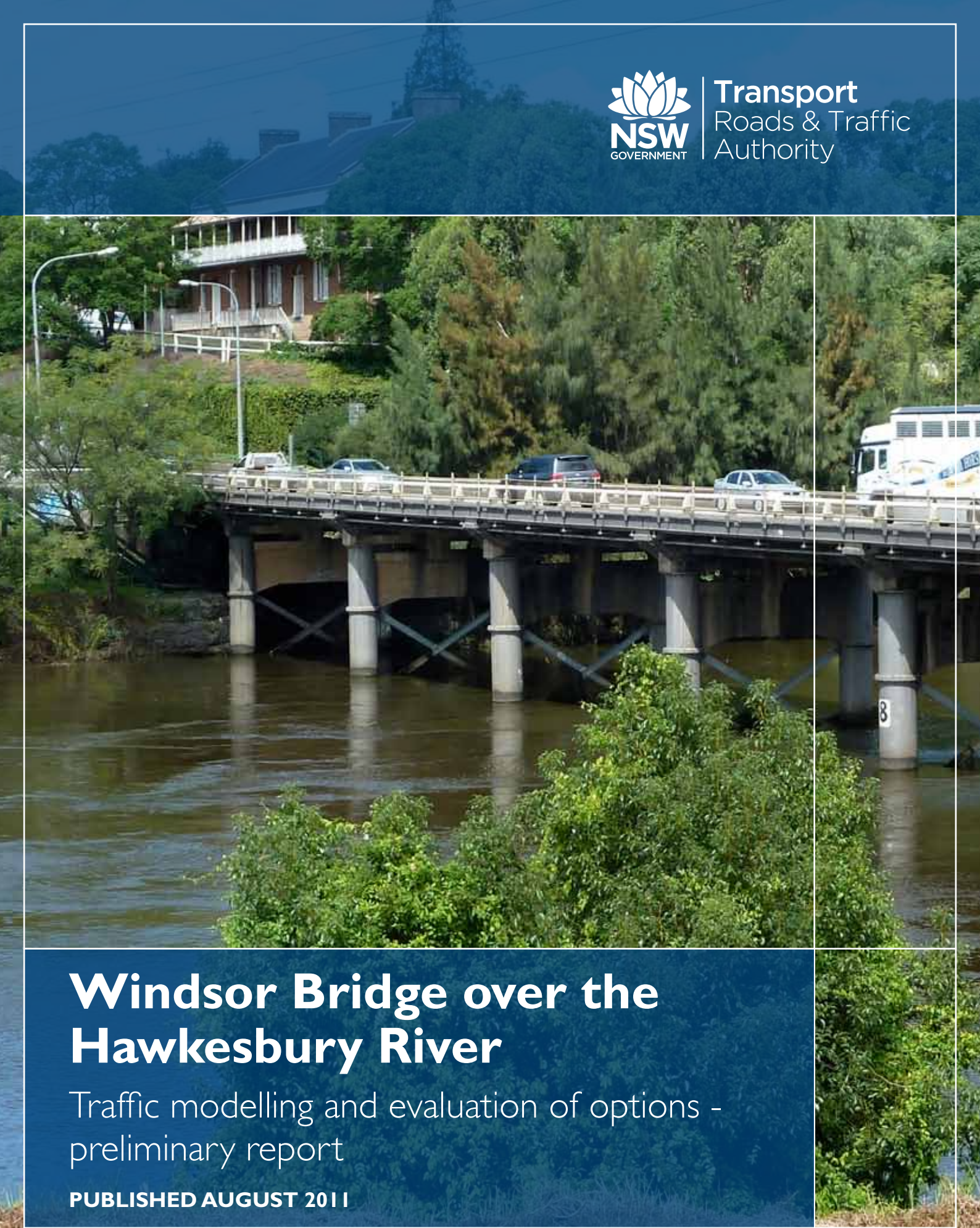
Appendix C RMS VISSIM Model Report



Transport
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NSW GOVERNMENT

Windsor Bridge over the Hawkesbury River

Traffic modelling and evaluation of options - preliminary report

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Roads and Traffic Authority

Traffic Modelling and Evaluation of Options - Preliminary Report

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Executive Summary

The existing bridge over Hawkesbury River at Windsor requires either major structural rehabilitation work or replacement with a new bridge. Options have been considered for this, including a number of proposals for locating the new bridge some distance from the existing structure. A comparison of the cost and traffic performance of these options has been undertaken using a traffic modelling study.

The study has found that little improvement could be made upon the total vehicle travel time and speed for each option as compared to the existing conditions. As a result, options 1 and 6 were refined and further modelling was carried out to determine whether these options could meet the 2026 travel demands. The results were then used to estimate and compare the cost of each option, subsequently determining that option 1 performed the best and should be further modelled under a number of variations. The variations involved alternative modelling of the George/Bridge street intersection and the addition of an extra lane to the bridge. It was found that scenario 1 performed better under both the current and future traffic demands.

Table of Contents

1 Introduction 1

2 Traffic surveys 2

3 Base model 3

4 Bridge upgrade options 4

5 Results of the traffic modelling 7

5.1 Option 1 and 2 7

5.2 Option 3 7

5.3 Options 4 and 5 8

5.4 Option 6 8

5.5 Option 7 8

5.6 Option 8 8

5.7 Options 9A and 9B 8

6 Further modelling of option 1 and option 6 9

7 Economic evaluation 12

8 Modelling of option 1 scenarios 14

8.1 Variations for option 1 14

8.1.1 Scenario 1 14

8.1.2 Scenario 2 15

8.1.3 Scenario 3 16

8.2 Performance of critical intersections 17

8.3 Results 19

8.4 Recommendation 20

List of Figures

Figure 1.1: Area included in the traffic model 1
Figure 4.1: Options 1 to 9 (excluding 8) 5
Figure 4.2: Option 8 6
Figure 6.1: Option 1 9
Figure 6.2: Option 6 9
Figure 8.1: George Street and Bridge Street – Scenario 1 14
Figure 8.2: George Street and Bridge Street – Scenario 2 15
Figure 8.3: George Street and Bridge Street – Scenario 3 16

List of Tables

Table 2.1: Origin-destination survey results 2
Table 5.1: Modelled traffic data for each option 7
Table 6.1: Modelled traffic data for the refined options 10
Table 7.1: Economic evaluation of options 13
Table 8.1: Intersection performances, 2011 17
Table 8.2: Intersection performances, 2026 18
Table 8.3: Total network performance 19

1 Introduction

This study covers eight options to replace, and one option for upgrading the existing Windsor Bridge, with the objective of identifying the options with best traffic outcomes for ongoing investigation.

The traffic study uses a micro-simulation approach that models the behaviour of individual vehicles. It uses the VISSIM software platform.

The model network covers the area shown in Figure 1.1.

