	1	1	2.1	0.0	0.6	1.1	2.3	1.2	0.0	2.2	621	756	605	736
The Northern Rd / Chain-O-Ponds Rd	South	Through	1	1	1	1	1	1	1	1	0.7	0.6	0.0	1.8	1.1	0.1	0.5	0.3	727	746	716	755
The Northern Rd / Chain-O-Ponds Rd	South	Left	1	1	1	1	1	1	1	1	0.0	1.4	2.0	2.0	0.8	1.4	2.0	3.3	1	2	1	2
The Northern Rd / Chain-O-Ponds Rd	West	Right	1	1	1	1	1	1	1	1	0.0	0.0	2.0	1.4	0.5	1.4	1.4	0.8	1	2	3	1
The Northern Rd / Chain-O-Ponds Rd	West	Left	1	1	1	1	1	1	0	1	1.8	1.8	1.0	1.1	0.3	1.3	5.1	2.0	11	8	11	14
The Northern Rd / Kings Hill Rd	North	Right	0	0	1	1	0	1	0	0	3.7	2.2	1.1	0.7	1.4	1.1	1.7	3.3	44	110	54	115
The Northern Rd / Kings Hill Rd	North	Through	1	1	1	1	1	1	1	1	1.4	0.7	0.4	0.7	1.6	1.3	1.1	0.7	561	578	546	567
The Northern Rd / Kings Hill Rd	South	Through	1	1	1	0	1	1	1	1	1.0	1.1	0.3	2.4	0.9	0.0	0.2	1.7	593	645	585	658
The Northern Rd / Kings Hill Rd	South	Left	1	1	1	1	1	1	1	1	2.0	0.0	2.4	1.2	1.6	3.5	2.4	2.0	3	4	3	1
The Northern Rd / Kings Hill Rd	West	Right	1	1	1	1	1	1	1	1	1.2	0.0	0.5	2.8	2.0	2.7	0.0	2.8	3	4	2	1
The Northern Rd / Kings Hill Rd	West	Left	0	1	0	0	0	1	0	0	3.7	0.2	3.4	1.5	2.5	1.1	2.0	5.1	108	52	112	68
The Northern Rd / Longview Rd	North	Right	1	1	1	1	1	1	1	1	0.8	2.4	3.3	0.6	3.3	2.7	1.4	2.4	2	3	5	9
The Northern Rd / Longview Rd	North	Through	1	1	1	1	1	1	1	1	1.2	0.9	0.2	0.5	1.9	0.7	1.1	1.5	562	579	546	558
The Northern Rd / Longview Rd	South	Through	1	1	1	0	1	1	1	1	0.9	1.3	0.1	2.6	0.5	0.4	0.4	0.7	593	646	584	647
The Northern Rd / Longview Rd	South	Left	1	1	1	1	1	1	1	1	0.8	1.4	0.0	0.0	0.6	2.0	3.0	1.4	1	3	1	1
The Northern Rd / Longview Rd	West	Right	1	1	1	1	1	1	1	1	1.4	1.9	2.4	0.5	1.4	1.4	2.0	1.4	2	2	3	2
The Northern Rd / Longview Rd	West	Left	1	1	1	1	1	1	1	1	1.6	0.6	2.4	0.8	3.3	0.0	2.4	3.0	3	3	3	9
The Northern Rd / Gates Rd	North	Through	1	1	1	1	1	1	1	1	0.9	0.9	0.1	0.7	2.2	1.3	0.6	1.7	551	562	537	545
The Northern Rd / Gates Rd	North	Left	1	1	1	1	1	1	1	1	3.0	0.0	1.6	0.0	0.0	1.6	2.3	0.8	4	8	3	9
The Northern Rd / Gates Rd	East	Right	1	1	1	1	1	1	1	1	0.7	1.2	1.1	3.3	2.1	1.0	0.4	1.0	7	7	6	7
The Northern Rd / Gates Rd	East	Left	1	1	1	1	1	1	1	1	2.7	3.6	1.4	0.0	0.0	2.4	3.0	1.4	6	2	2	4
The Northern Rd / Gates Rd	South	Right	1	1	1	1	1	1	1	1	0.0	0.8	2.4	1.6	3.0	0.5	2.7	0.0	3	5	3	3
The Northern Rd / Gates Rd	South	Through	1	1	1	1	1	1	1	1	1.6	0.3	1.0	1.6	0.3	0.1	0.1	0.9	585	626	575	633
The Northern Rd / Littlefields Rd	North	Right	1	1	1	1	1	0	1	1	2.0	0.9	0.9	0.7	0.9	2.9	0.2	0.2	16	26	17	28
The Northern Rd / Littlefields Rd	North	Through	1	1	1	1	1	1	1	1	1.6	1.4	0.2	0.5	1.8	0.2	0.1	1.3	542	538	522	522
The Northern Rd / Littlefields Rd	South	Through	1	1	1	1	1	1	1	1	2.0	0.4	0.3	1.5	0.1	0.5	0.0	0.2	564	615	549	613
The Northern Rd / Littlefields Rd	South	Left	1	1	1	1	1	1	1	1	0.2	0.6	1.2	0.9	0.0	1.2	0.1	1.9	26	42	25	47
The Northern Rd / Littlefields Rd	West	Right	1	1	1	1	1	1	1	1	0.3	0.4	0.6	0.2	0.6	1.3	1.7	1.0	42	23	40	25
The Northern Rd / Littlefields Rd	West	Left	1	1	0	1	1	0	1	1	1.6	0.2	2.9	1.3	1.2	4.5	0.8	0.8	24	16	31	23
The Northern Rd / Elizabeth Dr	In from N		1	1	1	0	1	1	1	1	1.0	0.3	0.1	2.2	1.4	0.3	0.4	0.9	584	553	564	544
The Northern Rd / Elizabeth Dr	Out to N		1	1	1	0	1	1	1	1	0.3	2.0	1.2	2.7	0.1	0.1	0.8	0.8	574	639	567	649
The Northern Rd / Elizabeth Dr	Circ past N		1	1	1	1	1	0	0	1	0.9	1.7	0.6	0.8	0.7	2.0	2.6	0.3	255	102	268	112
The Northern Rd / Elizabeth Dr	In from E		1	1	1	0	1	1	1	1	0.9	0.3	0.5	2.0	0.4	1.2	0.0	0.3	217	436	213	426
The Northern Rd / Elizabeth Dr	Out to E		1	1	1	1	1	1	0	1	0.9	1.6	1.5	0.2	1.3	1.1	2.2	0.2	463	210	473	217
The Northern Rd / Elizabeth Dr	Circ past E		1	1	1	0	1	1	1	1	1.6	0.8	1.0	2.2	1.1	0.5	0.3	1.0	376	445	359	439
The Northern Rd / Elizabeth Dr	In from S		1	1	1	1	1	1	1	1	0.6	2.4	0.6	1.3	0.6	0.8	1.2	0.9	708	552	720	564
The Northern Rd / Elizabeth Dr	Out to S		1	1	1	0	1	1	1	1	0.9	1.1	1.7	2.5	1.4	0.8	0.7	0.6	471	693	456	669
The Northern Rd / Elizabeth Dr	Circ past S		1	0	0	0	1	1	0	1	0.3	1.3	2.2	1.9	0.4	0.4	1.6	0.8	122	189	115	196
The Northern Rd / Park Rd	North	Right	0	1	1	1	1	0	1	1	1.6	0.7	0.7	0.2	0.2	2.2	0.5	0.3	74	205	73	197
The Northern Rd / Park Rd	North	Through	1	1	0	0	1	1	1	1	1.1	1.5	2.2	1.9	0.6	0.0	0.4	0.5	393	475	381	472
The Northern Rd / Park Rd	South	Through	1	1	1	1	1	1	1	1	1.5	2.0	0.2	0.5	0.7	1.8	0.1	0.9	493	467	496	477
The Northern Rd / Park Rd	South	Left	1	1	1	1	1	0	0	1	0.3	0.4	1.5	1.2	0.8	1.3	1.2	0.1	44	85	40	80
The Northern Rd / Park Rd	West	Right	1	1	0	1	1	1	1	1	0.6	0.5	1.7	1.0	1.4	0.2	1.3	0.0	62	37	59	33
The Northern Rd / Park Rd	West	Left	0	1	0	1	1	1	0	1	2.8	1.1	2.0	0.7	0.5	0.8	1.3	0.0	211	81	219	85
The Northern Rd / Blaxland Ave	North	Through	1	1	1	1	1	1	1	1	0.9	0.7	1.4	0.5	1.0	0.5	0.1	0.7	433	489	429	478
The Northern Rd / Blaxland Ave	North	Left	1	1	1	1	1	0	1	0	3.0	2.0	0.7	1.4	0.6	3.7	0.7	3.5	7	10	10	18
The Northern Rd / Blaxland Ave	East	Right	1	0	0	1	1	1	1	1	1.3	5.3	2.1	2.1	1.6	0.3	0.3	1.5	14	9	24	11
The Northern Rd / Blaxland Ave	East	Left	1	1	1	1	1	1	1	1	0.3	0.7	2.0	0.9	0.3	0.3	3.0	2.0	8	6	8	10
The Northern Rd / Blaxland Ave	South	Right	1	1	1	1	1	1	1	1	2.7	3.0	1.7	2.7	1.3	0.8	1.1	2.7	4	12	10	13
The Northern Rd / Blaxland Ave	South	Through	1	1	1	1	1	1	1	1	1.4	2.1	0.3	0.1	0.2	0.5	0.1	1.6	500	528	504	536
The Northern Rd / Roots Ave	North	Right	1	1	1	1	1	0	0	0	1.7	0.5	0.0	1.8	1.5	4.9	2.8	4.0	14	11	16	20
The Northern Rd / Roots Ave	North	Through	1	1	1	1	1	1	1	1	1.2	0.5	1.1	0.7	0.7	1.2	0.1	1.2	428	484	421	468
The Northern Rd / Roots Ave	South	Through	1	1	1	1	1	1	1	1	1.4	2.2	1.0	0.3	0.4	0.3	0.2	1.1	472	517	482	524
The Northern Rd / Roots Ave	South	Left	1	1	0	0	1	0	1	1	1.2	1.6	2.2	2.8	1.1	2.6	0.0	1.1	24	33	23	39
The Northern Rd / Roots Ave	West	Right	1	1	1	0	1	0	1	1	1.3	1.2	0.6	3.7	0.5	3.1	1.0	0.2	45	39	51	43
The Northern Rd / Roots Ave	West	Left	1	1	0	1	0	1	1	0	1.0	1.3	3.0	1.9	2.9	0.8	1.1	4.2	32	23	32	25
The Northern Rd / Adams Rd	North	Through	1	1	1	1	1	1	1	1	1.5	0.6	0.3	0.2	0.8	0.5	0.4	1.3	461	514	450	498
The Northern Rd / Adams Rd	North	Left	0	1	0	0	1	1	1	1	3.7	1.2	3.1	3.1	0.5	1.7	0.8	1.3	12	9	20	12
The Northern Rd / Adams Rd	East	Right	1	1	1	1	1	1	1	0	1.6	1.2	1.2	0.4	0.9	1.7	0.0	4.2	7	8	8	12
The Northern Rd / Adams Rd	East	Left	0	1	0	0	0	0	1	1	3.5	0.4	2.3	2.6	2.1	2.2	0.2	0.8	36	66	24	59
The Northern Rd / Adams Rd	South	Right	1	0	0	1	1	1	1	1	0.4	2.3	5.0	1.8	0.4	1.0	1.0	0.2	52	45	36	44
The Northern Rd / Adams Rd	South	Through	1	1	1	1	1	1	1	1	1.3	2.0	0.3	0.3	0.6	0.7	0.5	0.7	488	542	497	550
The Northern Rd / Dwyer Rd	North	Right	1	1	0	1	1	1	0	1	1.4	0.0	3.9	0.5	0.2	0.6	5.4	0.8	14	28	20	38
The Northern Rd / Dwyer Rd	North	Through	1	1	1	1	1	1	1	1	1.0	0.5	1.0	0.4	0.2	1.1	0.8	0.3	449	501	453	496
The Northern Rd / Dwyer Rd	South	Through	1	1	1	1	1	1	1	1	0.9	2.1	1.1	0.2	1.1	0.2	0.9	1.4	481	503	484	521
The Northern Rd / Dwyer Rd	South	Left	1	1	1	1	1	1	1	1	0.6	1.8	2.1	1.8	0.3	0.0	0.0	0.0	7	8	9	8
The Northern Rd / Dwyer Rd	West	Right	1	1	1	1	1	1	1	1	1.8	2.1	1.3	0.3	2.0	1.8	1.5	0.5	9	7	14	11
The Northern Rd / Dwyer Rd	West	Left	0	1	1	1	1	0	1	1	3.1	1.1	1.5	0.7	1.5	3.7	2.2	0.9	28	17	29	27
Elizabeth Dr / Luddenham R	North	Right	1	0	1	1	1	0	0	1	1.5	1.7	0.9	0.2	0.1	1.4	1.5	0.6	46	116	47	107
Elizabeth Dr / Luddenham R	North	Left	1	1	0	1	1	1	0	1	0.8	1.4	1.7	1.1	0.4	0.9	1.9	0.2	48	89	43	91
Elizabeth Dr / Luddenham R	East	Right	0	0	0	1	0	0	1	1	3.2	2.6	3.0	0.1	1.6	1.2	0.7	0.0	82	80	63	72
Elizabeth Dr / Luddenham R	East	Through	1	1	0	1	1	1	1	0	0.6	0.4	2.0	1.3	0.2	1.1	0.6	2.2	183	380	169	369
Elizabeth Dr / Luddenham R	West	Through	1	1	0	1	1	0	0	1	0.4	0.8	2.4	0.6	1.1	1.4	2.8	0.6	393	149	388	157
Elizabeth Dr / Luddenham R	West	Left	0	1	1	1	0	1	0	0	2.1	1.1	0.4	0.2	4.7	1.1	3.2	4.1	100	63	109	57
Park Rd / Campbell St	East	Through	0	0	0	1	1	1	1	1	1.2	1.0	1.6	0.4	1.2	1.6	0.6	0.8	110	279	113	277
Park Rd / Campbell St	East	Left	1	1	0	1	0	0	1	1	2.0	2.8	6.3	3.2	4.9	5.7	4.2	3.5	8	11	0	0
Park Rd / Campbell St	South	Right	1	1	0	1	0	1	1	1	1.4	2.4	5.1	2.8	5.3	2.4	2.8	2.0	5	6	0	0
Park Rd / Campbell St	South	Left	1	1	0	1	0	1	1	1	1.0	2.1	3.5	4.0	4.9	0.7	1.7	0.7	11	21	5	17
Park Rd / Campbell St	West	Right	0	0	0	1	0	0	0	0	2.7	4.9	4.0	0.3	5.8	7.1	4.4	4.7	45	23	26	3
Park Rd / Campbell St	West	Through	0	1	0	1	1	0	1	1	2.3	1.0	1.8	0.4	0.0	1.1	0.7	0.2	268	112	278	118

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THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL v03 Micro OS1

