New crossing of the Clarence River at Grafton

Traffic study report

DECEMBER 2009

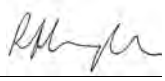
RTA/Pub. 09.552 ISBN 978-1-921692-61-1

Grafton Bridge

Traffic Study Report

Client: RTA – Northern Region
Reference: HS11120
GTA Consultants Office: Sydney

Quality Record

Issue	Date	Description	Prepared By	Checked By	Approved By
A	16/12/09	Final	Robert Dus	Reece Humphreys	
B	17/12/09	Revised Final	Robert Dus	Reece Humphreys	

GTAconsultants
20 years 1989-2009
Certified System Quality ISO 9001
MELBOURNE • SYDNEY • BRISBANE • CANBERRA
www.gta.com.au

Executive Summary

Grafton City is located within the Clarence Valley Council area in New South Wales that covers over 100,000 sq km with a population of approximately 50,000 people. The existing river crossing in Grafton was first opened to vehicle traffic in 1932.

The approaches to the bridge are generally four lane carriageways (two lanes in each direction) which merge to one lane in each direction over the Clarence River. The single lane and other geometric constraints result in large queues and delays on the approach to the bridge during the morning and afternoon peak periods.

Counts undertaken in June 2009 indicate that the weekday average volume across the Clarence River is approximately 27,000 vehicles per day. The report entitled *'Additional Crossing of the Clarence River'* (2003) indicated that in 2001 the northbound movement exceeded its capacity during the peak periods.

Origin destination surveys completed by GTA Consultants indicate that 53% of trips using the Grafton Bridge travel between external destinations and Grafton, 45% of trips are internal whilst only 2% of trips are those travelling directly through Grafton.

This report sets out the results of the modelling and analysis assuming the current road network and shows the likely traffic outcomes if no additional river crossing capacity is provided.

Regional and microsimulation modelling of Grafton and its surrounds has been undertaken to develop an understanding of the existing and future traffic demands and patterns within Grafton. In particular, future demands across the river have been estimated for a range of land use futures.

Figure 1: Grafton Bridge Traffic Study – Study Area

(Source: google.com.au)

A growth rate of 1.9% per annum has been adopted for testing purposes to the year 2039, along with strategic model sensitivity testing for various other growth rates.

The strategic model shows the following:

- Traffic demands across the river will increase significantly in the next 20 to 30 years.
- Additional river crossing capacity will be required in future to accommodate the additional demand. Doing nothing will lead to unacceptable road network operating conditions.
- The year in which the bridge capacity is reached, additional capacity is required and the period over which a duplicated river crossing maintains acceptable operating condition depends on the actual growth rate in coming years.
- Irrespective of the growth rate assumed, traffic growth will be such that it will adversely affect the amenity of the Grafton township in the future if it continues to pass through the town centre.
- Options to create an alternative route(s) to divert much or all of this future traffic growth should be considered to protect the vitality of the central commercial and retail areas.
- The additional growth will be significant and will require careful planning in terms of local road connections north and south of the river.

The conclusions of the modelling exercise are that doing nothing is not an option as it will lead to extended periods across the day where the existing bridge operates at or beyond saturation levels, with unacceptable vehicle delays and queuing.

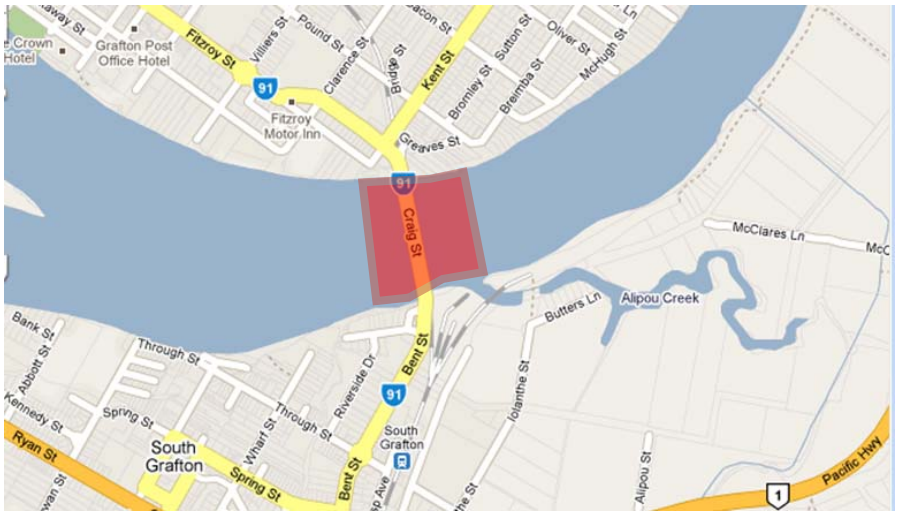
The microsimulation modelling confirms the following network outcomes are likely:

- Increased delays.
- Increased travel times.
- Localised congestion within the townships of Grafton and South Grafton.
- Increased queues on the approaches to key intersections.
- Peak spreading outside each of the peak periods.
- Queue lengths encroaching onto the Pacific Highway.

To be considered:

- An additional bridge crossing in the approximate locality shown in Figure 2, and
- Road approaches to determine the optimum location and impact on movement of traffic in and around Grafton and South Grafton

Figure 2: Grafton Bridge Traffic Study – Approximate Bridge Crossing Locality



(Source: google.com.au)

Table of Contents

Appendices

Figures

Tables

1. Introduction

1.1 Background

Grafton City is located within Clarence Valley Council area in New South Wales which covers over 100,000 sq km with a population of approximately 50,000 people. Grafton township has a population of approximately 17,000[1] and is strategically located on Pacific Highway between Sydney and Brisbane. Grafton functions as a sub-regional centre providing a focus for services to the Clarence Valley community.

The existing river crossing in Grafton was first opened to vehicular traffic in 1932. Grafton City Council began investigations regarding a second river crossing in 1960 with the Department of Main Road (DMR) advising at that time that the new bridge location would be adopted linking Fitzroy Street to Bent Street.

The approaches to the bridge are generally four lane carriageways (two lanes in each direction) which merge to one lane in each direction over the Clarence River. The single lane and other geometric constraints result in large queues and delays on the approach to the bridge during both the morning and afternoon peak periods.

GTA Consultants has been commissioned by the Roads and Traffic Authority (Northern Region) to undertake regional transport model and microsimulation model of Grafton and its surrounds, to develop an understanding of the existing traffic demands and patterns within Grafton.

1.2 Study Objectives

The objectives of the study are as follow:

- Obtain an understanding of the following items (both within the Grafton township and at a wider regional level):
  - existing transport demand
  - existing travel patterns
  - existing traffic flow
  - existing traffic constraints.
- Forecast future year travel demands, taking into consideration future developments and network growth.
- Identify any recommendation for improvements in the operation of the adjacent road network.

The output of this report is the result of the planning investigation including a comparison of the tested options and the degree to which they achieve the study objectives in terms both quantitative and qualitative measures.

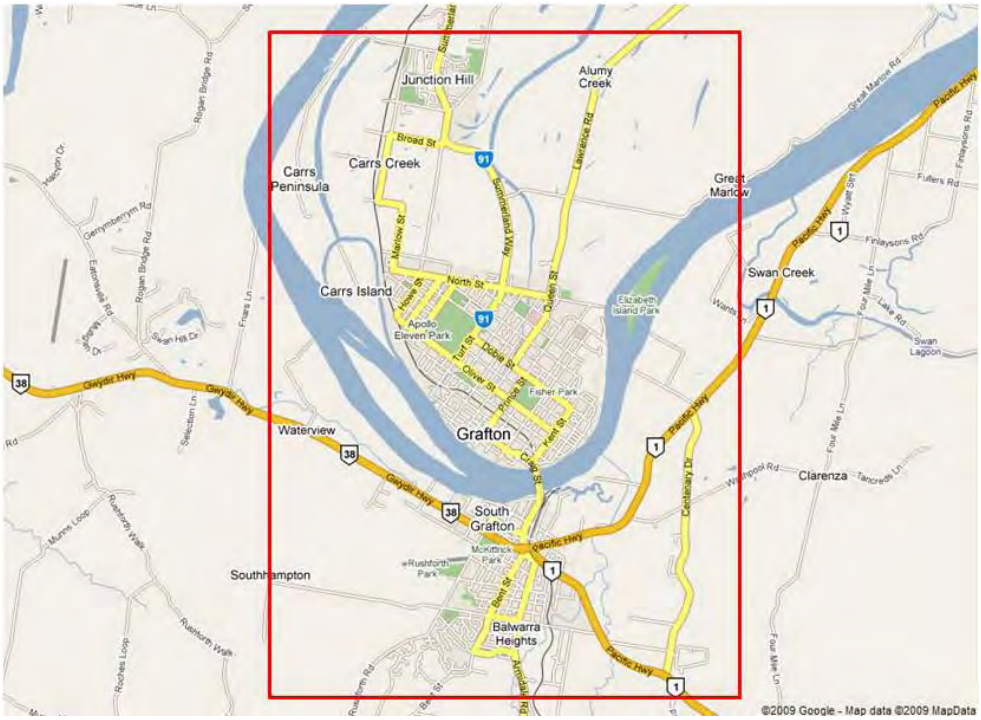
[1] ABS Census Data 2004

2. Existing Conditions

2.1 Transport Model Area

The study area is located within Grafton in New South Wales and is characterised by a wide variety of land use including residential, commercial and recreational uses. The area includes the existing bridge crossing of the Clarence River which connects Grafton and South Grafton. The extent of the study area, which corresponds roughly with the transport model area, is shown approximately in Figure 2.1.

Figure 2.1: Grafton Bridge Traffic Study – Study Area



(Source: google.com.au)

2.2 Microsimulation Road Network

For the purpose of the detailed analysis, the boundary of the existing conditions models includes all roads and intersections in the corridor, inclusive of any vehicle queuing on the approaches to each of the intersections. The extent of the corridor modelled area was also selected to adequately deal with existing and future year options testing in terms of vehicle queue lengths. The main study area included the centre of South Grafton and Grafton to include the Grafton Bridge, Fitzroy Street, Prince Street, Oliver Street and the following key intersections:

- Fitzroy Street / Prince Street
- Prince Street / Pound Street
- Fitzroy Street / Villiers Street
- Pound Street / Villiers Street.

The extent of the microsimulation model area is shown in Figure 2.2.

Figure 2.2: Grafton Bridge Traffic Study – Microsimulation Model Study Area

(Source: google.com.au)

Existing conditions information and traffic volume data was based on comprehensive surveys and site observations undertaken throughout the study area and supplemented with additional data sourced from the RTA and previous studies. Table 2.1 summarises the existing carriageway characteristics for the main roads within the study area.

Table 2.1: Grafton Bridge Traffic Study – Main Road Network Characteristics – Study Area

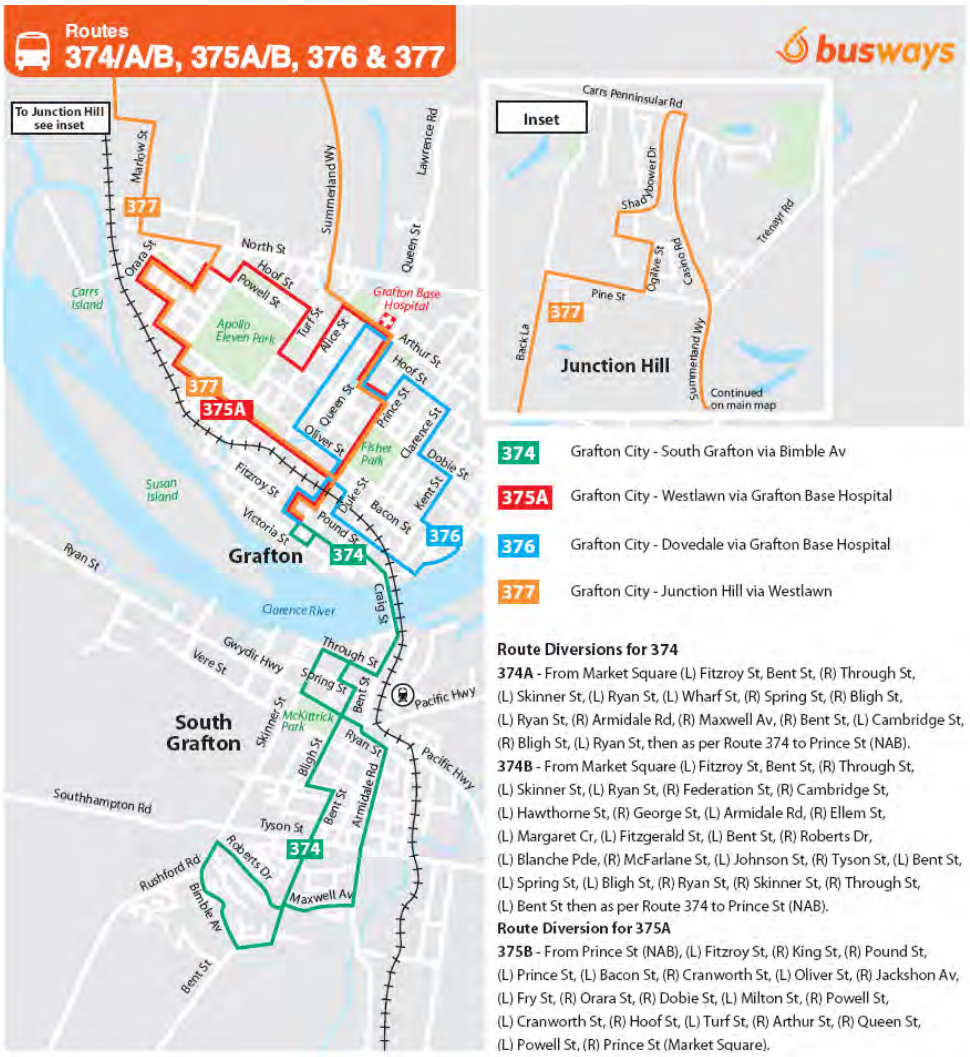
Road Name	Road Classification	Approx Carriageway Dimension (m)	Existing Daily Traffic Volume (veh)[2]	Parking
Pacific Highway	National Highway	7.0	8,100	No kerbside Parking
Ryan Street	State Road	10.0	2,400	No Kerbside Parking
Bent Street	State Road	16.0	27,000	Kerbside parking generally not permitted
Craig Street (Grafton Bridge)	State Road	6.5	27,000	No kerbside Parking
Fitzroy Street	State Road	14.0	11,500	60 degree parking between Duke and Prince
Prince Street	State Road	20.0	6,300	60 degree parking within the study area
Villiers Street	Local Road	13.0	9,500	kerbside parking

[2] Based on the peak hour traffic counts and assuming a peak-to-daily ratio of 10%.

2.3 Public Transport

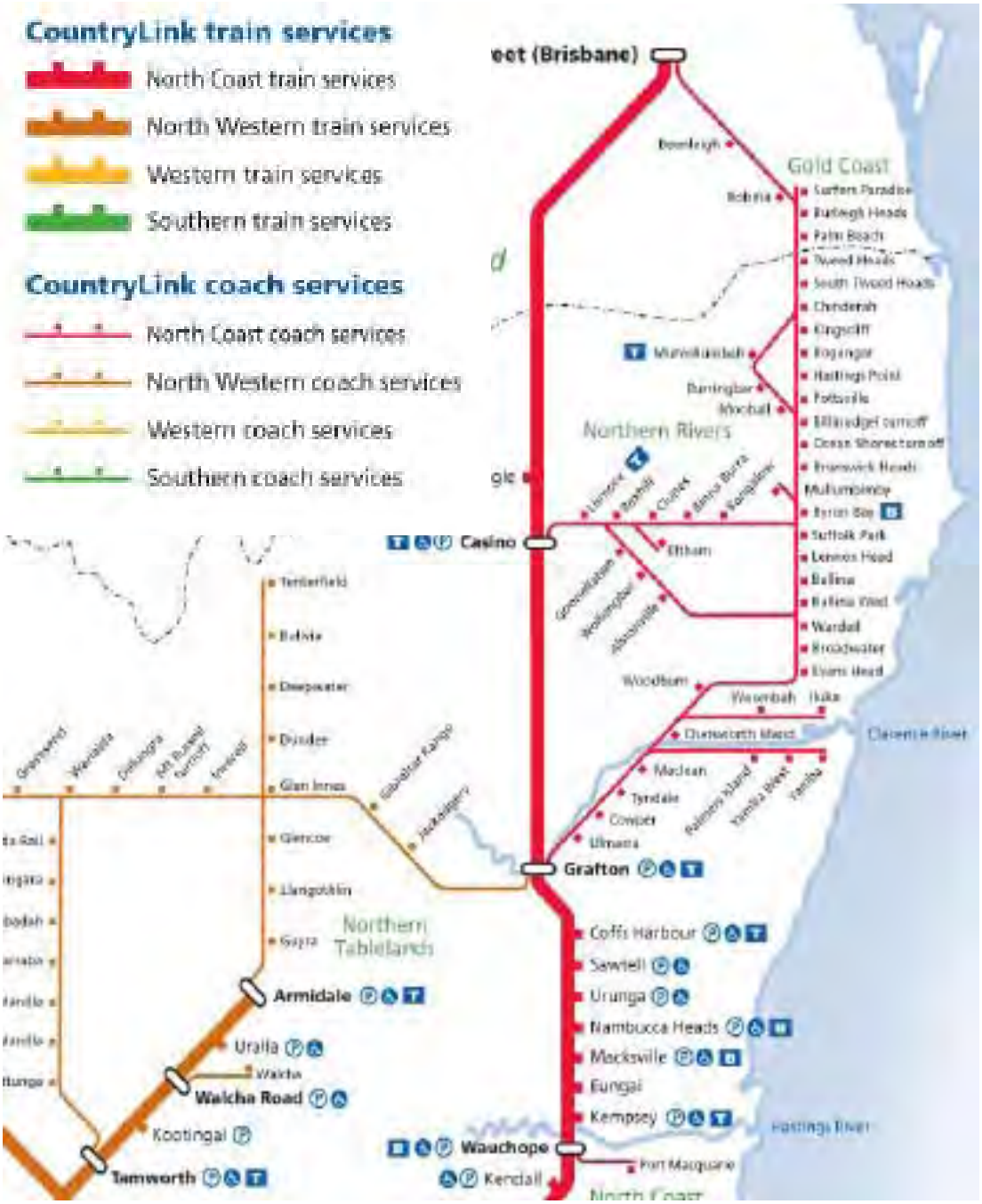
Figure 2.3 shows the existing public transport routes within the Grafton and South Grafton area.

Figure 2.3: Grafton Bridge Traffic Study - Public Transport Map



The Grafton railway station is located in South Grafton on Through Street, east of Bent Street. Daily train services operate to Sydney and Brisbane with additional coach services to Moree. Figure 2.4 illustrates the train line that services Grafton and its surrounds.

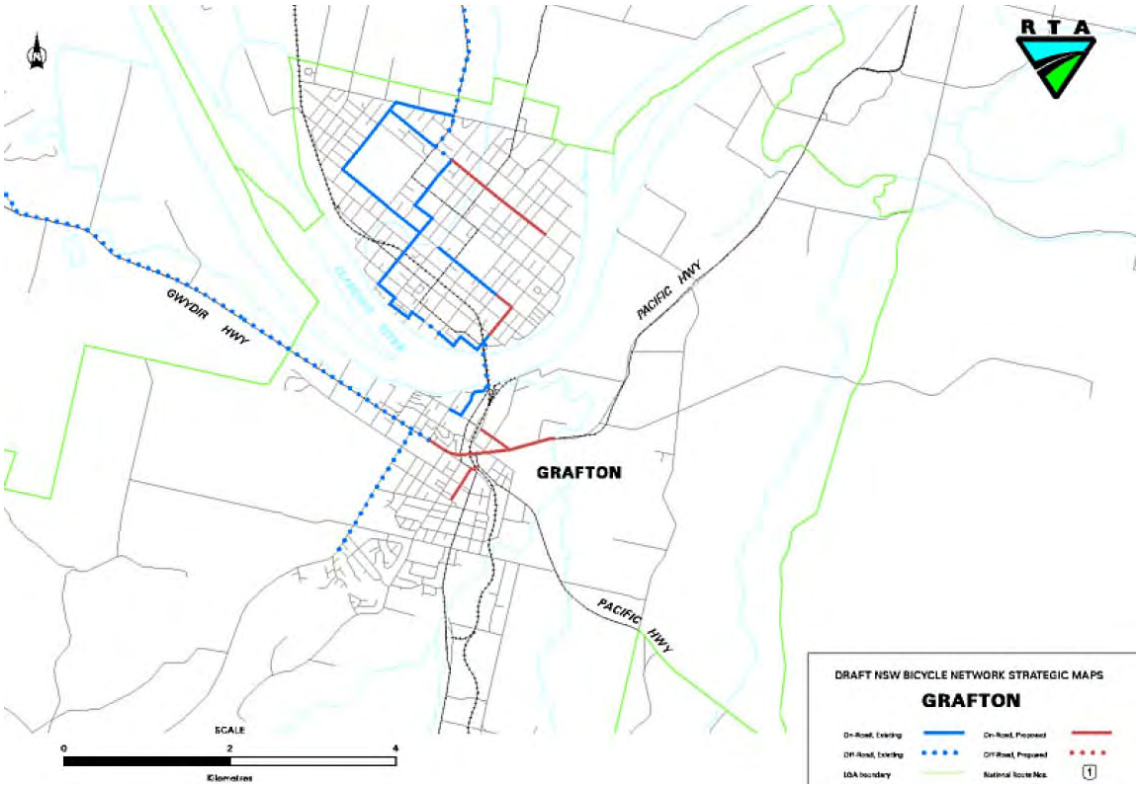
Figure 2.4: Grafton Bridge Traffic Study – Train Services Map



2.4 Pedestrian and Cyclists

Draft bicycle network maps have been sourced from the RTA. Figure 2.5 illustrates the existing and proposed bicycle facilities within the study area.

Figure 2.5: Grafton Bridge Traffic Study – Existing and Proposed Bicycle Facilities



3. Reference Documents

3.1 Summary of Previous Reports

This section deals with previous reports, relevant outputs, recommendations and constraints relevant to this study.

'Northern Rivers Regional Strategy, Clarence Valley Settlement Strategy', Various Councils in association with the Department of Urban Affairs and Planning, March 1999

The *Clarence Valley Settlement Strategy* was a sub-regional joint planning project forming part of the Northern Rivers Regional Strategy. The project involved a valley-wide strategic approach to future planning by the Councils of Copmanhurst, Grafton, Maclean, Nymboida and Ulmarra in conjunction with the Department of Urban Affairs and Planning.

The strategy provides a vision of how the Clarence Valley can grow sustainably over the next 20 years. It sought to locate population growth in areas which would have the least costs in environmental, social and economic terms.

'Additional Crossing of the Clarence River', RTA, February 2003

Business owners commenced campaigning for a second river crossing in 2001. This report notes the additional crossing of the Clarence River and the need for an additional link over the Clarence River to improve connectivity between Grafton and South Grafton. The existing bridge was opened to vehicular traffic in 1932 and initial correspondence with relation to a second crossing dates back to 1960. The purpose of this RTA study was to:

- "Identify broad strategic locations between Seelands and Maclean for an additional crossing of the Clarence River.
- Determine the traffic, community, environment and engineering impacts for each of the strategic locations.
- Identify the broad strategic locations that are feasible for an additional crossing."

As part of the study, a community questionnaire was conducted with some 1,900 responses received. The responses included 73% of persons having experienced delays on the bridge either daily (37%) or weekly (36%).

The study also recorded travel times for the section of Bent Street between the Gwydir Highway (Ryan Street) and Villers Street in various peak and off-peak periods. In the AM peak period, the northbound travel time tripled the off-peak travel time, with the southbound travel time doubling its off-peak travel time in the PM peak period.

The report states that surveys in 2001 indicated the practical lane capacity of the bridge (one way) as 1,400vph, or 350 vehicles in a 15 minute period. The counts recorded as part of the study in 2001 were such that the northbound movement exceeded capacity, with 1,450 vehicles observed in the road network during the AM peak hour.

The study indicates the most feasible location for an additional river crossing would be in the vicinity of the existing bridge.

'South Grafton Heights Precinct, a Strategy for the Future' Clarence Valley Council, June 2007

The report indicates that Grafton may reach a population of approximately 18,350 around 2016 following urban infill and additions to the existing residential zone. Grafton will continue to be a major commercial activity centre, fulfilling the role of sub-regional administrative centre for State Government.

One of the strategies highlights the need to revitalise the South Grafton CBD, which would reduce pressure on the existing bridge by providing more efficient services to valley residents living south of the river. Population data indicates a substantial population south of the river, which represents a catchment for more retail services in South Grafton. Therefore, any further commercial developments should be in the area bounded by Ryan Street, Bent Street, Cowan Street and the Clarence River.

'South Grafton Traffic Study', GTA Consultants, February 2009

The report sets out an assessment of the existing conditions for the South Grafton area and assesses expected future traffic conditions. It concludes that the Grafton Bridge is the 'bottle neck' resulting in congested conditions within South Grafton, especially during the AM peak period. If no changes were to be introduced to the existing road network travel times, queuing will progressively increase and the network will become more vulnerable to blockages or grid lock caused by the additional traffic demand.

A number of options are assessed, including increased bridge capacity. The results of the microsimulation modelling indicates that those options will provide marginal benefits to the operating performance of the network, predominantly due to the constraints experienced at the Grafton Bridge.

'Mid North Coast Regional Strategy 2006-2031', NSW Government Department of Planning, March 2009

The primary purpose of the Regional Strategy is to ensure that adequate land is available and appropriately located to accommodate the projected housing and employment needs of the region's population over the next 25 years. The strategy sets the policy to govern where and how growth can occur.

4. Study Methodology

4.1 Methodology Summary

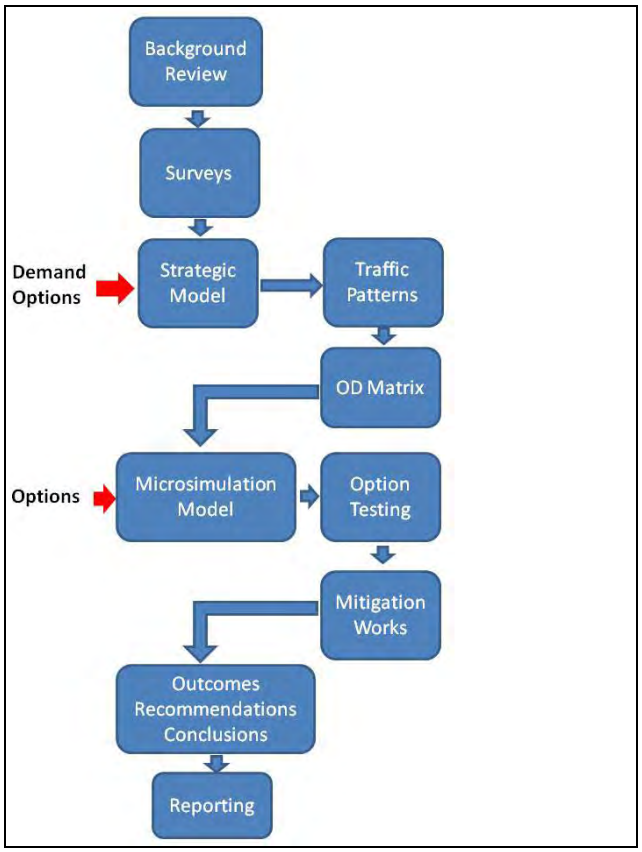
The study approach was designed to address both strategic and local operational issues. This section gives a broad outline of the methodology adopted with more detailed discussion of each of the two models contained in the sections that follow.

Strategic modelling using Cube TRIPS was focused on future demands and how the demands are expected to change as a result of land use and economic development, both within Grafton and the broader region of Clarence. These demands changes were then used to arrive at future demands across the river and to define broad traffic pattern changes.

Detailed microsimulation modelling using Q- Paramics was concerned with the road network assessment in order to provide key indicators for each option such as link flows, intersection turning movements, congestion levels and travel times.

Figure 4.1 provides a flow chart setting out the overall study methodology.

Figure 4.1: Grafton Bridge Traffic Study - Study Methodology



The study methodology is designed to be flexible and iterative to ensure that the best modelling outcomes are achieved.

5. Existing Traffic Demands

5.1 Introduction

Traffic information for the study was obtained from numerous sources including the RTA, Clarence Valley Council, previous reports and studies and surveys undertaken as part of this study. The data was sourced for the weekday morning and evening peak periods and included the following:

- traffic movement counts
- origin-destination surveys
- automated traffic counts
- travel time surveys
- site observations.

The surveys recorded data for a typical week spanning five days to provide an accurate representation of the existing traffic movements. Details of the traffic information used for this study are set out in the following sections and summarised in Table 5.1.

Table 5.1: Sources of Traffic Volume Data

Source	Type of Data	Date
Traffic Volume Data for Hunter and Northern Regions 2004, RTANSW	Annual Average Daily Traffic at key locations along State Highways	1982 to 2004 (data for each site varies)
Additional Crossing of the Clarence River , Feasibility Study Report, February 2003, RTANSW	Turning Movement Count Data at key intersections surrounding the bridge.	2000 / 2001
Surveys undertaken by AusTraffic on behalf of GTA Consultants as part of the South Grafton Paramics model, 2007 / 2008	Turning Movement Data and Origin Destination Data	2007
Traffic Volume data supplied by Clarence Valley Council (numerous sites)	Two-way daily traffic volume counts at numerous sites across the study area. Data also includes limited average speed data	2006-2009

5.2 Turning Movement Counts

Turning movement surveys at various intersections were conducted in November 2007 as part of the South Grafton Traffic Study. These counts have been supplemented by turning movement counts conducted on 11 March 2009, during the AM and PM periods, at the following intersections:

- Fitzroy Street / Prince Street
- Prince Street / Pound Street
- Fitzroy Street / Villers Street
- Pound Street / Villiers Street.

Details of the turning movement counts are located in Appendix A.

5.3 Origin Destination Surveys

Origin-destination surveys were undertaken during the AM and PM periods on 11 March 2009 to ascertain an understanding of the traffic patterns throughout the study area, and to provide a starting point for the matrix estimation. The origin-destination stations were set up at the following locations:

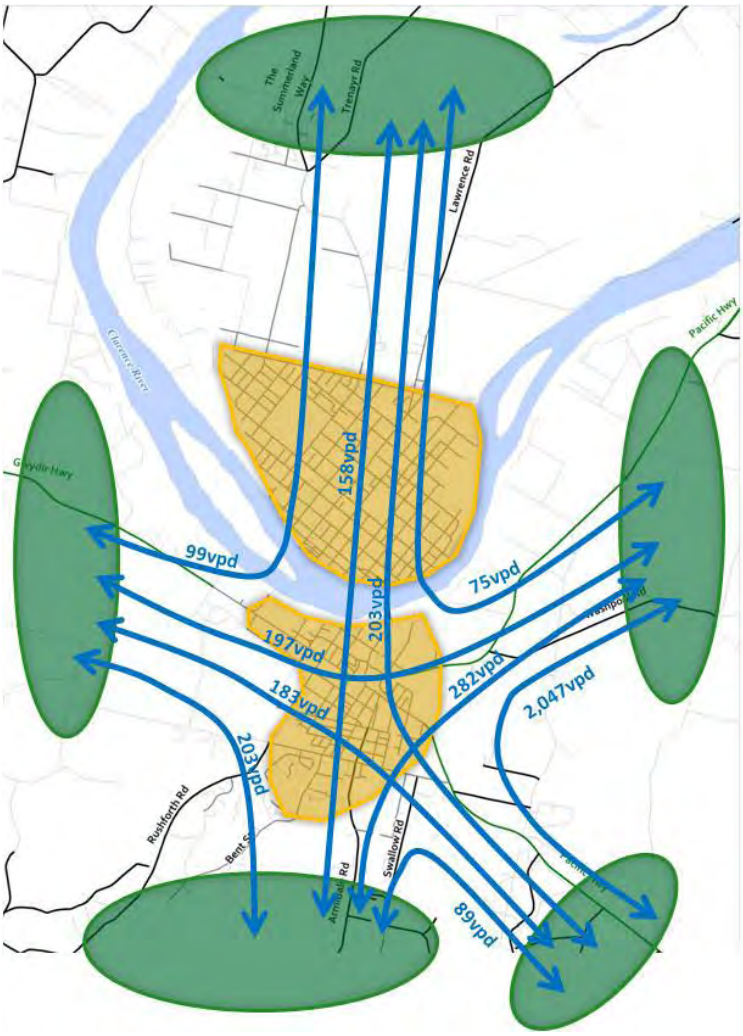
- Pacific Highway - south of Centenary Drive
- Bent Street - south of Vere Street
- Grafton Bridge
- Summerland Way - north of Carrs Peninsular Road
- Gwyrdir Highway - west of the South Grafton township
- Lawrence Road - north of North Street.