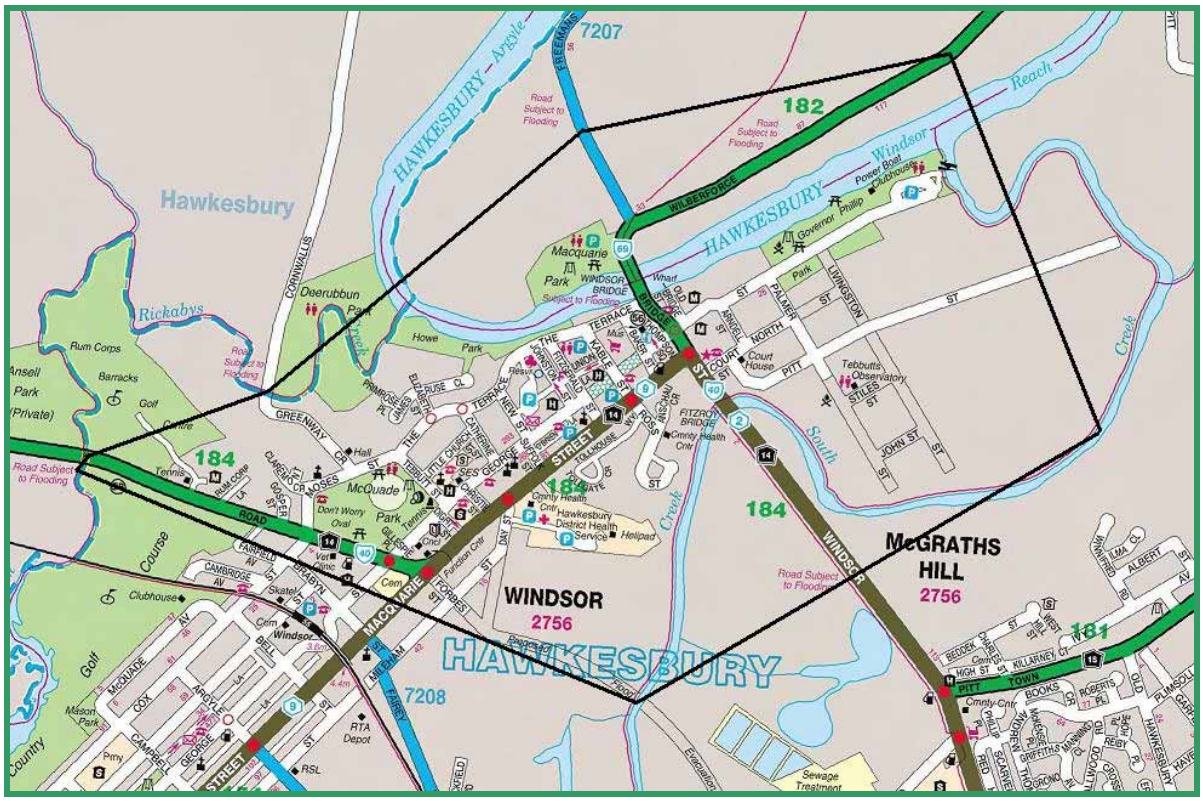


Figure 1.1: Area included in the traffic model

Traffic models have been developed representing 2 hour AM and PM peak periods in 2009, for the existing conditions (the base model) and for the options being considered. Results of the traffic modelling have been used to fine tune the design of each option, and to compare the economic performance.

2 Traffic surveys

To provide the basis for the modelled traffic demand, traffic surveys were undertaken on 18 June 2009 covering the morning and afternoon peak periods. Supplementary data was extracted from the SCATS traffic control system.

The study consisted of two components. An origin-destination survey was used to determine the vehicle travel patterns through the study area. This recorded vehicle number plates at 6 observation points around the perimeter of the study area, and at 3 points on a screen line located between New Street and Catherine Street, to examine travel patterns through the area.

Traffic counts were undertaken at 19 intersections within the study area, plus counts of traffic entering and leaving the four main parking areas in the town centre, and counts of pedestrians on the existing bridge and crossing Kable Street at George Street.

The origin-destination survey results were then adjusted to match the observed traffic counts, with the following results.

There were a total of 9700 trips in the morning peak 2 hours and 12,700 in the afternoon, of which 6% to 7% were trucks. A high proportion of the observed trips were passing through the study area, as follows in Table 2.1.

Table 2.1: Origin-destination survey results

Trip Type	AM Peak	PM Peak
Through	64%	51%
Arriving from outside the study area	17%	19%
Departing from inside the study area	12%	20%
Within the study area	6%	9%

3 Base model

The base model represents the existing traffic conditions on the existing network.

The 2009 base model showed the Bridge Street/George Street roundabout in combination with the nearby Bridge Street/Windsor Road/Macquarie Street signalised intersection experiencing random congestion in both AM and PM peaks.

In the AM peak, southbound traffic using the existing bridge experiences heavy queuing, on occasions stretching from Macquarie Street and/or George Street extending for several hundred meters, sometimes even beyond Freemans Reach Road intersection.

Queuing is less extensive in PM peak, however the northbound traffic queue may extend for several hundreds meters from the roundabout.

It appears that congestion is primarily caused by insufficient capacity at the intersections of Bridge Street with George Street and Macquarie Street, and the configuration of Bridge Street between them.

Traffic growth to 2026 was estimated using the Sydney Strategic Traffic Model. The forecast increase in trips to and from the Windsor study area was added to the 2009 traffic base model. The 2026 traffic demand exceeded the capacity of a number of key intersections in the base models, notably along Bridge Street and Hawkesbury Valley Way (the former Richmond Road). The traffic model showed traffic congestion. Therefore substantial improvements would be required to cater for the forecast traffic growth.

As a modelling expedient, the 2026 base networks were modified such that signal control delays at the intersections of Hawkesbury Valley Way with George Street and Macquarie Street were set to zero. This freed traffic flow in the western portion of the model, and allowed a more realistic model of the traffic performance of the options proposed for Windsor Bridge and approaches, in the eastern part of the study area.

4 Bridge upgrade options

The nine options, as shown to the community, for the bridge replacement or repair are outlined below (see Figure 4.1 and 4.2). Altogether there were a total of ten options modelled, as follows:

1. Option 1 – a high level bridge, approximately 35m downstream of the existing bridge, allowing clearance for service vehicles including coaches and garbage trucks passing under the bridge on The Terrace.
2. Option 2 – a low level bridge, on the same line as option 1, but providing clearance for cars and light vehicles passing under the bridge on The Terrace.
3. Option 3 – a high level bridge immediately upstream of the existing bridge.
4. Option 4 – crossing the river upstream of the existing bridge, on Baker Street.
5. Option 5 – crossing the river further upstream, on Kable Street.
6. Option 6 – a high level crossing of the river downstream of the existing bridge, on a line parallel to and east of Palmer Street. This option would require a new intersection on Windsor Road north of Pitt Town Road, and a new bridge over South Creek and a new intersection on Wilberforce Road.
7. Option 7 – crossing the river on Palmer Street, with access from Windsor Road via Court Street and North Street. This option would require a new intersection on Wilberforce Road.
8. Option 8 – crossing the river at Pitt Town, 5 km downstream of the existing bridge. The new crossing would connect Punt Road at Pitt Town Bottoms to King Road (Sackville Road) at Wilberforce. This option is located outside the area covered by the micro-simulation model and has been evaluated using the RTA's Sydney Strategic Traffic Model.
9. Option 9A – repair and rehabilitate the existing bridge. This would require the closure of the existing bridge for a period of 3 months. Traffic would detour via North Richmond, outside the area of the micro-simulation model. This was evaluated using the Sydney Strategic Traffic Model.
10. Option 9B – repair and widen the existing bridge, to provide wider lanes and footway. This would require the closure of the existing bridge for a period of 12 months. It was also evaluated using the Sydney Strategic Traffic Model.

Figure 4.1: Options 1 to 9 (excluding 8)