Traffic Volume Calibration Results : Light Vehicles

Intersection	Approac	Direction	Target volume								Modelled volume								Modelled vs target volume								Ave Target (vph)		Ave Modelled (vph)	
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	AM	PM	AM	PM
The Northern Rd S of Derby St	Northbound		1,151	1,427	1,461		1,101	1,253	1,126		1,099	1,390	1,500		1,139	1,193	1,156		-52	-37	39		38	-60	30		1,346	1,160	1,330	1,163
The Northern Rd S of Derby St	Southbound		823	946	935		1,249	1,401	1,397		810	942	960		1,282	1,413	1,361		-13	-4	25		33	12	-36		901	1,349	904	1,352
The Northern Rd / Jamison Rd	North	Right	74	112	171		173	227	233		90	121	168		211	231	254		16	9	-3		38	4	21		119	211	126	232
The Northern Rd / Jamison Rd	North	Through	754	881	948		1,492	1,410	1,365		765	904	977		1,481	1,437	1,306		11	23	29		-11	27	-59		861	1,422	882	1,408
The Northern Rd / Jamison Rd	North	Left	1	5	9		12	10	22		10	14	15		4	15	25		9	9	6		-8	5	3		5	15	13	15
The Northern Rd / Jamison Rd	East	Right	12	14	20		16	17	13		48	17	11		27	63	14		36	3	-9		11	46	1		15	15	25	35
The Northern Rd / Jamison Rd	East	Through	74	116	172		158	204	182		61	124	176		155	186	162		-13	8	4		-3	-18	-20		121	181	120	168
The Northern Rd / Jamison Rd	East	Left	20	27	40		64	75	38		29	40	30		88	101	53		9	13	-10		24	26	15		29	59	33	81
The Northern Rd / Jamison Rd	South	Right	14	27	36		12	9	16		21	22	33		18	15	11		7	-5	-3		6	6	-5		26	12	25	15
The Northern Rd / Jamison Rd	South	Through	908	1,360	1,467		1,073	1,013	1,079		921	1,327	1,483		1,100	1,006	1,088		13	-33	16		27	-7	9		1,245	1,055	1,244	1,065
The Northern Rd / Jamison Rd	South	Left	48	107	212		166	165	134		36	95	204		193	148	128		-12	-12	-8		27	-17	-6		122	155	112	156
The Northern Rd / Jamison Rd	West	Right	76	111	103		165	236	187		66	106	86		160	237	166		-10	-5	-17		-5	1	-21		97	196	86	188
The Northern Rd / Jamison Rd	West	Through	67	119	119		128	164	142		51	133	103		138	178	142		-16	14	-16		10	14	0		102	145	96	153
The Northern Rd / Jamison Rd	West	Left	100	119	131		108	159	100		125	104	112		105	192	99		25	-15	-19		-3	33	-1		117	122	114	132
The Northern Rd / Smith St	North	Right	30	54	81	70	105	88	134	89	34	61	75	61	111	98	119	94	4	7	-6	-9	6	10	-15	5	59	104	58	106
The Northern Rd / Smith St	North	Through	817	957	987	820	1,610	1,616	1,449	973	803	974	1,013	776	1,580	1,668	1,392	977	-14	17	26	-44	-30	52	-57	4	895	1,412	892	1,404
The Northern Rd / Smith St	North	Left	3	8	23	6	6	17	7	14	21	14	9	4	23	12	17	8	18	6	-14	-2	17	-5	10	-6	10	11	12	15
The Northern Rd / Smith St	East	Right	7	9	30	11	13	7	9	9	14	16	26	11	16	14	11	4	7	7	-4	0	3	7	2	-5	14	10	17	11
The Northern Rd / Smith St	East	Through	18	27	88	37	80	55	72	45	22	44	85	31	70	56	72	34	4	17	-3	-6	-10	1	0	-11	43	63	46	58
The Northern Rd / Smith St	East	Left	4	14	18	8	19	20	7	4	10	14	14	10	13	21	13	4	6	0	-4	2	-6	1	6	0	11	13	12	13
The Northern Rd / Smith St	South	Right	10	25	58	20	21	18	21	8	21	29	42	24	29	13	25	15	11	4	-16	4	8	-5	4	7	28	17	29	21
The Northern Rd / Smith St	South	Through	941	1,433	1,621	1,020	1,181	1,130	1,180	832	933	1,394	1,609	1,048	1,213	1,115	1,181	827	-8	-39	-12	28	32	-15	1	-5	1,254	1,081	1,246	1,084
The Northern Rd / Smith St	South	Left	20	24	49	42	63	55	58	31	26	37	41	28	60	50	74	40	6	13	-8	-14	-3	-5	16	9	34	52	33	56
The Northern Rd / Smith St	West	Right	38	57	61	37	83	103	83	37	30	48	74	34	89	81	81	34	-8	-9	13	-3	6	-22	-2	-3	48	77	47	71
The Northern Rd / Smith St	West	Through	34	74	146	55	73	84	78	63	43	87	154	77	81	91	92	67	9	13	8	22	8	7	14	4	77	75	90	83
The Northern Rd / Smith St	West	Left	22	52	64	51	57	50	40	32	29	47	71	52	57	61	41	26	7	-5	7	1	0	11	1	-6	47	45	50	46
The Northern Rd / Maxwell St / Bringelly Rd	North	Right	17	28	41		101	88	86		18	32	28		85	78	94		1	4	-13		-16	-10	8		29	92	26	86
The Northern Rd / Maxwell St / Bringelly Rd	North	Through	831	979	1,005		1,593	1,641	1,441		821	987	1,057		1,556	1,676	1,386		-10	8	52		-37	35	-55		938	1,558	955	1,539
The Northern Rd / Maxwell St / Bringelly Rd	North	Left	11	21	20		18	10	12		12	14	19		20	14	17		1	-7	-1		2	4	5		17	13	15	17
The Northern Rd / Maxwell St / Bringelly Rd	East	Right	8	35	56		48	37	15		15	37	45		56	53	18		7	2	-11		8	16	3		33	33	32	42
The Northern Rd / Maxwell St / Bringelly Rd	East	Through	49	103	174		214	187	228		39	107	184		201	200	237		-10	4	10		-13	13	9		109	210	110	213
The Northern Rd / Maxwell St / Bringelly Rd	East	Left	167	184	230		343	413	328		183	190	220		299	426	303		16	6	-10		-44	13	-25		194	361	198	343
The Northern Rd / Maxwell St / Bringelly Rd	South	Right	260	432	470		246	239	255		255	403	467		236	227	270		-5	-29	-3		-10	-12	15		387	247	375	244
The Northern Rd / Maxwell St / Bringelly Rd	South	Through	938	1,431	1,648		1,171	1,131	1,201		924	1,408	1,653		1,225	1,086	1,212		-14	-23	5		54	-45	11		1,339	1,168	1,328	1,174
The Northern Rd / Maxwell St / Bringelly Rd	South	Left	40	76	64		121	153	122		47	78	56		121	159	119		7	2	-8		0	6	-3		60	132	60	133
The Northern Rd / Maxwell St / Bringelly Rd	West	Right	267	293	229		231	262	246		283	264	213		239	268	252		16	-29	-16		8	6	6		263	246	253	253
The Northern Rd / Maxwell St / Bringelly Rd	West	Through	56	117	112		105	112	86		54	112	121		126	132	106		-2	-5	9		21	20	20		95	101	96	121
The Northern Rd / Maxwell St / Bringelly Rd	West	Left	25	16	24		46	35	43		39	27	20		38	41	42		14	11	-4		-8	6	-1		22	41	29	40
The Northern Rd / Castle Rd / Aspen St	North	Through	1,255	1,440	1,420	1,138	2,132	2,281	1,999	1,308	1,266	1,406	1,455	1,132	2,047	2,344	1,920	1,300	11	-34	35	-6	-85	63	-79	-8	1,313	1,930	1,315	1,903
The Northern Rd / Castle Rd / Aspen St	North	Left	10	16	44	22	35	35	16	6	21	32	30	19	28	37	31	15	11	16	-14	-3	-7	2	15	9	23	23	26	28
The Northern Rd / Castle Rd / Aspen St	East	Right	0	3	2	9	4	4	5	6	4	11	6	11	17	12	13	6	4	8	4	2	13	8	8	0	4	5	8	12
The Northern Rd / Castle Rd / Aspen St	East	Left	45	61	52	31	69	60	39	29	35	51	59	34	71	61	48	28	-10	-10	7	3	2	1	9	-1	47	49	45	52
The Northern Rd / Castle Rd / Aspen St	S+W to E		37	40	51	29	33	38	35	25	22	44	43	13	22	32	28	24	-15	4	-8	-16	-11	-6	-7	-1	39	33	31	27
The Northern Rd / Castle Rd / Aspen St	S to N+E		1,257	1,966	2,222	1,394	1,527	1,526	1,565	1,042	1,224	1,938	2,188	1,438	1,569	1,480	1,640	1,030	-33	-28	-34	44	42	-46	75	-12	1,710	1,415	1,697	1,430
The Northern Rd / Castle Rd / Aspen St	South	Left	73	121	199	92	202	188	196	124	74	100	247	91	206	197	221	136	1	-21	48	-1	4	9	25	12	121	178	128	190
The Northern Rd / Castle Rd / Aspen St	W to N+E		18	10	9	12	40	31	43	36	0	0	0	0	8	12	13	8	-18	-10	-9	-12	-32	-19	-30	-28	12	38	0	10
The Northern Rd / Castle Rd / Aspen St	S+W to N		1,238	1,936	2,180	1,377	1,534	1,519	1,573	1,053	1,205	1,887	2,152	1,424	1,560	1,460	1,626	1,013	-33	-49	-28	47	26	-59	53	-40	1,683	1,420	1,667	1,415
The Northern Rd / Tukara Rd / Frogmore Rd	North	Through	1,290	1,425	1,389		2,177	2,309	2,016		1,278	1,397	1,413		2,080	2,398	1,945		-12	-28	24		-97	89	-71		1,368	2,167	1,363	2,141
The Northern Rd / Tukara Rd / Frogmore Rd	North	Left	10	76	83		24	32	22		18	64	84		15	32	23		8	-12	1		-9	0	1		56	26	55	23
The Northern Rd / Tukara Rd / Frogmore Rd	East	Right	3	19	41		22	18	17		9	26	28		28	21	30		6	7	-13		6	3	13		21	19	21	26
The Northern Rd / Tukara Rd / Frogmore Rd	East	Left	31	85	109		74	28	54		37	81	98		82	35	43		6	-4	-11		8	7	-11		75	52	72	53
The Northern Rd / Tukara Rd / Frogmore Rd	South	Right	16	106	82		23	19	23		23	99	97		25	29	28		7	-7	15		2	10	5		68	22	73	27
The Northern Rd / Tukara Rd / Frogmore Rd	South	Through	1,265	1,989	2,288		1,658	1,628	1,686		1,234	1,922	2,308		1,684	1,610	1,747		-31	-67	20		26	-18	61		1,847	1,657	1,821	1,680
The Northern Rd / Tukara Rd / Frogmore Rd	South	Left	93	219	309		360	364	396		99	225	321		368	353	406		6	6	12		8	-11	10		207	373	215	376
The Northern Rd / Tukara Rd / Frogmore Rd	West	Left	62	79	92		49	68	58		61	89	115		64	60	64		-1	10	23		15	-8	6		78	58	88	63
The Northern Rd / M4 WB ramps	North	Through	465	672	675	507	1,277	1,341	1,235	858	465	636	737	524	1,202	1,432	1,141	854	0	-36	62	17	-75	91	-94	-4	580	1,178	591	1,157
The Northern Rd / M4 WB ramps	North	Left	856	838	823	667	974	996	835	502	878	798	822	655	969	994	830	538	22	-40	-1	-12	-5	-2	-5	36	796	827	788	833
The Northern Rd / M4 WB ramps	South	Right	641	594	500	292	299	242	257	150	662	549	496	299	338	231	272	156	21	-45	-4	7	39	-11	15	6	507	237	502	249
The Northern Rd / M4 WB ramps	South	Through	1,220	1,919	2,169	1,355	1,807	1,779	1,874	1,243	1,217	1,890	2,189	1,359	1,857	1,785	1,896	1,211	-3	-29	20	4	50	6	22	-32	1,666	1,676	1,664	1,687
The Northern Rd / M4 WB ramps	West	Right	196	341	325	157	254	269	242	184	175	324	314	164	218	254	256	191	-21	-17	-11	7	-36	-15	14	7	255	237	244	230
The Northern Rd / M4 WB ramps	West	Left	154	395	510	259	234	232	231	141	138	370	542	263	224	224	261	154	-16	-25	32	4	-10	-8	30	13	330	210	328	216
The Northern Rd / M4 EB ramps	North	Right	47	127	168	122	320	370	300	199	50	116	170	117	325	385	291	193	3	-11	2	-5	5	15	-9	-6	116	297	113	299
The Northern Rd / M4 EB ramps	North	Through	614	886	832	542	1,211	1,240	1,177	843	581	847	863	587	1,105	1,288	1,139	851	-33	-39	31	45	-106	48	-38	8	719	1,118	720	1,096
The Northern Rd / M4 EB ramps	East	Right	473	803	877	708	1,005	1,037	1,116	719	500	836	889	732	1,061	1,038	1,097	713	27	33	12	24	56	1	-19	-6	715	969	739	977
The Northern Rd / M4 EB ramps	East	Left	139	189	174	144	498	614	674	461	159	199	191	145	534	645	693	462	20	10	17	1	36	31	19	1	162	562	174	584

THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL v03 Micro OS1

Traffic Volume Calibration Results : Light Vehicles

Intersection	Approac	Direction	Target volume								Modelled volume								Modelled vs target volume								Ave Target (vph)		Ave Modelled (vph)	
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	AM	PM	AM	PM
The Northern Rd / M4 EB ramps	South	Through	1,388	1,710	1,792	939	1,101	984	1,015	674	1,380	1,629	1,783	909	1,127	973	1,065	655	-8	-81	-9	-30	26	-11	50	-19	1,457	944	1,425	955
The Northern Rd / M4 EB ramps	South	Left	135	235	317	313	373	419	348	304	127	238	327	296	407	425	387	332	-8	3	10	-17	34	6	39	28	250	361	247	388
The Northern Rd / Homestead Rd / Garswood Rd	North	Through	737	1,040	947	660	1,638	1,810	1,777	1,255	715	1,020	1,006	707	1,543	1,897	1,753	1,247	-22	-20	59	47	-95	87	-24	-8	846	1,620	862	1,610
The Northern Rd / Homestead Rd / Garswood Rd	North	Left	15	34	59	26	71	44	73	50	24	27	48	26	79	50	80	64	9	-7	-11	0	8	6	7	14	34	60	31	68
The Northern Rd / Homestead Rd / Garswood Rd	East	Right	21	17	21	25	63	44	45	30	21	25	25	18	73	47	61	28	0	8	4	-7	10	3	16	-2	21	46	22	52
The Northern Rd / Homestead Rd / Garswood Rd	East	Left	15	29	36	26	127	108	86	44	25	44	37	42	132	99	87	50	10	15	1	16	5	-9	1	6	27	91	37	92
The Northern Rd / Homestead Rd / Garswood Rd	South	Right	50	145	67	20	48	26	19	15	48	154	118	22	33	17	30	8	-2	9	51	2	-15	-9	11	-7	71	27	86	22
The Northern Rd / Homestead Rd / Garswood Rd	South	Through	1,288	1,693	1,822	1,057	1,236	1,232	1,184	820	1,281	1,628	1,853	968	1,291	1,234	1,236	804	-7	-65	31	-89	55	2	52	-16	1,465	1,118	1,433	1,141
The Northern Rd / Homestead Rd / Garswood Rd	South	Left	31	45	54	38	147	144	105	88	28	48	53	15	129	133	107	69	-3	3	-1	-23	-18	-11	2	-19	42	121	36	110
The Northern Rd / Homestead Rd / Garswood Rd	West	Left	213	234	266	170	175	127	133	128	214	211	256	187	175	125	146	140	1	-23	-10	17	0	-2	13	12	221	141	217	147
The Northern Rd / Glenmore Pkwy / Wentworth Rd	N to S,W,N		810	923	810	698	1,427	1,700	1,711	1,123	731	885	860	711	1,364	1,803	1,623	1,116	-79	-38	50	13	-63	103	-88	-7	810	1,490	797	1,477
The Northern Rd / Glenmore Pkwy / Wentworth Rd	S,E,N to N		775	1,242	1,444	657	1,042	1,002	1,014	540	764	1,225	1,439	645	1,116	1,043	994	536	-11	-17	-5	-12	74	41	-20	-4	1,030	900	1,018	922
The Northern Rd / Glenmore Pkwy / Wentworth Rd	Circ past N		24	105	92	15	40	25	27	11	34	125	80	32	28	22	50	18	10	20	-12	17	-12	-3	23	7	59	26	68	30
The Northern Rd / Glenmore Pkwy / Wentworth Rd	W to N		594	641	579	297	309	320	374	303	586	613	587	338	348	331	350	341	-8	-28	8	41	39	11	-24	38	528	327	531	343
The Northern Rd / Glenmore Pkwy / Wentworth Rd	E to W,N,E		28	220	327	53	247	114	118	41	30	235	297	83	269	108	114	36	2	15	-30	30	22	-6	-4	-5	157	130	161	132
The Northern Rd / Glenmore Pkwy / Wentworth Rd	W,S,E to E		58	285	202	32	94	49	53	25	77	275	202	47	74	40	68	34	19	-10	0	15	-20	-9	15	9	144	55	150	54
The Northern Rd / Glenmore Pkwy / Wentworth Rd	Circ past E		114	133	114	36	41	36	38	22	117	135	120	33	26	38	54	18	3	2	6	-3	-15	2	16	-4	99	34	101	34
The Northern Rd / Glenmore Pkwy / Wentworth Rd	N to E		53	196	184	38	180	59	25	31	41	188	235	52	196	64	37	50	-12	-8	51	14	16	5	12	19	118	74	129	87
The Northern Rd / Glenmore Pkwy / Wentworth Rd	S to N,E,S		754	1,138	1,249	595	847	869	883	456	741	1,132	1,249	577	881	890	903	466	-13	-6	0	-18	34	21	20	10	934	764	925	785
The Northern Rd / Glenmore Pkwy / Wentworth Rd	N,W,S to S		782	916	737	552	1,065	1,137	1,011	607	711	897	752	550	990	1,216	982	577	-71	-19	15	-2	-75	79	-29	-30	747	955	728	941
The Northern Rd / Glenmore Pkwy / Wentworth Rd	Circ past S		142	140	187	182	403	599	738	538	137	123	228	194	401	624	693	561	-5	-17	41	12	-2	25	-45	23	163	570	171	570
The Northern Rd / Glenmore Pkwy / Wentworth Rd	E to S		14	42	24	18	40	18	17	15	32	23	30	11	21	22	13	16	18	-19	6	-7	-19	4	-4	1	25	23	24	18
The Northern Rd / Glenmore Pkwy / Wentworth Rd	W to E,S,W		148	313	224	53	95	60	64	36	160	284	242	48	72	56	72	34	12	-29	18	-5	-23	-4	8	-2	185	64	184	59
The Northern Rd / Glenmore Pkwy / Wentworth Rd	E,N,W to W		125	151	227	158	415	555	698	484	110	137	257	177	406	558	666	510	-15	-14	30	19	-9	3	-32	26	165	538	170	535
The Northern Rd / Glenmore Pkwy / Wentworth Rd	Circ past W		45	209	287	77	235	158	158	95	57	219	269	101	264	174	140	88	12	10	-18	24	29	16	-18	-7	155	162	162	167
The Northern Rd / Glenmore Pkwy / Wentworth Rd	S to W		79	96	91	111	160	220	164	106	78	101	89	105	162	207	192	128	-1	5	-2	-6	2	-13	28	22	94	163	93	172
The Northern Rd / Bradley St	North	Right	106	261	282	198	366	426	400	273	115	259	280	198	329	461	374	274	9	-2	-2	0	-37	35	-26	1	212	366	213	360
The Northern Rd / Bradley St	North	Through	690	697	479	372	739	729	632	349	629	673	495	361	677	778	640	321	-61	-24	16	-11	-62	49	8	-28	560	612	540	604
The Northern Rd / Bradley St	South	Through	569	820	744	462	783	799	715	433	579	835	742	431	834	788	731	434	10	15	-2	-31	51	-11	16	1	649	683	647	697
The Northern Rd / Bradley St	South	Left	19	18	36	16	61	74	111	47	22	25	33	15	58	71	124	45	3	7	-3	-1	-3	-3	13	-2	22	73	24	75
The Northern Rd / Bradley St	West	Right	91	83	69	38	60	40	116	159	99	94	72	42	74	57	114	129	8	11	3	4	14	17	-2	-30	70	94	77	94
The Northern Rd / Bradley St	West	Left	264	414	596	244	224	290	332	129	256	421	561	255	218	321	340	142	-8	7	-35	11	-6	31	8	13	380	244	373	255
The Northern Rd / Defense Establishments Gates	North	Through	670	685	483	385	790	761	740	506	619	680	479	379	731	823	735	447	-51	-5	-4	-6	-59	62	-5	-59	556	699	539	684
The Northern Rd / Defense Establishments Gates	North	Left	111	95	65	25	10	8	8	2	112	83	91	29	19	7	24	8	1	-12	26	4	9	-1	16	6	74	7	79	15
The Northern Rd / Defense Establishments Gates	East	Right	7	16	90	14	102	82	38	20	22	22	93	20	119	73	36	17	15	6	3	6	17	-9	-2	-3	32	61	39	61
The Northern Rd / Defense Establishments Gates	East	Left	8	3	6	7	13	16	12	2	4	7	6	4	12	12	7	3	-4	4	0	-3	-1	-4	-5	1	6	11	5	9
The Northern Rd / Defense Establishments Gates	South	Right	34	29	16	8	0	0	0	0	22	17	38	12	1	2	3	1	-12	-12	22	4	1	2	3	1	22	0	22	2
The Northern Rd / Defense Establishments Gates	South	Through	581	822	690	464	743	791	788	459	580	846	675	427	779	778	821	460	-1	24	-15	-37	36	-13	33	1	639	695	632	710
The Northern Rd / Chain-O-Ponds Rd	North	Right	2	4	9	12	10	6	10	13	6	12	5	2	12	19	11	8	4	8	-4	-10	2	13	1	-5	7	10	6	13
The Northern Rd / Chain-O-Ponds Rd	North	Through	676	684	480	380	793	769	742	495	619	678	482	376	735	811	739	448	-57	-6	2	-4	-58	42	-3	-47	555	700	539	683
The Northern Rd / Chain-O-Ponds Rd	South	Through	612	833	694	463	732	781	786	453	601	849	686	430	773	778	790	444	-11	16	-8	-33	41	-3	4	-9	651	688	642	696
The Northern Rd / Chain-O-Ponds Rd	South	Left	0	1	1	2	2	1	2	1	1	3	0	0	1	0	0	8	1	2	-1	-2	-1	-1	-2	7	1	2	1	2
The Northern Rd / Chain-O-Ponds Rd	West	Right	0	2	2	0	3	1	1	1	1	3	6	0	4	0	0	1	1	1	4	0	1	-1	-1	0	1	2	3	1
The Northern Rd / Chain-O-Ponds Rd	West	Left	3	18	12	9	11	8	2	6	5	12	17	6	13	12	17	10	2	-6	5	-3	2	4	15	4	11	7	10	13
The Northern Rd / Kings Hill Rd	North	Right	31	39	49	54	130	117	118	62	53	52	51	48	111	102	138	88	22	13	2	-6	-19	-15	20	26	43	107	51	110
The Northern Rd / Kings Hill Rd	North	Through	605	644	426	327	619	649	536	299	574	620	428	323	591	691	507	286	-31	-24	2	-4	-28	42	-29	-13	501	526	486	519
The Northern Rd / Kings Hill Rd	South	Through	476	672	592	402	629	700	724	332	456	699	593	360	664	703	707	362	-20	27	1	-42	35	3	-17	30	536	596	527	609
The Northern Rd / Kings Hill Rd	South	Left	2	2	3	3	3	6	3	2	4	2	0	2	1	0	0	0	2	0	-3	-1	-2	-6	-3	-2	3	4	2	0
The Northern Rd / Kings Hill Rd	West	Right	2	1	4	4	2	6	3	4	4	1	4	0	0	1	3	0	2	0	0	-4	-2	-5	0	-4	3	4	2	1
The Northern Rd / Kings Hill Rd	West	Left	101	149	118	56	62	60	47	37	142	148	83	68	81	52	62	75	41	-1	-35	12	19	-8	15	38	106	52	110	68
The Northern Rd / Longview Rd	North	Right	2	2	1	2	3	2	6	2	1	7	7	3	12	8	9	7	-1	5	6	1	9	6	3	5	2	3	5	9
The Northern Rd / Longview Rd	North	Through	605	642	429	329	618	653	533	302	581	613	422	328	582	678	507	276	-24	-29	-7	-1	-36	25	-26	-26	501	527	486	511
The Northern Rd / Longview Rd	South	Through	476	671	588	405	630	702	722	332	458	701	587	360	654	695	700	344	-18	30	-1	-45	24	-7	-22	12	535	597	527	598
The Northern Rd / Longview Rd	South	Left	0	1	0	1	3	2	7	1	2	0	1	1	2	0	1	0	2	-1	1	0	-1	-2	-6	-1	1	3	1	1
The Northern Rd / Longview Rd	West	Right	1	0	3	3	3	3	2	0	3	4	0	4	6	1	0	0	2	4	-3	1	3	-2	-2	0	2	2	3	2
The Northern Rd / Longview Rd	West	Left	2	2	7	0	2	4	5	2	3	3	2	2	10	4	12	9	1	1	-5	2	8	0	7	7	3	3	3	9
The Northern Rd / Gates Rd	North	Through	591	637	421	324	616	625	514	291	577	609	418	315	572	666	500	260	-14	-28	-3	-9	-44	41	-14	-31	493	512	480	500
The Northern Rd / Gates Rd	North	Left	7	3	1	2	9	8	6	4	1	1	5	2	10	3	13	7	-6	-2	4	0	1	-5	7	3	3	7	2	8
The Northern Rd / Gates Rd	East	Right	5	5	9	6	5	10	5	4	7	5	6	1	11	8	6	3	2	0	-3	-5	6	-2	1	-1	6	6	5	7
The Northern Rd / Gates Rd	East	Left	7	8	5	1	5	3	1	0	2	1	2	2	5	0	7	3	-5	-7	-3	1	0	-3	6	3	5	2	2	4
The Northern Rd / Gates Rd	South	Right	4	0	3	1	9	3	5	2	4	2	0	4	2	4	1	3	0	2	-3	3	-7	1	-4	1	2	5	3	3
The Northern Rd / Gates Rd	South	Through	479	694	556	391	616	689	682	324	446	700	574	363	634	691	675	337	-33	6	18	-28	18	2	-7	13	530	578	521	584
The Northern Rd / Littlefields Rd	North	Right	11	7	21	20	30	27	25	16	19	11	17	16	27	42	25	15	8	4	-4	-4	-3	15	0	-1	15	25	16	27
The Northern Rd / Littlefields Rd	North	Through	587	638	405	305	591	601	490	275	558	597	406	301	556	616	485	252	-29	-41	1	-4	-35	15	-5	-23	484	489	466	477
The Northern Rd / Littlefields Rd	South	Through	465	661	540	373	596	684	672	314	421	671	541	347	608	675	663	316	-44	10	1	-26	12	-9	-9	2	510	567	495	566

