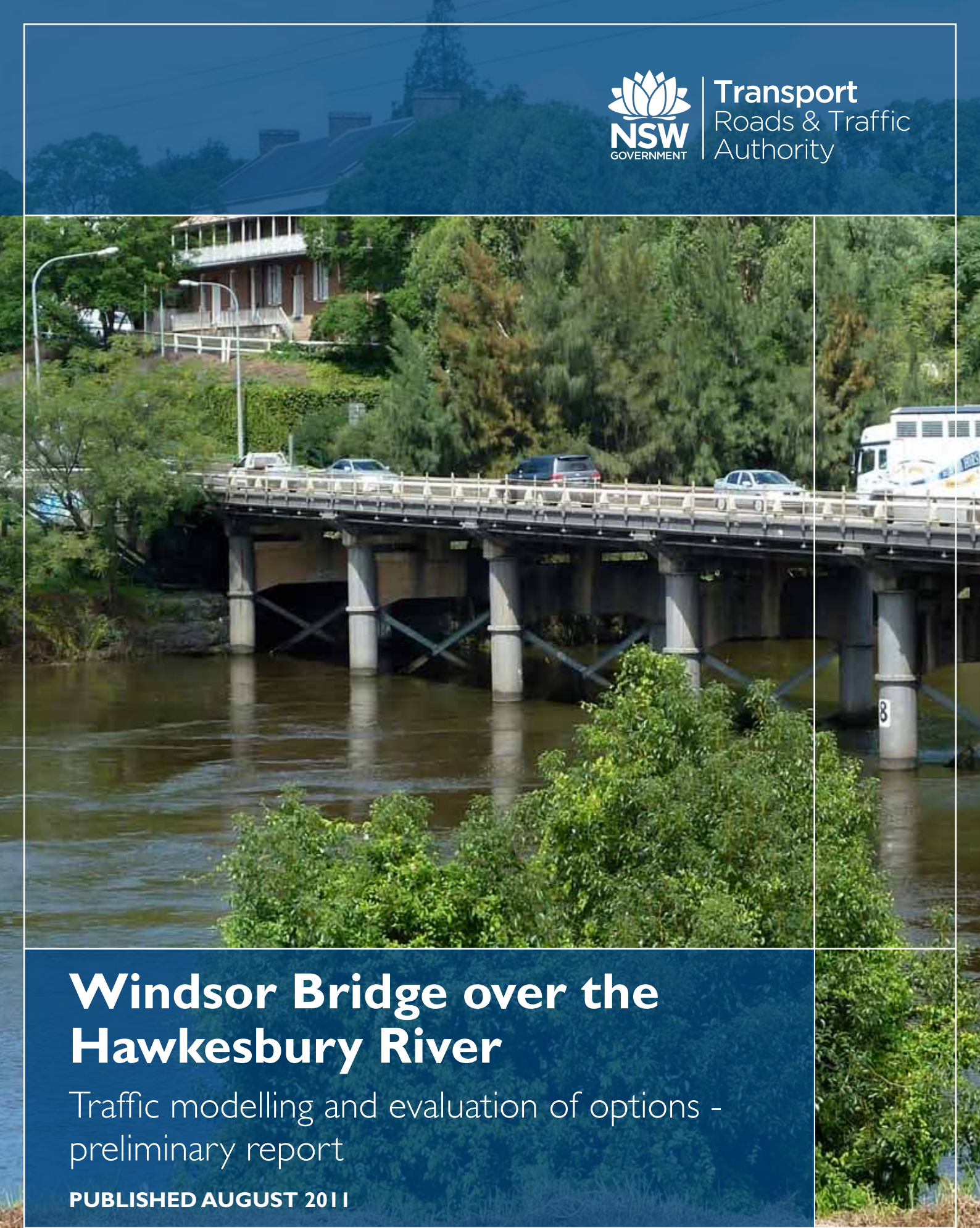

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Windsor Bridge over the Hawkesbury River

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.

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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.

