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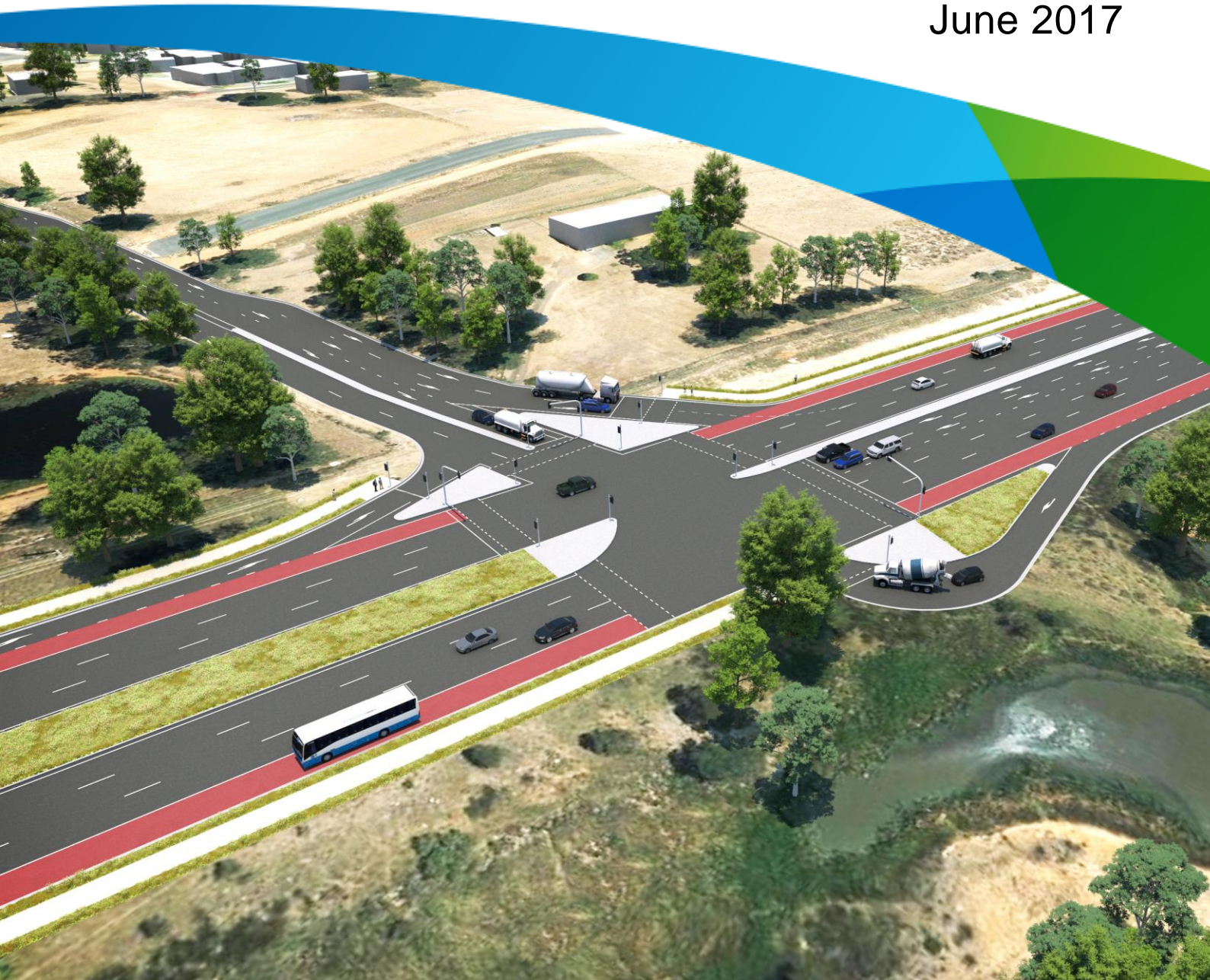


The Northern Road Upgrade Mersey Road, Bringelly to Glenmore Parkway, Glenmore Park

NSW Environmental Impact Statement /
Commonwealth Draft Environmental Impact Statement

Appendix G – Technical working paper: Traffic and Transport

June 2017





***The Northern Road Upgrade –
Mersey Road to Glenmore Parkway***

Prepared for Roads and Maritime Services by Jacobs Australia

Traffic and Transport Assessment

Final

15 May 2017



The Northern Road EIS

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Appendix C. Elizabeth Drive Technical Note

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C.4	Summary and Conclusion

List of legislative assessment requirements

This report has been prepared to meet the relevant Secretary's Environmental Assessment Requirements (SEARs) issued by the NSW Department of Planning and Environment (DP&E) to be addressed in the preparation of the Environmental Impact Assessment (EIS).

Since this report informs the EIS, it has been prepared to meet the relevant SEARs related to traffic and transport as listed below, with reference to where in the report each requirement has been addressed.

Secretary's Environmental Assessment Requirements (SEAR)	Location in report
Traffic and Transport	
details of how:	
<ul style="list-style-type: none"> the preferred alignment, design and staging, the proposed intersections, interchanges and connections to the surrounding road network, and associated road infrastructure facilities, meet the traffic and transport objectives of the proposal, taking into account the following local and regional issues:	Section 5.4
<ul style="list-style-type: none"> adjacent sensitive land uses 	Section 5.13.2
<ul style="list-style-type: none"> the proposed Western Sydney Airport 	Section 5.13.2
<ul style="list-style-type: none"> transport connectivity to and from existing communities and centres (such as South West Growth Centre) 	Section 5.13.2
<ul style="list-style-type: none"> future growth areas 	Section 5.13.2
<ul style="list-style-type: none"> the Broader Western Sydney Employment Area 	Section 5.13.2
<ul style="list-style-type: none"> approved and proposed infrastructure projects (including other proposed upgrades of The Northern Road, Bringelly Road Upgrade Stages 1 and 2, and the proposed M12 Motorway between M7 and The Northern Road) 	Section 5.13.2
<ul style="list-style-type: none"> traffic (vehicular, cyclist and pedestrian) needs 	Section 5
an assessment and modelling of operational traffic and transport impacts on the local and regional road network, and M4 Western Motorway, including an assessment of road user safety, and discussion of the currency of baseline traffic and transport data;	Section 5.4
a detailed assessment of public transport impacts and opportunities, including a summary of bus routes that would utilise the proposed bus lanes	Section 5.7
an assessment of potential impacts the proposal may have on aviation associated with the proposed Western Sydney Airport	Section 5.13.2
an assessment of impacts on cyclist and pedestrian access and safety,	Section 5.9

Secretary's Environmental Assessment Requirements (SEAR)	Location in report
and description of proposed cyclist and pedestrian routes, having consideration of opportunities to integrate cycleway and pedestrian elements with surrounding networks and facilitate connectivity between existing communities and with proposed future land uses	
construction traffic and transport impacts of the proposal (including ancillary facilities) and associated management measures, in particular:	Section 0
<ul style="list-style-type: none"> impacts to the road network (including safety and level of service, pedestrian and cyclist access, and disruption to public transport services and access to properties) 	Section 5.12.7
<ul style="list-style-type: none"> access and route identification and scheduling of transport movements 	Section 0
<ul style="list-style-type: none"> the number, frequency and size of construction related vehicles (passenger, commercial, heavy and oversized vehicles) 	Section 5.12.2
<ul style="list-style-type: none"> effects on commercial and industrial access, including staff and customer parking 	Section 5.12.2
<ul style="list-style-type: none"> the nature of existing traffic on construction access routes (including consideration of peak traffic times) 	Section 0
the need to close, divert or otherwise reconfigure elements of the road network associated with construction of the proposal	Section 5.12.4
having reference to the cumulative construction impacts of other major projects preparing for or commencing construction	Section 5.13

It is noted that although the project has been deemed a controlled action under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), no specific Commonwealth assessment requirements in relation to traffic and transport have been issued in the guidelines for the content of a draft Environmental Impact Statement for this project. General requirements related to the assessment of residual traffic impacts have been addressed in Section 7.

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
DP&E	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

Term / acronym	Meaning
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
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 appointed by Roads and Maritime Services (Roads and Maritime) to prepare an Environmental Impact Statement (EIS) for The Northern Road Upgrade between Mersey Road, Bringelly and Glenmore Parkway, Glenmore Park (the project).

The project comprises upgrading 16 km of The Northern Road from the existing two lane rural undivided road to a six and eight lane road separated by a wide central median. The project includes about eight kilometres of new road between Mersey Road and just south of the existing Elizabeth Drive, Luddenham, to realign the section of The Northern Road that currently bisects the Western Sydney Airport site and to bypass Luddenham.

The realigned Elizabeth Drive would form a new four-way signalised intersection with the existing and realigned The Northern Road. The new intersection would be around 200m south of the existing Elizabeth Drive/The Northern Road intersection.

North of Bradley Street, The Northern Road would be upgraded 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. This would tie in with the proposed upgrade of The Northern Road to an eight-lane divide road between just south of Glenmore Parkway, Glenmore Park to Jamison Road, South Penrith (subject to planning approval). Between Mersey Road, Bringelly and Bradley Street, Glenmore Park. The Northern Road would be a six-lane divided road with two general traffic lanes and a kerbside bus lane in each direction separated by a depressed grass (landscaped) median. This would tie into the upgrade of The Northern Road to a four-lane divided road south of Mersey Road (currently underway). The upgrade would have multiple signalised intersections, dedicated bus lanes and provisions for pedestrians and cyclists.

The assessment provided in this report will be used to inform the EIS 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 of the project and ten years after completion (both with and without the project). For the purposes of this study, the standard forecast years of 2021 and 2031 have been adopted as the year of completion and ten years after completion respectively
- Assessing the impacts of the proposed The Northern Road Upgrade (between Mersey Road and Glenmore Parkway) in 2021 and 2031
- Assessing the cumulative impact of the project with other developments and projects in and around the study area
- Assess impacts on pedestrians, cyclists and public transport
- Assess impacts of the construction phase of the project
- Identify mitigation measures required to address these impacts.

Future traffic and transport impacts

'Do minimum' scenario traffic performance

The 'Do minimum' modelling scenario indicates the performance of the intersections along the project corridor if the project was not built, considering proposed future development and associated forecast traffic along this section of The Northern Road. This includes assessment of traffic associated with the Western Sydney Airport and associated operation of the proposed M12 Motorway project. 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 by 2031.

In 2031, the 'Do Minimum' model shows that the majority of intersections would perform at Level of Service (LoS) F with unacceptable delays being likely along the corridor, particularly for priority controlled intersections. Away from intersections, the mid-block level of service would perform better, though increasingly affected by adjacent intersection performance.

Road upgrade scenario traffic performance

The modelling of the forecast traffic flows under the 2021 and 2031 traffic growth scenarios with the upgrade indicates that the project would relieve the capacity constraints along The Northern Road, particularly at the existing give-way and stop sign controlled intersections where traffic signals have been provided or right turn movements have been removed. Under 2021 and 2031 growth scenarios, the intersections along The Northern Road within the study area are likely to operate acceptably at Level of Service (LoS) D or better. Modelled intersection delays also show that the intersections would generally perform with higher delays in 2031 than 2021 (although still at an acceptable LoS), which is consistent with the increase in traffic forecast between these years as a consequence of additional adjacent land use development at the Western Sydney Airport and the operation of the proposed M12 Motorway from the mid 2020's. Modelled intersection delays under the road upgrade scenario are substantially lower than under the 'Do minimum' scenario. Although there is likely to be an increase in delays at intersections along The Northern Road from 2016 to 2021 and beyond under the project scenario when compared with the 'Do Minimum' scenario, these increases in delay under the project scenario are acceptable.

Assessment of travel times along The Northern Road corridor between Mersey Road and Glenmore Parkway show travel time improvements in future years with the project than compared to without the project, particularly between Elizabeth Drive and Glenmore Parkway.

Impacts on local roads and access

The project would have a number of impacts on local roads and access within the study area. Properties along The Northern Road currently have access and egress from all directions. As part of the upgrade, direct access from The Northern Road would be restricted to left in and left out only, with a central median along the project length. In addition, there would be a number of access changes for connecting side roads as follows:

- Mersey Road: traffic signals
- Dwyer Road: left in and left out only
- Western Sydney Airport southern boundary entry: traffic signals
- Western Sydney Airport service entry: traffic signals
- Existing The Northern Road (south of Luddenham) : traffic signals
- Eaton Road west: give way and cul de sac
- Eaton Road east: left in and left out only
- Elizabeth Drive realignment: Elizabeth Drive will be realigned from a point around 350m east of its existing connection with The Northern Road. The realigned Elizabeth Drive would form a new four way intersection with the existing and realigned The Northern Road. This new intersection would be the northern access into the bypassed Luddenham town centre.
- Existing Elizabeth Drive: Left out only and cul de sac at around 300 metres east of The Northern Road.
- Existing The Northern Road and realigned Elizabeth Drive: traffic signals
- Littlefields Road: traffic signals

- Gates Road: left in only. A new service road would be constructed connecting Gates Road and an eastern extension of Littlefields Road.
- Longview Road: left in and left out only
- Kings Hill Road: traffic signals
- Grosvenor Crescent (south): left in only
- Grosvenor Crescent (north): left out only
- Chain-O-Ponds Road: traffic signals
- Defence Establishment Orchard Hills entrance: traffic signals
- Bradley Street: traffic signals.

A number of u-turn bays and roundabouts would be implemented to address the loss of accessibility imposed by the provision of the central median on The Northern Road. New u-turn facilities would be provided at the following locations:

- The Northern Road at the new entry on southern boundary of the Western Sydney Airport
- Existing The Northern Road north of Luddenham
- Elizabeth Drive (450m east of The Northern Road)
- Defence Establishment Orchard Hills
- Bradley Street.

Roads and Maritime is also reviewing speed and load limits on local roads on approach to The Northern Road. For example, Longview and Vineyard roads do not currently have any speed limit signage along their length and do not meet the requirements of a built-up area as defined in the NSW Road Rules. As such, the default limit of 100 km/h applies. An assessment by Roads and Maritime of the proposed new intersection arrangements along these roads and the function they perform suggest lower speed limits would be appropriate. Roads and Maritime will develop an option for and justification of lower speed limits and present this to Penrith City Council for consideration and endorsement.

Impacts on public transport

The project includes the provision of a dedicated kerbside bus lane in each direction between Mersey Road and Glenmore Parkway. 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 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.

As part of the proposed upgrade, there would be a range of temporary and permanent impacts on current bus stops. As a general approach to ensure safe operation of bus stops, they will be sited within convenient walking distance to an adjacent set of traffic signals. Section 5.7 details the current bus stop locations along The Northern Road and changes proposed by the project. Most bus stops would be retained close to their existing location. The greatest impact would be to the existing northbound and southbound stops on The Northern Road located around 640 metres south of Littlefields Road. The southbound stop would be relocated to the southern side of the upgraded Littlefields Road, while the northbound bus stop would be relocated to the northern side of Littlefields Road.

Impacts on freight transport

The project would improve reliability and travel times for freight traffic currently travelling on The Northern Road by providing additional traffic capacity and relieving existing traffic constraints, particularly at existing priority and roundabout intersections along The Northern Road. The project would also reduce future travel times and improve reliability for freight travelling to the Sydney Motorway network via the M4 Western Motorway and providing an alternative route for freight traffic travelling to and from the Western Sydney Airport. In the future, The Northern Road would become the primary route for construction traffic from the Western Sydney Airport and M12 Motorway and would become the primary route from these construction activities to the Sydney Motorway network. The project would ensure that this construction traffic would have a safe and reliable route to the M4 Western Motorway. The heavy vehicle inspection stations located just south of Glenmore Parkway would be closed as part of the project. It is proposed to relocate these sites to safer locations which would have improved entry and exit conditions, proposed adjacent to Grover Crescent and Longview Road for the northbound and southbound travel directions respectively. This would improve safety for heavy vehicle operators and compliance and enforcement staff.

There would be impacts for freight transport through the introduction of the central median, similar to the impacts for general traffic. Certain trips would become longer due to the removal of turns imposed by the central median and the need to change route. This would have the greatest impact on adjacent property owners that operate freight vehicles from their premises.

Impacts on active transport

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

- A shared path along the western side of The Northern Road between Mersey Road and Glenmore Parkway
- A 5 m wide footway would be provided on the eastern side of The Northern Road between Mersey Road and Glenmore Parkway. A 1.5 m wide footpath would be located in the footway area where warranted for example between bus stops and adjacent intersections
- New signalised pedestrian crossings at all upgraded intersections where traffic lights are to be provided.

Impacts on parking

As parking is not currently permitted along the length of The Northern Road between Mersey Road and Glenmore Parkway, the project would not impact on parking. Realignment of The Northern Road around Luddenham town centre may introduce opportunities for on-street parking along the existing The Northern Road alignment.

Impacts on road safety

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

- The Northern Road would be upgraded with additional lanes and a divided carriageway, removing the need for opposing-lane overtaking, with the subsequent risk of head-on crashes
- Reduce congestion at intersections, which would reduce the vehicle crashes at intersection, especially the rear-end type crashes
- The new alignment of The Northern Road would be designed to a higher design speed allowing for safer travel along the corridor with intersection designs accommodating B-Double trucks

- Many existing priority-controlled intersections would be upgraded to signal control. This would provide more formal opportunities for making right hand turns into and out of The Northern Road. Other uncontrolled right hand turns would be removed, reducing conflicts along The Northern Road
- Formal pedestrian crossings would be provided at all signalised intersections and a wide off-road shared path would be provided along the length of the project to the west of The Northern Road as well as a footway to the east. This would reduce conflicts between pedestrians, cyclists and cars
- Realignment of The Northern Road around Luddenham town centre would reduce the volumes of cars and trucks travelling through this area and reduce conflicts with local traffic, however it is acknowledged that this may have other non-safety impacts such as potential reduction in the volume of associated pass-by trade for businesses in Luddenham (refer to the Socio-economic Assessment)
- Realignment of The Northern Road around Luddenham town centre would reduce the volumes of trucks travelling through this area and reduce potential conflict with pedestrians in this higher pedestrian activity area.

Construction traffic impacts

The project would be delivered through three separate construction contracts. Accordingly, construction of the project is assumed to take place over three stages, covering the following sections:

- Mersey Road, Bringelly to Eaton Road, Luddenham
- Eaton Road, Luddenham, to Littlefields Road, Luddenham
- Littlefields Road, Luddenham to Glenmore Parkway, Glenmore Park.

It is expected that the project would be built between late 2017 and mid-2020, subject to funding and planning approval.

Construction traffic generation

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

During peak traffic period, about 230 additional light vehicles are expected to be generated per day as a result of construction traffic. Assuming that 80 per cent of these light vehicles would arrive in the same hour, the likely peak hour volume on the busiest days would be in the order of 184 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 north, with a small proportion travelling from Elizabeth Drive from the east. Furthermore, the average traffic generation for any one worksite would be around one third of the peak volume at 62 two-way vehicle trips per day.

Impacts on existing developments

Access to the existing properties within the upgrade section may be affected by the construction activities. This could be through either the loss of existing access arrangements or the alterations of access arrangements. All existing access would generally be maintained at all times during the construction period, with property owners and residents consulted in advance of any potential access disturbance.

Impacts on road network operation

Construction traffic generation would have a minimal impact on the capacity of The Northern Road during construction. The primary impacts of construction traffic generation would be reduced speeds where traffic is unable to overtake slower moving heavy vehicles along The Northern Road.

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

- Reduced speed limits at traffic switches
- Construction over live traffic
- Temporary traffic calming.

Impacts on bus services

Bus route 789 operates between Penrith and Luddenham, predominantly along The Northern Road. This is a peak hour only service and operates twice a day on weekdays. No services are provided on weekends. During construction of the project the following impacts to buses and bus passengers are likely:

- Reductions in speed when travelling through construction activity areas
- Temporary relocation of stops away from construction zones
- Alternative access to relocated bus stops.

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

Construction cumulative impact

Construction of the project is likely to be undertaken at the same time as other projects within the region subject to their approval, including:

- The Northern Road upgrade between Glenmore Parkway and Jamison Road
- M4 Smart Motorway civil work
- Bringelly Road upgrade Stage 1 and 2

In addition to the impacts of concurrent construction, the following projects would take place in the surrounding area (subject to approval) following completion of the project:

- M12 Motorway
- Western Sydney Airport.

Both projects would have lengthy construction periods resulting in continuous construction activity in the area surrounding the project for up to five years when considered together.

Operational cumulative impacts

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

- M12 Motorway
- 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). Traffic modelling of the project shows that by 2031, average network speed would improve from 34 km/h to 60 km/h in the morning peak and from 20 km/h to 57 km/h in the evening peak as a result of the upgrade. The extra capacity provided by the project would also facilitate 21 per cent more trips in the morning peak and 27 per cent more trips in the evening peak, many of which would be generated by the South West Priority Growth Area, Western Sydney Priority Growth Area and Western Sydney Airport. Without the additional capacity provided by the project, but with similar levels of

development in the area, a majority of trips would still need to be made. However, they would take longer to make and/or extend further across the AM and PM peak periods. This is a natural response to traffic growth. As traffic volumes increase and without capacity improvements the peaks are seen to 'spread'. That is, the beginning of the morning and evening peaks commences earlier and finishes later.

Environmental management measures

Construction traffic management measures

The majority of long-term impacts of the project 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
- Provision of active transport facilities, addressed through the design by provision of a shared path along the length of The Northern Road

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).

1. Introduction

Roads and Maritime Services (Roads and Maritime) is proposing to upgrade The Northern Road between Mersey Road, Bringelly and Glenmore Parkway, Glenmore Park (the project). The Northern Road corridor is located about 45 km west of the Sydney Central Business District (CBD). North of Bradley Street, The Northern Road would upgrade 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. South of Bradley Street, The Northern Road would be a six-lane divided road with two general traffic lanes and a kerbside bus lane in each direction separated by a depressed grass (landscaped) median.

The Northern Road is classified as a State Road and forms part of route A9, which connects Campbelltown to Windsor. The Northern Road also provides connections between the Western Sydney Priority Growth Area, the M4 Western Motorway, and the site for the Western Sydney Airport.

This section of The Northern Road is currently a two lane road, largely undivided with overtaking allowed in the opposing lane. The majority of intersections along The Northern Road are priority (give way or stop sign) controlled, with roundabouts at Glenmore Parkway and Elizabeth Drive.

Roads and Maritime is upgrading The Northern Road as part of the Australian and NSW governments' Western Sydney Infrastructure Plan (WSIP), which would deliver \$3.6 billion in road infrastructure improvements over the next 10 years. The project was announced in April 2014 by the (then) Prime Minister as part of the WSIP program of works to support the Western Sydney Airport.

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

1.1 Description of the project

The project generally comprises the following key features:

- A six-lane divided road between Mersey Road, Bringelly and Bradley Street, Glenmore Park (two general traffic lanes and a kerbside bus lane in each direction). The wide central median would allow for an additional travel lane in each direction in the future, if required
- An eight-lane divided road between Bradley Street, Glenmore Park and about 100 m south of Glenmore Parkway, Glenmore Park (three general traffic lanes and a kerbside bus lane in each direction separated by a median)
- About eight kilometres of new road between Mersey Road, Bringelly and just south of the existing Elizabeth Drive, Luddenham, to realign the section of The Northern Road that currently bisects the Western Sydney Airport site and to bypasses Luddenham
- About eight kilometres of upgraded and widened road between the existing Elizabeth Drive, Luddenham and about 100 m south of Glenmore Parkway, Glenmore Park
- Closure of the existing The Northern Road through the Western Sydney Airport site
- Tie-in works with the following projects:
 - The Northern Road Upgrade, between Peter Brock Drive, Oran Park and Mersey Road, Bringelly (to the south)
 - The Northern Road Upgrade, between Glenmore Parkway, Glenmore Park and Jamison Road, South Penrith (to the north)
- New intersections including:
 - A traffic light intersection connecting the existing The Northern Road at the southern boundary of the Western Sydney Airport, incorporating a dedicated u-turn facility on the western side
 - A traffic light intersection for service vehicles accessing the Western Sydney Airport, incorporating 160 m of new road connecting to the planned airport boundary

- A traffic light intersection connecting the realigned The Northern Road with the existing The Northern Road (west of the new alignment) south of Luddenham
- A 'give way' controlled intersection (that is, no traffic lights) connecting the realigned The Northern Road with Eaton Road (east of the new alignment, left in, left out only)
- A four-way traffic light intersection formed from the realigned Elizabeth Drive, the realigned The Northern Road and the existing The Northern Road, north of Luddenham
- A traffic light intersection at the Defence Establishment Orchard Hills entrance, incorporating a u-turn facility.
- New traffic lights at four existing intersections:
 - Littlefields Road, Luddenham
 - Kings Hill Road, Mulgoa
 - Chain-O-Ponds Road, Mulgoa
 - Bradley Street, Glenmore Park incorporating a u-turn facility
- Modified intersection arrangements at:
 - Dwyer Road, Bringelly (left in, left out only)
 - Existing Elizabeth Drive, Luddenham (left out only)
 - Gates Road, Luddenham (left in only)
 - Longview Road, Luddenham (left in, left out only)
 - Grover Crescent south, Mulgoa (left in only)
 - Grover Crescent north, Mulgoa (left out only)
- Dedicated u-turn facilities at:
 - The existing The Northern Road at Luddenham, south-west of Elizabeth Drive
 - The existing Elizabeth Drive, Luddenham around 800 m east of The Northern Road
 - Chain-O-Ponds Road, Mulgoa
- Twin bridges over Adams Road, Luddenham
- Local road changes and upgrades, including:
 - Closure of Vicar Park Lane, east of the realigned The Northern Road, Luddenham
 - Eaton Road cul-de-sac, west of the realigned The Northern Road, Luddenham
 - Eaton Road cul-de-sac, east of the realigned The Northern Road, Luddenham
 - Elizabeth Drive cul-de-sac, about 300 m east of The Northern Road with a connection to the realigned Elizabeth Drive, Luddenham
 - Extension of Littlefields Road, east of The Northern Road, Mulgoa
 - A new roundabout on the Littlefields Road extension, Mulgoa
 - A new service road between the Littlefields Road roundabout and Gates Road, including a 'give way' controlled intersection (that is, no traffic lights) at Gates Road, Luddenham
 - Extension of Vineyard Road, Mulgoa between Longview Road and Kings Hill Road
 - A new roundabout on the Vineyard Road extension at Kings Hill Road, Mulgoa
- A new shared path on the western side of The Northern Road and footpaths on the eastern side of The Northern Road
- A new shared path on the western side of The Northern Road and footpaths on the eastern side of The Northern Road where required
- The upgrading of drainage infrastructure
- Operational ancillary facilities including:

- Heavy vehicle inspection bays for both northbound and southbound traffic, adjacent to Grover Crescent, Mulgoa and Longview Road, Mulgoa respectively
- An incident response facility on the south-western corner of the proposed four-way traffic light intersection at Elizabeth Drive, Luddenham
- New traffic management facilities including variable message signs (VMS)
- Roadside furniture and street lighting
- The relocation of utilities and services
- Changes to property access along The Northern Road (generally left in, left out only)
- Establishment and use of temporary ancillary facilities and access tracks during construction
- Property adjustments as required
- Clearance of undetonated explosive ordinance (UXO) within the Defence Establishment Orchard Hills as required.

1.2 Location and context

The Northern Road is about 45 km west of the Sydney central business district and traverses the local government areas of Penrith in the north and Liverpool in the south.

The Northern Road is a key north–south road between Narellan and Richmond, connecting the North West and South West Priority Growth Areas. The corridor intersects with a number of regional motorway, arterial and collector roads such as (north to south) Richmond Road, Great Western Highway, M4 Motorway, Elizabeth Drive, Bringelly Road, and Camden Valley Way.

South of Glenmore Parkway, the project area is surrounded by rural residential zoned land as well as pastures and grasslands. Land to the east of The Northern Road in this section is occupied by the Commonwealth Defence Establishment, Orchard Hills. Further south, The Northern Road passes through the village of Luddenham (including a small number of residential and commercial properties), before continuing through agricultural grasslands to its junction with Mersey Road (the northern extent of The Northern Road Upgrade, Mersey Road to Peter Brock Drive). A seven kilometre section of the existing The Northern Road alignment bisects the Western Sydney Airport site south-east of the Luddenham town centre.

The regional context of The Northern Road Upgrade is provided on **Figure 1-1**.

1.3 Need for the project

The Northern Road is a critical arterial connection between Bringelly and Penrith. It provides access to rural properties between Bringelly Road and The M4 Motorway as well as access to the Glenmore Park residential development and the Defence Establishment at Orchard Hills. In the longer term, The Northern Road would become the primary north-south route to key developments further to the south of the M4 Western Motorway, including the Western Sydney Airport and the South West Priority Growth Area.

Preliminary traffic modelling undertaken by Roads and Maritime has identified a need to upgrade The Northern Road to provide sufficient capacity for forecast growth along the corridor and to provide bus priority for planned rapid services between Liverpool and Penrith via the Western Sydney Airport.

1.4 Scope and purpose of this report

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

The assessment provided in this report would be used to inform the Environmental Impact Statement (EIS) being prepared 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 development and traffic growth in the study area without the project
- Assessing the impacts of future developments and growth in travel demand at completion of the project and ten years after completion. The standard forecast years of 2021 and 2031 have been adopted for the year of completion and ten years after completion respectively.
- Assessing the impacts of the proposed The Northern Road Upgrade (between Mersey Road and Glenmore Parkway) in 2021 and 2031
- Assessing the cumulative impact of the project with other developments and projects in and around the study area
- Assessing impacts on pedestrians, cyclists and public transport
- Assessing impacts of the construction phase of the project
- Identifying environmental management measures required to address these impacts.

1.5 Traffic modelling process

Traffic modelling is a core component of the appraisal of the project 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 project involved the following:

- Development of a microsimulation traffic model of The Northern Road under existing traffic conditions (2015)
- Development of future year (2021 and 2031) forecasts for The Northern Road corridor and testing of these forecasts in the microsimulation Aimsun model
- Assessment of intersection operation for key intersections along The Northern Road using the Aimsun microsimulation model. A list of the intersections that have been included in the model is provided in **Appendix A**. Assessment of midblock capacity was not undertaken as the primary constraints along The Northern Road under the Project will be intersections.

1.6 Limitations and assumptions

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

- Construction of the M12 Motorway between M7 Motorway and The Northern Road by the mid 2020's (ie by 2025)
- Opening of the Western Sydney Airport by the mid 2020's.
- Completion of The Northern Road upgrade between Glenmore Parkway and Jamison Road by 2021
- Completion of Bringelly Road upgrade between Camden Valley Way and The Northern Road before 2021

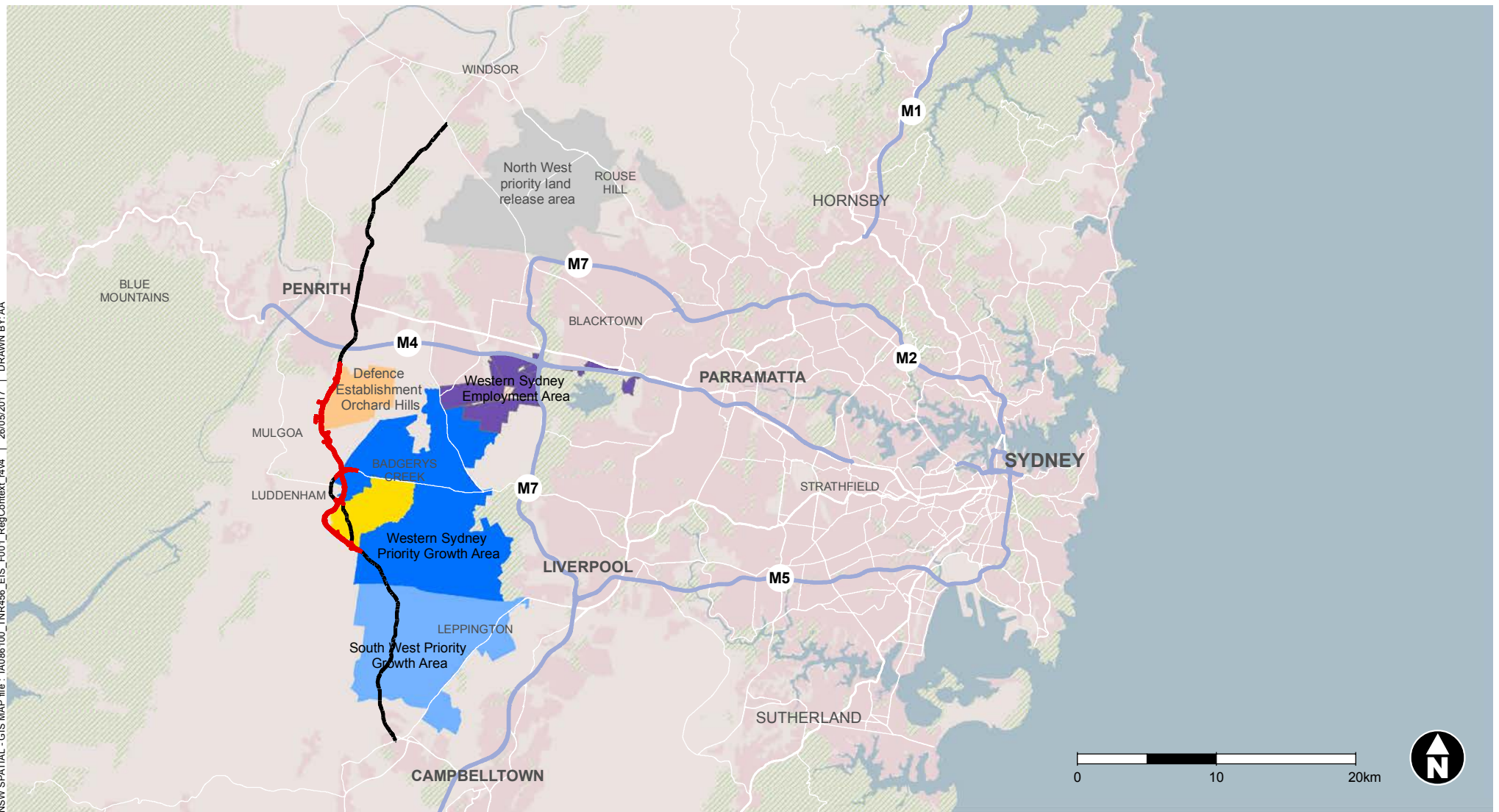
Traffic forecasts have been based on:

- Operation of the planned western Sydney airport by the mid 2020's
- Standard Land Use 2014 assumptions from Bureau of Statistics and Analytics (BSA) including South West Priority Growth Area, Western Sydney Priority Growth Area and planned 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 project
- Section 3 – Existing Conditions: summarises the existing conditions within The Northern Road Study area
- Section 4 – Traffic Model Development: outlines the traffic modelling process undertaken for this assessment
- Section 5 – Appraisal of Future Traffic and Transport Impacts – The Northern Road Upgrade between Mersey Road and Glenmore Parkway: outlines the key traffic and transport impacts of the project on The Northern Road corridor
- Section 6 – Environmental Management Measures: presents a summary of the environmental management measures that are proposed to mitigate the impacts outlined in Section 5
- Section 7 – Residual Impacts: presents a summary of the residual impacts that will remain after the implementation of environmental management measures outlined in Section 6
- Section 8 – Summary and Conclusions: presents a summary of the study findings and sets out the principal conclusions for the study.



Legend

- | | | | |
|---|---|-------------------------------------|------------------------|
| The Northern Road upgrade - Mersey Road to Glenmore Parkway | Western Sydney Airport site (Commonwealth Land) | Western Sydney Employment Area | Reserves and parklands |
| The Northern Road | Defence Establishment Orchard Hills | South West Priority Growth Area | Growth centres |
| | | Western Sydney Priority Growth Area | Built areas |

Figure 1-1 | Location of the project

The Northern Road upgrade - Mersey Road to Glenmore Parkway

2. Planning context

2.1 Overview

This section provides a summary of the key relevant planning, policies and controls affecting the project. This review establishes the transport and land use context of the project 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 are both key components 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
- 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 2,450 hectares 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 1-1**.

2.3 Transport context

The Western Sydney Infrastructure Plan (WSIP) announced in 2014 committed to a 10 year, \$3.6 Billion road investment program for western Sydney. Key features of the WSIP include:

- Upgrade to 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 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 Western Motorway, including two new east facing ramps on the M4 Western Motorway
- Part of the \$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 2-1**.

- Supporting the initiatives outlined in the latest *Sydney Strategic Plan – A Plan for Growing Sydney*; in particular improving transport connections 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 greenfield infrastructure for growth centres.

2.5 New South Wales

NSW Plan 2021

In September 2015 the NSW Government unveiled 30 “State Priorities” and 12 “Premier Priorities” to allow the government to measure and deliver projects that create a stronger, healthier and safer NSW. Priorities that are relevant to the project include:

- Creating jobs
- Building infrastructure.

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

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

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 project 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 project 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 2031* (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 impacts of the project 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 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 Priority Growth Area.

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

- Strengthen the diverse benefits to the economy proposed by the 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 State Infrastructure Strategy

In June 2014, the NSW Government announced Rebuilding NSW – a plan to turbocharge NSW. This plan would invest \$20 billion in new productive infrastructure that would create more than 100,000 jobs and would boost the economy by almost \$300 billion in 20 years. The actions in the NSW State Infrastructure Strategy that relate to the project include:

- Assess and prioritise further road and rail projects to serve Badgerys Creek airport, and preserve site capacity
- Support Badgerys Creek as a catalyst for development
- Better transport infrastructure in Western Sydney.

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 would:

- 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.

Western Sydney Infrastructure Plan

This plan was been developed in 2014 by the Commonwealth and NSW governments to improve transport infrastructure in western Sydney by providing high quality freight and passenger transport infrastructure, especially in the area surrounding the Western Sydney Airport in Badgerys Creek. The upgrade of The Northern Road, new M12 Motorway to connect the M7 Motorway and The Northern Road, upgrade of Bringelly Road, improvement of existing interchanges, Werrington Arterial Road are proposed as part of this plan. The Plan presents the joint commitment of the Australian and NSW governments to delivering a \$3.6 billion road investment program for western Sydney over the period to 2024/25.

A Plan for Growing Sydney

A Plan for Growing Sydney is a NSW Government strategic plan which was released in 2014 for the future of the Sydney Metropolitan Area over the next 20 years. The plan has been developed to ensure that Sydney would be able to accommodate its growing population, especially in Western Sydney. According to the Plan, within 20-25 years' time, significant population growth would occur in the North West and South West Growth Centres and around the Parramatta area with more than 900,000 additional people and this region would be home to more than half of all Sydney residents.