Traffic Volume Calibration Results : Light Vehicles

Intersection	Approac	Direction	Target volume								Modelled volume								Modelled vs target volume								Ave Target (vph)		Ave Modelled (vph)	
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	AM	PM	AM	PM
The Northern Rd / Littlefields Rd	South	Left	20	23	38	16	41	50	51	18	21	18	29	20	36	55	49	28	1	-5	-9	4	-5	5	-2	10	24	40	22	42
The Northern Rd / Littlefields Rd	West	Right	37	61	43	20	22	32	17	13	38	56	39	22	27	25	27	18	1	-5	-4	2	5	-7	10	5	40	21	39	24
The Northern Rd / Littlefields Rd	West	Left	18	33	19	19	29	8	15	12	30	32	32	25	33	26	11	15	12	-1	13	6	4	18	-4	3	22	16	30	21
The Northern Rd / Elizabeth Dr	In from N		606	684	459	346	593	629	512	290	596	665	456	310	573	641	523	271	-10	-19	-3	-36	-20	12	11	-19	524	506	507	502
The Northern Rd / Elizabeth Dr	Out to N		448	645	582	396	627	731	690	317	456	694	547	347	634	731	693	332	8	49	-35	-49	7	0	3	15	518	591	511	598
The Northern Rd / Elizabeth Dr	Circ past N		290	359	186	84	121	99	104	39	316	391	183	99	110	124	136	39	26	32	-3	15	-11	25	32	0	230	91	247	102
The Northern Rd / Elizabeth Dr	In from E		181	173	209	151	401	469	491	238	195	187	195	141	412	445	489	239	14	14	-14	-10	11	-24	-2	1	179	400	180	396
The Northern Rd / Elizabeth Dr	Out to E		512	635	346	180	218	223	214	93	551	672	329	192	205	245	251	93	39	37	-17	12	-13	22	37	0	418	187	436	199
The Northern Rd / Elizabeth Dr	Circ past E		384	408	299	250	496	505	402	236	361	385	309	217	477	519	409	217	-23	-23	10	-33	-19	14	7	-19	335	410	318	406
The Northern Rd / Elizabeth Dr	In from S		639	898	645	395	583	625	568	273	663	964	629	371	571	647	590	290	24	66	-16	-24	-12	22	22	17	644	512	657	525
The Northern Rd / Elizabeth Dr	Out to S		466	475	385	316	732	769	667	391	449	451	404	279	717	756	656	380	-17	-24	19	-37	-15	-13	-11	-11	411	640	396	627
The Northern Rd / Elizabeth Dr	Circ past S		99	106	123	85	165	205	226	83	107	121	101	76	172	207	243	77	8	15	-22	-9	7	2	17	-6	103	170	101	175
The Northern Rd / Park Rd	North	Right	61	46	68	54	194	207	224	125	47	60	72	57	201	182	220	131	-14	14	4	3	7	-25	-4	6	57	188	59	184
The Northern Rd / Park Rd	North	Through	421	422	312	256	514	543	442	261	401	383	337	230	518	544	457	251	-20	-39	25	-26	4	1	15	-10	353	440	338	443
The Northern Rd / Park Rd	South	Through	411	615	472	318	480	533	492	241	393	658	479	308	473	570	482	253	-18	43	7	-10	-7	37	-10	12	454	437	460	445
The Northern Rd / Park Rd	South	Left	28	40	39	42	68	105	95	45	25	44	28	36	75	90	81	42	-3	4	-11	-6	7	-15	-14	-3	37	78	33	72
The Northern Rd / Park Rd	West	Right	56	45	48	47	40	35	29	27	50	40	40	54	31	34	21	29	-6	-5	-8	7	-9	-1	-8	2	49	33	46	29
The Northern Rd / Park Rd	West	Left	228	283	172	71	103	85	70	32	269	301	144	70	97	95	87	34	41	18	-28	-1	-6	10	17	2	189	73	196	78
The Northern Rd / Blaxland Ave	North	Through	452	440	333	292	532	552	454	265	443	417	349	283	520	548	464	254	-9	-23	16	-9	-12	-4	10	-11	379	451	373	447
The Northern Rd / Blaxland Ave	North	Left	1	4	15	5	15	6	8	7	7	11	16	3	20	15	10	20	6	7	1	-2	5	9	2	13	6	9	9	16
The Northern Rd / Blaxland Ave	East	Right	7	15	23	11	6	13	11	4	11	44	34	5	12	14	10	9	4	29	11	-6	6	1	-1	5	14	9	24	11
The Northern Rd / Blaxland Ave	East	Left	7	8	11	4	10	9	3	2	8	10	5	6	12	10	11	6	1	2	-6	2	2	1	8	4	8	6	7	10
The Northern Rd / Blaxland Ave	South	Right	1	2	9	2	17	16	11	5	6	11	15	8	12	13	15	13	5	9	6	6	-5	-3	4	8	4	12	10	13
The Northern Rd / Blaxland Ave	South	Through	408	608	472	333	531	623	544	262	396	649	466	332	528	638	536	283	-12	41	-6	-1	-3	15	-8	21	455	490	461	496
The Northern Rd / Roots Ave	North	Right	9	16	25	3	21	6	10	3	15	14	25	10	17	24	21	15	6	-2	0	7	-4	18	11	12	13	10	16	19
The Northern Rd / Roots Ave	North	Through	450	432	319	294	521	553	447	264	434	414	330	279	515	532	456	245	-16	-18	11	-15	-6	-21	9	-19	374	446	364	437
The Northern Rd / Roots Ave	South	Through	388	575	429	323	506	619	535	259	373	616	450	318	516	627	525	271	-15	41	21	-5	10	8	-10	12	429	480	439	485
The Northern Rd / Roots Ave	South	Left	11	25	35	10	22	18	42	29	15	18	24	15	29	28	41	37	4	-7	-11	5	7	10	-1	8	20	28	18	34
The Northern Rd / Roots Ave	West	Right	36	58	57	12	57	26	37	24	33	52	58	24	59	46	30	22	-3	-6	1	12	2	20	-7	-2	41	36	42	39
The Northern Rd / Roots Ave	West	Left	21	35	52	12	42	21	20	8	29	44	33	21	25	24	25	25	8	9	-19	9	-17	3	5	17	30	23	32	25
The Northern Rd / Adams Rd	North	Through	481	472	362	299	564	569	478	285	456	452	357	292	553	566	476	262	-25	-20	-5	-7	-11	-3	-2	-23	404	474	389	464
The Northern Rd / Adams Rd	North	Left	5	18	14	7	14	10	6	4	10	15	25	15	17	16	8	7	5	-3	11	8	3	6	2	3	11	9	16	12
The Northern Rd / Adams Rd	East	Right	3	10	5	4	10	8	9	2	4	4	8	2	7	13	7	11	1	-6	3	-2	-3	5	-2	9	6	7	5	10
The Northern Rd / Adams Rd	East	Left	32	31	32	41	70	84	71	35	17	29	22	27	54	64	65	37	-15	-2	-10	-14	-16	-20	-6	2	34	65	24	55
The Northern Rd / Adams Rd	South	Right	46	69	49	34	57	57	33	19	43	51	20	25	54	53	37	22	-3	-18	-29	-9	-3	-4	4	3	50	42	35	42
The Northern Rd / Adams Rd	South	Through	396	590	459	329	518	629	568	286	385	629	467	330	534	645	553	296	-11	39	8	1	16	16	-15	10	444	500	453	507
The Northern Rd / Dwyer Rd	North	Right	11	10	13	13	29	26	20	23	12	12	30	8	33	25	49	20	1	2	17	-5	4	-1	29	-3	12	25	16	32
The Northern Rd / Dwyer Rd	North	Through	512	454	348	289	522	595	481	276	483	459	356	296	515	576	502	264	-29	5	8	7	-7	-19	21	-12	401	469	399	464
The Northern Rd / Dwyer Rd	South	Through	456	592	419	324	519	616	489	234	440	634	404	329	548	616	498	255	-16	42	-15	5	29	0	9	21	448	465	452	479
The Northern Rd / Dwyer Rd	South	Left	2	5	6	14	8	8	9	3	3	10	14	8	8	8	8	3	1	5	8	-6	0	0	-1	0	7	7	9	7
The Northern Rd / Dwyer Rd	West	Right	8	6	4	9	8	8	5	3	10	14	7	11	15	12	9	5	2	8	3	2	7	4	4	2	7	6	11	10
The Northern Rd / Dwyer Rd	West	Left	25	36	22	14	12	20	12	18	10	41	30	17	19	40	25	22	-15	5	8	3	7	20	13	4	24	16	25	27
Elizabeth Dr / Luddenham R	North	Right	41	45	56	32	122	136	113	76	50	36	57	31	122	118	104	72	9	-9	1	-1	0	-18	-9	-4	44	112	44	104
Elizabeth Dr / Luddenham R	North	Left	45	58	48	35	107	108	92	40	40	47	37	43	103	101	101	39	-5	-11	-11	8	-4	-7	9	-1	47	87	42	86
Elizabeth Dr / Luddenham R	East	Right	80	110	76	55	77	109	83	40	55	81	52	57	66	98	77	40	-25	-29	-24	2	-11	-11	-6	0	80	77	61	70
Elizabeth Dr / Luddenham R	East	Through	137	146	168	123	286	483	408	203	141	151	134	114	299	467	419	174	4	5	-34	-9	13	-16	11	-29	144	345	135	340
Elizabeth Dr / Luddenham R	West	Through	502	504	253	154	170	159	137	69	502	536	228	158	161	183	174	62	0	32	-25	4	-9	24	37	-7	353	134	356	145
Elizabeth Dr / Luddenham R	West	Left	85	155	109	39	69	62	60	56	92	171	115	40	35	71	85	29	7	16	6	1	-34	9	25	-27	97	62	105	55
Park Rd / Campbell St	East	Through	87	82	89	91	251	297	311	164	72	102	101	94	274	274	299	175	-15	20	12	3	23	-23	-12	11	87	256	92	256
Park Rd / Campbell St	East	Left	2	4	18	5	11	15	8	6	0	0	0	0	0	0	0	0	-2	-4	-18	-5	-11	-15	-8	-6	7	10	0	0
Park Rd / Campbell St	South	Right	0	3	13	3	13	3	4	2	0	0	0	0	0	0	0	0	0	-3	-13	-3	-13	-3	-4	-2	5	6	0	0
Park Rd / Campbell St	South	Left	2	10	22	8	45	15	13	8	5	5	9	0	19	19	20	10	3	-5	-13	-8	-26	4	7	2	11	20	5	17
Park Rd / Campbell St	West	Right	31	53	79	12	31	31	16	11	20	23	49	12	6	2	3	0	-11	-30	-30	0	-25	-29	-13	-11	44	22	26	3
Park Rd / Campbell St	West	Through	284	325	207	115	130	117	95	57	319	341	184	124	129	130	106	63	35	16	-23	9	-1	13	11	6	233	100	242	107

THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL v03 Micro OS1

Traffic Volume Calibration Results : Heavy Vehicles

Intersection	Approac	Direction	Target volume								Modelled volume								Modelled vs target volume								Ave Target (vph)		Ave Modelled (vph)	
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	AM	PM	AM	PM
The Northern Rd S of Derby St	Northbound		114	68	65		89	67	40		114	56	64		87	53	48		0	-12	-1		-2	-14	8		82	65	78	63
The Northern Rd S of Derby St	Southbound		59	84	67		94	69	27		62	79	60		77	67	34		3	-5	-7		-17	-2	7		70	63	67	59
The Northern Rd / Jamison Rd	North	Right	6	18	2		12	13	0		9	13	5		9	8	2		3	-5	3		-3	-5	2		9	8	9	6
The Northern Rd / Jamison Rd	North	Through	66	65	68		81	69	46		57	67	60		71	76	43		-9	2	-8		-10	7	-3		66	65	61	63
The Northern Rd / Jamison Rd	North	Left	1	0	0		0	0	0		0	0	0		0	0	0		-1	0	0		0	0	0		0	0	0	0
The Northern Rd / Jamison Rd	East	Right	0	0	0		2	1	0		0	0	0		2	0	0		0	0	0		0	-1	0		0	1	0	1
The Northern Rd / Jamison Rd	East	Through	3	2	9		3	6	4		9	7	15		4	10	3		6	5	6		1	4	-1		5	4	10	6
The Northern Rd / Jamison Rd	East	Left	1	1	2		2	0	0		5	2	2		2	0	0		4	1	0		0	0	0		1	1	3	1
The Northern Rd / Jamison Rd	South	Right	6	0	0		0	0	0		1	0	3		1	0	2		-5	0	3		1	0	2		2	0	1	1
The Northern Rd / Jamison Rd	South	Through	108	58	84		87	57	37		97	47	64		69	40	39		-11	-11	-20		-18	-17	2		83	60	69	49
The Northern Rd / Jamison Rd	South	Left	4	6	6		3	4	5		6	5	5		13	5	3		2	-1	-1		10	1	-2		5	4	5	7
The Northern Rd / Jamison Rd	West	Right	5	4	7		6	1	0		16	9	9		3	3	0		11	5	2		-3	2	0		5	2	11	2
The Northern Rd / Jamison Rd	West	Through	7	7	4		6	5	5		14	8	7		7	9	4		7	1	3		1	4	-1		6	5	10	7
The Northern Rd / Jamison Rd	West	Left	15	7	8		12	10	5		30	11	16		20	13	9		15	4	8		8	3	4		10	9	19	14
The Northern Rd / Smith St	North	Right	1	4	0	4	2	3	1	1	1	4	0	3	5	10	3	3	0	0	0	-1	3	7	2	2	2	2	2	5
The Northern Rd / Smith St	North	Through	70	64	77	100	85	66	45	25	77	68	70	84	70	62	42	23	7	4	-7	-16	-15	-4	-3	-2	78	55	75	49
The Northern Rd / Smith St	North	Left	1	2	0	0	2	1	0	1	0	6	0	0	1	5	0	0	-1	4	0	0	-1	4	0	-1	1	1	2	2
The Northern Rd / Smith St	East	Right	4	2	4	3	2	3	3	1	8	4	7	0	2	4	3	0	4	2	3	-3	0	1	0	-1	3	2	5	2
The Northern Rd / Smith St	East	Through	0	2	2	0	1	1	0	0	3	1	2	0	2	0	0	0	3	-1	0	0	1	-1	0	0	1	1	2	1
The Northern Rd / Smith St	East	Left	1	2	1	2	1	0	1	0	0	0	3	0	0	0	0	1	-1	-2	2	-2	-1	0	-1	1	2	1	1	0
The Northern Rd / Smith St	South	Right	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0
The Northern Rd / Smith St	South	Through	102	61	85	108	82	56	37	25	97	48	64	104	81	42	41	41	-5	-13	-21	-4	-1	-14	4	16	89	50	78	51
The Northern Rd / Smith St	South	Left	5	3	4	4	2	4	3	2	2	6	2	5	5	7	4	3	-3	3	-2	1	3	3	1	1	4	3	4	5
The Northern Rd / Smith St	West	Right	6	5	4	6	9	3	3	2	4	1	3	2	7	3	5	0	-2	-4	-1	-4	-2	0	2	-2	5	4	3	4
The Northern Rd / Smith St	West	Through	1	2	1	0	1	1	0	0	2	0	0	0	0	0	0	0	1	-2	-1	0	-1	-1	0	0	1	1	1	0
The Northern Rd / Smith St	West	Left	12	1	1	1	7	2	3	1	0	1	0	0	0	0	0	0	-12	0	-1	-1	-7	-2	-3	-1	4	3	0	0
The Northern Rd / Maxwell St / Bringelly Rd	North	Right	5	2	22		10	6	6		4	3	14		6	3	2		-1	1	-8		-4	-3	-4		10	7	7	4
The Northern Rd / Maxwell St / Bringelly Rd	North	Through	66	64	59		80	60	39		71	62	58		71	57	44		5	-2	-1		-9	-3	5		63	60	64	57
The Northern Rd / Maxwell St / Bringelly Rd	North	Left	7	5	2		4	3	6		4	5	3		2	5	0		-3	0	1		-2	2	-6		5	4	4	2
The Northern Rd / Maxwell St / Bringelly Rd	East	Right	0	2	8		3	1	0		1	0	1		2	1	0		1	-2	-7		-1	0	0		3	1	1	1
The Northern Rd / Maxwell St / Bringelly Rd	East	Through	1	0	1		1	1	0		0	0	0		0	1	0		-1	0	-1		-1	0	0		1	1	0	0
The Northern Rd / Maxwell St / Bringelly Rd	East	Left	15	20	28		27	5	5		17	22	37		33	14	6		2	2	9		6	9	1		21	12	25	18
The Northern Rd / Maxwell St / Bringelly Rd	South	Right	18	15	28		13	6	10		23	8	39		10	10	7		5	-7	11		-3	4	-3		20	10	23	9
The Northern Rd / Maxwell St / Bringelly Rd	South	Through	106	59	76		78	57	38		76	53	54		73	39	43		-30	-6	-22		-5	-18	5		80	58	61	52
The Northern Rd / Maxwell St / Bringelly Rd	South	Left	4	4	4		7	6	5		5	3	9		5	4	3		1	-1	5		-2	-2	-2		4	6	6	4
The Northern Rd / Maxwell St / Bringelly Rd	West	Right	10	5	7		6	10	8		12	8	2		6	10	9		2	3	-5		0	0	1		7	8	7	8
The Northern Rd / Maxwell St / Bringelly Rd	West	Through	1	3	0		2	1	2		0	5	0		0	1	0		-1	2	0		-2	0	-2		1	2	2	0
The Northern Rd / Maxwell St / Bringelly Rd	West	Left	1	3	7		4	3	2		21	1	11		10	8	2		20	-2	4		6	5	0		4	3	11	7
The Northern Rd / Castle Rd / Aspen St	North	Through	90	61	67	90	86	70	46	21	87	53	57	64	71	65	53	19	-3	-8	-10	-26	-15	-5	7	-2	77	56	65	52
The Northern Rd / Castle Rd / Aspen St	North	Left	1	28	27	19	27	5	6	7	13	39	40	21	38	17	6	9	12	11	13	2	11	12	0	2	19	11	28	18
The Northern Rd / Castle Rd / Aspen St	East	Right	21	10	3	17	5	4	2	5	22	17	5	17	11	6	4	3	1	7	2	0	6	2	2	-2	13	4	15	6
The Northern Rd / Castle Rd / Aspen St	East	Left	5	34	30	15	21	14	9	12	5	29	37	8	10	11	6	6	0	-5	7	-7	-11	-3	-3	-6	21	14	20	8
The Northern Rd / Castle Rd / Aspen St	S+W to E		13	12	2	18	12	6	8	10	9	14	4	16	21	6	23	10	-4	2	2	-2	9	0	15	0	11	9	11	15
The Northern Rd / Castle Rd / Aspen St	S to N+E		94	78	104	121	101	64	54	34	87	61	100	119	93	52	68	41	-7	-17	-4	-2	-8	-12	14	7	99	63	92	64
The Northern Rd / Castle Rd / Aspen St	South	Left	37	14	7	28	10	14	8	5	38	12	8	37	10	12	6	4	1	-2	1	9	0	-2	-2	-1	22	9	24	8
The Northern Rd / Castle Rd / Aspen St	W to N+E		27	2	2	18	5	9	3	5	4	0	0	4	4	2	3	3	-23	-2	-2	-14	-1	-7	0	-2	12	6	2	3
The Northern Rd / Castle Rd / Aspen St	S+W to N		108	68	104	121	94	67	49	29	81	48	96	107	77	48	49	34	-27	-20	-8	-14	-17	-19	0	5	100	60	83	52
The Northern Rd / Tukara Rd / Frogmore Rd	North	Through	91	90	96		105	79	53		83	77	90		77	72	56		-8	-13	-6		-28	-7	3		92	79	83	68
The Northern Rd / Tukara Rd / Frogmore Rd	North	Left	5	5	2		3	5	2		9	5	3		4	4	3		4	0	1		1	-1	1		4	3	6	4
The Northern Rd / Tukara Rd / Frogmore Rd	East	Right	0	0	4		1	2	1		5	4	6		1	3	0		5	4	2		0	1	-1		1	1	5	1
The Northern Rd / Tukara Rd / Frogmore Rd	East	Left	5	6	1		0	0	1		7	5	0		2	0	0		2	-1	-1		2	0	-1		4	0	4	1
The Northern Rd / Tukara Rd / Frogmore Rd	South	Right	0	1	0		2	2	0		1	0	0		2	2	1		1	-1	0		0	0	1		0	1	0	2
The Northern Rd / Tukara Rd / Frogmore Rd	South	Through	126	91	105		109	75	59		111	69	94		97	59	70		-15	-22	-11		-12	-16	11		107	81	91	75
The Northern Rd / Tukara Rd / Frogmore Rd	South	Left	0	22	10		12	31	20		1	24	8		16	36	19		1	2	-2		4	5	-1		11	21	11	24
The Northern Rd / Tukara Rd / Frogmore Rd	West	Left	4	0	5		0	1	3		11	2	4		6	1	4		7	2	-1		6	0	1		3	1	6	4
The Northern Rd / M4 WB ramps	North	Through	55	63	57	44	71	43	28	20	53	49	53	34	44	28	20	12	-2	-14	-4	-10	-27	-15	-8	-8	55	41	47	26
The Northern Rd / M4 WB ramps	North	Left	41	34	40	62	34	36	26	13	41	33	37	43	35	46	36	12	0	-1	-3	-19	1	10	10	-1	44	27	39	32
The Northern Rd / M4 WB ramps	South	Right	35	15	18	19	15	13	6	9	45	15	15	22	13	12	8	9	10	0	-3	3	-2	-1	2	0	22	11	24	11
The Northern Rd / M4 WB ramps	South	Through	85	100	101	109	109	105	77	38	63	78	91	104	91	91	81	42	-22	-22	-10	-5	-18	-14	4	4	99	82	84	76
The Northern Rd / M4 WB ramps	West	Right	26	32	30	26	34	48	37	17	21	39	33	22	43	47	35	14	-5	7	3	-4	9	-1	-2	-3	29	34	29	35
The Northern Rd / M4 WB ramps	West	Left	41	14	14	41	14	3	2	4	50	16	11	44	22	7	9	6	9	2	-3	3	8	4	7	2	28	6	30	11
The Northern Rd / M4 EB ramps	North	Right	4	16	10	15	17	7	6	4	4	12	10	12	15	7	3	1	0	-4	0	-3	-2	0	-3	-3	11	9	10	7
The Northern Rd / M4 EB ramps	North	Through	77	79	77	55	88	84	59	33	70	75	77	44	72	69	52	25	-7	-4	0	-11	-16	-15	-7	-8	72	66	67	55
The Northern Rd / M4 EB ramps	East	Right	41	46	53	56	53	52	37	23	30	46	58	55	52	51	37	27	-11	0	5	-1	-1	-1	0	4	49	41	47	42
The Northern Rd / M4 EB ramps	East	Left	11	16	21	34	31	35	22	17	11	20	18	23	36	35	15	12	0	4	-3	-11	5	0	-7	-5	21	26	18	25

THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL v03 Micro OS1

Traffic Volume Calibration Results : Heavy Vehicles

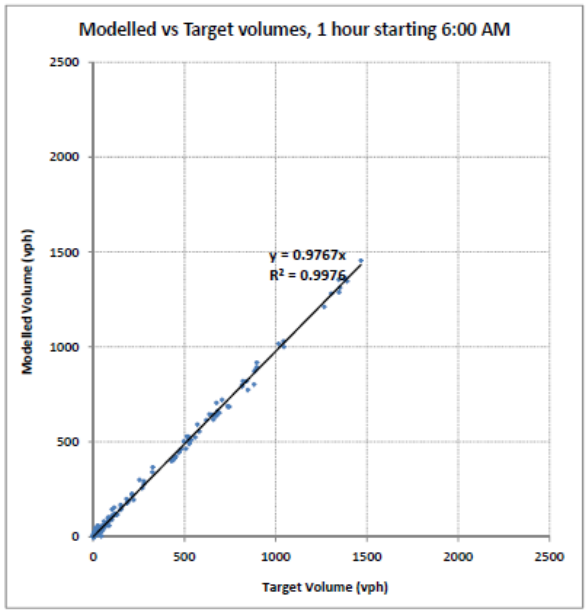
Intersection	Approac	Direction	Target volume								Modelled volume								Modelled vs target volume								Ave Target (vph)		Ave Modelled (vph)	
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	AM	PM	AM	PM
The Northern Rd / M4 EB ramps	South	Through	79	69	66	72	71	66	46	24	74	47	48	72	51	51	52	24	-5	-22	-18	0	-20	-15	6	0	72	52	60	45
The Northern Rd / M4 EB ramps	South	Left	16	7	16	26	20	21	12	15	17	6	20	26	12	24	16	17	1	-1	4	0	-8	3	4	2	16	17	17	17
The Northern Rd / Homestead Rd / Garswood Rd	North	Through	78	81	78	83	107	108	74	45	75	71	77	59	86	89	61	31	-3	-10	-1	-24	-21	-19	-13	-14	80	84	71	67
The Northern Rd / Homestead Rd / Garswood Rd	North	Left	10	14	20	6	12	11	7	5	6	24	18	7	20	17	6	6	-4	10	-2	1	8	6	-1	1	13	9	14	12
The Northern Rd / Homestead Rd / Garswood Rd	East	Right	6	3	2	0	1	2	0	1	7	4	0	5	2	6	0	0	1	1	-2	5	1	4	0	-1	3	1	4	2
The Northern Rd / Homestead Rd / Garswood Rd	East	Left	2	4	1	3	7	5	1	1	0	9	5	7	5	5	1	3	-2	5	4	4	-2	0	0	2	3	4	5	4
The Northern Rd / Homestead Rd / Garswood Rd	South	Right	8	3	3	5	3	3	3	3	4	2	9	2	1	1	6	3	-4	-1	6	-3	-2	-2	3	0	5	3	4	3
The Northern Rd / Homestead Rd / Garswood Rd	South	Through	88	71	78	96	86	83	56	36	75	46	65	83	58	64	67	42	-13	-25	-13	-13	-28	-19	11	6	83	65	67	58
The Northern Rd / Homestead Rd / Garswood Rd	South	Left	7	4	3	0	6	3	10	3	5	3	4	7	3	5	2	2	-2	-1	1	7	-3	2	-8	-1	4	6	5	3
The Northern Rd / Homestead Rd / Garswood Rd	West	Left	1	2	2	2	4	2	2	1	5	3	3	10	4	4	1	0	4	1	1	8	0	2	-1	-1	2	2	5	2
The Northern Rd / Glenmore Pkwy / Wentworth Rd	N to S,W,N		71	78	74	85	93	96	53	25	71	74	86	66	71	80	44	16	0	-4	12	-19	-22	-16	-9	-9	77	67	74	53
The Northern Rd / Glenmore Pkwy / Wentworth Rd	S,E,N to N		66	52	75	105	86	69	62	34	57	37	77	87	55	59	69	34	-9	-15	2	-18	-31	-10	7	0	75	63	65	54
The Northern Rd / Glenmore Pkwy / Wentworth Rd	Circ past N		1	4	1	1	5	1	2	0	4	4	3	0	5	2	6	4	3	0	2	-1	0	1	4	4	2	2	3	4
The Northern Rd / Glenmore Pkwy / Wentworth Rd	W to N		25	15	18	6	8	11	7	9	27	13	9	7	8	11	10	13	2	-2	-9	1	0	0	3	4	16	9	14	11
The Northern Rd / Glenmore Pkwy / Wentworth Rd	E to W,N,E		4	9	11	7	17	7	1	7	0	7	8	2	6	1	9	6	-4	-2	-3	-5	-11	-6	8	-1	8	8	4	6
The Northern Rd / Glenmore Pkwy / Wentworth Rd	W,S,E to E		1	10	2	1	5	3	2	0	4	7	3	0	5	2	6	3	3	-3	1	-1	0	-1	4	3	4	3	4	4
The Northern Rd / Glenmore Pkwy / Wentworth Rd	Circ past E		5	3	0	0	3	1	0	1	1	6	1	0	2	1	0	1	-4	3	1	0	-1	0	0	0	2	1	2	1
The Northern Rd / Glenmore Pkwy / Wentworth Rd	N to E		2	11	13	5	15	1	2	3	3	2	2	0	7	0	1	0	1	-9	-11	-5	-8	-1	-1	-3	8	5	2	2
The Northern Rd / Glenmore Pkwy / Wentworth Rd	S to N,E,S		61	50	66	89	75	58	63	25	58	34	73	78	54	55	68	33	-3	-16	7	-11	-21	-3	5	8	67	55	61	53
The Northern Rd / Glenmore Pkwy / Wentworth Rd	N,W,S to S		66	67	65	66	87	62	43	22	64	64	75	51	71	50	36	14	-2	-3	10	-15	-16	-12	-7	-8	66	54	64	43
The Northern Rd / Glenmore Pkwy / Wentworth Rd	Circ past S		10	14	9	19	9	35	10	4	9	16	11	16	3	31	8	3	-1	2	2	-3	-6	-4	-2	-1	13	15	13	11
The Northern Rd / Glenmore Pkwy / Wentworth Rd	E to S		0	1	0	0	2	1	0	0	0	0	0	0	7	2	7	2	0	-1	0	0	5	1	7	2	0	1	0	5
The Northern Rd / Glenmore Pkwy / Wentworth Rd	W to E,S,W		5	9	1	0	3	3	0	1	1	9	1	0	2	1	0	0	-4	0	0	0	-1	-2	0	-1	4	2	3	1
The Northern Rd / Glenmore Pkwy / Wentworth Rd	E,N,W to W		8	17	10	9	10	30	10	2	6	16	11	10	3	26	10	4	-2	-1	1	1	-7	-4	0	2	11	13	11	11
The Northern Rd / Glenmore Pkwy / Wentworth Rd	Circ past W		6	6	10	17	16	12	1	9	3	7	8	8	6	6	7	5	-3	1	-2	-9	-10	-6	6	-4	10	10	7	6
The Northern Rd / Glenmore Pkwy / Wentworth Rd	S to W		11	20	21	19	5	9	7	14	11	29	15	15	12	7	12	10	0	9	-6	-4	7	-2	5	-4	18	9	18	10
The Northern Rd / Bradley St	North	Right	13	14	12	10	7	5	12	3	9	9	13	12	10	1	11	2	-4	-5	1	2	3	-4	-1	-1	12	7	11	6
The Northern Rd / Bradley St	North	Through	55	55	53	56	85	58	31	19	56	54	63	39	66	53	33	12	1	-1	10	-17	-19	-5	2	-7	55	48	53	41
The Northern Rd / Bradley St	South	Through	68	58	75	101	69	60	61	37	67	58	82	89	61	58	66	41	-1	0	7	-12	-8	-2	5	4	76	57	74	57
The Northern Rd / Bradley St	South	Left	1	2	1	4	4	4	4	0	3	2	0	4	3	4	7	1	2	0	-1	0	-1	0	3	1	2	3	2	4
The Northern Rd / Bradley St	West	Right	15	13	13	10	10	6	9	16	14	20	18	5	19	3	8	21	-1	7	5	-5	9	-3	-1	5	13	10	14	13
The Northern Rd / Bradley St	West	Left	4	12	12	7	11	7	9	2	1	6	7	4	3	9	10	4	-3	-6	-5	-3	-8	2	1	2	9	7	5	7
The Northern Rd / Defense Establishments Gates	North	Through	66	67	64	66	94	63	38	34	69	72	79	45	87	54	39	32	3	5	15	-21	-7	-9	1	-2	66	57	66	53
The Northern Rd / Defense Establishments Gates	North	Left	4	1	2	0	1	1	2	1	3	1	1	1	0	1	1	3	-1	0	-1	1	-1	0	-1	2	2	1	2	1
The Northern Rd / Defense Establishments Gates	East	Right	0	1	3	2	0	3	1	0	4	0	3	3	1	2	0	0	4	-1	0	1	1	-1	-1	0	2	1	3	1
The Northern Rd / Defense Establishments Gates	East	Left	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
The Northern Rd / Defense Establishments Gates	South	Right	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	0	0	0	0	1	0	0	0
The Northern Rd / Defense Establishments Gates	South	Through	69	59	73	103	73	61	64	37	65	59	81	92	62	60	73	43	-4	0	8	-11	-11	-1	9	6	76	59	74	60
The Northern Rd / Chain-O-Ponds Rd	North	Right	0	0	0	1	1	0	1	0	0	2	1	0	0	0	0	0	0	2	1	-1	-1	0	-1	0	0	1	1	0
The Northern Rd / Chain-O-Ponds Rd	North	Through	66	67	64	65	93	63	37	33	68	72	76	47	85	56	39	31	2	5	12	-18	-8	-7	2	-2	66	57	66	53
The Northern Rd / Chain-O-Ponds Rd	South	Through	69	58	73	104	69	61	64	37	62	58	81	94	60	59	74	39	-7	0	8	-10	-9	-2	10	2	76	58	74	58
The Northern Rd / Chain-O-Ponds Rd	South	Left	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0
The Northern Rd / Chain-O-Ponds Rd	West	Right	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	-1	0	0	0	0
The Northern Rd / Chain-O-Ponds Rd	West	Left	0	1	1	0	4	0	0	0	2	0	0	0	1	0	1	2	2	-1	-1	0	-3	0	1	2	1	1	1	1
The Northern Rd / Kings Hill Rd	North	Right	0	0	0	2	2	5	3	2	2	2	6	3	5	8	3	5	2	2	6	1	3	3	0	3	1	3	3	5
The Northern Rd / Kings Hill Rd	North	Through	70	63	54	56	92	55	34	27	64	68	61	46	79	48	36	27	-6	5	7	-10	-13	-7	2	0	61	52	60	48
The Northern Rd / Kings Hill Rd	South	Through	54	42	52	83	68	64	46	18	52	45	58	74	58	59	57	20	-2	3	6	-9	-10	-5	11	2	58	49	57	49
The Northern Rd / Kings Hill Rd	South	Left	0	0	0	1	2	0	0	0	2	0	0	0	1	0	0	0	2	0	0	-1	-1	0	0	0	0	1	1	0
The Northern Rd / Kings Hill Rd	West	Right	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0
The Northern Rd / Kings Hill Rd	West	Left	3	1	1	2	0	0	0	0	3	0	2	2	2	0	0	0	0	-1	1	0	2	0	0	0	2	0	2	1
The Northern Rd / Longview Rd	North	Right	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0
The Northern Rd / Longview Rd	North	Through	70	63	55	56	92	55	34	27	64	68	58	48	79	48	35	27	-6	5	3	-8	-13	-7	1	0	61	52	60	47
The Northern Rd / Longview Rd	South	Through	54	42	52	84	70	64	46	18	52	47	56	74	59	59	57	20	-2	5	4	-10	-11	-5	11	2	58	50	57	49
The Northern Rd / Longview Rd	South	Left	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
The Northern Rd / Longview Rd	West	Right	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
The Northern Rd / Longview Rd	West	Left	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0
The Northern Rd / Gates Rd	North	Through	72	55	53	52	85	59	34	23	62	59	58	47	72	51	35	24	-10	4	5	-5	-13	-8	1	1	58	50	57	46
The Northern Rd / Gates Rd	North	Left	0	1	1	0	3	0	0	1	0	3	0	0	2	1	0	0	0	2	-1	0	-1	1	0	-1	1	1	1	1
The Northern Rd / Gates Rd	East	Right	2	0	0	2	0	1	0	1	2	3	0	0	0	0	0	0	0	3	0	-2	0	-1	0	-1	1	1	1	0
The Northern Rd / Gates Rd	East	Left	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	-1	-1	0	-1	0	0	0	0	1	0	0	0
The Northern Rd / Gates Rd	South	Right	0	1	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	-1	0	0	0	0	-1	-1	1	1	0	0
The Northern Rd / Gates Rd	South	Through	48	45	47	78	68	66	44	15	44	45	55	71	57	61	55	19	-4	0	8	-7	-11	-5	11	4	55	48	54	48
The Northern Rd / Littlefields Rd	North	Right	1	2	0	0	2	0	1	2	1	1	0	1	0	2	0	2	0	-1	0	1	-2	2	-1	0	1	1	1	1
The Northern Rd / Littlefields Rd	North	Through	72	54	54	53	83	59	33	21	60	58	58	48	73	49	35	22	-12	4	4	-5	-10	-10	2	1	58	49	56	45
The Northern Rd / Littlefields Rd	South	Through	44	45	47	79	68	66	45	16	44	44	53	74	54	60	55	18	0	-1	6	-5	-14	-6	10	2	54	49	54	47

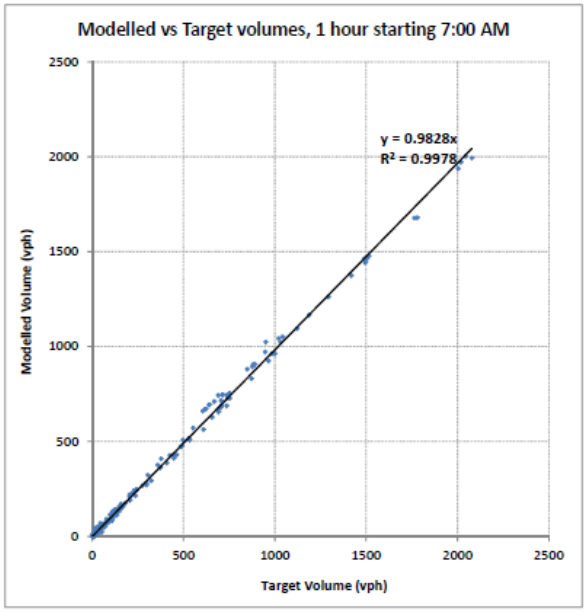
THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL v03 Micro OS1

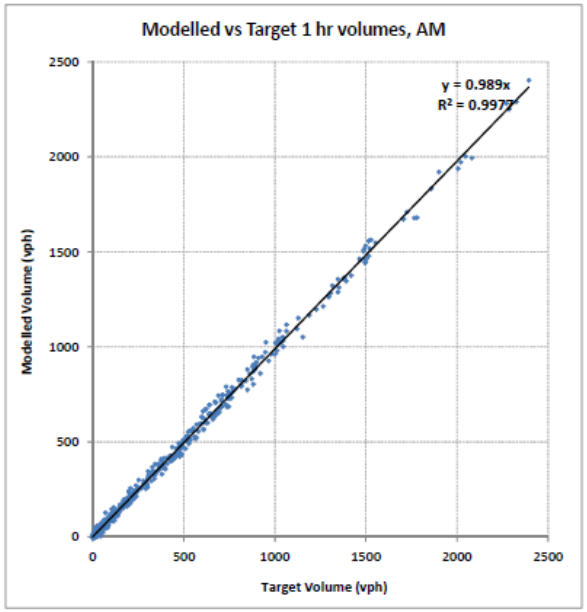
Traffic Volume Calibration Results : Heavy Vehicles

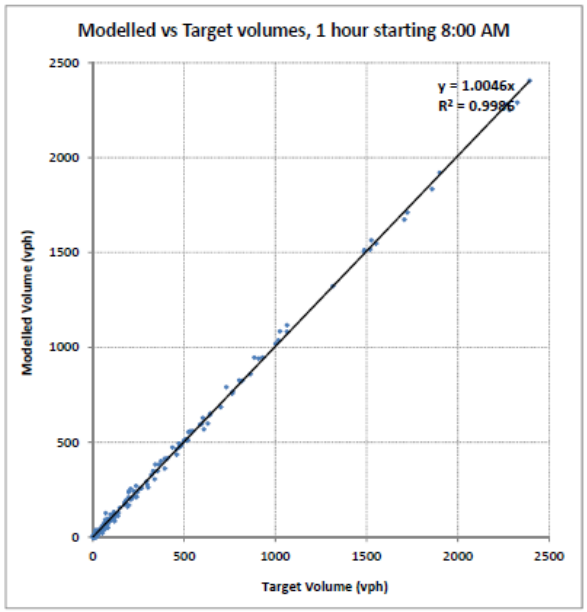
Intersection	Approac	Direction	Target volume								Modelled volume								Modelled vs target volume								Ave Target (vph)		Ave Modelled (vph)	
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	AM	PM	AM	PM
The Northern Rd / Littlefields Rd	South	Left	4	1	0	3	1	4	1	1	2	3	2	3	6	8	4	0	-2	2	2	0	5	4	3	-1	2	2	3	5
The Northern Rd / Littlefields Rd	West	Right	3	3	0	1	2	1	2	1	0	5	0	0	0	1	0	0	-3	2	0	-1	-2	0	-2	-1	2	2	1	0
The Northern Rd / Littlefields Rd	West	Left	4	1	0	0	0	0	0	0	0	1	2	0	3	1	1	0	-4	0	2	0	3	1	1	0	1	0	1	1
The Northern Rd / Elizabeth Dr	In from N		76	55	55	54	83	51	32	21	60	65	56	47	66	46	30	24	-16	10	1	-7	-17	-5	-2	3	60	47	57	42
The Northern Rd / Elizabeth Dr	Out to N		49	45	48	83	67	68	39	17	47	49	53	75	58	71	57	17	-2	4	5	-8	-9	3	18	0	56	48	56	51
The Northern Rd / Elizabeth Dr	Circ past N		35	17	22	28	20	10	10	3	25	18	16	22	23	7	8	1	-10	1	-6	-6	3	-3	-2	-2	26	11	20	10
The Northern Rd / Elizabeth Dr	In from E		32	31	35	54	62	43	29	12	32	22	42	36	42	41	30	7	0	-9	7	-18	-20	-2	1	-5	38	37	33	30
The Northern Rd / Elizabeth Dr	Out to E		58	34	47	41	45	20	18	7	41	39	34	32	38	16	15	5	-17	5	-13	-9	-7	-4	-3	-2	45	23	37	19
The Northern Rd / Elizabeth Dr	Circ past E		53	38	30	41	58	41	24	17	44	44	38	37	51	37	23	20	-9	6	8	-4	-7	-4	-1	3	41	35	41	33
The Northern Rd / Elizabeth Dr	In from S		66	52	56	79	56	51	37	15	59	59	56	76	52	48	44	14	-7	7	0	-3	-4	-3	7	-1	63	40	63	40
The Northern Rd / Elizabeth Dr	Out to S		67	59	51	63	89	57	41	24	63	56	69	52	64	47	33	23	-4	-3	18	-11	-25	-10	-8	-1	60	53	60	42
The Northern Rd / Elizabeth Dr	Circ past S		18	10	14	32	31	27	12	5	13	10	11	21	29	31	20	4	-5	0	-3	-11	-2	4	8	-1	19	19	14	21
The Northern Rd / Park Rd	North	Right	9	17	20	20	29	20	14	6	10	9	23	15	25	13	10	4	1	-8	3	-5	-4	-7	-4	-2	17	17	14	13
The Northern Rd / Park Rd	North	Through	48	40	30	42	57	36	29	18	44	46	46	36	39	35	22	20	-4	6	16	-6	-18	-1	-7	2	40	35	43	29
The Northern Rd / Park Rd	South	Through	35	28	39	52	37	43	30	11	21	36	37	52	28	48	38	13	-14	8	-2	0	-9	5	8	2	39	30	37	32
The Northern Rd / Park Rd	South	Left	7	6	9	6	10	8	8	0	8	5	10	4	10	10	10	2	1	-1	1	-2	0	2	2	2	7	7	7	8
The Northern Rd / Park Rd	West	Right	17	12	14	10	6	2	4	4	18	13	9	11	6	4	5	2	1	1	-5	1	0	2	1	-2	13	4	13	4
The Northern Rd / Park Rd	West	Left	25	21	17	26	21	4	7	3	31	23	18	20	21	2	2	1	6	2	1	-6	0	-2	-5	-2	22	9	23	7
The Northern Rd / Blaxland Ave	North	Through	74	52	41	49	55	41	30	27	63	59	52	49	42	34	23	26	-11	7	11	0	-13	-7	-7	-1	54	38	56	31
The Northern Rd / Blaxland Ave	North	Left	0	2	0	1	5	0	0	0	0	0	2	0	3	3	0	0	0	-2	2	-1	-2	3	0	0	1	1	1	2
The Northern Rd / Blaxland Ave	East	Right	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	-1	0	1	0	0
The Northern Rd / Blaxland Ave	East	Left	1	0	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	-1	0	0	0	1	0	1	0
The Northern Rd / Blaxland Ave	South	Right	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0
The Northern Rd / Blaxland Ave	South	Through	45	31	45	57	43	56	43	8	28	44	44	56	42	54	49	14	-17	13	-1	-1	-1	-2	6	6	45	38	43	40
The Northern Rd / Roots Ave	North	Right	0	0	0	2	3	1	0	0	0	0	0	0	0	3	0	0	0	0	0	-2	-3	2	0	0	1	1	0	1
The Northern Rd / Roots Ave	North	Through	75	52	42	47	53	40	30	27	64	59	53	49	42	31	23	26	-11	7	11	2	-11	-9	-7	-1	54	38	56	31
The Northern Rd / Roots Ave	South	Through	41	31	43	56	43	55	43	8	27	44	43	56	42	53	48	14	-14	13	0	0	-1	-2	5	6	43	37	43	39
The Northern Rd / Roots Ave	South	Left	3	5	2	3	12	1	1	5	4	4	1	10	12	4	2	4	1	-1	-1	7	0	3	1	-1	3	5	5	6
The Northern Rd / Roots Ave	West	Right	4	7	5	1	4	6	0	0	16	4	9	6	6	6	1	1	12	-3	4	5	2	0	1	1	4	3	9	4
The Northern Rd / Roots Ave	West	Left	4	1	2	1	0	1	0	0	1	0	1	0	0	2	0	0	-3	-1	-1	-1	0	1	0	0	2	0	1	1
The Northern Rd / Adams Rd	North	Through	78	57	47	48	56	46	30	27	69	64	59	52	48	37	24	27	-9	7	12	4	-8	-9	-6	0	58	40	61	34
The Northern Rd / Adams Rd	North	Left	1	2	0	0	1	0	0	0	9	0	3	3	0	0	0	0	8	-2	3	3	-1	0	0	0	1	0	4	0
The Northern Rd / Adams Rd	East	Right	1	3	0	1	2	1	0	0	4	4	0	4	2	1	2	3	3	1	0	3	0	0	2	3	1	1	3	2
The Northern Rd / Adams Rd	East	Left	3	0	2	1	2	1	2	0	0	0	0	0	1	2	10	3	-3	0	-2	-1	-1	1	8	3	2	1	0	4
The Northern Rd / Adams Rd	South	Right	4	1	2	1	1	7	2	2	4	1	1	0	1	3	4	0	0	0	-1	-1	0	-4	2	-2	2	3	2	2
The Northern Rd / Adams Rd	South	Through	43	33	45	58	53	55	44	13	27	44	44	62	52	58	46	15	-16	11	-1	4	-1	3	2	2	45	41	44	43
The Northern Rd / Dwyer Rd	North	Right	0	6	1	3	5	3	4	3	4	4	3	6	2	1	10	10	4	-2	2	3	-3	-2	6	7	3	4	4	6
The Northern Rd / Dwyer Rd	North	Through	68	42	45	39	47	41	24	16	72	49	58	40	50	32	21	23	4	7	13	1	3	-9	-3	7	49	32	55	32
The Northern Rd / Dwyer Rd	South	Through	25	25	40	41	49	56	36	11	21	37	31	40	46	61	47	12	-4	12	-9	-1	-3	5	11	1	33	38	32	42
The Northern Rd / Dwyer Rd	South	Left	0	0	2	0	1	0	2	0	0	0	0	0	0	0	3	0	0	0	-2	0	-1	0	1	0	1	1	0	1
The Northern Rd / Dwyer Rd	West	Right	4	5	0	1	1	0	0	1	9	5	0	0	1	2	0	0	5	0	0	-1	0	2	0	-1	3	1	4	1
The Northern Rd / Dwyer Rd	West	Left	6	3	2	4	2	0	3	0	6	5	2	4	1	0	0	0	0	2	0	0	-1	0	-3	0	4	1	4	0
Elizabeth Dr / Luddenham R	North	Right	0	3	4	1	3	4	7	4	1	1	10	3	4	6	0	3	1	-2	6	2	1	2	-7	-1	2	5	4	3
Elizabeth Dr / Luddenham R	North	Left	0	1	0	5	3	5	2	0	0	2	0	4	3	3	12	2	0	1	0	-1	0	-2	10	2	2	3	2	5
Elizabeth Dr / Luddenham R	East	Right	6	1	0	1	9	1	1	0	4	4	0	0	6	0	1	0	-2	3	0	-1	-3	-1	0	0	2	3	2	2
Elizabeth Dr / Luddenham R	East	Through	49	35	28	46	54	55	26	5	37	25	35	39	38	46	28	4	-12	-10	7	-7	-16	-9	2	-1	40	35	34	29
Elizabeth Dr / Luddenham R	West	Through	18	48	49	44	35	16	8	0	27	36	33	32	28	11	7	2	9	-12	-16	-12	-7	-5	-1	2	40	15	32	12
Elizabeth Dr / Luddenham R	West	Left	0	2	4	4	1	1	2	0	13	0	2	2	1	1	5	0	13	-2	-2	-2	0	0	3	0	3	1	4	2
Park Rd / Campbell St	East	Through	15	23	27	26	38	27	20	6	18	14	33	19	35	22	21	6	3	-9	6	-7	-3	-5	1	0	23	23	21	21
Park Rd / Campbell St	East	Left	0	0	2	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	-2	0	-1	-1	-1	0	1	1	0	0
Park Rd / Campbell St	South	Right	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	0	0	0	0	0	0	0
Park Rd / Campbell St	South	Left	1	1	1	0	2	1	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	0	-2	-1	0	0	1	1	0	0
Park Rd / Campbell St	West	Right	3	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0	-3	0	-2	-1	0	0	-1	0	2	0	0	0
Park Rd / Campbell St	West	Through	42	33	31	35	26	6	11	7	49	36	27	31	27	6	7	3	7	3	-4	-4	1	0	-4	-4	35	13	36	11