This discussion below collates the results of the origin-destination surveys and summarises the existing traffic flows through, to/from and within the study area. The factor to convert the peak period (7-9am) trips to daily trips is 7.57 as derived from the 2009 surveys, meaning that the two hour peak period between 7am and 9am represents 13.2% of the daily flow and the one hour period between 8am and 9am 8.1%.

External to External Trips (i.e. through traffic)

Vehicle movements across the bridge without stopping in Grafton or South Grafton were obtained from the origin-destination surveys. Figure 5.1 shows the existing external to external traffic movements including those that cross the Grafton Bridge. These trips do not have an origin or destination within Grafton or South Grafton.

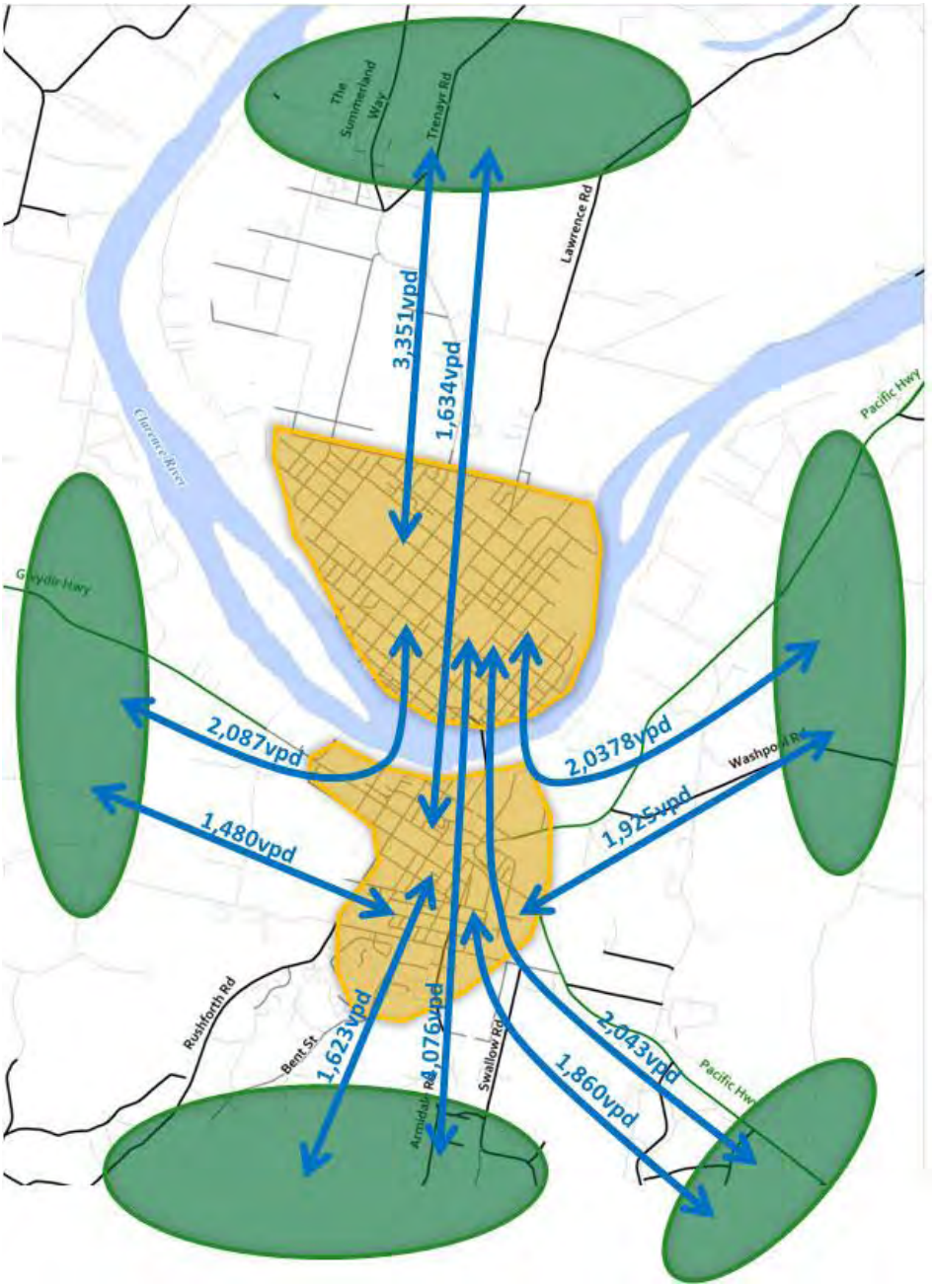
Figure 5.1: Grafton Bridge Traffic Study – Existing Daily Traffic through Movements across the River



External to Internal

Vehicle movements using the Grafton Bridge from external locations travelling to either Grafton or South Grafton were also obtained from the origin-destination counts and are shown in Figure 5.2.

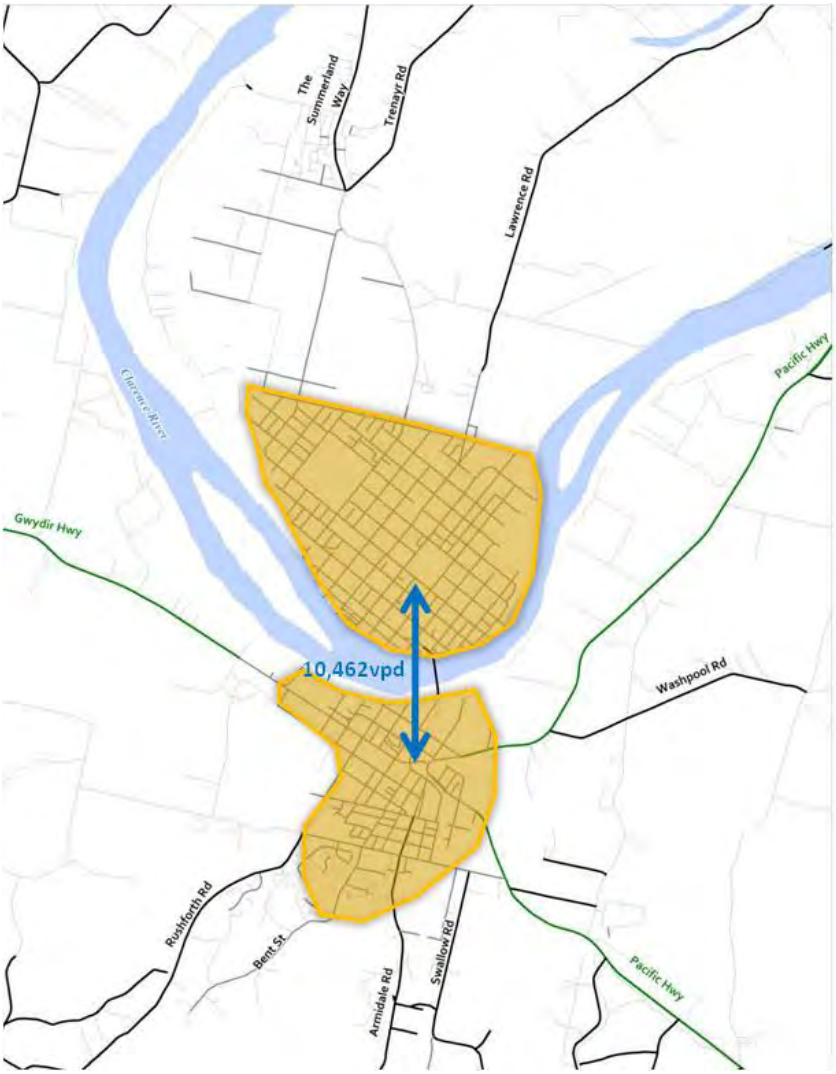
Figure 5.2: Grafton Bridge Traffic Study –Existing Daily Traffic To/From Grafton across the River



Trips within Grafton

The bridge carries a significant amount of traffic between Grafton and South Grafton as shown in Figure 5.3.

Figure 5.3: Grafton Bridge Traffic Study – Existing Traffic Movements within Grafton across the River



Summary

Based on the information presented in Figures 5.1 to 5.3, a summary of the traffic flow breakdown on the existing Bridge is set out in Table 5.2. Note that the daily traffic figure below is based on the origin-destination surveys only. The automated traffic count discussion that follows contains the most accurate and recent estimate of existing traffic demands across the River.

Table 5.2: Grafton Bridge Traffic Study – Breakdown of Existing Traffic Flows across the River

Trip Type	Vpd*	Percent (%)
External to External (through)	533	2%
External to Grafton / South Grafton	12,219	53%
Internal - Grafton to/from South Grafton	10,462	45%
Total	**23,214**	**100%**

* Based on a peak to daily ratio of 7.57

Table 5.2 shows that of the traffic using the bridge, approximately two percent of motorists do not have an origin or destination within Grafton or South Grafton.

5.4 Automated Traffic Counts

Pacific Highway

Automated vehicle counts where undertaken on the 11 and 12 March 2009 to supplement existing information provided by the RTA. Table 5.1 is a summary of the counts undertaken and their results.

Table 5.3: Grafton Bridge Traffic Study – Automated Traffic Count Summary

Road Name	Location	Direction	Peak Hour Volume (veh)	Daily Volume (veh)
Pacific Highway	South of Grafton	Northbound	375	4,140
Pacific Highway	South of Grafton	Southbound	376	3,957

Grafton Bridge Traffic Counts

24 hour classified counts were undertaken on the Bridge between Monday 8 June 2009 and Thursday 2 July 2009. The counts were located on Bent Street on the southern side of the Clarence River. Table 5.4 is a summary of the survey information.

Table 5.4: Grafton Bridge Traffic Study – Classified Count Summary June 2009 for Weekdays

Time Period	Northbound	Southbound	Combined
AM Peak Average (8-9am)	1339	856	2194
2 hr AM Peak Average (7-9am)	2197	1379	3575
PM Peak Average (3-4pm)	1165	1242	2407
2 hr PM Peak Average (3-5pm)	2139	2588	4727
Daily (24 hr) Weekday Average	13530	13535	27064

Table 5.4 indicates that the weekday average volume across the Clarence River is more than 27,000 vehicles per day. During the AM peak, traffic flow is directional northbound into Grafton, whilst during the PM peak the peak direction is southbound. The counts represent a peak 2 hour AM peak period to weekday daily ratio of 7.57. This figure has been used in the strategic modelling that follows to convert modelled peak periods to daily flows ratio of ratio of 7.57. This is the factor used to convert 2 hour AM peak period strategic model flows into daily flows.

5.5 Historical RTA traffic counts

Table 5.5 compares the historical RTA traffic data for a number of years at key roads feeding into town and on the Bridge itself. Note that the volumes in this table are AADT and therefore include weekend flows. This is why the bridge count is lower than in Table 5.4.

Table 5.5: RTA Historical AADT Traffic Count Data and Growth Rates

Location	1990 AADT	2004 AADT	2009 AADT [1]	Growth '90-'04 pa	Growth '04-'09 pa	Growth '90-'09 pa
Bridge	20,548	23,641	24,193	1.0%	0.5%	0.9%
Pacific Hwy sth of Charles St	8,101	11,292		2.4%		
Gwydir Hwy west of Bent St	7,276	8,405		1.0%		
Summerland Way north of North St	5,447	6,755		1.5%		
Total	**41,372**	**50,093**		**1.4%**		

[1] 2009 figure based on recent traffic counts as described in Table 5.2, not RTA historical data

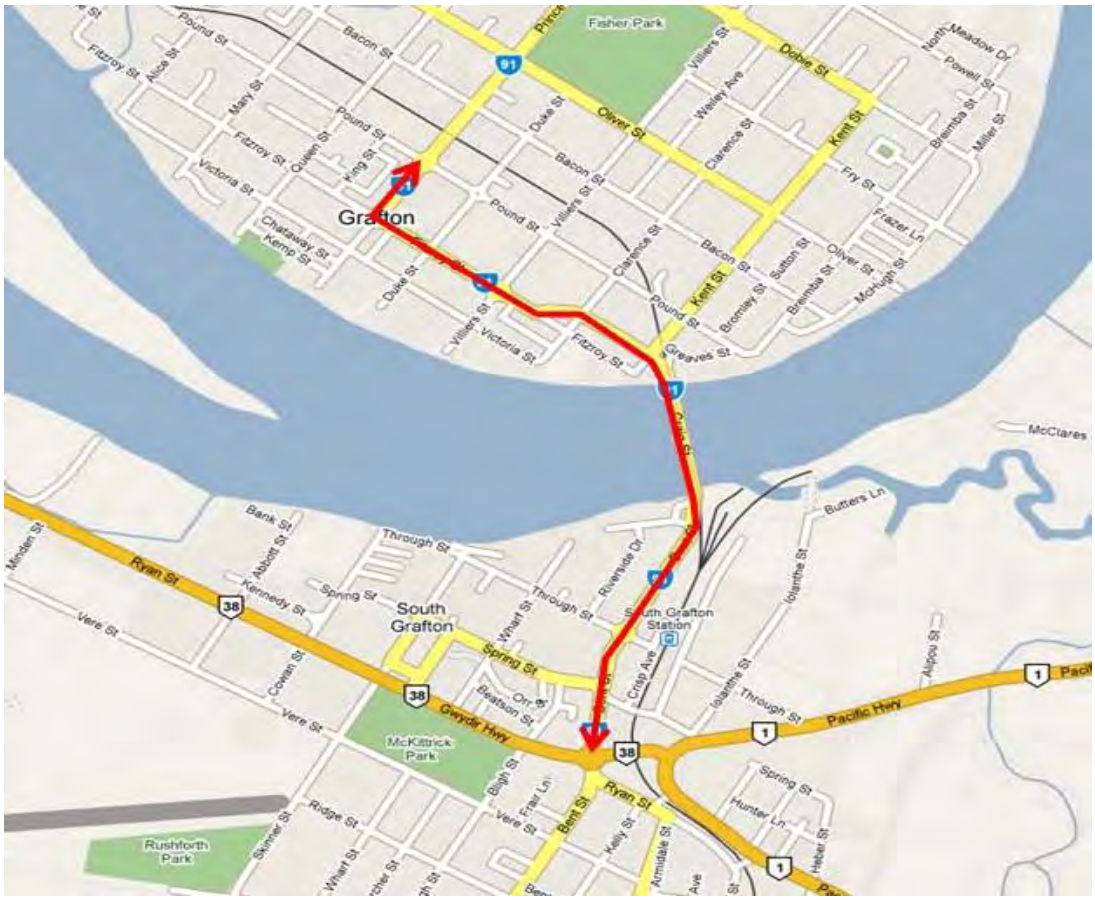
5.6 Travel Time Surveys

Travel time information for the study area was recorded for use in the calibration and validation of the microsimulation and strategic models. This provided:

- travel times between a range of specified points along the survey route
- an indication of the delay time along each surveyed section of the route
- the average speed between two points.

The surveys were conducted along Bent Street and Fitzroy Street during the AM and PM peak periods for a period of one week. Figure 5.4 shows the travel time survey routes.

Figure 5.4: Grafton Bridge Traffic Study – Travel Time Survey Routes



The surveys were conducted by RTA between 3 and 7 November 2008. In addition, GTA also conducted travel time surveys on 12 March 2009. The average travel time runs for the AM and PM peak periods are summarised in Table 5.6, whilst full results are presented in Appendix B.

Table 5.6: Grafton Bridge Traffic Study – Summary of travel time runs for each route (seconds)

Route	AM Peak		PM Peak	
	8:00-9:00	9:00-10:00	3:00-4:00	4:00-5:00
Southbound	284	319	295	289
Northbound	543	506	319	291

5.7 Site Observations

In addition to journey time surveys, spot queue length observations were also undertaken to provide an input into the microsimulation model calibration and validation process. A range of other on-site checks were performed as input to the strategic modelling with these checks discussed in the sections that follow.

6. Strategic Model

6.1 Introduction

The CUBE-TRIPS platform has been used for strategic modelling purposes in this study. It is a link-based travel demand network model.

Separate models have been prepared for 2009 to represent existing conditions and 2019 and 2039 to represent future conditions for the purposes of testing demands across the river.

The network contains all major highways, arterial roads and other significant local roads covering Grafton and South Grafton and the roads into and out of town. There are 39 transport zones (including 10 external zones) in the model which are based on Census Collector Districts (CCD) and disaggregated where necessary. The model zones have been selected to reflect road, geographical and land use boundaries and to be consistent where required with the microsimulation modelling to enable integration of inputs and outputs.

The model is run for an AM Peak period being a two hour model representing typical travel for the 7am to 9am period. Daily volumes are then arrived at by factoring the peak period models by 10. The peak period to daily factor is derived from various traffic counts in the area.

6.2 Purpose of the Strategic Model

The purpose of the strategic modelling is to establish the pattern of existing travel demands across the river and identify any changes in travel patterns into the future.

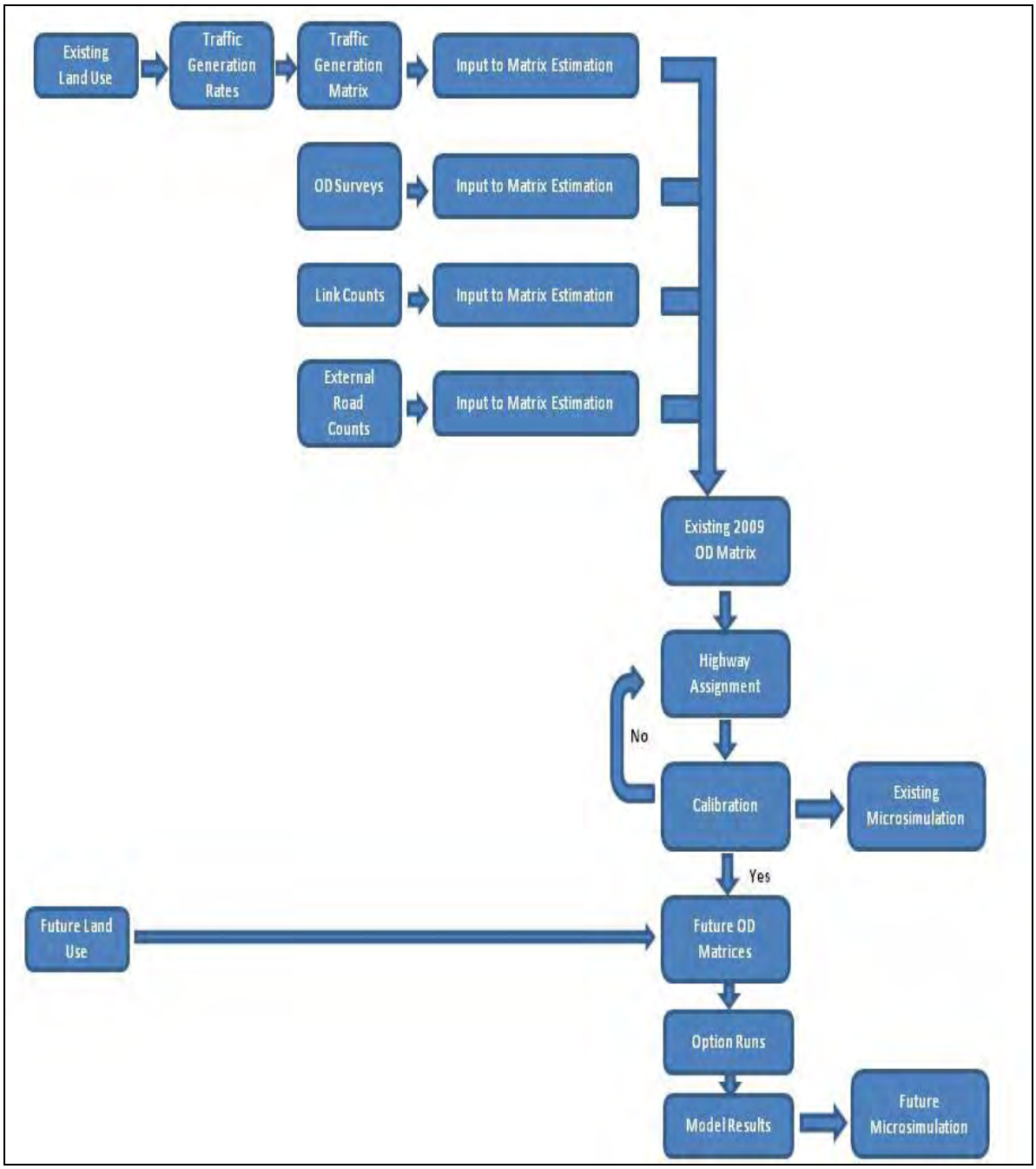
The strategic model has been used to:

- Understand the travel patterns through the study area for existing and future conditions, including the network-wide origins and destinations of traffic using key routes within and through the study area (inclusive of the bridge over the river).
- Run tests to determine changes in traffic patterns across the study area for input to the microsimulation model in current and future year runs.
- Run the year 2019 and 2039 to comment on longer term traffic issues.

6.3 Strategic Model Methodology

Figure 6.1 describes the general process adopted for the strategic model development.

Figure 6.1: Grafton Bridge Study – Strategic Model Methodology



6.4 Model Establishment

The strategic model network was produced based on the road network, which extends approximately 15km from the centre of Grafton and includes South Grafton, Junction Hill, Clarenza and Maclean, closely reflecting actual road characteristics (speed and capacity), road alignment and orientation.

Road network features such as existing speed limits, link capacities and turn bans were confirmed through on-site observations along with general network operating conditions in terms of travel times, vehicle delays and queue lengths. Particular attention was paid to the river crossing (bridge) approaches during peak periods.

6.5 Existing Land Use

The land use inputs to the modelling have been aggregated to the zone level and developed using information provided by RTA and the referenced reports described earlier. The main source of information is 2006 Australian Bureau of Statistics data which separates land use into population and employment estimates.

A listing of existing land uses at zone level for the study area is contained in Table 6.1. External zones are not provided with land use as they use traffic volumes based on the surveys undertaken for the existing conditions matrix.

Table 6.1: Grafton Bridge Study – Existing Land Use by Transport Zone

Zone	2009 Land Use			
	Population	Dwellings	No. of Jobs	School Enrolments
1	1237	495	480	257
2	717	298	295	149
3	383	176	148	69
4	1245	583	456	224
5	1990	798	908	467
6	505	209	216	104
7	579	231	257	133
8	248	96	112	51
9	254	114	113	47
10	72	39	33	11
11	54	29	24	9
12	144	78	65	23
13	920	437	338	161
14	523	215	154	122
15	448	202	152	79
16	28	12	10	7
17	14	6	5	3
18	33	16	11	5
19	33	16	11	5
20	100	47	32	14
21	104	34	51	34
22	104	34	51	34
23	987	431	324	192
24	217	87	80	49
25	1864	720	602	413
26	708	290	265	150
27	14	6	5	3
28	14	6	5	3
29	965	380	433	220
Total	**14502**	**6081**	**5632**	**3037**

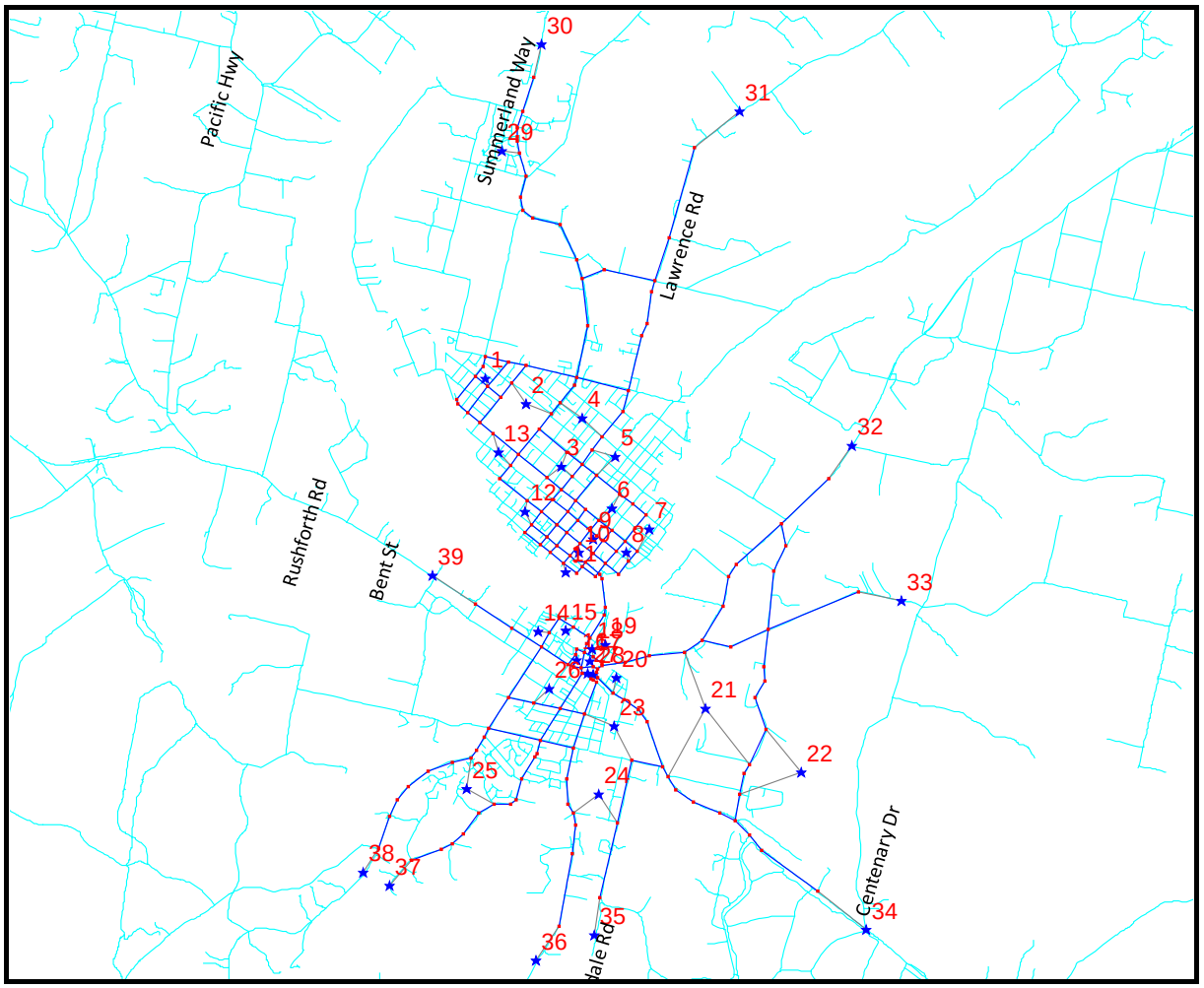
6.6 Zone Structure

The geographic region covered by the model is divided into smaller areas, referred to as transport zones. The zones were developed to provide the following:

- Sufficient detail to realistically enable the loading of traffic on to the road network to allow for testing of options and as an input to the microsimulation modelling.
- Consistency with the available demographic data (population and employment).
- Appropriate size to minimise intra-zonal motorised trips.
- Consistency with the Australian Bureau of Statistics Census Collection Districts (CCD's). Whilst the CCD's are of adequate resolution for the base year land use and road network, sub-division of a number of CCD's was undertaken, particularly in South Grafton, to account for future residential and industrial developments.

In total, the model consists of 39 transport zones set out in Figure 6.2. It is noted that these zones differ from those in the microsimulation model.

Figure 6.2: Grafton Bridge Study – Strategic Model Transport Zones



6.7 Road Network (Links and Nodes)

The road network adopted for the strategic model comprises all roads with a posted speed limit of 60km/h and above. In addition, roads with speed limit less than 60km/h that had daily two-way counts greater than 1,000 vehicles and roads which are important connecting routes were also included.

The existing conditions road network is also shown in Figure 6.2.

6.8 Matrix Estimation

Figure 6.1 sets out the model methodology and the various inputs to the matrix estimation process. Initial traffic generation inputs are used to assist in converting the land use in Table 6.1 to a set of internal traffic demands.

The next step involves the calculation of vehicle trips between zones, i.e. how trips are distributed. The volume of traffic crossing the boundary of the study area (referred to as external stations) was determined directly from traffic counts and origin-destination surveys at the external cordon points or zones of which there are 10.

The internal to external and external to internal trip ends at the external stations were determined from the difference between the total boundary crossing traffic count and the through traffic at each site.

The TRIPS matrix estimator is then run which takes the input matrix from above and assigns it to the road network using various network information such as link counts with associated confidence levels, to arrive at a 2009 existing conditions matrix that is an acceptable fit between modelled and actual volumes. This acceptable match is the calibrated matrix as detailed below.

6.9 Calibration and Validation

In order to model future conditions on the road network, an existing conditions model is run and compared against existing traffic data such as traffic counts. When the model results match the existing traffic flows in an acceptable fashion, the model is calibrated and therefore suitable for use as the base to prepare future model runs. Strategic network models are generally calibrated to reflect existing traffic counts across a wide corridor or regional area. Strategic network models are not expected to accurately match traffic counts at individual locations, instead model validation is measured by comparing counts across a number of screenlines and across the entire modelled area. All future model run results can then be interpreted against the calibrated existing conditions model.

For this study a 2009 model run was undertaken and compared against the VicRoads document *"Guidelines on the Validation Process and Criteria for Strategic Transport Modelling (October 2006)"*. The Percent Root Mean Square Error (%RMSE) statistic and Coefficient of Determination (R^2) statistic are used to measure the level of calibration where the targets are R^2 of greater than 0.90 and %RMSE of less than 30% for the study area. A total of 54 counts have been used to calibrate the model.

The model calibration results for the AM peak period are shown in Appendix C with the plot depicting modelled volumes versus counts in Figure 6.3.

Figure 6.3: Grafton Bridge Traffic Study - Modelled versus Count Volumes for Links

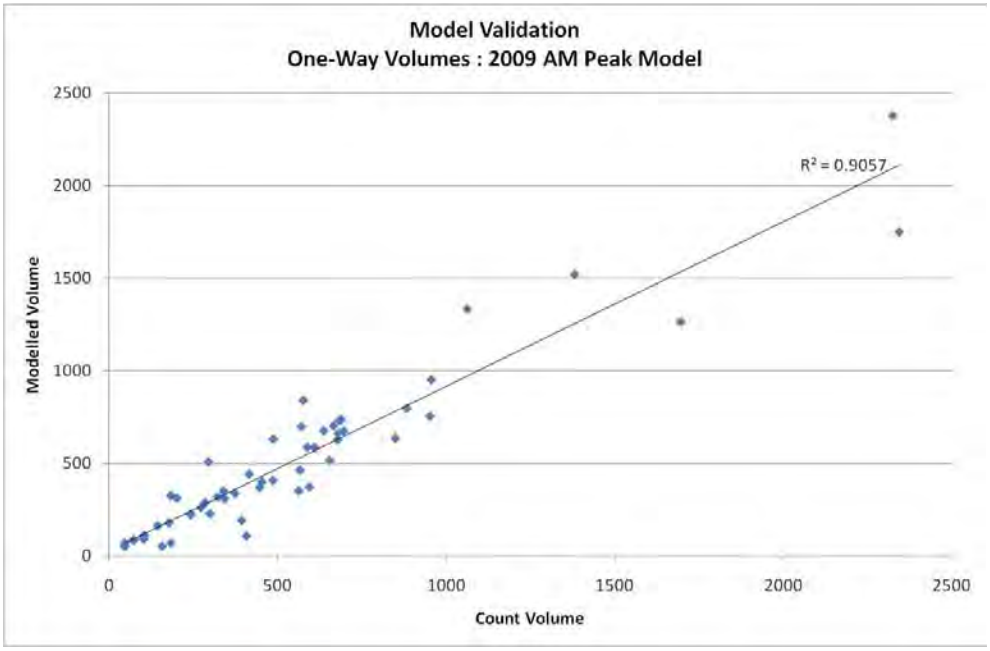


Figure 6.3 confirms that the AM peak model meets the R^2 statistic of greater than 0.90. In addition, the results meet the %RMSE of less than 30% as required in the model calibration guidelines. The 2009 existing conditions model run is therefore suitable for use in the future modelling of the area.

A list of modelled versus count locations is contained in Appendix C.

A summary of the modelled versus count (survey) locations for various areas within the model is set out in Table 6.2.

