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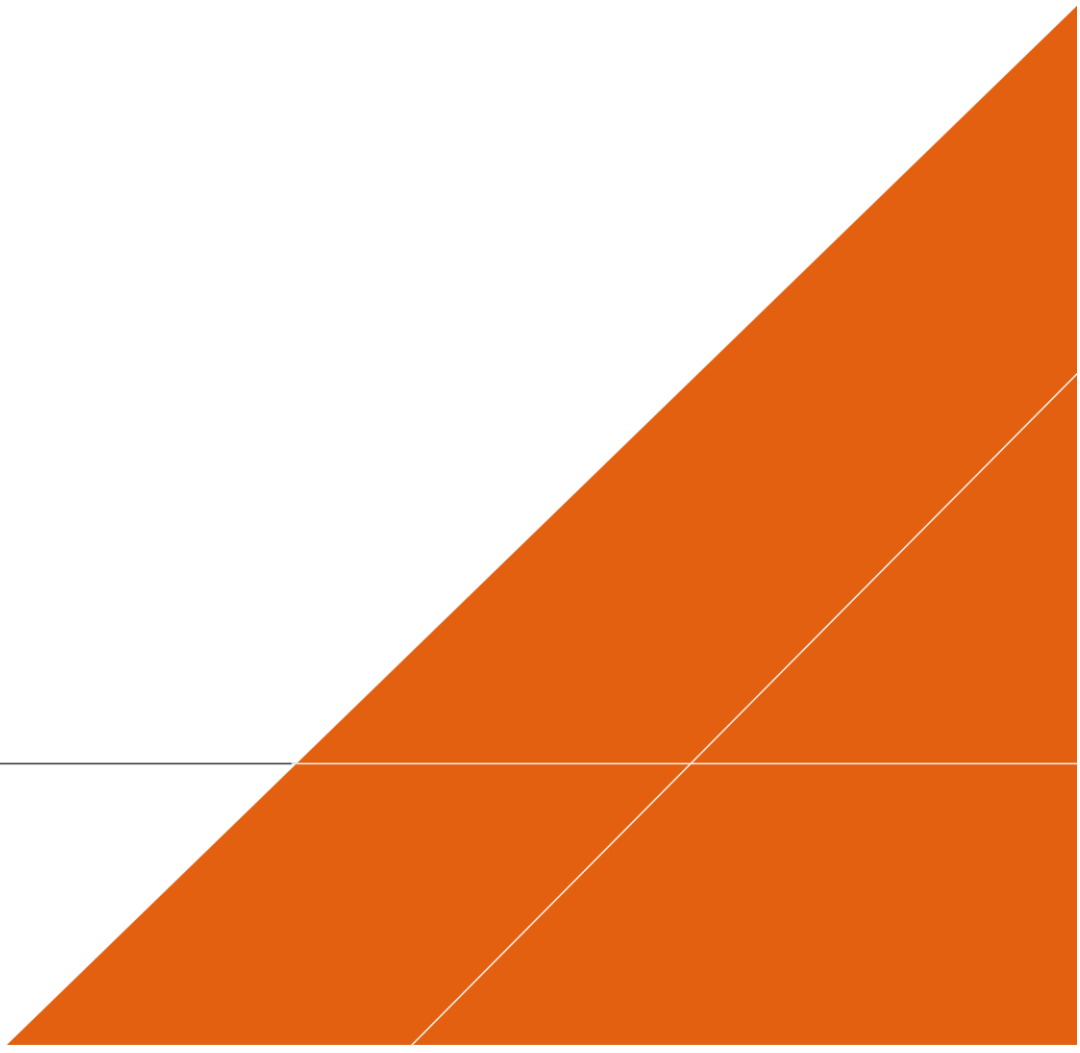
WINDSOR BRIDGE REPLACEMENT PROJECT

Traffic and Options Modelling Report



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ROADS AND MARITIME SERVICES (ROADS AND MARITIME) WINDSOR BRIDGE REPLACEMENT PROJECT

Traffic and Options Modelling

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REVISIONS

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G	21 June 2017	Final Report	KN	MR
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CONTENTS

APPENDIX

1 Introduction

1.1 Report Purpose

This Traffic and Options Modelling Report is intended to document a traffic and options modelling assessment undertaken for the proposed Windsor Bridge Replacement project (the 'project'). In the course of preparing this report, documents relevant to development of the project were reviewed.

This report documents existing 2017 traffic conditions and future traffic growth in the vicinity of Windsor Bridge, and provides an assessment of performance of the Concept Design of the project from a traffic perspective.

This report has been prepared to assess the network performance of the Concept Design and identify possible cost-effective improvements.

1.2 Background

Roads and Maritime Services (Roads and Maritime) proposes to replace the existing bridge over the Hawkesbury River at Windsor (known as 'Windsor Bridge'), and has developed a Concept Design for this proposal. The project includes a replacement bridge 35 metres downstream from the existing bridge, modifications to the existing intersections, new bridge approach roads to accommodate the new bridge location, and provision of a shared pedestrian and cycle pathway for access to and across the replacement bridge.

The replacement bridge would provide wider lanes and shoulders and greater sight distances for road users in comparison to the existing bridge. Adjustments would also be made to the bridge approach roads and existing intersections at Wilberforce Road / Freemans Reach Road, Bridge Street / George Street, Bridge Street / Count Street and Bridge Street / Macquarie Street. All of these elements of the project would contribute to improvements in traffic capacity and safety.

1.3 Study Area

Figure 1-1 shows the model study area road network and key intersections.