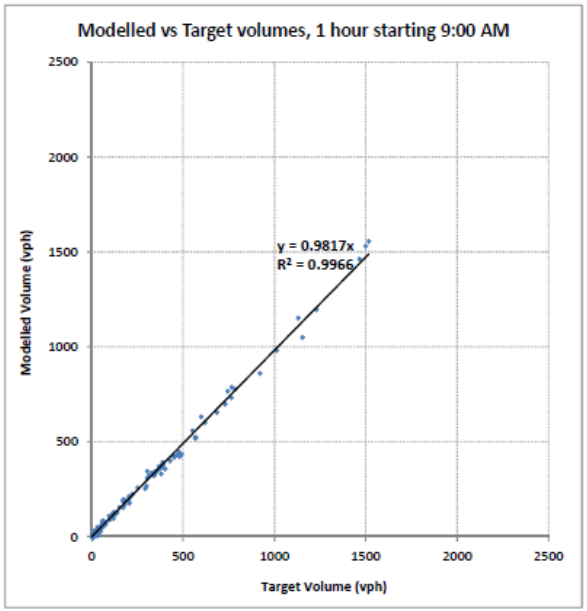
Appendix B. Regression Plots











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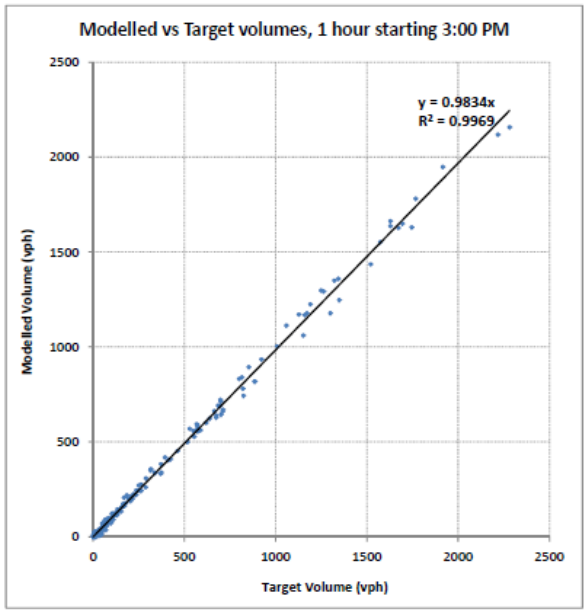
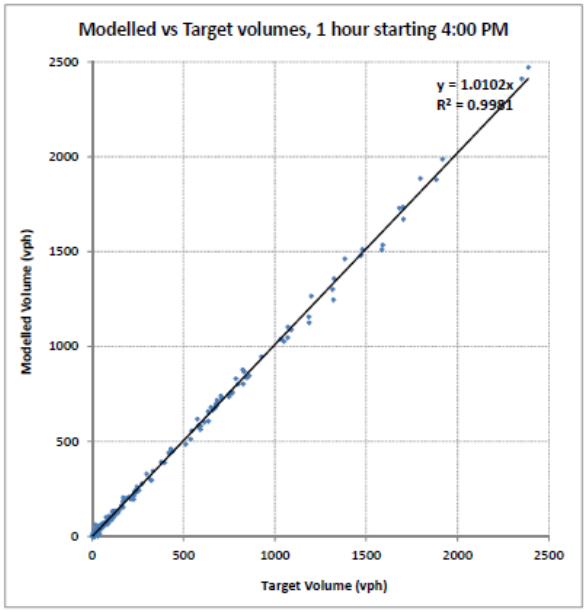
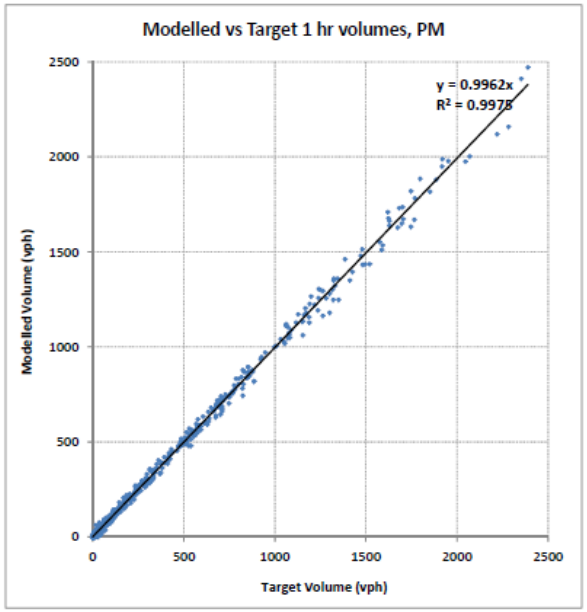
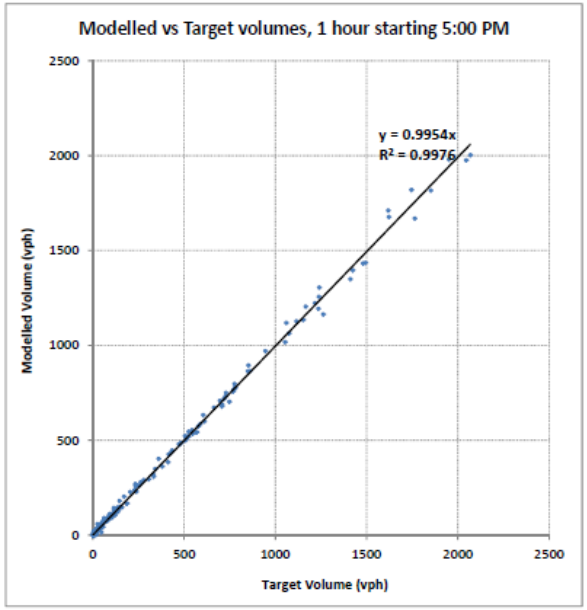
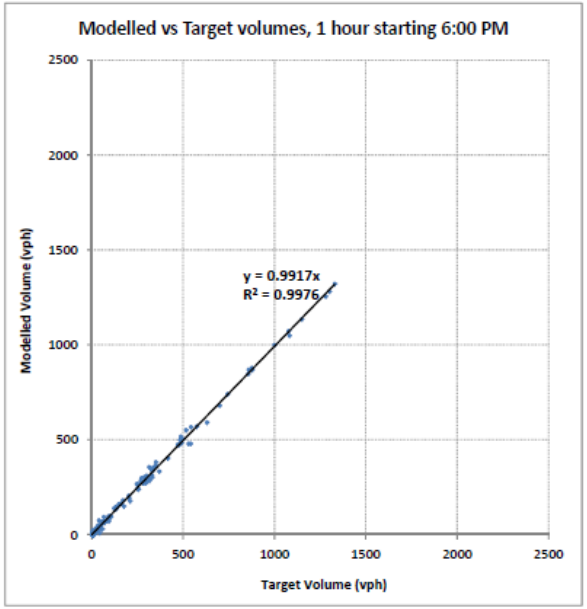
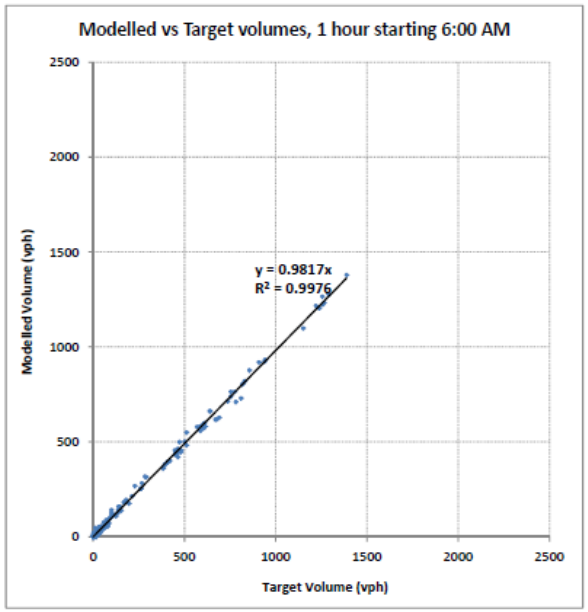

Modelled vs Target volumes, 1 hour starting 3:00 PM
y = 0.9834x
R² = 0.9969
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

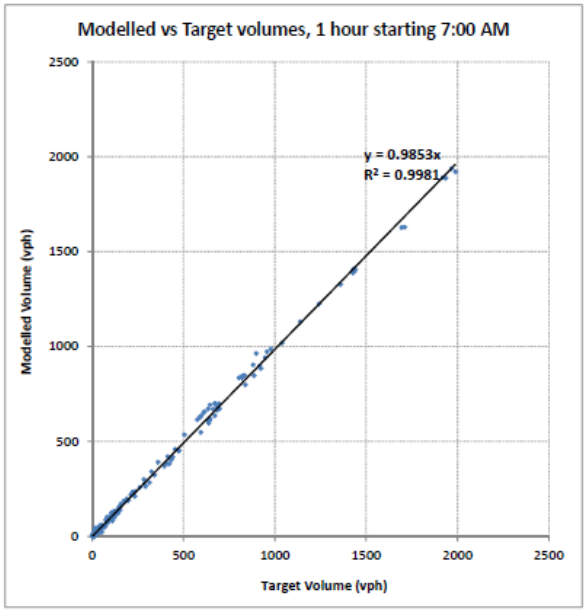

Modelled vs Target volumes, 1 hour starting 4:00 PM
y = 1.0102x
R² = 0.9981
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

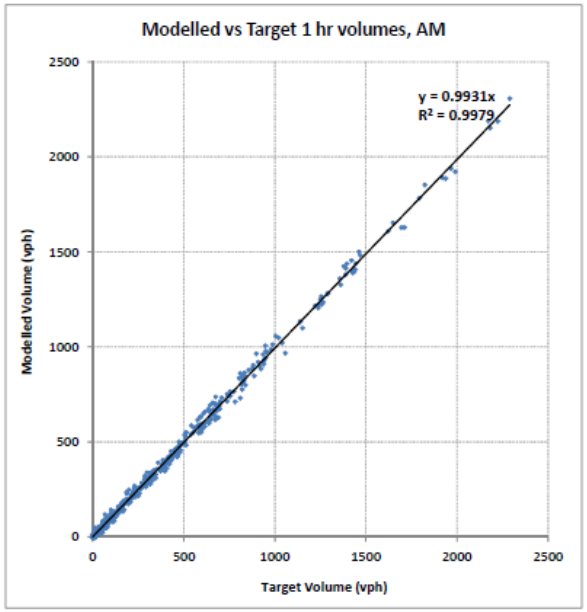

Modelled vs Target 1 hr volumes, PM
y = 0.9962x
R² = 0.9975
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

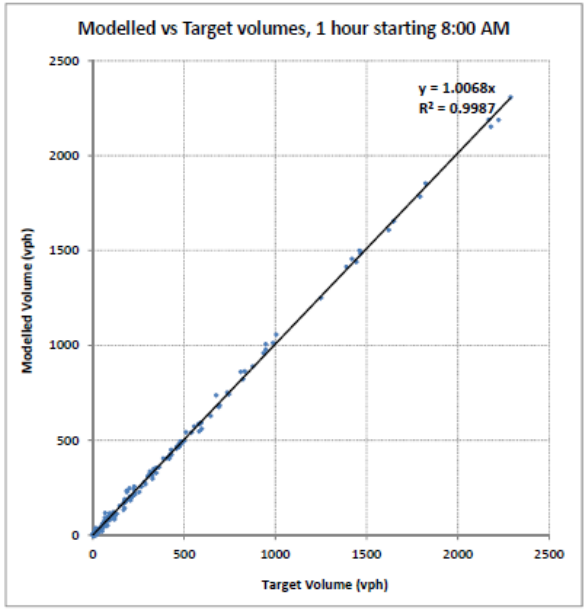

Modelled vs Target volumes, 1 hour starting 5:00 PM
y = 0.9954x
R² = 0.9976
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

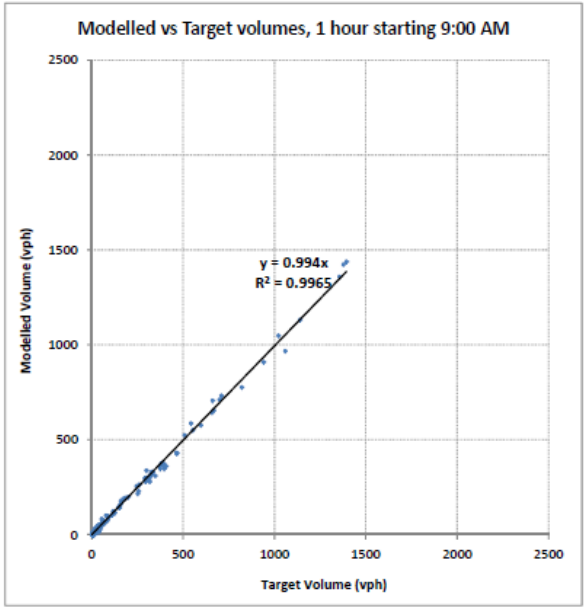

Modelled vs Target volumes, 1 hour starting 6:00 PM
y = 0.9917x
R² = 0.9976
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

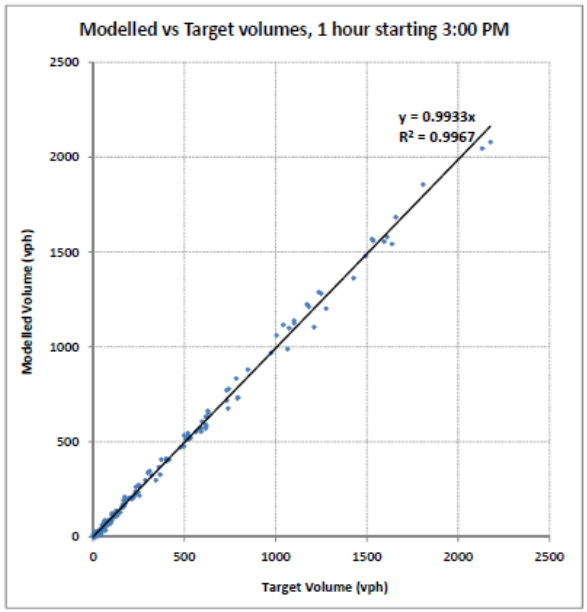

Modelled vs Target volumes, 1 hour starting 6:00 AM
y = 0.9817x
R² = 0.9976
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