This Plan identifies all the major transport infrastructure projects in Greater Sydney area. This includes Upgrade of The Northern Road, Bringelly Road and Elizabeth Drive, and the proposed Outer Sydney Orbital (M10 Motorway) and M12 Motorway, and the extension of South-West Rail from North Bringelly to St Marys.

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 project 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 would 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 project 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, "We Can Get Around the City", is relevant to the project 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 project. 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 Mersey Road and Glenmore Parkway. The Northern Road serves as the main arterial road for the area, providing access to the M4 Western Motorway. The surrounding land use is mainly residential directly south-west of Glenmore Parkway with the remainder of the study area primarily a mix of light industrial and semi-rural.

The Western Sydney Priority Growth Area is located to the east of the study area. This area has been identified for new jobs, homes and services around the Western Sydney Airport. The project 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 these planned development activities.

3.3 Existing road network

The Northern Road is a major arterial road that extends between Narellan and South Windsor. The Northern Road is a two lane undivided road throughout the study area.

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

3.3.1 Regional road network

Within the context of the study area, the regional road network comprises The Northern Road and Elizabeth Drive, which are the key north-south and east-west routes for regional trips. All other roads in the study area are considered to be local roads. Other regional routes in western Sydney (e.g. M4 Motorway, M7 Motorway, Mulgoa Road, Mamre Road) have not been included either because of their distance from the study area, or because they are not considered viable alternatives to a fully upgraded The Northern Road.

Elizabeth Drive is a rural local road managed by Roads and Maritime. It is a two-lane undivided carriageway signposted at 80 km/h. Elizabeth Drive is 10 metres wide with unsealed shoulders and intersects with The Northern Road at a roundabout.

3.3.2 Local road network

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

- Mersey Road is a rural local road managed by Liverpool Council. It is a two-lane undivided carriageway with no sign-posted speed limit. Mersey Road is six metres wide with unsealed shoulders and intersects with The Northern Road at a give-way sign
- Dwyer Road is a rural collector road owned and managed by Liverpool Council. It is a two-lane undivided carriageway signposted at 80 km/h. Dwyer Road is six metres wide with unsealed shoulders and intersects with The Northern Road at a give-way sign
- Eaton Road is a rural local road that connects to The Northern Road at either end (north and south) and is owned and managed by Liverpool Council. It is a two-lane unsealed road with no signposted speed limit and intersects at either end (north and south) with The Northern Road via a T-intersection

- Adams Road is a rural collector road managed by Liverpool Council. It is a two-lane undivided carriageway signposted at 70 km/h. Adams Road is eight metres wide with unsealed shoulders and intersects with The Northern Road at a T-intersection
- Park Road is a rural local road managed by Liverpool Council. It is a two-lane undivided carriageway signposted at 80 km/h. Park Road is seven metres wide with unsealed shoulders and intersects with The Northern Road at a stop sign
- Elizabeth Drive is a rural local road managed by Roads and Maritime. It is a two-lane undivided carriageway signposted at 80 km/h. Elizabeth Drive is 10 metres wide with unsealed shoulders and intersects with The Northern Road at a roundabout
- Littlefields Road is a rural collector road managed by Penrith Council. It is a two-lane undivided carriageway signposted at 80 km/h. Littlefields Road is 11 m wide with unsealed shoulders and intersects with The Northern Road at a give-way sign
- Gates Road is a rural collector road managed by Penrith Council. It is a two-lane undivided carriageway signposted at 60 km/h. Gates Road is seven metres wide with unsealed shoulders and intersects with The Northern Road at a give-way sign
- Vineyard Road is a rural local road managed by Penrith Council. It is a one-lane carriageway with no sign-posted speed limit. Vineyard Road is five metres wide with unsealed shoulders and intersects with Longview Road, running parallel to The Northern Road
- Longview Road is a rural collector road managed by Penrith Council. It is a one-lane carriageway with no sign-posted speed limit. Longview Road is six metres wide with unsealed shoulders and intersects with The Northern Road at a T-intersection
- Kings Hill Road is a rural collector road managed by Penrith Council. It is a two-lane undivided carriageway signposted at 70 km/h. Kings Hill Road is six metres wide with unsealed shoulders and intersects with The Northern Road at a T-intersection
- Chain-O-Ponds Road is a rural collector road managed by Penrith Council. It is a two-lane undivided carriageway signposted at 70 km/h. Chain-O-Ponds Road is six metres wide and intersects with The Northern Road at a T-intersection
- Defence Establishment entry is a private road connection with The Northern Road providing access to the Defence Establishment Orchard Hills (DEOH). The site is a joint command establishment for the Australian Defence Force providing for storage of munitions, training and logistics, weapon and firing ranges and fuel storage
- Bradley Street is a collector road managed by Penrith Council. It is a two-lane undivided carriageway with no sign-posted speed limit. Bradley Street is six metres wide with unsealed shoulders and intersects with The Northern Road at a stop sign.

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

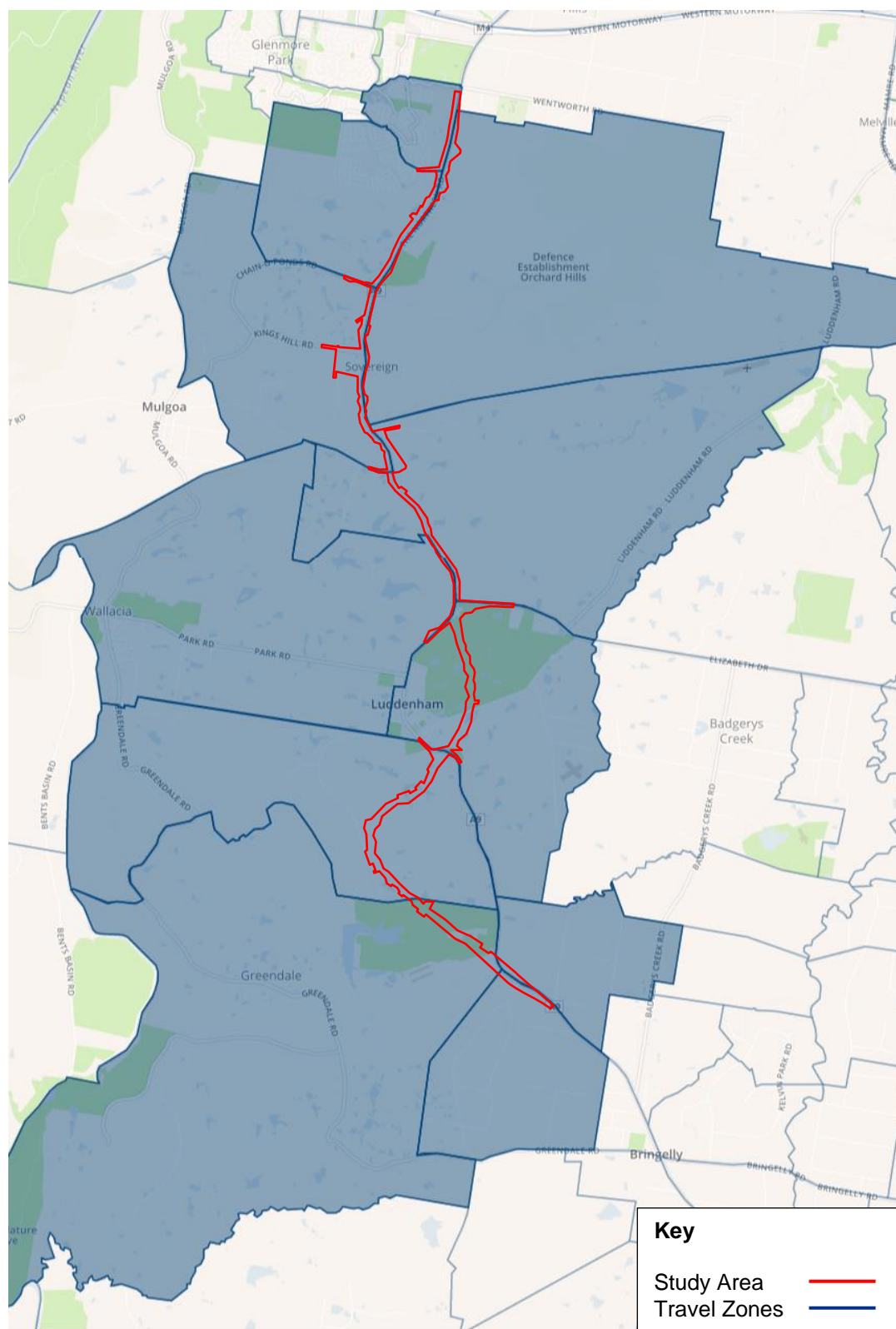
Road	Between	ADT (vehicles per day)	AM peak (8:00- 9:00am)	PM peak (4:30- 5:30pm)
The Northern Road	Glenmore Parkway and Bradley Street	21,982	1,601	1,878
	Chain-O-Ponds Rd and Kings Hill Road	17,499	1,285	1,563
	Littlefields Rd and Elizabeth Drive	15,206	1,097	1,371
	Elizabeth Drive and Park Road	15,737	1,096	1,397
	Park Rd and Blaxland Avenue	13,233	878	1184
Bradley Street	West of The Northern Road	6,832	534	541
DEOH Access	East of The Northern Road	1,513	168	66
Chain-O-Ponds Road	West of The Northern Road	290	27	16
Kings Hill road	West of The Northern Road	2,532	219	186
Longview Road	East of The Northern Road	Not available	13	15
Gates Road	East of The Northern Road	Not available	19	25
Littlefields Road	West of The Northern Road	1,752	131	144
Elizabeth Drive	East of The Northern Road	11,534	849	919
Park Road	West of The Northern Road	6,342	470	501
Adams Road	East of The Northern Road	Not available	134	161
Dwyer Road	South of The Northern Road	Not available	50	74

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. Employment trips provide a good indication of the total mode share of the area and are particularly relevant given the major developments would be employment related.

Journey to Work travel zones used for this analysis are shown in **Figure 3-1**.

Figure 3-1 : Journey to work travel zones



In 2011 there were 1,292 jobs in the study area and 4,056 residents. The data shown in Table 3-2 indicates that car journeys to work, whether as passenger or driver make up some 90 per cent of the total trips into or out of the study area. Only two per cent 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 outside of the study area. Eight per cent of these trips use public transport. Car usage however remains dominant with 88 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	84%	83%
Car Passenger	6%	5%
Mode not stated	2%	2%
Train	1%	7%
Bus	1%	1%
Other	6%	2%

Source: BTS Journey to Work 2011 – TZ – 3626,4971,3625,4969,4970,4967,4965,4964,4963,4937

Figure 3-2 and **Figure 3-3** present the mode share data by origin and destination respectively.

Figure 3-2 : Study area mode share by origin

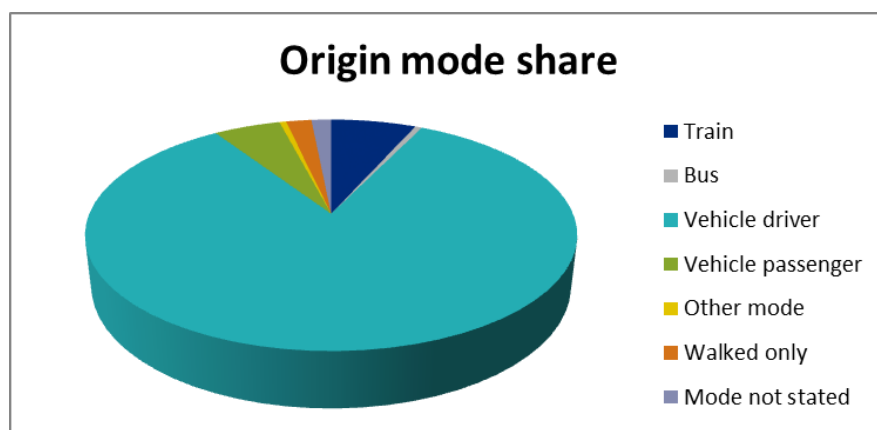
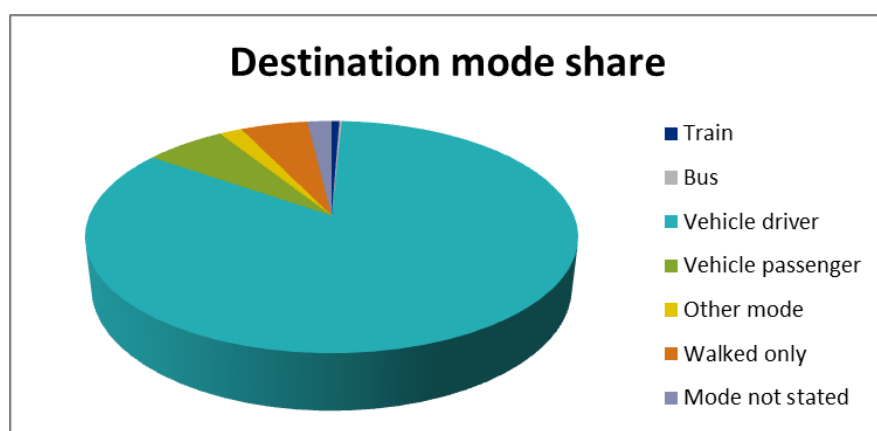


Figure 3-3 : Study area mode share by destination



3.5 Public transport

Public transport in the study area is provided exclusively by bus services.

Route 789 operates between Penrith and Luddenham, predominantly along The Northern Road. This is a peak hour only service and only operates twice a day on weekdays. No services are provided on weekends.

There are currently fourteen bus stops associated with this bus route within the study area located as follows:

- Northbound stop located on Adams Road (stop ID: 2745186)
- Southbound stop located at The Northern Road north of Elizabeth Drive (stop ID: 2745120)
- Northbound stop located at The Northern Road north of Elizabeth Drive (stop ID: 2745123)
- Southbound stop located at 2787 The Northern Road (stop ID: 2745119)
- Northbound stop located at 2787 The Northern Road (stop ID: 2745124)
- Southbound stop located at The Northern Road north of Gates Road (stop ID: 2745118)
- Southbound stop located at The Northern Road south of Longview Rd (stop ID: 274818)
- Northbound stop located at The Northern Road north of Longview Rd (stop ID: 2745125)
- Northbound stop located at The Northern Road south of Chain-O-Ponds Road (stop ID: 2745126)
- Southbound stop located at The Northern Road north of Chain-O-Ponds Road (stop ID: 274817)
- Southbound stop located at the Defence Establishment at Orchard Hills (stop ID: 274816)
- Northbound stop located at the Defence Establishment at Orchard Hills (stop ID: 2745127)
- Southbound stop located at Truck Stop on The Northern Road (stop ID: 274815)
- Northbound stop located at The Northern Road (stop ID: 2745128).

Figure 3-4 shows the 789 bus route and bus stops through the study area.

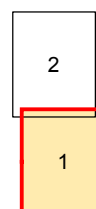
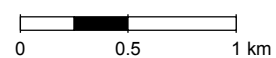
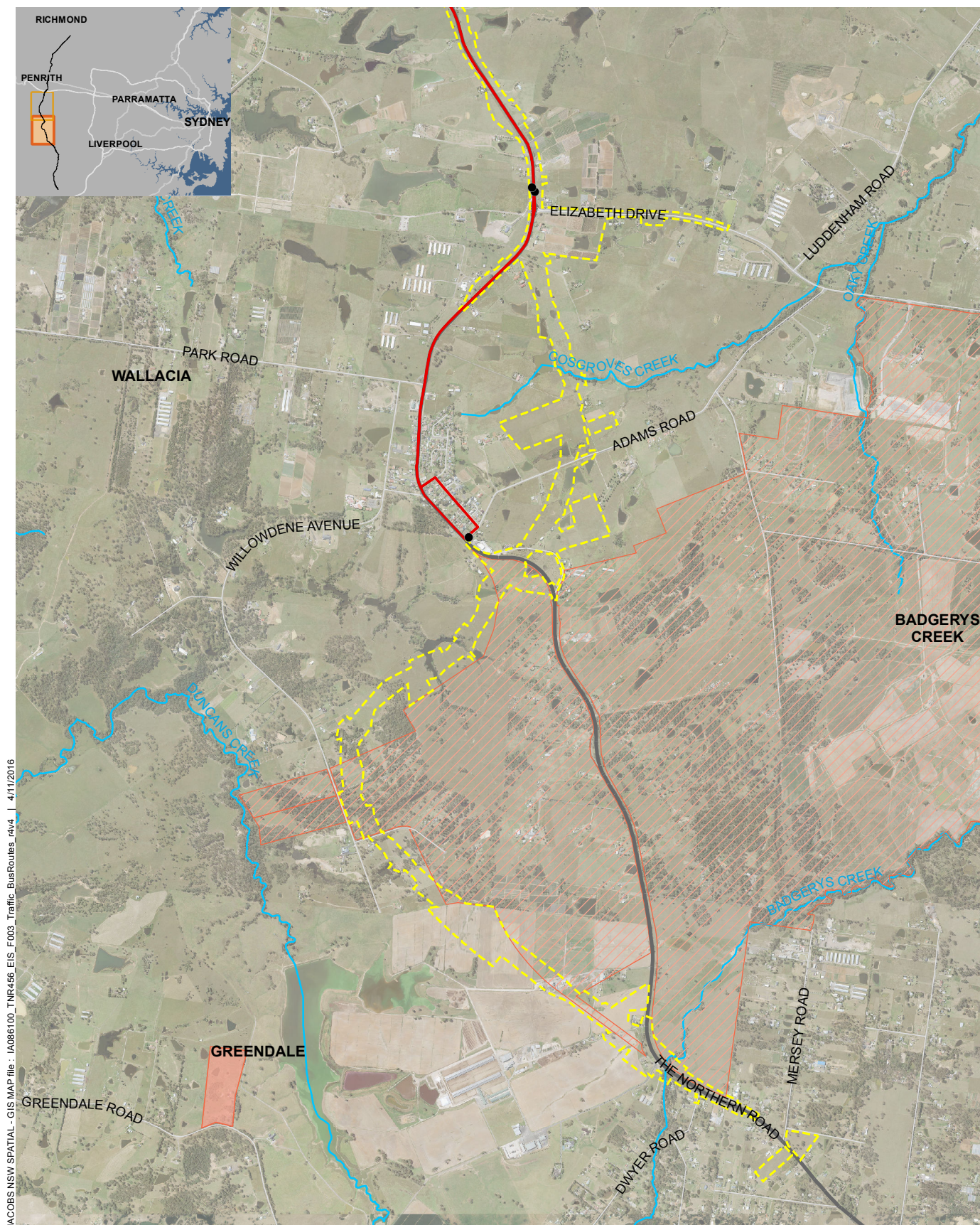
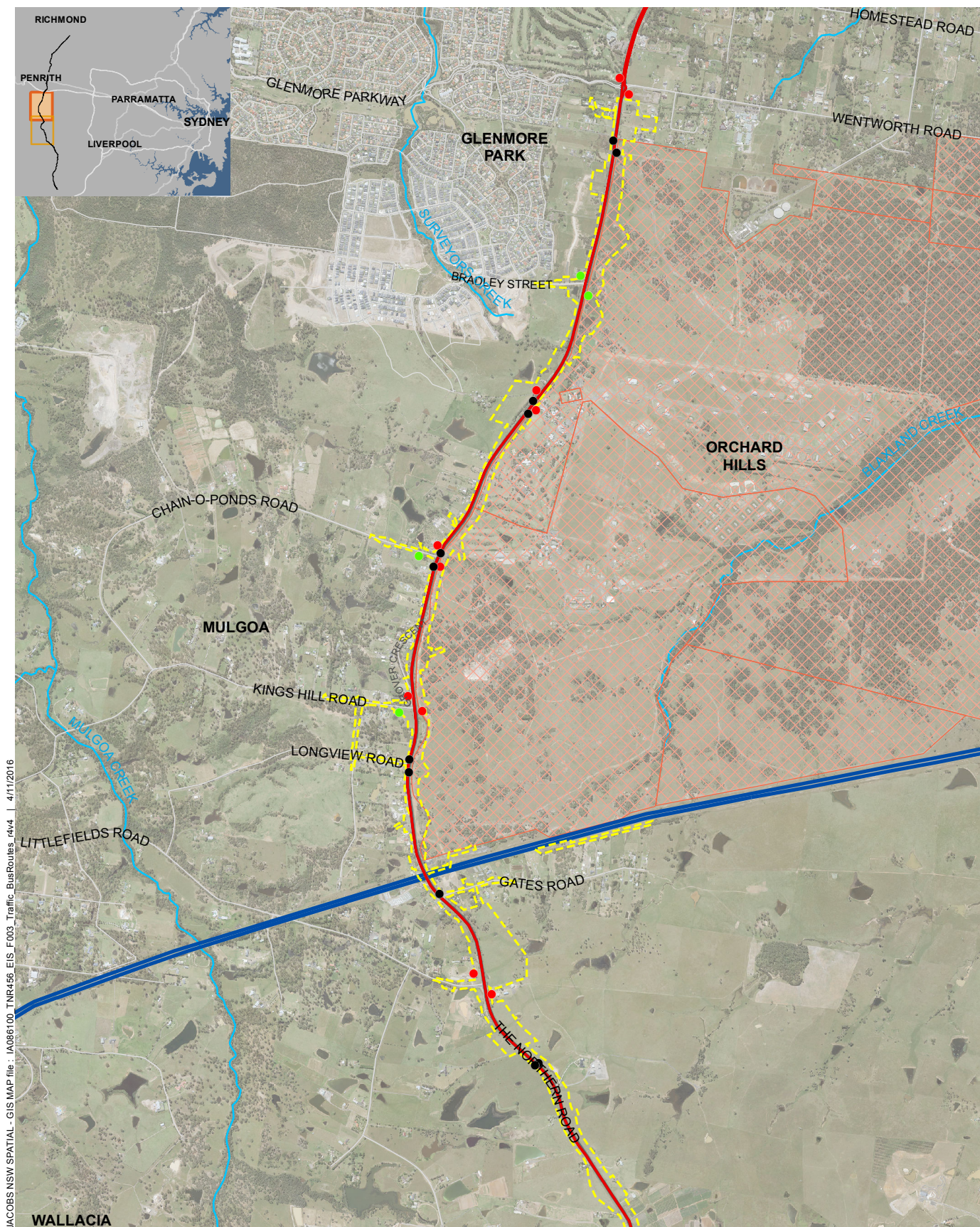


Figure 3.4 | Bus routes in the proposal area



- The Northern Road (Existing)
- Bus route 789
- Project area
- WaterNSW supply pipelines
- Existing bus stop to be removed
- New bus stop
- Western Sydney Airport site (Commonwealth Land)
- Relocated bus stop
- Defence Establishment Orchard Hills (Commonwealth Land)
- Commonwealth Lands

0 0.5 1 km

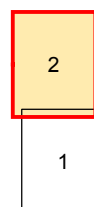
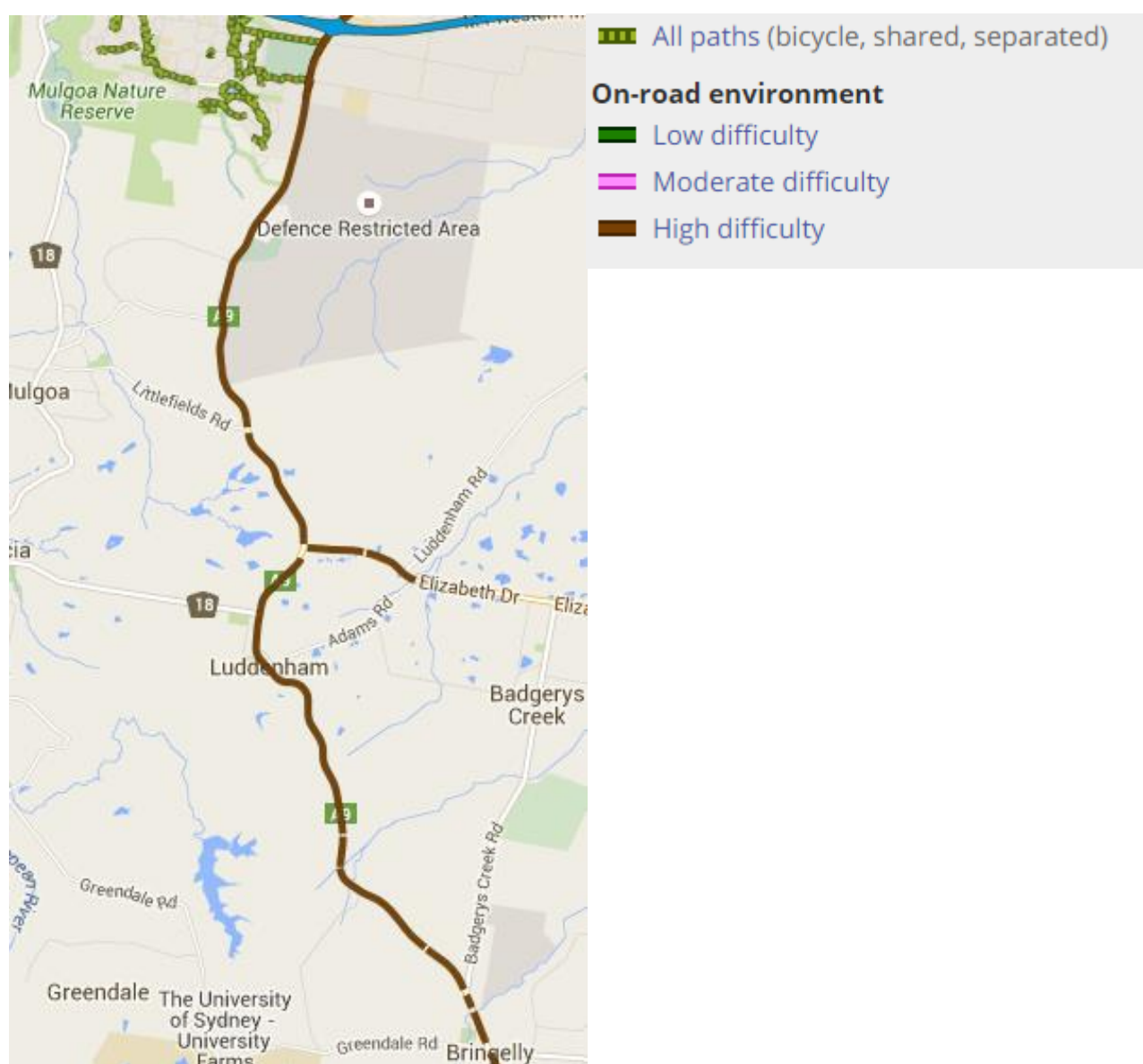


Figure 3.4 | Bus routes in the proposal area

3.6 Active transport

There is currently limited pedestrian infrastructure provided in the study area. There are no formal continuous footpaths provided along The Northern Road in the majority of the study area. However, a short section of footpath is provided on the western side of the road between Roots Avenue and the service station near Park Road at Luddenham. There are no formal cycle facilities provided in the study area. The study area is covered by the *Penrith Accessible Trails Hierarchy Strategy (2012)* and the *Liverpool City Council Bike Plan (2009)*; neither of these documents identify any plans for future cycle facilities in the study area. The Roads and Maritime Cycleway Finder classifies The Northern Road as a high difficulty on-road environment for cyclists, as shown in **Figure 3-5**.

Figure 3-5 : Cycling routes in the study area



Source: Roads and Maritime Cycleway Finder

3.7 Freight routes

The Northern Road forms a significant north-south freight function in the region. The route is approved for the 26 metre B-doubles and 4.6 metre high vehicles between Mersey Road and Glenmore Parkway. Elizabeth Drive to the east of The Northern Road and Park Road to the west are also approved routes for 26 metre B-doubles. **Figure 3-6** shows the approved B-Double routes through the project area.

Figure 3-6 : Approved B-Double Routes through the study area



Source: NSW Roads and Maritime Services

A summary of average weekday daily heavy vehicle volumes at various locations along The Northern Road between Mersey Road and Glenmore Parkway is provided in Table 3-3

Table 3-3 : Summary of heavy vehicle flows along The Northern Road (average weekday)

Location	Northbound Flow (veh/day)	Proportion of total flow	Southbound Flow (veh/day)	Proportion of total flow
Between Mersey Road and Dwyer Road	862	13%	995	15%
Between Dwyer Road and Eaton Road	782	11%	1,326	19%
Between Blaxland Avenue and Park Road	985	14%	958	14%
Between Park Road and Elizabeth Drive	1,083	12%	1,219	15%
Between Elizabeth Drive and Littlefields Road	931	12%	1,141	14%
Between Kings Hill Road and Chain-O-Ponds Road	1,135	13%	1,138	12%
Between Bradley Street and Glenmore Parkway	1,866	16%	1,502	13%

Analysis of existing heavy vehicle flows shows that heavy vehicles comprise between 11 and 19 per cent of daily traffic along The Northern Road between Mersey Road and Glenmore Parkway. Heavy vehicle volumes are generally higher to the north of Elizabeth Drive and comprise a higher proportion of daily traffic.

3.8 Existing road network performance

Assessment of the existing road network has been based on modelled traffic flows for the morning and evening peak period using The Northern Road microsimulation traffic model. The Northern Road 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*.

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 also assists in the assessment and scoping of proposed intersections along the corridor as well as providing 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 that are the critical capacity control points. The 'Level of Service' (LoS) is the standard measure used to assess the operational performance of the intersections. Level of service is ranked from LoS A to LoS F, with LoS A representing the best performance and LoS F the worst. The Level of Service is based on the average delay experienced by cars driving through the intersection, and is defined as the average delay of the worst movement for priority intersections (stop and give-way signs) and roundabouts and for signalised intersections is defined as the weighted average delay of all movements.

The criteria used to determine intersection Level of Service on the basis of average delay is outlined in Table 3-4 as defined by Roads and Maritime in the *Guide to Traffic Generating Developments (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

Intersection Level of Service for key intersections within the study area, derived from the The Northern Road microsimulation traffic model under the base year (2015), is shown in Table 3-5.

Table 3-5 : Existing intersection performance

Intersection	2015 AM Peak		2015 PM Peak	
	Average delay (sec)	Level of Service	Average delay (sec)	Level of Service
The Northern Road/Bradley St	27	B	34	C
The Northern Road/DEOH Access	10	A	16	B
The Northern Road/Chain-O-Ponds Rd	8	A	10	A
The Northern Road/Kings Hill Rd	11	A	10	A
The Northern Road/Littlefields Rd	13	A	13	A
The Northern Road/Elizabeth Rd	24	B	19	B
The Northern Road/Park Road	26	B	19	B

The microsimulation model shows that currently all intersections operate satisfactorily during the peak periods.

Queuing at the intersection of The Northern Road and Bradley Street has been observed increasing as the development of the Glenmore Park residential subdivision has proceeded. Completion of this subdivision is likely to increase traffic flows out of Bradley Street in the morning peak and into Bradley Street in the evening peak and consequently increase delays at this intersection. To address this issue in the short-term, the installation of temporary traffic signals at this intersection has been committed to by Roads and Maritime should the project go ahead (pending planning approval). These traffic signals are likely to be in place by the end of 2017 and would remain until the intersection is reconfigured as part of the project, at which time this would be replaced with a new upgraded signalised intersection.

3.8.3 Existing travel times and travel speeds

Travel times and travel speeds provide an additional means of assessing the functional performance of a road. The criteria for determining the Level of Service based on average travel speeds is outlined in Table 3-6 as defined by *Austroads Guide to Traffic Management, Part 3: Traffic Studies and Analysis (2013)*.

Table 3-6 : Level of Service criteria for urban roads

Travel speed as a percentage of free-flow travel speed (%)	Level of Service (volume to capacity <1)	Level of Service (volume to capacity >1)
>85%	A	F
67-85%	B	F
50-67%	C	F
40-50%	D	F
30-40%	E	F
<30%	F	F

Travel times and travel speeds along the two key sections of The Northern Road through the study area are shown in Table 3-7 being The Northern Road between Mersey Road and Elizabeth Drive and The Northern Road between Elizabeth Drive and Glenmore Parkway. Analysis of observed average speeds (based on floating car travel time surveys) along The Northern Road shows that traffic travels generally slower than the sign posted speed limits. This is due primarily to delays at roundabouts, traffic turning right at priority intersections and delays caused by cars being unable to overtake heavy vehicles. Despite these delays, current observed travel times and average travel speeds correspond to a Level of Service C or better.

Table 3-7 : Existing travel speeds along The Northern Road

Segment	Direction	Travel Time (mm:ss)	Average Travel Speed (km/hr)	LoS
Morning Peak				
Between Mersey Road and Elizabeth Dr	NB	06:47	65	B
	SB	07:27	60	B
Between Elizabeth Dr and Glenmore Parkway	NB	07:22	60	B
	SB	07:03	63	B
Evening Peak				
Between Mersey Road and Elizabeth Dr	NB	06:30	68	B
	SB	07:31	59	C
Between Elizabeth Dr and Glenmore Parkway	NB	07:53	56	C
	SB	06:51	65	B

3.9 Existing road safety trends

An analysis of crash history data has been carried out in the study area. Crash statistics recorded by Roads and Maritime 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 Roads and Maritime and is presented below.

Table 3-8 shows the number of crashes in the study area by year. Crash frequency has remained relatively stable since 2009 with an average of 24 reported crashes per year with a spike in 2010.

Table 3-8 : Number of crashes

Period	Reported crashes
2009-2010	21
2010-2011	36
2011-2012	17
2012-2013	22
2013-2014	25
Total	121

Table 3-9 shows the type of crashes that have occurred on The Northern Road between Mersey Road and Glenmore Parkway. Rear end type crashes were the most prevalent reported crashes, accounting for 40 percent of all crashes.

Table 3-9 : Summary of crash types

Type of crash	Reported crashes (number)	Reported Crashes (per cent of total)
Rear End	56	40%
Head On - not overtaking	19	13%
Off to left - Curve	10	7%
Off to left - Straight	7	5%
Emerging from driveway	6	4%
Intersection - right turn	6	4%
Off to right - Curve	6	4%
Off to right - Straight	4	3%
Lane Change	4	3%
U Turn	3	2%
Intersection - cross traffic	2	1%
Out of control on carriageway -	2	1%

Type of crash	Reported crashes (number)	Reported Crashes (per cent of total)
Straight		
Animal	2	1%
Turning	2	1%
Out of control on carriageway - Curve	2	1%
Side Swipe	2	1%
Other manoeuvring	2	1%
Object on carriageway	1	1%
Fell from vehicle	1	1%
Overtaking	1	1%
Head On - overtaking	1	1%
Off end of T intersection - Straight	1	1%

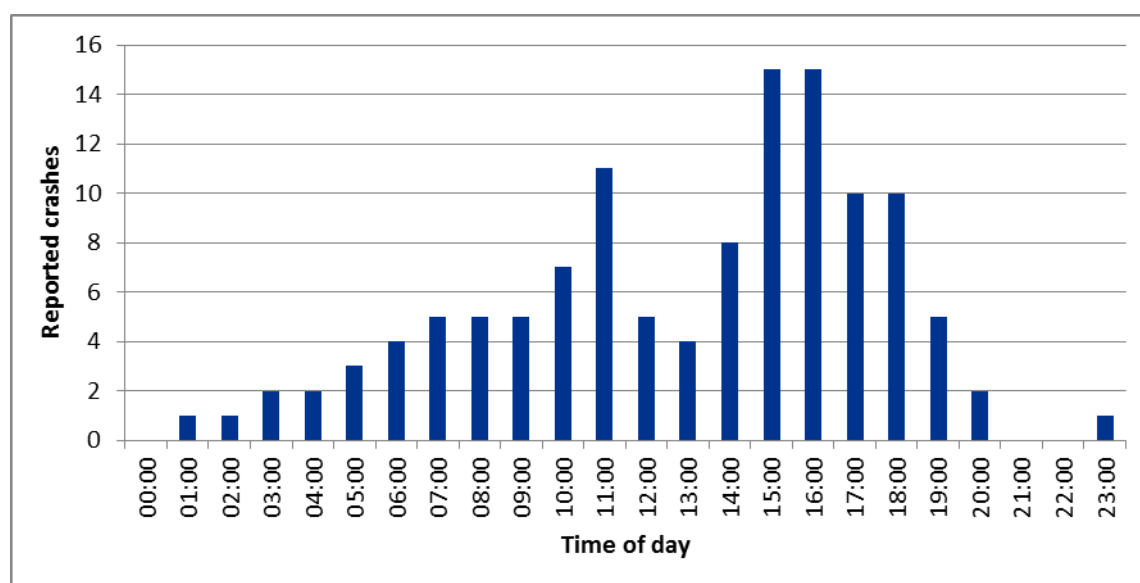
Table 3-10 outlines the severity of crashes along The Northern Road. There were five fatal crashes in the reporting period. The remaining crashes were relatively evenly split between injury and non-injury crashes.

Table 3-10 : Summary of crash severity

Severity	Reported crashes
Fatal	5
Injury	57
Non-injury	59

Figure 3-7 shows reported crashes by time of day. The majority of crashes occurred during the day, with a peak in the afternoon between 3pm-6pm.

Figure 3-7 : 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 km per year.

Table 3-11 outlines these crash rates. It is observed that the casualty crash rate per km per year is significantly lower than the average performance of similar roads (i.e. class 3U) in NSW.

Table 3-11 : 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*
15,993	16	25.9	1.5	0.81	3.54

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. Traffic model development

4.1 Modelling overview

To inform the impact assessment of the project an Aimsun microsimulation traffic model was developed. The microsimulation model allows the simulation of 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 Northern Road Upgrade between Mersey Road and Jamison Road, Penrith.

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

4.2 Geographic model extents

The microsimulation traffic model for The Northern Road Upgrade extends along The Northern Road between Mersey Road and Jamison Road. A plot of the model extents is provided in **Figure 4-1**.