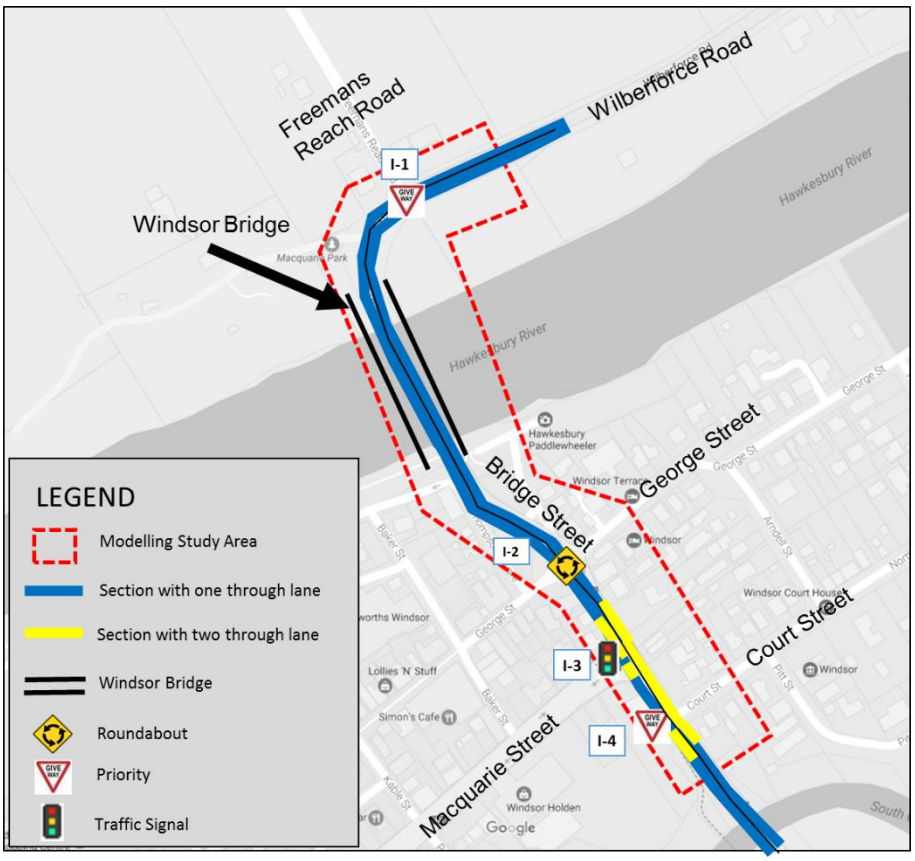


Figure 1-1 Modelling Study Area and Key Intersections

Bridge Street is a sub-arterial road running in a north-west and south-east direction within the study area. It links Windsor Road (A2) and Wilberforce Road from Mulgrave to Windsor. It integrates the existing Windsor Bridge and forms part of the A2. Key intersecting roads include Court Street, Macquarie Street, George Street and Freemans Reach Road. It is primarily one lane in each direction, with additional turning lanes provided at the intersection with Macquarie Street and Court Street. The posted speed limit is 60 km/h and the road bends sharply at both ends of the bridge.

Truck and bus travel speeds are limited to 40 km/h on the bridge. Bridge Street is part of the B-double route from Windsor Road to Wilberforce Road.

Wilberforce Road is a sub-arterial road running north-east and south-west from Bridge Street, connecting Windsor to Wilberforce and forming part of State Route 69 to Singleton. The road is one lane in each direction with a posted speed limit of 80 km/h in the section approaching Windsor Bridge. Wilberforce Road is part of a B-double route running from Windsor Road via Bridge Street.

Key intersections in the study area include:

- Wilberforce Road and Freemans Reach Road;
- Bridge Street and George Street;
- Bridge Street and Count Street; and
- Bridge Street and Macquarie Street.

1.4 Study Scope and Objective

The scope of this study is to assess the Concept Design of the Windsor Bridge Replacement project. Traffic modelling has been undertaken to assess the performance of the Concept Design. A road-based traffic model was developed for the study area using SIDRA Network software version 7.0. Key objectives of the traffic modelling assessment were to:

- Determine the level of service of the proposed upgrades taking into account expected traffic growth for 2026 and 2036; and
- Prepare Traffic and Options Modelling Report.