Table 6.2: Grafton Bridge Traffic Study - Modelled versus Count Volumes (AM Peak 2 Hour Period)

Model Area or Location	Count	Modelled Volume	% Difference
Cordon points (external zones)	4812	4745	-1%
North Grafton	11542	10099	-14%
South Grafton	9524	9202	-3%
Bridge Northbound	2326	2379	2%
Bridge Southbound	1382	1521	10%
All points	**29586**	**27946**	**-6%**

6.10 Future Year Growth

The proportion of traffic travelling through Grafton (i.e. external trips) is not as significant as the traffic generated to/from and within Grafton itself. A separate growth factor for external flows within the trip matrix has been applied based on a regional growth forecast.

Table 6.3 is a land use summary for the Mid North Coast region between the years 2009 and 2039 which is based on information obtained from various planning reports. Growth rate forecasts are provided for both population and employment changes.

Table 6.3: Regional land use Annual Growth Rate Forecast Summary (Source: various recent planning reports)

Land Use	Year 2009-2019	Year 2019-2029	Year 2029-2039	Year 2009-2039
Population	1.0%	0.9%	1.1%	1.0%
Employment	1.7%	1.5%	1.5%	1.6%

This review, which includes the NSW Department of Planning *Mid North Coast Regional Strategy* dated March 2009, indicates that the region of Grafton will experience long term regional traffic growth rates of between 1% and 2% per annum. This typically covers trips between regional centres as opposed to traffic flows within the centres themselves. The growth rate in traffic is typically higher than that of underlying population and/or employment growth reflecting economic growth amongst other things. As a result an annual growth rate of 2% has been adopted for external trips, which is broadly consistent with historical growth rates observed in the past 10 to 15 years on roads into and out of Grafton as described earlier.

The remaining trips represent the majority of travel demands across the river. A common future year growth rate for both trips to/from and within Grafton has been adopted. However, as there is no formal agreed future land use forecast for Grafton covering population and employment, we have adopted a conservative view about future growth, and provided a range of forecasts based on different growth rates.

The *South Grafton Traffic Study Report 2009* prepared by GTA Consultants has been used as a starting point for developing the future year growth rates. It adopted indicative annual growth rates of between 8% and 14% across residential, commercial and retail land uses. These growth rates were dependent on a range of variables including the quantum of floor space for each of the three uses, the side of the river it was developed on and the nature of travel to and from each use.

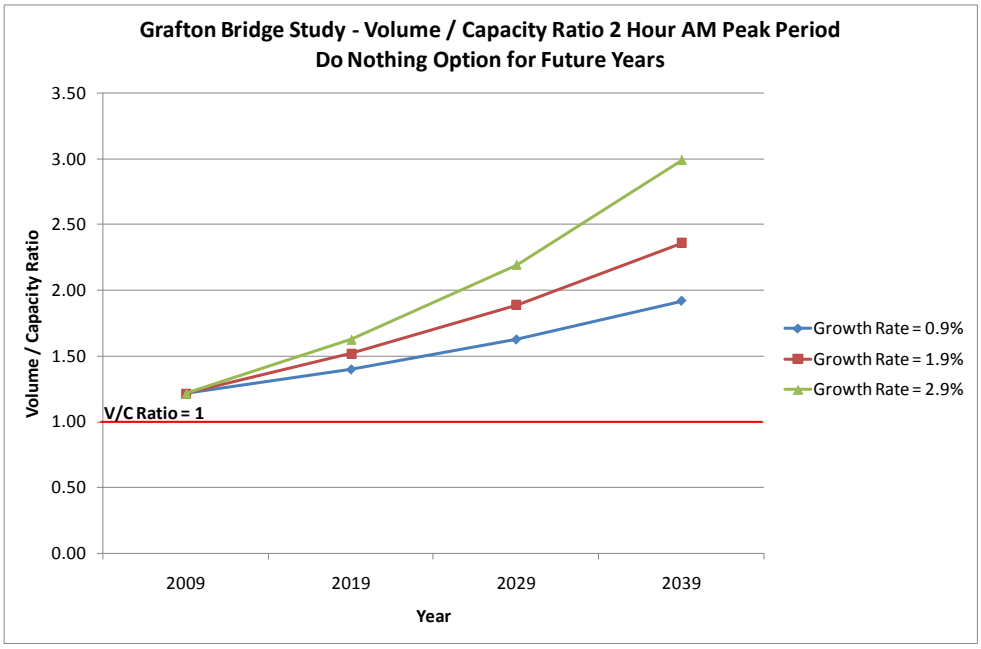
While the land use changes adopted for the South Grafton area were relevant for the previous work, they are considered too high to be applied to the full period between 2009 and 2039 across the whole of the Grafton township. It is also expected that trips to and from Grafton will grow at a lower rate than trips within Grafton. Annual compound growth rates approaching those above are very high and seldom expected over an extended time period in established areas, whether metropolitan or regional. While Grafton may experience short bursts of growth of that magnitude, it is not expected that it will occur over the 30 year model period and the whole of the model area.

It is assumed that the 2% growth rate adopted for the trips through Grafton represents a reasonable approximate estimate of future traffic growth within Grafton for this study. However, in the absence of detailed and agreed land use forecasts, and so as to provide a robust basis on which to plan for major transport infrastructure investment, a range of growth rates have been assessed being 1.5%, 2.5% and 3.5%. When these are combined with the 2% growth rate for external trips the resulting four traffic growth scenarios become 0.9%, 1.9% and 2.9% per annum.

The discussion that follows sets out the network operating performance across the River if nothing is done (i.e. there is no capacity increase across the river).

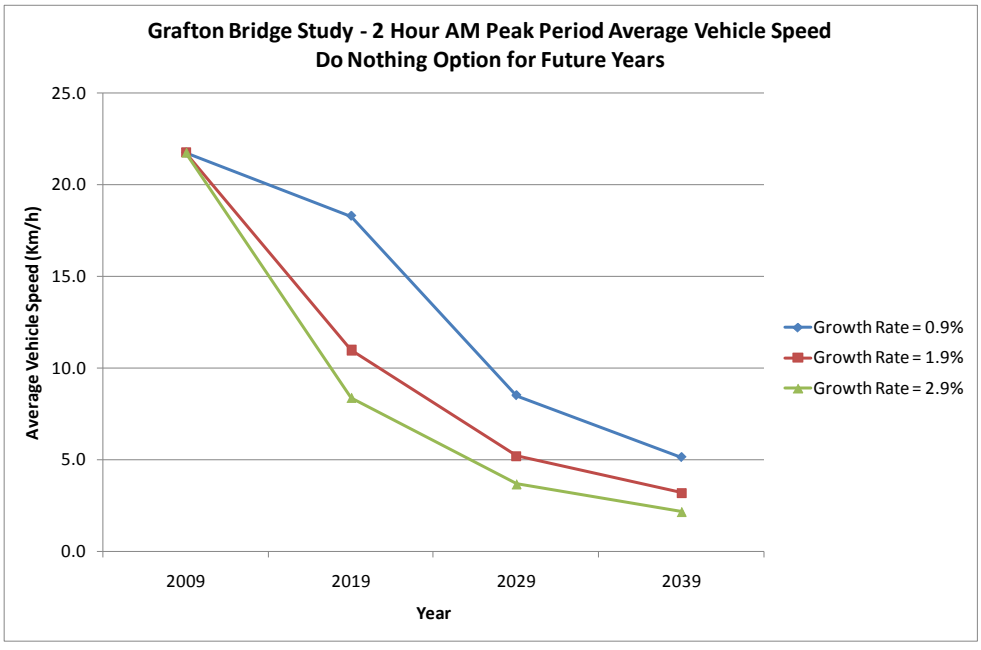
Figure 6.4 shows the road network performance in terms of volume to capacity ratios for the years 2009 to 2039 assuming the existing road network (i.e. no additional river crossing capacity).

Figure 6.4: Volume Capacity Ratio for 2 Hour AM Peak Grafton Model (at River Crossing)



As expected, the results show that conditions will steadily deteriorate leading to heavy congestion. Figure 6.5 shows the average vehicle speeds on the road network for the years 2009 to 2039 assuming the existing road network (i.e. no additional river crossing capacity).

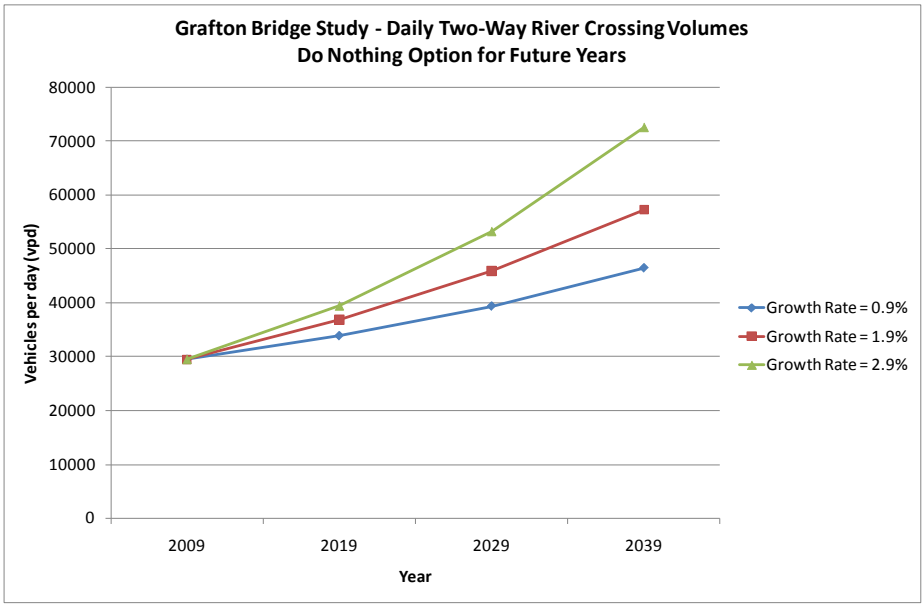
Figure 6.5: Average Vehicle Speeds for 2 Hour AM Peak Grafton (Strategic Model Coverage)



As expected, speeds gradually reduce on the road network to unacceptable levels during peak periods if the additional river crossing is not provided.

Figure 6.6 shows the forecast daily flows across the River in future with the range of assumed growth rates.

Figure 6.6: Daily Traffic Flows across River for Existing Road Network



* Daily flows calculated by multiplying AM peak period (2 hour) flows by 7.57 based on survey data

The results indicate that a duplicated bridge crossing will be required in the near future irrespective of the growth rate assumed as volumes will increase rapidly beyond the capacity of a two-lane bridge. The growth rate affects the year in which the extra capacity should be provided and the duration over which that additional capacity is expected to maintain acceptable road network conditions.

6.11 Summary of Model Outcomes for Existing Road Network

The results show that traffic within Grafton crossing the river gradually increases as a proportion of total traffic across the river. As previously mentioned, external trips are relatively low in comparison with the other demands across the river.

The additional volumes are significant and warrant construction of additional capacity to maintain acceptable operating conditions on the road network. The increases are also such that they are likely to adversely affect the level of amenity of the commercial and retail centres on both sides of the river.

Appendix D provides plots of the strategic model results for the years of 2009 and the future year runs with the existing road network at a growth rate of 1.9%. A difference plot is also included showing the change in daily volumes between 2009 and 2039.

The key model input assumptions are as follows:

- Historical traffic growth rates in recent times across the river have been in the order of 1%pa for Annual Average Daily Traffic.
- A 2% growth rate has been adopted for external (through) traffic based on regional planning studies and long term expected regional population and employment growth rates.
- Official detailed land use forecasts for Grafton are not available and as such a range of growth rates between 1.5% and 3.5% have been tested for internal traffic flows to provide a robust basis on which to consider the study outcomes.
- The resulting overall growth rates tested are 0.9%, 1.9% and 2.9%.
- A growth rate of 1.9% is recommended as the most likely outcome and therefore it forms the basis of model testing.

The results show the following:

- Resulting traffic demands across the river will increase significantly in the next 20 and 30 year periods.
- Additional river crossing capacity will be required in future to accommodate the additional demand. Doing nothing will lead to severely degraded and unacceptable road network operating conditions.
- The year in which additional capacity is required and the period over which a duplicated river crossing maintains acceptable operating conditions is dependent on the actual growth rate in coming years.
- Irrespective of the growth rate assumed, traffic growth will be such that it will adversely affect the amenity of the Grafton township if it continues to pass through the centre in future.
- Options to create an alternative route(s) to divert much or all of this future traffic growth should be considered to protect the vitality of the central commercial and retail areas.
- The additional growth will be significant in its own right and will require careful detailing in terms of local road connections north and south of the river.

The conclusion of the modelling exercise is that doing nothing is not an option as it will lead to extended periods across the day where the existing bridge operates at or beyond saturation levels, with unacceptable vehicle delays and queuing.

7. Microsimulation Model

7.1 Introduction

Q-Paramics microsimulation modelling is a computer software package that has the ability to individually model each vehicle, including buses, taxis, trains, trams, etc. within a road network. It enables a realistic representation of driver behaviour such as overtaking and lane changing and can also illustrate network performance. Q-Paramics is a particularly useful tool in modelling congested road networks where over-saturation and resulting vehicle queuing impacts on upstream intersections. It also allows testing of how the method of control and signal timings can be modified to ensure that more effective congestion management strategies can be designed and tested.

7.2 Purpose of Microsimulation Model

Microsimulation models are generally prepared in cases where an existing network is already over-saturated or a proposed scheme is likely to over-saturate the study network. In such cases what is of interest is the impact of over-saturation on upstream intersections and how their method of control and timing plans be modified to make sure that effective strategies can be designed and tested.

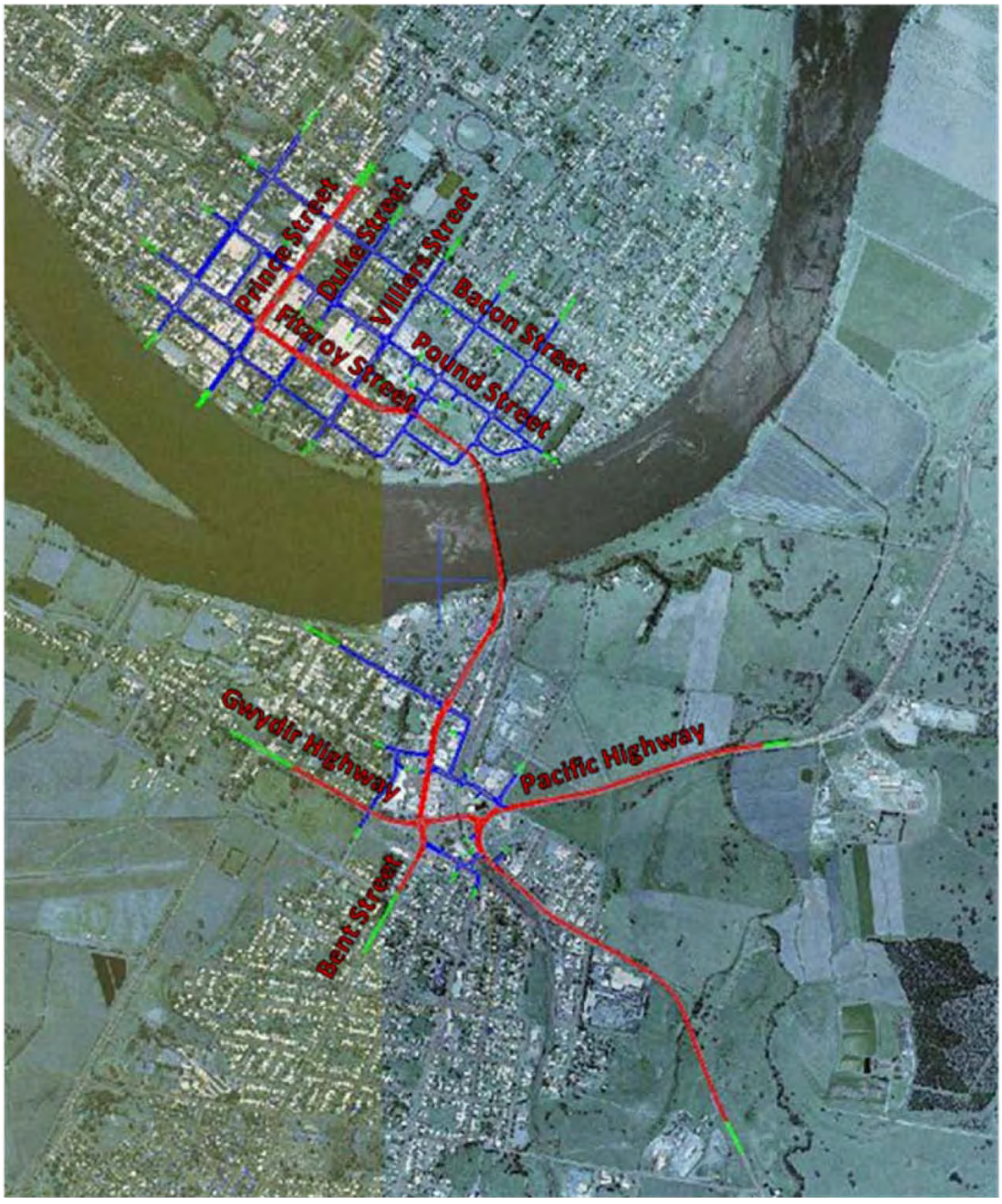
The unique features of the Grafton Bridge required that the selected software, in this case Q-Paramics, was able to analyse the movement of traffic over the Grafton Bridge and assess its operation.

7.3 Model Build Methodology

7.3.1 Model Extents

The existing conditions Paramics models included all key intersections within the study area discussed in Section 2 of the report. The Paramics model previously produced for the South Grafton Traffic Study was extended to include all key approach roads into the study area, the Grafton business district and its approach roads. The extents of the modelled area are shown graphically in Figure 7.1.

Figure 7.1: Grafton Bridge Traffic Study – Paramics Model Extents



The model extents were selected to adequately deal with existing and future year testing in terms of vehicle queue lengths and the like.

7.3.2 Network Layout and Geometric Data

The existing road network was constructed with the use of a scaled ECW aerial photograph. The aerial photograph contained basic geometric data such as the number of lanes, lane widths and lengths. Layouts of the recent road works in Prince Street were obtained to supplement the ECW aerial. In addition, site visits during peak hours were also carried out to establish specific road network characteristics such as turn bans, stop line locations and turn lane disciplines.

7.3.3 Traffic Composition

The traffic composition allows defining the vehicle mix of each input in the study network, and is based on the vehicle composition files developed by the RTA. The RTA 'vehicles' file was then adjusted to represent the traffic composition in Grafton. The composition used for the Paramics model consists of three main vehicle classes comprising of cars and large goods vehicles (LGV), heavy goods vehicles (HGV) and B-double trucks.

7.3.4 Model Time Periods

The following two peak periods were analysed:

- AM Peak (6.30am – 10.30am)
- PM Peak (2.30pm – 6.00pm).

Each of the periods allowed for a warm up and warm down period. To add to the level of accuracy of the existing conditions model, the traffic flow demand profile through the network was input in 15 minute interval.

7.3.5 Traffic Demand

Paramics microsimulation models define traffic demands in the form of vehicle trips between origin and destinations, knows as zones. Hence, existing and future traffic demands have to be developed in this format, known as an origin-destination matrix.

The volume of traffic to and from each zone was based on the origin-destination matrix estimate using the available O-D data and turning count data.

7.3.6 Zone Structure

Zones within the study area were defined to represent areas or locations of major traffic generation and a total of 39 zones were modelled. The microsimulation model was developed at a more 'localised' level and as such the microsimulation zones do not align with the strategic model zones 'one for one'.

Figure 7.2 shows the location of the zones and their corresponding zone number, whilst Table 7.1 shows the correlation between the microsimulation and strategic model zones.

Figure 7.2: Grafton Bridge Study – Paramics Microsimulation Zone Structure

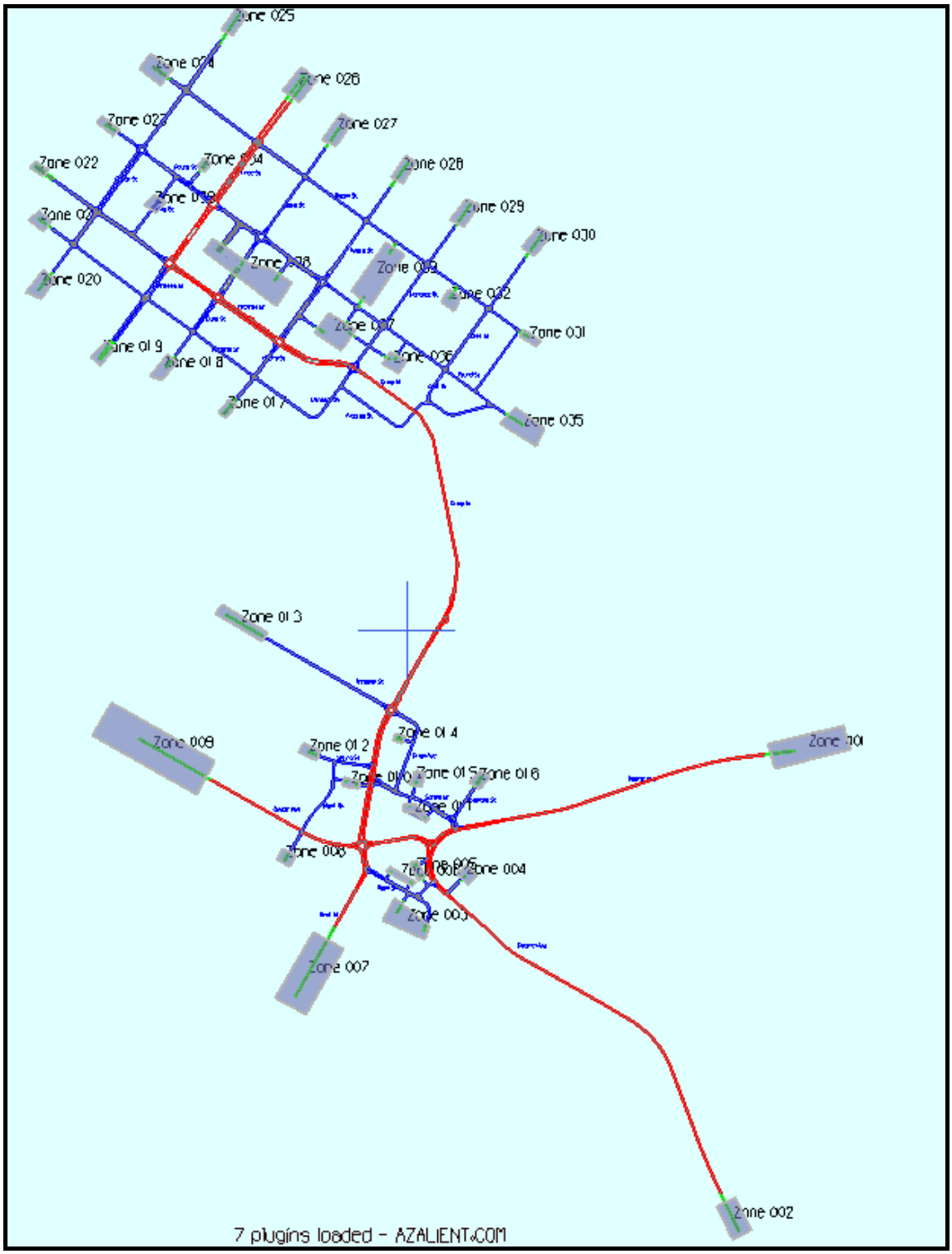


Table 7.1: Grafton Bridge Study – Microsimulation and Strategic Model Zone Alignment

Microsimulation	Strategic	Microsimulation	Strategic
1	21,32,33	21	12
2	22,34	22	12
3	23,24,35,36	23	13
4	20	24	13
5	28	25	3
6	27	26	1,2,4,29,30,31
7	25,26,37	27	6
8	25,38	28	5,6
9	39	29	6
10	16	30	7
11	17	31	8
12	16	32	9
13	14,15	33	9
14	18	34	13
15	19	35	8
16	19	36	10
17	11	37	10
18	11	38	10
19	11	39	12
20	12		

Table 7.1 shows that although 39 zones exist for both the strategic and microsimulation models, these do not align or correspond directly with one another.

7.3.7 Public Transport

A number of bus routes operate within the study area and were included in the Paramics model. The locations of all bus stops were input into the models and the arrival and departure times were based on the current bus time table.

7.4 Calibration and Validation

Calibration and Validation Guidelines

The calibration and validation process was carried out in accordance with the criteria set out in the 'UK Design Manual for Roads and Bridges (Vol 12, Section 2, Part 1 – Traffic Appraisal in Urban Areas)'.

The guidelines provide criteria to compare modelled and observed flows for items such as: turn counts, link flows, vehicle travel times and a visual assessment of operating conditions including vehicle queues. The targets set out in the guidelines are shown in Table 7.2.

Table 7.2: Grafton Bridge Traffic Study – Calibration and Validation Criteria

Criteria and Measurements	Calibration Acceptable Targets
Hourly Flows, Modelled Versus Observed	
Individual Link Flows	
Within 15%, for 700 veh/h < Flow < 2700 veh/h	> 85% of cases
Within 100 veh/h, for Flow < 700 veh/h	> 85% of cases
Sum of All Link Flows	Within 5% of sum of all link counts
GEH Statistic < 5 for Individual Link Flows	> 85% of cases
Travel Times, Model Versus Observed	
Journey Times Within 15% (or 1 min, if higher)	> 85% of cases
Visual Audits	
Visually Acceptable Speed-Flow Relationship	To analyst's satisfaction
Visually Acceptable Queuing	To analyst's satisfaction

Seed Runs

In order to test the robustness of the model, five seeds were tested and the average results of the five seed runs were reported. The seed runs utilised in the analysis are 28, 560, 2849, 7771 and 86524.

A summary of the calibration and validation process are set out below with detailed results presented in the Model Calibration and Validation Report located in Appendix E.

Calibration Results

Tables 7.3 and 7.4 summarise the hourly turning movement comparison between the modelled and observed flows at the key intersection within the study area:

Table 7.3: Grafton Bridge Traffic Study – Existing Conditions AM Calibration Summary

Criteria UK Design Manual for Roads and Bridges	Within 15% for 700 veh/h < Flow < 2700 veh/h	Within 100 veh/h, for Flow < 700 veh/h	GEH less than 5	Sum of all link flows
Target	>85%	>85%	>85%	within 5%
7:00 – 8:00	100%	96%	88%	0.5%
8:00 – 9:00	100%	95%	86%	2.9%
9:00 – 10:00	100%	94%	81%	5.2%
Total Average	**100%**	**95%**	**85%**	**2.90%**

Table 7.4: Grafton Bridge Traffic Study – Existing Conditions PM Calibration Summary

Criteria UK Design Manual for Roads and Bridges	Within 15% for 700 veh/h < Flow < 2700 veh/h	Within 100 veh/h, for Flow < 700 veh/h	GEH less than 5	Sum of all link flows
Target	>85%	>85%	>85%	within 5%
3:00 – 4:00	99%	100%	87%	1.0%
4:00 – 5:00	100%	98%	86%	4.0%
5:00 – 6:00	99%	98%	84%	9%
Total Average	**99%**	**99%**	**86%**	**4.7%**

Tables 7.3 and 7.4 indicate that the modelled flows for both peak periods meet the criterion set in the guidelines and therefore provide satisfactorily calibrated models.

Validation Results

Vehicle travel times for the routes nominated in Section 6 were also compared with data extracted from the model. The comparison between observed and modelled travel times are shown in Tables 7.5 and 7.6.

Table 7.5: Grafton Bridge Traffic Study - Existing Travel Time Results (AM Peak) (Unit: Sec)

Time Period	8:00 - 9:00			9:00 - 10:00		
Direction	Average Observed (s)	Modelled Average (s)	% Difference	Average Observed (s)	Modelled Average (s)	% Difference
Northbound Gwydir Hwy to Pound St	543	474	-12.7	506	420	16.9
Southbound Pound St to Gwydir Hwy	284	281	-0.01	319	278	-11.9

Table 7.6: Grafton Bridge Traffic Study - Existing Travel Time Results (PM Peak) (Unit: Sec)

Time Period	3:00 – 4:00			4:00 -5:00		
Direction	Average Observed (s)	Modelled Average (s)	% Difference	Average Observed (s)	Modelled Average (s)	% Difference
Northbound Gwydir Hwy to Pound St	319	296	-7.2	291	284	0.34
Southbound Pound St to Gwydir Hwy	295	362	22.6	289	369	27.7

The results presented in Table 7.5 and 7.6 indicate that the journey times generally meet the requirements set out in the validation criteria. The only discrepancy is the southbound journey times during the PM peak, however after several site visits during the afternoon peak period, the model has been calibrated to represent slow forming queues on the north side of the Grafton River and is considered acceptable.

External Model Audit

An independent audit was undertaken of the model in May 2009. A response to the audit was provided by GTA on the 19th of June 2009, incorporating the majority of changes recommended by the auditor.

7.5 Base Year Model Results

7.5.1 General Network Statistics

This section of the report sets out the operating conditions for each of the tested design years in terms of overall network performance. The results of the network performance parameters include the following:

- the peak period travel time for identified routes
- number of completed vehicle trips per simulation period
- Vehicle Kilometres Travelled
- average speed
- average delay by approach to key intersections and for the network
- Levels of Service Characteristics both on the bridge and on approaches to key intersections.

Table 7.7 is a summary of the existing network performance for the AM and PM peak periods.

Table 7.7: Grafton Bridge Study AM and PM Peak Network Performance

Statistic	AM Peak (8-9am)	PM Peak (4-5pm)
No. Completed Trips	5546	5813
Average Km per vehicle (km/veh)	1.8	1.8
Average Travel Time per vehicle (min/veh)	3.3	3.3
Average Speed (km/hr)	33.1	33.2
No. of Stops	22582	16755
Vehicle Kilometres Travelled (VKT)	10421.4	10614
Vehicle Hours Travelled (VHT)	324.1	320.8
Unreleased Vehicles	41	4

Further details on the model operation and network statistics are located in the Microsimulation Model Operational report in Appendix F.

7.6 Future Year Traffic Forecast

The future year traffic forecast rates discussed in Section 7.10 have been utilised in assessing the road network operation in the design years of 2019, 2029 and 2039. The growth rate of 2.5% p.a. was adopted for all internal zones and trips within Grafton and South Grafton, whilst a lower rate of 1.9% p.a. was used for trips travelling over the Grafton Bridge (i.e. between Grafton and South Grafton).

Smaller zones that are unlikely to generate increased demands such as petrol stations, and established residential zones, have not been applied growth.

Table 7.8 is a summary of the growth factor used in determining future year traffic demands.

Table 7.8: Grafton Bridge Study AM Peak Network Performance

Trip Type	Design Year			
	2009	2019	2029	2039
External Trips	1.0	1.21	1.46	1.76
Internal Trips	1.0	1.28	1.64	2.10

Table 8.8 shows that the traffic demands in Grafton are likely to increase by between 20% and 30% within 10 years and double within 30 years. The impact of the increased growth on the existing road network has been assessed using the microsimulation model and is set out in the following sections.

7.7 Future Year Testing (Do Nothing)

Network Statistics

The existing road network has been tested utilising future year travel demands of 2019, 2029 and 2039, without any changes to the geometry. Table 7.9 and 7.10 are a summary of the future year network operation for the AM and PM peak periods.

Table 7.9: Grafton Bridge Study AM Peak (8-9am) Network Performance

Statistic	Design Year			
	2009	2019	2029	2039[2]
No. Completed Trips	5537	6077	5573	3020
Unreleased Vehicles	100	146	236	476
Average Km per vehicle (km/veh)	1.8	1.8	1.6	1.5
Average Travel Time per vehicle (min/veh)	3.2	4.0	4.1	3.7
Average Speed (km/hr)	34.1	26.9	24.1	25.7
No. of Stops	21361	34202	33068	20755
Vehicle Kilometres Travelled (VKT)	10396.0	11275.4	9671.6	5198.2
Vehicle Hours Travelled (VHT)	311.9	437.1	457.7	365.2

[1] Network Statistics are for all Completed Vehicle Trips within the nominated hour. Does not include uncompleted trips within the network
[2] 2039 Results are incomplete due to excessive network congestion and breakdown

Table 7.10: Grafton Bridge Study PM Peak (4-5pm) Network Performance

Statistic	Design Year			
	2009	2019	2029	2039[2]
No. Completed Trips	5844	5869	1094	11
Unreleased Vehicles	54	316	498	565
Average Km per vehicle (km/veh)	1.8	1.7	1.6	0.8
Average Travel Time per vehicle (min/veh)	3.0	3.4	3.1	29.2
Average Speed (km/hr)	35.8	29.7	34.3	18.1
No. of Stops	14244	21561	6838	2
Vehicle Kilometres Travelled (VKT)	10579.2	10658.0	2132.0	7.9
Vehicle Hours Travelled (VHT)	297.6	419.2	230.3	1.0

[1] Network Statistics are for all Completed Vehicle Trips within the nominated hour. Does not include uncompleted trips within the network
[2] 2039 Results are incomplete due to excessive network congestion and breakdown

Tables 7.9 and 7.10 show that as the traffic demands in Grafton increase, the network operating performance decreases in terms of average speeds and travel times, the level of congestion is also reflected by the number of unreleased vehicles which increases in each of the design years.