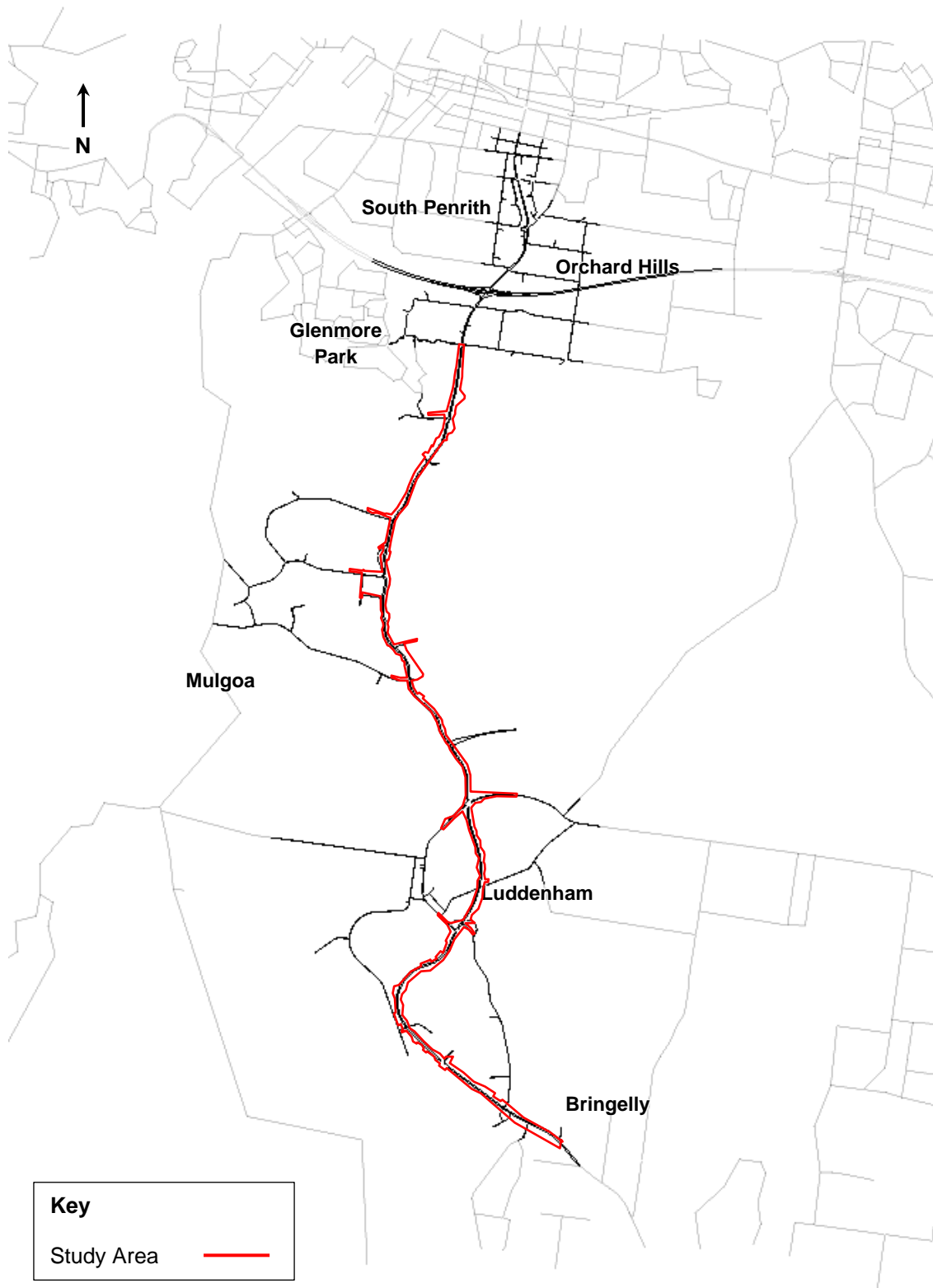
4.3 Data sources

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 (traffic signal system) 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. This 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. This is typical for turning movements with low flows.

Figure 4-1 : Microsimulation model extents



4.4 Model development

Development of the base microsimulation 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 Strategic Travel Model (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 static assignment to a suitable level
- Calibrate the microsimulation assignment to the final calibration standards
- Generate future year demand matrices for year of opening and year of opening plus 10 years based on forecast traffic volumes from Roads and Maritime Sydney Traffic Assignment Model (STAM)
- Develop 'Do minimum' scenario models based on committed road works (i.e., M12 Motorway and Western Sydney Airport)
- Develop The Northern Road Upgrade (between Mersey Road and Glenmore Parkway) scenario models based on the concept design
- Run and optimise The Northern Road Upgrade (between Mersey Road and Glenmore Parkway) scenario under microsimulation
- Undertake detailed modelling of individual intersection using SIDRA Intersection to optimise intersection designs.

Traffic assignment was based on microsimulation 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.

4.5 Calibration and validation

4.5.1 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 Roads and Maritime *Traffic Modelling Guidelines (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 generally over-assigning (greater than 1) or under-assigning (less than 1) traffic across the network.

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

A summary of intersection turning movement comparisons for all vehicle types is provided in Table 4-1. A breakdown of these comparisons by vehicle type is provided in Table 4-2.

Table 4-1 : 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
<i>6am to 10am (Aggregate)</i>	<i>694 (99%)</i>	<i>8 (1%)</i>	<i>0.998</i>	<i>0.989</i>
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
<i>3pm to 7pm (Aggregate)</i>	<i>690 (98%)</i>	<i>12 (2%)</i>	<i>0.998</i>	<i>0.992</i>

Table 4-2 : 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
<i>6am to 10am (Aggregate)</i>	<i>0.998</i>	<i>0.993</i>	<i>0.956</i>	<i>0.925</i>
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
<i>3pm to 7pm (Aggregate)</i>	<i>0.997</i>	<i>1.000</i>	<i>0.954</i>	<i>0.896</i>

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
- R² 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 high forecast growth in traffic through the study area under future years, this underestimation of base year heavy vehicle flows does not substantially impact the operational assessment of the project.

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

4.5.2 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 Northern Road base models have been validated against travel times recorded during the same period as the turning movement surveys.

As recommended by the 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 each route to be within 1 minute, or 15 per cent (whichever is higher) of observed travel times.

The performance of the model against these targets is summarised in Table 4-3.

Table 4-3 : 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 (northbound between 7:00am to 8:00am). 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 project.

4.6 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 Strategic Traffic Assignment Model (STAM) for 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 2019/20. 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 Northern Road Upgrade (between Mersey Road and Glenmore Parkway).

The forecasts provided by Roads and Maritime include the following key developments surrounding the project:

4.6.1 Western Sydney Airport

According to the recently released The Western Sydney Airport Draft Environmental Impact Statement 2016 (DIRD, 2016), the operation of Stage 1 of the airport is expected to result in approximately 41,858 vehicles entering and leaving the airport site each day by 2030. Future traffic demand forecasts provided by Roads and Maritime Services for use in future travel demand development reflect the traffic generation and trip distribution available as at February 2016 and have been included in this assessment.

4.6.2 South West Priority Growth Area

The South West Priority Growth Area comprises 18 precincts and covers about 17,000 hectares. It is expected to accommodate about 110,000 new dwellings for 300,000 people (DP&E, 2015). To date, seven precincts within the South West Priority Growth Area have been rezoned to allow urban development, which have the potential for about 42,560 new homes. Detailed planning for stage 1 of Leppington Precinct (south-east of the project area) has recently been finalised. Upon rezoning, it is expected the Leppington Precinct will provide land for approximately 2500 additional homes. As the 2014 Standard Land Use includes these assumptions, traffic growth from the South West Priority Growth Area Western Sydney Priority Growth Area has been included in this assessment.

4.6.3 Western Sydney Priority Growth Area

The Western Sydney Priority Growth Area (formerly Broader Western Sydney Employment Area) is identified in A Plan for Growing Sydney (NSW Planning and Environment, December 2014). It extends from the intersection of the M4 Western Motorway and WestLink M7 Motorway, to south of The Northern Road / Elizabeth Drive intersection.

The WSPGA identifies about 10,000 hectares of currently low intensity rural activity lands to be developed as a diverse employment centre, providing businesses in the region with land for industry and employment, catering for transport and logistics, warehousing and office space. It is anticipated to provide over 57,000 jobs over the next 30 years, and over 200,000 jobs once it is fully established.

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 with the project is provided in Table 4-5. Although forecast traffic volumes are shown for 2041, the underlying land use assumptions for 2041 are less certain than those for 2021 and 2031 and consequently are less reliable. For this reason, operational assessment of the project has focused on 2021 and 2031 only.

Table 4-5 : Modelled traffic flows on The Northern Road (morning and evening peak hour) with the project

Sections	Direction	2015 (veh/hr)		2021 (veh/hr)		2031 (veh/hr)		2041 (veh/hr)	
		AM	PM	AM	PM	AM	PM	AM	PM
South of Bradley Street	NB	929	1,008	1001	1439	1,470	1,956	1,739	2,402
	SB	722	855	1013	1026	1,617	1,819	1,948	2,077
North of Chain-O-Ponds Road	NB	944	968	1006	1373	1,469	1,916	1,713	2,346
	SB	665	848	965	1004	1,563	1,833	1,903	1,964
South of Chain-O-Ponds Road	NB	926	954	999	1379	1,463	1,871	1,708	2,324
	SB	668	837	964	1009	1,555	1,840	1,901	1,987

Sections	Direction	2015 (veh/hr)		2021 (veh/hr)		2031 (veh/hr)		2041 (veh/hr)	
North of Kings Hill Road	NB	900	921	990	1373	1,451	1,916	1,692	2,346
	SB	660	786	984	1004	1,550	1,833	1,903	1,964
South of Kings Hill Road	NB	727	853	821	1288	1,284	1,811	1,480	2,233
	SB	602	677	901	818	1,504	1,654	1,820	1,797
North of Littlefields Road	NB	707	835	817	1288	1,274	1,804	1,483	2,219
	SB	587	651	917	804	1,513	1,641	1,827	1,777
South of Littlefields Road	NB	729	897	819	1365	1,302	2,078	1,534	2,548
	SB	632	671	961	795	1,668	1,647	2,084	1,793
South of M12	NB	722	897	816	1373	1,316	2,069	1,540	2,537
	SB	628	664	982	790	1,684	1,657	2,094	1,792
South of Elizabeth Dr	NB	721	893	726	850	1,281	863	1,685	1,588
	SB	628	664	365	662	521	1,265	1,092	1,478
North of The Northern Road (south Luddenham access)	NB	849	606	726	850	1,281	863	1,685	1,588
	SB	466	857	370	665	518	1,264	1,096	1,481
South of The Northern Road (south Luddenham Access)	NB	657	777	767	962	1,439	1,062	1,791	2,002
	SB	487	713	698	913	807	1,520	1,627	1,858
North of Western Sydney Airport Access	NB	635	743	767	962	1,439	1,062	1,791	2,002
	SB	472	704	698	913	807	1,520	1,627	1,858
South of Western Sydney Airport Access	NB	627	748	758	960	1,426	1,050	2,322	1,396
	SB	487	702	693	904	802	1,506	1083	2,259

4.7 Planned future network improvements

A number of road network upgrades have been planned on or around the project. These include:

- 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.

4.7.1 M12 Motorway

The M12 Motorway would provide direct access to the Western Sydney Airport and connect to the rest of Sydney's motorway network via the M7. The project is comprised of an east-west motorway of about 15 - 17km between the M7 Motorway and The Northern Road that would provide increased road capacity and reduce congestion and travel times to the Western Sydney Airport 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 Growth Area and the Western Sydney Priority Growth Area. For the purposes of this assessment, the M12 is assumed to be open by 2031 and would connect with The Northern Road at an at-grade signalised intersection.

4.7.2 Elizabeth Drive

Elizabeth Drive currently connects the M7 with The Northern Road and forms the northern border to the Western Sydney Airport. For the purposes of this assessment, it is assumed that the existing intersection of Elizabeth Drive and The Northern Road would be upgraded from a roundabout to a signalised

intersection with realignment of Elizabeth Drive and the construction of a new link to Luddenham town centre included as part of this intersection upgrade. Details of the development of this intersection are provided in Appendix B.

4.7.3 Western Sydney Airport

The Western Sydney Airport is on the existing Commonwealth land between Elizabeth Drive, Badgerys Creek and extends west beyond the existing The Northern Road, south of Luddenham. The Australian Government's Department of Infrastructure and Regional Development estimates that on opening in the mid-2020s, the Western Sydney 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 Western Sydney Airport and in surrounding business districts. A second parallel runway would be required by around 2050. The second runway would provide the capacity to meet growth in demand for air travel. The Western Sydney Airport is still in the concept planning stage. However, current plans propose two accesses to the Western Sydney Airport. A main passenger access would connect directly to the 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.

4.7.4 Future public transport network assumptions

In addition to the road network assumptions identified above, traffic forecasting undertaken by Roads and Maritime also included the following public transport network assumptions:

- Rapid and suburban bus routes as outlined in Sydney's Bus Future (2013)
- Construction of the South West Rail Link Extension (after 2031).

5. Appraisal of future traffic and transport impacts

5.1 Overview

The following section provides an assessment of the traffic and transport impacts of the project. The study has assessed the traffic and transport impacts for two design years (2021 and 2031) for the weekday peak periods.

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 also considers the impacts on all road users including public transport, pedestrians and cyclists.

5.2 Modelling approach

The traffic and transport assessment considered the following scenarios:

- Existing 2015 (Base case)
- 2021 and 2031 'with no The Northern Road Upgrade (between Mersey Road and Glenmore Parkway)' ('Do minimum')
- 2021 and 2031 'with The Northern Road Upgrade (between Mersey Road and Glenmore Parkway)'.

The 'with no The Northern Road Upgrade (between Mersey Road and Glenmore Parkway)' scenario includes the following road upgrades:

- M12 Motorway (by 2031)
- Western Sydney Airport (by 2031)
- Realignment of the existing The Northern Road around the Western Sydney Airport site to a two-lane undivided road¹.

The 'with The Northern Road Upgrade (between Mersey Road and Glenmore Parkway)' scenario assumes all the 'Do minimum' upgrades as well as the completion of The Northern Road Upgrade between Mersey Road and Glenmore Parkway.

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 project	2021 with the project	2031 without the project	2031 with the project
M12 Motorway	×	×	×	✓	✓
Western Sydney Airport	×	×	×	✓	✓
The Northern Road Upgrade (between Mersey Road and Glenmore Parkway)	×	×	✓	×	✓

¹ This effectively would provide a like-for-like replacement of the existing The Northern Road, while also achieving the objective of moving the road from the Western Sydney Airport site.

5.3 Desired standards of service

The assessment criteria for road network planning for the project 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
- Minimising queue length and turn bay overflow along The Northern Road
- Minimising travel times along The Northern Road
- Provision of optimum intersection configurations that are sensitive to physical constraints and land ownership
- Minimising impacts on all other road users such as public transport, pedestrian and cyclists.

5.4 Impacts on road network performance

The intersection performance criteria outlined in **Section 5.3** have been used to assess the performance of intersections along The Northern Road. Assessment of these intersections has been undertaken based on outputs from The Northern Road microsimulation traffic model, with average delays for intersections extracted from Aimsun for the morning (07:30 to 08:30) and evening (16:30 to 17:30) peak periods. As the M4 Motorway is outside of the project study area, the impacts of the project on the M4 are not considered in this assessment. These impacts are considered in the Review of Environmental Factors for The Northern Road upgrade between Glenmore Parkway and Jamison Road, which includes the project as one of the key assumptions.

5.4.1 Without The Northern Road upgrade (between Mersey Road and Glenmore Parkway)

Table 5-2 summarises the intersection operation along the existing The Northern Road corridor if the project was not built. In general, testing of the forecast traffic flows on The Northern Road under the future year scenarios shows that intersections along The Northern Road would continue to perform acceptably by 2021, with the exception of The Northern Road and Bradley Street. Delays at this intersection have been observed increasing as development in Glenmore Park has proceeded, and this growth is likely to increase delays at this intersection to beyond acceptable levels by 2021.

Analysis of later future scenarios shows there would be insufficient capacity along The Northern Road under the existing arrangement by 2031. This corresponds with increased traffic associated with the planned M12 Motorway and the Western Sydney Airport and associated land uses.

Table 5-2 : Intersection performance summary 'Without The Northern Road upgrade' (between Mersey Road and Glenmore Parkway)

Intersection	2015		2021		2031	
	Av. Delay (sec)	LoS	Av. Delay (sec)	LoS	Av. Delay (sec)	LoS
<i>Morning peak</i>						
The Northern Road/Bradley Street	27	B	30	C	>100	F
The Northern Road/DEOH Access	10	A	10	A	57	E
The Northern Road/Chain-O-Ponds Road	8	A	10	A	46	D
The Northern Road/Kings Hill Road	11	A	11	A	>100	F
The Northern Road/Littlefields Road	13	A	15	B	>100	F
The Northern Road/M12	-	-	-	-	>100	F
The Northern Road/Elizabeth Road	24	B	20	B	>100	F
The Northern Road/Park Road	26	B	14	A	>100	F
The Northern Road/ Western Sydney Airport Access	-	-	-	-	>100	F
<i>Evening peak</i>						
The Northern Road/Bradley Street	34	C	58	E	>100	F
The Northern Road/DEOH Access	16	B	17	B	86	F
The Northern Road/Chain-O-Ponds Road	10	A	12	A	59	E
The Northern Road/Kings Hill Road	10	A	9	A	63	E
The Northern Road/Littlefields Road	13	A	15	A	98	F
The Northern Road/M12	-	-			>100	F
The Northern Road/Elizabeth Road	19	B	18	B	>100	F
The Northern Road/Park Road	19	B	14	A	>100	F
The Northern Road/Western Sydney Airport Access	-	-	-	-	>100	F

5.4.2 With The Northern Road upgrade (between Mersey Road and Glenmore Parkway)

Table 5-3 summarises the performance of the intersections following implementation of The Northern Road Upgrade (between Mersey Road and Glenmore Parkway) in 2021 and 2031. In 2015, the results are for The Northern Road as it existed in 2015 and as such, the results are the same as those presented in table 5-2 which represents the base case.

In general, testing of the forecast traffic flows with The Northern Road upgrade shows that the project would relieve the capacity constraints that currently exist along The Northern Road, particularly at the existing give-way and stop sign controlled intersections where traffic signals would be provided or right turn movements would be removed.

Modelled intersection delays show that the intersections would generally perform with higher delays in 2031 than 2021, which is consistent with the increase in traffic forecast between these years as a consequence of additional land use at the Western Sydney Airport and the construction of the M12 Motorway.

Analysis of the intersection performance along The Northern Road under the project shows that most of the intersections within the study area would operate satisfactorily under the 2021 and 2031 future year scenarios with Level of Service (LoS) C or better. The only exception being the intersection of The Northern Road and Elizabeth Drive which would be operating near capacity in the evening peak hour at LoS D by 2021. This is due to the large volumes of conflicting traffic movements that are forecast to travel through this intersection by 2021.

Table 5-3 : Intersection performance summary 'With The Northern Road upgrade' (between Mersey Road and Glenmore Parkway)

Intersection	2015		2021		2031	
	Av. Delay (sec)	LoS	Av. Delay (sec)	LoS	Av. Delay (sec)	LoS
Morning peak						
The Northern Road/Bradley Street	27	B	30	C	36	C
The Northern Road/DEOH Access	10	A	22	B	31	C
The Northern Road/Chain-O-Ponds Road	8	A	11	A	17	B
The Northern Road/Kings Hill Road	11	A	15	B	27	B
The Northern Road/Littlefields Road	13	A	17	B	33	C
The Northern Road/M12	1	1	1	1	27	B
The Northern Road/Elizabeth Drive	24	B	41	C	41	C
The Northern Road/Park Road ²	-	-	21	B	26	B
The Northern Road/ Western Sydney Airport Northern Access	1	1	1	1	30	C
The Northern Road/Western Sydney Airport Southern Access	1	1	1	1	23	B
Evening peak						
The Northern Road/Bradley Street	34	C	33	C	42	C
The Northern Road/DEOH Access	16	B	20	B	25	B
The Northern Road/Chain-O-Ponds Road	10	A	14	A	22	B
The Northern Road/Kings Hill Road	10	A	26	B	32	C
The Northern Road/Littlefields Road	13	A	15	B	18	B
The Northern Road/M12	1	1	1	1	33	C
The Northern Road/Elizabeth Drive	19	B	44	D	45	D
The Northern Road/Park Road ²	-	-	18	B	22	B
The Northern Road/ Western Sydney Airport Northern Access	1	1	1	1	40	C
The Northern Road/ Western Sydney Airport Southern Access	1	1	1	1	26	B

¹ M12 and Western Sydney Airport would be built after 2021². Proposed The Northern Road Upgrade is not directly connected with Park but through the existing The Northern Road

5.5 Travel times along The Northern Road

Assessment of travel times along The Northern Road between Mersey Road and Glenmore Parkway for morning (07:30 to 08:30) and evening (16:30 to 17:30) peak hours has been undertaken based on The Northern Road microsimulation traffic model.

Table 5-4 provides a comparison of modelled travel times along The Northern Road with and without the project. The modelled travel times indicate that the project would result in reduction of travel times in both directions along The Northern Road when comparing the project scenario with the Do Minimum scenario. In this section, northbound travel times are likely to remain similar to those without the project.

This is because the project would introduce delays at 5 new intersections, while the scenario 'without the project' would create delays further south through Luddenham..

Table 5-4 : Comparison of modelled travel times along The Northern Road for 'without project' and 'with project'

Segment	Direction	2021 (mm:ss)	2031 (mm:ss)
<i>Morning Peak</i>			
Between Mersey Road and Elizabeth Dr	NB ⁽¹⁾	07:41	>30:00
	NB ⁽²⁾	06:41	07:11
	SB ⁽¹⁾	07:31	26:55
	SB ⁽²⁾	06:03	06:59
Between Elizabeth Dr and Glenmore Parkway	NB ⁽¹⁾	07:35	08:36
	NB ⁽²⁾	05:36	06:40
	SB ⁽¹⁾	08:11	25:39
	SB ⁽²⁾	06:53	08:24
<i>Evening Peak</i>			
Between Mersey Road and Elizabeth Dr	NB ⁽¹⁾	09:30	>30:00
	NB ⁽²⁾	06:57	07:24
	SB ⁽¹⁾	07:55	>30:00
	SB ⁽²⁾	06:11	06:27
Between Elizabeth Dr and Glenmore Parkway	NB ⁽¹⁾	11:06	11:05
	NB ⁽²⁾	05:44	06:27
	SB ⁽¹⁾	11:58	>30:00
	SB ⁽²⁾	07:08	08:40

(1) Without the project

(2) With the project

5.6 Impacts on local roads and access

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

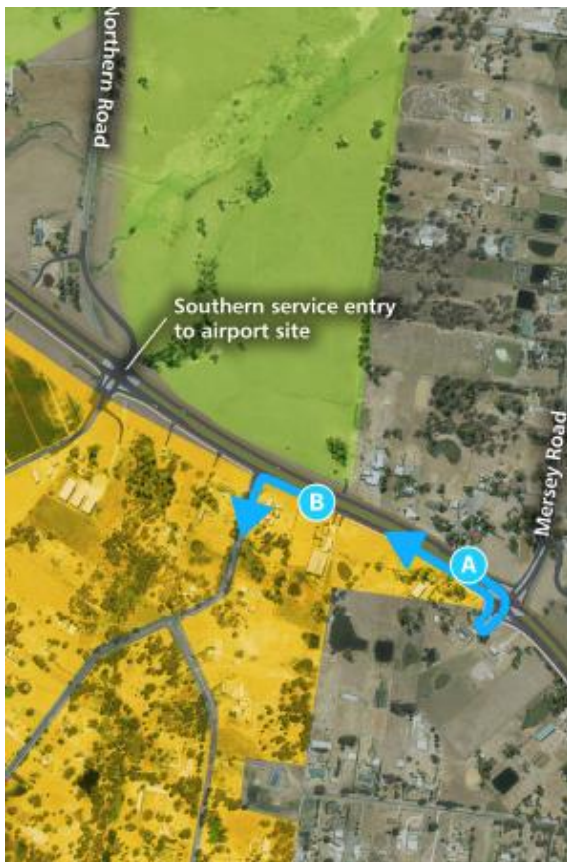
5.6.1 Mersey Road to the existing The Northern Road at the southern boundary of the Western Sydney Airport

Right turns across The Northern Road between Mersey Road and the existing The Northern Road at the southern boundary of the Western Sydney Airport access are currently permitted. Under the project, these turns would no longer be permitted as this section would become a divided carriageway with a median. This would affect the following existing movements:

- Right turn from The Northern Road (coming from the north) into properties to the west of The Northern Road: Maximum additional travel of 1.6 km (2:32 minutes)
- Right turn into The Northern Road (to travel south) from properties to the west of The Northern Road: Maximum additional travel of 1.6 km (2:32 minutes)
- Right turn from The Northern Road (coming from the south) into properties to the east of The Northern Road: Maximum additional travel of 1.7 km (2:37 minutes)
- Right turn into The Northern Road (to travel north) from properties to the east of The Northern Road: Maximum additional travel of 0.9 km (2:01 minutes).

Plots of each of the proposed alternative access routes to affected properties in this section are shown in **Figure 5-1**.

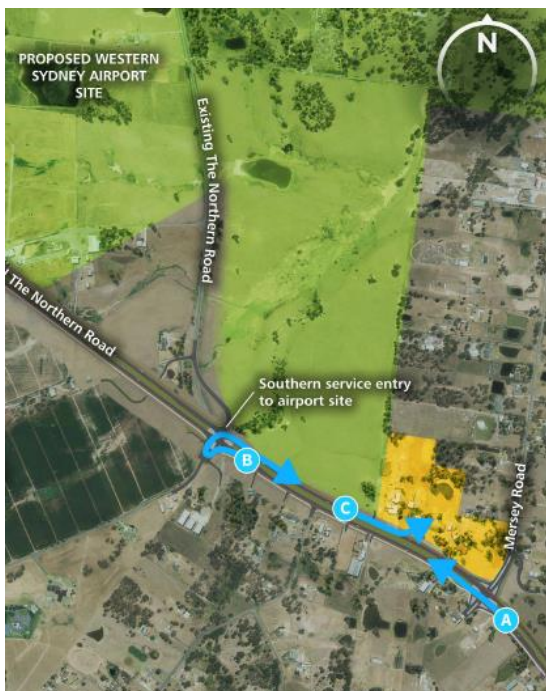
Figure 5-1 : Alternative access arrangements for properties between Mersey Road and Western Sydney Airport access



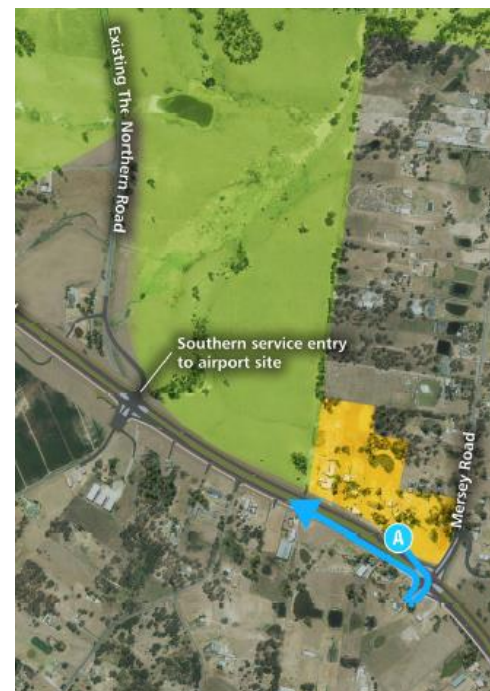
To western properties from the north



From western properties to the south



To eastern properties from the south



From eastern properties to the north

5.6.2 Existing The Northern Road at the southern boundary of the Western Sydney Airport to Luddenham southern access

Right turns across The Northern Road between the existing The Northern Road at the southern boundary of the Western Sydney Airport access and proposed southern access to Luddenham (existing alignment of The Northern Road) are currently permitted. Under the project, these turns would no longer be permitted as this section would become a divided carriageway with a median. This would affect the following existing movements:

- Right turn from The Northern Road (coming from the south) into properties to the east of The Northern Road: Maximum additional travel of 8.8 km (9:10 minutes)
- Right turn into The Northern Road (to travel north) from properties to the east of The Northern Road: Maximum additional travel of 5.8 km (5:40 minutes).

Plots of each of the proposed alternative access routes to affected properties in this section are shown in **Figure 5-2**.

Figure 5-2 : Alternative access arrangements for properties between Western Sydney Airport access and Luddenham southern access



To eastern properties from the south

From eastern properties to the north

5.6.3 Luddenham southern access to Eaton Road

Right turns across The Northern Road between the proposed southern access to Luddenham (existing alignment of The Northern Road) and Eaton Road are currently permitted. Under the project, these turns would no longer be permitted as this section would become a divided carriageway with a median; the existing right turn into and out of Eaton Road would also no longer be possible. This would affect the following existing movements:

- Right turn from The Northern Road (south) into properties to the east of The Northern Road: Maximum additional travel of 4.7 km (4:52 minutes)
- Right turn to The Northern Road (north) from properties to the east of The Northern Road: Maximum additional travel of 1.0 km (2:03 minutes).

Plots of each of the proposed alternative access routes to affected properties in this section are shown in **Figure 5-3**.

Figure 5-3 : Alternative access arrangements for properties between Luddenham Southern Access and Eaton Road



To eastern properties from the south

From eastern properties to the north

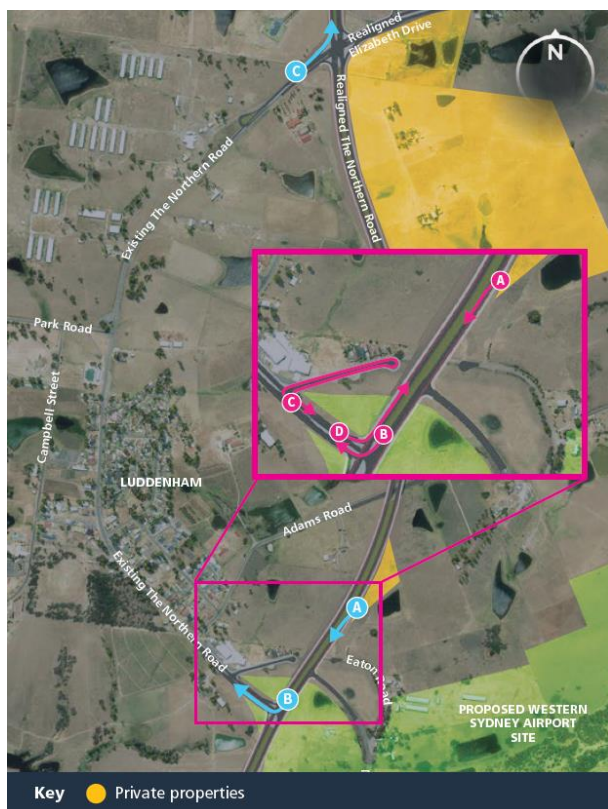
5.6.4 Eaton Road to Elizabeth Drive

Properties on the eastern side of the realigned The Northern Road between Elizabeth Drive and the proposed southern Luddenham access (existing The Northern Road alignment) would not be able to turn right onto or off The Northern Road as it would be an undivided carriageway with a median. This would affect the following movements:

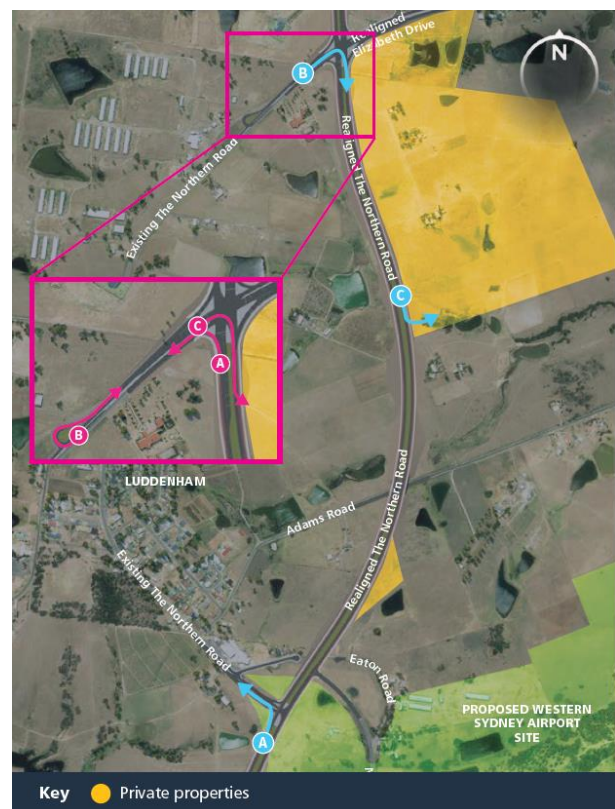
- Right turn into The Northern Road (to travel north) from properties to the east of The Northern Road: Maximum additional travel of 4.9 km (5:02 minutes)
- Right turn from The Northern Road (coming from the south) into properties to the east of The Northern Road: Maximum additional travel of 0.4 km (0:58 minutes).

Plots of each of the proposed alternative access routes to affected properties in this section are shown in **Figure 5-4**.

Figure 5-4 : Alternative access arrangements for properties between Luddenham Southern Access and Elizabeth Drive



From eastern properties to the north



To eastern properties from south

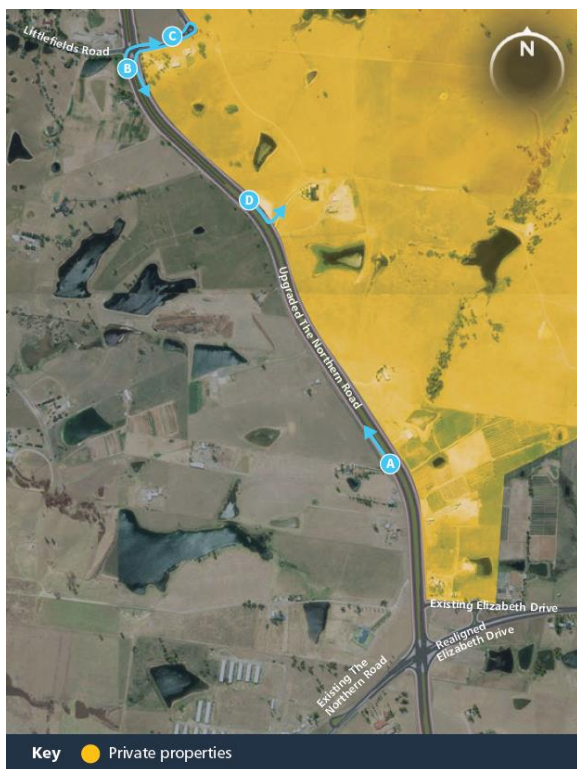
5.6.5 Elizabeth Drive to Littlefields Road

Right turns across The Northern Road between Elizabeth Drive and Littlefields Road are currently permitted. Under the project, these turns would no longer be permitted as this section would become a divided carriageway with a median. This would affect the following existing movements:

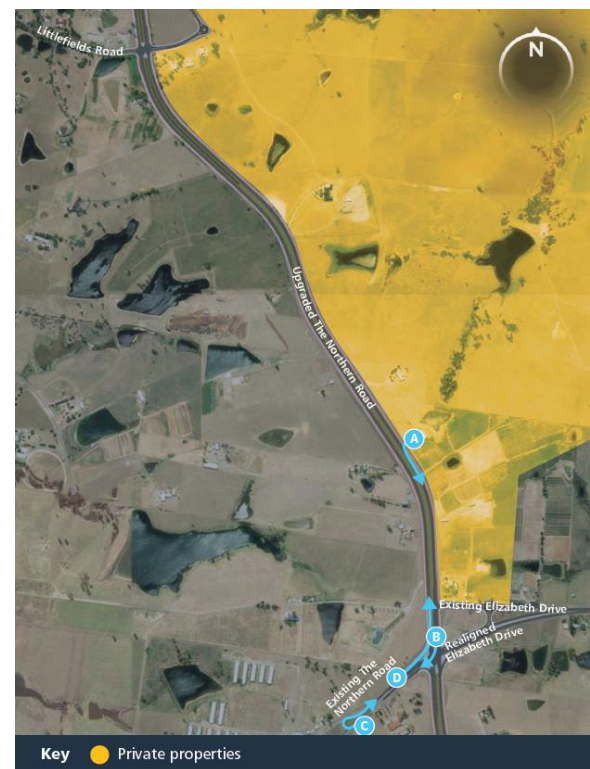
- Right turn from The Northern Road (south) into properties to the east of The Northern Road: Maximum additional travel of 4.4 km (4:39minutes)
- Right turn into The Northern Road (north) from properties to the east of The Northern Road: Maximum additional travel of 4.2 km (4:28minutes)
- Right turn from The Northern Road (north) into properties to the west of The Northern Road: Maximum additional travel of 4.8 km (4:54 minutes)
- Right turn into The Northern Road (south) from properties to the west of The Northern Road: Maximum additional travel of 4.9 km (5:02 minutes).

Plots of each of the proposed alternative access routes to affected properties in this section are shown in **Figure 5-5**.