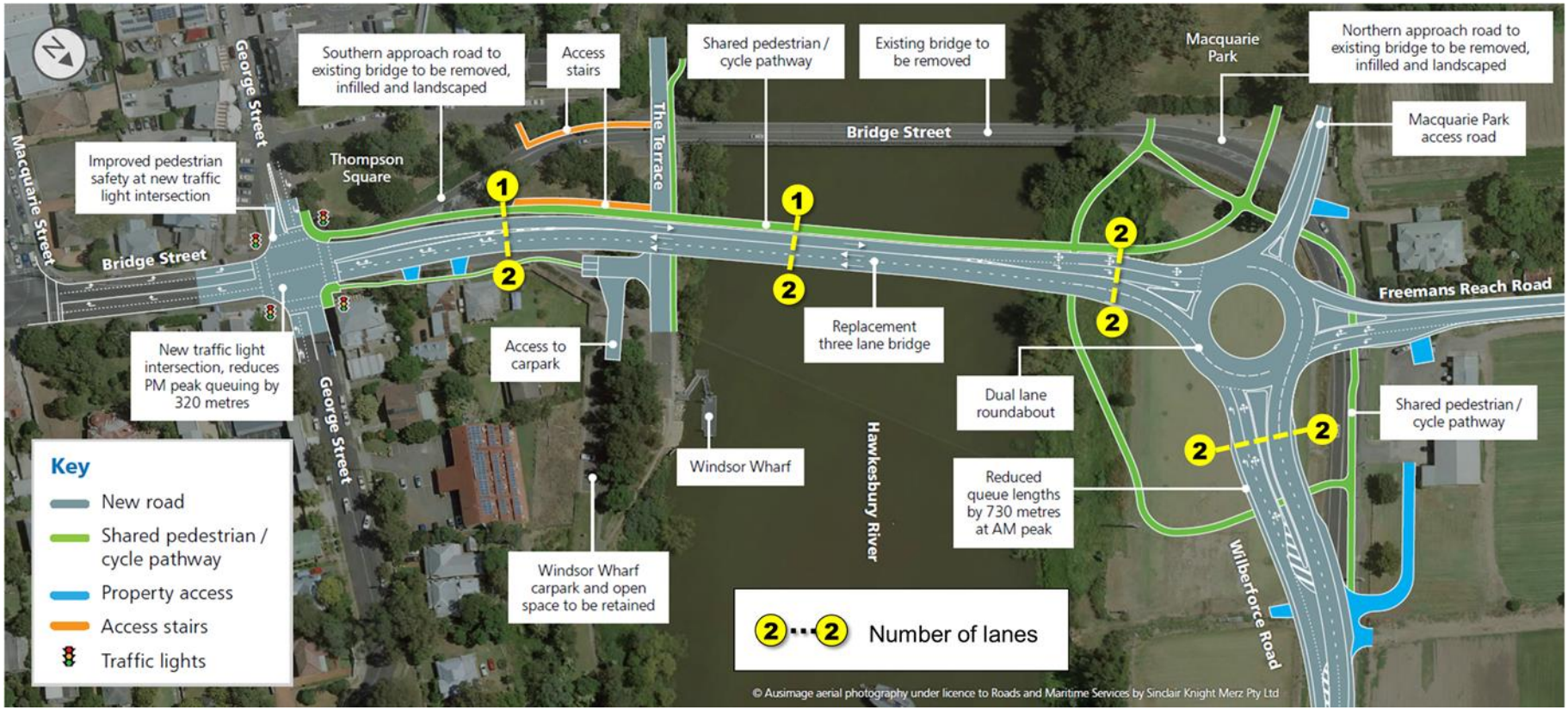
1.5 Concept Design

Roads and Maritime has developed a Concept Design for the Windsor Bridge Replacement project between Wilberforce Road and Court Street, Windsor (hereafter referred to as the 'Concept Design'). The Concept Design involves removal of the existing bridge and construction of a new three lane bridge and upgrade of approach roads and intersections.

The Concept Design includes the following key features:

- Removal of the existing two lane bridge and provision of a new three lane bridge consisting of two lanes in the southbound direction and one lane in the northbound direction;
- A new dual lane roundabout replacing the existing priority control at Bridge Street / Wilberforce Road / Freemans Reach Road. The new roundabout will be located approximately 35 metres south of the Bridge Street / Wilberforce Road / Freemans Reach Road intersection. The new roundabout intersection will form a four-way intersection allowing access to Macquarie Park via the western approach;
- New traffic signals replacing the existing roundabout at Bridge Street / George Street;
- Linemarking the right turn lane on Bridge Street southbound heading to Macquarie Street to formalise it as a turning lane; and
- Linemarking the left turn lane on Bridge Street northbound heading to George Street to formalise it as a turning lane.

Figure 1-2 shows Roads and Maritime's Concept Design.



Source: Source: Windsor Bridge Replacement Project Update, December 2016, Roads and Maritime Services

Figure 1-2 Roads and Maritime's Concept Design

1.6 Study Approach

The study approach involved undertaking a new 2017 traffic survey, traffic analysis based on wider-area strategic traffic modelling obtained from Roads and Maritime's Strategic Traffic Forecasting Model (STFM, EMME model), development of a SIDRA Network model (using SIDRA Network version 7), and assessment of the Concept Design.

Ongoing consultation involving Roads and Maritime project team constituted an important element of this study. Two Technical Notes were prepared and subsequently reviewed by Roads and Maritime project team over the course of this project including:

- Technical Note 1 – Future traffic growth assumption (traffic growth assumptions were agreed with Roads and Maritime project team subsequent to preparation of this Technical Note); and
- Technical Note 2 – Existing conditions and traffic performance of the Concept Design.

Feedback from Roads and Maritime project team was incorporated into the traffic and options modelling study findings at various stages of Arcadis' investigation.

Key steps in Arcadis' modelling approach included the following:

- Analysis of new traffic survey data for the 2017 traffic condition. A new traffic survey was conducted by Matrix in March 2017. This provided key input to development of the base case model. Four types of data were collected including intersection turning movement counts, midblock traffic counts, queue length survey and travel time survey;
- Analysis of future traffic growth using data obtained from Roads and Maritime's Strategic Traffic Forecasting Model (STFM, EMME model), and preparation of traffic forecasts for future years 2026 and 2036;
- Development of SIDRA Network models for the existing year 2017 and future years 2026 and 2036, for both the morning (AM) and afternoon (PM) peaks;
- Assessment of traffic performance of the Concept Design using SIDRA Network, and identification of any modifications to the Roads and Maritime Concept Design; and
- Preparation of a Traffic and Options Modelling Report.

1.7 Reference Traffic Data and Model

For the purpose of the study, future traffic growth data was sourced from Roads and Maritime's Strategic Traffic Forecasting Model (STFM). Arcadis used appropriate traffic growth data from the STFM relevant to the study area. The future growth assumptions to be used in the SIDRA models were then reviewed and agreed with Roads and Maritime project team.

In consultation with Roads and Maritime project team, a new traffic survey was undertaken to satisfy the need and purpose of the study. This included intersection classified turning movement counts (cars and heavy vehicles), midblock traffic counts, queue length, and travel time surveys. This traffic survey was undertaken in March 2017.

To assess network and intersection performance, Arcadis used SIDRA Network modelling software (version 7).