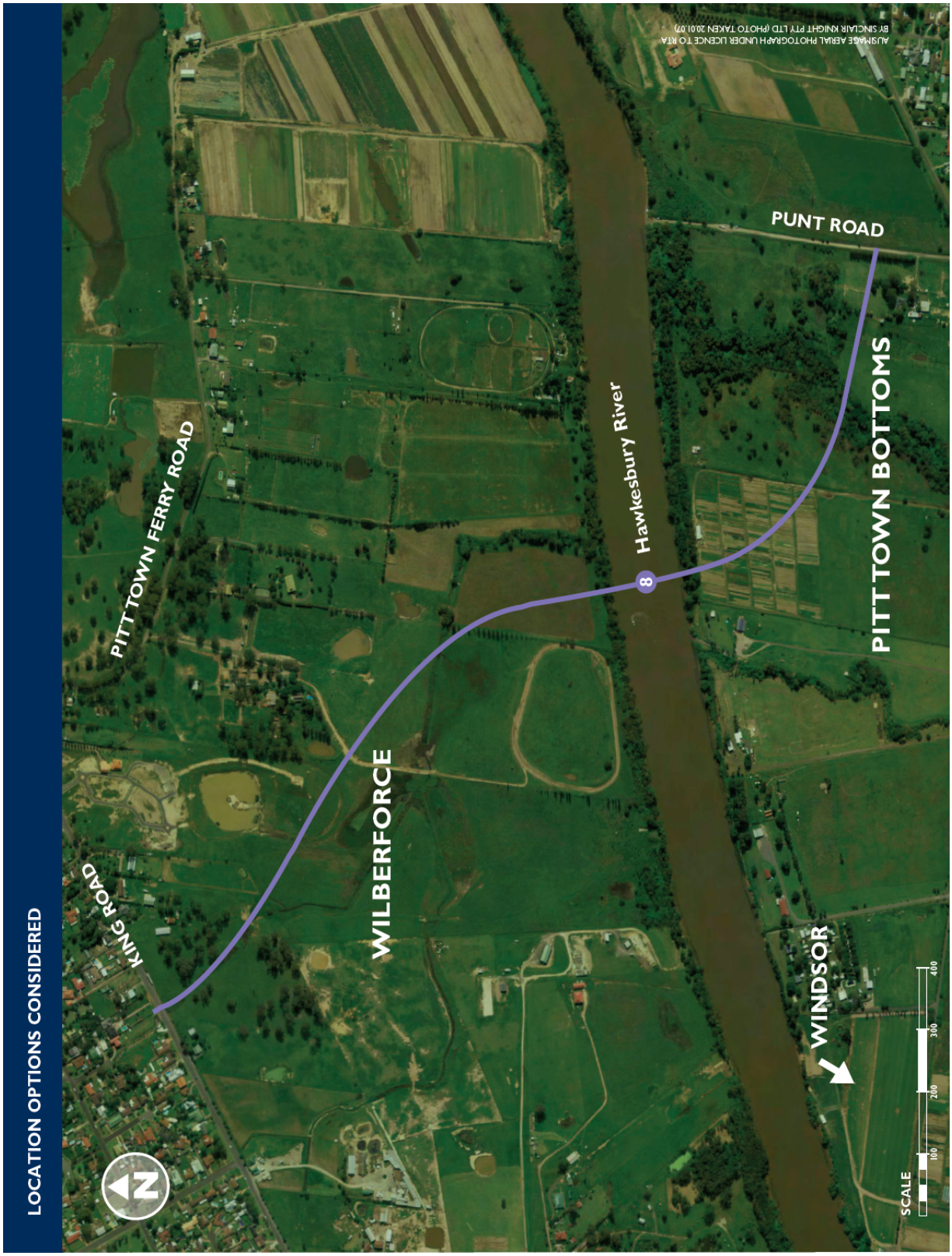


Figure 4.2: Option 8

5 Results of the traffic modelling

The evaluation of the options is based on measures of delay extracted from the traffic models. The measures reported are the total vehicle travel time (in vehicle hours) and the average travel speed (kilometres per hour) in each model, as shown in Table 5.1.

Table 5.1: Modelled traffic data for each option

Option	Morning Peak		Afternoon Peak	
	Total travel time (veh hrs)	Average Speed (km/h)	Total travel time (veh hrs)	Average Speed (km/h)
Existing	508	40.5	649	38.5
Option 1	478	42.9	650	38.4
Option 2	478	42.9	650	38.4
Option 3	495	41.8	659	38.7
Option 4	513	40.5	642	39.1
Option 5	495	42.9	656	38.8
Option 6	517	42.5	726	37.2
Option 7	488	43.8	673	38.7

The following observations were on the traffic conditions for each option.

5.1 Option 1 and 2

Traffic performance, although similar to the existing, is slightly better in the AM peak, where the provision of a roundabout at Wilberforce Rd/Freemans Reach helps to control traffic flow arriving at the George St roundabout, reducing queuing. Performance in the PM peak is almost identical to the existing.

5.2 Option 3

Modelled traffic performance is almost identical to options 1 and 2, except for a slight increase in travel times due to the slightly longer travel distance across the bridge.

5.3 Options 4 and 5

Options 4 and 5 would likely require right turn lanes for access to the shopping centre, adjacent parking sites and at The Terrace, and would probably experience more pedestrian and local traffic interference than the modelling indicates. In addition the proposed layouts of the intersections of Macquarie Street/Baker Street (option 4) and Macquarie Street/Kable Street (option 5) would require significant modification to meet to safety and pedestrian requirements.

5.4 Option 6

This option increases the distance of travel between Windsor and the northern side of the river. This is reflected in the poor economic performance of this option. Modelling showed that the proposed junction connecting the new bypass to Macquarie Street has inadequate capacity, particularly in the PM peak. It is likely that an improved layout for this junction would improve the overall performance of this option.

5.5 Option 7

This proposal includes two closely spaced major T-junctions on Windsor Rd at Macquarie Street/Bridge Road (existing) and Court Street (new). It is likely to create future traffic congestion due to queuing between the junctions. It increases the travel distance between Windsor and the northern side of the river, which again is reflected in the option's poor economic performance.

5.6 Option 8

Since this option involves a bridge located outside the modelled area, it was necessary to use a different modelling approach, the RTA's Sydney Strategic Traffic Model. The results showed that the large increase in travel distance between Windsor and Freemans Reach would impose substantial additional travel costs on the community.

5.7 Options 9A and 9B

These options were also modelled using the Sydney Strategic Traffic Model, since the closure of the existing bridge required all traffic to detour via North Richmond, well outside the area covered by the simulation model. The large increase in the travel distance between Windsor and Freemans Reach would impose very large additional travel costs on the community for the duration of the work.

6 Further modelling of option 1 and option 6

At the government stakeholder workshop held in September 2009, it was suggested that option 1 and option 6 should be refined and analysed further.

Option 1 is a 3-lane bridge, 35 metres downstream of the existing bridge.

Figure 6.1: Option 1

Option 6 is a 2-lane bridge (future capacity for three lanes), 400 metres downstream of the existing bridge, on a line parallel to and east of Palmer Street. This option would require a new intersection on Windsor Road north of Pitt Town Road, and a new bridge over South Creek.

Figure 6.2: Option 6

The original concept for option 1 considered a roundabout at the northern end of the bridge at the junction of Freemans Reach Road and Wilberforce Road. In the traffic modelling it was identified that the roundabout was not operating satisfactorily with 2009 traffic, and would create additional congestion with future traffic growth. It was identified that installing traffic signals would permit the intersection to operate satisfactorily under 2026 traffic volumes. However, the increased traffic volumes would require an upgrade of the Bridge/George/Macquarie Street intersections south of the bridge.

Similarly, the original concept for option 6 resulted in a low level of service. Similar to option 1, option 6 required traffic signals at the intersection to the north of the new bridge. It included a new intersection on Windsor Road between South Creek and McGraths Hill. Preliminary modelling found that this layout would not operate satisfactorily, and the design was revised to include additional turning lanes. This in turn required a wider structure for the new crossing of South Creek.

Some congestion was also caused by the existing 2-lane Fitzroy Bridge over South Creek. A modification to option 6 was tested with Fitzroy Bridge line-marked with one southbound and two northbound lanes, within the overall width of the existing structure. This achieved an improved level of service.

Table 6.1 summarises the performance of these options in terms of total vehicle travel time (vehicle hours) and the average travel speed (kilometres per hour) in each model.

Table 6.1: Modelled traffic data for the refined options

Options	Morning Peak		Afternoon Peak	
	Total travel time (veh hrs)	Average Speed (km/h)	Total travel time (veh hrs)	Average Speed (km/h)
2009				
Base	513	40.1	649	38.6
Option 1	471	43.8	649	38.6
Option 6	502	43.8	668	40.2
2026				
Option 1	703	45.6	911	40.5
Option 6	718	47.4	928	43.3

Option 6 increases the travel distance for trips between the northern side of the river and the town of Windsor compared to the existing conditions. As a result, this increases the total modelled travel time, even though a higher average travel speed is achieved.

The model showed that the 2026 travel demand would be close to capacity for option 1. Traffic flow on Bridge Street shows signs of instability, especially in the morning peak. Long

queues occasionally develop from the Macquarie Street intersection, extending through George Street and across the bridge.

The model data for 2026 showed that option 6 had stable traffic flow, with less queuing. A test with a 10% increase in traffic over the 2026 AM peak (a rough estimate of 2031 traffic) showed that option 6 performed significantly better than option 1.

7 Economic evaluation

The project presented an unusual method of economic analysis. An economic analysis usually compares a base case (without a project, often termed the "do nothing" case) with an improved case (with the project completed). The capital cost of the project and its lifetime maintenance costs are compared against the benefits of the project to the community. For a road project, the benefits usually consist of reductions in travel time, vehicle operating costs and crash costs.

In this case, "do nothing" is not an acceptable option, since the existing bridge requires extensive rehabilitation and ongoing maintenance. The "do minimum" option is the closure and demolition of the existing bridge which has an estimated cost of $540,000. It will also impose substantial ongoing travel costs on the community as all traffic is then required to detour via North Richmond.

The total economic cost of each option is the present value of the road and bridge works, plus the present value of any increase in travel costs for the community. The appropriate indicator for an economic comparison of alternative options is net present value (NPV), which in this case is the difference between the total economic costs of the option and the "do minimum" case.

To simplify the initial comparison of options, the value of travel time was taken as the measure of road user costs. Experience has shown that the value of travel time makes up two thirds of total road user costs across the Sydney network, so it will be a sufficiently reliable measure for initial comparison of options.

As a further simplification, road user costs were extracted from the 2009 traffic models, and a growth in road user costs of 2.2% per annum has been adopted based on forecasts of overall traffic growth obtained from the Sydney Strategic Traffic Model.