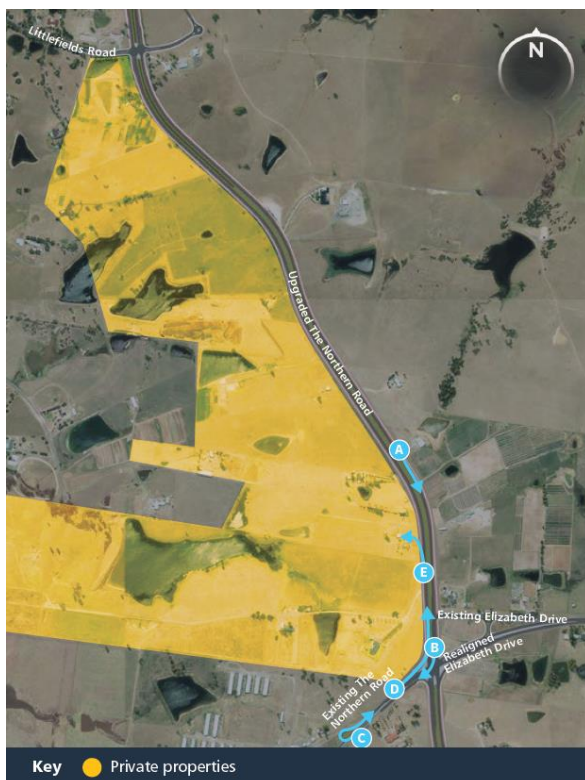
Figure 5-5 : Alternative access arrangements for properties between Elizabeth Drive and Littlefields Road



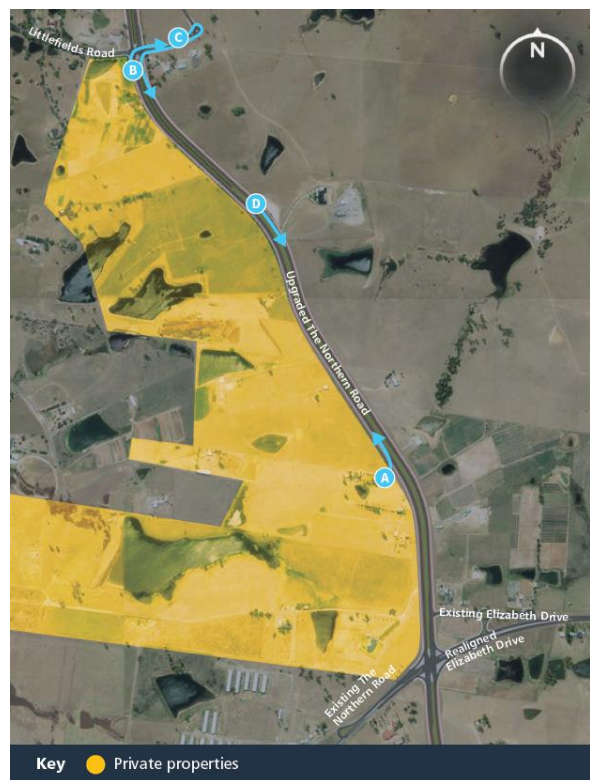
From eastern properties to the north



From eastern properties to the north



To western properties from the north



From western properties to the north

5.6.6 Existing Elizabeth Drive

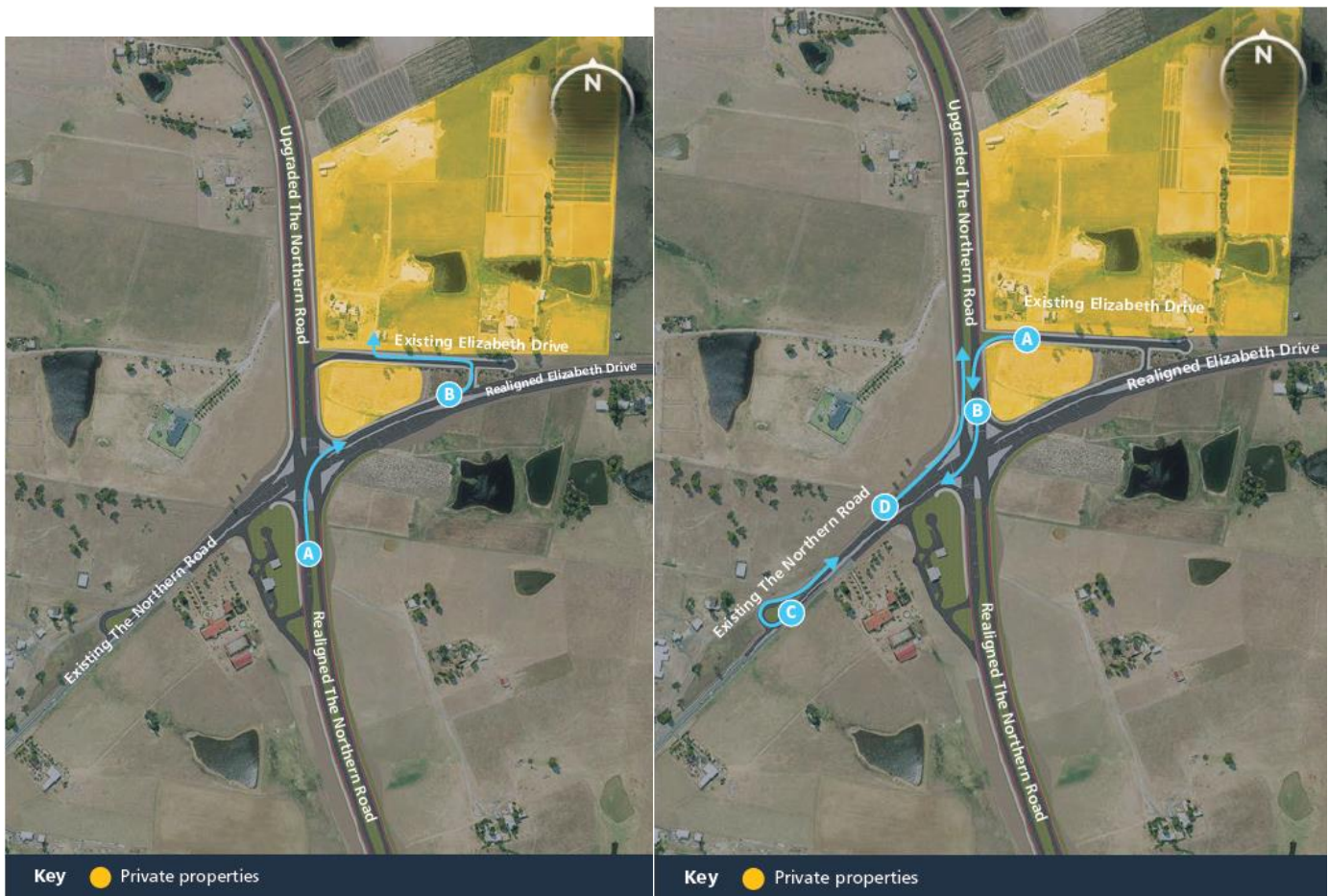
Elizabeth Drive would be realigned from around 400 metres east of its current connection with The Northern Road to form a new four-way signalised intersection with the existing The Northern Road and the realigned The Northern Road. The western 350 metres of the existing Elizabeth Drive would be retained as a local access road providing a connection to the two properties on the north-eastern corner of the Elizabeth Drive/The Northern Road intersection.

Right turns across this section of the existing Elizabeth Drive alignment are currently permitted. Under the project, these properties in this section would no longer have direct access to Elizabeth Drive. This would affect the following existing movements:

- Right turn from The Northern Road (coming from the south) into properties to the east of The Northern Road: Maximum additional travel of 1.2 km (2:14 minutes)
- Right turn into The Northern Road (to travel north) from properties to the east of The Northern Road: Maximum additional travel of 1.5 km (2:29 minutes).

Plots of each of the proposed alternative access routes to affected properties in this section are shown in **Figure 5-6**.

Figure 5-6 : Alternative access arrangements for properties along existing Elizabeth Drive alignment



To eastern properties from the south

From eastern properties to the north

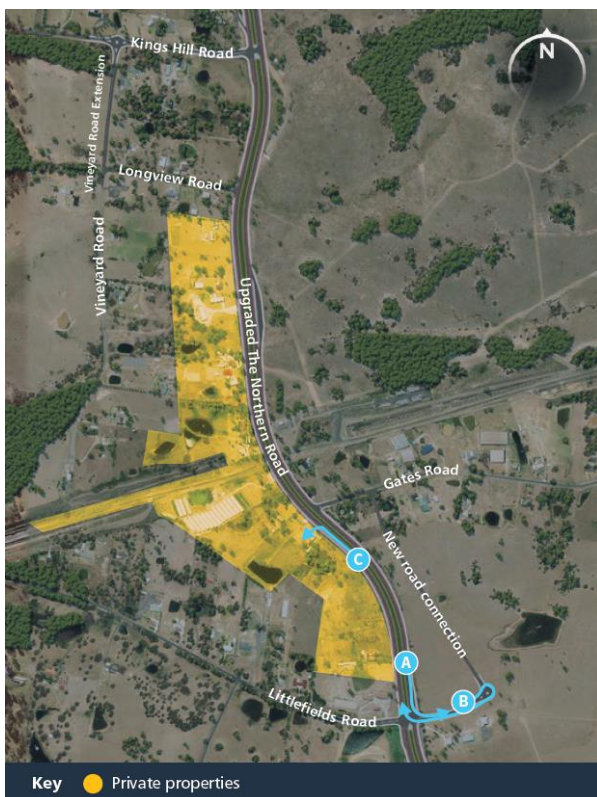
5.6.7 Littlefields Road to Longview Road

Right turns across The Northern Road between Littlefields Road and Longview Road are currently permitted. Under the project, these turns would no longer be permitted as this section would become a divided carriageway with a median; the existing right turn into and out of Gates Road would also no longer be possible. This would affect the following existing movements:

- Right turn from The Northern Road (north) into properties to the west of The Northern Road: Maximum additional travel of 3.4 km (3:12 minutes)
- Right turn into The Northern Road (south) from properties to the west of The Northern Road: Maximum additional travel of 4.3 km (3:54 minutes)
- Right turn from The Northern Road (south) into properties to the east of The Northern Road: Maximum additional travel of 3.0 km (2:54 minutes)
- Right turn into The Northern Road (north) from properties to the east of The Northern Road: Maximum additional travel of 2.3 km (2:24 minutes)
- Right turn into Gates Road from The Northern Road (south): Maximum additional travel of 0.29 km (0:54 minutes)
- Right turn out of Gates Road to The Northern Road (north): Maximum additional travel of 1.7 km (1:54 minutes).

Plots of each of the proposed alternative access routes to affected properties in this section are shown in **Figure 5-7**.

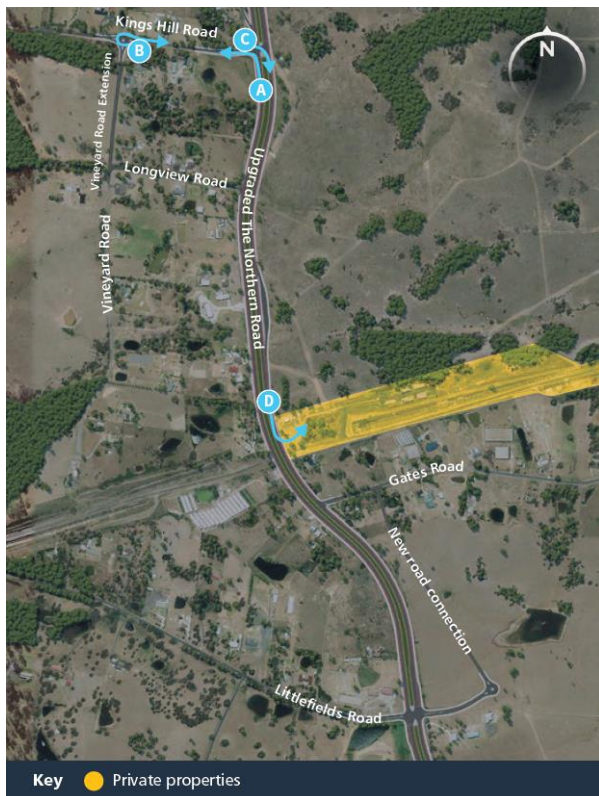
Figure 5-7 : Alternative access arrangements for properties between Littlefields Road and Longview Road



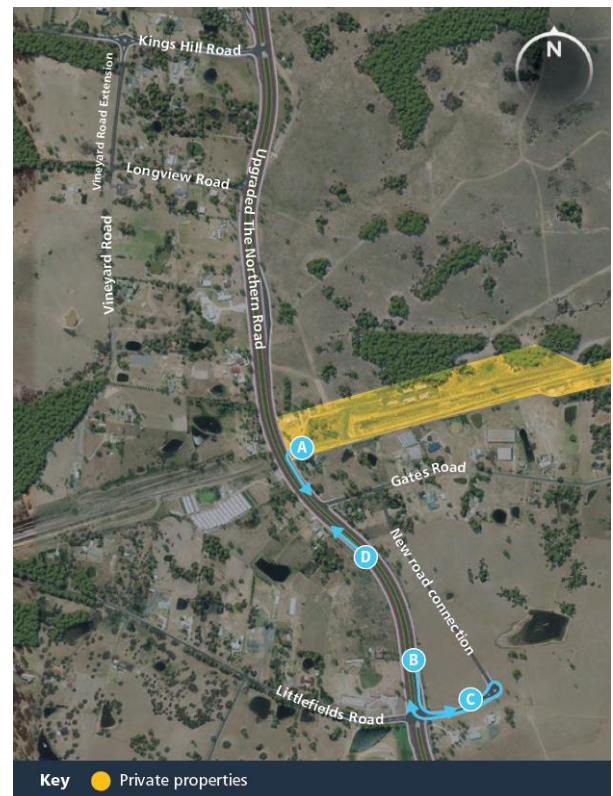
To western properties from the north



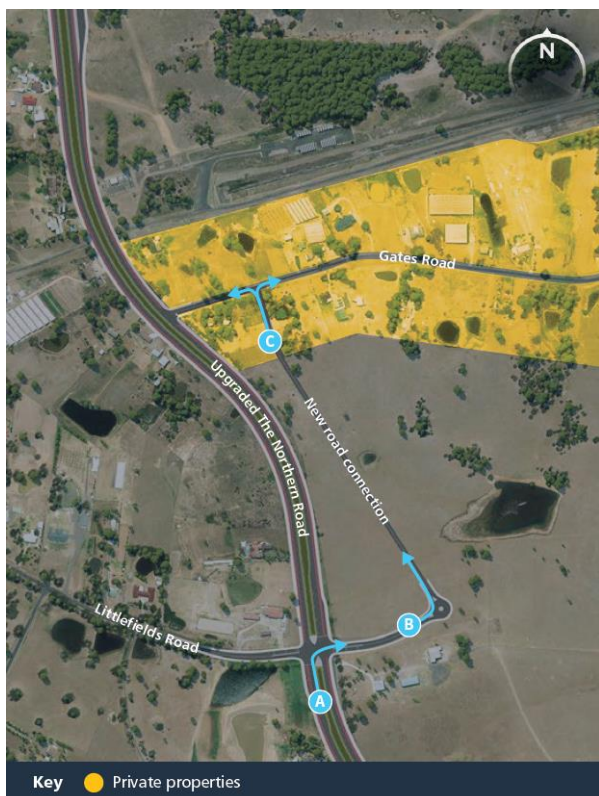
From western properties to the south



To eastern properties from the south



From eastern properties to the north



To Gates Road from the south



From Gates Road to the north

5.6.8 Longview Road to Kings Hill Road

Right turns across The Northern Road between Longview Road and King Hill Road are currently permitted. Under the project, these turns would no longer be permitted as this section would become a divided carriageway with a median; the existing right turn into and out of Longview Road would also no longer be possible. This would affect the following existing movements:

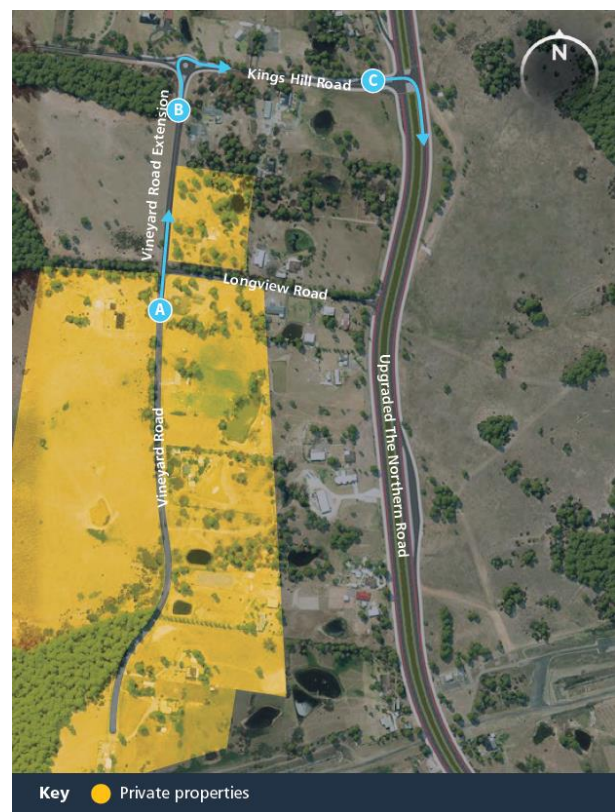
- Right turn from The Northern Road (north) into properties to the west of The Northern Road and properties along the existing Vineyard Road: Maximum additional travel of 1.2 km (1:36 minutes)
- Right turn into The Northern Road (north) from properties to the west of The Northern Road and properties along the existing Vineyard Road: Maximum additional travel of 0.9 km (1:18 minutes).

Plots of each of the proposed alternative access routes to affected properties in this section are shown in **Figure 5-8**.

Figure 5-8 : Alternative access arrangements for properties between Longview Road and Kings Hill Road



To western properties from the north



From western properties to the south

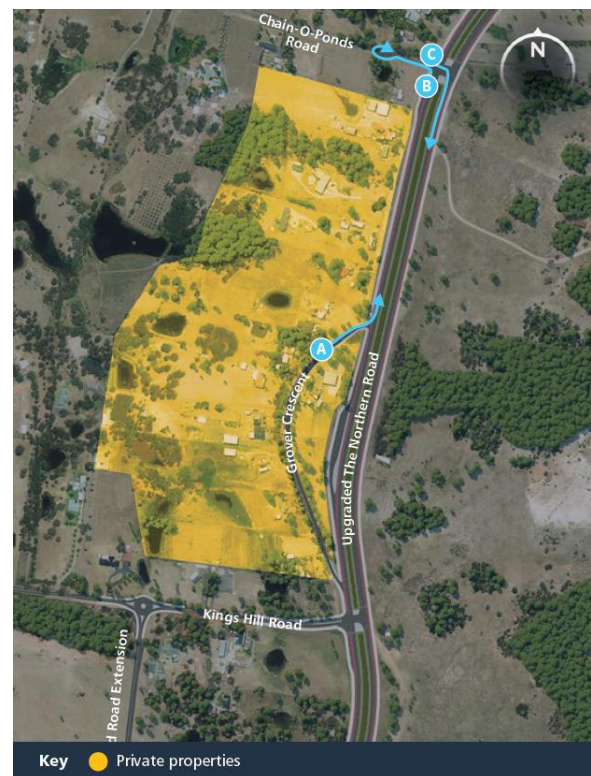
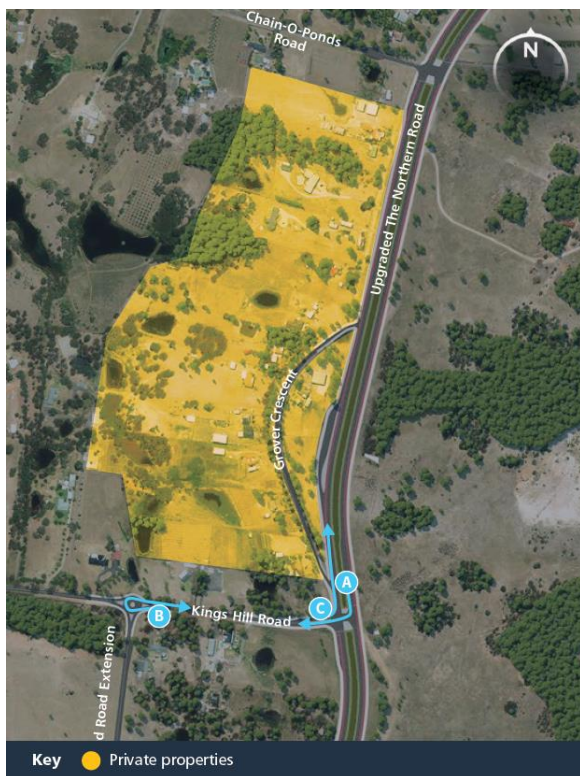
5.6.9 Kings Hill Road to Chain-O-Ponds Road

Right turns across The Northern Road between Kings Hill Road and Chain-O-Ponds Road are currently permitted. Under the project, these turns would no longer be permitted as this section would become a divided carriageway with a median; the existing right turn into and out of Grover Crescent would also no longer be possible. This would affect the following existing movements:

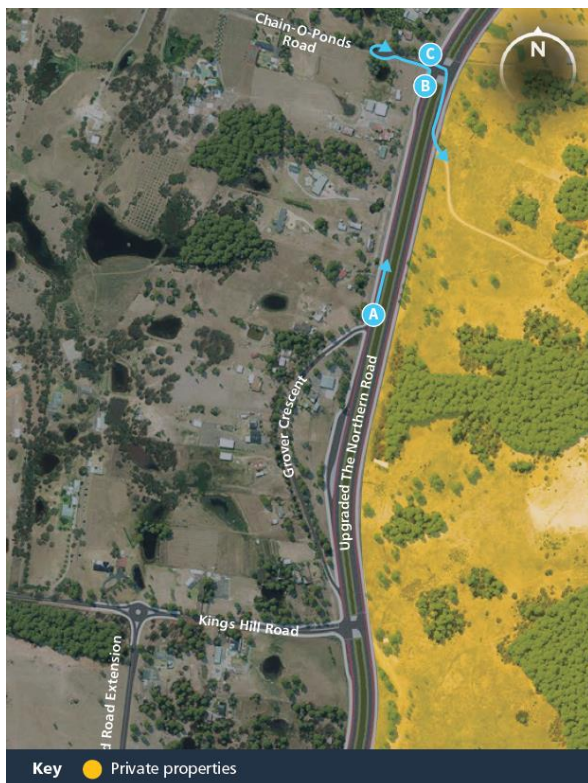
- Right turn from The Northern Road (coming from the north) into properties to the west of The Northern Road: Maximum additional travel of 2.5 km (3:12 minutes)
- Right turn into The Northern Road (to travel south) from properties to the west of The Northern Road: Maximum additional travel of 1.7 km (2:37 minutes)
- Right turn from The Northern Road (coming from the south) into properties to the east of The Northern Road: Maximum additional travel of 1.0 km (2:05 minutes)
- Right turn into The Northern Road (to travel north) from properties to the east of The Northern Road: Maximum additional travel of 2.5 km (3:12 minutes).

Plots of each of the proposed alternative access routes to affected properties in this section are shown in **Figure 5-9**.

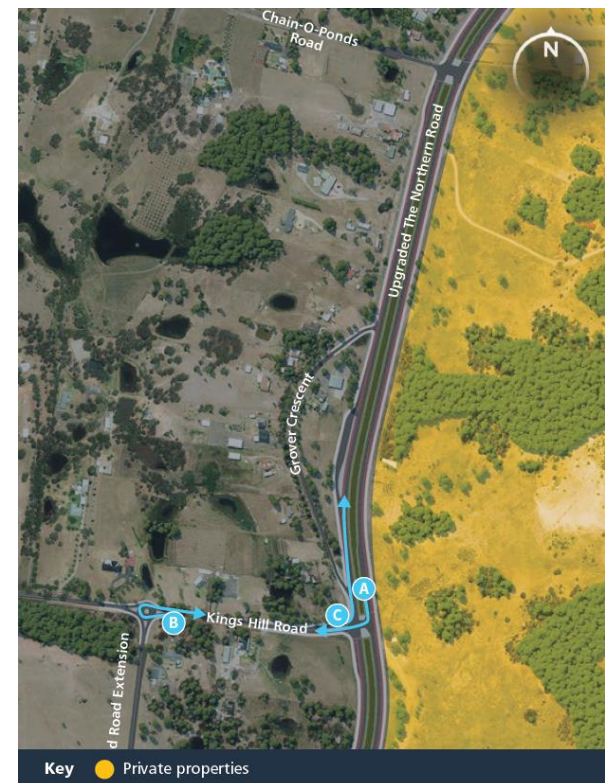
Figure 5-9 : Alternative access arrangements for properties between Kings Hill Road and Chain-O-Ponds Road



To western properties from the north



From western properties to the south



To eastern properties from the south

From eastern properties to the north

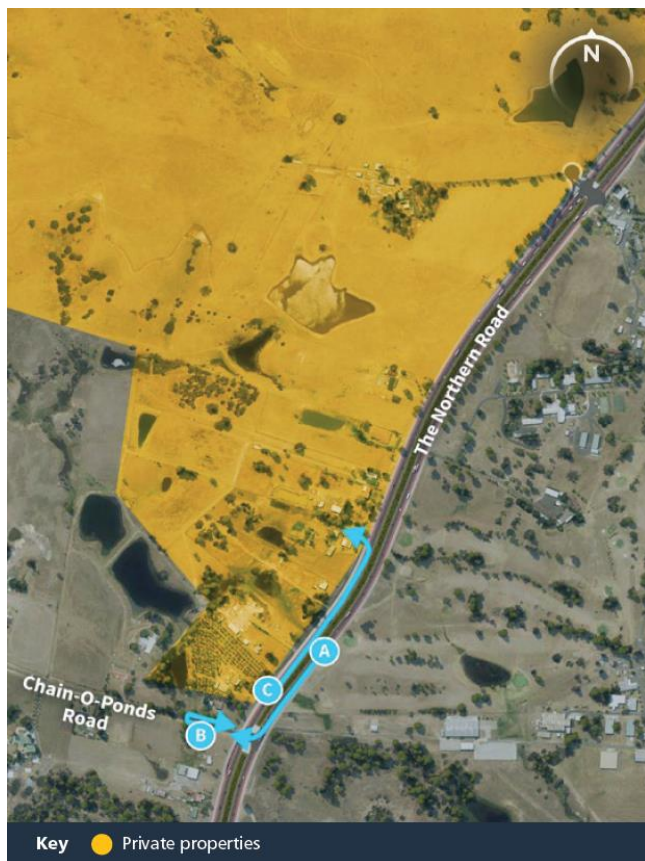
5.6.10 Chain-O-Ponds Road to Defence Establishment Orchard Hills

Right turns across The Northern Road between Chain-O-Ponds Road and Defence Establishment Orchard Hills are currently permitted. Under the project, these turns would no longer be permitted as this section would become a divided carriageway with a median. This would affect the following existing movements:

- Right turn from The Northern Road (north) into properties to the west of The Northern Road: Maximum additional travel of 2.1 km (2:12 minutes)
- Right turn to The Northern Road (south) from properties to the west of The Northern Road: Maximum additional travel of 2.1 km (2:12 minutes).

Plots of each of the proposed alternative access routes to affected properties in this section are shown in **Figure 5-10**.

Figure 5-10 : Alternative access arrangements for properties between Chain-O-Ponds Road and Defence Establishment Orchard Hills



To western properties from the north



From western properties to the south

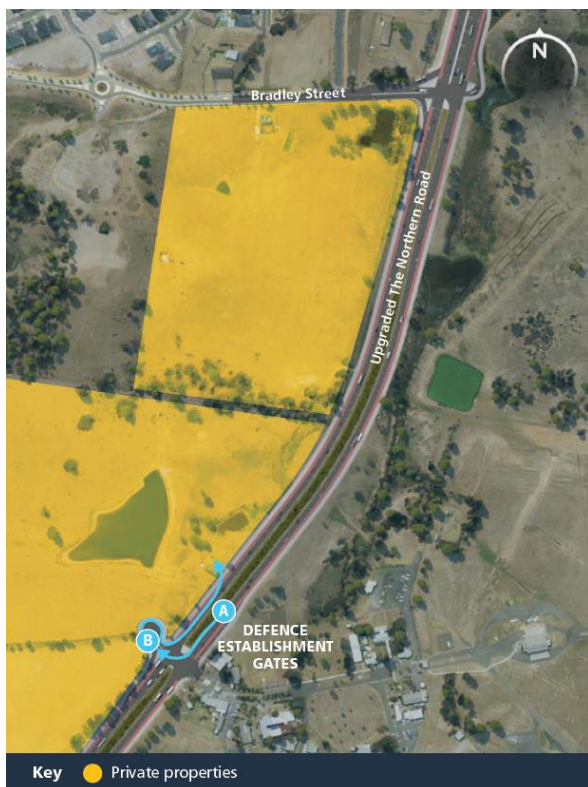
5.6.11 Defence Establishment Orchard Hills to Bradley Street

Right turns across The Northern Road between Defence Establishment Orchard Hills and Bradley Street are currently permitted. Under the project, these turns would no longer be permitted as this section would become a divided carriageway with a median; the right turn into and out of Defence Establishment Orchard Hills would be retained at a new signalised intersection. This would affect the following existing movements:

- Right turn from The Northern Road (north) into properties to the west of The Northern Road: Maximum additional travel of 1.1 km (1:30 minutes)
- Right turn to The Northern Road (south) from properties to the west of The Northern Road: Maximum additional travel of 1.6 km (1:54 minutes)
- Right turn into Defence Establishment Orchard Hills from the Northern Road (south): No additional travel distance but possible increase in traffic signal delay of 0:42 minutes
- Right turn out of Defence Establishment Orchard Hills to the Northern Road (north): No additional travel distance but possible increase in traffic signal delay of 0:42 minutes.

Plots of each of the proposed alternative access routes to affected properties in this section are shown in **Figure 5-11**.

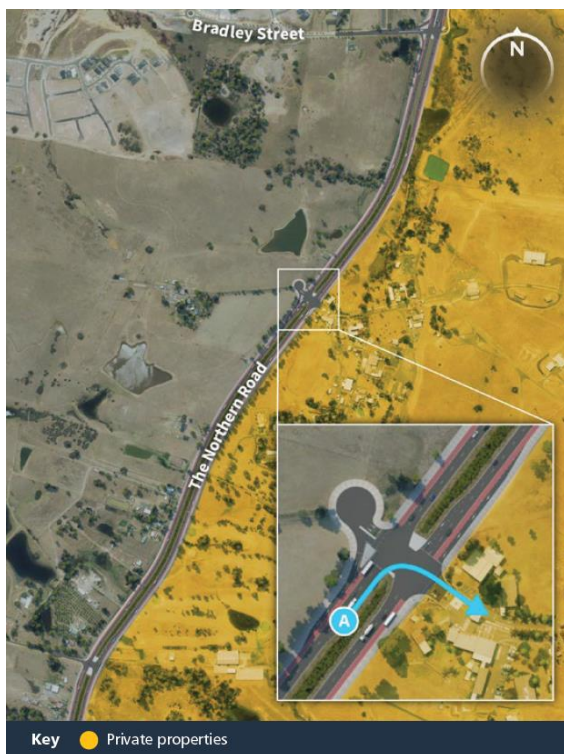
Figure 5-11 : Alternative access arrangements for properties between Defence Establishment Orchard Hills and Bradley Street



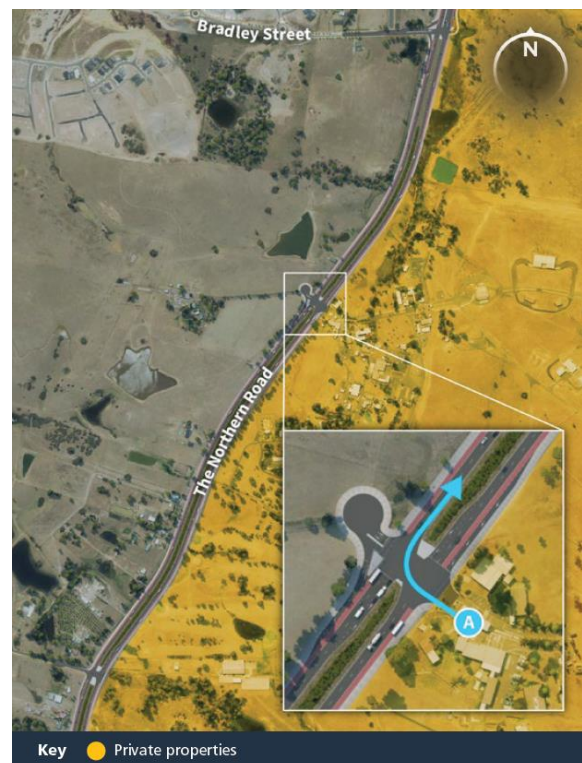
To western properties from the north



From western properties to the south



To Defence Establishment Orchard Hills from the south



From Defence Establishment Orchard Hills to the north

5.6.12 Bradley Street to Glenmore Parkway

Right turns across The Northern Road between Bradley Street and Glenmore Parkway are currently permitted. Under the project, these turns would no longer be permitted as this section would become a divided carriageway with a median. This would affect the following existing movements:

- Right turn from The Northern Road (north) into properties to the west of The Northern Road: Maximum additional travel of 2.4 km (2:30 minutes)
- Right turn to The Northern Road (south) from properties to the west of The Northern Road: Maximum additional travel of 3.2 km (3:06 minutes)
- Right turn from The Northern Road (south) into properties to the east of The Northern Road: Maximum additional travel of 1.3 km (1:36 minutes)
- Right turn into The Northern Road (north) from properties to the east of The Northern Road: Maximum additional travel of 2.2 km (2:18 minutes).

Plots of each of the proposed alternative access routes to affected properties in this section are shown in **Figure 5-12**.

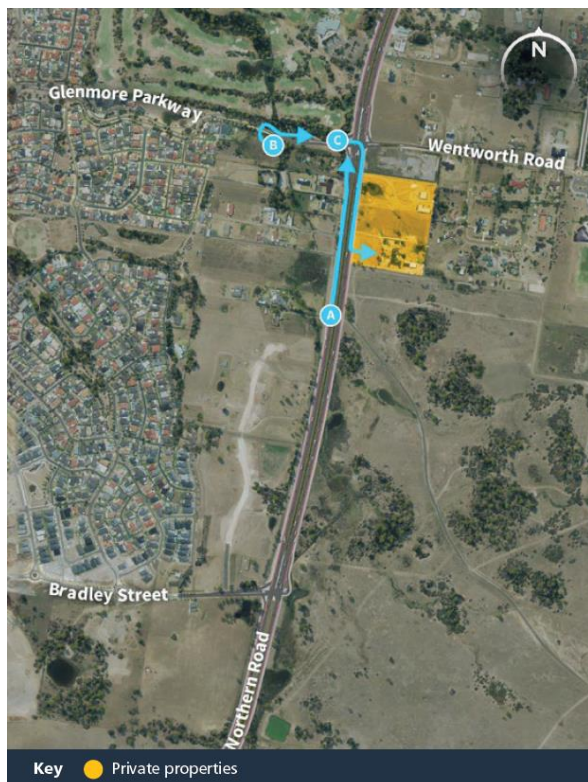
Figure 5-12 : Alternative access arrangements for properties between Bradley Street and Glenmore Parkway



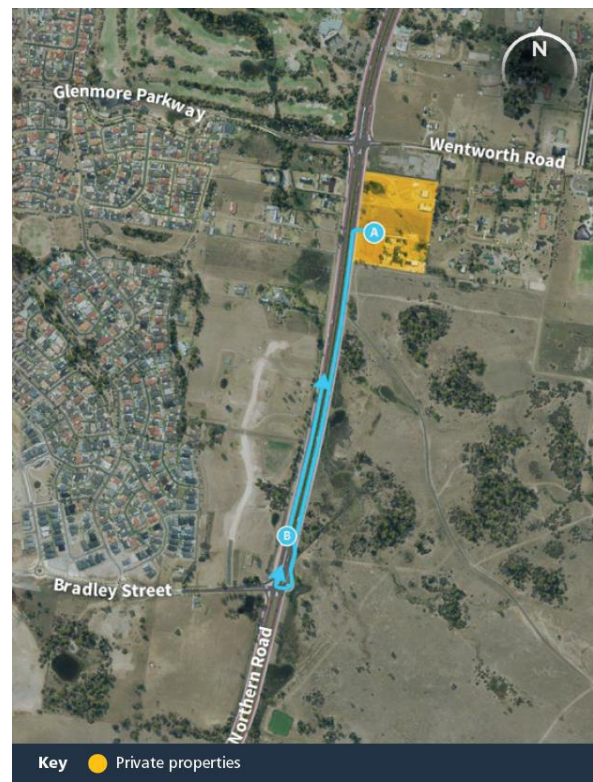
To western properties from the north



From western properties to the south



To eastern properties from the south



From eastern properties to the north

5.7 Impacts on public transport

The project includes the provision of a dedicated kerbside bus lane in each direction between Mersey Road and Glenmore Parkway. This bus lane would allow buses to travel north and south along The Northern Road without being affected by general traffic congestion and delays. The impacts of the project on the existing 789 bus route would be minimal as this bus would travel in its own lane for the length of the route within the study area. The signalisation of intersections on The Northern Road between Elizabeth Drive and Glenmore Parkway may add up to two minutes of delay to this route, however this is well within the variability of long cross-regional bus route.

These bus lanes would support the operation of a high-frequency, 'rapid' tier bus service between Liverpool and Penrith via the 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 priority provided by the project, rationalisation and relocation of existing bus stops will be undertaken. In general, existing bus stops will be relocated from mid-block locations to intersections to increase accessibility to bus stops for passengers on roads adjacent to The Northern Road and ensure that access to these stops is consistent for both northbound and southbound buses. These intersection stops will be located on the exit side of the intersection for the purposes of minimising the impacts of these stops on operation of the traffic signals. The following bus stops will be relocated or removed as a part of the project:

- Southbound stop located at The Northern Road north of Elizabeth Drive (stop ID: 2745120) to be retained
- Northbound stop located at The Northern Road north of Elizabeth Drive (stop ID: 2745123) to be retained
- Southbound stop located at 2787 The Northern Road (stop ID: 2745119) relocated to Littlefields Road
- Northbound stop located at 2787 The Northern Road (stop ID: 2745124) Relocated to Littlefields Road
- Southbound stop located at The Northern Road north of Gates Road (stop ID: 2745118) to be removed. Adjacent stops at Littlefields Road and Kings Hill Road
- Southbound stop located at The Northern Road south of Longview Rd (stop ID: 274818) to be relocated to Kings Hill Road
- Northbound stop located at The Northern Road north of Longview Rd (stop ID: 2745125) to be relocated to Kings Hill Road
- Northbound stop located at The Northern Road south of Chain-O-Ponds Road (stop ID: 2745126) to be relocated to the departure side of the intersection
- Southbound stop located at The Northern Road north of Chain-O-Ponds Road (stop ID: 274817) to be relocated to the departure side of the intersection
- Southbound stop located at the Defence Establishment at Orchard Hills (stop ID: 274816) to be relocated to the departure side of the intersection
- Northbound stop located at the Defence Establishment at Orchard Hills (stop ID: 2745127) to be relocated to the departure side of the intersection
- Southbound stop located at Truck Stop on The Northern Road (stop ID: 274815) to be relocated to Glenmore Parkway
- Northbound stop located at The Northern Road (stop ID: 2745128) to be relocated to Glenmore Parkway.

The following new bus stops will be provided as part of the project:

- Southbound stop located on The Northern Road south of Bradley Street
- Northbound stop located at The Northern Road north of Bradley Street.

Although the majority of relocated bus stops would only be moved from the entry side to the exit side of an intersection, bus stops between Kings Hill Road and Littlefields Road would be relocated a substantial distance from existing stops. The maximum additional distance passengers would need to travel as a result of relocated bus stops would be for the bus stop located at Gates Road, where passengers would need to travel up to an additional 650m to reach the relocated bus stop at Littlefields Road.

Impacts of construction on public transport operations are detailed in Section 5.12.6.

A map of the proposed new and relocated bus stops within the project is provided in **Figure 3-4**.

5.8 Impacts on freight transport and aviation

The project would improve reliability and travel times for freight traffic currently travelling on The Northern Road by providing additional traffic capacity and relieving existing traffic constraints, particularly at existing priority and roundabout intersections along The Northern Road. The project would also reduce travel time and improve reliability for freight travelling to the Sydney Motorway network via the M4 Western Motorway and providing an alternative route for freight traffic travelling to and from the Western Sydney Airport.

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

Design of the project has been undertaken based on requirements to conform to restrictions associated with height and visibility when in close proximity to the Western Sydney Airport. Furthermore, the design accounts for an access to the Western Sydney Airport and consequently there is unlikely to be any impact of the project on associated aviation activities.