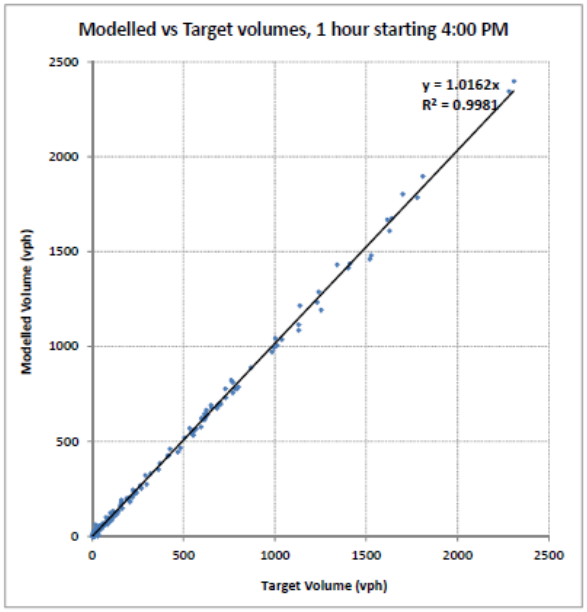

Modelled vs Target volumes, 1 hour starting 7:00 AM
y = 0.9853x
R² = 0.9981
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

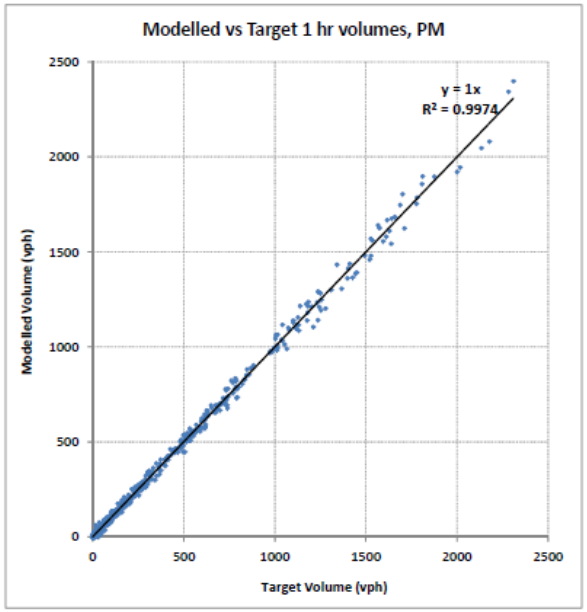

Modelled vs Target 1 hr volumes, AM
y = 0.9931x
R² = 0.9979
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

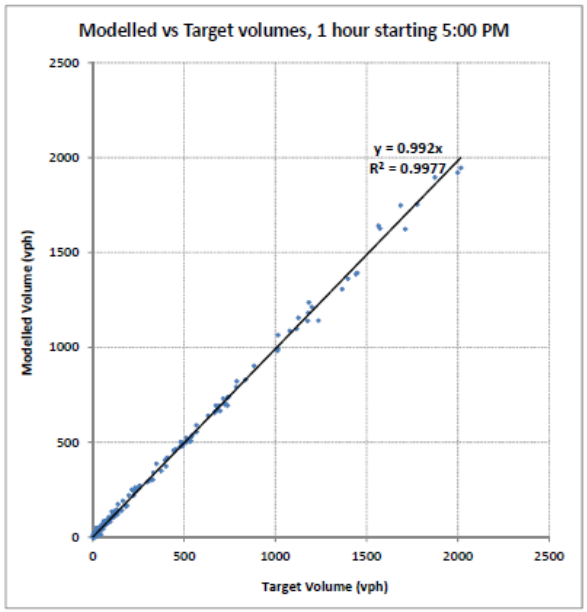

Modelled vs Target volumes, 1 hour starting 8:00 AM
y = 1.0068x
R² = 0.9987
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

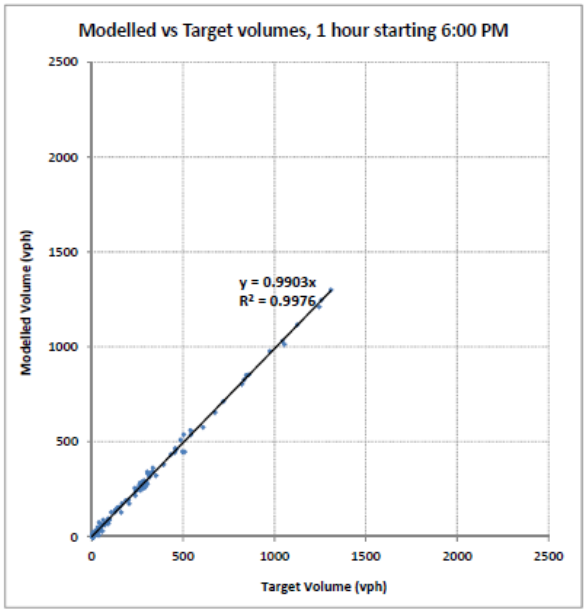

Modelled vs Target volumes, 1 hour starting 9:00 AM
y = 0.994x
R² = 0.9965
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

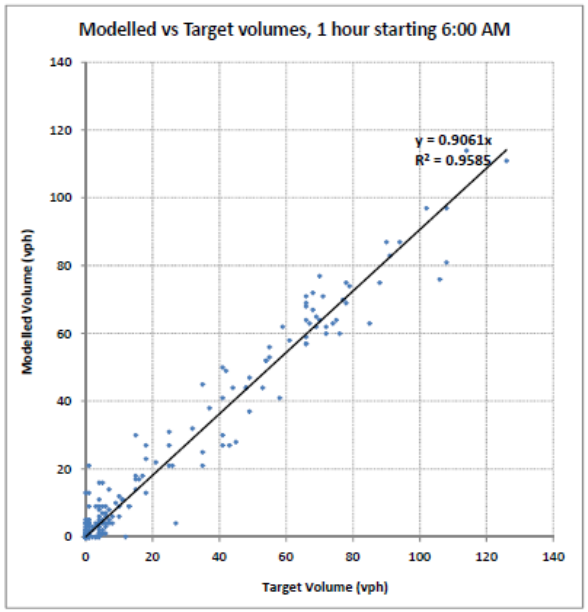

Modelled vs Target volumes, 1 hour starting 3:00 PM
y = 0.9933x
R² = 0.9967
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

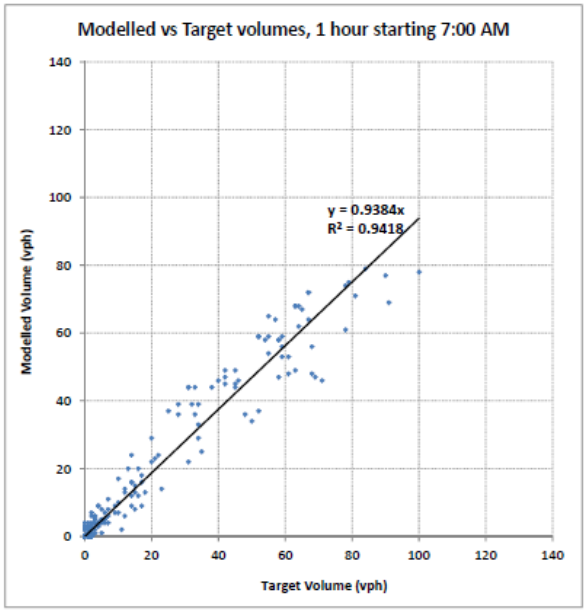

Modelled vs Target volumes, 1 hour starting 4:00 PM
y = 1.0162x
R² = 0.9981
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

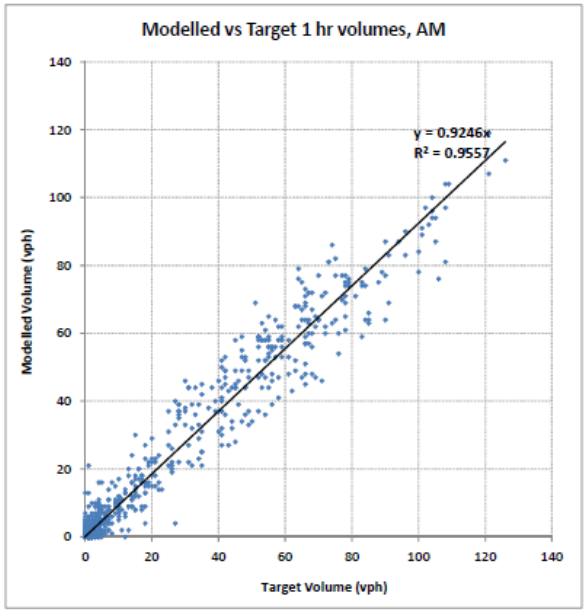

Modelled vs Target 1 hr volumes, PM
y = 1x
R² = 0.9974
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

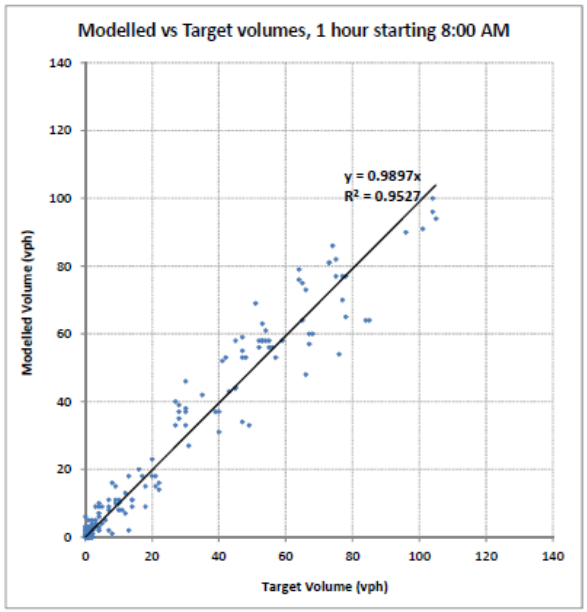

Modelled vs Target volumes, 1 hour starting 5:00 PM
y = 0.992x
R² = 0.9977
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500

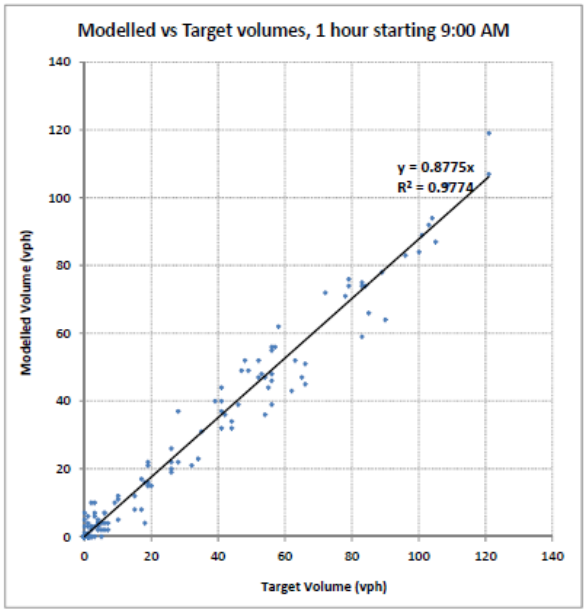

Modelled vs Target volumes, 1 hour starting 6:00 PM
y = 0.9903x
R² = 0.9976
Modelled Volume (vph)
Target Volume (vph)
0
500
1000
1500
2000
2500











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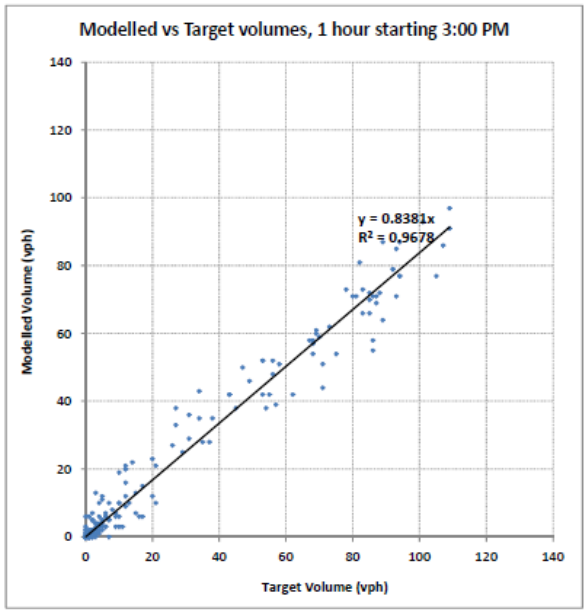

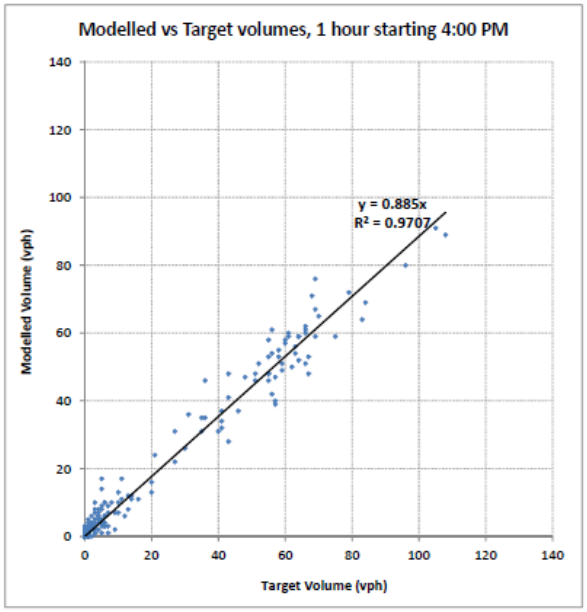

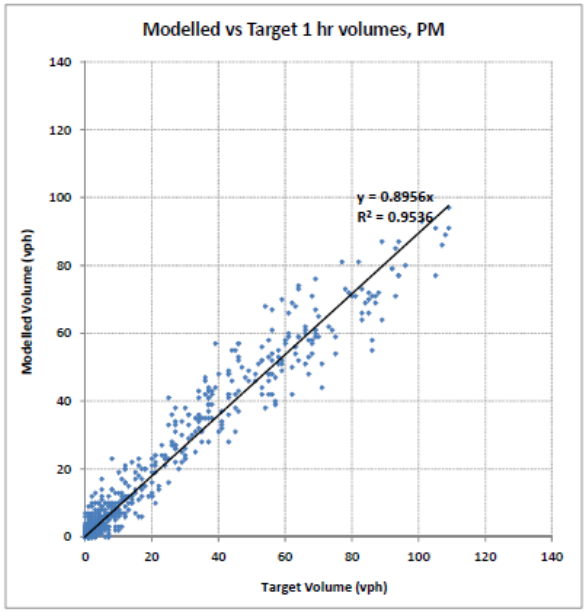

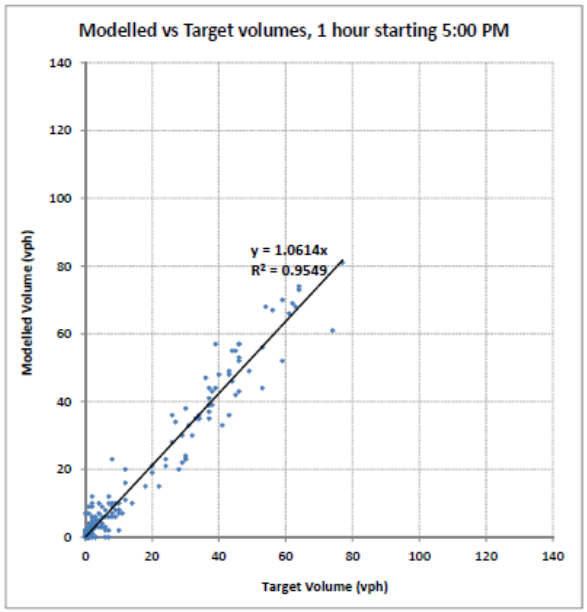

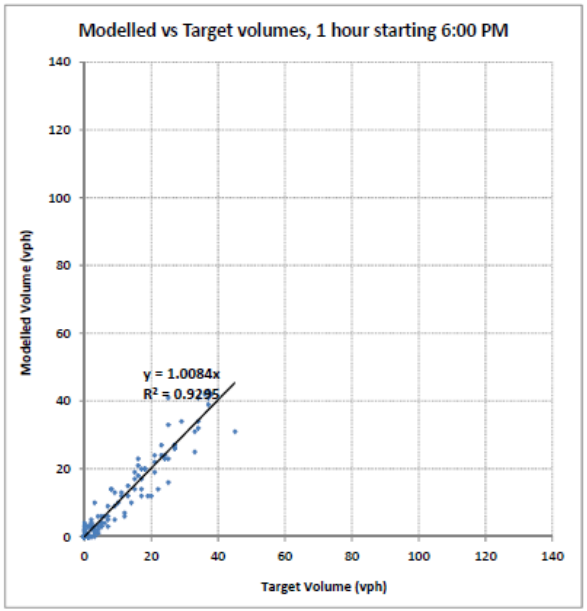

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Appendix C. Cumulative counter peak travel time graphs

Figure C.1 : Cumulative travel time, model vs observed – counter peak direction, 6am to 7am