The results of the economic evaluation of each of the options are outlined in Table 7.1.

Table 7.1: Economic evaluation of options

Option	Capital Cost ($M)	Present Value of RTA Costs ($M)	Present Value of Increased Travel Costs ($M)	Benefit Cost Ratio	Net Present Value ($M)
Close Bridge	0.54	0.50	166.77		
Option 1	45.40	41.25	-17.96	4.5	143.98
Option 2	45.40	41.25	-17.96	4.5	143.98
Option 3	53.40	48.45	0.87	3.5	117.96
Option 4	50.10	45.54	1.26	3.7	120.47
Option 5	52.90	48.01	-0.87	3.5	120.13
Option 6	82.90	75.13	8.82	2.1	83.32
Option 7	56.50	51.34	6.25	3.2	109.69
Option 8	130.60	113.01	252.37	-0.8	-198.11
Option 9A	18.00	17.62	10.01	9.2	139.64
Option 9B	24.67	23.80	40.03	5.4	103.44

A comparison of the net present value shows that option 1 and 2 performed better than the other options and therefore option 1 was further analysed for various intersection scenarios. Option 1 is to be delivered in two stages with the estimated project costs for stage 1 at $31 million (2011 dollars).

8 Modelling of option 1 scenarios

A modelling study was undertaken to compare variations for option 1. These variations involved alternative treatments of the bridge and the intersection of George Street and Bridge Street. The key features of the variations were as follows:

8.1 Variations for option 1

8.1.1 Scenario 1

Scenario 1 contains the following configuration, as shown in Figure 8.1.

- The bridge to be line-marked as three lanes (one lane northbound, two lanes southbound).
- A signal controlled intersection at George Street and Bridge Street.
- Right turns allowed only from George Street east and Bridge Street south.

Figure 8.1: George Street and Bridge Street – Scenario 1

8.1.2 Scenario 2

Scenario 2 contains the following configuration, as shown in Figure 8.2.

- The bridge to be line-marked as three lanes (one lane northbound, two lanes southbound).
- A signal controlled intersection at George Street and Bridge Street.
- All right turns allowed.

Figure 8.2: George Street and Bridge Street – Scenario 2

8.1.3 Scenario 3

Scenario 3 contains the following configuration, as shown in Figure 8.3.

- The bridge line-marked as two lanes with shoulders.
- Retain the existing single lane roundabout at George Street and Bridge Street.

Figure 8.3: George Street and Bridge Street – Scenario 3

8.2 Performance of critical intersections

The performance of the three critical intersections in 2011 and 2026, under each scenario for option 1 are given in Tables 8.1 and 8.2 respectively. The three critical intersections are:

1. Windsor Road and Macquarie Street.
2. George Street and Bridge Street.
3. Wilberforce Road and Freemans Reach Road.

Table 8.1: Intersection performances, 2011

Intersection / Scenario	Average delay per vehicle (seconds)	Level of Service	Max queue (metres)	Number of stops per vehicle
Base Case 2011 AM				
Windsor Rd/Macquarie St	22.8	B	180	0.5
Windsor Rd/George St/Bridge St	31.9	C	420	0.3
Wilberforce Rd/Freemans Reach Rd	37.3	C	200	0.8
Scenario 1 2011 AM				
Windsor Rd/Macquarie St	20.1	B	250	0.6
Windsor Rd/George St/Bridge St	12.1	A	140	0.3
Wilberforce Rd/Freemans Reach Rd	14.7	B	60	0.4
Scenario 2 2011 AM				
Windsor Rd/Macquarie St	17.8	B	250	0.5
Windsor Rd/George St/Bridge St	23.5	B	240	0.5
Wilberforce Rd/Freemans Reach Rd	14.3	B	60	0.4
Scenario 3 2011 AM				
Windsor Rd/Macquarie St	16.3	B	170	0.5
Windsor Rd/George St/Bridge St	13.9	A	370	0.2
Wilberforce Rd/Freemans Reach Rd	14.8	B	60	0.4
Base Case 2011 PM				
Windsor Rd/Macquarie St	46.2	D	800	0.9
Windsor Rd/George St/Bridge St	13.4	A	180	0.6
Wilberforce Rd/Freemans Reach Rd	1.1	A	120	0.0
Scenario 1 2011 PM				
Windsor Rd/Macquarie St	23.1	B	160	0.6
Windsor Rd/George St/Bridge St	12.2	A	100	0.4
Wilberforce Rd/Freemans Reach Rd	7.4	A	50	0.2
Scenario 2 2011 PM				
Windsor Rd/Macquarie St	45.0	D	390	1.1
Windsor Rd/George St/Bridge St	48.3	D	230	1.1
Wilberforce Rd/Freemans Reach Rd	6.9	A	50	0.2

Scenario 3 2011 PM				
Windsor Rd/Macquarie St	22.9	B	240	0.6
Windsor Rd/George St/Bridge St	10.0	A	110	0.4
Wilberforce Rd/Freemans Reach Rd	8.1	A	50	0.2

Table 8.2: Intersection performances, 2026

Intersection / Scenario	Average delay per vehicle (seconds)	Level of Service	Max queue (metres)	Number of stops per vehicle
Base Case 2026 AM				
Windsor Rd/Macquarie St	30.4	C	470	0.6
Windsor Rd/George St/Bridge St	54.2	D	420	1.5
Wilberforce Rd/Freemans Reach Rd	90.3	F	810	0.8
Scenario 1 2026 AM				
Windsor Rd/Macquarie St	24.8	B	380	0.6
Windsor Rd/George St/Bridge St	15.4	B	140	0.4
Wilberforce Rd/Freemans Reach Rd	15.7	B	80	0.4
Scenario 2 2026 AM				
Windsor Rd/Macquarie St	19.1	B	410	0.5
Windsor Rd/George St/Bridge St	52.8	D	380	1.3
Wilberforce Rd/Freemans Reach Rd	22.0	B	110	0.6
Scenario 3 2026 AM				
Windsor Rd/Macquarie St	15.8	B	230	0.4
Windsor Rd/George St/Bridge St	30.4	C	380	0.4
Wilberforce Rd/Freemans Reach Rd	150.2	F	800	3.9
Base Case 2026 PM				
Windsor Rd/Macquarie St	321.6	F	810	3.3
Windsor Rd/George St/Bridge St	32.4	C	420	0.7
Wilberforce Rd/Freemans Reach Rd	41.9	C	810	0.8
Scenario 1 2026 PM				
Windsor Rd/Macquarie St	34.7	C	350	0.8
Windsor Rd/George St/Bridge St	12.9	A	100	0.4
Wilberforce Rd/Freemans Reach Rd	9.6	A	60	0.3
Scenario 2 2026 PM				
Windsor Rd/Macquarie St	79.7	F	810	1.6
Windsor Rd/George St/Bridge St	40.2	C	340	0.9
Wilberforce Rd/Freemans Reach Rd	8.8	A	60	0.2
Scenario 3 2026 PM				
Windsor Rd/Macquarie St	131.2	F	810	2.6
Windsor Rd/George St/Bridge St	24.2	B	350	0.8
Wilberforce Rd/Freemans Reach Rd	9.5	A	80	0.3

Table 8.3 summarises the overall performance of each modelled network.

Table 8.3: Total network performance

Item	Unit	Base Case	Scenario 1	Scenario 2	Scenario 3
2011 AM					
Total travel time	h	487	403	404	420
Average speed	km/h	42.7	52.3	51.8	51.2
Average delay time per vehicle	sec	47.8	24.7	26.2	25.9
Average number of stops per vehicles		0.6	0.6	0.5	0.5
2011 PM					
Total travel time	h	527	517	548	636
Average speed	km/h	48.2	49.6	46.3	40.7
Average delay time per vehicle	sec	31.2	25.1	35.0	45.5
Average number of stops per vehicles		0.7	0.6	0.8	0.8
2026 AM					
Total travel time	h	2526	548	585	910
Average speed	km/h	11.6	49.6	45.9	29.4
Average delay time per vehicle	sec	492.2	33.4	44.6	113.7
Average number of stops per vehicles		1.4	0.7	1.0	1.7
2026 PM					
Total travel time	h	6805	677	1494	1387
Average speed	km/h	3.9	46.6	20.0	22.1
Average delay time per vehicle	sec	1154.3	36.3	214.9	183.5
Average number of stops per vehicles		4.7	0.8	2.3	2.7

8.3 Results

The following was found when reviewing the modelling data for each scenario.