5.9 Impacts on active transport

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

- A shared path along the western side of The Northern Road between Mersey Road and Glenmore Parkway
- A 5 m wide footway would be provided on the eastern side of The Northern Road between Mersey Road and Glenmore Parkway, with a 1.5m wide footpath provided as warranted such as between bus stops and adjacent intersections
- New signalised pedestrian crossings at all upgraded intersections where traffic lights are to be provided.

The project would facilitate the following cyclist and pedestrian routes:

- The Northern Road between Mersey Road and Glenmore Parkway.

The project would facilitate cycle and pedestrian connectivity of the local community with the following community uses and facilities:

- Glenmore Park residential area
- Orchard Hills golf course
- Luddenham town centre including Holy Family Catholic Primary School and Luddenham Public School.

The shared path along the length of the project would also provide opportunities for future connection to the following pedestrian and cycle networks:

- Shared path facilities that may be included as part of the M12 Motorway
- Pedestrian and cycle access to the Western Sydney Airport.

The relocation of bus stops will mean that some pedestrians will need to walk further to access bus stops, however the majority of stops are being relocated from mid-block locations to the exit sides of intersections. For most residents along The Northern Road, as well as those on local streets adjacent to The Northern Road, this will reduce the walking distance to stops and make them more convenient to access.

Overall, the project would improve the accessibility and safety for pedestrians and cyclists along The Northern Road by providing dedicated facilities for cyclists and pedestrians that are separated from traffic thus reducing the risk of conflicts with cars. Formal crossings would also be provided at all signalised intersections which would improve safety for pedestrians and cyclists to cross roads that would otherwise be uncontrolled. Impacts of construction on active transport operations are detailed in **Section 5.12.7**.

5.10 Impacts on parking

As parking is not currently permitted along the length of The Northern Road between Mersey Road and Glenmore Parkway, the project would have a minimal impact on parking. Realignment of The Northern Road around Luddenham town centre may introduce opportunities for on-street parking along the existing The Northern Road alignment.

5.11 Impacts on road safety

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

- The Northern Road would be upgraded with additional lanes and a divided carriageway, removing the need for opposing-lane overtaking and the associated risk of head-on crashes
- Reduced congestion at intersections, which would reduce the likelihood of vehicle crashes at intersections, especially rear-end type crashes
- The new alignment of The Northern Road would be designed to a higher design speed allowing for safer travel along the corridor with intersection designs accommodating B-Double trucks
- Many existing priority-controlled intersections would be upgraded to signal control. This would provide more formal opportunities for making right hand turns onto and off The Northern Road. Other uncontrolled right hand turns would be removed, reducing conflicts along The Northern Road
- Formal pedestrian crossings would be provided at all signalised intersections and a wide off-road shared path would be provided along the length of the project. This would reduce conflicts between pedestrians, cyclists and cars
- Realignment of The Northern Road around Luddenham town centre would reduce the volumes of cars and trucks travelling through this area and reduce conflicts with local traffic and pedestrians in this higher pedestrian activity area
- New heavy vehicle inspection areas would be constructed as part of the project at Grover Crescent and south of Longview Road. These stations would increase safety of heavy vehicle operations along The Northern Road by ensuring that heavy vehicles would not be registered without passing safety inspections.

5.12 Impacts of construction

A detailed construction traffic impact assessment has not been undertaken because details related to the construction activities and sequence of work are not currently known. A more detailed construction traffic impact assessment would be required once a detailed construction plan has been developed. For the

purpose of this assessment, construction of the project is assumed to take place over three stages, covering the following sections of road upgrade:

- Mersey Road, Bringelly to Eaton Road, Luddenham
- Eaton Road, Luddenham, to Littlefields Road, Luddenham
- Littlefields Road, Luddenham to Glenmore Parkway, Glenmore Park.

It is expected that the project would be built between 2017 and 2020, subject to funding and planning approval. The majority of the work would take place during the 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
- Saturday 8am to 1pm
- Sundays and public holidays: no work.

Table 5-1 outlines the indicative construction timeframe for the various construction stages of the project. The construction workforce is expected to fluctuate, depending on the type of construction and the overlap of project construction staging. Construction phase timing would be confirmed once a construction contractor is appointed to the project, however it is expected that the indicative durations of construction activities outlined in Table 5-1 would apply to the project.

Table 5-1 Indicative construction activity timing

Construction activity	Duration of activity	Work outside standard hours Yes/No	Haulage % at night
Early works	2 months	Y	5 nights
Earthworks	18 months	N	N/A
Road work (widening and new roads) and intersection work	4 months	Y	20 nights
Construction of bridge over Adam Road	N/A	N/A	N/A
Drainage work	12 months	Y	15 nights
Pavements	15 months	Y	30 nights
Utility relocation	9 months	Y	5 nights
Finishing work	6 months	Y	15 nights

There may be the need to work outside of these hours to minimise traffic disruptions and to ensure the safety of both the travelling public and road workers. Potential locations in the study area that could be subject to work outside standard construction hours would include:

- Installation of traffic controls, such as concrete barriers
- Some bridge and underpass works, including piling, installing structures such as girders, concrete decking and drainage
- Re-surfacing of the existing asphalt pavement
- Removal of existing static signage and installation of new signs
- Removal of existing traffic barriers and installation of temporary and permanent traffic barriers
- Removal of existing lane marking and application of new lane marking

- Delivery of plant and materials outside standard hours where required for safety reasons and/or as requested by police or other authorities
- Installation of lighting and CCTV
- Other works that do not cause noise emissions to be audible at any sensitive receptor
- Emergency work to avoid the loss of lives, property and/or to prevent environmental harm.

This work would ensure that there would be minimal disruption to road users, including businesses and landowners in the study area. All out-of-hours works would be undertaken in accordance with the relevant out-of-hours works procedures developed for the project as part of the Construction Environmental management Plan (CEMP).

Potential impacts related to construction traffic are discussed in the following section.

5.12.1 Construction compounds and heavy vehicle routes

A map showing the locations of the proposed construction compounds is shown in **Figure 5-13**. The final type, location and number of ancillary facilities would be determined by the construction contractor and identified in an ancillary facilities management plan, prepared as part of the CEMP. The potential use of each compound along with proposed access points for each compound are described in Table 5-2.

Table 5-2 Proposed construction ancillary facility areas

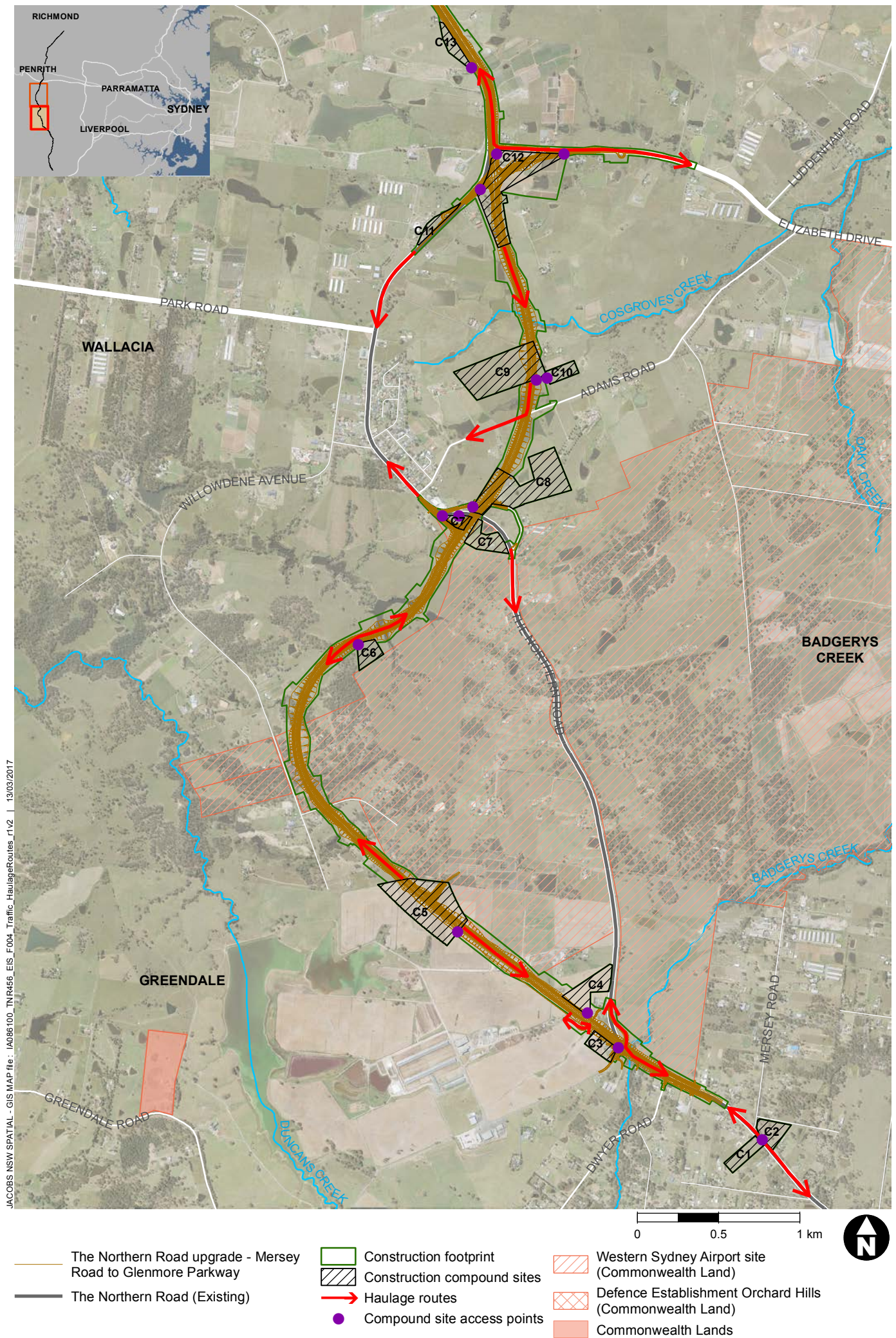
Ancillary facility location	Proposed ancillary facility use	Site access points
C1	Storage facility to be used for pits, pipes and culvert material. No stockpiling of earthworks.	From The Northern Road.
C2	Storage facility to be used for pits, pipes and culvert material. No stockpiling of earthworks.	From The Northern Road.
C3	Outpost site office (secondary compound). The site would consist of a shed, lunch room, portable toilets and parking facilities. The size and number of office facilities at the secondary site compound would be less than the main site compound.	External access to compound via the entry road to the Leppington Pastoral Company dairy farm. Access to construction of mainline would be direct from the compound. Unsignalised entry to all movements.
C4	Outpost site office (secondary compound) and storage of storage of say concrete pits, pipes and culverts. Could be used to stockpile topsoil and mulch and drainage backfill materials. The secondary site compound would consist of a shed, lunch room, portable toilets and parking facilities. The size and number of office facilities at the secondary site compounds would be less than the main site compound. It would also be a storage area for concrete pits, pipes and culverts, stockpile topsoil and mulch and drainage backfill materials.	External access to compound via the entry road to the Leppington Pastoral Company dairy farm. Access to construction of mainline would be direct from the compound. Unsignalised entry to all movements.

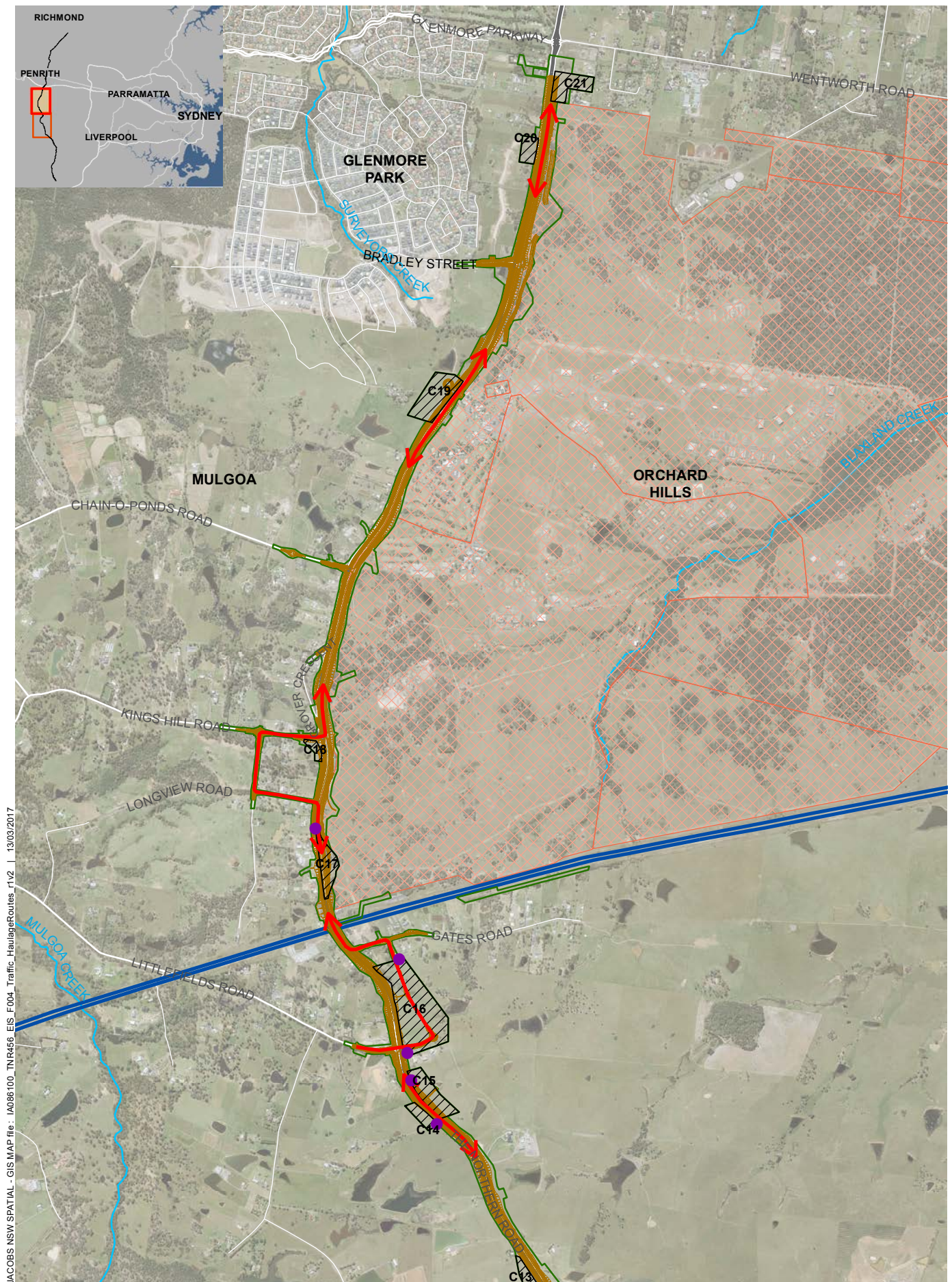
Ancillary facility location	Proposed ancillary facility use	Site access points
C5	Storage of concrete pits, pipes and culverts. Could be used to stockpile topsoil and mulch and drainage backfill materials. Possible pug mill site.	Access to construction of mainline would be direct from the compound. Access to existing arterial road network to be via the nearest access point to The Northern Road.
C6	Storage of concrete pits, pipes and culverts. Could be used to stockpile topsoil and mulch and drainage backfill materials.	Access to construction of mainline would be direct from the compound. Access to existing arterial road network to be via the nearest access point to The Northern Road.
C7	Storage of concrete pits, pipes and culverts. Could be used to stockpile topsoil and mulch and drainage backfill materials.	From The Northern Road and using Eaton Road.
C8	Main compound site. The site would consist of office facilities for the contractor and RMS including toilets, amenities, carpark, shed and lunch room. Storage area for concrete pits, pipes and culverts. Stockpile topsoil and mulch and drainage backfill materials. Possible pug mill site.	Temporary traffic signals at the intersection of the existing The Northern road and the proposed new alignment to give access to and from the existing road and access to the main admin site compound.
C9	A secondary site compound. The secondary site compound would consist of a shed, lunch room, portable toilets and parking facilities. The size and number of office facilities at the secondary site compounds would be less than the main site compound.	Accessed via a haul road off Adams Road. However, C9 and C10 will also be accessed from the new alignment of The Northern Road once the Cosgrove Creek crossing is completed.
C10	Storage of concrete pits, pipes and culverts. Could be used to stockpile topsoil, mulch and drainage backfill materials.	Accessed via a haul road off Adams Road. However, C9 and C10 will also be accessed from the new alignment of The Northern Road once the Cosgrove Creek crossing is completed.
C11	Storage of concrete pits, pipes and culverts. Could be used to stockpile topsoil, mulch and drainage backfill materials.	From The Northern Road
C12	Main compound site. The site will consist of office facilities for the contractor and RMS, toilets, amenities, tool sheds and carpark.	From The Northern Road and Elizabeth Drive
C13	Storage of concrete pits, pipes and culverts. Could be used to stockpile topsoil, mulch and drainage backfill materials.	From The Northern Road
C14	Alternate site compound or small site office shed with amenities and car park and storage of concrete pits, pipes and culverts. Could be used to stockpile topsoil, mulch and drainage backfill materials.	From The Northern Road

Ancillary facility location	Proposed ancillary facility use	Site access points
C15	Storage of concrete pits, pipes and culverts. Could be used to stockpile topsoil, mulch and drainage backfill materials.	From The Northern Road
C16	Storage of concrete pits, pipes and culverts. Could be used to stockpile topsoil, mulch and drainage backfill materials.	From The Northern Road
C17	Stockpile site early in construction, however, once the new southbound carriageway is completed, it is unlikely to be used further a stockpile site.	From The Northern Road
C18	Storage of concrete pits, pipes and culverts. Could be used to stockpile topsoil, mulch and drainage backfill materials.	From The Northern Road and Kings Hill Road
C19	Storage of concrete pits, pipes and culverts. Could be used to stockpile topsoil, mulch and drainage backfill materials.	From The Northern Road
C20	Main compound site. The site will consist of office facilities for the contractor and RMS, toilets, amenities, tool sheds and carpark.	From The Northern Road
C21	Storage of concrete pits, pipes and culverts. Could be used to stockpile topsoil, mulch and drainage backfill materials.	From The Northern Road

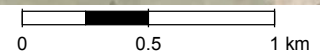
Any additional or alternative sites identified by the construction contractor would be considered against the site selection criteria identified below. Where any alternative sites are located outside the construction footprint, further environmental assessment would be required.. The majority of compounds would be accessed directly from the existing The Northern Road, with the exception of compounds located on greenfield sites adjacent to the proposed new sections of road to be constructed, which would be accessed through these worksites as the project is built.

Access to and from these compounds to the motorway network would be via The Northern Road and the M4 Western Motorway, as well as via Elizabeth Drive and the M7 Motorway. A plot of proposed heavy vehicles routes is also shown on **Figure 5-13**. Heavy vehicles would be restricted to travel along these routes while light vehicles would be permitted to travel along local roads surrounding the worksites.





JACOBS NSW SPATIAL - GIS MAP file: IA086100_TNR456_EIS_F004_Traffic_HaulageRoutes_r1v2 | 13/03/2017



- | | | |
|---|-----------------------------|---|
| The Northern Road upgrade - Mersey Road to Glenmore Parkway | Construction footprint | Western Sydney Airport site (Commonwealth Land) |
| The Northern Road (Existing) | Construction compound sites | Defence Establishment Orchard Hills (Commonwealth Land) |
| WaterNSW supply pipelines | Haulage routes | Commonwealth Lands |
| | Compound site access points | |

Figure 5-13 | Potential locations of construction ancillary facilities (sheet 2)

5.12.2 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 vehicle movements would be associated with staff movements to and from the site. Staff would comprise of project managers, various trades and general construction staff. At any one stage of construction, the peak construction workforce is likely to up to 40 construction, site management personnel and sub-contractors. The time of greatest impact of construction traffic to the surrounding road network would be during the morning and evening peak period.

Peak period traffic generation is likely to be in the order of 230 additional light vehicle movements 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 184 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 north, with a small proportion travelling along Elizabeth Drive from the east. This volume of traffic would be well within the capacity that these roads have been designed for and within the daily fluctuation of observed traffic volumes along The Northern Road and Elizabeth Drive. Furthermore, the average traffic generation for any one worksite would be around one third of the peak volume at 62 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 projects. This would equate to some 12-13 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 (19m), heavy rigid vehicles (12.5m) and concrete trucks (8.8m).

Table 5-3 shows the likely daily traffic volumes on The Northern Road and Elizabeth Drive during construction. These traffic volumes assume that 90 per cent of light and heavy vehicle trips associated with construction travel along The Northern Road, with the remaining 10 per cent travelling on Elizabeth Drive. The increase in daily traffic as a result of construction activities would be less than a five per cent increase in traffic over the day, which is likely to have a negligible impact on the Level of Service along The Northern Road and Elizabeth Drive.

Table 5-3 : Daily traffic volumes during construction

Road	Between	ADT (vehicles per day)	Additional construction traffic (vehicles per day)	Increase in traffic due to construction
The Northern Road	Glenmore Parkway and Bradley Street	21,982	22,279	+1.4%
	Chain-O-Ponds Rd and Kings Hill Road	17,499	17,796	+1.7%
	Littlefields Rd and Elizabeth Drive	15,206	15,503	+2.0%
	Elizabeth Drive and Park Road	15,737	16,034	+1.9%
	Park Rd and Blaxland Avenue	13,233	13,530	+2.2%
Elizabeth Drive	East of The Northern Road	11,534	11,567	+0.3%

5.12.3 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 existing access arrangements or the alterations of access arrangements. All the existing access would be maintained at all times during the construction period. A construction plan would be prepared to identify and address access issues that are not already covered by the proposed access plan outlined in **Section 5.6**.

Staff parking is likely to be provided on site at each construction compound. It is not expected that surplus parking demand from construction activities would reduce the availability of surrounding public parking.

5.12.4 Impacts on road safety

Construction activity along The Northern Road is likely to have the following impacts on road safety:

- Increased risk of loss of traction or control on temporary pavement surfaces
- Increased risk of conflicts between cars, trucks and construction vehicles
- Reduced lane widths and increased proximity to barriers increasing risk of collisions
- Increased risk of driver distraction around construction activities
- Decreased visibility of temporary line marking and other traffic control measures
- Increased risk of collision at construction site egress points

Road safety impacts from construction are addressed through the development of a Construction Traffic Management Plan (CTMP) as detailed in Section 6.

5.12.5 Impacts on road network operation

As outlined in Section 5.12.2, construction traffic generation would have a minimal impact on the capacity of The Northern Road during construction. Similarly, it is expected that parking for construction vehicles and workers will be provided on-site within the work compounds and there will be no impact on existing public parking as a result of construction activity. The primary impacts of construction traffic generation would be reduced speeds where traffic is unable to overtake slower moving heavy vehicles along The Northern Road.

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

- Reduced speed limits at traffic switches: During construction of the Mersey Road to Eaton Road section, traffic would be diverted from the existing The Northern Road alignment to a single carriageway to allow for the closure of the existing The Northern Road alignment through the Western Sydney Airport site. Traffic would be required to travel at reduced speed through locations where traffic would be redirected to the opposing carriageway during construction works
- Construction over live road: reduced speed limits and active traffic control would be required wherever construction activities would be taking place over live traffic. That is likely to occur at the locations of tie-in and bridge work. Construction over live road would occur during night works and is unlikely to affect traffic during peak periods
- Temporary traffic calming: A temporary roundabout is likely to be in operation during the construction of traffic signals at the intersection of The Northern Road and Luddenham south access. Reduced speed limits would be required in the vicinity of this temporary roundabout.

5.12.6 Impacts on bus services

Route 789 operates between Penrith and Luddenham, predominantly along The Northern Road. This is a peak hour only service and operates twice a day on weekdays. No services are provided on weekends. During construction of the project 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 the prevailing construction speed limit (most likely between 40 to 60 km/h subject to the specific construction activity being completed and safety requirements)
- 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 pairs of stops at any one time during construction for a period of up to two years
- 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.

A communication plan would be required to liaise with bus operators regarding the relocation of bus stops and to advise local residents and businesses of any changes to bus operations and access during construction.

5.12.7 Impacts on pedestrian and cyclist access

There is currently limited pedestrian infrastructure provided in the study area. There are no formal footpaths provided along The Northern Road in the majority of the study area. There are no formal cycle facilities provided in the study area.

During construction, pedestrian and cyclists may need to use alternative temporary paths where one side of The Northern Road may be inaccessible. This may involve the provision of temporary alternative access routes to properties in the study area to ensure that safe pedestrian and cycling access is maintained during the course of construction. As construction would take place in stages, these temporary arrangements are likely to be in place for up to three years.

5.13 Cumulative impacts

5.13.1 Construction cumulative impacts

Construction of the project is likely to be undertaken at the same time as other projects within the region, including:

- The Northern Road upgrade between Glenmore Parkway and Jamison Road
- M4 Smart Motorway civil work
- Bringelly Road upgrade Stage 1 and 2

As construction of these projects would take place simultaneously, traffic generated by these combined construction projects would impact primarily on the arterial road network with additional trucks travelling along the key arterials through the surrounding area. This would mean that higher than normal car and truck movements (in the order of 200 to 300 trucks per day and 450 to 700 light vehicles per day) would be likely to occur on The Northern Road and Elizabeth Drive.

For heavy vehicles, this would represent up to a 37 per cent increase in heavy vehicle volumes on the Northern Road and an increase in total traffic volumes of 4 per cent. Heavy vehicles would be travelling largely outside of the peak period and would represent a small proportion of the hourly and daily traffic volumes, being well within the design capacities for these roads and unlikely to reduce their Level of Service .

For light vehicles, traffic generation is likely to be concentrated in the morning and evening peak periods, with an average cumulative traffic generation of between 120 to 180 vehicles per hour during these periods along The Northern Road. This would represent an increase in peak period traffic volumes of

between 13 and 15 per cent. This increase in traffic volume would be in excess of forecast 2021 traffic volumes on The Northern Road. Based on modelling of the 2021 and 2031 Do Minimum scenario shown in Section 5.4.1, if all of this traffic were to use The Northern Road, this would likely result in some intersections along the Northern Road performing at unacceptable Levels of Service. However, given the location of works being undertaken for other projects in the area, it is unlikely that all of the traffic generated by these projects will use The Northern Road, as these construction areas are more directly accessed via the M4 Motorway (The Northern Road upgrade between Glenmore Parkway and Jamison Road, M4 Smart Motorway civil work) or Camden Valley Way (Bringelly Road upgrade).

In addition to the impacts of concurrent construction, the following projects would be taking place in the surrounding area following completion of the project:

- Proposed M12 Motorway
- Western Sydney Airport.

Both these projects would have lengthy construction periods and would result in continuous construction activity taking place in the area surrounding the project for up to five years. Construction traffic management plans for this project should be developed in consultation with plans for these projects so that increased traffic on the local road network would be spread over the road network to ensure that construction traffic is not concentrated on any one particular route if there are alternatives available. This consultation process would be managed by and/or through lines of communication agreed through Roads and Maritime Services.

Construction activities and the additional traffic associated with them is likely to result in lower travel speeds and increased delays at intersections along The Northern Road. Increased heavy vehicle volumes may also result in delays in sections where cars are unable to overtake vehicles along The Northern Road. Vehicles wishing to avoid these delays may use alternative routes to travel north or south through the area, such as:

- Mulgoa Road
- Luddenham Road
- Elizabeth Drive
- Mamre Road
- Greendale Road.

These alternative routes are comparable in capacity and speed to The Northern Road and would be a detour of between 2 and 10 kilometres for drivers wishing to avoid The Northern Road.

5.13.2 Operational cumulative impacts

In assessing the effects of the project the traffic modelling has taken into account the likely cumulative effects of the project with other planned road upgrade and traffic generating development projects in place (subject to relevant funding and planning approval), namely:

- The Northern Road upgrade between Glenmore Parkway and Jamison Road
- Bringelly Road upgrade
- South west priority growth area
- Western Sydney priority growth area
- M12 Motorway
- Western Sydney Airport and associated accesses.

The assessment has 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). Broader traffic implications of other employment lands in the broader

Western Sydney Employment Area, as well as the Western Sydney Airport, have all been accounted for in future travel demand provided by Roads and Maritime for the project.

The microsimulation traffic model for The Northern Road also includes the proposed The Northern Road upgrade between Glenmore Parkway and Jamison Road. Consequently the likely cumulative impacts of the projects listed above have been reflected within this assessment, as they are included within the core set of assumptions that underlie the traffic modelling discussed in Section 4.

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 project is shown in Table 5-5. Analysis of these network statistics shows that average network speeds are consistently higher for all scenarios with the project.

Table 5-5 : Summary of network statistics

Scenario	VHT (hours)	VKT (km)	Average Speed (km/hr)	Unreleased Traffic (4 hours)
2021 AM without project	2,083	122,599	58.8	116
2021 AM with project	2,145	132,899	62.0	0
<i>Difference</i>	62	10,300	3.2	-116
2031 AM without project	4,166	140,195	33.6	5,407
2031 AM with project	3,583	203,767	56.9	0
<i>Difference</i>	-583	63,572	23.3	-5,407
2021 PM without project	3,166	158,190	50.0	398
2021 PM with project	2,826	167,154	59.2	0
<i>Difference</i>	-340	8,964	9.2	-398
2031 PM without project	8,054	162,478	20.2	8,945
2031 PM with project	4,694	256,586	54.7	0
<i>Difference</i>	-3,360	94,108	34.5	-8,945

The table above shows that with the project, vehicles travel further in less time and with greatly improved average network travel speeds. Furthermore, analysis of the modelled scenario without the project shows that there is insufficient capacity through the corridor to serve the cumulative forecast traffic demand that results from the completion of the projects and developments likely to arise in the surrounding area.

The large volumes of unreleased traffic (traffic that was unable to enter the model during the modelled period due to congestion or queuing), particularly in the 2031 scenarios demonstrate that a substantial amount of forecast traffic would be unable to travel along the corridor if the project was not built due to capacity constraints. At the 2031 forecast year, these unreleased trips account for between 21 and 27 per cent of forecast traffic demand through the corridor.

In reality, it is unlikely that this unreleased traffic demand would be realised; it is likely that some proportion of these trips would take place outside of the modelled period, while others may redistribute across the wider road network (although current alternatives are limited to Mulgoa Road, Luddenham Road and Mamre Road, which have comparably low capacity to The Northern Road).

Overall, the project would improve the road network performance in the study area, reducing overall delays and travel distances and increasing the average network speeds. This would facilitate the projected traffic increase associated with future growth and development planned for the surrounding areas, including the Western Sydney Airport. It is also likely that the project would unlock other development potential for surrounding land that would otherwise remain undeveloped by facilitating travel to and from these areas.

6. Environmental management measures

6.1 Mitigation of operational impacts

The majority of operational impacts of the project have been addressed through the concept design and include the following:

- Maintenance of access to existing roads 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
- Provision of active transport facilities, addressed through the design by provision of a shared path along the length of The Northern Road.

6.2 Mitigation of construction impacts

The majority of project impacts 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 and operation of the project on traffic and transport.

The key environmental management measure required to address the impacts of construction on traffic and transport would be Construction Traffic Management Plans (CTMPs) 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), taking into consideration where possible other construction works utilising similar haulage and access routes
- 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 existing alignment of 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
- Consult with bus operators regarding temporary bus stop relocations during construction and proposed bus stops during operation.

7. Residual impacts

The environmental management measures identified in Section 6 would generally be effective in mitigating the traffic and access impacts of the project both during construction and in operation to an acceptable level. However it is expected that a residual impact would remain following implementation of the environmental management measures. A summary of these residual impacts is presented below, including reasoning as to why avoidance or mitigation of these impacts would not be able to be achieved.

7.1 Construction

Potential residual impacts that may occur as a result of construction of the project would include:

- Reduced travel speeds and increased delays through construction areas. This would be necessary to ensure that construction work is carried out safely in and around operational roads. Residual delays as a result of reduced travel speeds are expected to be minor.
- Temporary changes to accessibility for pedestrian and cyclists when access to roadside areas may need to be restricted during construction. This would require pedestrians and cyclist to potentially travel further to reach their destination and would be necessary to undertake construction in these locations. The residual delays for pedestrians and cyclists as a result of temporary access changes are likely to be minor.
- Temporary changes to the location and accessibility of bus stops during relocation and construction. This would result in passengers not being able to board or alight from buses at the locations they are used to and may require them to travel further to and from temporary or relocated bus stops. These would be necessary to undertake construction in these areas. The residual delays for bus passengers travelling to and from temporarily relocated bus stops is likely to be minor.

7.2 Operation

Potential residual impacts that may occur following the completion of the project when it is in operation would include:

- Access to and from properties along The Northern Road would generally be restricted to left in and left out access arrangements due to the construction of a median along the centreline of The Northern Road. This would restrict right turn movements to intersections and U-turn bays, which would require motorists to travel further to access these facilities. Overall, this would result in longer travel distances and times for trips for those affected by this change in access. It would also increase traffic along the local roads that provide these turning facilities. This would be necessary as part of the design which includes a solid median along The Northern Road for the length of the project. Longer travel distances and higher travel times resulting from changes to access arrangements are likely to be minor.
- Bus stops would be relocated along The Northern Road. For some passengers, these stops may be closer to their destination, however for others they could potentially be further increasing the distance and time travelled to reach their bus stop, by as much as 650 m. This is necessary to place bus stops at strategic locations along the corridor, coinciding with major intersections and areas of primary public transport demand. Relocation of bus stops along The Northern Road to the exit side of intersections is likely to be a minor improvement in accessibility, particularly for bus passengers living on local roads adjacent to The Northern Road.
- Immediately after construction, it is likely that delays along The Northern Road would increase at existing intersections where traffic signals are proposed. These traffic signals would delay vehicles travelling north or south along The Northern Road, however this is unlikely to be the case for vehicles entering or exiting The Northern Road. Over time, as traffic growth is realised, this residual impact of traffic signal installation would decline. This would be necessary to maintain safe and efficient operation of these intersections under the proposed design speed and geometry. Travel speeds and

intersection performance are likely to improve and providing substantial travel time savings for traffic in the long-term when compared with a Do Minimum scenario.

- Traffic volumes along The Northern Road through Luddenham town centre are likely to decrease as a result of the project, as the project would provide a faster alternative for vehicles travelling between Eaton Road and Elizabeth Drive. This is a consequence of providing a high speed and high capacity alternative route past Luddenham town centre. The increase in amenity as a result of decreased heavy vehicle volumes and lower traffic volumes overall is likely to be substantial.

8. Summary and conclusions

8.1 Overview

Traffic modelling of the proposed The Northern Road Upgrade (between Mersey Road and Glenmore Parkway) has been undertaken using the Aimsun microsimulation modelling platform. The microsimulation 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.

8.2 Key findings

Overall, analysis of the road network performance under the 2021 and 2031 future horizon years shows that The Northern Road upgrade (between Mersey Road and Glenmore Parkway) 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 Mersey Road and Glenmore Parkway would improve access and travel times through the corridor and ensure the future M12 Motorway and Western Sydney Airport access to operate within a reasonable level of service.

The potential impacts to traffic and transport from the project would include the following potential 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 number of heavy vehicles, including B-Doubles from the Luddenham town centre due to the realignment of The Northern Road which would increase safety for drivers, cyclists and pedestrians
- Reduced travel times along The Northern Road corridor between Mersey Road and Glenmore Parkway in future years with the upgrade in operation than without the upgrade.

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

- Changes to access arrangements for the majority of properties that currently have access directly onto The Northern Road and some properties that have access along roads that connect to The Northern Road. The majority of these right turn movements into and out of The Northern Road would no longer be possible and would involve detours of up to 6.6 km for those properties worst affected
- 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
- Although no formal pedestrian or cycling facilities are currently provided on The Northern Road, access to properties along The Northern Road for pedestrian and cyclists may be restricted during construction.

8.3 Recommendations

Traffic and transport impacts associated with construction of the project would need to be mitigated through environmental management measures. These measures would include the development and implementation of 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. Intersections included in traffic model

The following intersections within the study area have been included within the The Northern Road traffic model:

- The Northern Road and Mersey Road
- The Northern Road and Dwyer Road
- The Northern Road and Leppington Pastoral Company Access
- The Northern Road and Eaton Road south
- The Northern Road and Eaton Road north
- The Northern Road and IGA Access
- The Northern Road and Adams Road
- The Northern Road and Roots Avenue
- The Northern Road and Blaxland Avenue
- The Northern Road and Park Road
- The Northern Road and Elizabeth Drive
- The Northern Road and Littlefields Road
- The Northern Road and Gates Road
- The Northern Road and Longview Road
- The Northern Road and Kings Hill Road
- The Northern Road and Grover Crescent south
- The Northern Road and Grover Crescent south
- The Northern Road and Chain-O-Ponds Road
- The Northern Road and Defence Establishment Orchard Hills Access
- The Northern Road and Bradley Street.

Appendix B. 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
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Appendix A. Detailed calibration results

Appendix B. Regression Plots

Appendix C. Cumulative counter peak travel time graphs

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.