A detailed summary of the network statistics, including route travel times, for the duration of the modelled period is located in Appendix G.

Queue Lengths

Plots of the queue lengths within the modelled network during the AM peak (9.00am) and PM peak (4.00pm) have been extracted from the model for 2009, 2019, 2029 and 2039, and are shown graphically in Figures 7.3 - 7.10.

Figure 7.3: 2009 Existing Conditions AM Peak Queue Length Plots (9:00am)

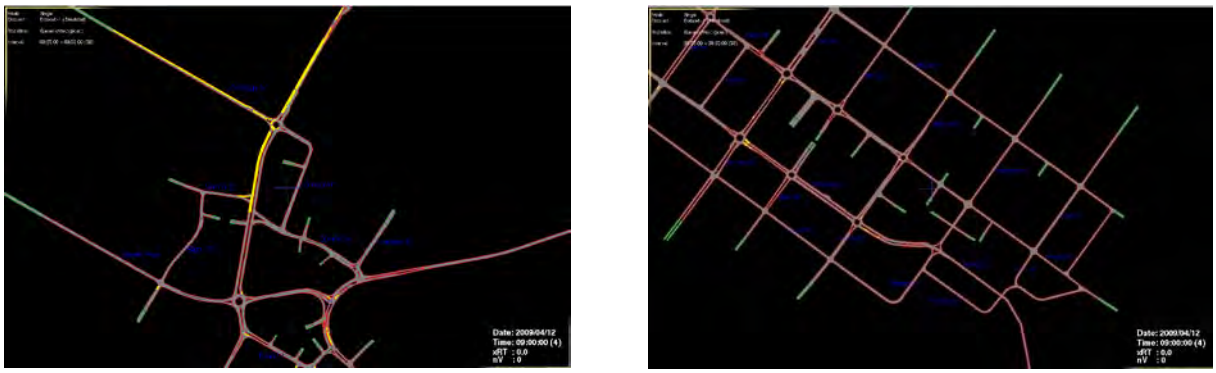


Figure 7.4: 2009 Existing Conditions PM Peak Queue Length Plots (4:00pm)

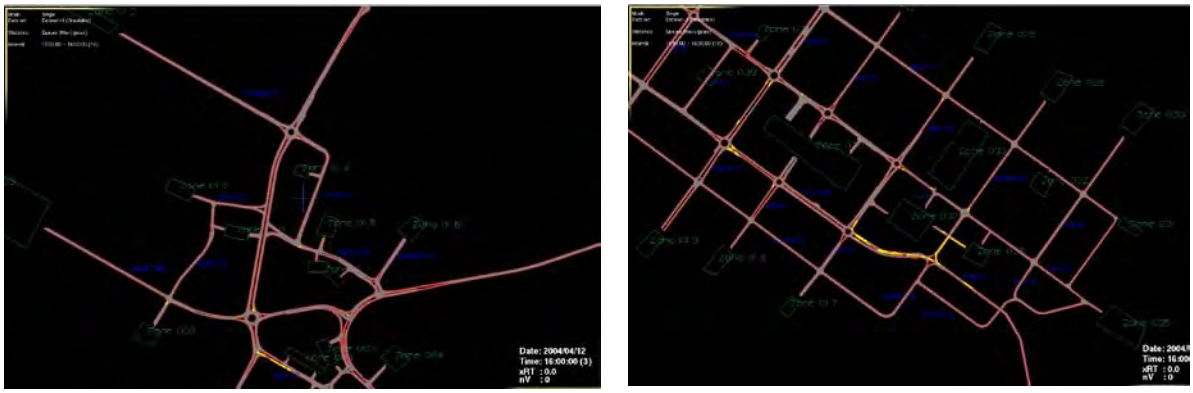


Figure 7.5: 2019 Existing Conditions AM Peak Queue Length Plots (9:00am)

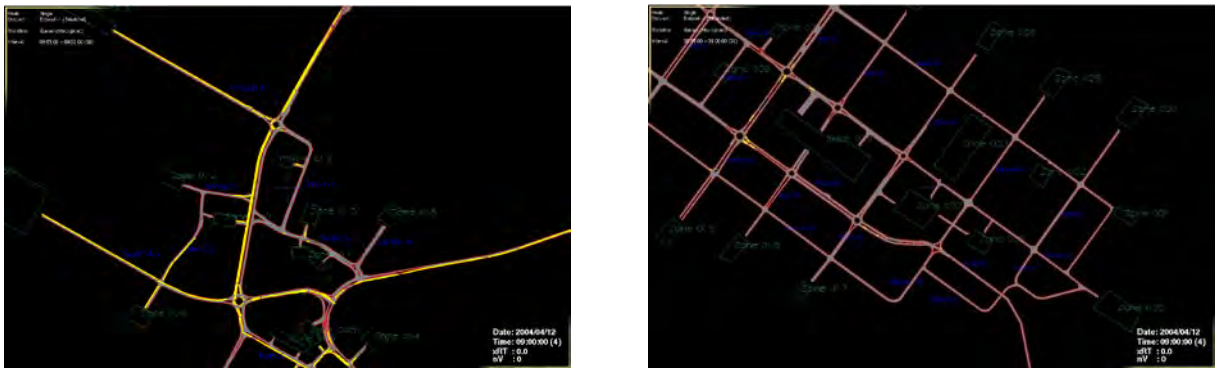


Figure 7.6: 2019 Existing Conditions PM Peak Queue Length Plots (4:00pm)

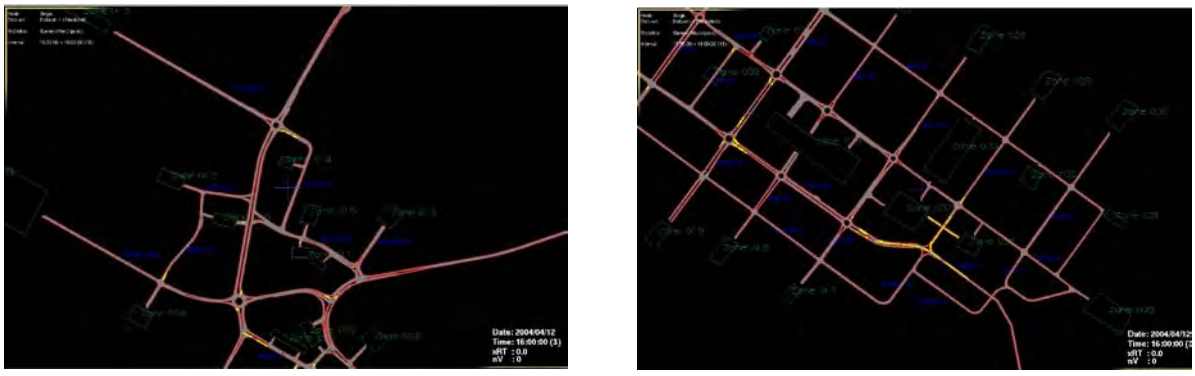


Figure 7.7: 2029 Existing Conditions AM Peak Queue Length Plots (9:00am)

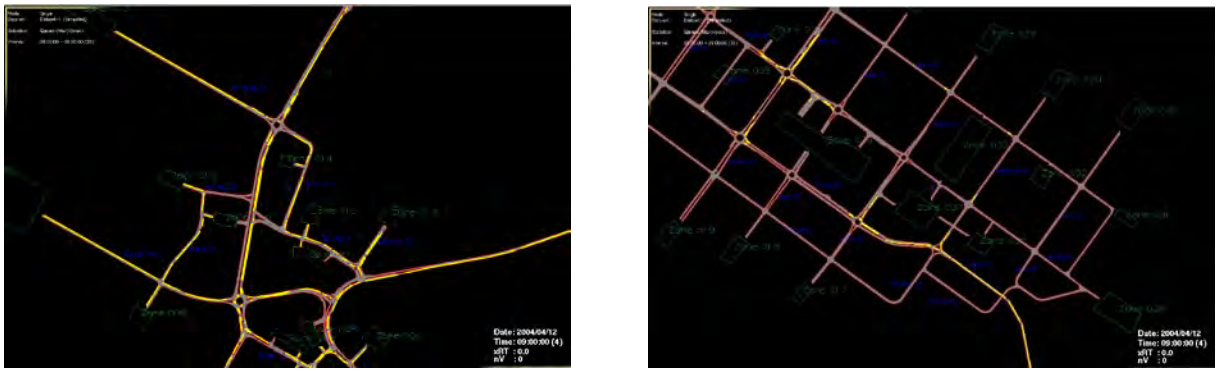


Figure 7.8: 2029 Existing Conditions PM Peak Queue Length Plots (4:00pm)

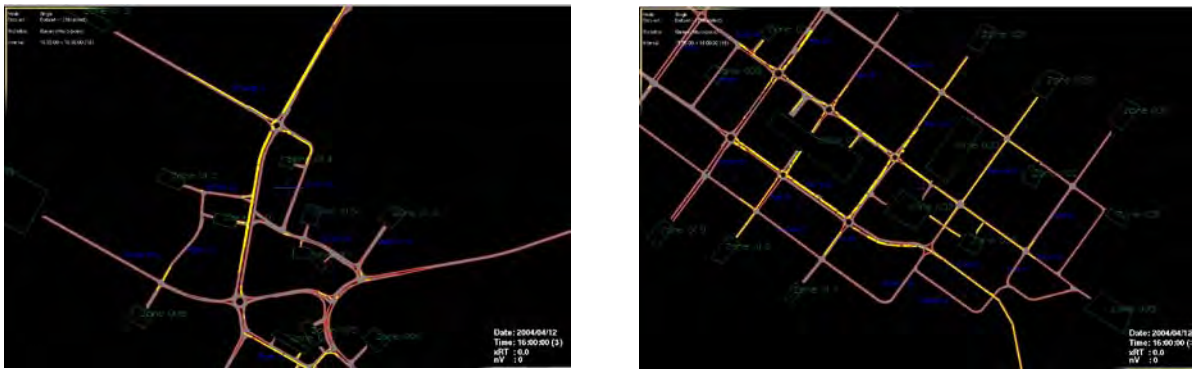


Figure 7.9: 2039 Existing Conditions AM Peak Queue Length Plots (9:00am)

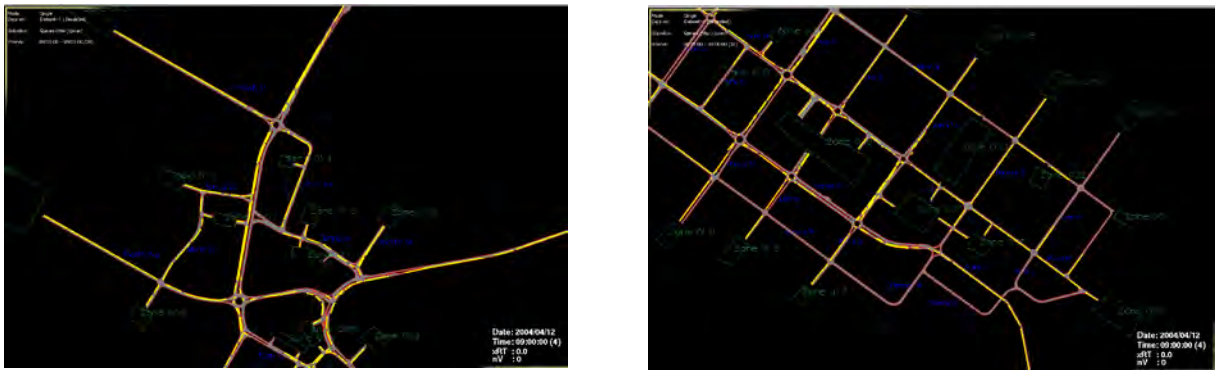
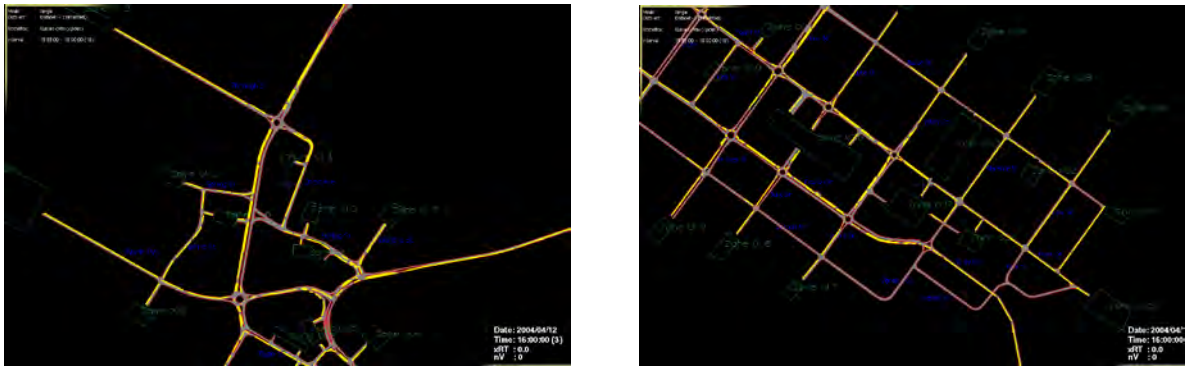


Figure 7.10: 2039 Existing Conditions PM Peak Queue Length Plots (4:00pm)



Figures 7.3 – 7.10 show the expected levels of increased queue lengths within Grafton and South Grafton and that the network reaches gridlock after 2019.

Travel Times

Vehicle travel times between the Pacific Highway in South Grafton and Prince Street in Grafton have been recorded for each of the modelled years. Table 7.11 shows the anticipated travel times for the northbound movement during the AM peak period (8-9am) and southbound movement during the PM peak period (4-5pm).

Table 7.11: Grafton Bridge Study – Vehicle Travel Times (sec)

Trip Type	Design Year			
	2009	2019	2029	2039
Pacific Highway to Prince Street (Northbound) – AM Peak	526	605	642	793
Prince Street to Pacific Highway (Southbound) – PM Peak	371	379	404	524

Table 7.11 shows that travel times are likely to increase by up to 267 seconds (4:27) for the northbound movement and 153 seconds (2:33) for the southbound movement by 2039.

7.8 Microsimulation Summary

The increased traffic demands within Grafton will result in the road network becoming more congested in the form of:

- Increased delays and localised congestion within the town centres of Grafton and South Grafton resulting in motorists experiencing unacceptable delays by 2039.
- Increased travel times on the approaches to the bridge.
- Increased queues on the approaches to key intersections, within Grafton and South Grafton.
- Peak periods being extended during the AM and PM peak periods.
- Queue lengths encroaching back onto the Pacific Highway causing blockages and spilling.

Should traffic levels reach the growth anticipated, congestion levels are likely to reach a point of traffic flow breakdown between 2019 and 2029.

8. Summary

The existing traffic demands and constraints in Grafton have been assessed using a regional CUBE TRIPS model and a Q-Paramics microsimulation model. The key model input assumptions are as follows:

- Historical traffic growth rates in recent times across the river have been in the order of 1%pa for Annual Average Daily Traffic.
- A 2% growth rate has been adopted for external (through) traffic based on regional planning studies and long term expected regional population and employment growth rates.
- Official detailed land use forecasts for Grafton are not available and as such a range of growth rates between 1.5% and 3.5% have been tested for internal traffic flows to provide a robust basis on which to consider the study outcomes.
- A growth rate of 1.9% is recommended as the most likely outcome and therefore it forms the basis of model testing.
- Existing travel times between Grafton and South Grafton are exceeding eight minutes during the peak periods, this is an increase of three minutes from 2001 surveys.
- Origin-destination surveys indicate that 53% of trips using the Grafton Bridge where external to Grafton, 45% of trips are trips to and from Grafton whilst 2% of trips are those travelling directly through Grafton.

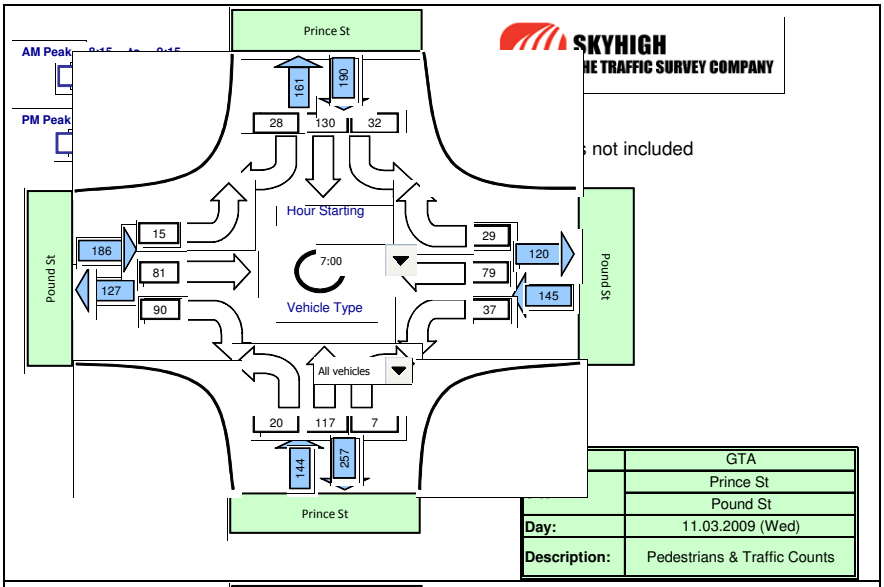
The following comments are provided in relation to the results presented in this report:

- Traffic demands across the river will increase significantly in the next 20 and 30 year periods.
- Additional river crossing capacity will be required in future to accommodate the additional demand. Doing nothing will lead to unacceptable road network operating conditions.
- The year in which additional capacity is required and the period over which a duplicated river crossing maintains acceptable operating conditions depends on the actual growth rate in coming years.
- Irrespective of the growth rate assumed, traffic growth will be such that it will adversely affect the amenity of the Grafton township if it continues to pass through the town centre in future.
- Options to create an alternative route(s) to divert much or all of this future traffic growth should be considered to protect the vitality of the central commercial and retail areas.
- The additional growth will be significant in its own right and will require careful detailing in terms of local road connections north and south of the river.

The net outcome of the modelling is that doing nothing is not an option as it will lead to extended periods across the day where the existing bridge operates at or beyond saturation levels, with unacceptable vehicle delays and queuing.

Appendix A

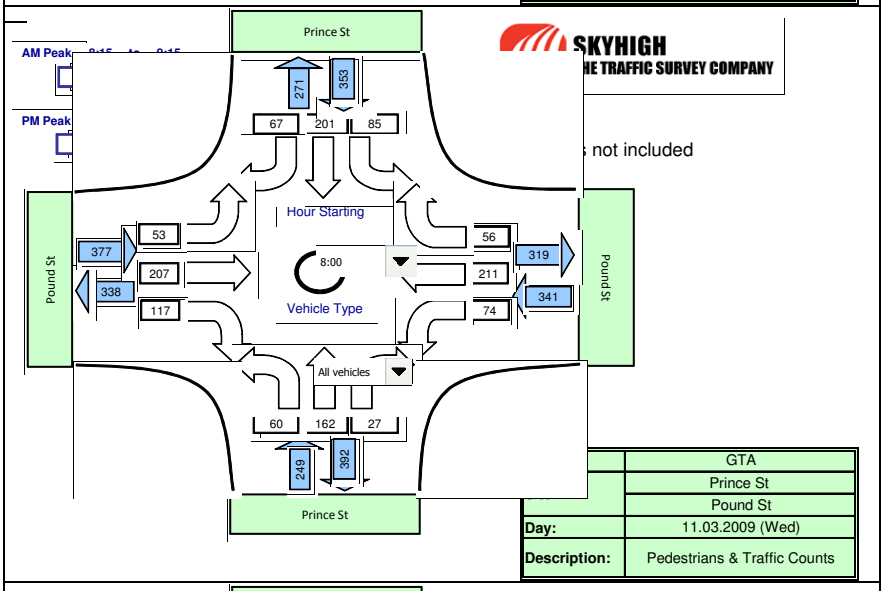
Turning Movement Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

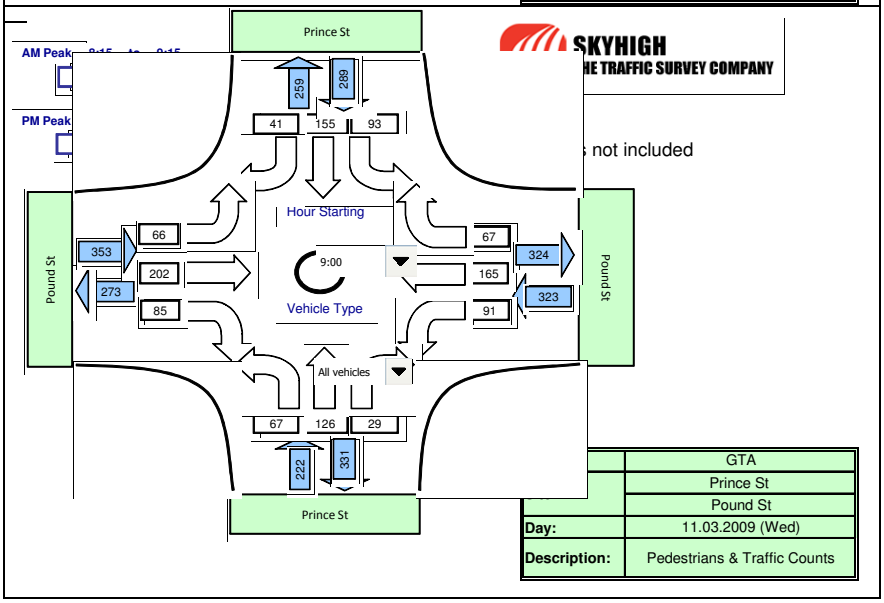
	GTA
	Prince St
	Pound St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

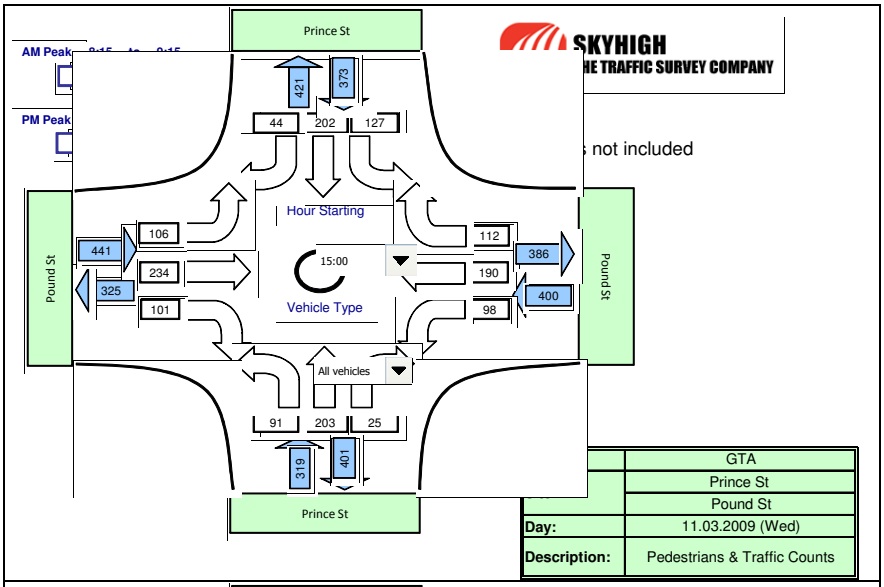
	GTA
	Prince St
	Pound St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

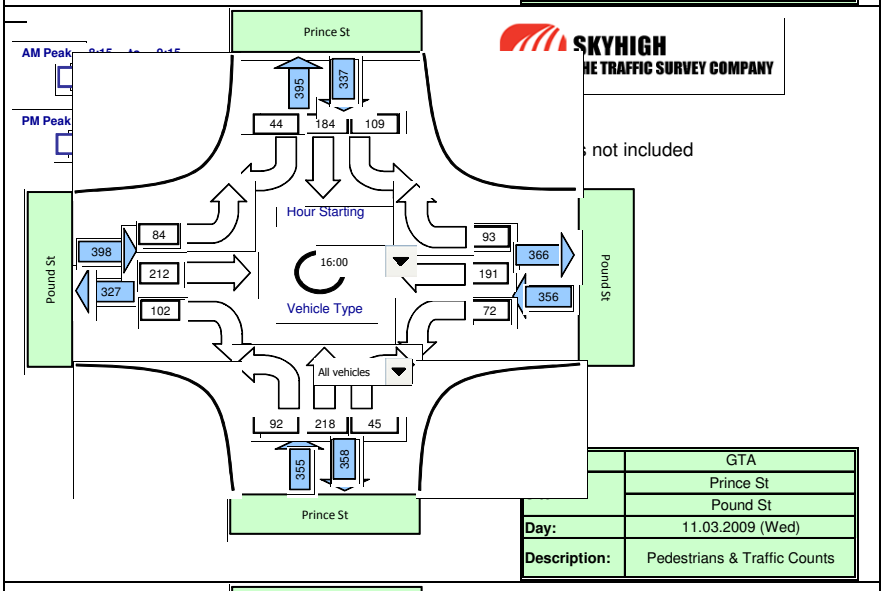
	GTA
	Prince St
	Pound St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

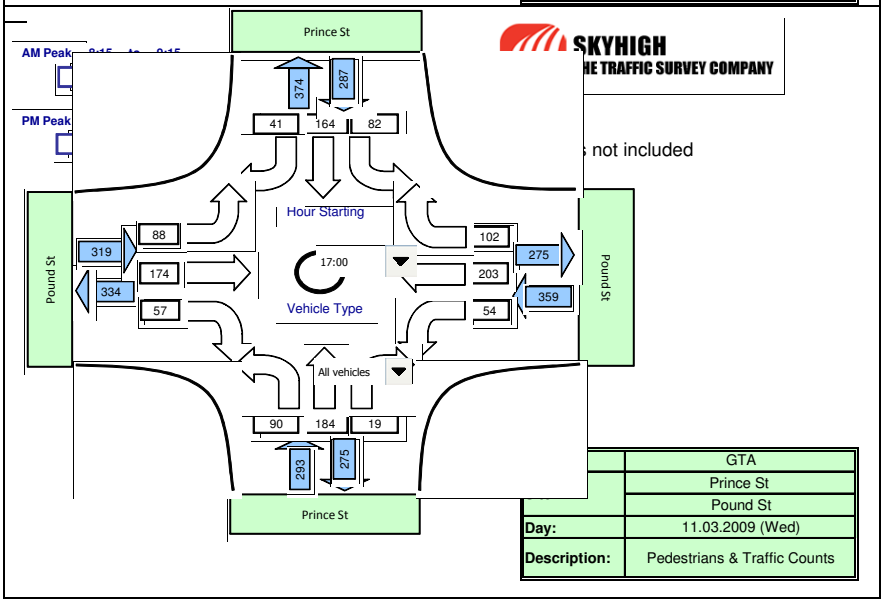
	GTA
	Prince St
	Pound St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

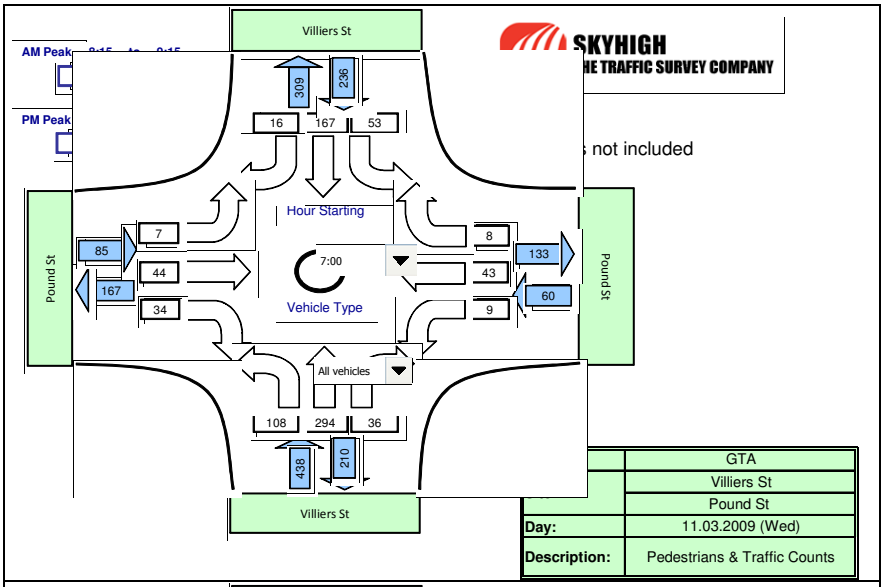
	GTA
	Prince St
	Pound St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

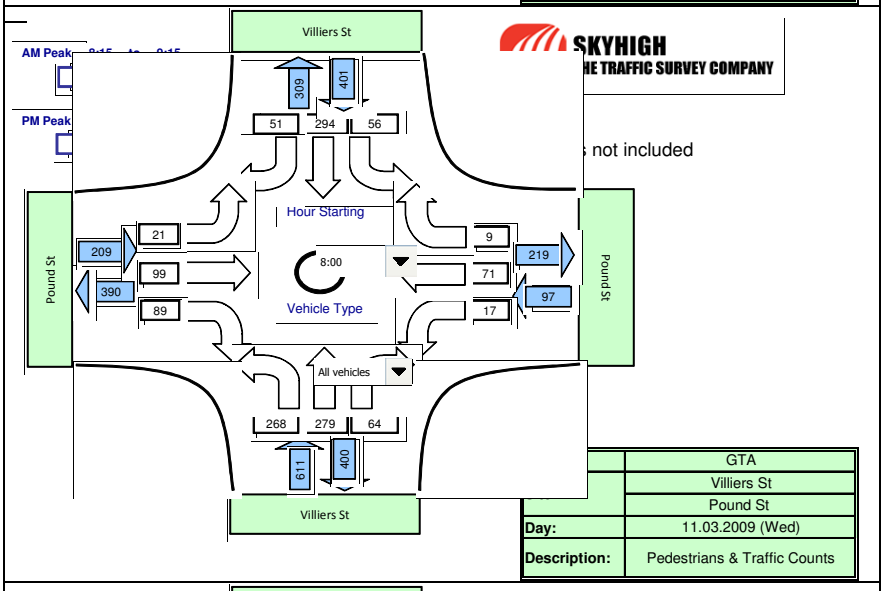
	GTA
	Prince St
	Pound St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

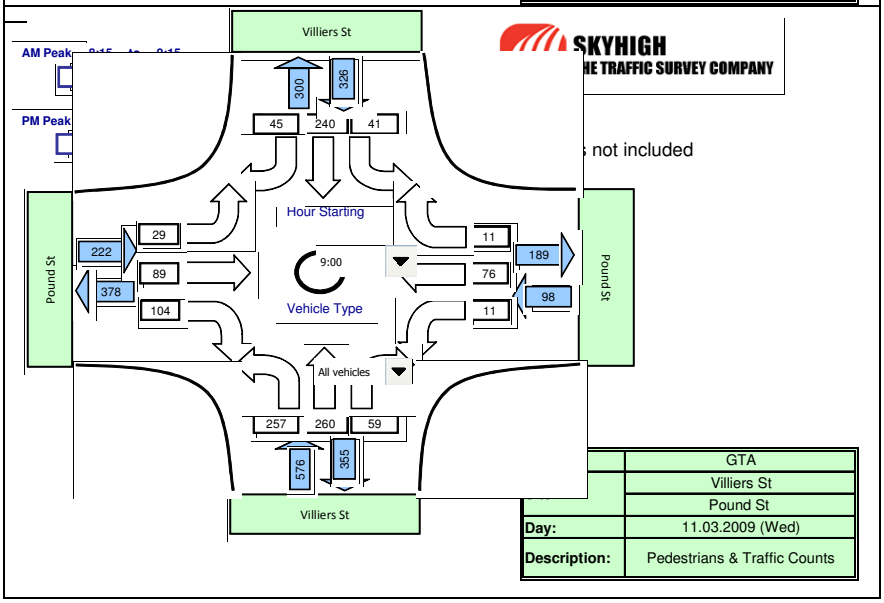
	GTA
	Villiers St
	Pound St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