1.8 Report Structure

The remainder of this report is structured as follows:

- **Chapter 2 –** Existing Traffic and Transport **–** Provides context of the existing traffic and transport network within the Windsor Bridge Replacement study area.
- **Chapter 3 –** Existing Road Network Performance **–** Establishes existing traffic performance, summarises traffic survey results, develops the SIDRA Network model for the study area, assesses existing bridge capacity and intersection level of service, and identifies current network issues.
- **Chapter 4 -** Future Traffic Performance of the Upgrade **–** Provides an overview of future traffic growth, forecast traffic volumes on Windsor Bridge, assesses the future traffic performance of the proposed Windsor Bridge Replacement project using the SIDRA Network, and identifies issues and potential modifications to Roads and Maritime's Concept Design.
- **Chapter 5 –** Conclusions **–** Provides a summary of key traffic modelling findings of the study.

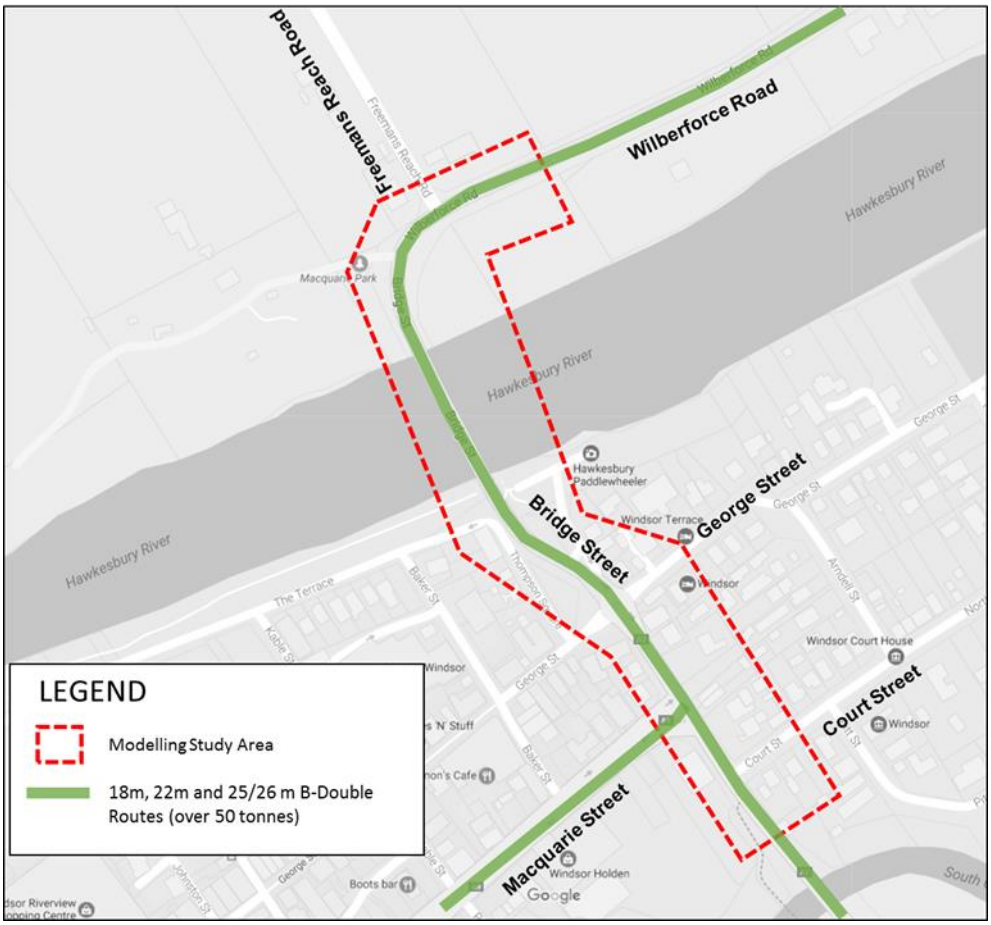
2 Existing Traffic and Transport Conditions

Existing traffic and transport conditions in the study area are described in this chapter. It is intended to provide the traffic context within which the assessment has been undertaken.

2.1 Route and Speed Environment

Bridge Street and Wilberforce Road are sub-arterial roads linking Wilberforce and Windsor to Rouse Hill via Windsor Road to the south and to Wilberforce to the east. Currently Bridge Street and Wilberforce Road are two lane roads (one lane in each direction).

Bridge Street, Wilberforce Road and Macquarie Street are designated B-double routes for trucks up to 26 metres long. Figure 2-1 shows designated B-double routes in the study area (sourced from Roads and Maritime).



Source: RMS Restricted Access Vehicle Map NSW (map as of 27 March 2017)

Figure 2-1 Designated B-Double Routes in the Study Area

The posted speed limit on Bridge Street and Wilberforce Road between Court Street and Freemans Reach Road is 60 km/h. Over the Windsor Bridge, the posted speed limit for trucks and buses is 40 km/h. The speed limit on Bridge Street and Wilberforce Road increases to 80 km/h approximately 550 metres south of Court Street and 200 metres east of Freemans Reach Road. The posted speed limit on George Street and Court Street is 50 km/h. The posted speed limit on Macquarie Street is 60 km/h. Freemans Reach Road has a posted speed limit of 80 km/h decreasing to 60 km/h

approaching the intersection with Wilberforce Road. Figure 2-2 shows posted speed limits in the vicinity of the study area.