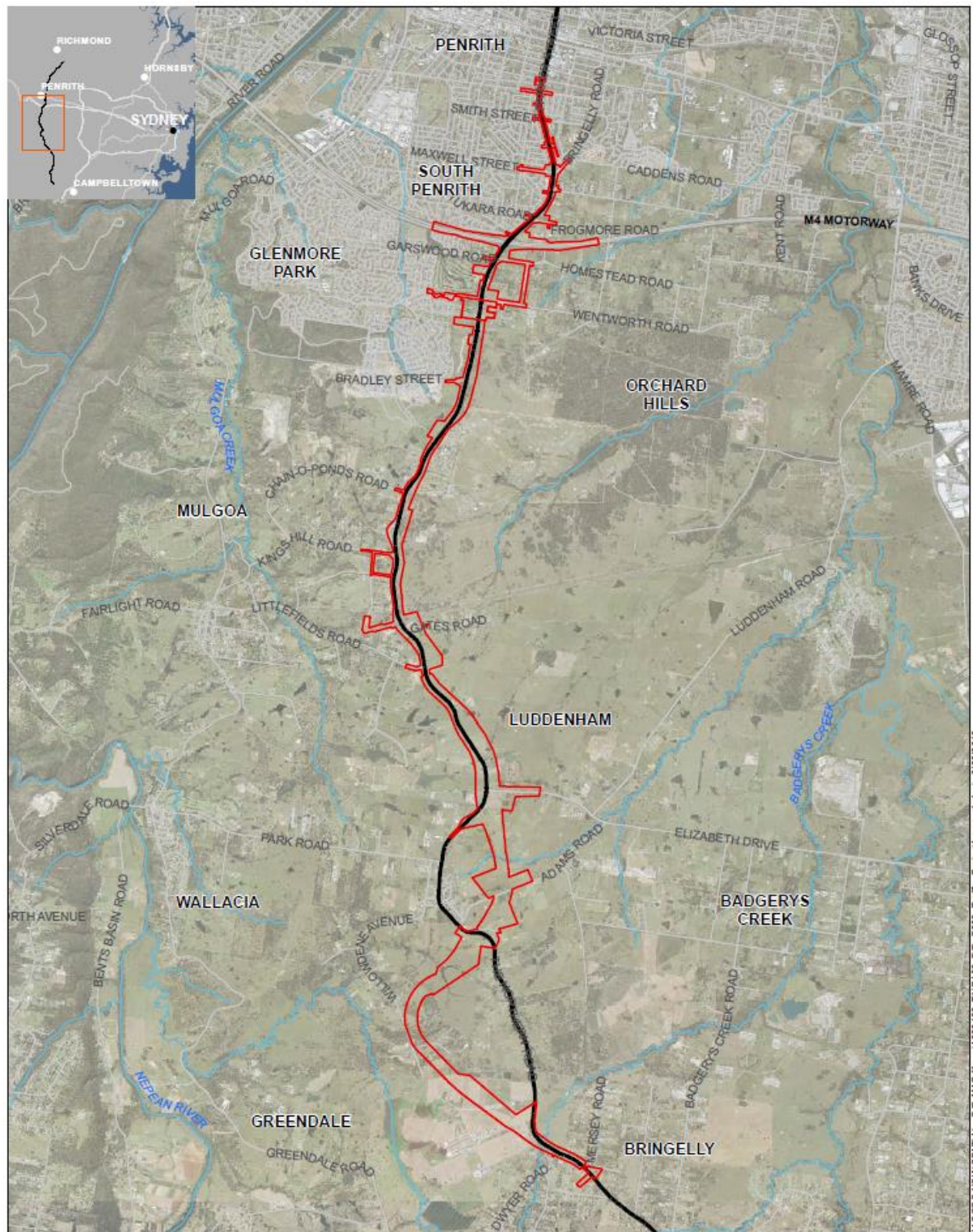
2. Study Area

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

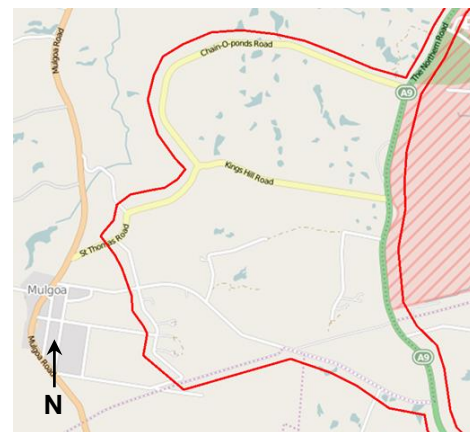
Figure 3.1 : The Northern Road Upgrade model extents



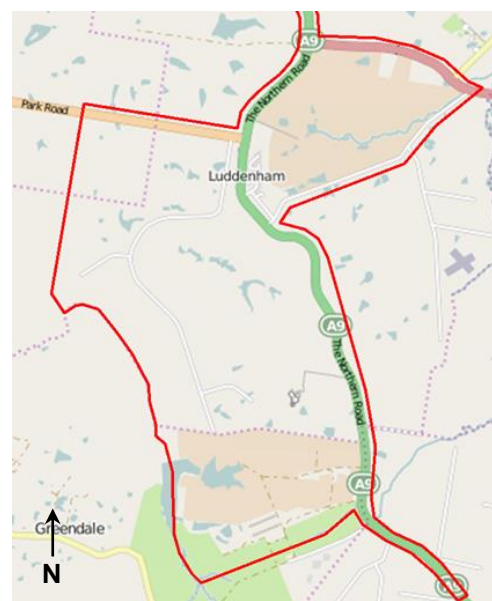
Overall model area



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 cordons.

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

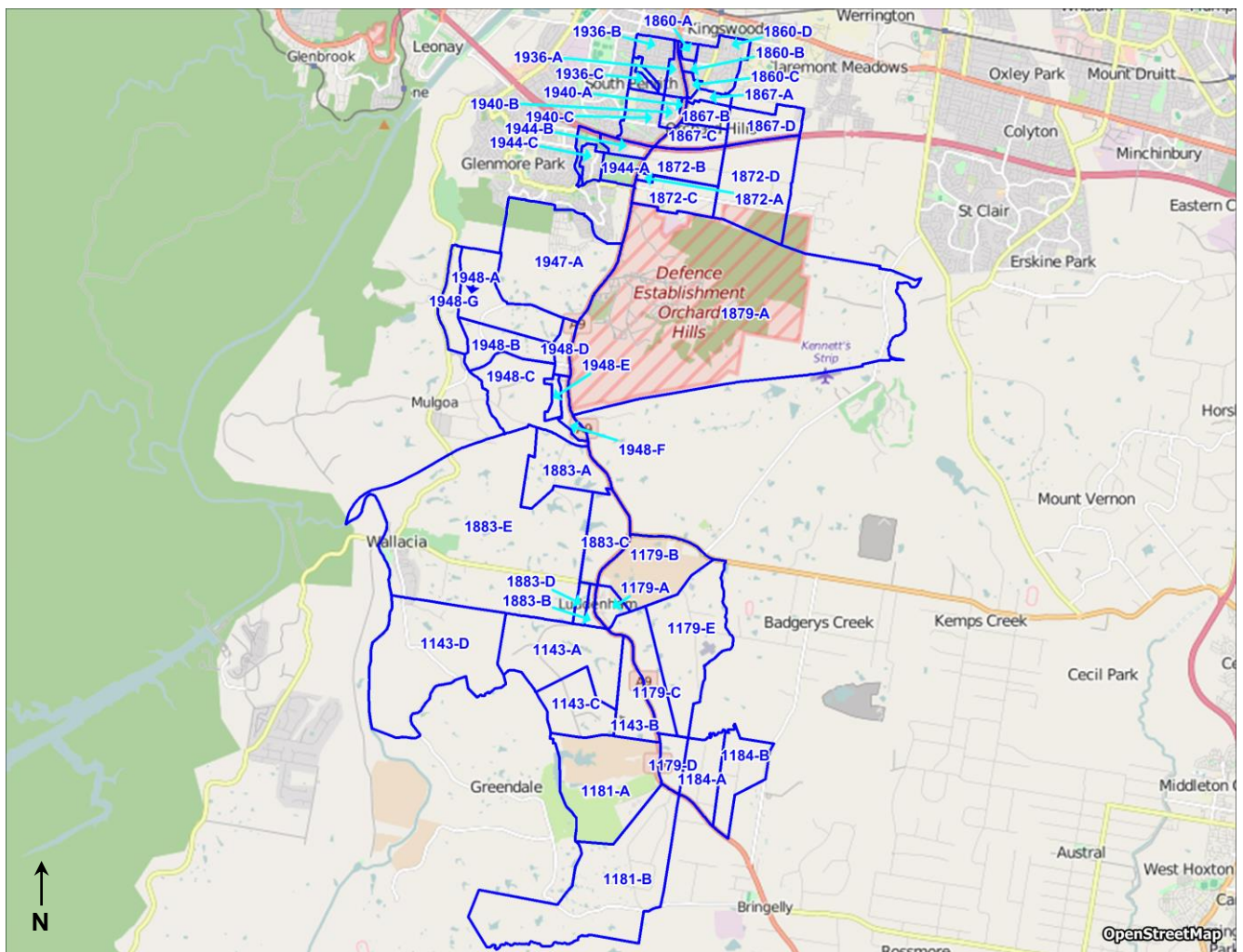
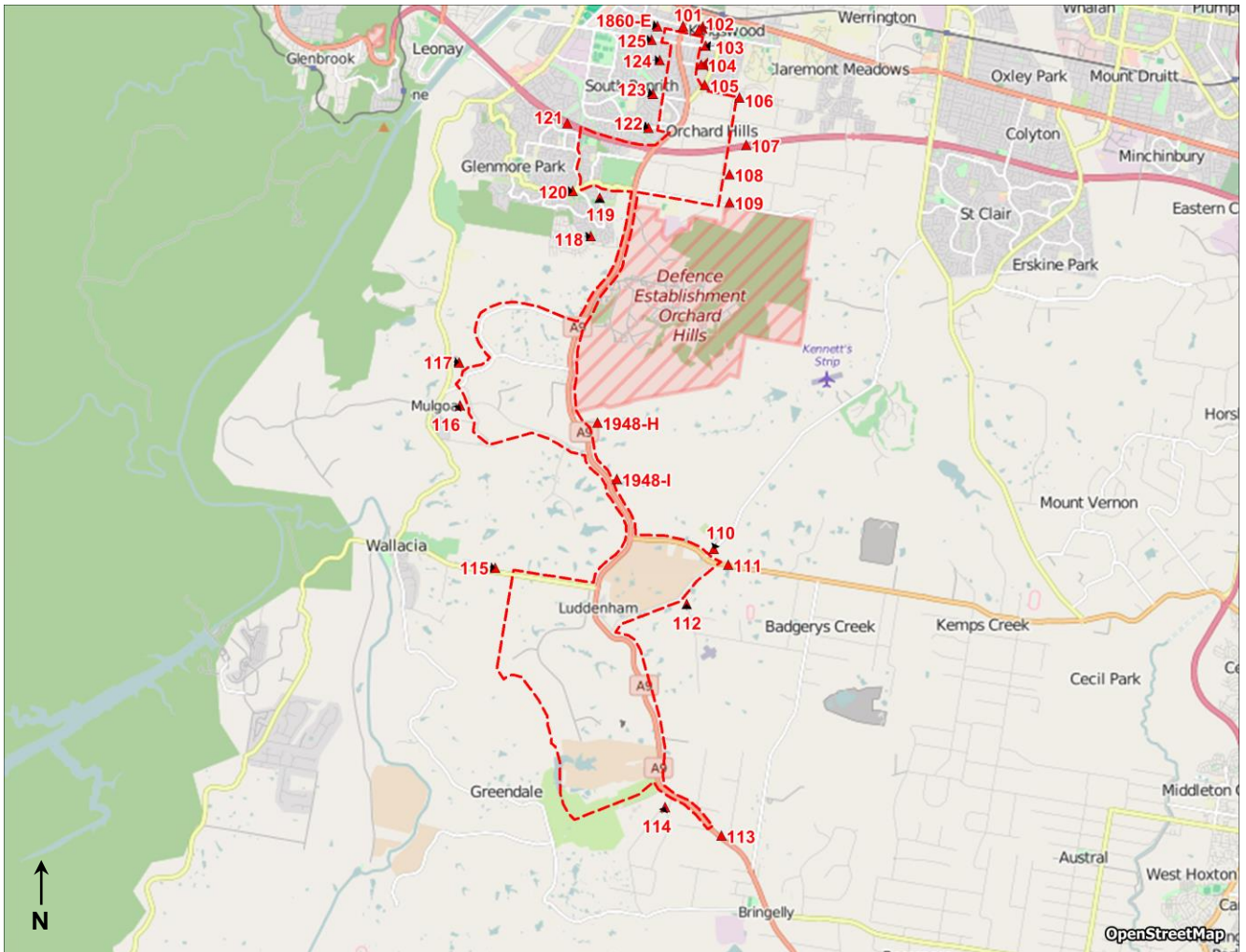


Figure 3.3 : Aimsun model external travel zones



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 Road 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

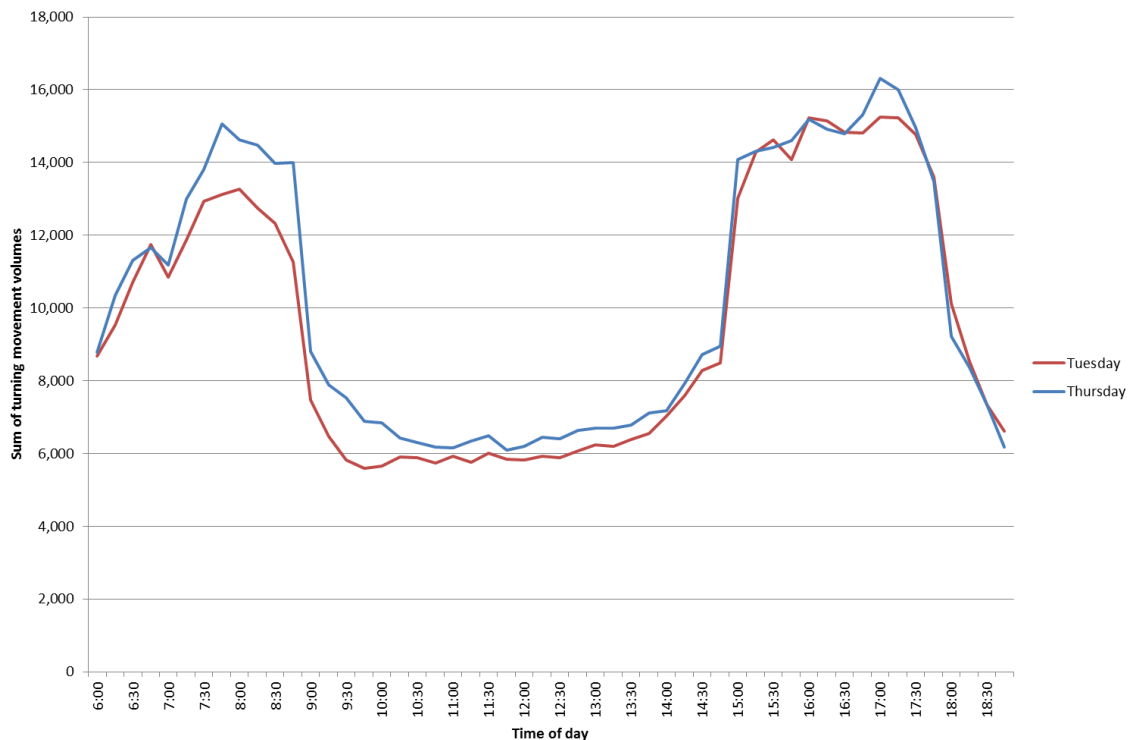
These two RDSs are not the same because the Aimsun adjustment processes require target volumes for every time interval in the modelled period, warm up and cool down, while the count data available covers different time periods in different locations. The available count data has been extrapolated to 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

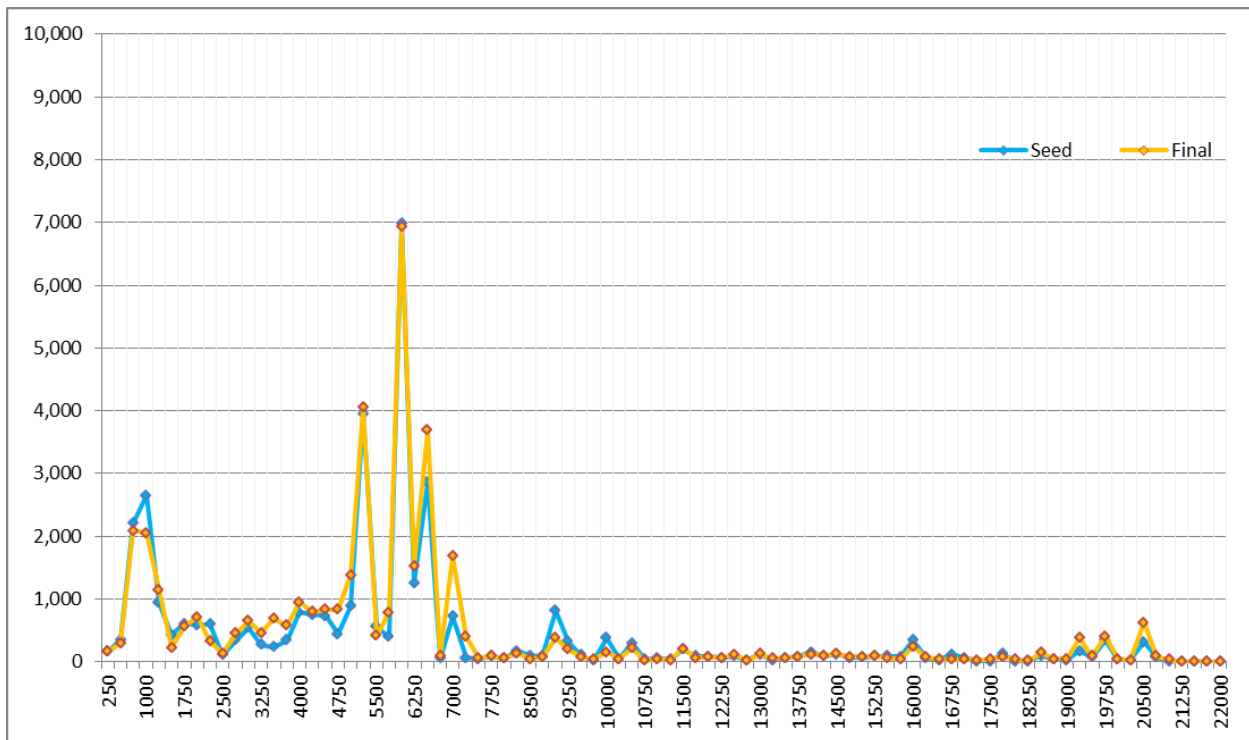
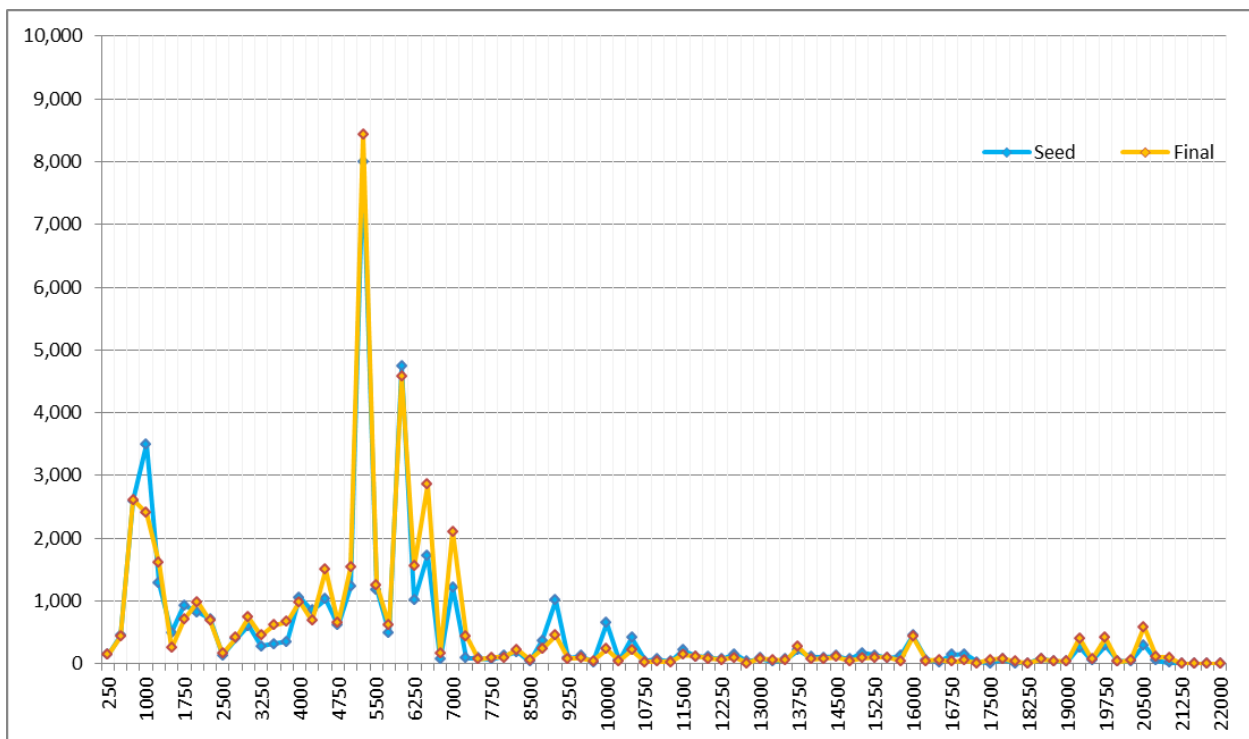


Figure 4.2 : Trip length distribution comparison – PM peak



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 defined 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:

- R² greater than 0.95
- Slope between 1.05 and 0.95

The R² 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

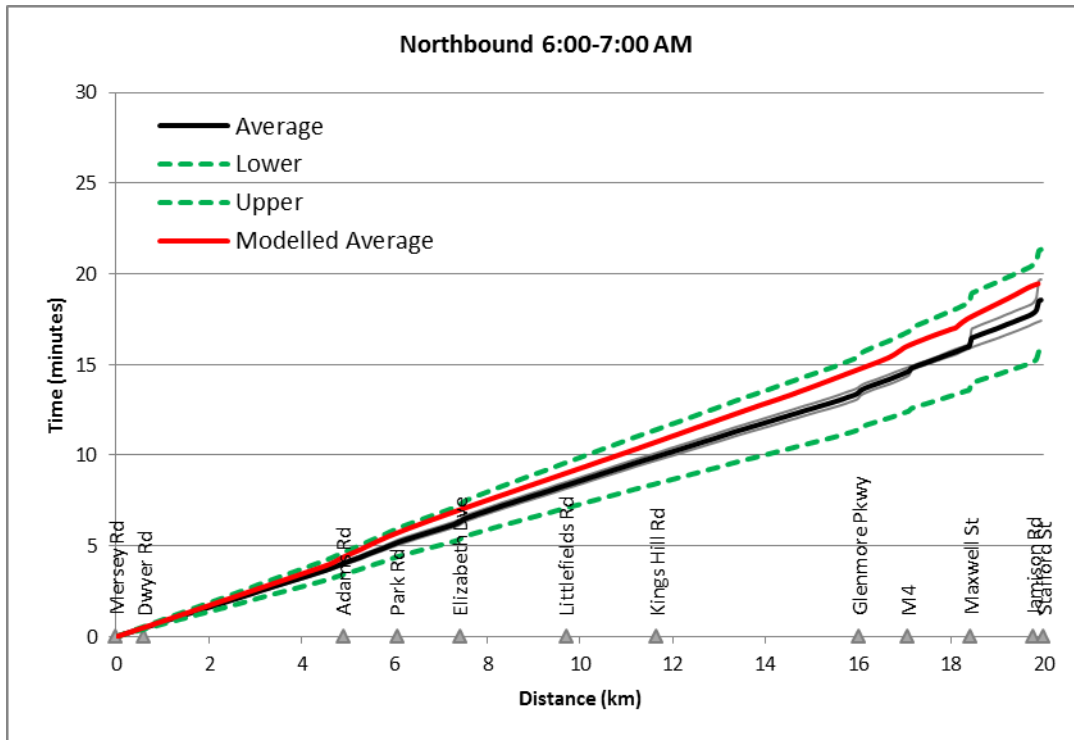


Figure 6.2 : Cumulative travel time, model vs observed – northbound, 7am to 8am

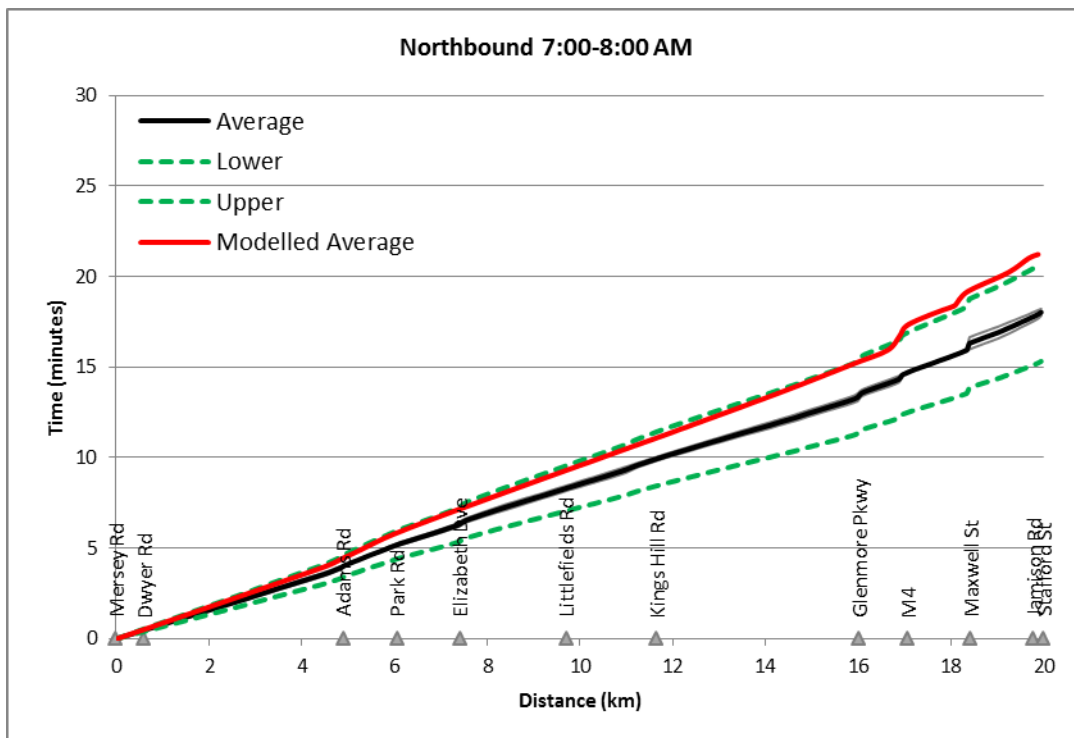


Figure 6.3 : Cumulative travel time, model vs observed – northbound, 8am to 9am

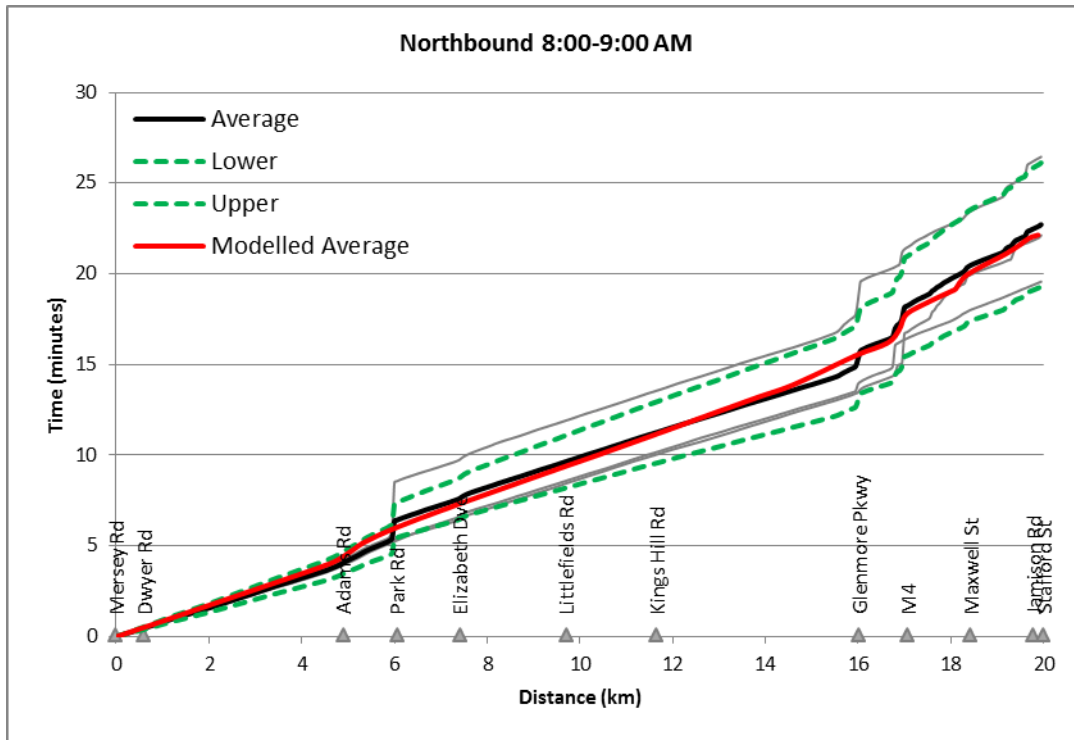


Figure 6.4 : Cumulative travel time, model vs observed – northbound, 9am to 10am

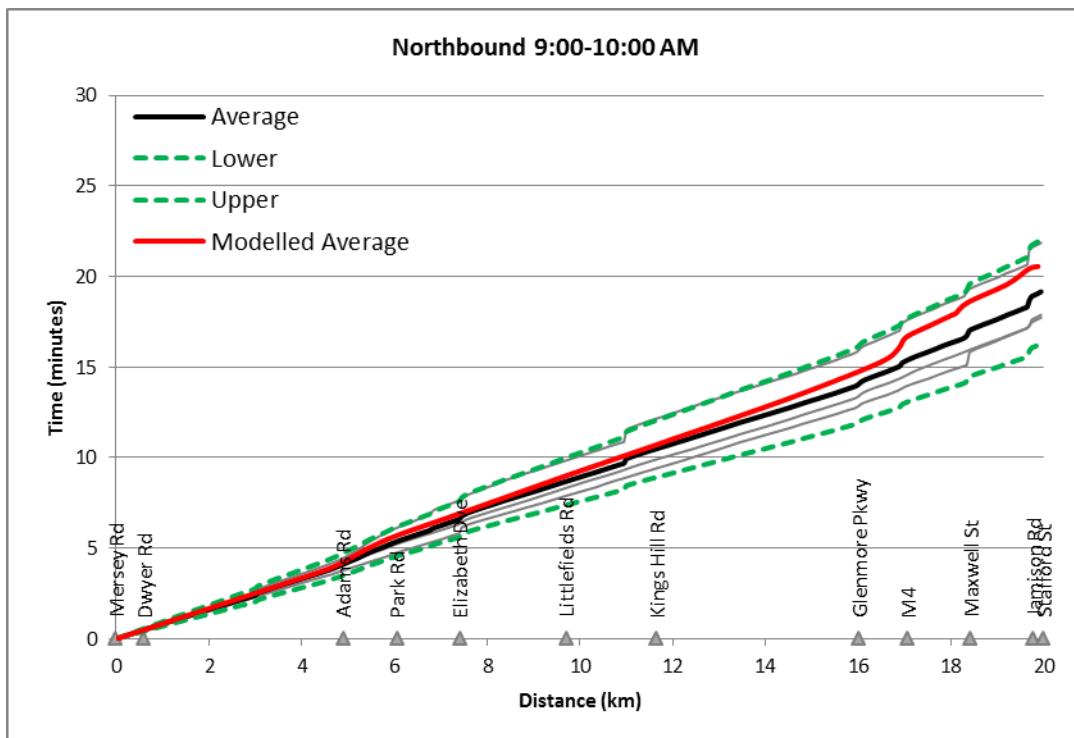


Figure 6.5 : Cumulative travel time, model vs observed – southbound, 3pm to 4pm

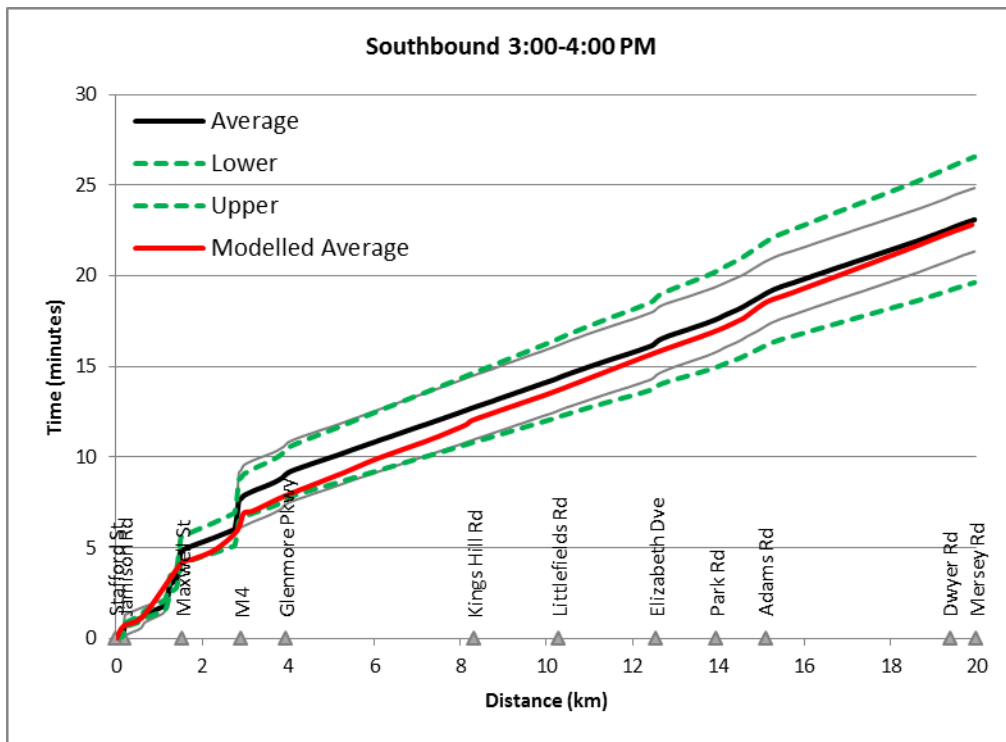


Figure 6.6 : Cumulative travel time, model vs observed – southbound, 4pm to 5pm

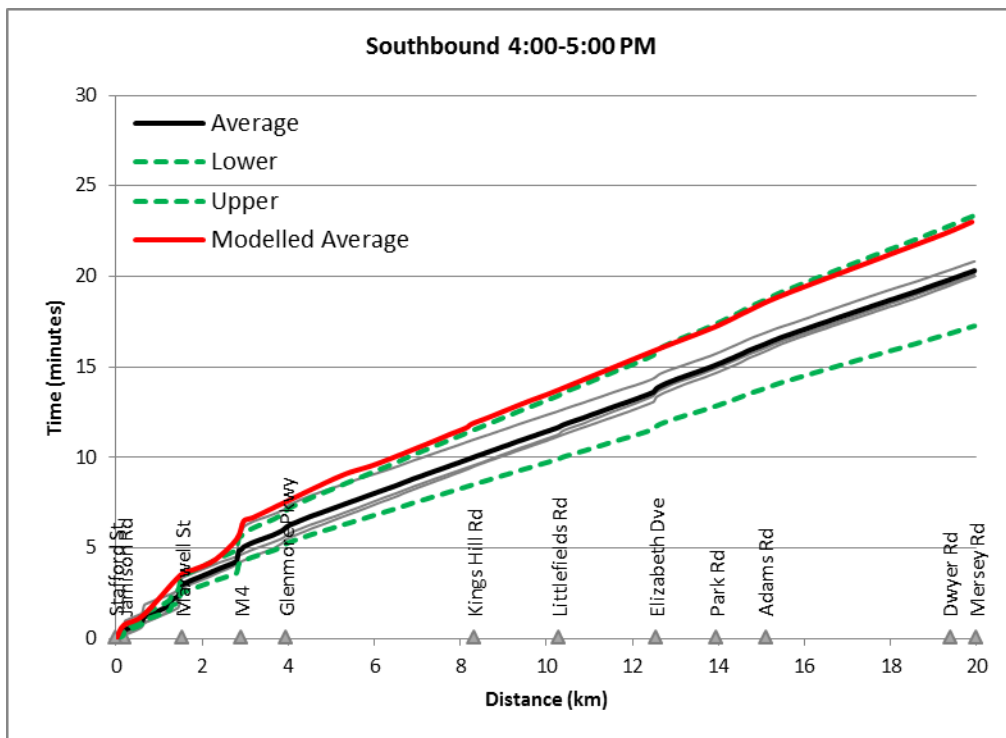


Figure 6.7 : Cumulative travel time, model vs observed – southbound, 5pm to 6pm

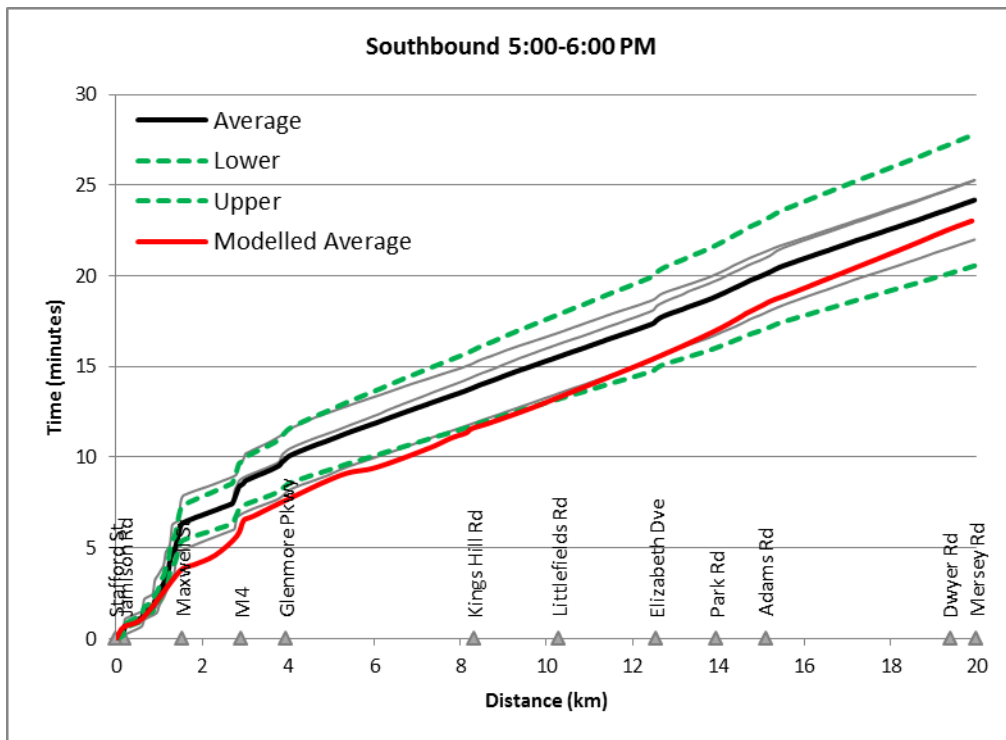
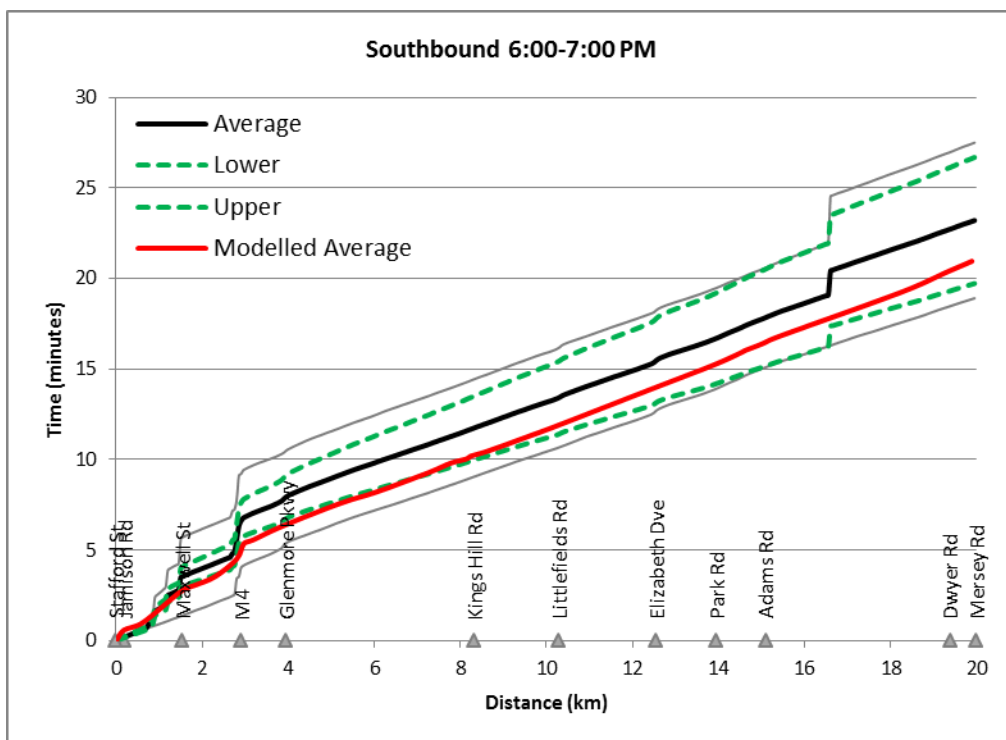