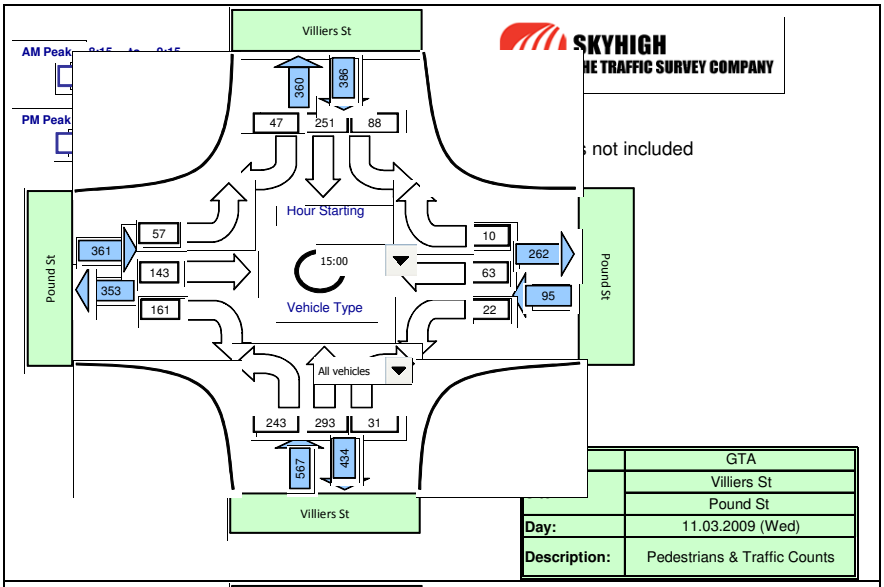
	GTA
	Villiers St
	Pound St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

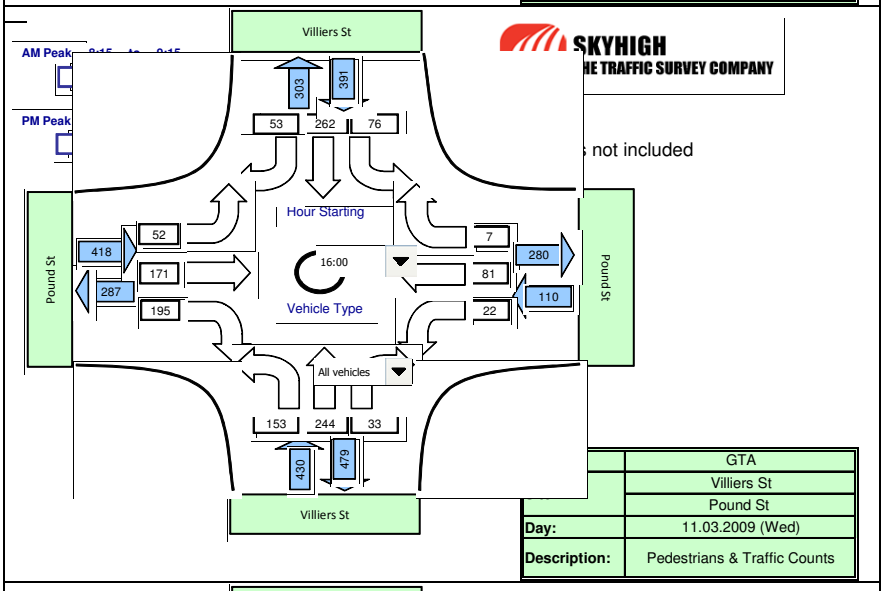
	GTA
	Villiers St
	Pound St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

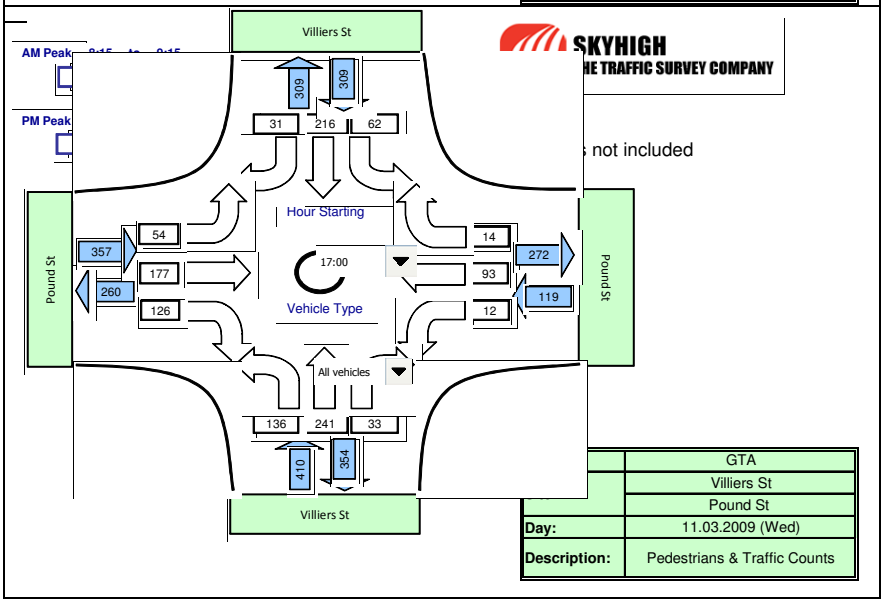
	GTA
	Villiers St
	Pound St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

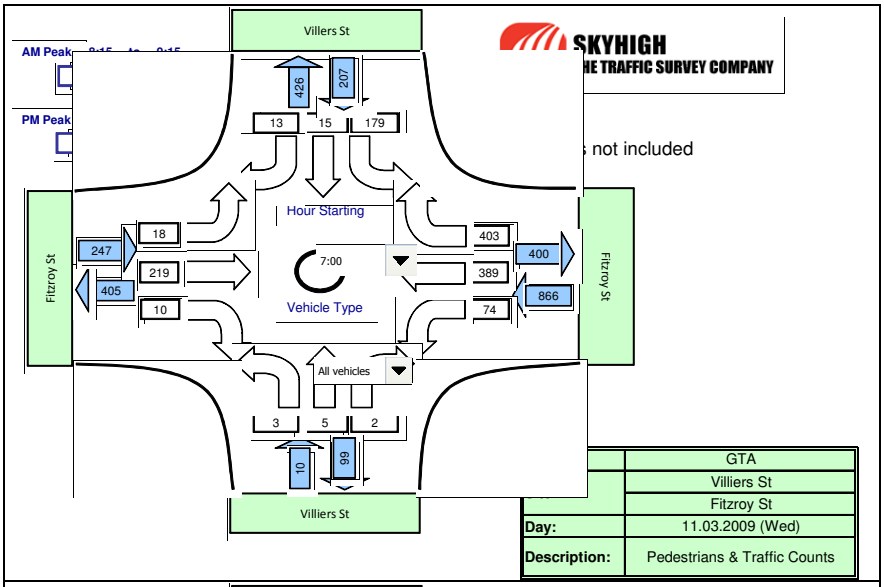
	GTA
	Villiers St
	Pound St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

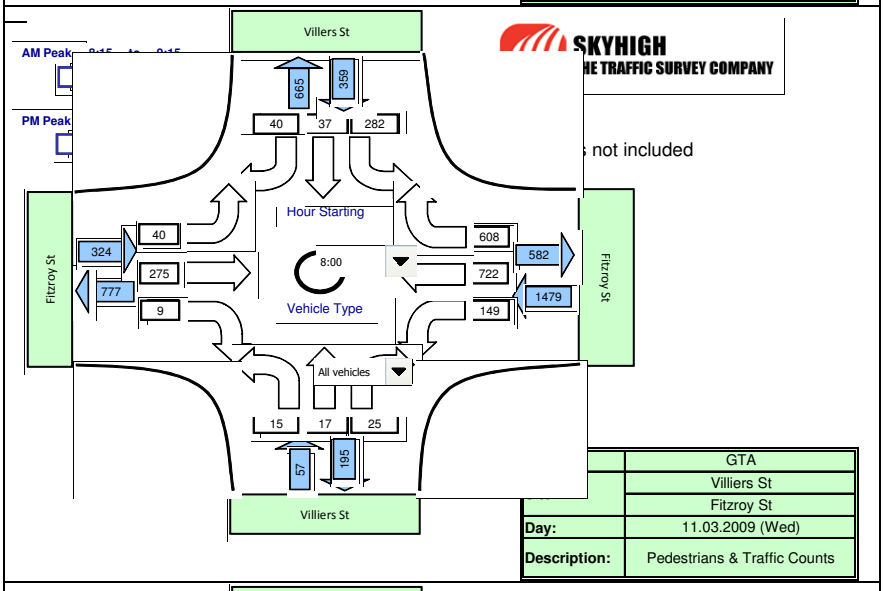
	GTA
	Villiers St
	Pound St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

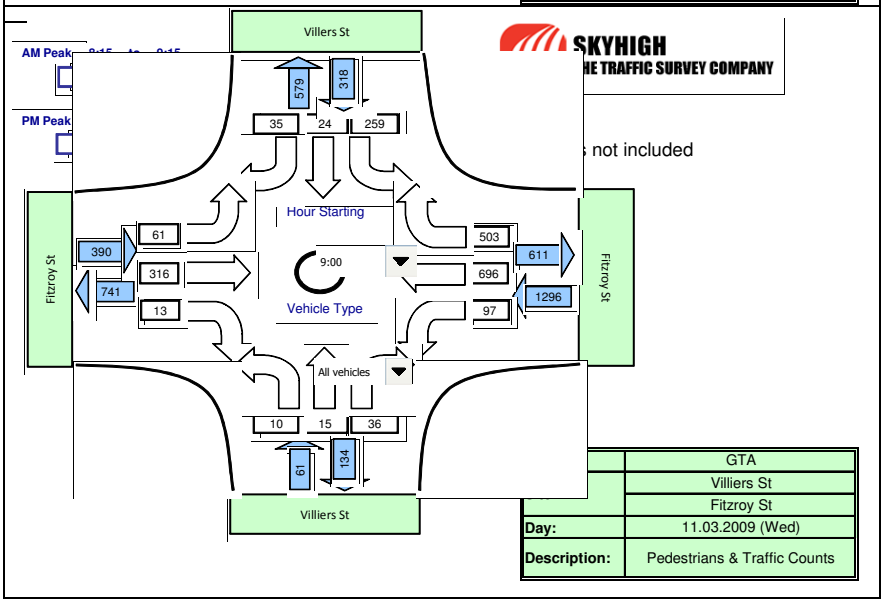
	GTA
	Villiers St
	Fitzroy St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

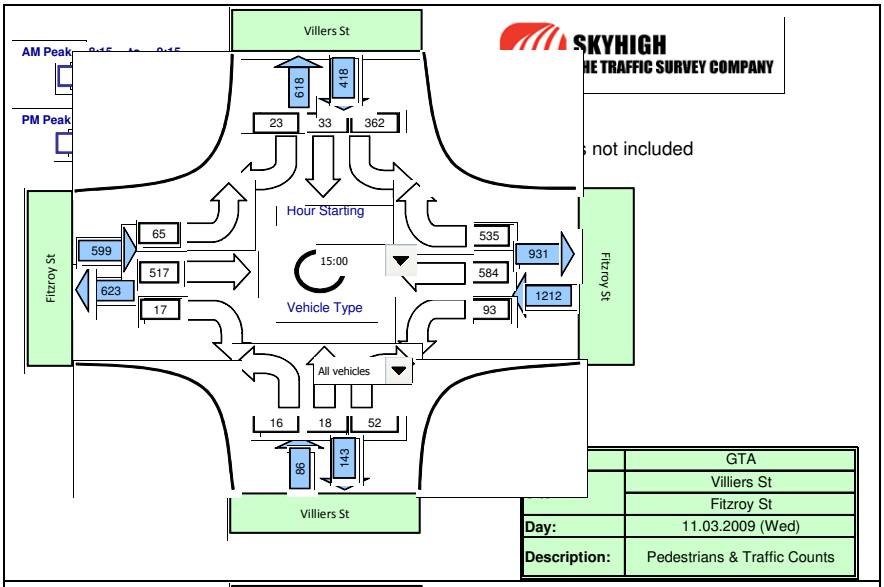
	GTA
	Villiers St
	Fitzroy St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

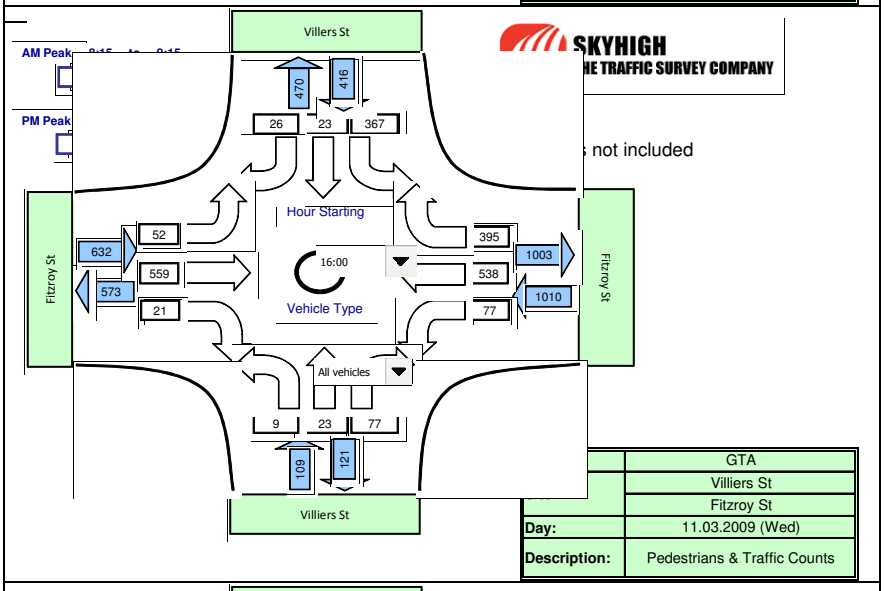
	GTA
	Villiers St
	Fitzroy St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

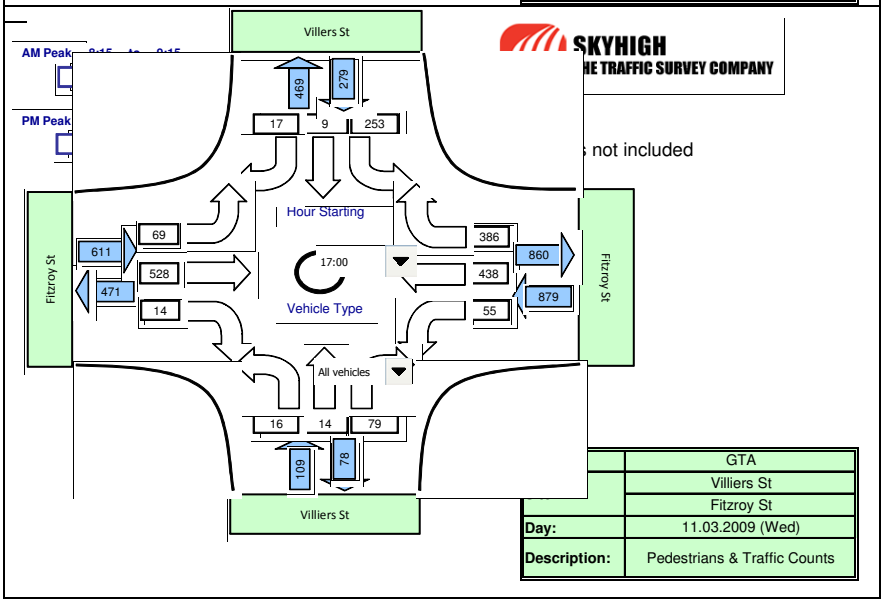
	GTA
	Villiers St
	Fitzroy St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

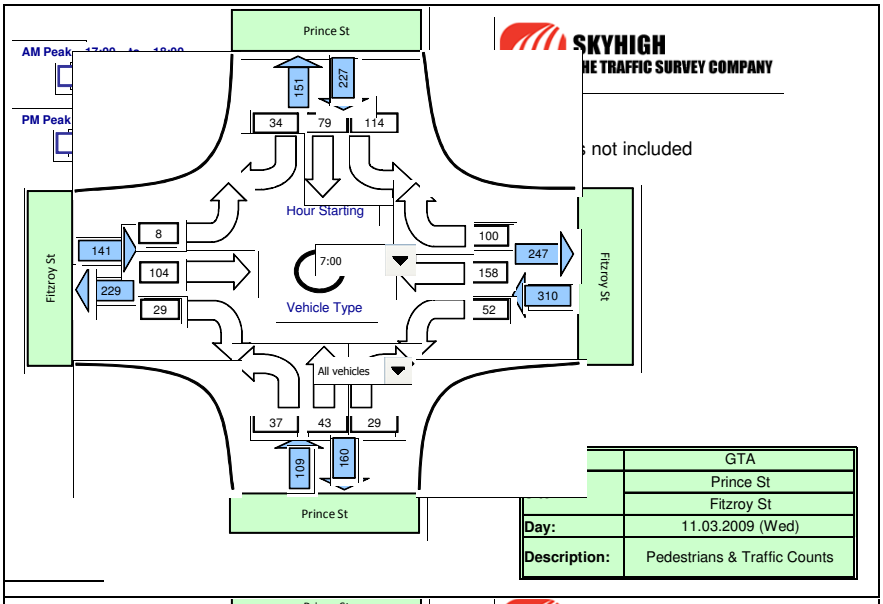
	GTA
	Villiers St
	Fitzroy St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

not included

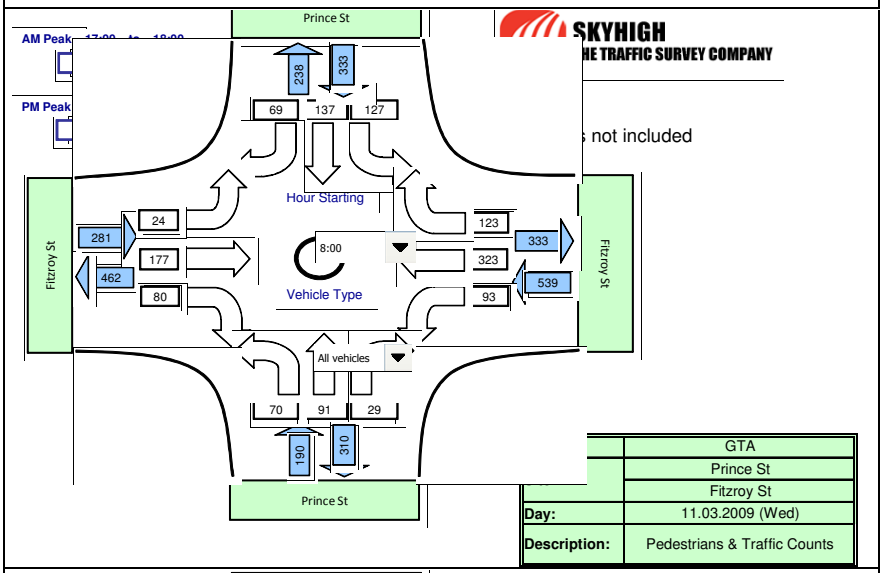
	GTA
	Villiers St
	Fitzroy St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

s not included

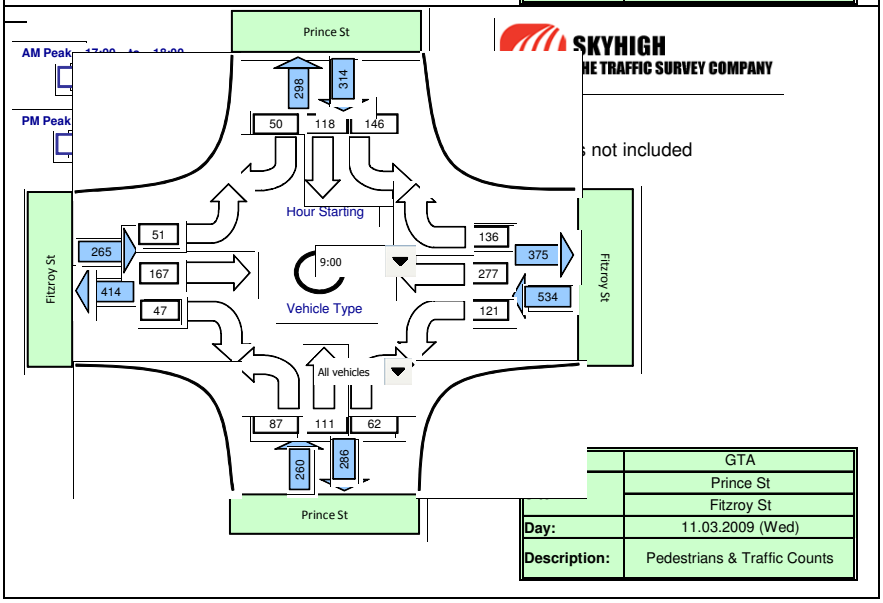
	GTA
	Prince St
	Fitzroy St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

s not included

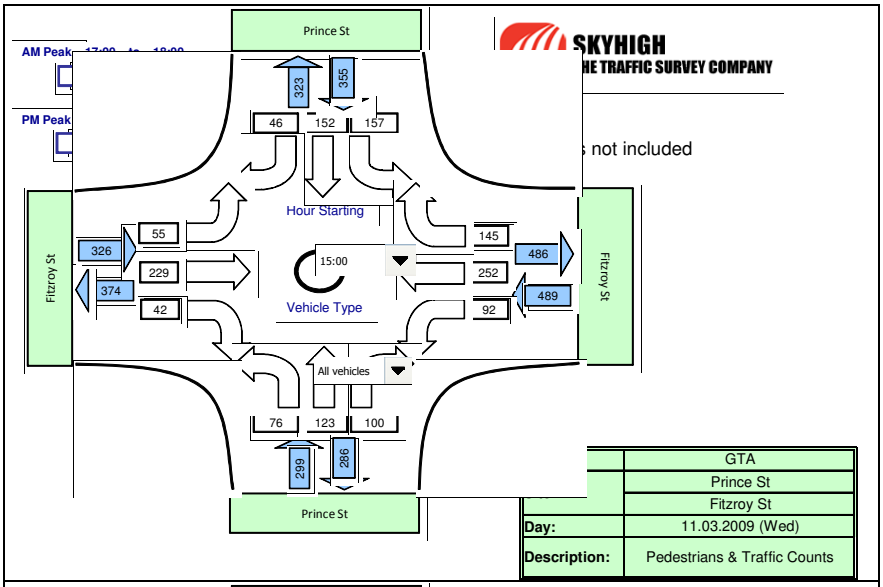
	GTA
	Prince St
	Fitzroy St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

s not included

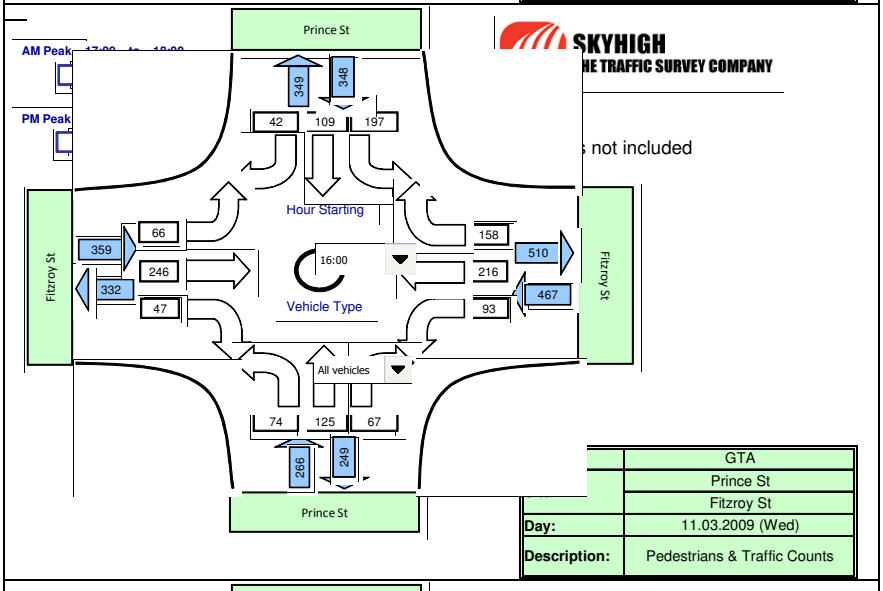
	GTA
	Prince St
	Fitzroy St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

s not included

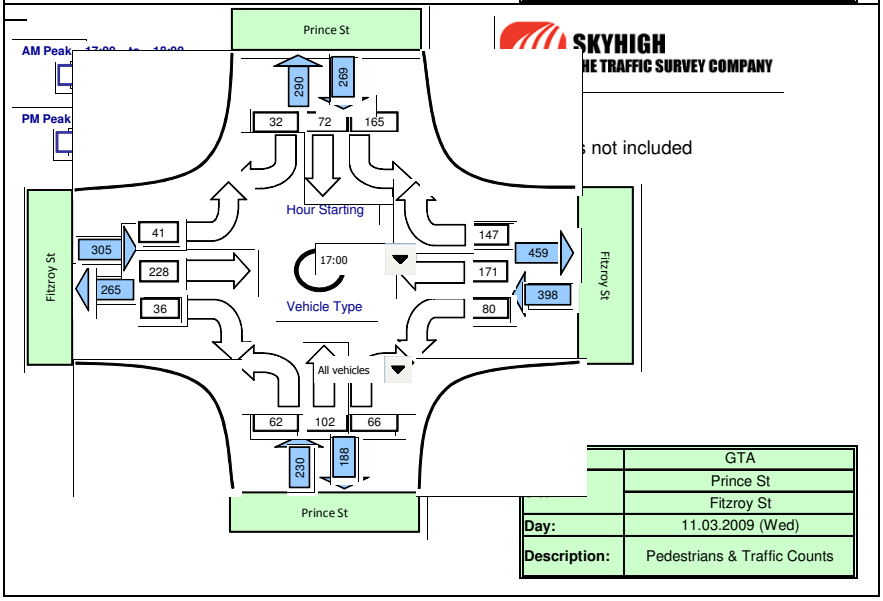
	GTA
	Prince St
	Fitzroy St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

s not included

	GTA
	Prince St
	Fitzroy St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts



SKYHIGH
THE TRAFFIC SURVEY COMPANY

s not included

	GTA
	Prince St
	Fitzroy St
Day:	11.03.2009 (Wed)
Description:	Pedestrians & Traffic Counts

Appendix B

Travel Time Survey Results

Travel Time Survey Data (Average Results)

GTA Data

	8:00-8:30	8:30-9:00	9:00-10:00	15:00-15:30	15:30-16:00	16:00-16:30	16:30-17:00
Northbound Section 1-5 (Gwydir Hwy - Pound St)	**495**	**582**	**506**	**336**	**302**	**292**	**302**
Northbound Section 1 (Gwydir - Through)	142	250	103	61	57	53	66
Northbound Section 2 (Through - Bridge bend)	160	149	129	63	54	71	59
Northbound Section 3 (Bridge bend - Villers)	91	97	157	108	93	96	79
Northbound Section 4 (Villers - Prince)	64	51	83	59	55	43	51
Northbound Section 5 (Fitzroy - Pound)	38	35	34	45	43	29	47
Southbound Section 5-1 (Pound St - Gwydir Hwy)	**287**	**268**	**319**	**298**	**291**	**284**	**299**
Southbound Section 5 (Pound - Fitzroy)	38	32	44	49	49	32	30
Southbound Section 4 (Prince - Villers)	59	62	85	68	63	47	87
Southbound Section 3 (Villers - Bridge band)	92	83	107	103	94	103	97
Southbound Section 2 Bridge band - Through)	42	43	40	40	39	59	36
Southbound Section 1 (Through - Gwydir)	56	48	43	38	46	43	49

RTA Data

	8:00-8:30	8:30-9:00	9:00-10:00	15:00-15:30	15:30-16:00	16:00-16:30	16:30-17:00
Northbound Section 1-5 (Gwydir Hwy - Pound St)	**513**	-	-	-	-	-	**277**
Northbound Section 1 (Gwydir - Through)	147	-	-	-	-	-	44
Northbound Section 2 (Through - Bridge bend)	172	-	-	-	-	-	39
Northbound Section 3 (Bridge bend - Villers)	99	-	-	-	-	-	88
Northbound Section 4 (Villers - Prince)	56	-	-	-	-	-	56
Northbound Section 5 (Fitzroy - Pound)	39	-	-	-	-	-	50
Southbound Section 5-1 (Pound St - Gwydir Hwy)	**290**	**290**	-	-	-	-	**287**
Southbound Section 5 (Pound - Fitzroy)	41	41	-	-	-	-	39
Southbound Section 4 (Prince - Villers)	67	67	-	-	-	-	60
Southbound Section 3 (Villers - Bridge band)	97	97	-	-	-	-	106
Southbound Section 2 Bridge band - Through)	43	43	-	-	-	-	40
Southbound Section 1 (Through - Gwydir)	42	42	-	-	-	-	42

Combined Data

	8:00-8:30	8:30-9:00	9:00-10:00	15:00-15:30	15:30-16:00	16:00-16:30	16:30-17:00
Northbound Section 1-5 (Gwydir Hwy - Pound St)	**504**	**582**	**506**	**336**	**302**	**292**	**290**
Northbound Section 1 (Gwydir - Through)	145	250	103	61	57	53	55
Northbound Section 2 (Through - Bridge bend)	166	149	129	63	54	71	49
Northbound Section 3 (Bridge bend - Villers)	95	97	157	108	93	96	84
Northbound Section 4 (Villers - Prince)	60	51	83	59	55	43	54
Northbound Section 5 (Fitzroy - Pound)	39	35	34	45	43	29	49
Southbound Section 5-1 (Pound St - Gwydir Hwy)	**289**	**279**	**319**	**298**	**291**	**284**	**293**
Southbound Section 5 (Pound - Fitzroy)	40	37	44	49	49	32	35
Southbound Section 4 (Prince - Villers)	63	65	85	68	63	47	74
Southbound Section 3 (Villers - Bridge band)	95	90	107	103	94	103	102
Southbound Section 2 Bridge band - Through)	43	43	40	40	39	59	38
Southbound Section 1 (Through - Gwydir)	49	45	43	38	46	43	46

	8:00-9:00	9:00-10:00	15:00-16:00		16:00-17:00	
Northbound Section 1-5 (Gwydir Hwy - Pound St)	**543**	**506**	**319**	**-**	**291**	**-**
Northbound Section 1 (Gwydir - Through)	197	103	59	-	54	-
Northbound Section 2 (Through - Bridge bend)	158	129	59	-	60	-
Northbound Section 3 (Bridge bend - Villers)	96	157	101	-	90	-
Northbound Section 4 (Villers - Prince)	56	83	57	-	48	-
Northbound Section 5 (Fitzroy - Pound)	37	34	44	-	39	-
Southbound Section 5-1 (Pound St - Gwydir Hwy)	**284**	**319**	**295**	**-**	**289**	**-**
Southbound Section 5 (Pound - Fitzroy)	38	44	49	-	33	-
Southbound Section 4 (Prince - Villers)	64	85	66	-	60	-
Southbound Section 3 (Villers - Bridge band)	92	107	99	-	102	-
Southbound Section 2 Bridge band - Through)	43	40	40	-	49	-
Southbound Section 1 (Through - Gwydir)	47	43	42	-	44	-