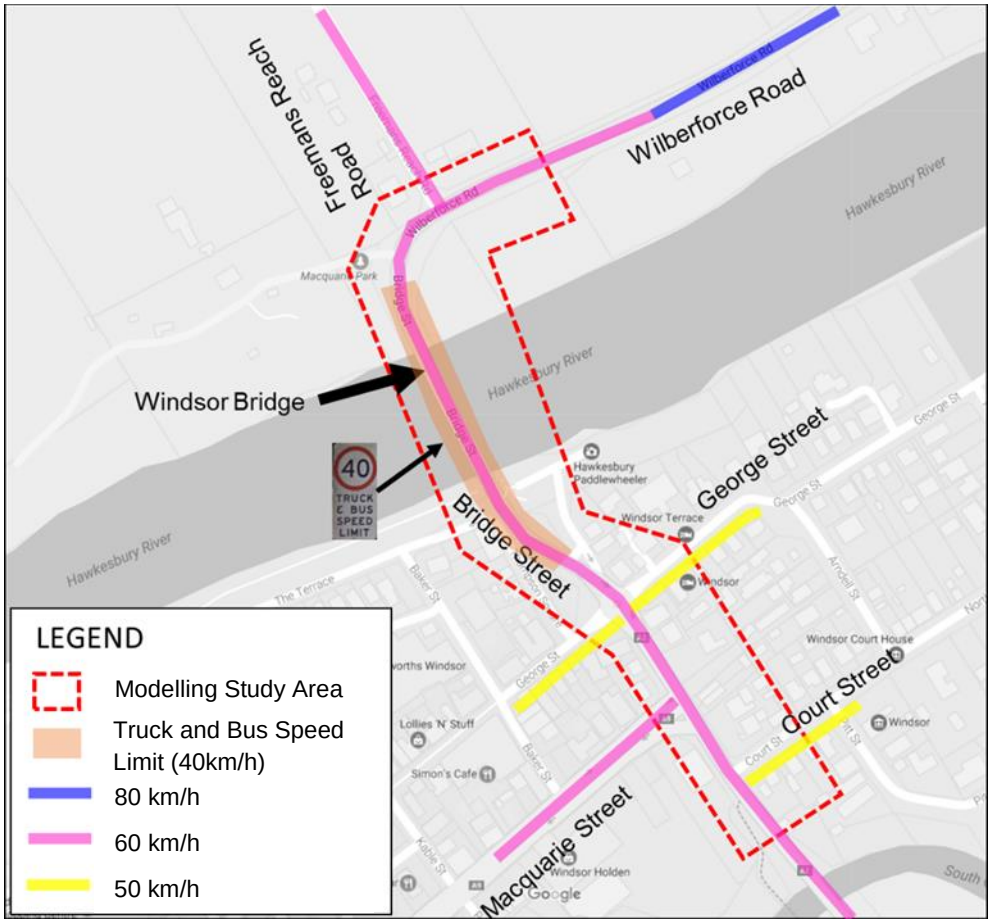
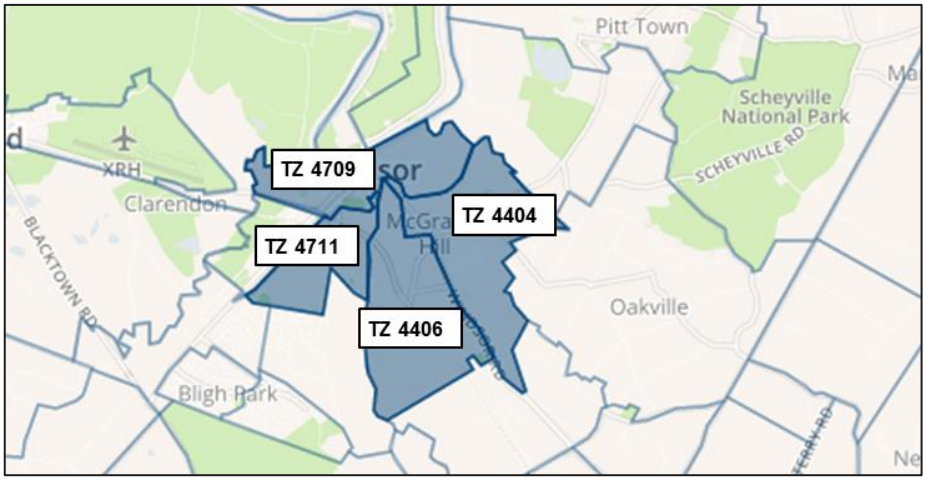


Figure 2-2 Posted Speed Limits in the Study Area

2.2 Commuter Mode Share

Transport Performance and Analytics (TPA) provides journey to work data (JTW) for the Sydney Greater Metropolitan Area (GMA), which comprises a comprehensive sample of commuter travel collected during the 2011 Census. Work trip origin and destinations are coded to the 2011 travel zones and shown in Figure 2-3. Table 2-1 summarises the work trips by mode of travel reported for the study area.



Source: Transport Performance and Analytics (TPA)

Figure 2-3 Travel Zones in the Study Area

Table 2-1 Commuter Mode Share in Study Area

Travel Mode	Study Area as Workplace (Outbound trips)	Study Area as Workplace (Outbound trips) %	Study Area as Home (Inbound trips)	Study Area as Home (Inbound trips) %
Car Driver	1,621	70%	4,928	76%
Car Passenger	119	5%	412	6%
Train	125	5%	118	2%
Bus	17	1%	30	0%
Ferry/ Tram	1	0%	5	0%
Walked Only	79	3%	97	1%
Other	28	1%	46	1%
Worked at home/ Did not travel/ Not stated	326	14%	891	14%
Total	**2,317**	**100%**	**6,525**	**100%**

Selected travel zones (TZ11): 4404, 4406, 4709, 4711

Source: 2011 Journey to Work Data

In 2011, about 2,317 residents travelled from the study area to work. About 14 per cent of people did not travel to work or worked from home on Census day. The Census data showed that around 75 per cent of work trips from the study area were made by motorists in a private vehicle, with five per cent of those as car passengers. About six per cent of workers travelled by public transport, and three per cent walked. Of the five per cent public transport users, only one per cent of the trips were made by bus, with the remaining five per cent of trips made by train.