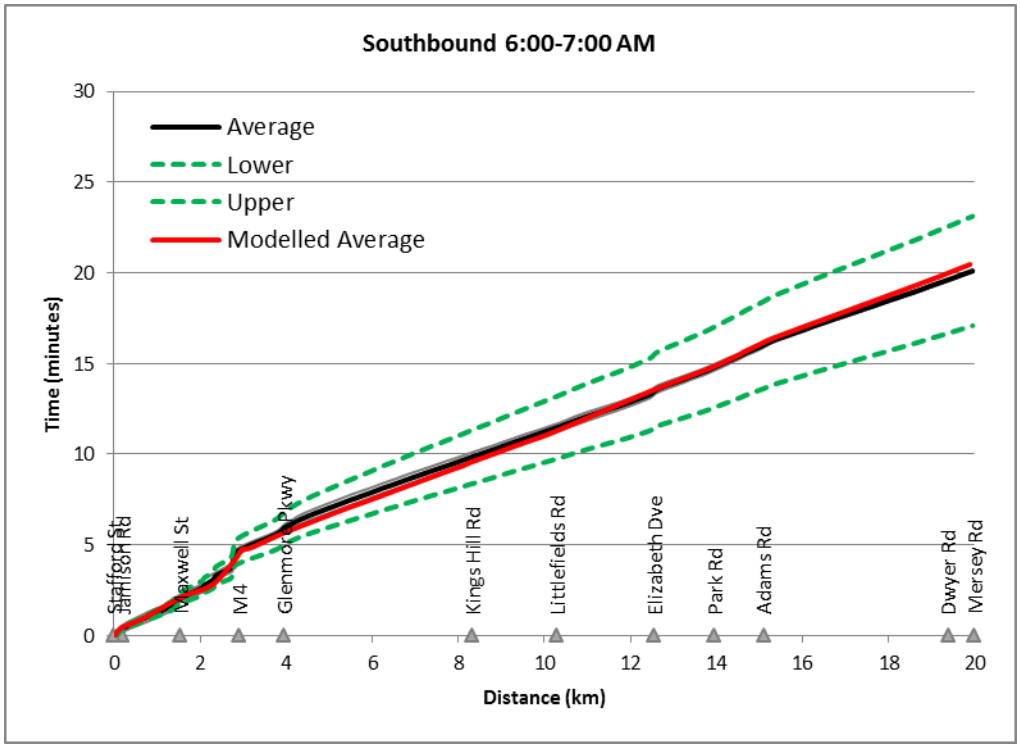

Figure C.2 : Cumulative travel time, model vs observed – counter peak direction, 7am to 8am

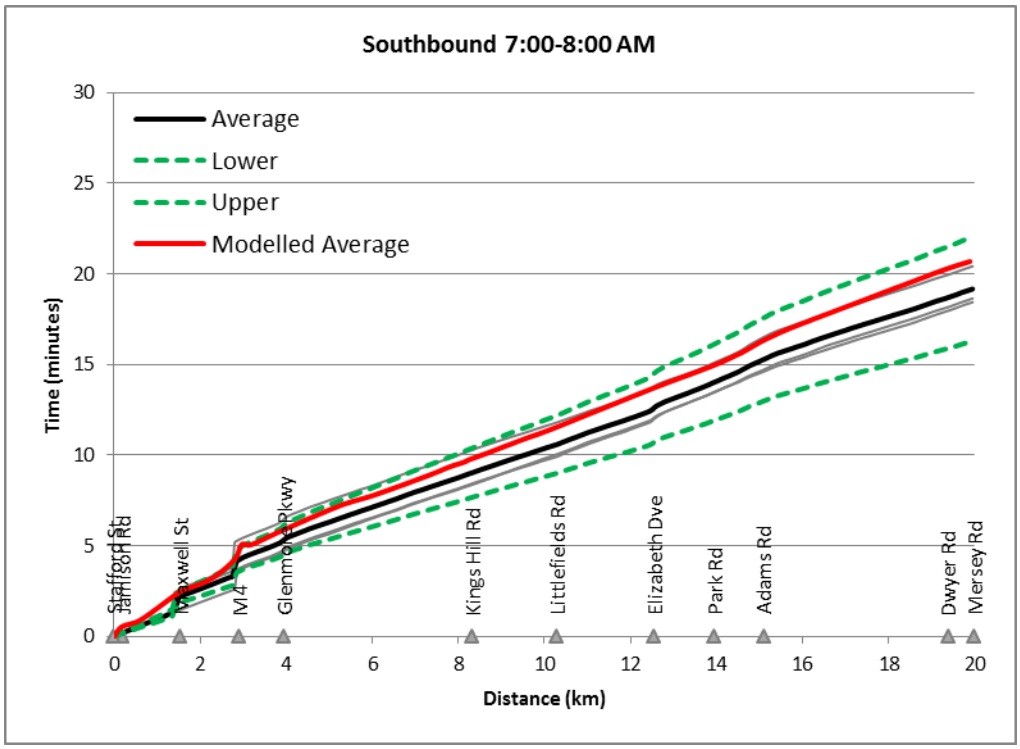

Figure C.3 : Cumulative travel time, model vs observed – counter peak direction, 8am to 9am

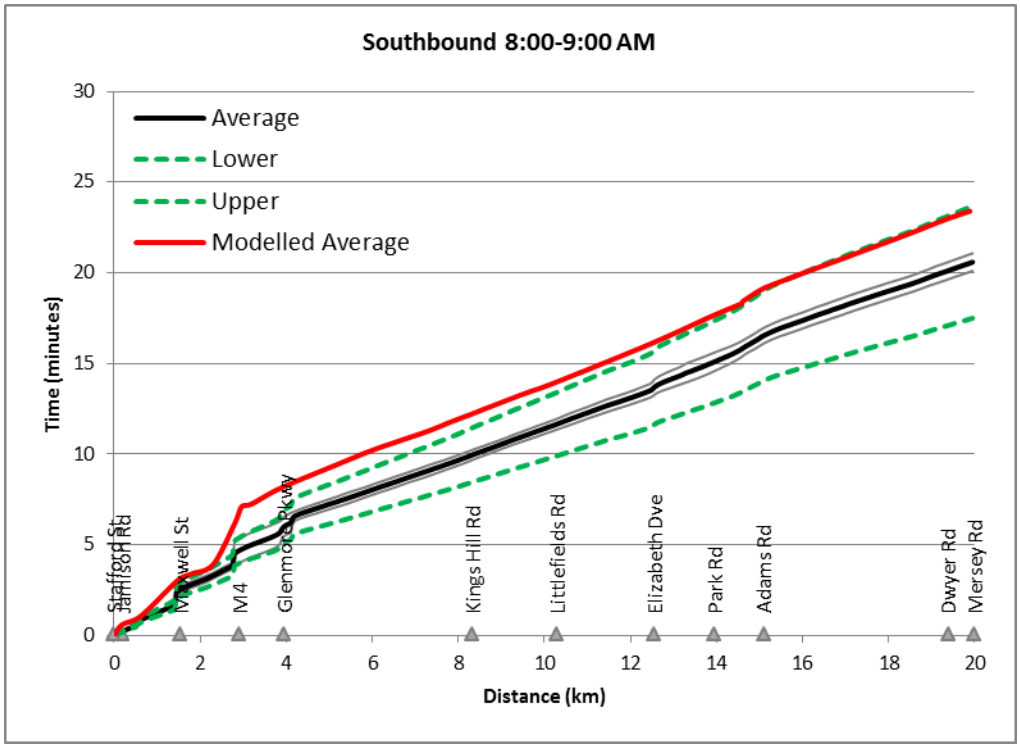

Figure C.4 : Cumulative travel time, model vs observed – counter peak direction, 9am to 10am

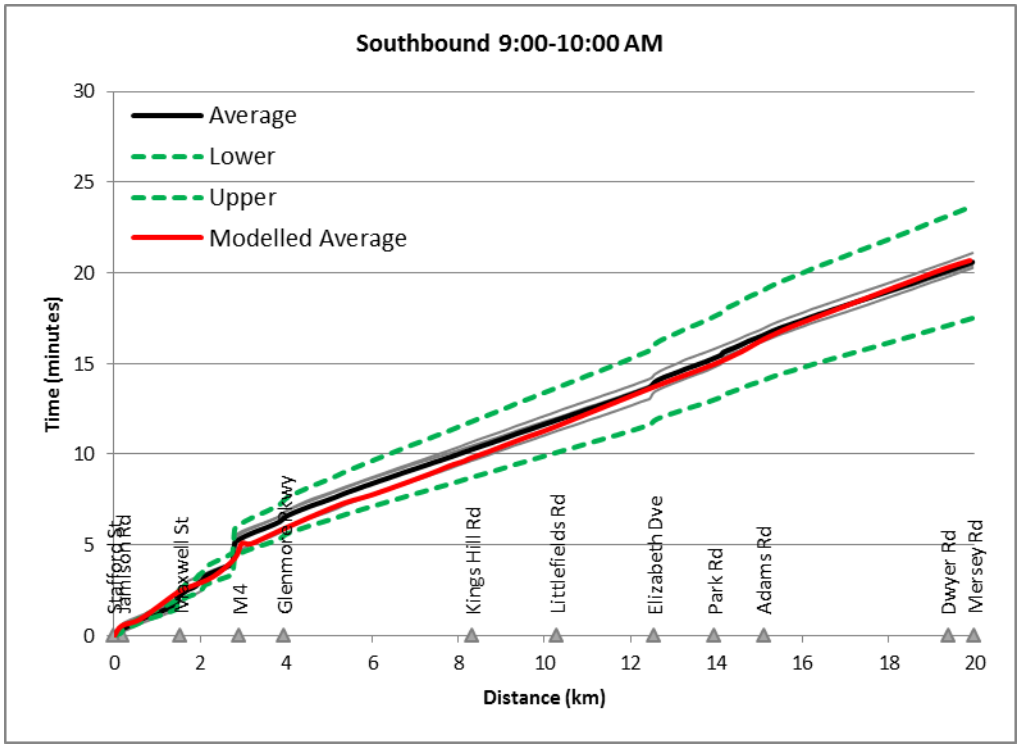

Figure C.5 : Cumulative travel time, model vs observed – counter peak direction, 3pm to 4pm

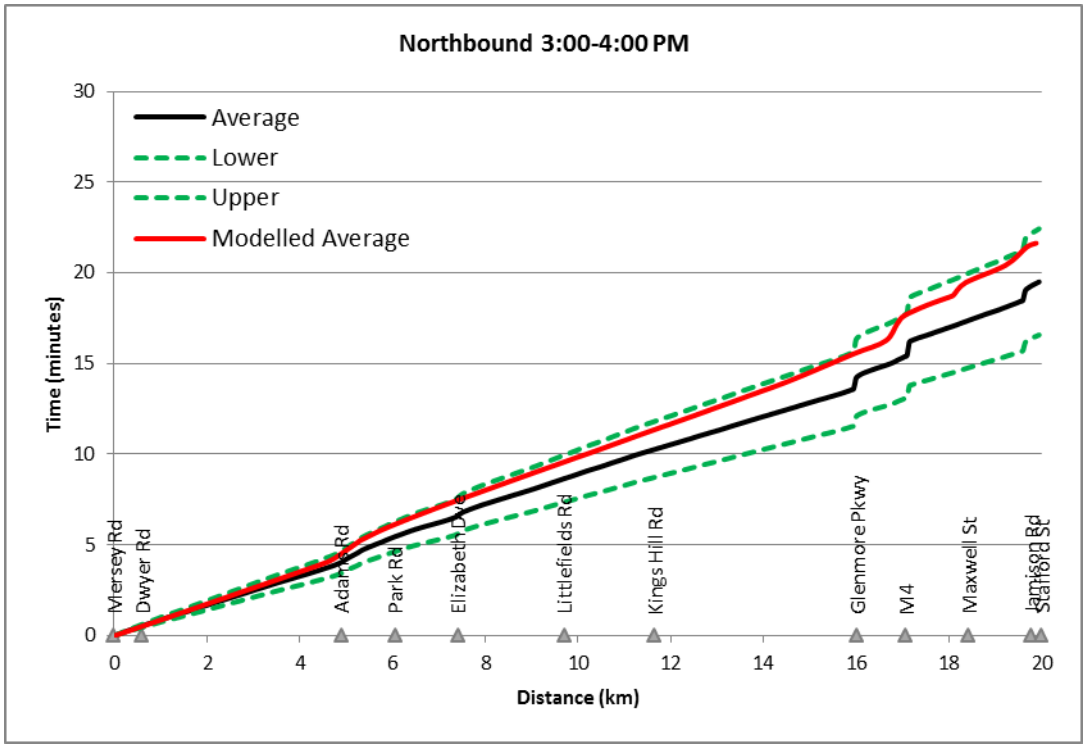

Figure C.6 : Cumulative travel time, model vs observed – counter peak direction, 4pm to 5pm

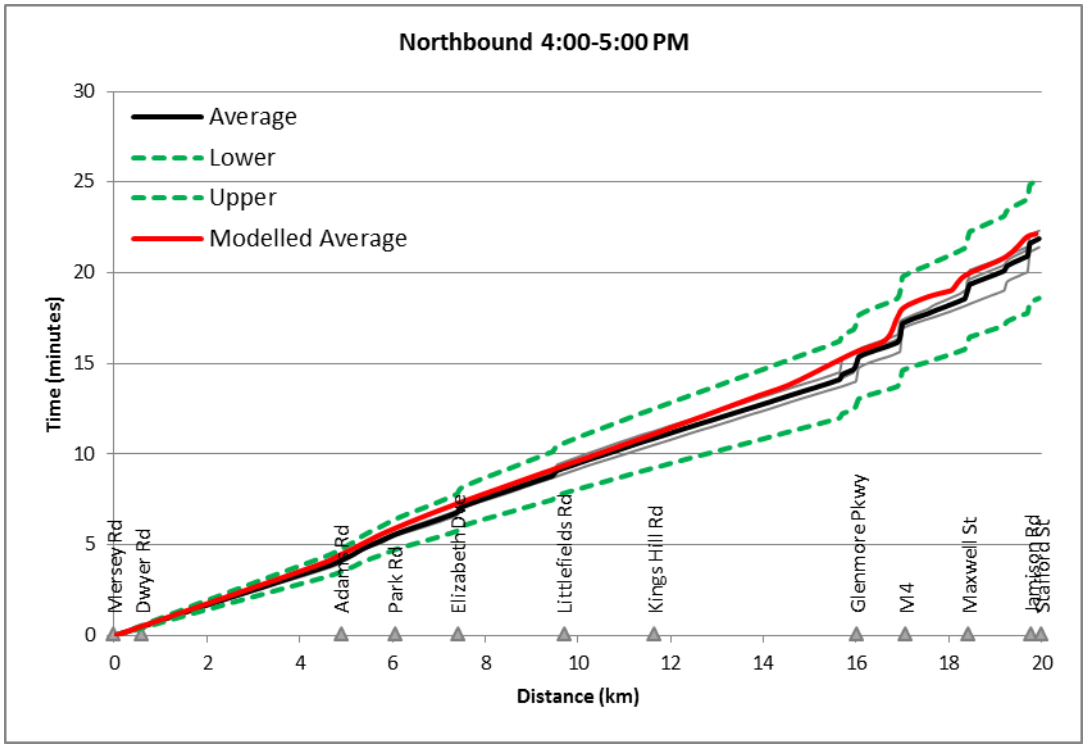

Figure C.7 : Cumulative travel time, model vs observed – counter peak direction, 5pm to 6pm

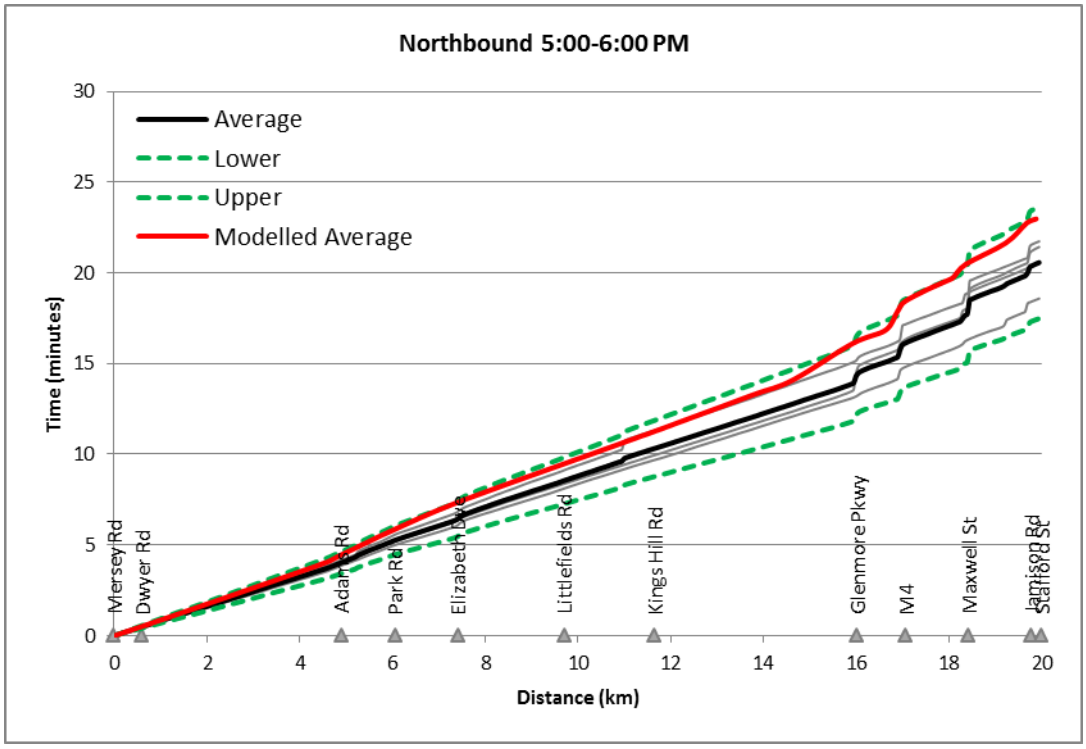

Figure C.8 : Cumulative travel time, model vs observed – counter peak direction, 6pm to 7pm