Appendix C

Strategic Model Existing Conditions Data

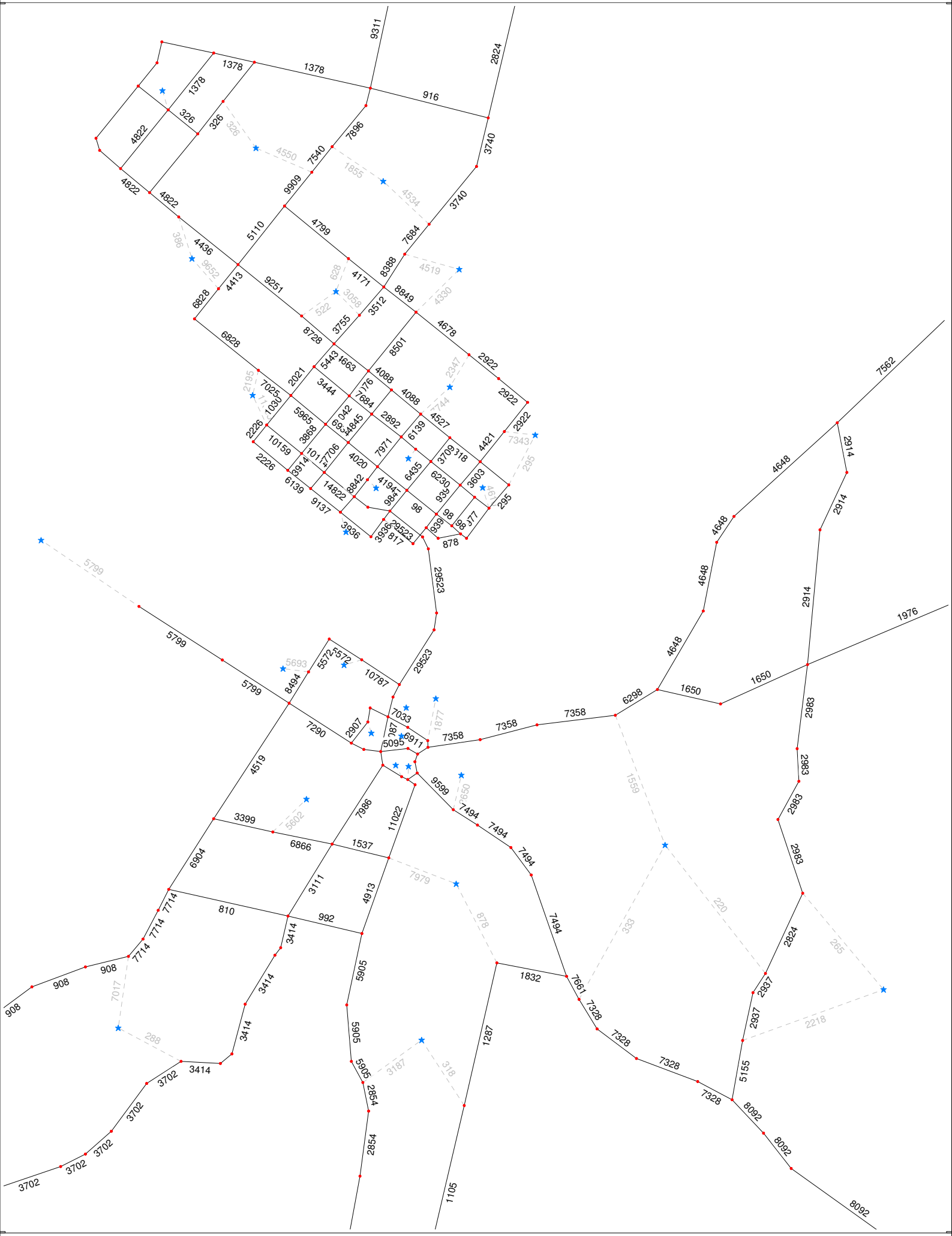
Appendix C
2009 Calibration AM Peak 2 Hour Period - TRIPS Model Results

Location	Count (Various)	Modelled Volumes	Modelled - Count	% Difference	(M-C)^2	R^2
Bridge - Northbound	2326	2379	53	2%	2809	0.91
Bridge - Southbound	1382	1521	139	10%	19321	
Fitzroy St/Villiers St	2345	1750	-595	-25%	354025	
Bent St/Spring St	1697	1264	-433	-26%	187489	
Bent St/Spring St	1063	1334	271	25%	73441	
Fitzroy St/Prince St	956	952	-4	0%	16	
Bent St/Gwydir Hwy	952	755	-197	-21%	38809	
Pacific Hwy/Gwydir Hwy	883	797	-86	-10%	7396	
Fitzroy St/Prince St	849	638	-211	-25%	44521	
Gwydir Hwy/Bligh St	696	675	-21	-3%	441	
Bent St/Gwydir Hwy	688	738	50	7%	2500	
Pacific Hwy	683	731	48	7%	2304	
Pacific Hwy/Gwydir Hwy	680	663	-17	-3%	289	
Pacific Hwy	678	628	-50	-7%	2500	
Bent St	665	704	39	6%	1521	
Prince St	654	516	-138	-21%	19044	
Villiers St/Pound St	637	677	40	6%	1600	
Gwydir Hwy	609	587	-22	-4%	484	
Prince St	594	373	-221	-37%	48841	
Bent St/Gwydir Hwy	588	588	0	0%	0	
Prince St	576	841	265	46%	70225	
Fitzroy St/Villiers St	571	699	128	22%	16384	
Fitzroy St/Villiers St	566	464	-102	-18%	10404	
Prince St/Pound St	563	351	-212	-38%	44944	
Prince St	487	632	145	30%	21025	
Prince St/Pound St	486	408	-78	-16%	6084	
Gwydir Hwy/Bligh St	453	401	-52	-11%	2704	
Pacific Hwy	447	371	-76	-17%	5776	
Pacific Hwy/Gwydir Hwy	415	443	28	7%	784	
Queen St	407	108	-299	-73%	89401	
Prince St/Pound St	393	193	-200	-51%	40000	
Pacific Hwy	373	338	-35	-9%	1225	
Queen St	342	310	-32	-9%	1024	
Bent St	339	351	12	4%	144	
Summerland Way	321	319	-2	-1%	4	
Fitzroy St/Prince St	299	228	-71	-24%	5041	
Villiers St/Pound St	294	509	215	73%	46225	
Through St	285	289	4	1%	16	
Lawrence Rd	272	261	-11	-4%	121	
Bent St	242	228	-14	-6%	196	
Bent St	242	223	-19	-8%	361	
Bent St/Spring St	200	313	113	57%	12769	
Duke St	183	70	-113	-62%	12769	
Duke St	183	327	144	79%	20736	
Gwydir Hwy	177	179	2	1%	4	
Villiers St/Pound St	157	53	-104	-66%	10816	
Summerland Way	144	164	20	14%	400	
Lawrence Rd	104	112	8	8%	64	
Bent St/Spring St	102	107	5	5%	25	
Gwydir Hwy/Bligh St	102	92	-10	-10%	100	
Swallow Rd	72	85	13	18%	169	
Swallow Rd	72	87	15	21%	225	
Rushforth Rd	46	51	5	11%	25	
Rushforth Rd	46	69	23	50%	529	
Total	**29586**	**27946**	**-1640**	**-6%**		

Appendix D

Strategic Model Future Conditions Results with Existing Network

Grafton Bridge Study
2009 Base Case - Daily Two Way Volumes (2 Hour AM Peak Period to Daily Factor = 7.57)

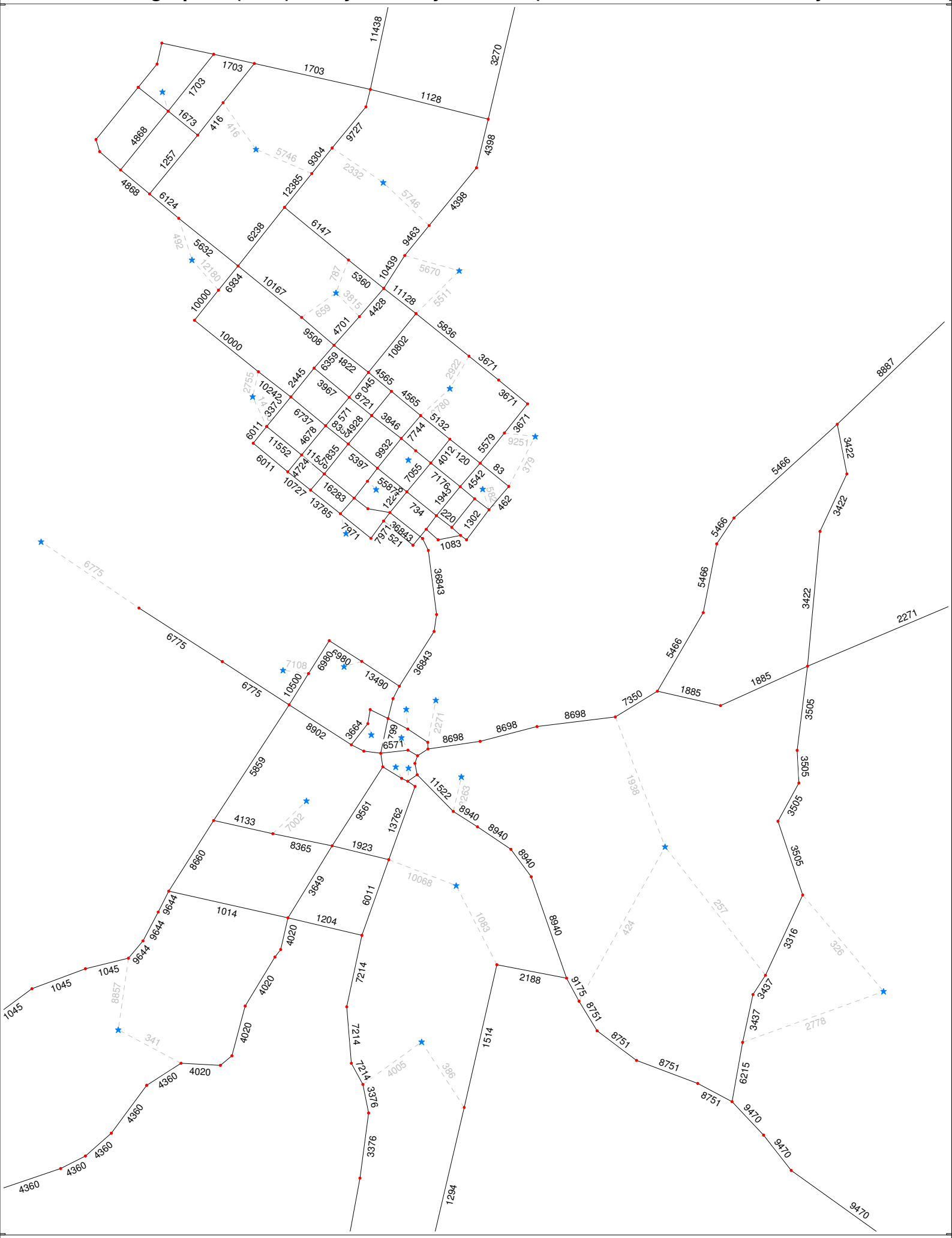


M:\Melbourne Model (GTA)\Base\Grafton2009\HY_LOAD_AM_Peak_Extra_Grafton2009.NET
9/07/2009

cube

Grafton Bridge Study

2019 Do Nothing Option (1.9%) - Daily Two Way Volumes (2 Hour AM Peak Period to Daily Factor = 7.57)

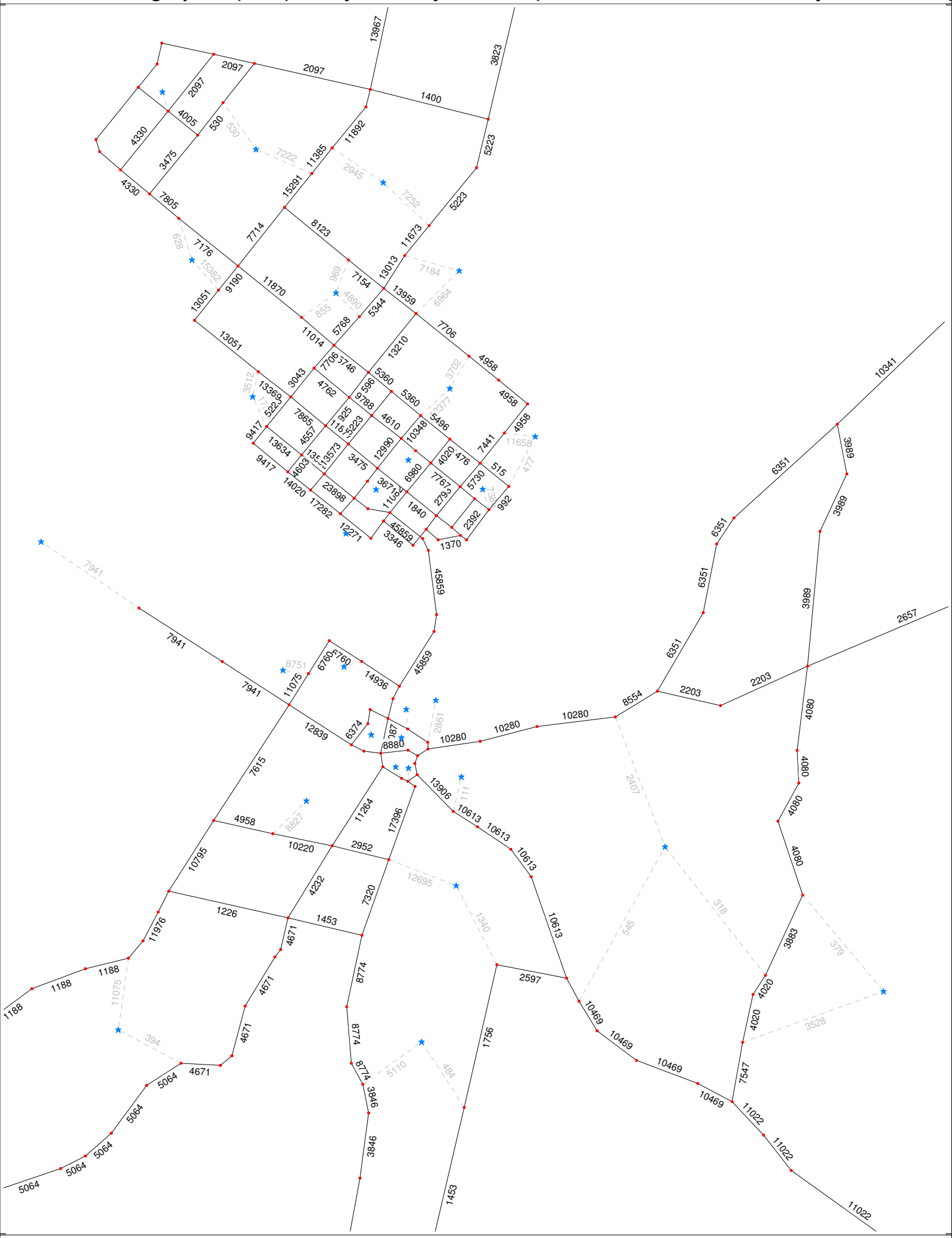


M:\Melbourne Model (GTA)\Base\Grafton2019\DN19\HY_LOAD_AM_Peak_Extra_DN19.NET
10/07/2009

cube

Grafton Bridge Study

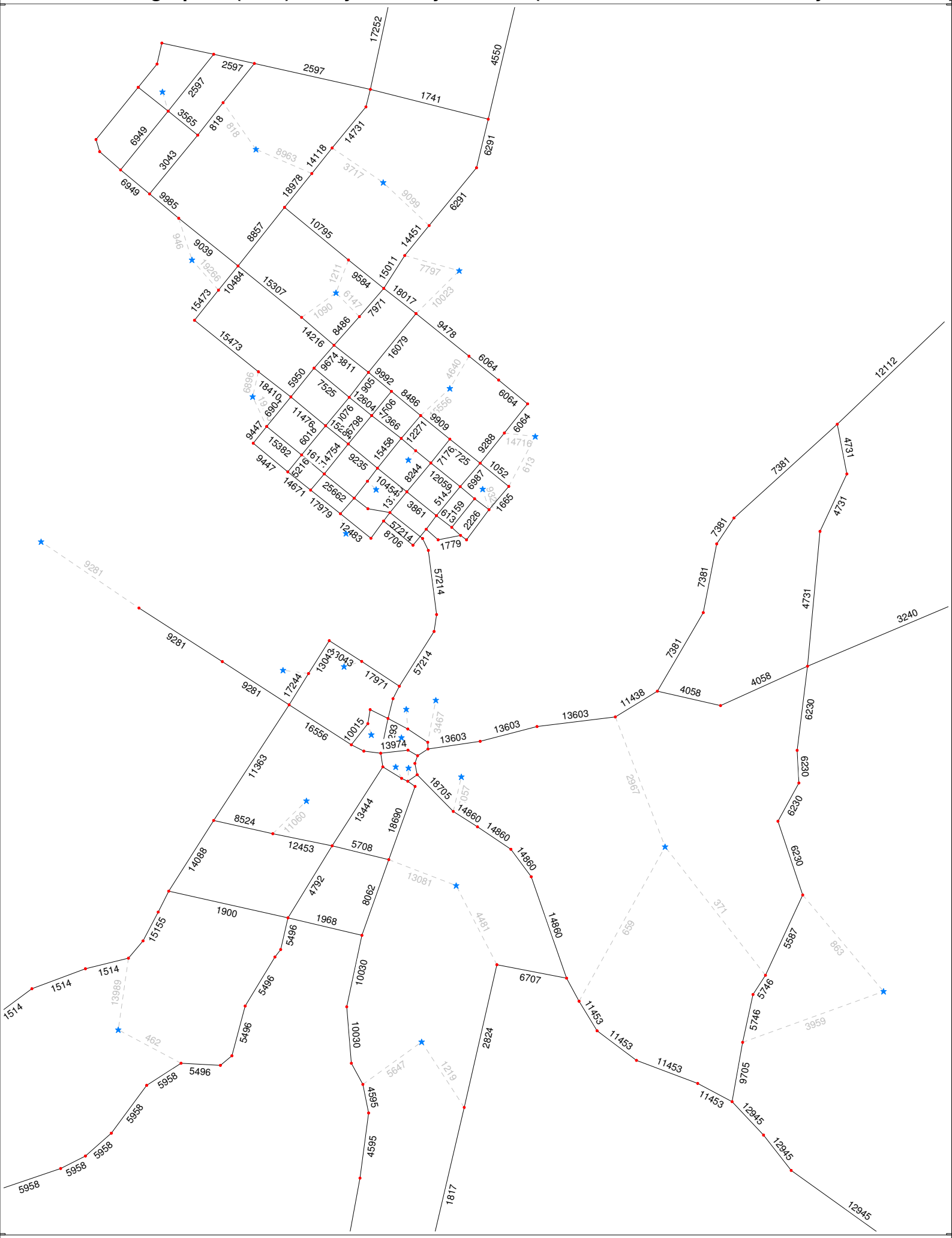
2029 Do Nothing Option (1.9%) - Daily Two Way Volumes (2 Hour AM Peak Period to Daily Factor = 7.57)



M:\Melbourne Model (GTA)\Base\Grafton2029\DN19\HY_LOAD_AM_Peak_Extra_DN19.NET
10/07/2009

Grafton Bridge Study

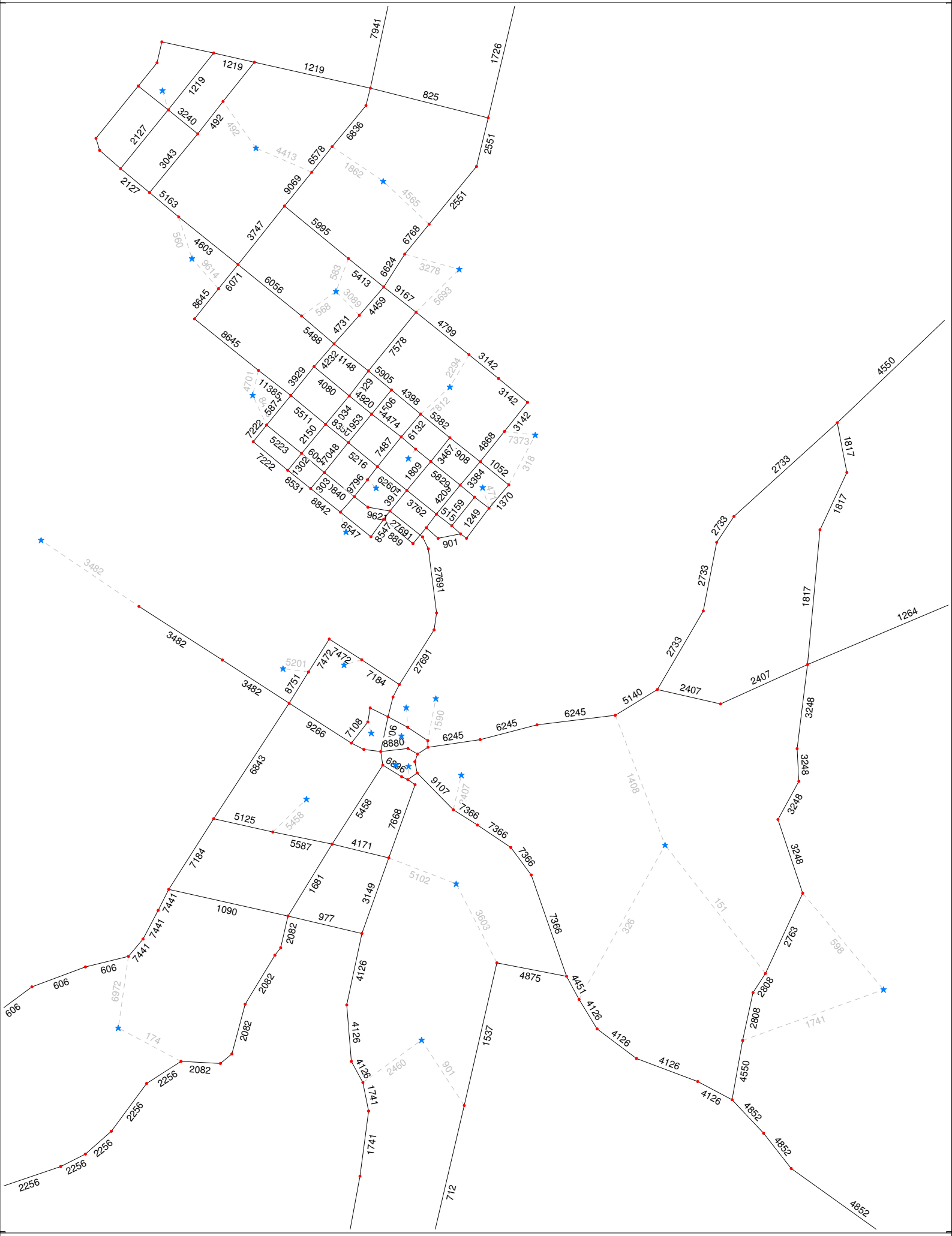
2039 Do Nothing Option (1.9%) - Daily Two Way Volumes (2 Hour AM Peak Period to Daily Factor = 7.57)



M:\Melbourne Model (GTA)\Base\Grafton2039\DN19\HY_LOAD_AM_Peak_Extra_DN19.NET
10/07/2009

cube

Grafton Bridge Study
Daily Difference Plot: 2039 Do Nothing Option (1.9%) - 2009 Base Case



M:\Melbourne Model (GTA)\~Project Apps\HM10750-CranEastandWest\Run06and08DifferencePlot.NET
10/07/2009

Appendix E

Microsimulation Model Calibration and Validation Report

Grafton Bridge Traffic Study

Microsimulation Calibration & Validation Report

GTAconsultants

Grafton Bridge Traffic Study

Microsimulation Calibration & Validation Report

Client: RTA – Northern Region
Reference: HS11120
GTA Consultants Office: Sydney

Quality Record

Issue	Date	Description	Prepared By	Checked By	Approved By
A	19/06/09	Final	Robert Dus	Reece Humphreys	
B		Final – amended	Robert Dus	Reece Humhreys	

GTAconsultants
BRISBANE • SYDNEY • MELBOURNE
www.gta.com.au

Table of Contents

Figures

Tables

1. Introduction

1.1 Background

GTA Consultants was commissioned by RTA for the development of a Q-Paramics model of Grafton and South Grafton, in Northern NSW. As part of the project the existing road network was constructed with an aim of representing an existing traffic conditions.

The report discusses the calibration and validation of the Paramics model, to confirm its 'fitness for purpose' as a basis for future options testing to be undertaken as part of this assignment.

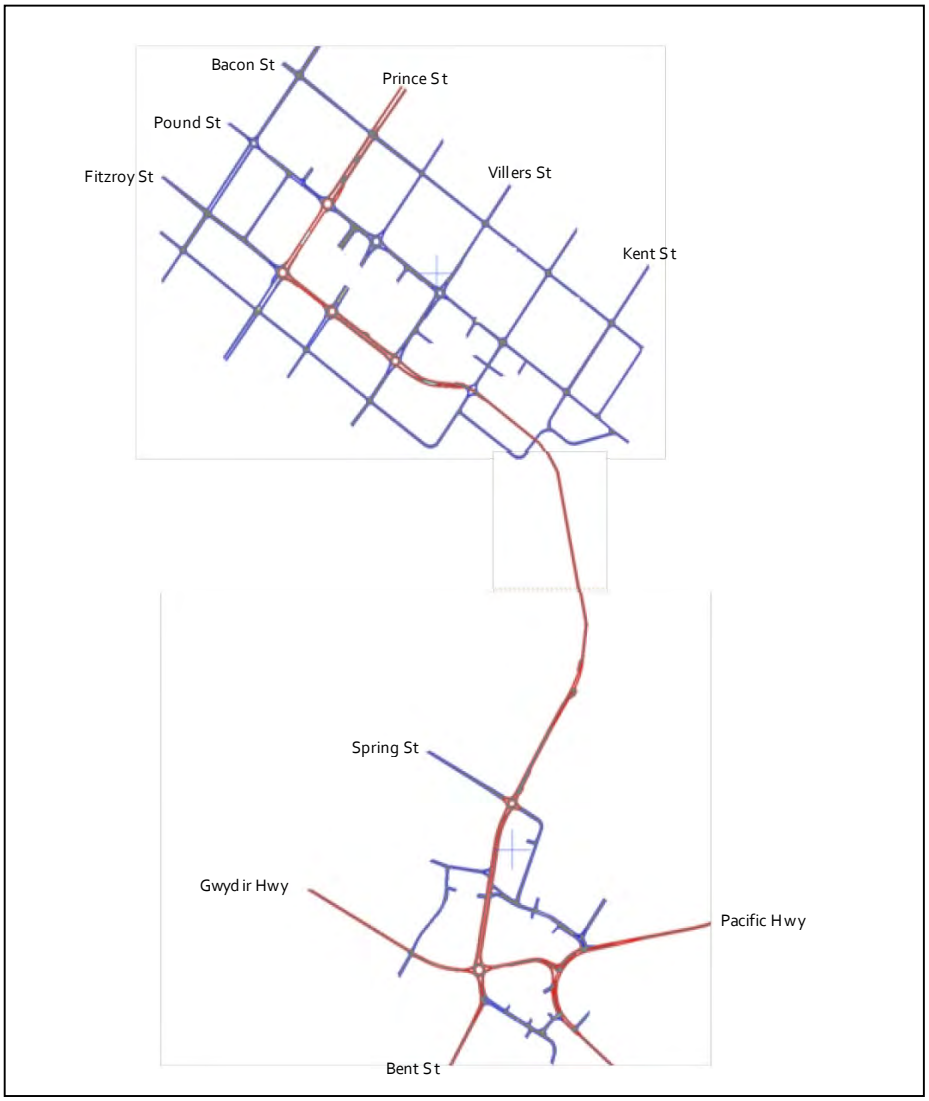
1.2 Study Area

The model area is located within Grafton in northern New South Wales and includes the town centres of Grafton and South Grafton and the existing bridge crossing of the Clarence River. The study area includes Fitzroy Street, Prince Street, Oliver Street, Bent Street, Gwyrdir Highway and Pacific Highway and includes the following key intersections:

- Fitzroy Street / Prince Street
- Prince Street / Pound Street
- Fitzroy Street / Villiers Street
- Pound Street / Villiers Street
- Bent Street / Through Street
- Bent Street / Ryan Street (Gwyrdir Highway), and
- Pacific Highway / Gwyrdir Highway.

The Q-Paramics model includes all intersecting roads within the area and is shown in Figure 1.1 below.

Figure 1.1: Model Extents



The model was constructed with the use of aerial photography enabling the physical road geometry, lane and line-marking, to be matched to the existing layout.

Existing conditions information and traffic volume data was based on comprehensive surveys and site observations undertaken throughout the study area and supplemented with additional data sourced from RTA NSW and previous studies. The manual turning movements and origin-destination surveys were undertaken at key intersections for matrix estimation process.

The model has been calibrated and validated in accordance with the criteria set out in the 'UK Design Manual for Roads and Bridges (Vol 12, Section 2, Part 1 – Traffic Appraisal in Urban Areas)'.

The purpose of the Paramics Modelling is to represent the existing operation of the network. This will then provide an accurate base for which to test the impact of various scenarios.

2. Model Specification

2.1 Software

The model was built using version 5.2 of Q-Paramics. To supplement the Paramics core, the Lane Choice and Route Choice plug-ins were used.

2.2 Network Coverage

The brief was to build a model of Grafton in northern New South Wales and includes the town centres of South Grafton and the existing bridge crossing of the Clarence River. The modelled area includes Fitzroy Street, Prince Street, Oliver Street, Bent Street, Gwyrdir Highway and Pacific Highway.

2.3 Temporal Coverage

The base model covers AM and PM peak hour periods augmented by warm up and cool down periods as follows:

- 6:30am to 7:00am (AM warm up period)
- 7:00am to 8:00am (1st AM peak hour)
- 8:00am to 9:00am (2nd AM peak hour)
- 9:00am to 10:00am (3rd AM peak hour)
- 10:00am to 10:30am (AM cool down period)
- 2:30pm to 3:00pm (PM warm up period)
- 3:00pm to 4:00pm (1st PM peak hour)
- 4:00pm to 5:00pm (2nd PM peak hour)
- 5:00pm to 6:00pm (3rd PM peak hour)
- 6:00pm to 7:00pm (PM cool down period)

Thirty minute warm up periods were considered appropriate to pre-load the network before the peak hours.

3. Network Build

3.1 Overlay

The aerial photograph overlay was imported into Paramics model as a starting point at 94 Lambert projection. This base aerial photo representing the whole modelled area was under low scale and the road geometry, lane and line-marking were not clearly seen. Therefore, a series of smaller scaled aerial photographs were imported in the model and scaled to the base aerial photograph and checked to ensure all the scales were correct.

3.2 Configuration

The RTA standard configuration file was used. No changes were made to the RTA standard. The RTA's standard five seeds were also used to generate model outputs for validation.

3.3 Nodes

Nodes were input into the model at all key intersections and geometric locations.

Zone connectors were coded at model entry points where it is appropriate the vehicles enter the network at speed.

3.4 Links

Link geometry, lanes and restrictions were coded on the basis of the aerial photograph.

Link speeds were coded to sign-posted speed limits and link categories defined using the RTA standard categories file.

3.5 Kerbs and Stoplines

The aerial photograph overlay was used as the basis for the positioning of kerbs and stoplines. Adjustments were made to ensure realistic progression of vehicles between links.

3.6 Junctions

There are a number of priority junctions in the network. Priority junctions within the network were coded using the default Paramics priority – 'minor', 'medium' and 'major' hierarchy. All U-turns in the model were barred.

3.7 Nextlane Rules

Nextlanes were applied in various locations throughout the network to achieve appropriate lane changing behaviour.

3.8 Lane Choice Rules

The lane choice plug-in was used throughout the network as a supplement to the limited functionality of signposting in the Paramics core.

3.9 Route Choice Rules

The route choice plug-in was used specifically at roundabouts to controls which routes vehicle use by specifying which exit vehicles must use when approaching an intersection.

4. Modelling Details and Assumptions

The following assumptions were made with regard to the development and calibration of the model.

- The speed on the southbound and northbound approaches to the bridge have been reduced in the model to reflect the road geometry and existing conditions at this locations
- Speeds at the approaches to the roundabouts within the study area were adjusted to more realistically represent observed traffic conditions
- A number of route choices were applied to reflect the results of traffic surveys and site observations
- HGV and B-Double vehicles were restricted from travelling on residential streets. In addition, B-doubles were only permitted to travel on Pacific Highway, Bent Street, Fitzroy Street and Villers Street
- Lower end speed factors were applied on links with unsignalised pedestrian crossings in the town centre
- Zone release percentages were applied to zones representing major activity centres reflecting traffic surveys and site observations, and
- A number of bus routes currently operate within the study area and were included in the base model. The locations of all bus stops were input into the models and the arrival and departure times were based on the current bus time table.

5. Model Stability

A full summary of the link counts and turn counts are provided in Appendix A of this report.

Seed values of 28, 560, 2849, 7771 and 86524 were used to test the stability and sensitivity of the model. The following graph shows a comparison of the network vehicles within the model for each seed run. The following graphs show an acceptable range of sensitivity with similar peaks over the time period indicating that the model is robust in both the AM and PM Peak periods.