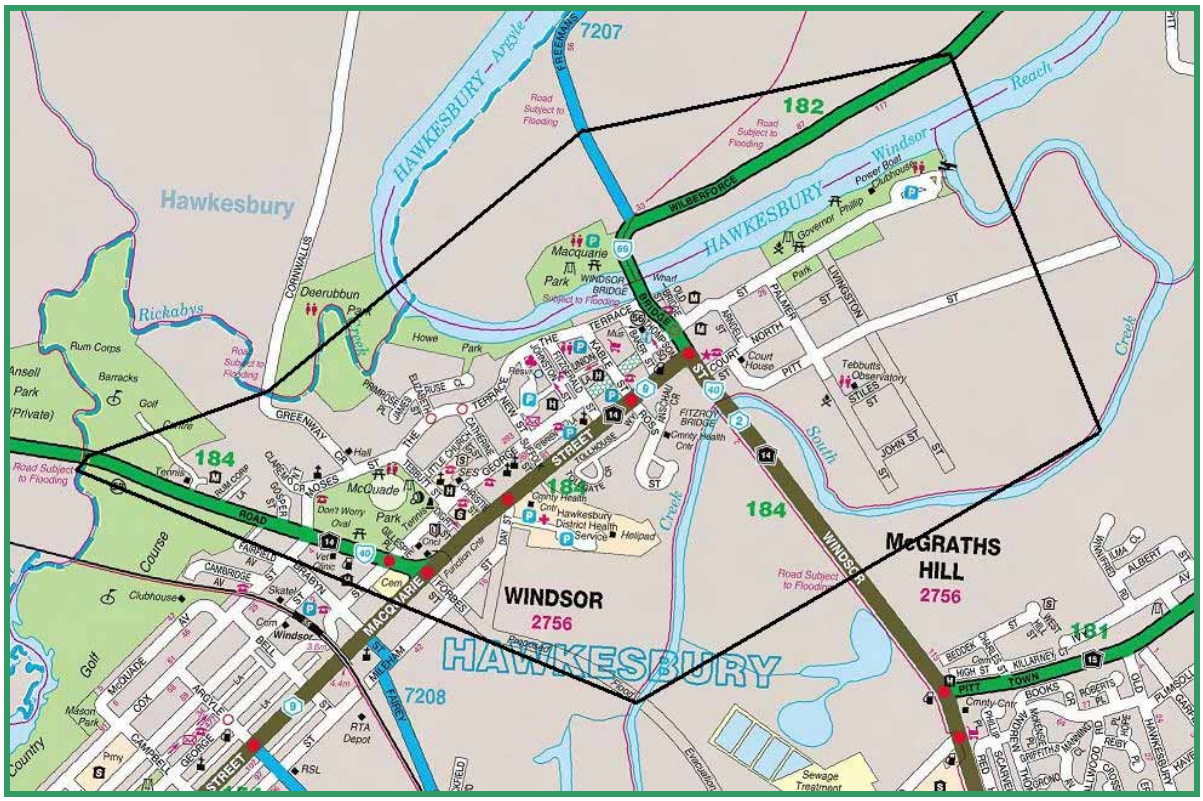

Figure 1.1: Area included in the traffic model

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)

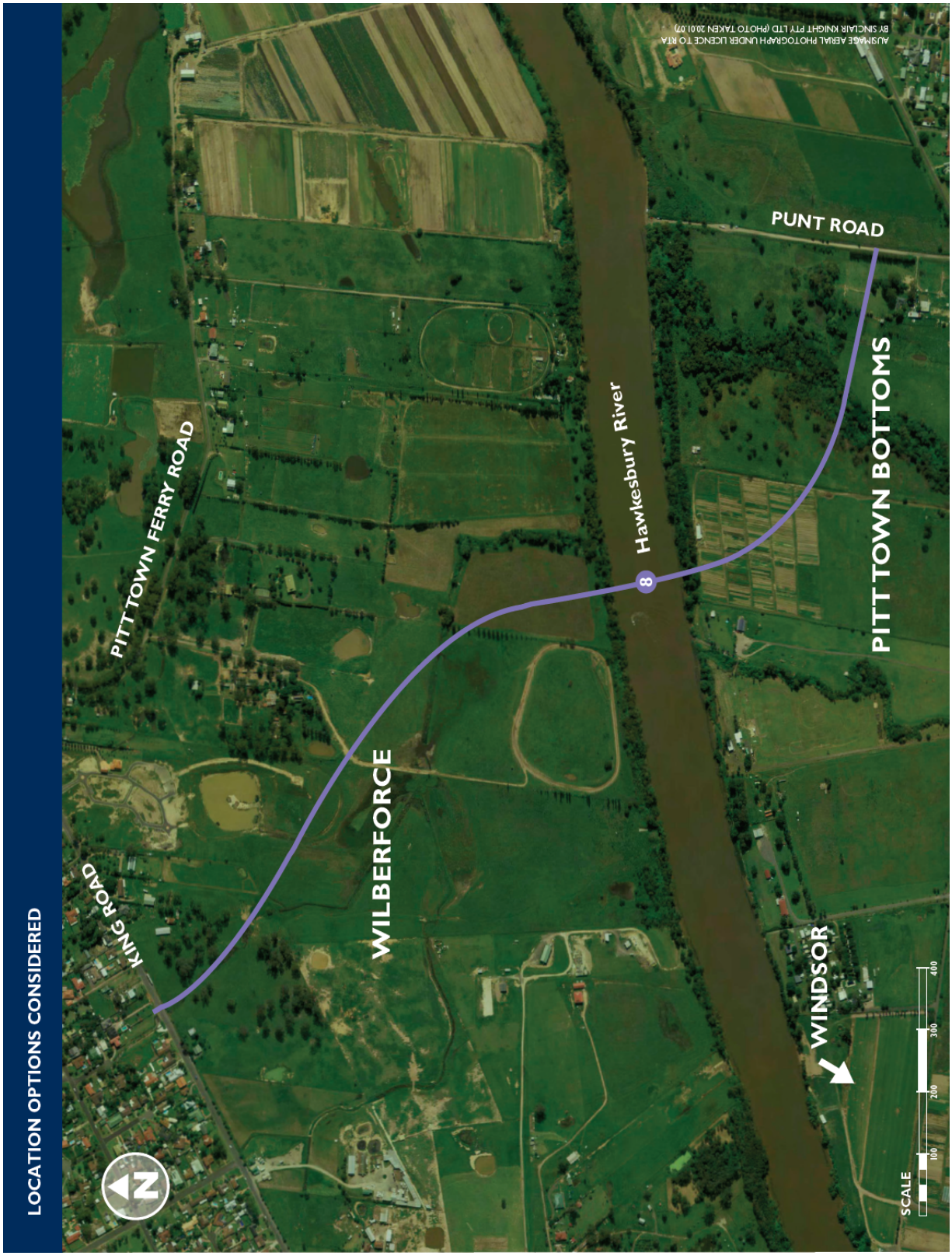

Figure 4.2: Option 8

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.