- Scenario 1 performs well under all of the traffic flow regimes.
- Scenario 2 performs adequately except in the 2026 PM peak, when queues from the intersection of George/Bridge Street block the intersection of Windsor/Macquarie Street.
- Scenario 3 performs poorly in both the 2026 AM and PM peaks.

The performance of scenario 1 was obtained by banning two right turn movements at the intersection of George Street and Macquarie Street, increasing the travel time and distance for

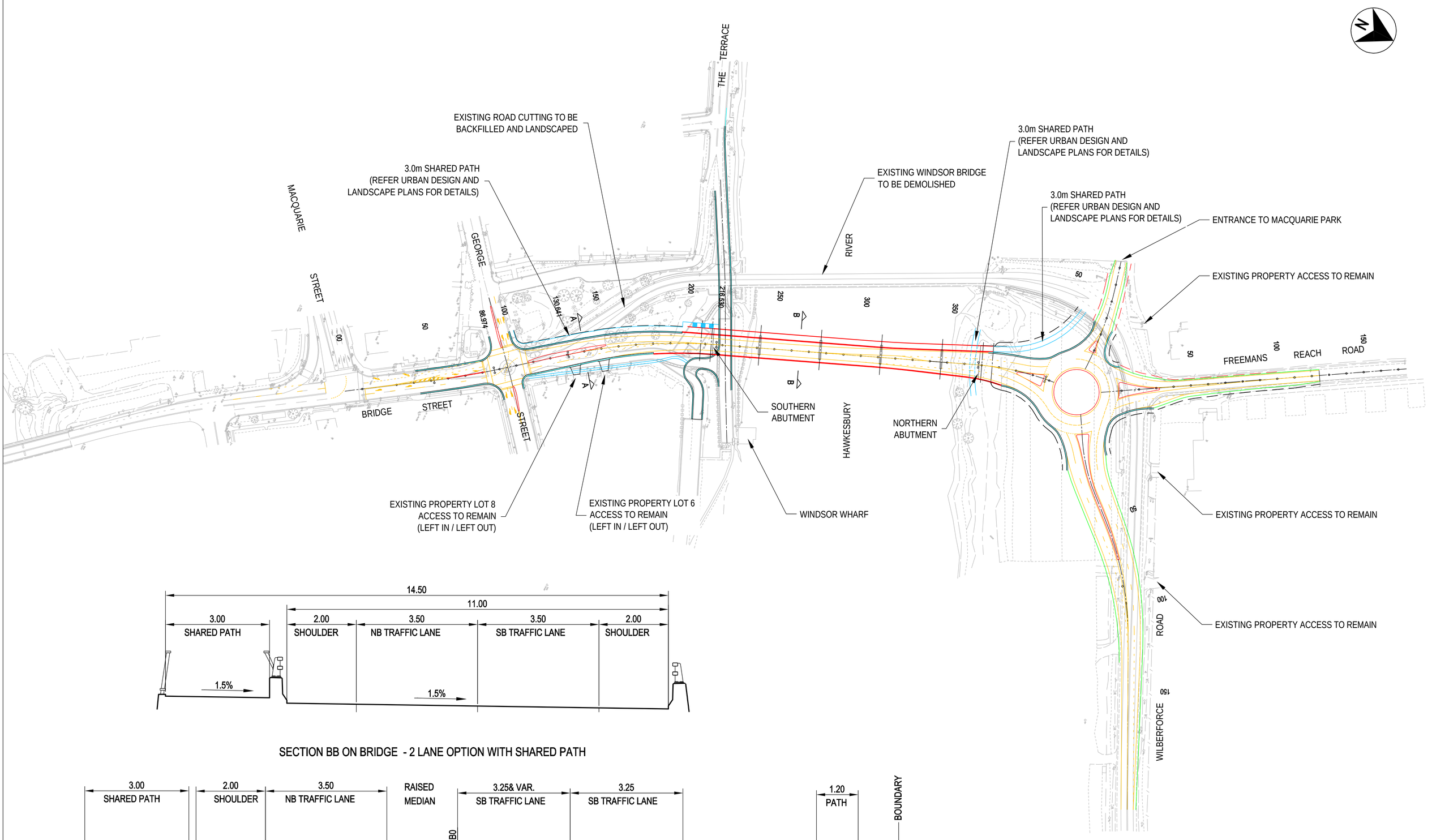
some trips. Modelling of scenario 2 demonstrates that the proposed layout for that intersection is unable to accommodate all turns without causing unacceptable delays in the 2026 PM peak. It is possible that a more efficient signal phase plan, allowing diamond turns, would be able to accommodate all turns without causing excessive delays, but this would require a larger intersection footprint.

8.4 Recommendation

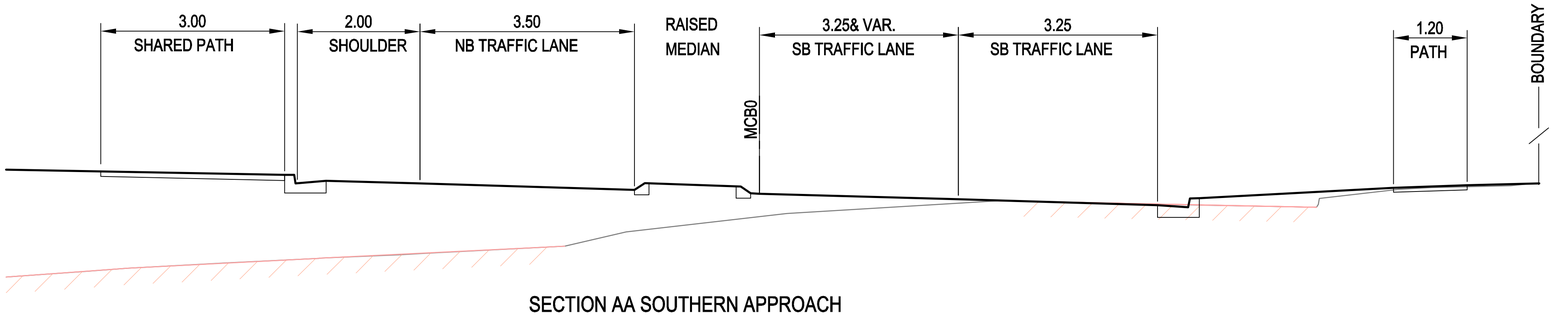
- Scenario 1 is preferred, since it provides good performance in 2026 AM and PM peaks.
- Scenario 2 performs adequately in the 2026 AM peak, but performs poorly in the PM peak.
- Scenario 3 performs poorly in the 2026 AM and PM peaks.

If scenario 1 is not favoured due to its turning bans, consideration may be given to modifying scenario 2 by enlarging the intersection of George Street and Bridge Street, so as to permit the signal phase plan to provide for diamond turns.

Appendix D Concept Option 5 Layout



SECTION BB ON BRIDGE - 2 LANE OPTION WITH SHARED PATH



SECTION AA SOUTHERN APPROACH

MR182 - BRIDGE ST WINDSOR

WINDSOR BRIDGE REPLACEMENT -OPTION 5 GENERAL ARRANGEMENT PLAN

SCALE 1:1000 (A1)

Appendix E VISSIM Model development

The results of the stand alone intersection modelling identify the intersection layouts that would work best in isolation at each of the locations considered. Whilst stand alone models are generally acceptable, it is required in this case to consider the interaction between the intersections north and south of the bridge, and whether a delay at one has an impact on the operation of the other.

To allow this modelling to be carried out, RMS provided SKM with VISSIM models previously prepared for Windsor bridge in August 2011. A Technical Note describing these models and their development which accompanied the models is provided in **Appendix C**.

9.1.1.1 Methodology

Morning and evening tests were undertaken for a 2026 assessment year, using the flows defined previously. The VISSIM model periods are AM peak (7.00am – 9.00am) and PM peak (3.00pm – 5.00pm).

Each of the tests carried out were based upon the following models supplied by RMS:

- s1_2026am\1_2026am.inp
- s1_2026pm\1_2026pm.inp

In discussions with RMS a simple replacement approach was adopted to incorporate the revised intersection configurations into the existing model. Intersection layouts for both the north and south intersections were coded separately and then placed into a standard network template. The advantage of this method was to minimise potential inconsistencies between each AM and PM option. With the exception of minor changes at the George Street and Macquarie Street intersections, no other network amendments have been made to the models provided by RMS. At this stage, models have been run based on a minimum cost assignment.