5.1 Seed Run Comparison for Network Vehicles (NV)

Figure 5.1: Comparison of Seed Runs for Network Vehicles (NV) - AM Peak

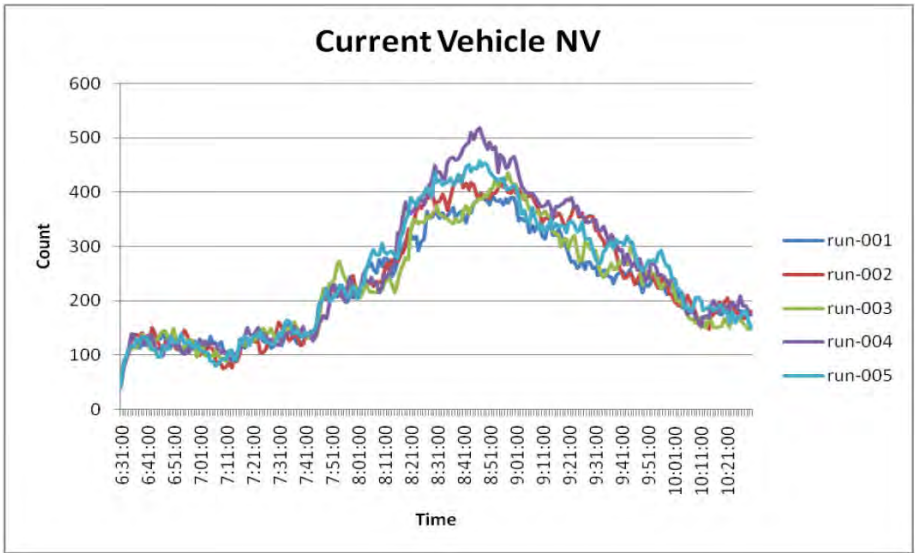
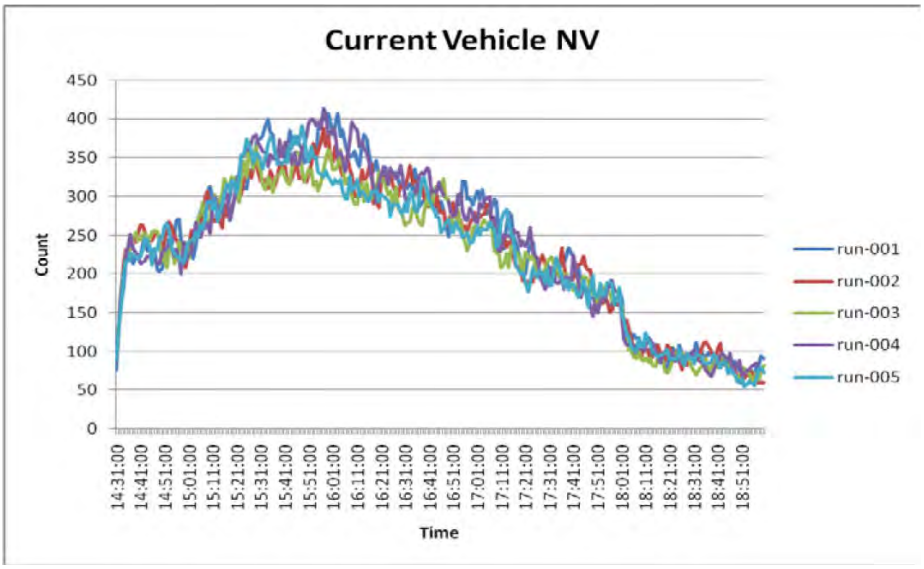


Figure 5.2: Comparison of Seed Runs for Network Vehicles (NV) - PM Peak



5.2 Vehicle Kilometres Travelled (VKT)

Figure 5.3: Vehicles Kilometres Travelled (VKT) - AM Peak

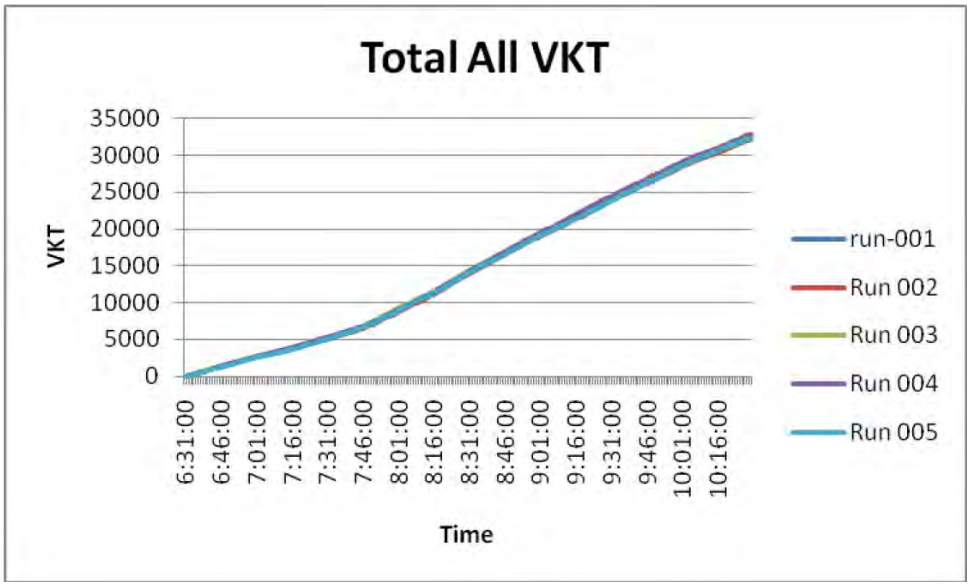
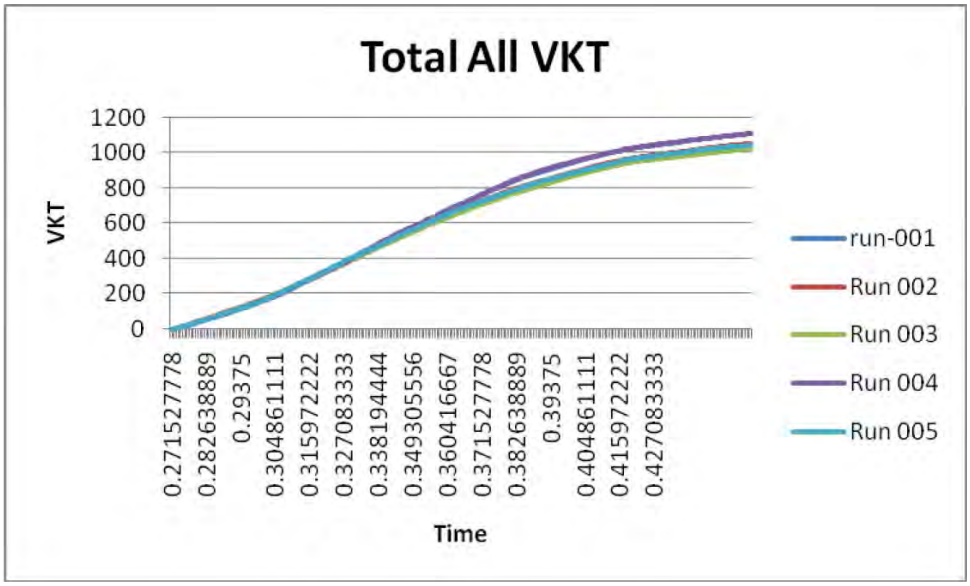


Figure 5.4: Vehicles Kilometres Travelled (VKT) - PM Peak



5.3 Vehicles Hours Travelled (VHT)

Figure 5.5: Vehicles Hours Travelled (VHT) - AM Peak

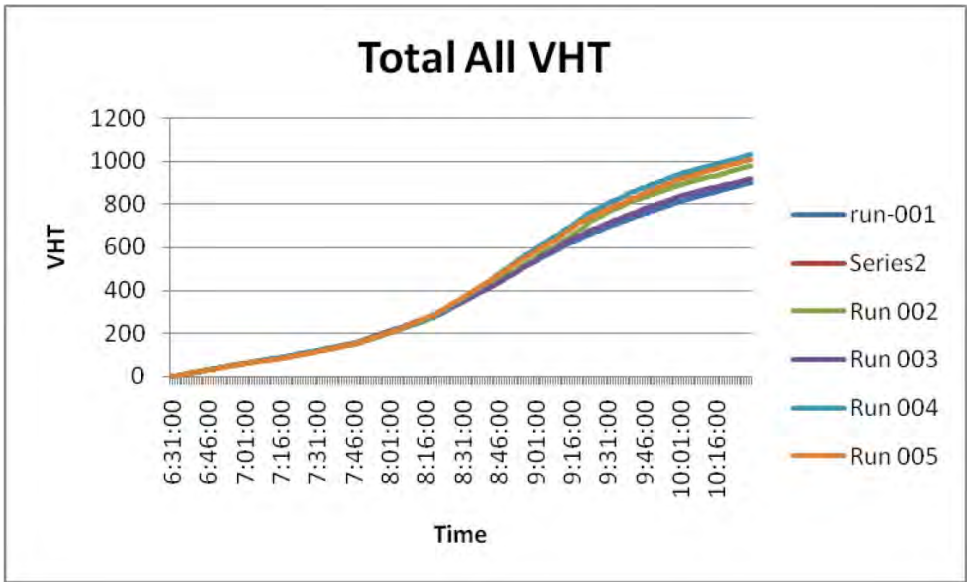
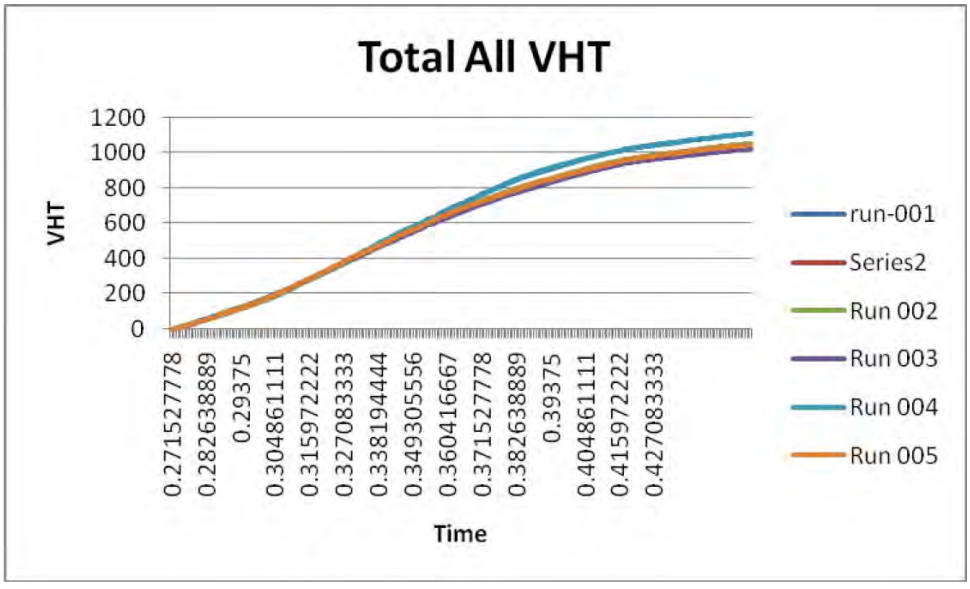


Figure 5.6: Vehicles Hours Travelled (VHT) - PM Peak



6. Calibration and Validation

6.1 Calibration and Validation Guidelines

The aim of the microsimulation models is to obtain the best possible match between the model results and the field measurements. The calibration and validation process was carried out in accordance with the criteria set out in the 'UK Design Manual for Roads and Bridges (Vol 12, Section 2, Part 1 – Traffic Appraisal in Urban Areas)'.

The targets set out in the guidelines are shown in Table 6.1.

Table 6.1: Microsimulation Modelling Calibration and Validation Criteria

Criteria and Measurements	Calibration Acceptable Targets
Hourly Flows, Modelled Versus Observed	
Individual Link Flows	
Within 15%, for 700 veh/h < Flow < 2700 veh/h	> 85% of cases
Within 100 veh/h, for Flow < 700 veh/h	> 85% of cases
Sum of All Link Flows	Within 5% of sum of all link counts
GEH Statistic < 5 for Individual Link Flows	> 85% of cases
Travel Times, Model Versus Observed	
Journey Times Within 15% (or 1 min, if higher)	> 85% of cases
Visual Audits	
Visually Acceptable Speed-Flow Relationship	To analyst's satisfaction
Visually Acceptable Queuing	To analyst's satisfaction

Source: 'UK Design Manual for Roads and Bridges (Vol 12, Section 2, Part 1 – Traffic Appraisal in Urban Areas)'

The hourly flow criteria set out in Table 6.1 were utilised to calibrate the model, whilst queuing and visual audits were used to validate the model.

6.2 Turning Movements Calibration Results

Tables 6.2 and 6.3 show the results obtained from the comparison of turn flows for both the AM and PM peak periods in relation to GEH Requirement.

The GEH statistic is a standard measure of the "goodness of fit" between observed and modelled flows. Unlike comparing percentage difference the GEH statistic places more emphasis on larger flows rather than on small flows.

The GEH statistic is defined as follows:

$$GEH = \sqrt{\frac{(M-C)^2}{(M+C)/2}}$$

where M and C are the modelled and observed flows respectively.

A smaller GEH value illustrates better fit and the Q-Paramics model of the existing situation will aim for all GEH values less than 5.

The GEH statistic is designed to measure one hour flows and as such, it is applied to hourly flows within the model. A GEH greater than 10 indicates no correlation between the observed and modelled data. A GEH between 5 and 10 indicates an acceptable match for modelling purposes, and a GEH below 5 indicates a good correlation. Tables 6.2 and 6.3 summarise the AM and PM calibration results.

Table 6.2: AM Calibration Summary

Criteria UK Design Manual for Roads and Bridges	Within 15% for 700 veh/h < Flow < 2700 veh/h	Within 100 veh/h, for Flow < 700 veh/h	GEH less than 5	Sum of all link flows
Target	>85%	>85%	>85%	within 5%
7:00 – 8:00	100%	96%	87%	1.9%
8:00 – 9:00	100%	95%	86%	3.3%
Total Average	**100%**	**96%**	**87%**	**2.60%**

Table 6.3: PM Calibration Summary

Criteria UK Design Manual for Roads and Bridges	Within 15% for 700 veh/h < Flow < 2700 veh/h	Within 100 veh/h, for Flow < 700 veh/h	GEH less than 5	Sum of all link flows
Target	>85%	>85%	>85%	within 5%
3:00 – 4:00	100%	98%	88%	3.5%
4:00 – 5:00	100%	98%	86%	2.9%
Total Average	**100%**	**98%**	**87%**	**3.2%**

Table 6.2 and Table 6.3 indicate that the AM and PM model meet the UK Design Manual for Roads and Bridges (Vol 12, Section 2, Part 1 – Traffic Appraisal in Urban Areas) and GEH turning movement criterion. Full details of the turn flows comparisons are included in Appendix A.

6.3 Travel Time Validation

Travel times along the route were recorded for each of the AM and PM peak periods and compared with data extracted from the model. 85% of the Q-Paramics values should be within 15% of the observed values. Because the journey times vary greatly in the real world, a sufficient number of on-site observations were made and average journey times were calculated for the main sections within the study area. For the purpose of the study, two main sections were set up:

- South – North (between Gwydir Hwy/Bend St Roundabout and Prince St/Pound St Roundabout), and
- North – South (between Prince St/Pound St Roundabout and Gwydir Hwy/Bend St Roundabout).

Tables 6.4 and 6.5 summarise the observed and modelled average travel time for both northbound and southbound traffic during the AM and PM peak periods.

Table 6.4: AM Travel Time Summary

Time Period	8:00 - 9:00			9:00 - 10:00		
Direction	Average Observed (s)	Modelled Average (s)	% Difference	Average Observed (s)	Modelled Average (s)	% Difference
Northbound Gwydir Hwy to Pound St	543	474	-12.7	506	420	16.9
Southbound Pound St to Gwydir Hwy	284	281	-0.01	319	278	-11.9

Table 6.5: PM Travel Time Summary

Time Period	3:00 – 4:00			4:00 -5:00		
Direction	Average Observed (s)	Modelled Average (s)	% Difference	Average Observed (s)	Modelled Average (s)	% Difference
Northbound Gwydir Hwy to Pound St	319	296	-7.2	291	284	0.34
Southbound Pound St to Gwydir Hwy	295	362	22.6	289	369	27.7

The results presented in Table 6.4 and 6.5 indicate that the journey times generally meet the requirements set out in the validation criteria. The only discrepancy is the southbound journey times during the PM peak, however after several site visits during the afternoon peak period, the model has been calibrated to represent slow forming queues on the north side of the Grafton River and is considered acceptable.

6.4 External Model Audit

An independent audit was undertaken of the model in May 2009. A response to the audit was provided to the RTA on the 19th of June 2009, incorporating the majority of changes recommended by the auditor.

7. Conclusion

The existing model has been build and calibrated using sound modelling practice, as outlined in the this report. The data used to build the model was thoroughly analysed to ensure the quality of model inputs.

Modelled turning movement counts achieved a high level of correlation to observed counts. Modelled travel times also reflected observed travel times to an anticipated statistical confidence.

The quality of input data, model building and calibration has produced a sound model, validated by travel time data. GTA considers that the model is "fit for purpose".

Appendix A

Turn Flow Comparison Results

	Observed Flows			Modelled Flows			Actual Difference			Percentage Difference			GEH		
Turn Flow	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00
96:97:36 [A]	37	90	81	49	63	30	2	-27	-39	6	-30	-48	1.83	3.09	6.85
100:98:97 [L]	88	105	80	70	142	177	-17	26	97	-19	25	121	2.03	3.33	8.56
100:98:36 [R]	329	506	500	305	419	499	-11	-71	-11	-3	-14	-2	1.35	4.05	0.04
43:40:45 [L]	11	45	19	10	42	12	-3	-2	-3	-24	-5	-18	0.31	0.45	1.78
43:40:44 [A]	8	20	13	15	41	9	6	17	-4	73	84	-32	2.06	3.80	1.21
43:40:39 [R]	4	19	8	9	38	12	5	16	4	125	82	55	1.96	3.56	1.26
39:40:43 [L]	8	11	15	20	25	42	16	14	34	203	124	224	3.21	3.30	5.06
39:40:45 [A]	119	233	247	95	183	224	-11	-37	-10	-9	-16	-4	2.32	3.47	1.50
44:40:39 [L]	23	42	52	12	36	38	-12	-6	-19	-50	-15	-37	2.63	0.96	2.09
44:40:43 [A]	12	25	22	6	27	8	-8	-2	-13	-70	-9	-60	2.00	0.39	3.61
44:40:45 [R]	13	11	13	9	2	14	-4	-9	1	-32	-84	5	1.21	3.53	0.27
45:40:44 [L]	14	39	9	7	30	10	-6	-5	1	-46	-13	16	2.16	1.53	0.32
45:40:39 [A]	224	329	300	245	318	285	25	-15	-26	11	-5	-9	1.37	0.61	0.88
45:40:43 [R]	13	26	35	12	27	34	-2	-4	-2	-18	-15	-6	0.28	0.19	0.17
63:60:58 [L]	221	264	281	210	230	219	-9	-35	-56	-4	-13	-20	0.75	2.16	3.92
63:60:389 [R]	65	100	80	63	71	53	-5	-21	-22	-8	-21	-27	0.25	3.14	3.31
389:60:63 [L]	46	75	49	25	64	37	-25	-10	-12	-54	-13	-25	3.52	1.32	1.83
389:60:58 [R]	16	45	17	30	78	58	88	134	106	548	298	624	2.92	4.21	6.70
58:60:389 [L]	29	59	42	41	78	67	9	11	25	31	19	59	2.03	2.30	3.39
58:60:63 [R]	178	220	232	118	170	164	-57	-43	-71	-32	-19	-31	4.93	3.58	4.83
62:24:78 [L]	24	52	46	39	95	64	14	46	22	58	89	47	2.67	5.02	2.43
62:24:80 [R]	55	95	50	72	70	66	11	-29	18	20	-30	37	2.13	2.75	2.10
81:62:389 [L]	31	42	33	29	66	52	72	129	88	232	306	266	0.37	3.27	2.91
81:24:78 [A]	299	332	318	307	385	325	-69	-49	-53	-23	-15	-17	0.46	2.80	0.39
25:24:80 [A]	185	246	312	179	250	244	4	28	-81	2	11	-26	0.44	0.25	4.08
23:24:62 [A]	42	83	47	23	107	67	-21	9	12	-51	11	26	3.33	2.46	2.65
7:9:16 [L]	159	433	211	241	376	266	120	18	112	76	4	53	5.80	2.83	3.56
7:9:299 [R]	141	108	182	93	132	180	-82	-49	-35	-58	-46	-19	4.44	2.19	0.15
300:9:3 [L]	96	171	102	100	191	129	3	9	25	3	5	25	0.40	1.49	2.51
300:9:16 [R]	33	70	50	18	46	26	-15	-25	-24	-46	-36	-48	2.97	3.15	3.89
12:9:299 [L]	118	146	142	115	142	138	-11	2	3	-9	1	2	0.28	0.33	0.34
12:9:3 [R]	159	227	190	210	217	188	46	-14	-4	29	-6	-2	3.75	0.67	0.15
22:26:27 [A]	173	223	187	154	255	199	-80	-64	-49	-46	-29	-26	1.49	2.07	0.86
22:14:15 [R]	189	229	212	203	263	214	-2	26	12	-1	12	6	1.00	2.17	0.14
21:14:20 [A]	128	213	203	108	196	120	-18	-9	-80	-14	-4	-39	1.84	1.19	6.53
16:14:19 [A]	82	302	110	150	226	172	103	-9	115	126	-3	105	6.31	4.68	5.22
390:18:15 [L]	97	152	145	124	95	112	29	-47	-38	30	-31	-26	2.57	5.13	2.91
390:18:14 [R]	98	113	155	95	162	190	3	50	10	3	44	6	0.31	4.18	2.66
Gwydir-Bent East Left	25	22	47	17	56	17	-8	33	-27	-33	152	-57	1.75	5.44	5.30
Gwydir-Bent East Through	36	53	155	44	34	75	11	-12	-74	31	-22	-47	1.26	2.88	7.46
Fitzroy-Villers East Right	403	608	503	439	616	600	39	1	69	10	0	14	1.75	0.32	4.13
Fitzroy-Villers South Left	3	15	10	4	24	9	1	8	1	33	53	14	0.53	2.04	0.32
Fitzroy-Villers South Through	5	17	15	2	22	26	-3	6	12	-56	34	80	1.60	1.13	2.43
Fitzroy-Villers South Right	2	25	36	11	25	32	7	-2	-3	370	-6	-9	3.53	0.00	0.69
Fitzroy-Villers West Left	18	40	61	29	130	93	15	91	32	86	227	53	2.27	9.76	3.65
Fitzroy-Villers West Through	219	275	316	147	200	264	-52	-69	-62	-24	-25	-20	5.32	4.87	3.05
Fitzroy-Villers West Right	10	9	13	9	5	4	-3	-5	-10	-30	-51	-74	0.32	1.51	3.09
Fitzroy-Villers North Left	179	282	259	190	306	318	18	15	62	10	5	24	0.81	1.40	3.47
Fitzroy-Villers North Through	15	37	24	30	27	12	16	-7	-6	108	-19	-27	3.16	1.77	2.83
Fitzroy-Villers North Right	13	40	35	19	66	43	8	26	6	65	66	17	1.50	3.57	1.28
Villers-Pound East Left	9	17	11	32	58	47	21	34	38	238	200	347	5.08	6.70	6.69
Villers-Pound East Through	43	43	76	64	59	69	18	19	-5	43	44	-6	2.87	2.24	0.82
Villers-Pound East Right	8	8	11	8	2	5	-3	-4	-5	-33	-50	-44	0.00	2.68	2.12
Villers-Pound South Left	108	268	257	168	335	308	57	58	43	53	22	17	5.11	3.86	3.03
Villers-Pound South Through	294	279	260	224	333	326	-64	51	58	-22	18	22	4.35	3.09	3.86
Villers-Pound South Right	36	64	59	69	94	83	37	36	14	103	56	23	4.55	3.38	2.85
Villers-Pound West Left	7	21	29	46	131	58	41	110	37	591	526	127	7.58	12.62	4.40
Villers-Pound West Through	44	99	89	14	50	19	-33	-43	-69	-76	-44	-77	5.57	5.68	9.53
Villers-Pound West Right	34	89	104	81	145	146	48	68	42	142	77	40	6.20	5.18	3.76
Villers-Pound North Left	53	56	41	42	66	55	-5	11	14	-10	19	35	1.60	1.28	2.02
Villers-Pound North Through	176	294	240	132	211	164	-37	-104	-70	-21	-35	-29	3.55	5.22	5.35
Villers-Pound North Right	7	51	45	17	74	28	14	18	-14	194	36	-31	2.89	2.91	2.81
Fitzroy-Princes East Left	52	93	121	45	62	64	-3	-34	-56	-5	-37	-46	1.01	3.52	5.93
Fitzroy-Princess East Through	158	323	277	84	260	176	-76	-57	-106	-48	-18	-38	6.73	3.69	6.71
Fitzroy-Princes East Right	100	123	136	82	109	116	-12	-5	-29	-12	-4	-21	1.89	1.30	1.78
Fitzroy-Princes South Left	37	70	87	14	17	44	-23	-51	-41	-62	-73	-47	4.55	8.04	5.31
Fitzroy-Princes South Through	43	91	111	47	59	72	3	-31	-41	7	-34	-37	0.60	3.70	4.08
Fitzroy-Princes South Right	29	29	62	12	40	77	-14	15	12	-48	51	19	3.75	1.87	1.80
Fitzroy-Princes West Left	8	24	51	20	37	39	10	16	-12	128	67	-23	3.21	2.35	1.79
Fitzroy-Princes West Through	104	177	167	93	136	161	-2	-33	-9	-2	-19	-5	1.11	3.28	0.47
Fitzroy-Princes West Right	29	80	47	12	49	29	-15	-24	-20	-50	-30	-42	3.75	3.86	2.92
Fitzroy-Princes North Left	114	127	146	65	90	90	-46	-35	-60	-41	-28	-41	5.18	3.55	5.16
Fitzroy-Princes North Through	79	137	118	100	168	113	27	41	-8	34	30	-7	2.22	2.51	0.47
Fitzroy-Princes North Right	34	69	50	36	65	39	7	-12	-19	22	-17	-37	0.34	0.49	1.65
Princes-Pound East Left	37	74	91	25	21	38	-12	-52	-57	-31	-71	-63	2.16	7.69	6.60
Princes-Pound East Through	79	211	118	110	198	140	36	-16	9	46	-7	8	3.19	0.91	1.94
Princes-Pound East Right	29	56	67	50	71	73	29	21	1	99	38	1	3.34	1.88	0.72
Princes-Pound South Left	20	60	67	23	61	66	11	5	0	55	8	-1	0.65	0.13	0.12
Princes-Pound South Through	117	162	126	123	132	154	-1	-23	20	-1	-14	16	0.55	2.47	2.37
Princes-Pound South Right	7	27	29	3	12	6	-3	-11	-25	-46	-41	-88	1.79	3.40	5.50
Princes-Pound West Left	15	53	66	21	65	55	8	14	-16	52	27	-24	1.41	1.56	1.41
Princes-Pound West Through	81	207	202	120	223	172	40	25	-28	49	12	-14	3.89	1.09	2.19
Princes-Pound West Right	90	117	85	66	65	61	-16	-52	-21	-18	-44	-24	2.72	5.45	2.81
Princes-Pound North Left	32	85	93	60	100	86	34	16	-17	106	18	-18	4.13	1.56	0.74
Princes-Pound North Through	130	207	155	111	238	141	-13	33	-27	-10	16	-17	1.73	2.08	1.15
Princes-Pound North Right	28	67	41	9	45	45	-19	-21	4	-69	-31	9	4.42	2.94	0.61

	Observed Flows			Modelled Flows			Actual Difference			Percentage Difference			GEH		
Turn Flow	15:00 - 16:00	16:00 - 17:00	17:00 - 18:00	15:00 - 16:00	16:00 - 17:00	17:00 - 18:00	15:00 - 16:00	16:00 - 17:00	17:00 - 18:00	15:00 - 16:00	16:00 - 17:00	17:00 - 18:00	15:00 - 16:00	16:00 - 17:00	17:00 - 18:00
37:108:107 [L]	37	37	39	61	44	54	24	7	13	39	16	32	3.43	1.10	2.20
37:108:106 [R]	724	724	686	768	731	569	44	7	-120	6	1	17	1.61	0.26	4.67
96:97:36 [A]	120	120	102	141	130	46	21	10	-60	15	6	58	1.84	0.89	6.51
100:98:36 [R]	942	942	991	894	922	647	-48	-20	-374	5	2	38	1.58	0.66	12.02
109:107:106 [A]	47	47	31	65	38	61	18	-9	21	27	25	67	2.41	1.38	4.42
43:40:45 [L]	22	22	20	22	24	18	0	2	3	3	5	17	0.00	0.42	0.46
43:40:44 [A]	8	8	10	23	15	17	15	7	5	64	43	52	3.81	2.06	1.91
43:40:39 [R]	9	9	11	24	18	14	15	9	4	62	45	40	3.69	2.45	0.85
39:40:43 [L]	20	20	16	59	53	42	39	33	28	65	62	176	6.21	5.46	4.83
39:40:45 [A]	361	361	380	345	355	280	-16	-6	-86	5	2	23	0.85	0.32	5.50
39:40:44 [R]	19	19	9	3	4	2	-16	-15	-8	768	556	91	4.82	4.42	2.98
44:40:39 [L]	89	89	89	75	59	70	-14	-30	-23	20	51	26	1.55	3.49	2.13
44:40:43 [A]	32	32	32	36	39	17	4	7	-11	6	16	36	0.69	1.17	3.03
44:40:45 [R]	43	43	30	45	31	30	2	-12	-3	3	49	9	0.30	1.97	0.00
45:40:44 [L]	26	26	26	25	14	27	-1	-12	3	8	82	13	0.20	2.68	0.19
45:40:39 [A]	278	278	283	299	286	261	21	8	-26	7	2	9	1.24	0.48	1.33
45:40:43 [R]	18	18	29	19	13	5	1	-5	-22	4	50	77	0.23	1.27	5.82
58:60:389 [L]	47	47	44	44	49	20	-3	2	-24	8	3	55	0.44	0.29	4.24
58:60:63 [R]	369	369	352	352	329	234	-17	-40	-94	5	12	27	0.90	2.14	6.89
62:24:78 [L]	39	39	35	36	34	28	-3	-5	-2	9	21	6	0.49	0.83	1.25
62:24:80 [R]	75	75	47	70	39	23	-5	-36	-23	7	97	49	0.59	4.77	4.06
81:62:389 [L]	47	47	40	90	86	45	43	39	3	47	45	7	5.20	4.78	0.77
81:24:78 [A]	309	309	246	376	275	195	67	-34	-34	18	12	14	3.62	1.99	3.43
25:24:80 [A]	411	411	410	395	309	389	-16	-102	-31	4	33	8	0.80	5.38	1.05
23:24:62 [A]	53	53	54	55	60	57	2	7	-6	2	10	11	0.27	0.93	0.40
7:9:16 [L]	237	237	225	270	218	281	33	-19	60	12	9	27	2.07	1.26	3.52
7:9:299 [R]	88	88	90	119	78	79	31	-10	-10	26	13	11	3.05	1.10	1.20
300:9:3 [L]	169	169	172	214	192	152	45	23	-42	21	12	24	3.25	1.71	1.57
300:9:16 [R]	99	89	90	78	89	47	-11	0	-46	16	1	52	1.20	0.00	5.20
12:9:299 [L]	124	124	100	125	93	77	1	-31	-17	0	35	17	0.09	2.98	2.44
12:9:3 [R]	248	248	210	254	192	164	6	-56	-40	2	30	19	0.38	3.78	3.36
22:26:27 [A]	164	164	140	190	129	95	26	-35	-40	14	27	28	1.95	2.89	4.15
22:14:15 [R]	231	231	173	266	208	149	35	-23	-10	13	11	6	2.22	1.55	1.89
21:14:20 [A]	254	254	225	228	169	278	-26	-85	52	12	51	23	1.67	5.84	3.34
16:14:19 [A]	80	80	99	120	138	50	40	58	-47	33	41	48	4.00	5.56	5.68
390:18:15 [L]	130	130	146	114	76	91	-16	-54	-57	14	70	39	1.45	5.32	5.05
390:18:14 [R]	202	202	231	224	199	167	22	-3	-82	10	2	36	1.51	0.21	4.54
Fitzroy-Villers East Left	93	77	55	80	75	67	-13	-2	0	17	4	0	1.40	0.23	1.54
Fitzroy-Villers East Through	584	530	438	532	485	385	-52	-45	-45	10	9	10	2.20	2.00	2.61
Fitzroy-Villers East Right	535	403	386	468	344	387	-67	-59	-12	15	18	3	2.99	3.05	0.05
Fitzroy-Villers South Left	16	9	16	14	7	9	-2	-2	-9	37	40	55	0.52	0.71	1.98
Fitzroy-Villers South Through	23	23	14	28	41	13	5	18	-2	17	42	13	0.99	3.18	0.27
Fitzroy-Villers South Right	52	77	79	41	73	51	-11	-4	-24	28	7	30	1.61	0.46	3.47
Fitzroy-Villers West Left	65	52	69	80	111	73	15	59	2	19	53	3	1.76	6.54	0.47
Fitzroy-Villers West Through	517	559	528	471	466	379	-46	-93	-161	10	20	30	2.07	4.11	7.00
Fitzroy-Villers West Right	17	21	14	11	13	3	-6	-8	-11	57	102	77	1.60	1.94	3.77
Fitzroy-Villers North Left	362	367	253	620	576	400	258	209	89	41	36	35	11.64	9.63	8.14
Fitzroy-Villers North Through	33	23	9	32	28	13	-1	5	2	5	16	27	0.18	0.99	1.21
Fitzroy-Villers North Right	23	26	17	31	24	9	8	-2	-9	24	12	51	1.54	0.40	2.22
Villers-Pound East Left	22	22	12	351	197	82	329	175	13	94	89	112	24.09	16.72	10.21
Villers-Pound East Through	63	81	93	149	121	132	86	40	37	57	33	40	8.35	3.98	3.68
Villers-Pound East Right	10	7	14	2	1	2	-8	-6	-12	650	600	84	3.27	3.00	4.24
Villers-Pound South Left	243	153	136	220	203	129	-23	50	-7	11	24	5	1.51	3.75	0.61
Villers-Pound South Through	293	244	241	252	210	249	-41	-34	-7	17	17	3	2.48	2.26	0.51
Villers-Pound South Right	31	33	33	105	82	94	74	49	62	71	60	188	8.97	6.46	7.65
Villers-Pound West Left	57	52	54	126	129	86	69	77	30	54	59	56	7.21	8.09	3.82
Villers-Pound West Through	143	171	177	90	111	57	-53	-60	-113	59	54	64	4.91	5.05	11.09
Villers-Pound West Right	161	195	126	133	188	176	-28	-7	54	21	4	43	2.31	0.51	4.07
Villers-Pound North Left	88	76	62	80	101	93	-8	25	33	11	25	53	0.87	2.66	3.52
Villers-Pound North Through	251	262	216	208	230	156	-43	-32	-65	22	14	30	2.84	2.04	4.40
Villers-Pound North Right	47	53	31	54	42	27	7	-11	-5	10	36	17	0.99	1.60	0.74
Fitzroy-Princes East Left	92	93	80	120	104	71	28	11	-2	23	10	2	2.72	1.11	1.04
Fitzroy-Princess East Through	252	216	171	217	222	183	-35	6	3	17	3	2	2.29	0.41	0.90
Fitzroy-Princes East Right	145	158	147	207	143	135	62	-15	-18	30	11	12	4.67	1.22	1.01
Fitzroy-Princes South Left	76	74	62	48	31	47	-28	-43	-14	60	146	23	3.56	5.93	2.03
Fitzroy-Princes South Through	123	125	102	98	127	98	-25	2	-4	26	0	4	2.38	0.18	0.40
Fitzroy-Princes South Right	100	67	66	77	82	70	-23	15	3	31	16	4	2.44	1.74	0.49
Fitzroy-Princes West Left	41	66	41	35	67	39	-6	1	-1	19	0	1	0.97	0.12	0.32
Fitzroy-Princes West Through	228	246	228	157	216	182	-71	-30	-60	47	14	26	5.12	1.97	3.21
Fitzroy-Princes West Right	36	47	36	15	30	32	-21	-17	-3	147	58	9	4.16	2.74	0.69
Fitzroy-Princes North Left	165	197	165	124	120	77	-41	-77	-89	34	65	54	3.41	6.12	8.00
Fitzroy-Princes North Through	72	109	72	83	92	116	11	-17	37	13	20	52	1.25	1.70	4.54
Fitzroy-Princes North Right	32	42	32	28	56	27	-4	14	-1	15	23	4	0.73	2.00	0.92
Princes-Pound East Left	98	72	54	16	30	27	-82	-42	-28	556	143	51	10.86	5.88	4.24
Princes-Pound East Through	190	191	203	125	159	212	-65	-32	5	54	21	3	5.18	2.42	0.62
Princes-Pound East Right	112	93	102	110	62	75	-2	-31	-26	3	54	25	0.19	3.52	2.87
Princes-Pound South Left	91	92	90	94	75	94	3	-17	-4	3	24	4	0.31	1.86	0.42
Princes-Pound South Through	203	218	184	232	237	172	29	19	-5	13	8	3	1.97	1.26	0.90
Princes-Pound South Right	25	45	19	13	25	6	-12	-20	-15	98	83	79	2.75	3.38	3.68
Princes-Pound West Left	106	84	88	105	78	91	-1	-6	3	2	8	3	0.10	0.67	0.32
Princes-Pound West Through	234	212	174	228	229	204	-6	17	23	3	7	13	0.39	1.14	2.18
Princes-Pound West Right	101	102	57	66	76	41	-35	-26	-16	55	38	28	3.83	2.76	2.29
Princes-Pound North Left	127	109	82	168	146	84	41	37	0	24	25	0	3.38	3.28	0.22
Princes-Pound North Through	202	184	164	154	167	148	-48	-17	-18	32	11	11	3.60	1.28	1.28
Princes-Pound North Right	44	44	41	67	44	26	23	0	-14	34	3	34	3.09	0.00	2.59