In 2011 about 6,525 employees travelled to the study area from work. From the inbound trip statistics, it can be seen that private vehicles are still the dominant mode of transport to work, accounting for about 82 per cent. About two per cent of employees travelled by public transport and one per cent walked. The percentage of people who did not go to work or worked from home remained at 14 per cent when compared to outbound trips.

2.3 Work Trips Distribution

The JTW data was further analysed to understand the distribution of work trips to and from study area. Outbound work trip distribution made by private car (both as driver and as passenger) from the study area are summarised in Table 2-2. Inbound work trips distribution made by private car (both as driver and as passenger) to the study area are summarised in Table 2-3.

The results indicate the following work trip patterns:

- Outbound work trip distribution shows that substantial trips are made to Richmond - Windsor (25 per cent) and Rouse Hill – McGraths Hill (16 per cent). In addition to this, 9 per cent of outbound trips travelled to Blacktown.
- Inbound work trip distribution shows that substantial trips are made from Richmond - Windsor (27 per cent) and Hawkesbury (20 per cent). In addition to this, 11 per cent of inbound trips travelled from Rouse Hill – McGraths Hill.

Table 2-2 Daily Car Trips from the Study Area (Outbound)

Geographic Area	Number of car trips from study area (Outbound)	% Outbound trips from Study Area
Richmond - Windsor	434	25%
Rouse Hill - McGraths Hill	276	16%
Blacktown	163	9%
Baulkham Hills	126	7%
Mount Druitt	76	4%
Penrith	76	4%
Parramatta	59	3%
Hawkesbury	58	3%
Dural - Wisemans Ferry	52	3%
Other	303	17%
Total	**1,740**	**100%**

Source: 2011 Journey to Work Data

Table 2-3 Daily Car Trips to the Study Area (Inbound)

Geographic Area	Number of car trips to study area (Inbound)	% Inbound trips to Study Area
Richmond - Windsor	1,424	27%
Hawkesbury	1073	20%
Rouse Hill - McGraths Hill	587	11%
Blacktown	499	9%
Penrith	472	9%
Mount Druitt	222	4%
Baulkham Hills	209	4%
Blue Mountains	175	3%
Dural - Wisemans Ferry	121	2%
St Marys	106	2%
Other	453	8%
Total	**5,339**	**100%**