9.1.1.2 Option Testing

Various option scenarios were initially tested in both peak periods, considering combinations of intersection types north and south of the bridge. Each of the intersection layouts tested are listed below, with northern intersection layouts denoted ‘N’ and southern intersection layouts denoted ‘G’:

- N1: 4 leg, single lane roundabout, 30 m diameter.
- N3: 4 leg signals with continuous lane for left movements from Wilberforce Road (E).
- N4: 4 leg, dual lane roundabout.
- G1: Existing single lane roundabout.
- G2: Signals with right turn bays for Bridge St (N) and Bridge St (S) approaches.
- G3: Signals with right turn bay for Bridge St (S) approach only.

The combinations of options tested were as follows:

- N1 on the north of the bridge, G1 south of the bridge.
- N1 on the north of the bridge, G2 south of the bridge.

- N1 on the north of the bridge, G3 south of the bridge.
- N3 on the north of the bridge, G1 south of the bridge.
- N3 on the north of the bridge, G2 south of the bridge.
- N3 on the north of the bridge, G3 south of the bridge.
- N4 on the north of the bridge, G1 south of the bridge.
- N4 on the north of the bridge, G2 south of the bridge.
- N4 on the north of the bridge, G3 south of the bridge.

The Macquarie Street / Bridge Street intersection was modelled in its existing (unchanged) configuration in all test scenarios

9.1.1.3 Option Testing Results

The results of the above options tests were presented at an RMS Value Management Workshop held on Monday 30 April 2012. These results were considered together with the intersection modelling results to define the preferred option to be taken forward for more detailed testing in VISSIM. The following intersection treatments were agreed as the preferred option:

- Dual lane roundabout intersection at Wilberforce Road and Freemans Reach Road (designated for modelling purposes as intersection N4).
- Signal controlled intersection at George Street and Bridge Street (designated for modelling purposes as intersection G3).
- Retain existing signal controlled intersection at Bridge Street and Macquarie Street.

The road network considered within the VISSM modelling exercise is defined as Bridge Street and Wilberforce Road from Macquarie Street to point east of Freemans Reach Road.

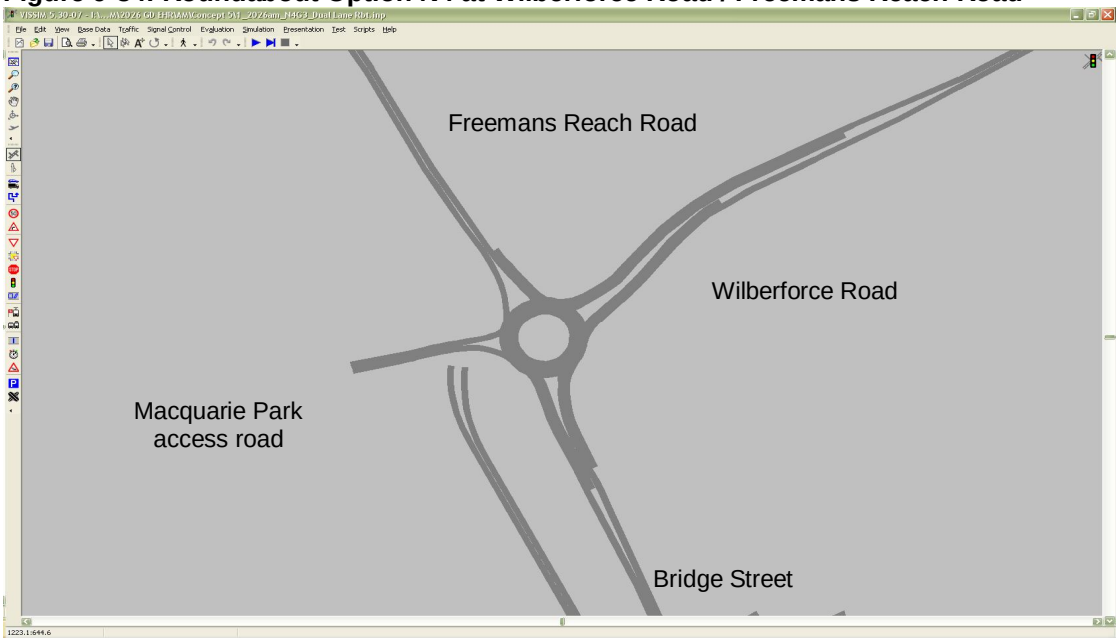
Roundabout at Wilberforce Road / Freemans Reach Road / Bridge Street (N4)

The general layout of the dual circulatory carriageway option with two lane flared approaches on Wilberforce Road and Bridge Street is shown in **Figure 9-34**.

Conflict areas have been applied on each approach. The “anticipate routes” check box has been flagged so that, for example, vehicles on the approach to the junction from Bridge Street (Windsor bridge) do not give way to those exiting the junction to Bridge Street (Windsor bridge).

An additional priority rule has been applied to the Wilberforce Road leg. This reinforces the rule that vehicles cannot enter the roundabout while another vehicle is on the outside lane of the roundabout.

Figure 9-34: Roundabout Option N4 at Wilberforce Road / Freemans Reach Road

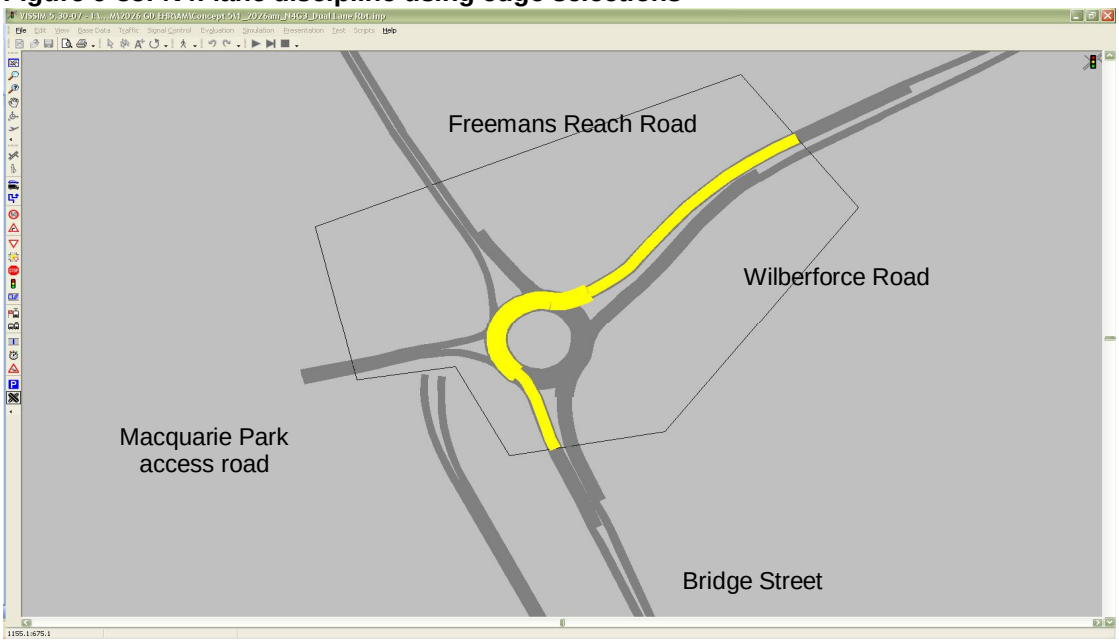


The length of merge and diverge lanes have been modelled based on the lengths shown in Concept Option 5 which comply with the minimum lengths required for a Design Speed of 50km/h. The length of flare (localised widening) including diverge on Wilberforce Road (southbound) is about 120 metres. The Bridge Street (Windsor bridge) approach flare (northbound) is about 70 metres long. The merge taper length on Wilberforce Road (northbound) is approximately 70 metres and the merge taper length on Bridge Street (southbound) is approximately 70 metres.

A number of very short links have been coded on the dual lane approaches and circulatory area. These allow greater control of routing on the roundabout and ensure better lane observation.

In order to increase capacity in the morning peak, it has been necessary to allow traffic from Wilberforce Road to use both approach lanes to the roundabout and be permitted to enter Bridge Street from both circulating lanes of the roundabout. Similarly, in the evening peak, right turning traffic from Bridge Street to Wilberforce Road is permitted to use both lanes as shown in **Figure 9-35**.