Appendix B

Travel Time Comparison Results

		2009 Grafton Northbound					
		28	560	2849	7771	86524	AVG
7:00-8:00	**Northbound Section 1-5 (Gwydir Hwy - Pound St)**	300	300	290	290	290	294
	Northbound Section 1 (Gwydir - Through)	42	42	42	42	42	42
	Northbound Section 2 (Through - Bridge bend)	39	38	38	38	39	38
	Northbound Section 3 (Bridge bend - Villers)	96	97	96	96	96	96
	Northbound Section 4 (Villers - Prince)	58	59	59	58	58	58
	Northbound Section 5 (Fitzroy - Pound)	51	51	51	50	49	50
8:00-9:00	**Northbound Section 1-5 (Gwydir Hwy - Pound St)**	410	410	400	480	460	432
	Northbound Section 1 (Gwydir - Through)	65	96	80	190	160	118
	Northbound Section 2 (Through - Bridge bend)	150	150	130	150	170	150
	Northbound Section 3 (Bridge bend - Villers)	97	98	98	98	98	98
	Northbound Section 4 (Villers - Prince)	58	59	59	58	59	59
	Northbound Section 5 (Fitzroy - Pound)	49	49	48	49	49	49
9:00-10:00	**Northbound Section 1-5 (Gwydir Hwy - Pound St)**	400	460	430	510	470	454
	Northbound Section 1 (Gwydir - Through)	45	67	58	80	59	62
	Northbound Section 2 (Through - Bridge bend)	130	150	150	170	170	154
	Northbound Section 3 (Bridge bend - Villers)	97	97	97	97	97	97
	Northbound Section 4 (Villers - Prince)	57	58	58	58	58	58
	Northbound Section 5 (Fitzroy - Pound)	48	49	49	48	49	49

		2009 Grafton Southbound					
		28	560	2849	7771	86524	AVG
7:00-8:00	**Southbound Section 5-1 (Pound St - Gwydir Hwy)**	280	280	280	280	280	280
	Southbound Section 5 (Pound - Fitzroy)	39	40	40	40	41	40
	Southbound Section 4 (Prince - Villers)	54	54	55	55	55	55
	Southbound Section 3 (Villers - Bridge band)	100	100	100	100	100	100
	Southbound Section 2 Bridge band - Through)	38	38	38	38	38	38
	Southbound Section 1 (Through - Gwydir)	44	44	45	44	44	44
8:00-9:00	**Southbound Section 5-1 (Pound St - Gwydir Hwy)**	290	280	290	280	280	284
	Southbound Section 5 (Pound - Fitzroy)	41	41	43	41	42	42
	Southbound Section 4 (Prince - Villers)	56	56	56	56	56	56
	Southbound Section 3 (Villers - Bridge band)	100	100	100	100	100	100
	Southbound Section 2 Bridge band - Through)	38	38	38	38	38	38
	Southbound Section 1 (Through - Gwydir)	44	44	45	45	45	45
9:00-10:00	**Southbound Section 5-1 (Pound St - Gwydir Hwy)**	280	290	280	280	280	282
	Southbound Section 5 (Pound - Fitzroy)	40	40	39	39	39	39
	Southbound Section 4 (Prince - Villers)	57	59	57	56	56	57
	Southbound Section 3 (Villers - Bridge band)	100	100	100	100	100	100
	Southbound Section 2 Bridge band - Through)	38	38	38	38	38	38
	Southbound Section 1 (Through - Gwydir)	44	44	44	44	44	44

		2009 Grafton Northbound					
		28	560	2849	7771	86524	AVG
15:00-16:00	**Northbound Section 1-5 (Gwydir Hwy - Pound St)**	300	290	290	300	300	296
	Northbound Section 1 (Gwydir - Through)	42	42	42	42	42	42
	Northbound Section 2 (Through - Bridge bend)	40	40	41	45	46	42
	Northbound Section 3 (Bridge bend - Villers)	99	97	97	97	97	97
	Northbound Section 4 (Villers - Prince)	60	60	60	61	60	60
	Northbound Section 5 (Fitzroy - Pound)	50	50	50	50	49	50
16:00-17:00	**Northbound Section 1-5 (Gwydir Hwy - Pound St)**	290	290	290	290	290	290
	Northbound Section 1 (Gwydir - Through)	42	42	42	42	42	42
	Northbound Section 2 (Through - Bridge bend)	39	40	39	39	38	39
	Northbound Section 3 (Bridge bend - Villers)	96	96	97	96	96	96
	Northbound Section 4 (Villers - Prince)	58	58	58	58	58	58
	Northbound Section 5 (Fitzroy - Pound)	49	49	48	48	49	49
17:00-18:00	**Northbound Section 1-5 (Gwydir Hwy - Pound St)**	280	290	280	290	290	286
	Northbound Section 1 (Gwydir - Through)	42	42	42	42	42	42
	Northbound Section 2 (Through - Bridge bend)	38	38	37	37	38	38
	Northbound Section 3 (Bridge bend - Villers)	95	95	95	95	95	95
	Northbound Section 4 (Villers - Prince)	58	58	57	58	59	58
	Northbound Section 5 (Fitzroy - Pound)	49	49	48	49	49	49

		2009 Grafton Southbound					
		28	560	2849	7771	86524	AVG
15:00-16:00	**Southbound Section 5-1 (Pound St - Gwydir Hwy)**	400	340	340	350	370	360
	Southbound Section 5 (Pound - Fitzroy)	41	40	40	40	40	40
	Southbound Section 4 (Prince - Villers)	60	58	56	57	57	58
	Southbound Section 3 (Villers - Bridge band)	210	160	160	170	200	180
	Southbound Section 2 Bridge band - Through)	39	39	40	39	39	39
	Southbound Section 1 (Through - Gwydir)	46	45	45	46	45	45
16:00-17:00	**Southbound Section 5-1 (Pound St - Gwydir Hwy)**	390	380	350	370	350	368
	Southbound Section 5 (Pound - Fitzroy)	42	42	43	40	41	42
	Southbound Section 4 (Prince - Villers)	58	59	61	58	59	59
	Southbound Section 3 (Villers - Bridge band)	210	190	170	190	160	184
	Southbound Section 2 Bridge band - Through)	40	39	39	39	39	39
	Southbound Section 1 (Through - Gwydir)	45	45	45	45	45	45
17:00-18:00	**Southbound Section 5-1 (Pound St - Gwydir Hwy)**	320	320	330	320	320	322
	Southbound Section 5 (Pound - Fitzroy)	39	40	42	40	40	40
	Southbound Section 4 (Prince - Villers)	56	57	59	58	57	57
	Southbound Section 3 (Villers - Bridge band)	140	140	140	130	140	138
	Southbound Section 2 Bridge band - Through)	39	39	39	39	39	39
	Southbound Section 1 (Through - Gwydir)	45	45	45	45	45	45

traffic and transport

www.gta.com.au

Brisbane

GTA Consultants (QLD) Pty Ltd t/a

GTA Consultants

ABN: 98 137 610 274

A Level 6, 269 Wickham Street
PO Box 555
FORTITUDE VALLEY QLD 4006

P +617 3113 5000

F +617 3113 5010

E brisbane@gta.com.au

Sydney

GTA Consultants (NSW) Pty Ltd t/a

GTA Consultants

ABN: 31 131 369 376

A Level 2, 815 Pacific Highway
CHATSWOOD NSW 2067
PO Box 5254
WEST CHATSWOOD NSW 1515

P +612 8448 1800

F +612 8448 1810

E sydney@gta.com.au

Melbourne

Greg Tucker & Associates Pty Ltd t/a

GTA Consultants

ABN: 34 005 839 645

A 87 High Street South
PO Box 684
KEW VIC 3101

P +613 9851 9600

F +613 9851 9610

E melbourne@gta.com.au

Appendix F

Microsimulation Model Operational Report

Appendix G

Appendix G

Microsimulation Model Future Year Network Results

Figure G1: 2009 Existing Conditions 7:30am

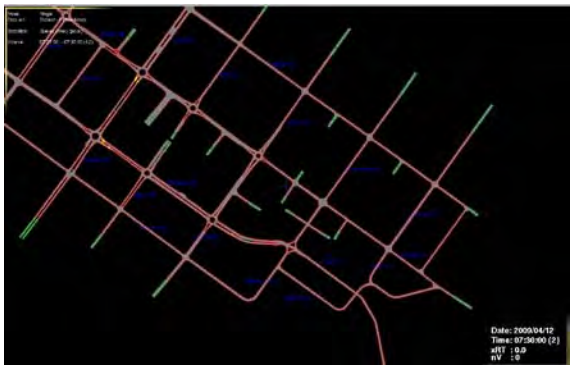


Figure G2: 2009 Existing Conditions 8:00am

Figure G3: 2009 Existing Conditions 8:30am

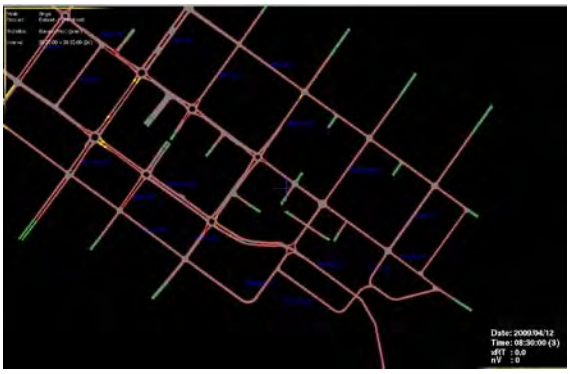


Figure G4: 2009 Existing Conditions 9:00am

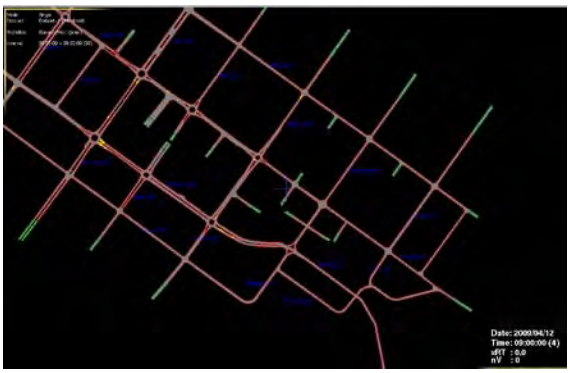
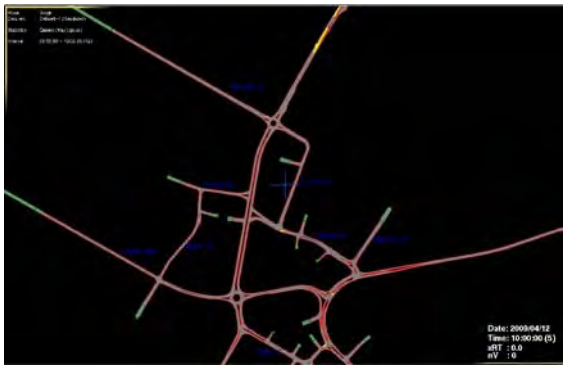


Figure G5: 2009 Existing Conditions 9:30am

Figure G6: 2009 Existing Conditions 10:00am



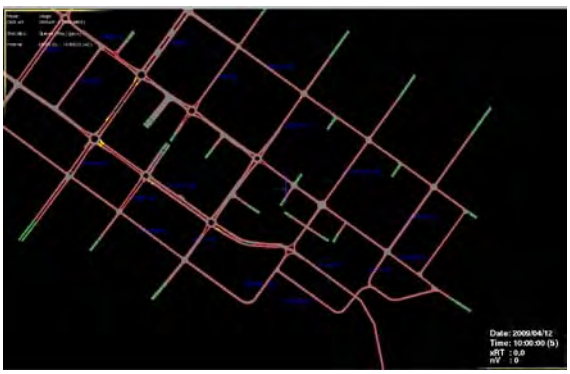


Figure G7: 2009 Existing Conditions 3:30pm

Figure G8: 2009 Existing Conditions 4:00pm

Figure G9: 2009 Existing Conditions 4:30pm

Figure G10: 2009 Existing Conditions 5:00pm

Figure G11: 2009 Existing Conditions 5:30pm

Figure G12: 2009 Existing Conditions 6:00pm

Figure G13: 2019 Existing Conditions 7:30am

Figure G14: 2019 Existing Conditions 8:00am

Figure 15: 2019 Existing Conditions 8:30am

Figure 16: 2019 Existing Conditions 9:00am

Figure 17: 2019 Existing Conditions 9:30am

Figure 18: 2019 Existing Conditions 10:00am

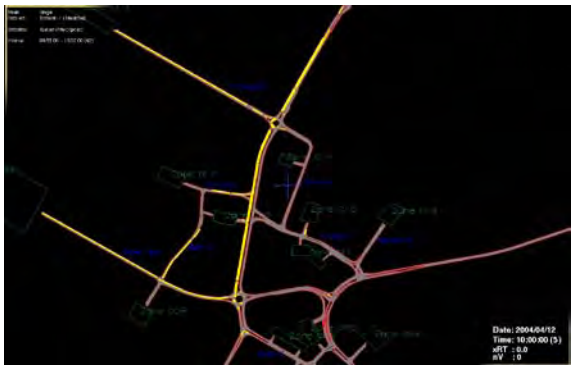


Figure 19: 2019 Existing Conditions 3:30pm

Figure 20: 2019 Existing Conditions 4:00pm

Figure 21: 2019 Existing Conditions 4:30pm

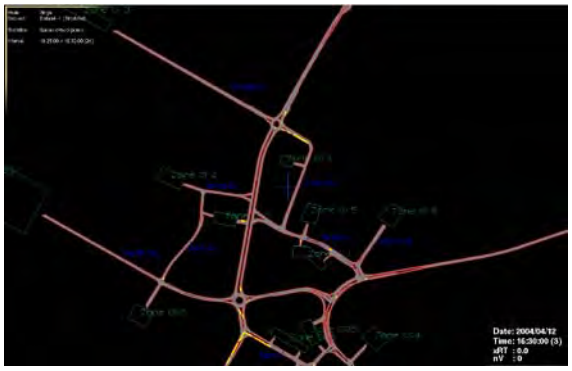


Figure 22: 2019 Existing Conditions 5:00pm

Figure 23: 2019 Existing Conditions 5:30pm

Figure 24: 2019 Existing Conditions 6:00pm

Figure 25: 2029 Existing Conditions 7:30am

Figure 26: 2029 Existing Conditions 8:00am

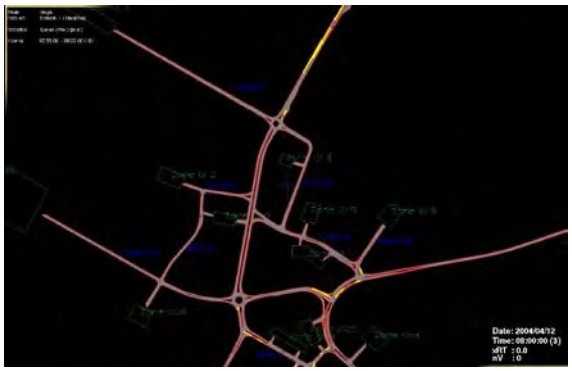


Figure 27: 2029 Existing Conditions 8:30am

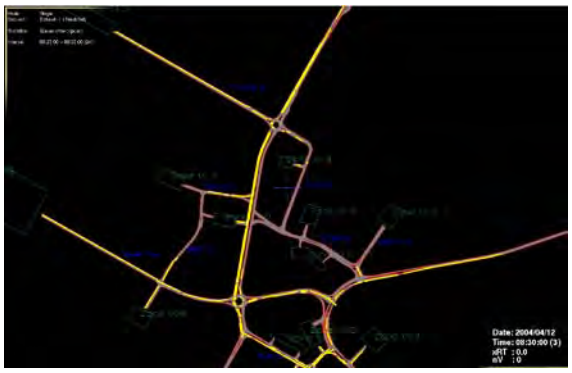


Figure 28: 2029 Existing Conditions 9:00am

Figure 29: 2029 Existing Conditions 9:30am

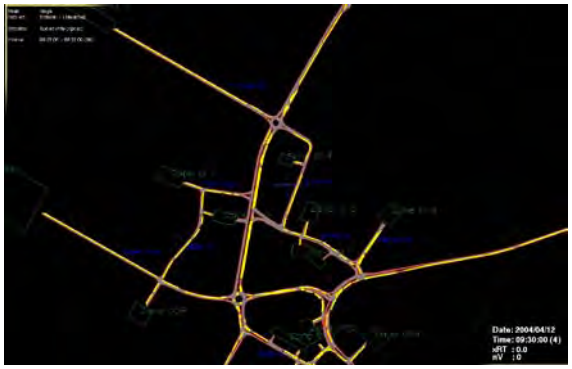


Figure 30: 2029 Existing Conditions 10:00am

Figure 31: 2029 Existing Conditions 3:30pm

Figure 32: 2029 Existing Conditions 4:00pm

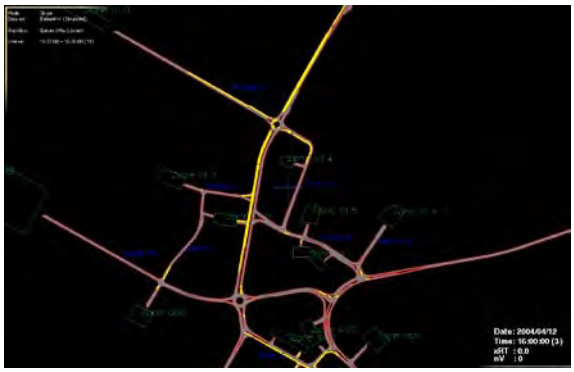


Figure 33: 2029 Existing Conditions 4:30pm

Figure 34: 2029 Existing Conditions 5:00pm

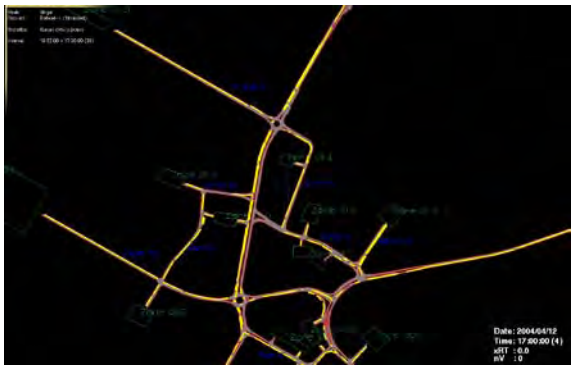


Figure 35: 2029 Existing Conditions 5:30pm

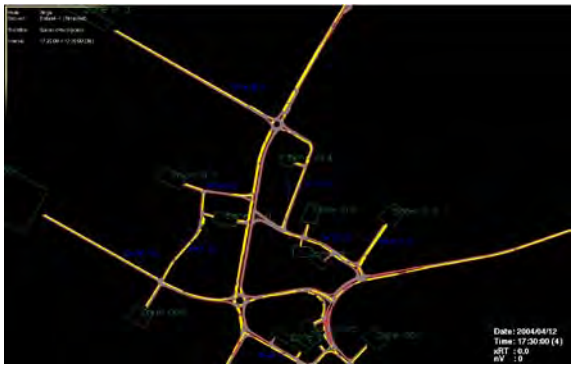
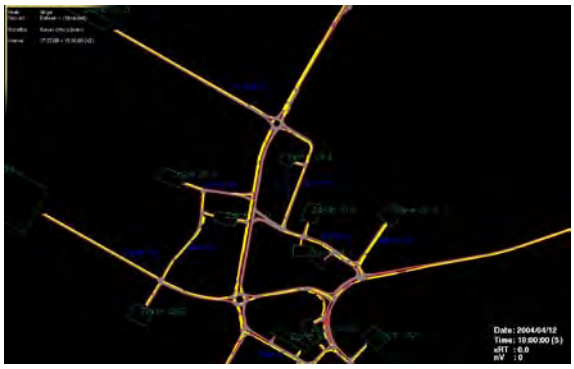


Figure 36: 2029 Existing Conditions 6:00pm



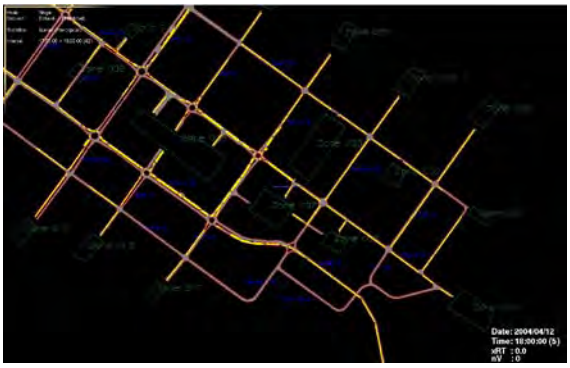


Figure 37: 2039 Existing Conditions 7:30am

Figure 38: 2039 Existing Conditions 8:00am

Figure 39: 2039 Existing Conditions 8:30am

Figure 40: 2039 Existing Conditions 9:00am

Figure 41: 2039 Existing Conditions 9:30am

Figure 42: 2039 Existing Conditions 10:00am

Figure 43: 2039 Existing Conditions 3:30pm

Figure 44: 2039 Existing Conditions 4:00pm

Figure 45: 2039 Existing Conditions 4:30pm

Figure 46: 2039 Existing Conditions 5:00pm

Figure 47: 2039 Existing Conditions 5:30pm

Figure 48: 2039 Existing Conditions 6:00pm

Network Statistics - Existing Network 2009

	AM Peak			PM Peak		
Network Statistics	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	3:00 - 4:00	4:00 - 5:00	5:00 - 6:00
Total no. of incompleted trips (no. of vehicles)	47	100	59	65	54	38
Total no. of completed trips (no. of vehicles)						
- Cars	3896	4981	4610	7862	5266	4296
- Light	344	431	387	637	464	358
- Heavy	210	125	126	178	114	88
TOTAL	4450	5537	5124	8677	5844	4743
Average vehicle KM travelled per vehicle (km/veh)	1.9	1.8	1.9	1.8	1.8	1.8
Average travel time per vehicle (min/veh)	2.7	3.2	4.1	2.8	3.0	2.7
Average speed (km/h)	43.7	34.1	27.8	37.9	35.8	39.7
Total no. of Stops*						
- Cars	4624	19171	19904	17243	12843	7526
- Light	413	1714	1561	1321	1129	690
- Heavy	290	476	502	397	271	135
TOTAL	5328	21361	21967	18961	14244	8351
Total Vehicle Kilometres Travelled (VKT)	8720.8	10396.0	9944.6	15547.4	10579.2	8604.4
Total vehicle hours travelled (VHT)	199.9	311.9	360.6	410.6	297.6	217.1

*A stop is classified as when a vehicle travels below 5 km/h

Network Statistics - Existing Network 2019

	AM Peak			PM Peak		
Network Statistics	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	3:00 - 4:00	4:00 - 5:00	5:00 - 6:00
Total no. of incompleted trips (no. of vehicles)	56	146	196	92	316	402
Total no. of completed trips (no. of vehicles)						
- Cars	4642	5475	4344	9165	5297	1382
- Light	390	459	371	770	445	117
- Heavy	265	143	122	213	126	44
TOTAL	5297	6077	4836	10148	5869	1543
Average vehicle KM travelled per vehicle (km/veh)	1.9	1.8	1.7	1.7	1.7	1.7
Average travel time per vehicle (min/veh)	2.6	4.0	5.3	2.8	3.4	2.1
Average speed (km/h)	43.4	26.9	19.6	36.6	29.7	52.3
Total no. of Stops*						
- Cars	6166	30746	31074	24268	19503	3411
- Light	520	2543	2631	1980	1569	248
- Heavy	403	913	831	504	490	55
TOTAL	7089	34202	34535	26752	21561	3714
Total Vehicle Kilometres Travelled (VKT)	10233.6	11275.4	9077.6	17803.6	10658.0	2731.9
Total vehicle hours travelled (VHT)	236.0	437.1	490.9	488.3	419.2	97.6

*A stop is classified as when a vehicle travels below 5 km/h

Network Statistics - Existing Network 2029

	AM Peak			PM Peak		
Network Statistics	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	3:00 - 4:00	4:00 - 5:00	5:00 - 6:00
Total no. of incompleted trips (no. of vehicles)	86	236	490	329	498	505
Total no. of completed trips (no. of vehicles)						
- Cars	5632	5060	459	10250	976	3
- Light	487	412	38	856	82	0
- Heavy	336	101	0	258	36	0
TOTAL	6455	5573	497	11364	1094	3
Average vehicle KM travelled per vehicle (km/veh)	1.9	1.6	0.8	1.7	1.6	0.5
Average travel time per vehicle (min/veh)	2.7	4.1	1.4	3.3	3.1	6.2
Average speed (km/h)	42.5	24.1	35.5	30.2	34.3	18.9
Total no. of Stops*						
- Cars	9090	29834	896	45887	6301	1
- Light	753	2448	66	3612	384	0
- Heavy	541	786	0	1067	153	0
TOTAL	10384	33068	962	50566	6838	1
Total Vehicle Kilometres Travelled (VKT)	12338.6	9671.6	534.0	19793.0	2132.0	3.8
Total vehicle hours travelled (VHT)	291.0	457.7	93.7	692.0	230.3	0.5

*A stop is classified as when a vehicle travels below 5 km/h

Network Statistics - Existing Network 2039

	AM Peak			PM Peak		
Network Statistics	7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	3:00 - 4:00	4:00 - 5:00	5:00 - 6:00
Total no. of incompleted trips (no. of vehicles)	178	476	507	549	565	568
Total no. of completed trips (no. of vehicles)						
- Cars	6645	2731	10	6021	10	6
- Light	564	236	0	488	1	0
- Heavy	420	53	0	148	0	0
TOTAL	7630	3020	10	6657	11	6
Average vehicle KM travelled per vehicle (km/veh)	1.9	1.5	1.1	1.6	0.8	0.4
Average travel time per vehicle (min/veh)	2.8	3.7	22.0	3.3	29.2	7.7
Average speed (km/h)	41.2	25.7	3.4	30.2	18.1	20.0
Total no. of Stops*						
- Cars	13776	18832	30	32141	2	1
- Light	1122	1474	2	2430	0	0
- Heavy	786	449	0	592	0	0
TOTAL	15684	20755	31	35163	2	1
Total Vehicle Kilometres Travelled (VKT)	14838.6	5198.2	16.4	11782.0	7.9	3.0
Total vehicle hours travelled (VHT)	367.1	365.2	10.5	735.2	1.0	1.0

*A stop is classified as when a vehicle travels below 5 km/h

Melbourne

Greg Tucker & Associates Pty Ltd t/a

GTA Consultants

ABN: 34 005 839 645

A 87 High Street South
PO Box 684
KEW VIC 3101

P +613 9851 9600

F +613 9851 9610

E melbourne@gta.com.au

Sydney

GTA Consultants (NSW) Pty Ltd t/a

GTA Consultants

ABN: 31 131 369 376

A Level 2, 815 Pacific Highway
CHATSWOOD NSW 2067
PO Box 5254
WEST CHATSWOOD NSW 1515

P +612 8448 1800

F +612 8448 1810

E sydney@gta.com.au

Brisbane

GTA Consultants (QLD) Pty Ltd t/a

GTA Consultants

ABN: 98 137 610 274

A Level 6, 269 Wickham Street
PO Box 555
FORTITUDE VALLEY QLD 4006

P +617 3113 5000

F +617 3113 5010

E brisbane@gta.com.au

Canberra

Greg Tucker & Associates Pty Ltd t/a

GTA Consultants

ABN: 34 005 839 645

A Level 11, 60 Marcus Clarke Street
CANBERRA ACT 2601
PO Box 1109
CIVIC SQUARE ACT 2608

P +612 6243 4826

F +612 6243 4848

E canberra@gta.com.au