Figure 6.8 : Cumulative travel time, model vs observed – southbound, 6pm to 7pm



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)

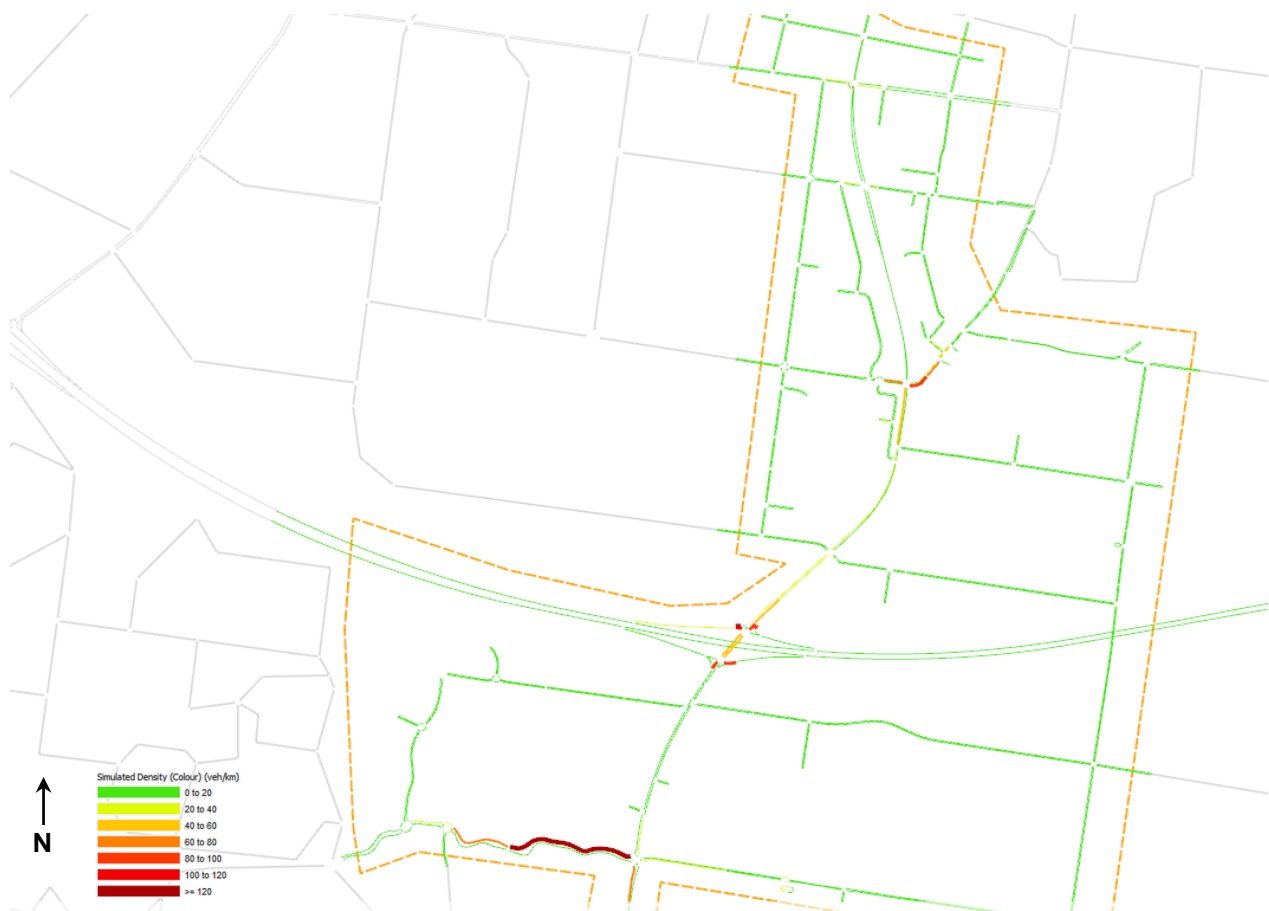
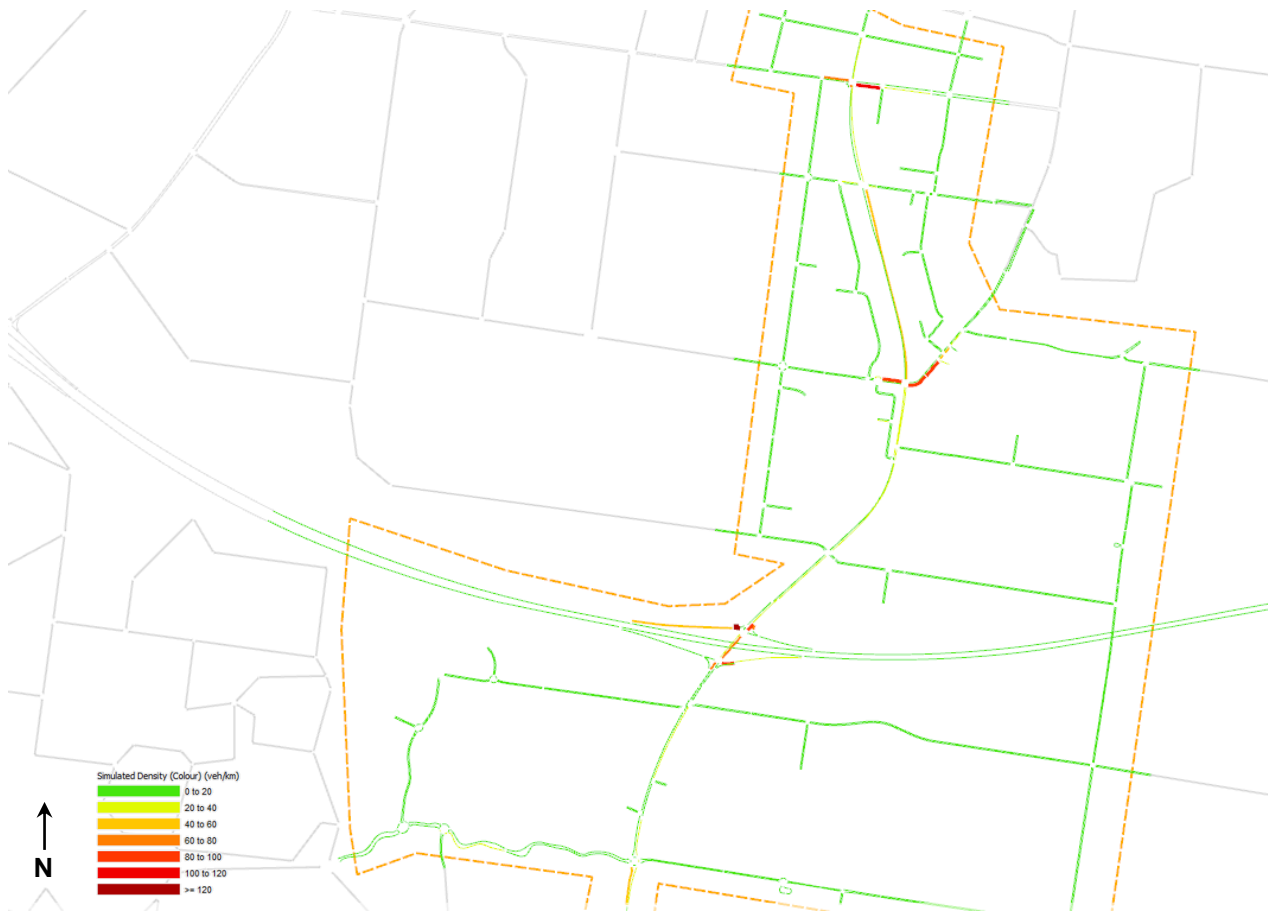


Figure 6.10 : Key congestion areas, PM peak (4:45pm)



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

Traffic Volume Calibration Results : Total Vehicles

Traffic Volume Calibration Results : Total Vehicles

903

Micro OSI

[illegible]

THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL
Traffic Volume Calibration Results : Total Vehicles

v03 Micro OS1

Interaction	Approach Direction										Target volume										Modelled volume										Modelled vs target volume										Meets 'core area' target?										GHI : 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																								
The Northern Rd / Defense Establishments Gates	North Through	735	752	547	451	884	824	778	540	688	753	556	434	818	878	774	479	-48	1	11	27	66	54	4	-61	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	622	757	606	737																		
The Northern Rd / Defense Establishments Gates	North Left	1156	96	67	25	11	8	10	3	115	84	92	30	19	8	25	11	0	-12	25	8	8	-1	-15	8	1	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	76	8	80	16																	
The Northern Rd / Defense Establishments Gates	North Right	7	17	93	16	102	85	39	20	26	22	96	23	120	75	36	17	19	-4	5	3	7	18	-10	-3	-3	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	33	62	42	62																		
The Northern Rd / Defense Establishments Gates	East Left	8	3	6	7	13	16	12	2	4	7	6	4	12	12	7	3	1	-4	4	0	-3	-1	-4	-5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	6	11	5	9																		
The Northern Rd / Defense Establishments Gates	East Right	34	9	2	0	7	10	10	0	1	1	1	38	32	1	7	0	1	22	17	0	1	1	2	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	27	0	0	0																		
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	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	715	754	707	769																		
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	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	2.0	3.3	1.1	4.0																		
The Northern Rd / Chain-O-Ponds Rd	North Through	742	751	544	445	886	832	779	528	687	751	556	423	820	868	778	479	-55	0	14	-22	-66	36	-1	-49	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	621	756	605	736																		
The Northern Rd / Chain-O-Ponds Rd	North Left	681	891	767	567	801	842	850	490	663	908	767	524	833	838	864	483	-18	17	0	43	32	-4	-14	-7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	727	746	716	755																		
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	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2																		
The Northern Rd / Chain-O-Ponds Rd	South Right	0	3	2	0	3	1	1	2	1	1	3	6	0	1	0	0	1	1	0	4	0	1	-1	-1	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	1																			
The Northern Rd / Chain-O-Ponds Rd	West Left	3	1	13	3	3	1	1	1	1	12	3	0	1	1	1	0	1	4	7	2	1	1	6	2	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																		
The Northern Rd / Kings Hill Rd	North Right	31	39	49	56	132	122	121	64	55	54	57	51	116	110	143	93	24	15	8	5	-16	-12	20	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.7	2.2	1.1	0.7																		
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	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																		
The Northern Rd / Kings Hill Rd	North Left	530	714	644	485	697	764	770	350	508	745	651	434	722	763	764	382	-22	31	7	-51	25	-1	-6	32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																			
The Northern Rd / Kings Hill Rd	South Left	2	2	3	4	5	6	3	2	6	2	0	2	0	4	0	-2	0	-3	-2	-3	-6	-3	-2	-2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																			
The Northern Rd / Kings Hill Rd	South Right	2	1	5	4	2	6	3	4	4	1	4	0	0	2	0	-1	-1	-4	-2	-5	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																				
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	23	-8	15	38	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	8.7	0.2	0.4	1.5																		
The Northern Rd / Kings Hill Rd	West Right	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																			
The Northern Rd / Kings Hill Rd	West Through	31	39	49	56	132	122	121	64	55	54	57	51	116	110	143	93	24	15	8	5	-16	-12	20	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.7	2.2	1.1	0.7																		
The Northern Rd / Kings Hill Rd	West Right	104	150	119	58	62	60	47	37	145	148	85	70	83	52	62	75	41	-2	34	12	23	-8	15	38	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	8.7	0.2	0.4	1.5																	
The Northern Rd / Longview Rd	North Right	7	205	484	385	710	708	567	329	645	682	480	376	661	727	542	303	-30	-23	4	-9	-49	19	-25	-26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																		
The Northern Rd / Longview Rd	North 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	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																			
The Northern Rd / Longview Rd	North Left	0	1	0	3	3	2	7	1	2	0	1	1	2	0	1	0	2	-1	1	0	-1	-2	-6	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																			
The Northern Rd / Longview Rd	South Left	0	1	0	3	3	2	7	0	3	4	0	1	2	0	1	0	2	-1	1	0	-1	-2	-6	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																			
The Northern Rd / Longview Rd	South Right	0	1	0	3	3	2	7	0	3	4	0	1	2	0	1	0	2	-1	1	0	-1	-2	-6	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																			
The Northern Rd / Longview Rd	West Left	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																			
The Northern Rd / Gates Rd	North Through	674	474	376	701	684	548	314	639	682	478	362	642	718	533	784	384	-34	23	2	3	0	34	32	13	30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																		
The Northern Rd / Gates Rd	North Left	7	4	2	12	6	5	1	12	4	13	7	2	12	4	13	7	2	12	4	13	7	2	12	4	13	7	2	12	4	13	7	2	12	4	13	7	2	12	4	13	7	2	12	4	13	7																	
The Northern Rd / Gates Rd	North Right	7	5	9	8	5	11	5	6	5	9	8	5	11	5	9	8	5	6	5	9	8	5	11	5	9	8	5	6	5	9	8	5	11	5	9	8	5	6	5	9	8	5	6	5	9	8																	
The Northern Rd / Gates Rd	East Left	8	9	6	2	5	3	0	2	1	3	2	5	0	2	1	3	2	5	0	2	1	3	2	5	0	2	1	3	2	5	0	2	1	3	2	5	0	2	1	3	2	5	0	2	1	3																	
The Northern Rd / Gates Rd	East Right	4	1	3	2	9	3	2	0	3	4	2	0	5	2	4	1	3	0	1	3	2	9	3	2	0	1	3	2	9	3	2	0	1	3	2	9	3	2	0	1	3	2	9	3	2	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	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																		
The Northern Rd / Littlefield Rd	North Right	21	21	20	32	27	26	18	20	12	17	17	47	27	44	25	17	8	1	4	-3	-5	17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																			
The Northern Rd / Littlefield Rd	North Through	692	628	474	408	628	674	408	529	618	658	474	408	618	658	474	408	-41	-36	6	-58	-2	-14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																			
The Northern Rd / Littlefield Rd	North Left	509	706	587	452	664	750	717	330	465	716	594	421	662	736	718	334	-44	10	7	-31	-2	-14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																			
The Northern Rd / Littlefield Rd	South Left	24	24	38	19	42	54	52	19	38	21	31	23	42	63	53	28	-1	-3	-7	4	0	9	1	9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																			
The Northern Rd / Littlefield Rd	South 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	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																				
The Northern Rd / Littlefield Rd	West Left	22	34	19	19	29																																																										

THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL

v03

Micro OS1

Traffic Volume Calibration Results : Light Vehicles

Intersection		Approach 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		12	-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															

THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL

v03

Micro OS1

Traffic Volume Calibration Results : Light Vehicles

Intersection			Approach 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	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	2	112	83	91	29	19	7	24	8	1	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	-						

THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL

v03

Micro OS1

Traffic Volume Calibration Results : Light Vehicles

Intersection	Approach 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											

THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL

v03

Micro OS1

Traffic Volume Calibration Results : Heavy Vehicles

Intersection		Approach 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		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	4	0	3		5	10	3	3	0	0	0	-1	3	7	2	2	2	2	5		
The Northern Rd / Smith St		Through		70	64	77		100	85	66	45	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		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	1	-1	-2	2	-2	-1	0	-1	1	2	1	1	0	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	-1	0	0	0	0	0	0	0	0	
The Northern Rd / Smith St		South	Through	102	61	85		108	82	56	37	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	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		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	20	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</																							

THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL

v03

Micro OS1

Traffic Volume Calibration Results : Heavy Vehicles

Intersection			Approach 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	6	3	10	3	5	3	4	7	3	5	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	4	2	2	1	5	3	3	10	4	4	1	0	4	1	1	8	0	2	-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	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																															

THE NORTHERN ROAD STAGES 3 & 4 AIMSUN MODEL

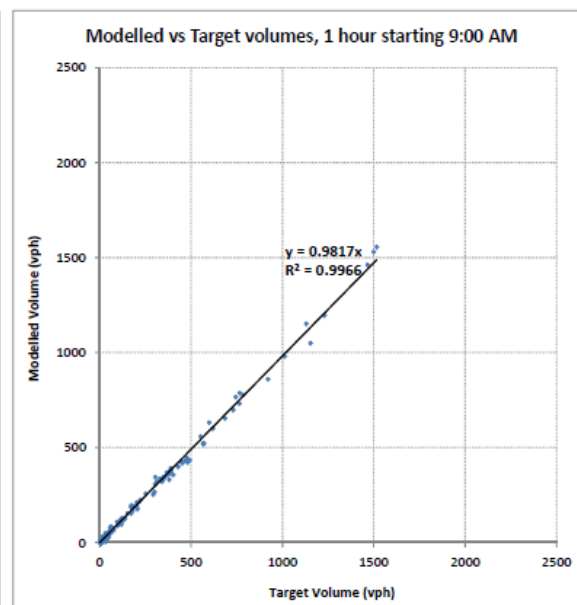
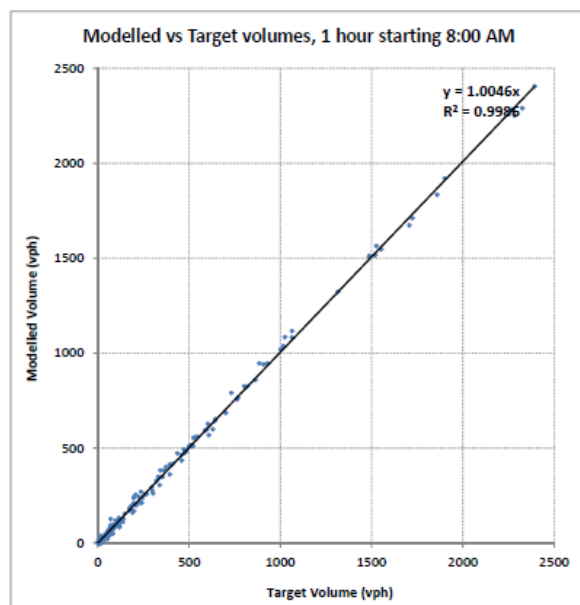
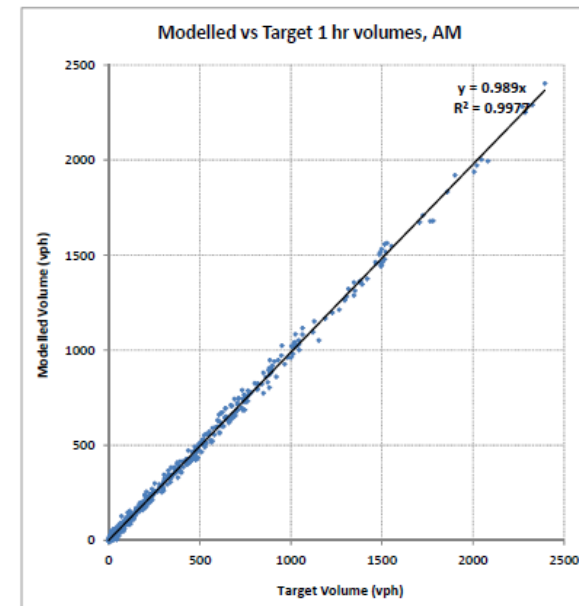
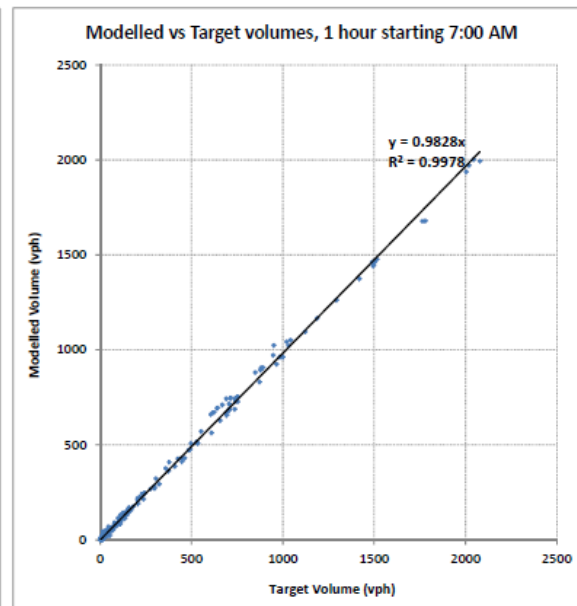
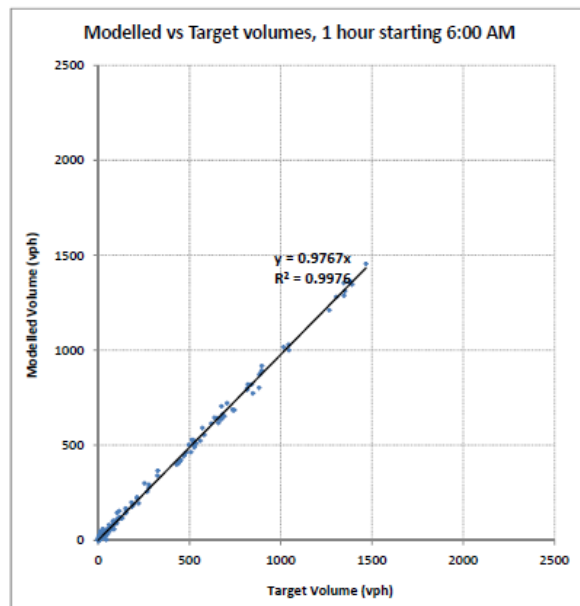
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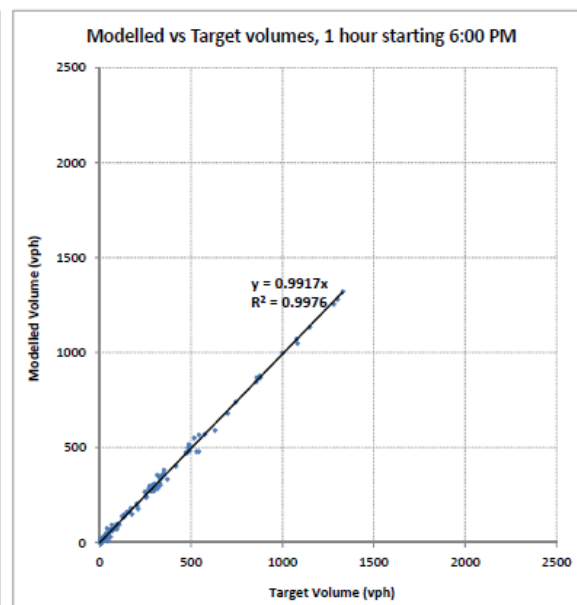
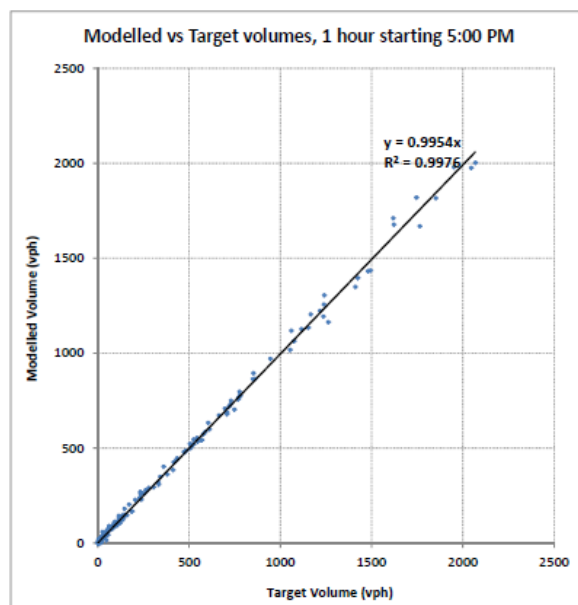
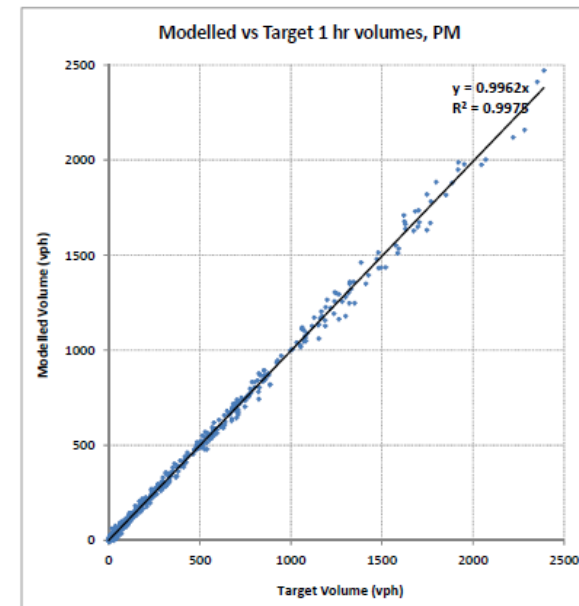
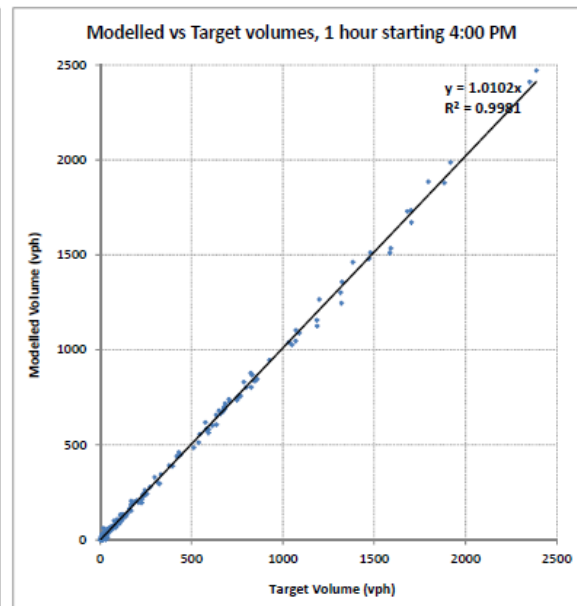
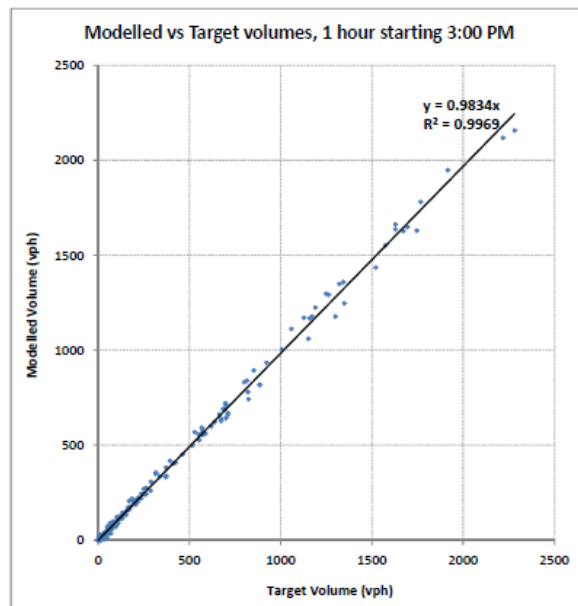
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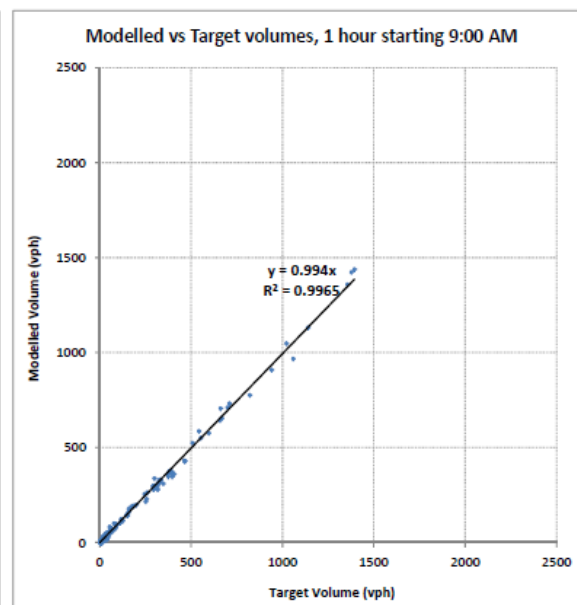
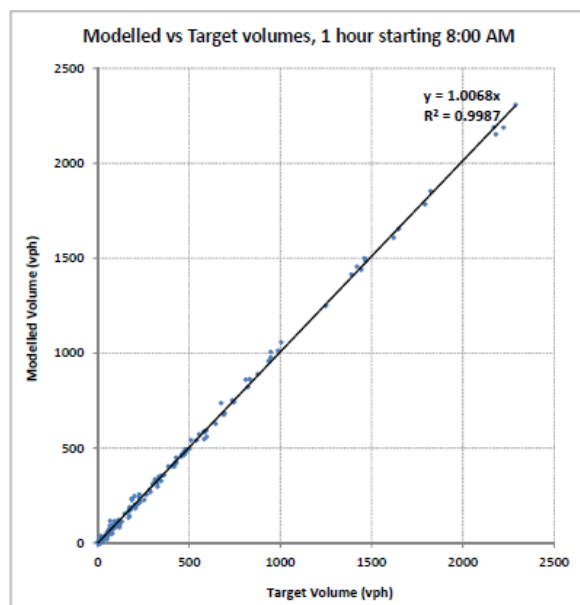
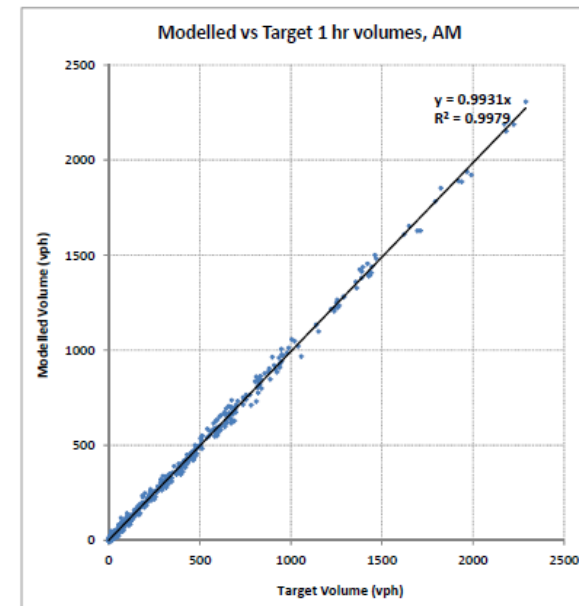
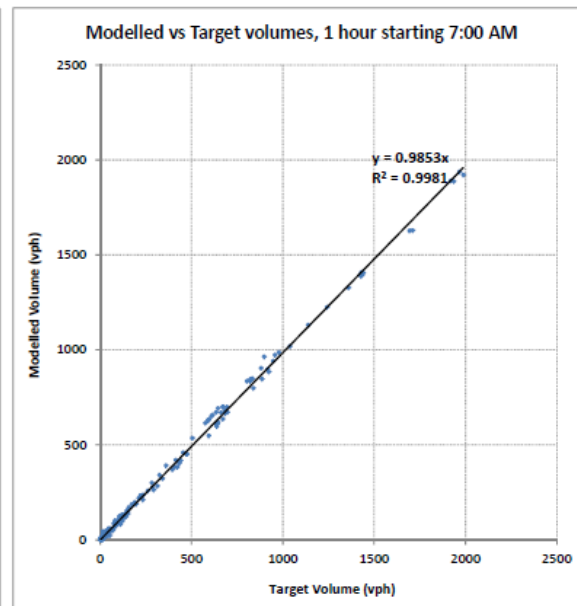
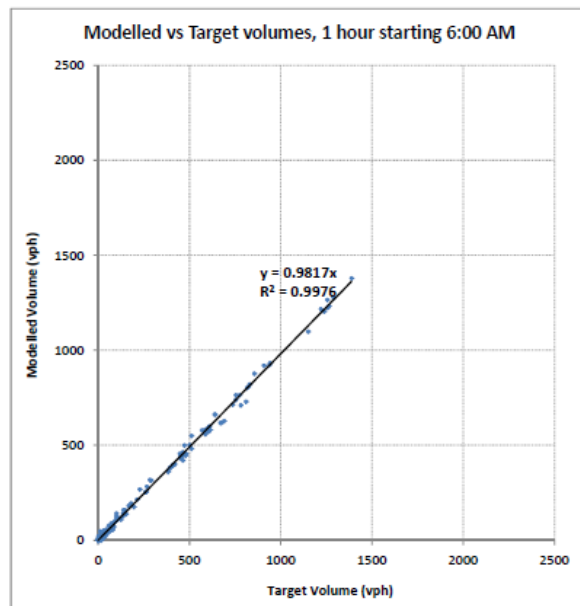
Traffic Volume Calibration Results : Heavy Vehicles

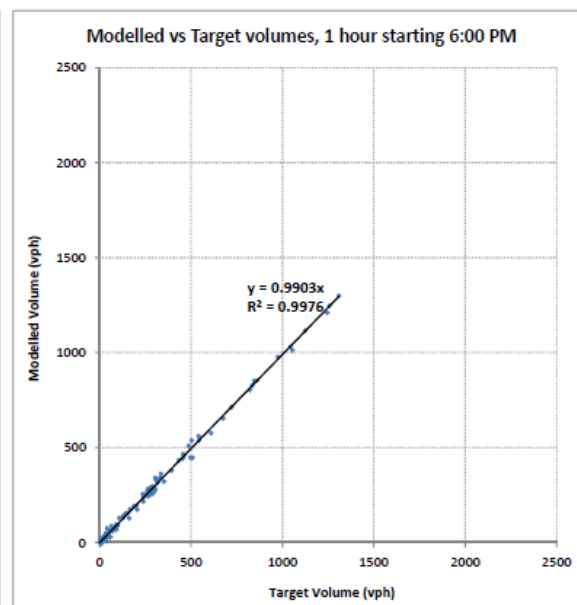
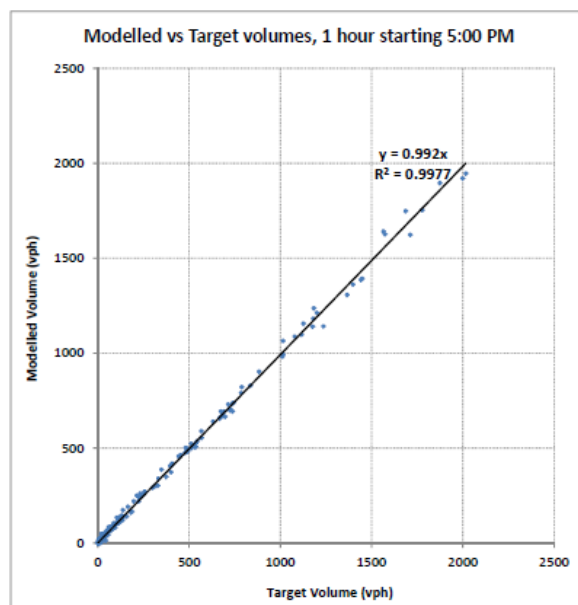
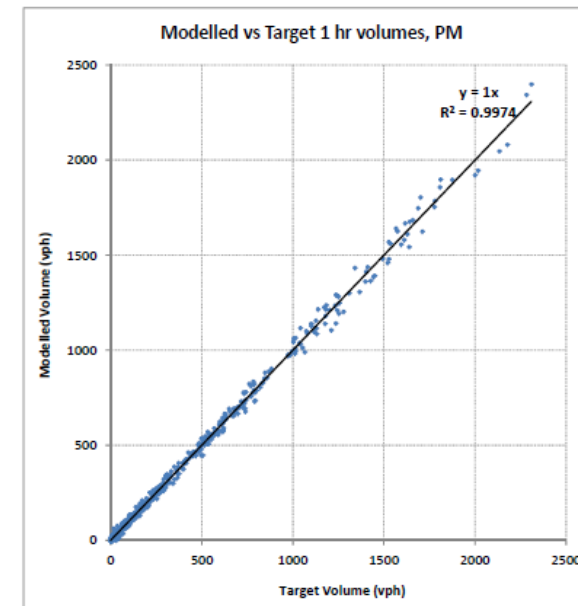
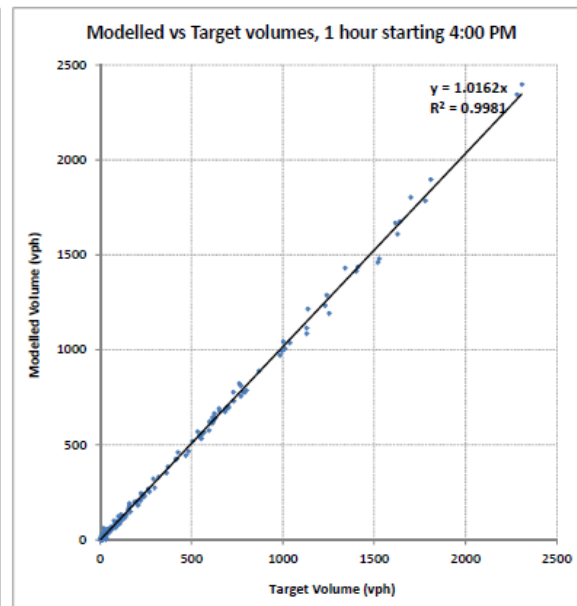
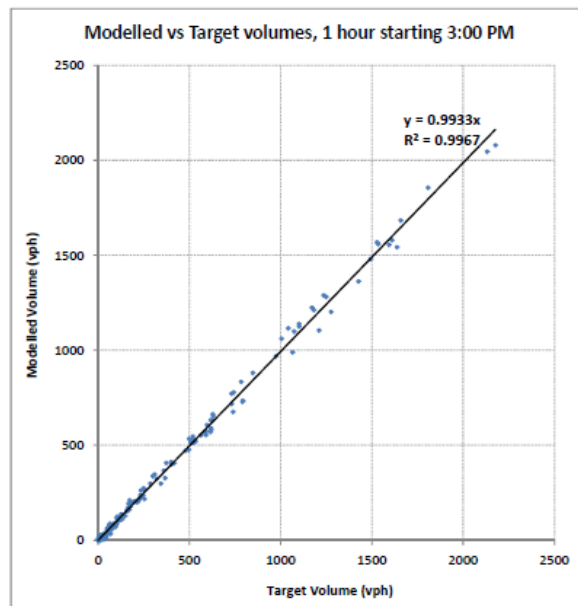
Intersection	Approach	Direction	Target volume								Modelled volume								Modelled vs target volume								Ave Target (vph)		Ave Modelled (vph)	
			6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	6:00	7:00	8:00	9:00	15:00	16:00	17:00	18:00	AM	PM	AM	PM
The Northern 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	-1	0	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	7	2	2	4	1	1	0	1	3	4	0	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