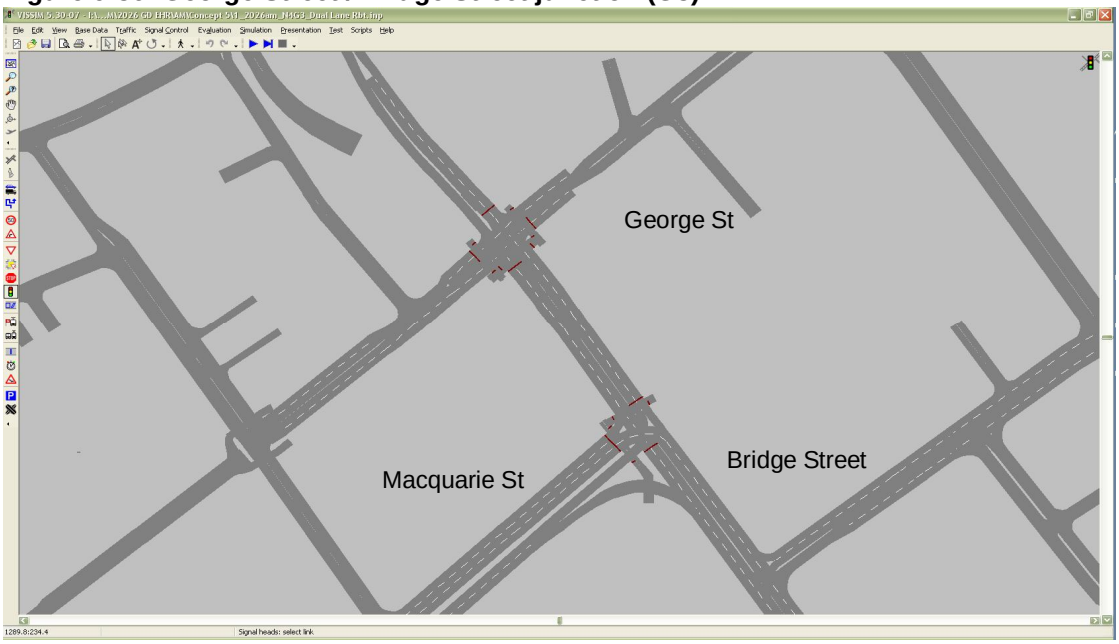
Figure 9-35: N4: lane discipline using edge selections



Bridge Street / George Street traffic signals (G3)

The coding of the traffic signal controlled intersection (G3) is shown in **Figure 9-36**, and is based upon the RMS coding supplied in the VISSIM model.

Figure 9-36: George Street / Bridge Street junction (G3)



Bridge Street and George Street both have two lane approaches at the stop line of the traffic signals; the length of flare from the single lane on the bridge deck to the Bridge Street (southbound) stop line is approximately 90m. Right turn movements from Bridge Street North into George Street West have been prohibited in both AM and PM peak periods to limit queuing vehicles immediately south of the bridge.

A further prohibition is the movement from Bridge St South to George St East. This mitigates potential queuing which would otherwise occur northbound on Windsor Road in the evening peak.

VISVAP files were not supplied and so changes to the staging included in the provided model have been minimised. No significant changes to timings have been made in the AM peak; in the PM peak maximum green times have been adjusted at George St. Details on cycle times and green times are included in **Appendix A**.

9.1.1.4 Traffic Demands

To calculate accurate 2026 traffic demand within the model, the 'existing' 2026 VISSIM matrices were used as a starting point. The forecast 2026 peak hour demand for Freeman's Reach Rd (VISSIM Zone 1) and Wilberforce Rd (VISSIM Zone 2) were obtained from the Sydney Strategic Travel Model. The peak hour, "existing" demands for VISSIM Zones 1 and 2 were factored to match the forecast values. Individual factors were applied for origin and destination trips instead of a global factor to ensure accuracy. Demands for trips not involving these two zones were not amended. The factors calculated for the peak hour were then also used to factor the off-peak hour matrices and the warm-up period matrices.

The observed flows, growth rates and forecast future traffic are provided in **Table 9-1** to **Table 9-4**. The demand modelled for each movement is provided for comparison.

Table 9-1: Wilberforce Road / Freemans Reach Road / Bridge Street Traffic Flows (AM Peak Hour)

Movement	2011 Demand	2026 Growth Rate	Forecast 2026 Demand	Modelled Demand
Freemans Reach Rd - LT	1	-	1	0
Freemans Reach Rd - AH	391	29%	504	503
Freemans Reach Rd - RT	-	-	-	0
Wilberforce Rd - LT	840	20%	1008	938
Wilberforce Rd - AH	-	-	-	0
Wilberforce Rd – RT	0	-	0	11
Bridge St - LT	-	-	-	0
Bridge St – AH	138	41%	194	186
Bridge St - RT	274	37%	375	365

LT – Left turn RT – Right turn AH – Ahead

Table 9-2: Wilberforce Road / Freemans Reach Road / Bridge Street Traffic Flows (PM Peak Hour)

Movement	2011 Demand	Growth Rate	Forecast 2026 Demand	Modelled Demand
Freemans Reach Rd - LT	0	-	0	0
Freemans Reach Rd - AH	176	30%	229	224
Freemans Reach Rd - RT	-	-	-	0
Wilberforce Rd - LT	354	26%	447	445
Wilberforce Rd - AH	-	-	-	0
Wilberforce Rd – RT	3	-	3	0
Bridge St - LT	-	-	-	0
Bridge St – AH	613	26%	771	728
Bridge St - RT	701	19%	831	776

LT – Left turn RT – Right turn AH – Ahead

Table 9-3: Bridge Street / George Street Traffic Flows (AM Peak Hour)

Movement	2011 Demand	Growth Rate	Forecast 2026 Demand	Modelled Demand
Bridge St (N) – LT	4	18%	5	23
Bridge St (N) – AH	910	23%	1118	1414
Bridge St (N) – RT	209	18%	246	0 (banned)
George St (E) - LT	2	18%	2	47
George St (E) – AH	8	18%	9	89
George St (E) - RT	2	18%	2	5
Bridge St (S) – LT	59	18%	70	29
Bridge St (S) – AH	349	38%	483	497
Bridge St (S) – RT	3	18%	4	23
George St (W) - LT	59	18%	70	50
George St (W) – AH	2	18%	2	0
George St (W) - RT	29	18%	34	39

N – North E – East S – South W – West LT – Left turn RT – Right turn AH – Ahead

Table 9-4: Bridge Street / George Street Traffic Flows (PM Peak Hour)

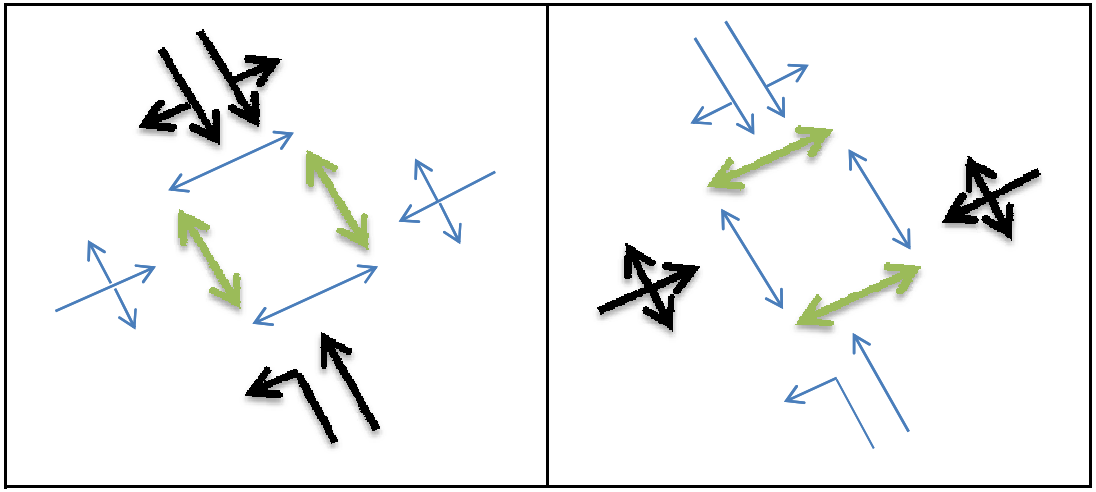
Movement	2011 Demand	Growth Rate	Forecast 2026 Demand	Modelled Demand
Bridge St (N) – LT	6	18%	7	5
Bridge St (N) – AH	293	28%	374	671
Bridge St (N) – RT	159	18%	187	0 (banned)
George St (E) - LT	25	18%	29	53
George St (E) – AH	32	18%	38	84
George St (E) - RT	323	18%	381	39
Bridge St (S) – LT	14	18%	16	39
Bridge St (S) – AH	643	22%	784	1213
Bridge St (S) – RT	2	18%	2	24
George St (W) - LT	251	18%	296	247
George St (W) – AH	12	18%	14	21
George St (W) - RT	34	18%	40	47