Source: 2011 Journey to Work Data

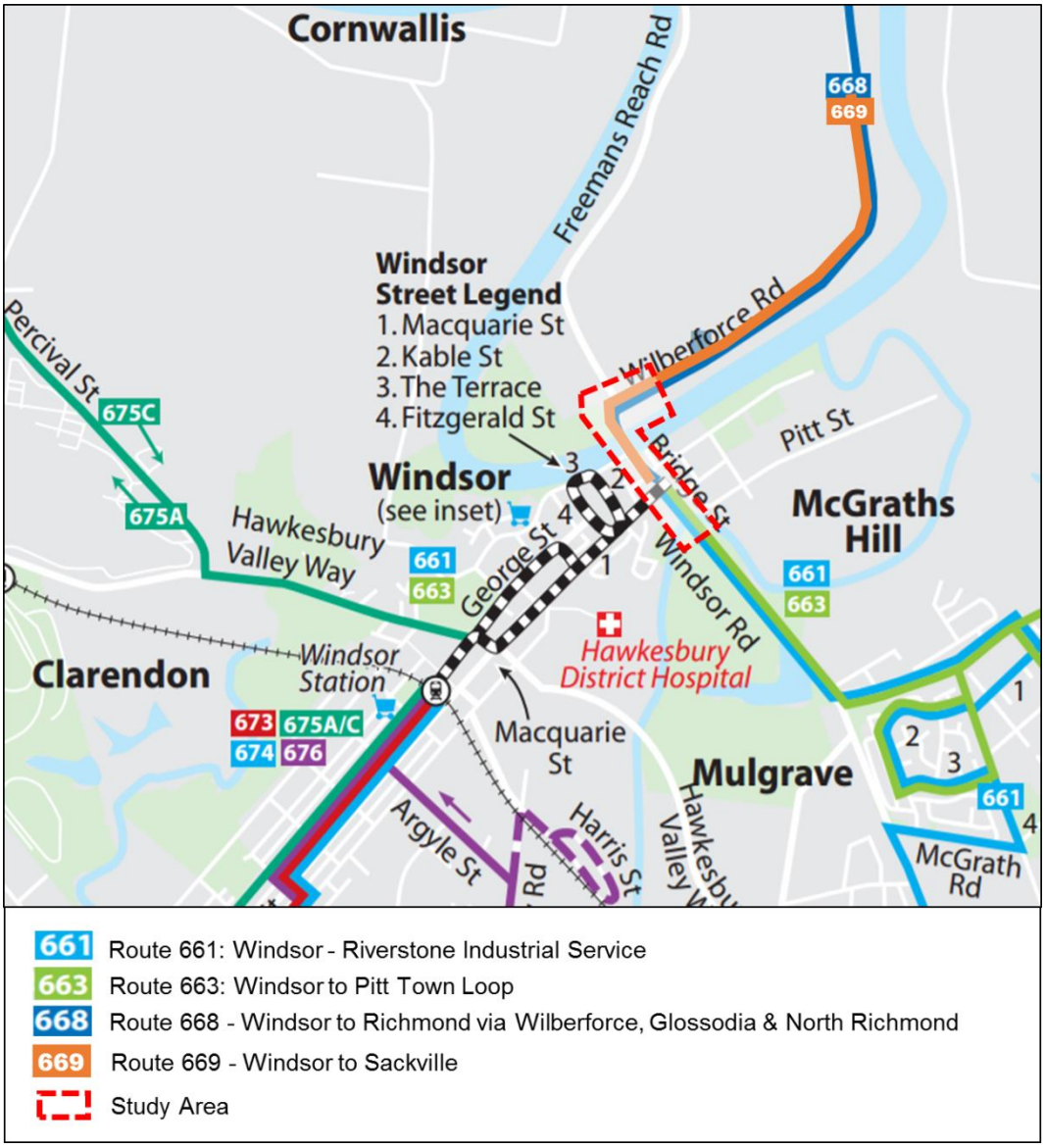
2.4 Travel Patterns

Significant proportions of morning (AM) and afternoon (PM) peak trips to and from the study area have an origin and destination to the surrounding areas including Richmond, Hawkesbury, Rouse Hill and Blacktown. Analysis of travel patterns from the journey to work (JTW) data indicated that approximately 67 per cent of the catchment area's workers live in Richmond, Hawkesbury, Rouse Hill and Blacktown.

The JTW data indicated about 54 per cent of the catchment area's residents travelled to Richmond, Hawkesbury, Rouse Hill and Blacktown.

2.5 Public Transport

The study area is serviced by four routes all operated by Busways. Routes 661, 663, 668 and 669 run along Bridge Street, Wilberforce Road and Macquarie Street. Figure 2-4 shows the bus routes in the study area.



https://www.busways.com.au/sites/default/files/network_maps/R1TimetableNetworkMap201116.pdf

Figure 2-4 Bus Routes Servicing the Study Area

The study area has no direct rail service. The nearest railway station by road is Windsor Station (see Figure 2-5). Windsor Station is approximately two kilometres away from Bridge Street via Macquarie Street and George Street.