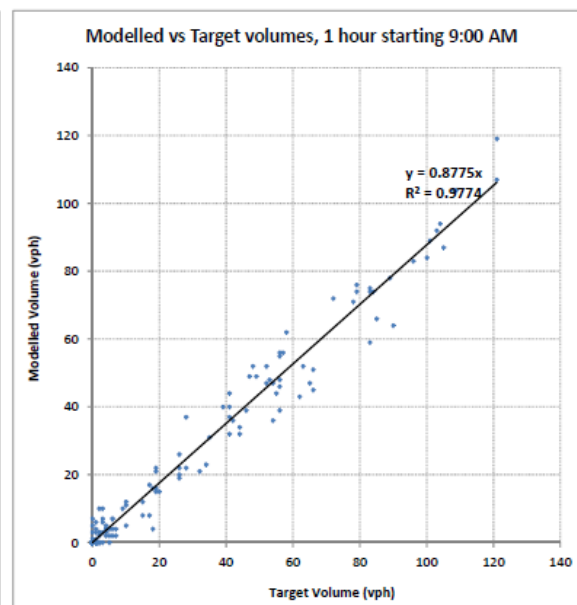
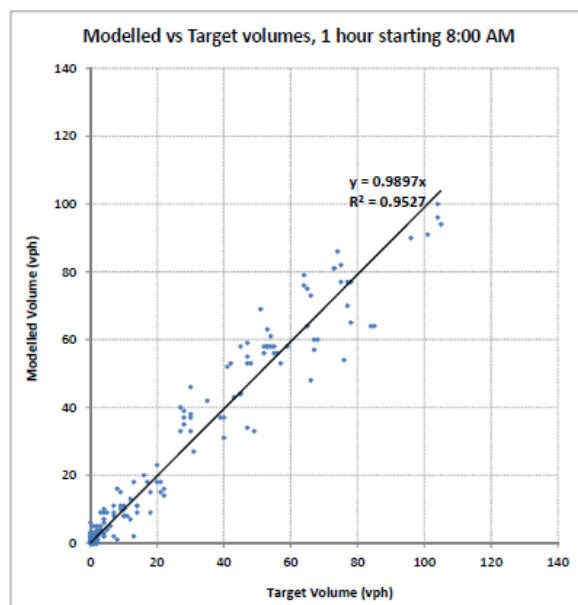
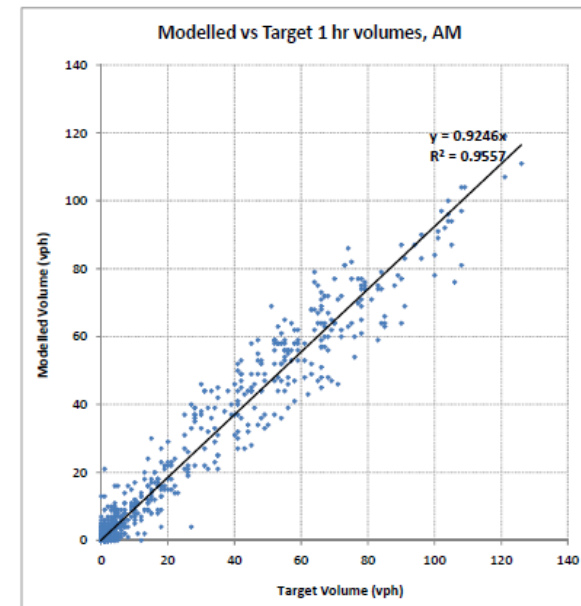
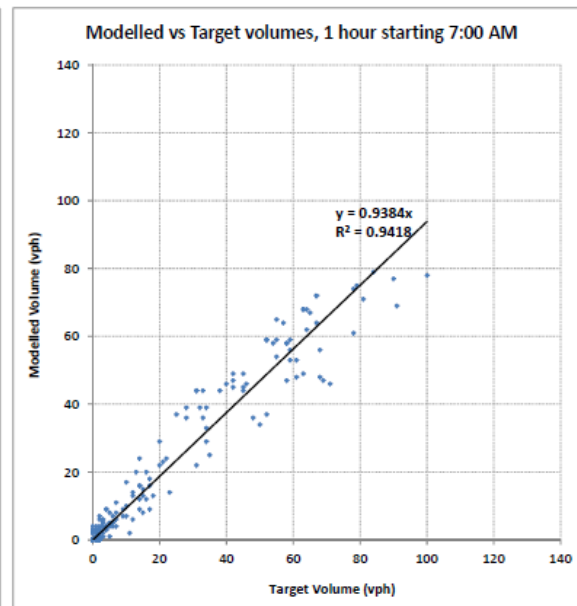
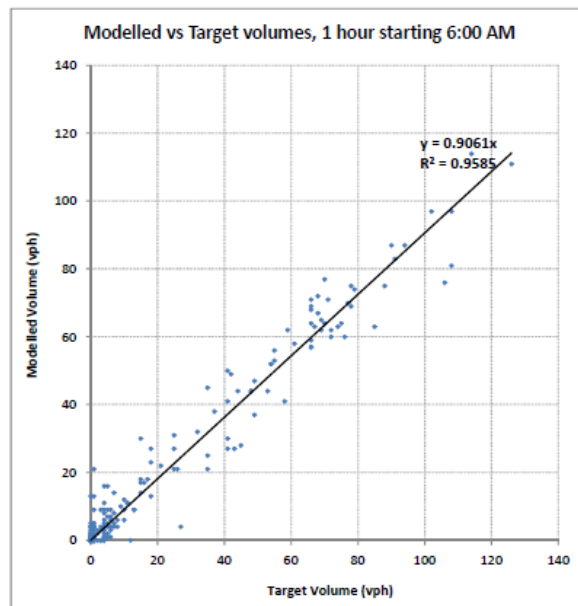
Appendix B. Regression Plots

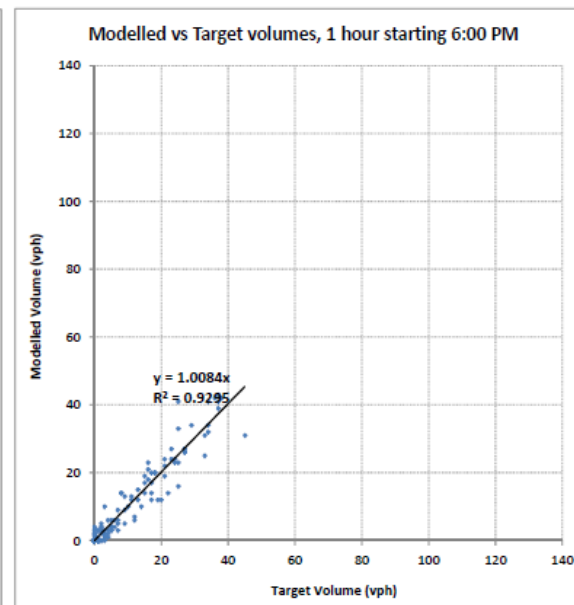
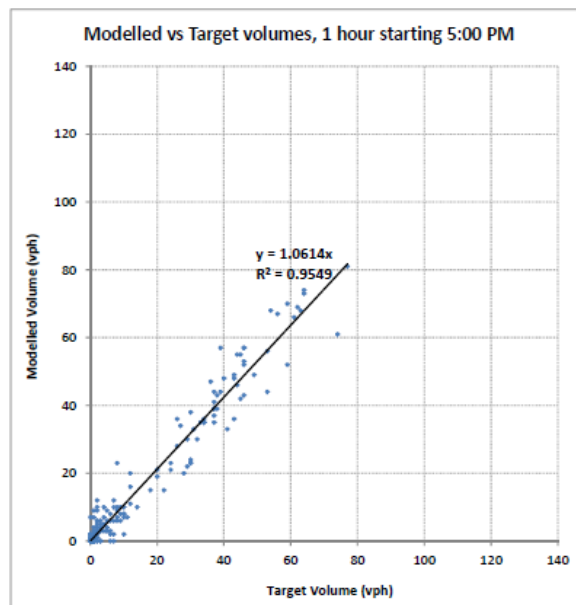
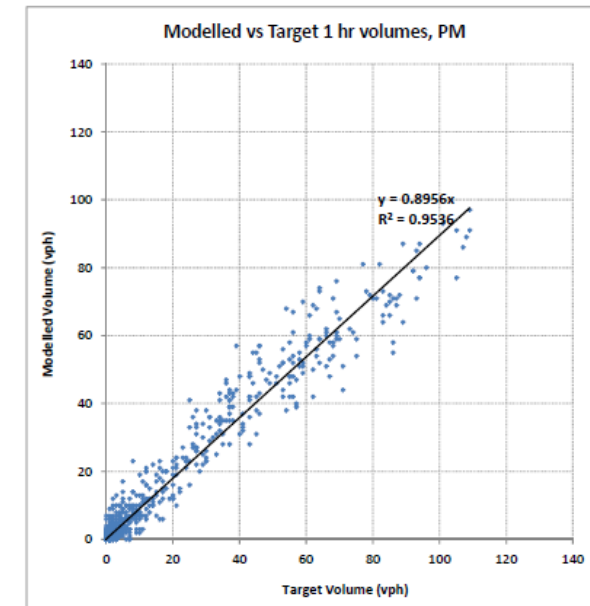
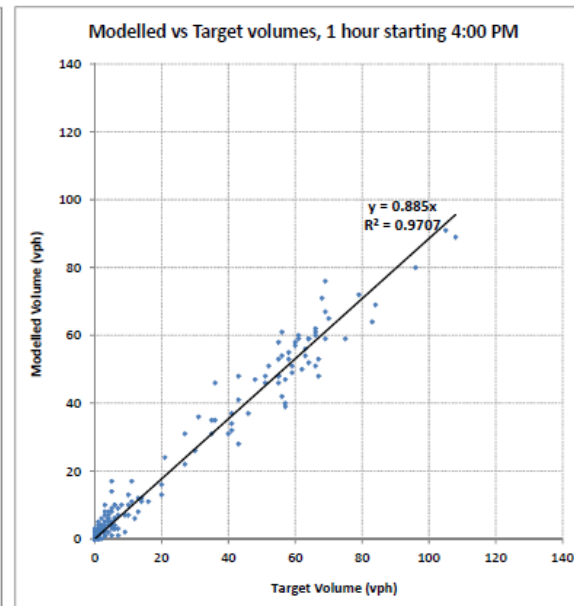
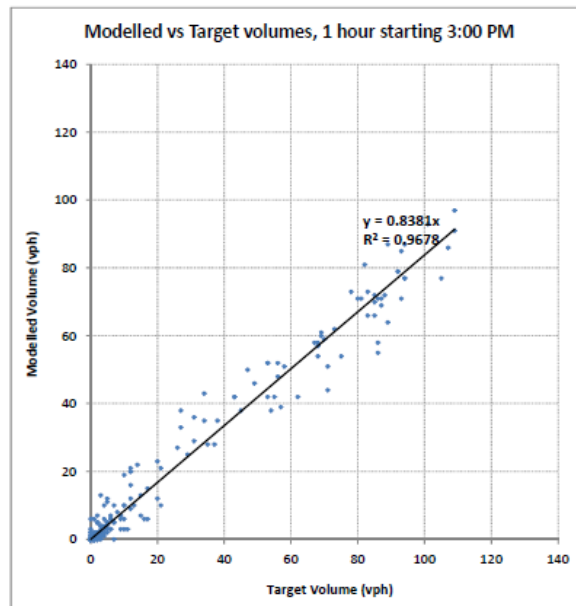












Appendix C. Cumulative counter peak travel time graphs

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

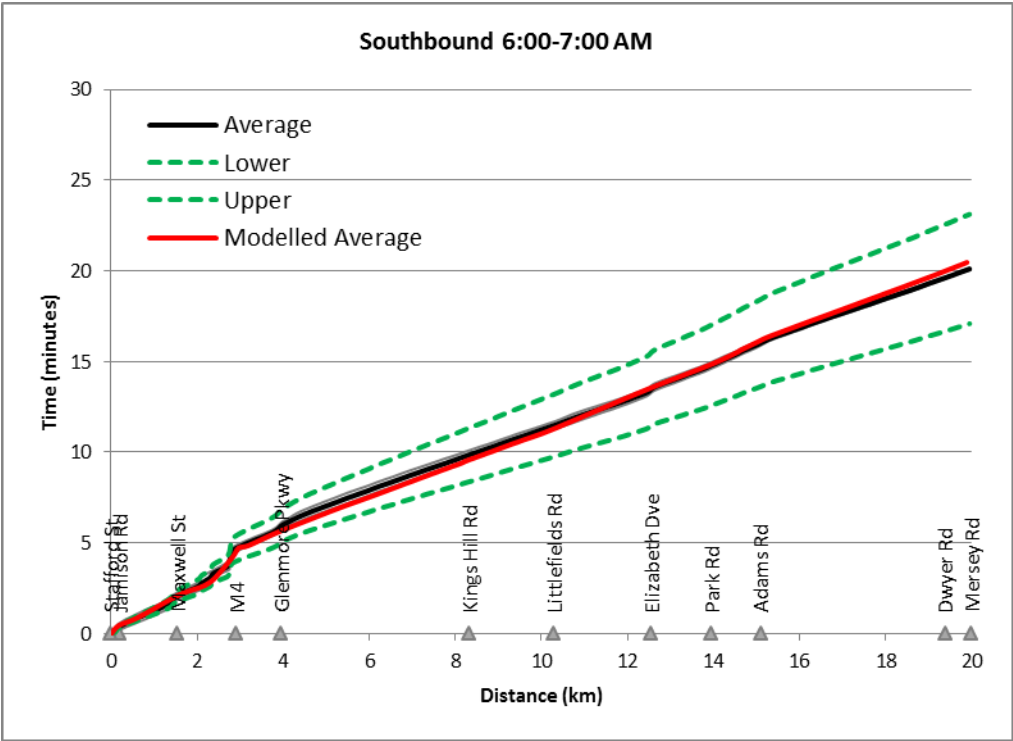


Figure C.2 : Cumulative travel time, model vs observed – counter peak direction, 7am to 8am

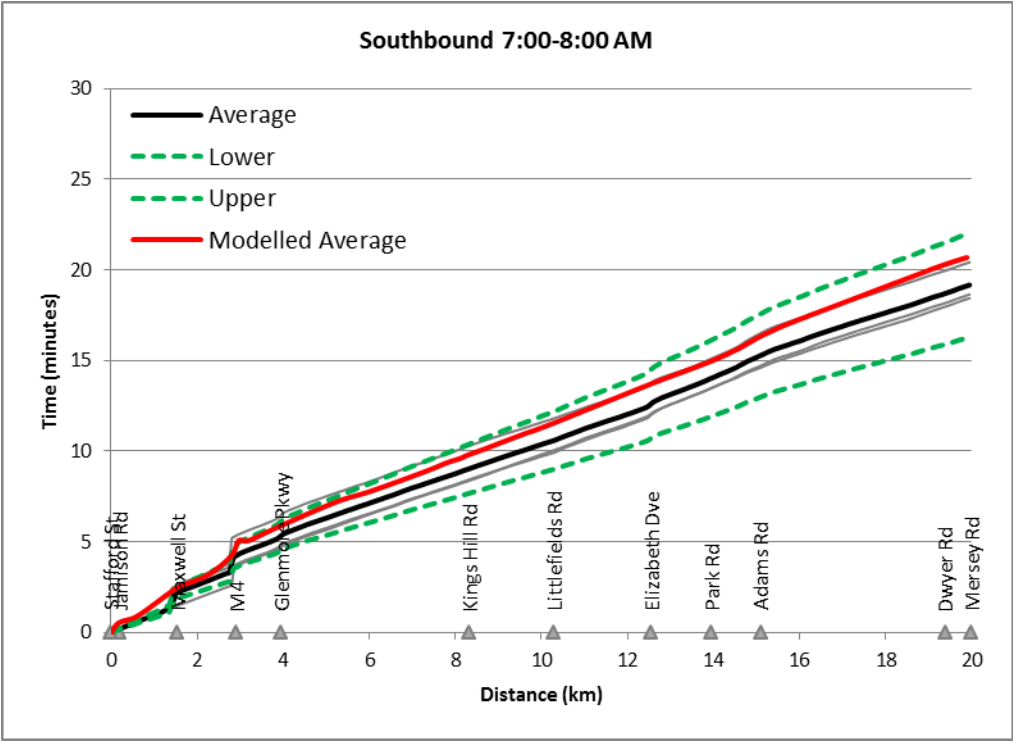


Figure C.3 : Cumulative travel time, model vs observed – counter peak direction, 8am to 9am

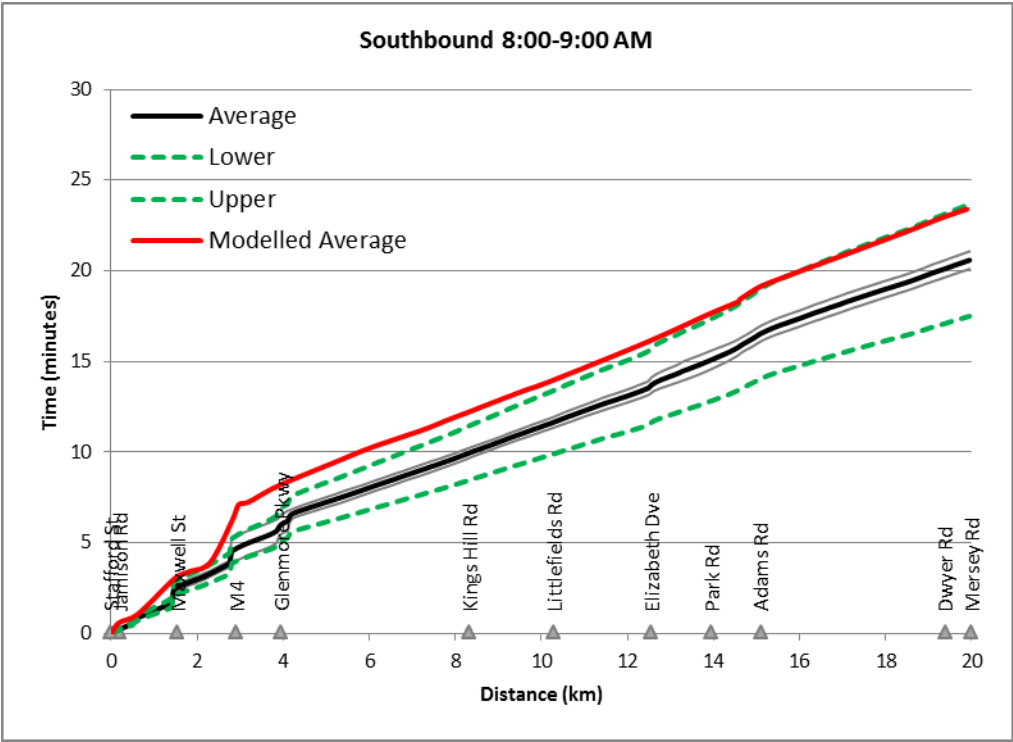


Figure C.4 : Cumulative travel time, model vs observed – counter peak direction, 9am to 10am

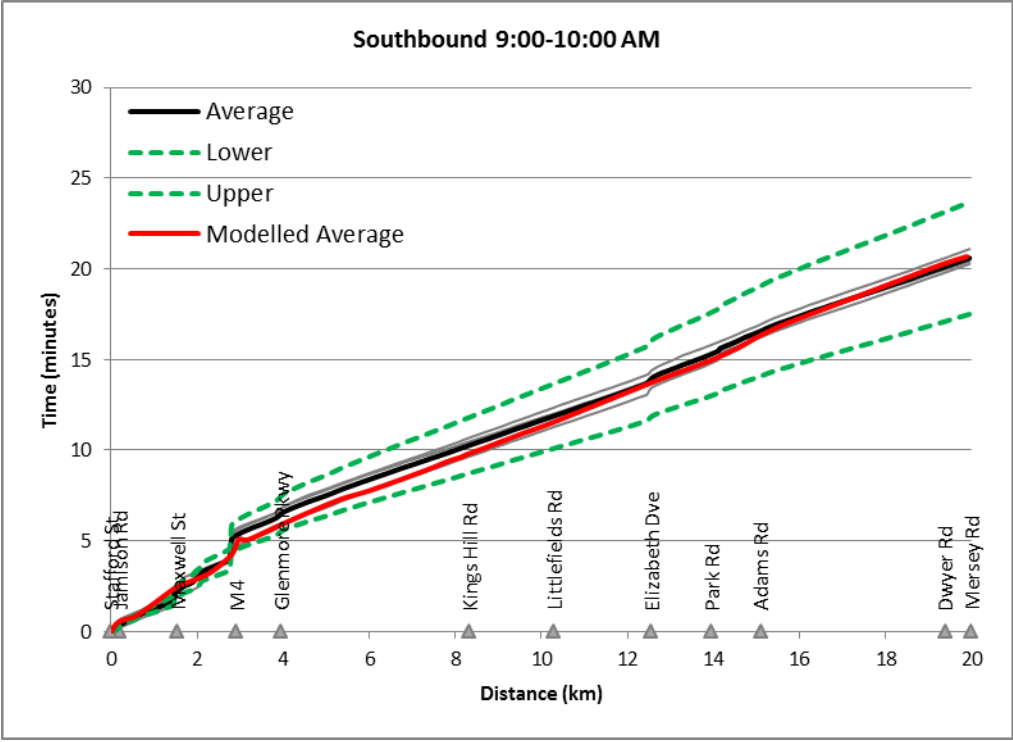


Figure C.5 : Cumulative travel time, model vs observed – counter peak direction, 3pm to 4pm

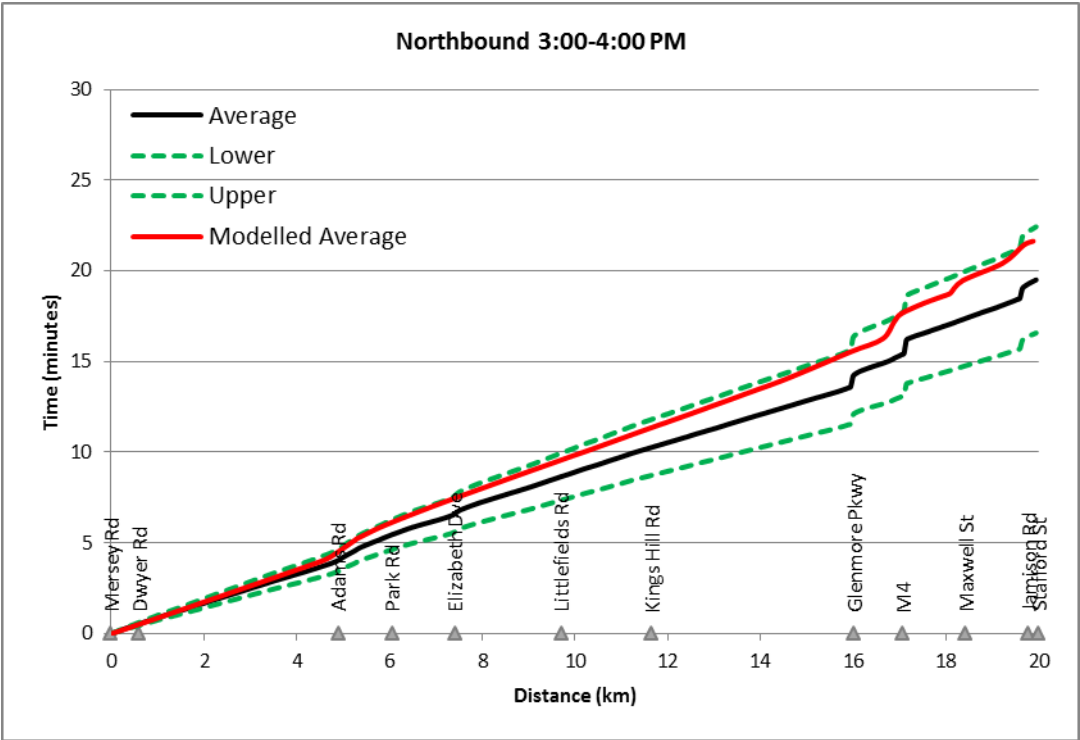


Figure C.6 : Cumulative travel time, model vs observed – counter peak direction, 4pm to 5pm

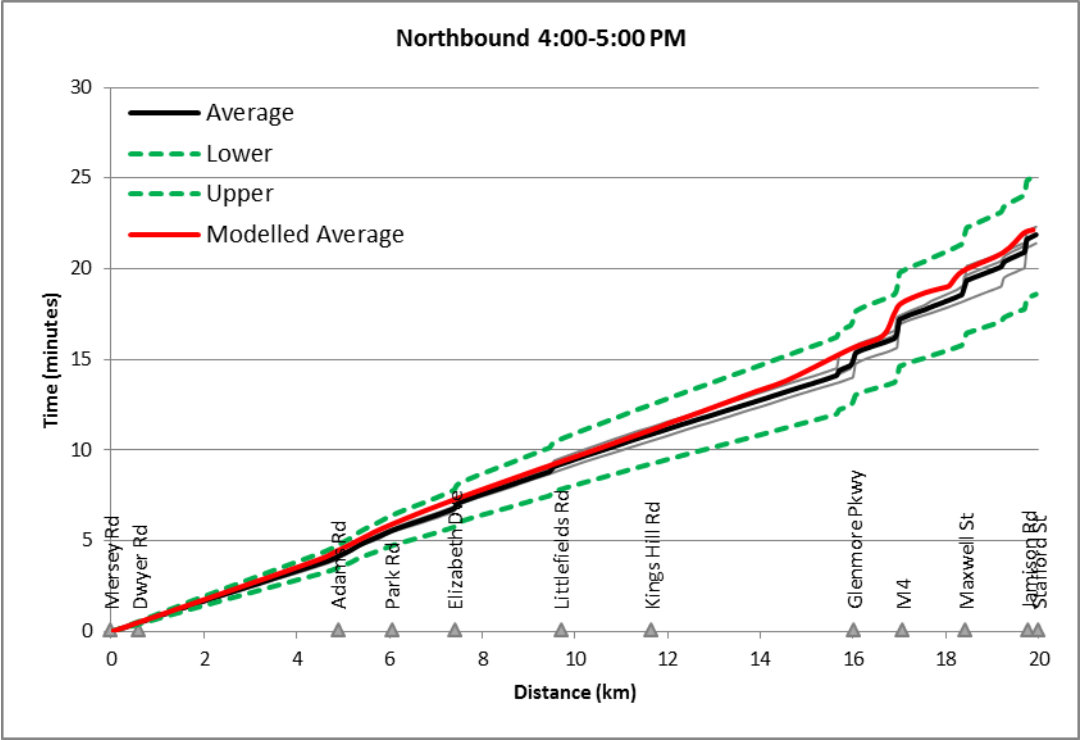


Figure C.7 : Cumulative travel time, model vs observed – counter peak direction, 5pm to 6pm

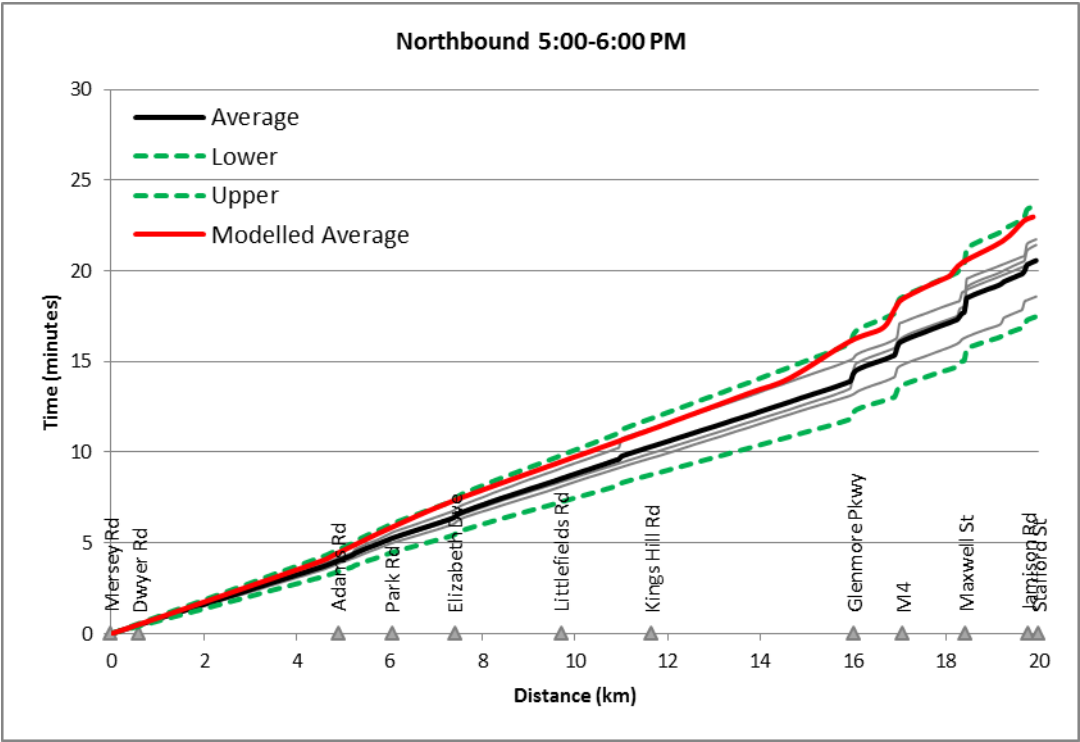
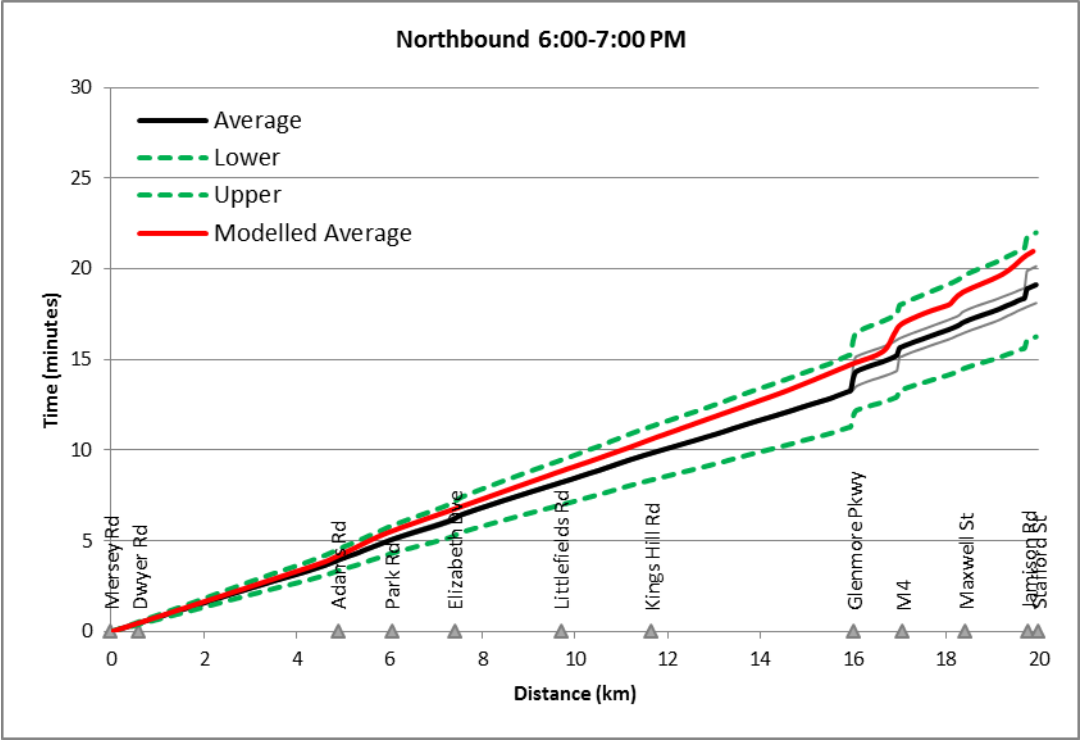


Figure C.8 : Cumulative travel time, model vs observed – counter peak direction, 6pm to 7pm



Appendix C. Elizabeth Drive Technical Note

C.1 Introduction

This technical note presents an assessment of the relative traffic performance on options for provision of connections between Elizabeth Drive and Luddenham (existing The Northern Road) and the realigned and upgraded The Northern Road as part of the upgrade of The Northern Road between Mersey Road, Bringelly and Glenmore Parkway, Glenmore Park. The options considered are:

- Two signalised T-intersections offset by around 500m; and
- 4-way signalised intersection formed by a realignment of Elizabeth Drive

The purpose of this assessment is to identify any differences in the traffic performance of the proposed options.

C.2 Methodology

To assess the relative merits of the proposed 4-way against two signalised T-intersections the following methodology was undertaken:

- Code and optimise 4-way intersection for 2041 horizon year in Aimsun;
- Code and optimise two signalised T-intersections for 2041 horizon year in Aimsun; and
- Cordon out a sub-model area (M12 Motorway to Adams Road) and model both options within this sub-area under micro simulation.

The cordoned out sub-area model is shown below.



C.3 Results

Optimisation of the proposed four-way intersection design determined that the following design changes would be required to achieve Level of Service D or better in 2041:

- Duplication of the right turn bay on The Northern Road (north approach)
- Duplication of the right turn bay on Old Northern Road (west approach)

A comparison of travel speeds along The Northern Road, network statistics including Vehicle Kilometres of Travel (VKT), Vehicle Hours of Travel (VHT), average network speed and overall intersection Level of Service for AM and PM peak is provided in Tables C1 to C4. A summary of network statistics is provided in Table C5.

Table C1: The Northern Road Travel Time and Speed – Adams Road to M12 (2041 AM Peak)

AM Peak	Northbound			Southbound		
	T	Cross	Diff.	T	Cross	Diff.
Travel Time (s)	189.8	181.3	4%	199.4	187.7	6%
Distance (m)	3,230	3,230	0%	3,344	3,344	0%
Average Speed (km/hr)	61.3	64.1	-5%	60.4	64.1	-6%

Table C2: The Northern Road Travel Time and Speed – Adams Road to M12 (2041 PM Peak)

PM Peak	Northbound			Southbound		
	T	Cross	Diff.	T	Cross	Diff.
Travel Time (s)	185.7	192.8	-4%	193.9	194.0	0%
Distance (m)	3,230	3,230	0%	3,344	3,344	0%
Average Speed (km/hr)	62.6	60.3	4%	62.1	62.1	0%

Table C3: Overall Intersection Level of Service (2041 AM Peak)

AM Peak	Average Delay (sec)		LoS	
	T	Cross	T	Cross
The Northern Road/Elizabeth Drive	49	46	D	D
The Northern Road/Park Road	35	-	C	-

Table C4: Overall Intersection Level of Service (2041 PM Peak)

PM Peak	Average Delay (sec)		LoS	
	T	Cross	T	Cross
The Northern Road/Elizabeth Drive	41	55	C	D
The Northern Road/Park Road	35	-	C	-

Table C5: Network Statistics

Total	AM Peak			PM Peak		
	T	Cross	Diff.	T	Cross	Diff.
Vehicle Kilometres of Travel (VKT)	106,129	105,539	1%	128,402	127,436	1%
Vehicle Hours of Travel (VHT)	1,735	1,634	6%	2,155	2,137	1%
Average Network Speed (km/hr)	61.2	64.6	-6%	59.6	59.6	0%

C.4 Summary and Conclusion

Analysis of the traffic performance of the proposed two signalised T-intersections and 4 way intersection shows that there is minimal difference between either options under the 2041 forecast year.

Based on the tables presented in Section C.3, overall traffic performance would be very similar between two signalised T-intersections option and one 4-way intersection. The two signalised T-intersections provide better intersection Level of Service due to the less complex phasing required to operate the two signalised T-intersections when compared with a single cross, however these cannot be directly compared. While the individual levels of service at each of the individual T-intersections (LOS C) appears better than the overall performance of the 4 way intersection (LOS D), the level of service is based on average delays and this result indicates that motorists on average experience slightly less delay at each of the T-intersections than they would at the one 4 way intersection. For any motorist that was travelling through both the T intersections, the overall delay would (on average) be greater than for the individual 4 way intersection.

Analysis of travel speed along The Northern Road indicates that average travel speeds would be higher under the 4-way intersection option than 2 T-intersections option in the morning peak but lower in the evening peak. In the morning peak with less traffic volume the 2 T-intersections option causes more stops with 2 intersection delays while in the evening peak with more traffic volume the 2 T-intersections option provide more capacity causing less congested delays compared to the 4-way intersection option.

The comparative performance of the two options depends largely on the volume of traffic travelling from Elizabeth Drive to the existing The Old Northern Road (east to west) and from the existing The Northern Road to Elizabeth Drive (west to east). Current traffic forecasts show that this movement is comparatively low.

Based on this analysis, either option would perform acceptably under the forecast demand, however the cross-intersection would perform better from an overall network perspective. The difference in traffic performance between the two options is small and may be outweighed by other factors such as community consideration, traffic signal operational factors, constructability, property impacts or cost.

While it is understood there was an overall community preference for less traffic signals located along The Northern Road, there are a multitude of other factors (as identified above) that require consideration. These factors will be considered further by the project team and would be the subject of further reporting.