N – North E – East S – South W – West LT – Left turn RT – Right turn AH – Ahead

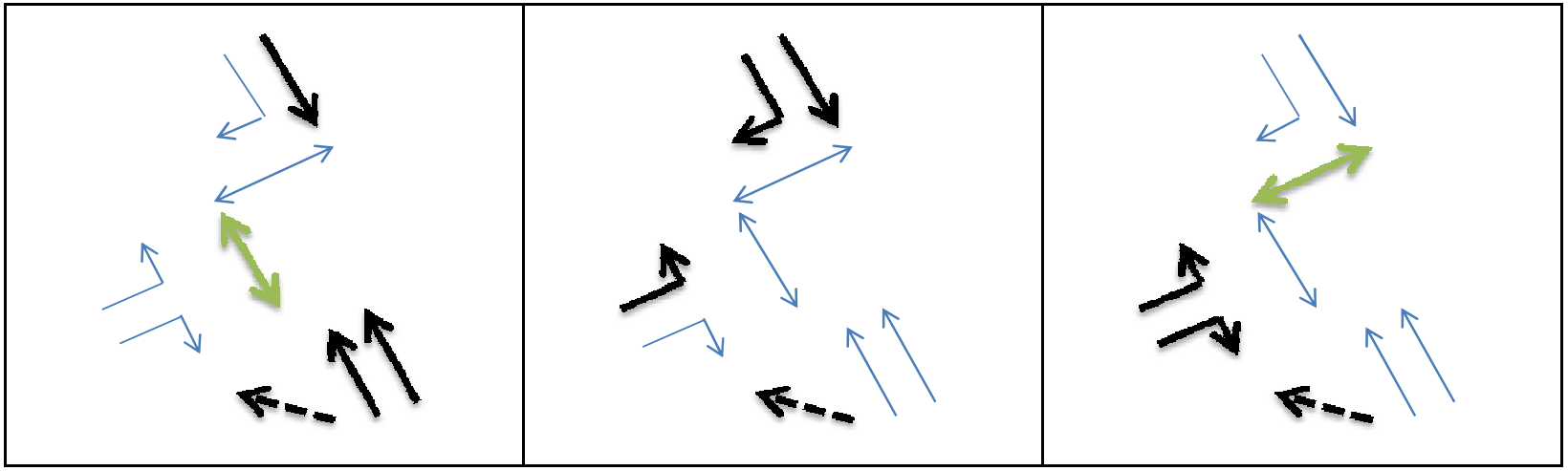
As is evident in **Table 9-1** to **Table 9-4** there are some locations at which the modelled flows do not match those forecast using SKM traffic counts and EMME traffic growth rates, flows are both higher and lower at some locations. The forecast flows provide an indication of the levels of traffic expected to be travelling through the network in the future year but should not be used as a target, factors such as delay and route re-assignment can change traffic flows within the model. That is, the flows used in the model have an accuracy level which is adequate for comparison of the impact of a variety of network options but should not be used as an absolute prediction of actual future traffic flows.

Appendix F VISSIM Signal Phasing

Bridge St / George St junction



Bridge St / Macquarie St junction



Appendix G VISSIM level of service Results

AM 2026

Level of service

		Project case (1 lane SB on Windsor Bridge)				Project case (2 lane SB on Windsor Bridge)			
	Description	Total node delay (s)	Total vehicle movements	Delay per vehicle	LOS	Total node delay (s)	Total vehicle movements	Delay per vehicle	LOS
Wilberforce Road / Freemans Reach Road / Bridge Street									
from	**to**								
Freemans Reach Road	Freemans Reach Road	0	0	n/a	-	0	0	n/a	-
Freemans Reach Road	Wilberforce Road	0	0	n/a	-	0	0	n/a	-
Freemans Reach Road	Local access	0	0	n/a	-	0	0	n/a	-
Freemans Reach Road	Bridge Street	10309	498	21	B	3622	503	7	A
Wilberforce Road	Freemans Reach Road	865	11	79	F	295	13	23	B
Wilberforce Road	Wilberforce Road	0	0	n/a	-	0	0	n/a	-
Wilberforce Road	Local access	0	0	n/a	-	0	0	n/a	-
Wilberforce Road	Bridge Street	69595	898	78	F	15512	988	16	B
Bridge Street	Freemans Reach Road	763	186	4	A	837	186	5	A
Bridge Street	Wilberforce Road	1643	365	5	A	1241	365	3	A
Bridge Street	Local access	0	0	n/a	-	0	0	n/a	-
Bridge Street	Bridge Street	0	0	n/a	-	0	0	n/a	-
		83215	**1958**	**43**	**D**	**21578**	**2055**	**11**	**A**
Bridge Street / George Street									
from	**to**								
Bridge Street S	Bridge Street N	2500	500	5	A	2395	499	5	A
Bridge Street S	George Street W	168	29	6	A	255	29	9	A
Bridge Street S	George Street E	0	0	n/a	-	0	0	n/a	-
Bridge Street N	Bridge Street S	31882	1107	29	C	36885	1186	31	C
Bridge Street N	George Street E	357	23	16	B	472	23	21	B
Bridge Street N	George Street W	7526	256	29	C	10190	271	38	C
George Street W	Bridge Street S	1849	39	47	D	1778	39	46	D
George Street W	Bridge Street N	2285	50	46	D	2185	50	44	D
George Street W	George Street E	598	23	26	B	646	23	28	C
George Street E	Bridge Street S	2337	53	44	D	2390	53	45	D
George Street E	Bridge Street N	188	5	38	C	186	5	37	C
George Street E	George Street W	378	10	38	C	378	10	38	C
		50068	**2095**	**24**	**B**	**57760**	**2188**	**26**	**B**

PM 2026

Level of service

		Project case (1 lane SB on Windsor Bridge) Bridge St (N) to George St (W) movement open				Project case (1 lane SB on Windsor Bridge) Bridge St (N) to George St (W) movement closed			
	Description	Total node delay (s)	Total vehicle movements	Delay per vehicle	LOS	Total node delay (s)	Total vehicle movements	Delay per vehicle	LOS
Wilberforce Road / Freemans Reach Road / Bridge Street									
from	**to**								
Freemans Reach Road	Freemans Reach Road	0	0	n/a	-	0	0	n/a	-
Freemans Reach Road	Wilberforce Road	68	4	17	B	61	4	15	B
Freemans Reach Road	Local access	0	0	n/a	-	0	0	n/a	-
Freemans Reach Road	Bridge Street	2930	222	13	A	3492	221	16	B
Wilberforce Road	Freemans Reach Road	21	3	7	A	24	3	8	A
Wilberforce Road	Wilberforce Road	0	0	n/a	-	0	0	n/a	-
Wilberforce Road	Local access	0	0	n/a	-	0	0	n/a	-
Wilberforce Road	Bridge Street	2141	446	5	A	2230	446	5	A
Bridge Street	Freemans Reach Road	10138	719	14	B	13688	748	18	B
Bridge Street	Wilberforce Road	10201	767	13	A	13182	780	17	B
Bridge Street	Local access	0	0	n/a	-	0	0	n/a	-
Bridge Street	Bridge Street	0	0	n/a	-	0	0	n/a	-
		25500	**2161**	**12**	**A**	**32590**	**2202**	**15**	**B**
Bridge Street / George Street									
from	**to**								
Bridge Street S	Bridge Street N	32723	1221	27	B	22160	1238	18	B
Bridge Street S	George Street W	2506	36	70	E	1338	39	34	C
Bridge Street S	George Street E	0	0	n/a	-	0	0	n/a	-
Bridge Street N	Bridge Street S	22483	529	43	D	12692	668	19	B
Bridge Street N	George Street E	191	5	38	C	133	5	27	B
Bridge Street N	George Street W	13703	127	108	F	0	0	n/a	-
George Street W	Bridge Street S	4599	45	102	F	5035	48	105	F
George Street W	Bridge Street N	48374	222	188	F	14725	250	59	E
George Street W	George Street E	7180	39	184	F	2394	42	57	E
George Street E	Bridge Street S	2122	54	39	C	4529	52	87	F
George Street E	Bridge Street N	2399	39	62	E	5134	38	135	F
George Street E	George Street W	781	16	49	D	9485	81	117	F
		137059	**2333**	**59**	**E**	**77625**	**2461**	**32**	**C**