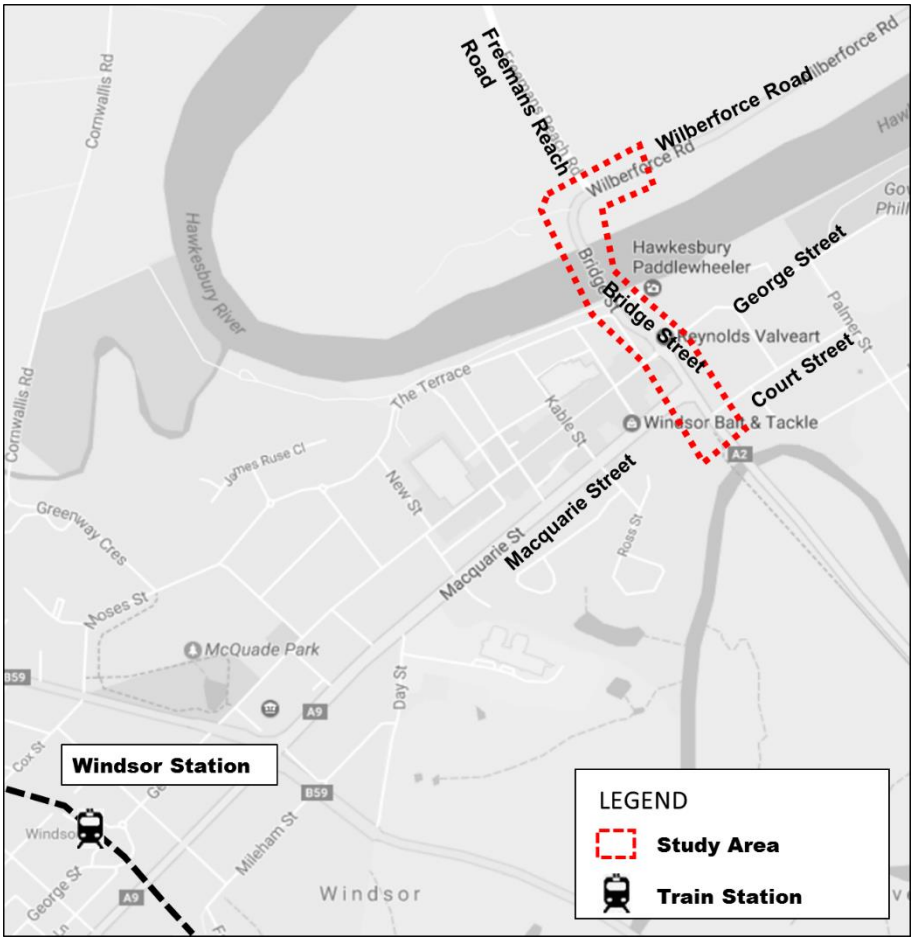


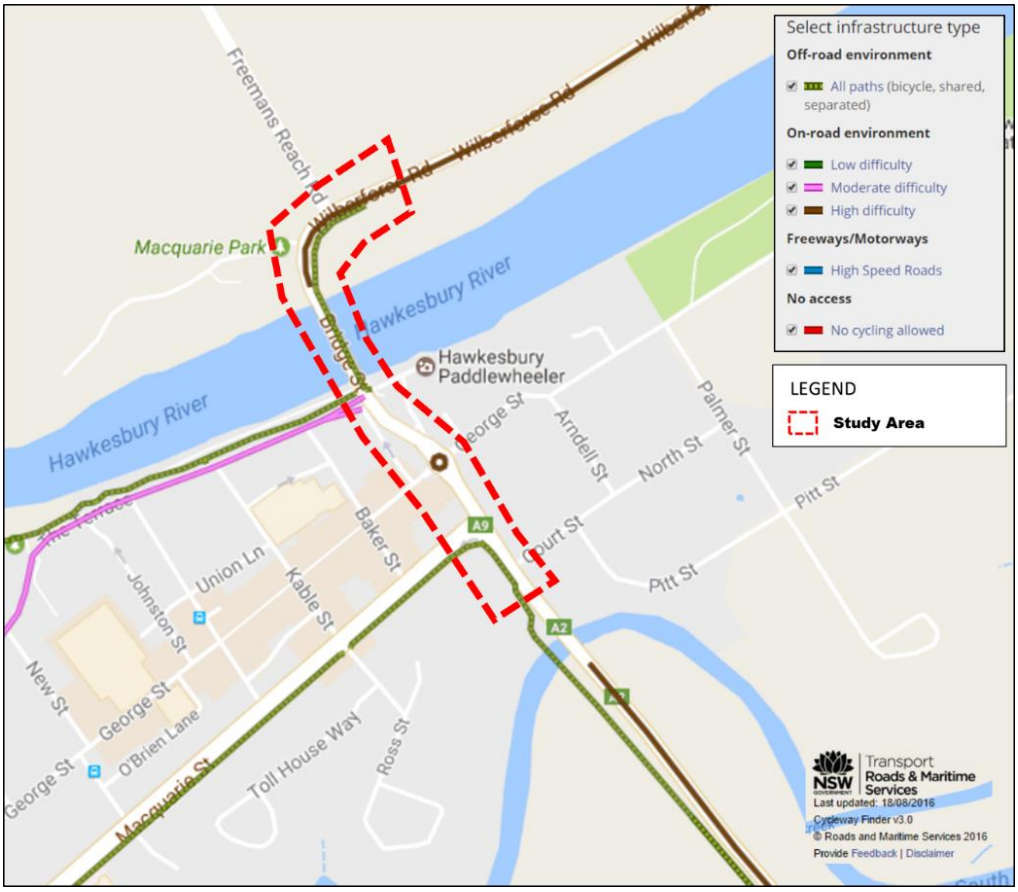
Figure 2-5 Train Stations in Close Proximity to the Study Area

2.6 Walking and Cycling

There are dedicated footpaths along Bridge Street, Macquarie Street, George Street and Court Street. Windsor Bridge has a narrow pedestrian and cycle path on its eastern side. This shared path links The Terrace and Old Bridge Street in the south with the intersection of Wilberforce and Freemans Reach Roads to the north. The shared path on the existing bridge also forms an off-road link in the local cycle network.

Pedestrian access and amenity at the Bridge Street / George Street roundabout is currently poor. Pedestrian access is typically poor at roundabout controlled intersections and is made worse in this case by the fact that the intersection is located at the top of a crest. The existing intersection presents a road safety hazard for pedestrians and cyclists due to the high peak traffic volumes and poor sight distance at the intersection. No facilities are provided at the current roundabout controlled intersection to assist crossing Bridge Street, and pedestrians have difficulty identifying a safe gap in which to cross during peak traffic periods. As well as being a considerable safety risk to pedestrians crossing at this point, it provides a barrier to pedestrian movements from the eastern section of the town, where much of the accommodation is located, to the town centre.

An on-road cycle way is currently provided on Bridge Street and Wilberforce Road. A designated off-road cycle way exists on Bridge Street, Wilberforce Road and Macquarie Street. Figure 2-6 shows the different types of cycle routes in the study area.



Source: Roads and Maritime Cycleway Finder V3

Figure 2-6 Existing Cycleways in the Study Area

2.7 Crash Data

This assessment is based on the crash data supplied by Roads and Maritime between July 2011 and December 2016. The crash data includes fatal, injury or vehicle damage accidents. The crash analysis was undertaken for Bridge Street and Wilberforce Road between Freemans Reach Road and Macquarie Street.

Table 2-4 below summarises recorded crashes by road and location. There were 52 crashes recorded between July 2011 and December 2016 on Bridge Street and Wilberforce Road between Freemans Reach Road and Macquarie Street. Of all crashes reported, 41 crashes occurred at intersections, 8 crashes occurred on the undivided road sections, and 3 crashes occurred on the divided road sections.

The severity of crashes classified as fatal, injury and non-casualty are shown in Table 2-5. Of the total 52 crashes recorded in the study area between July 2011 and December 2016, no fatal crashes were recorded. About 20 crashes (38 per cent) were recorded as injury, with 20 people injured in total. About 32 crashes (62 per cent) were recorded as non-casualty (i.e. tow-away).

Table 2-4 Locations of Crashes

Road	Total Number Crashes Recorded	Intersection*	Non-intersection	
			Two-way undivided road	Divided Road
Bridge Street	23	17	4	2
George Street	1	1	0	0
Macquarie Street	4	3	0	1
Wilberforce Road	24	20	4	0
Total	**52**	**41**	**8**	**3**

*Source: Roads and Maritime crash data between July 2011 and December 2016, Note: * Up to 10 metres from an intersection*

Table 2-5 Number of Crashes by Severity

Crash Severity	Number of Crashes Recorded	%	Casualties
Fatal	0	0%	
Injury	20	38%	20 people injured
Non-casualty	32	62%	
Total	**52**	**100%**	**20**

Figure 2-7 shows the number of crashes per movement type. The four most common types of crashes account for around 87 per cent of the reported crashes within the study area:

- Intersection, from adjacent approaches (38 per cent);
- Opposing vehicles, turning (21 per cent);
- Rear-end (15 per cent); and
- Off carriageway, on curve, hit object (8 per cent).

Crashes other than the above constitute the remaining 17 per cent.

It is likely that safety will deteriorate along Bridge Street and Wilberforce Road and associated intersections in their current configuration for all road users as traffic levels and congestion increase, which is of ongoing and substantial concern to Roads and Maritime and the local community.

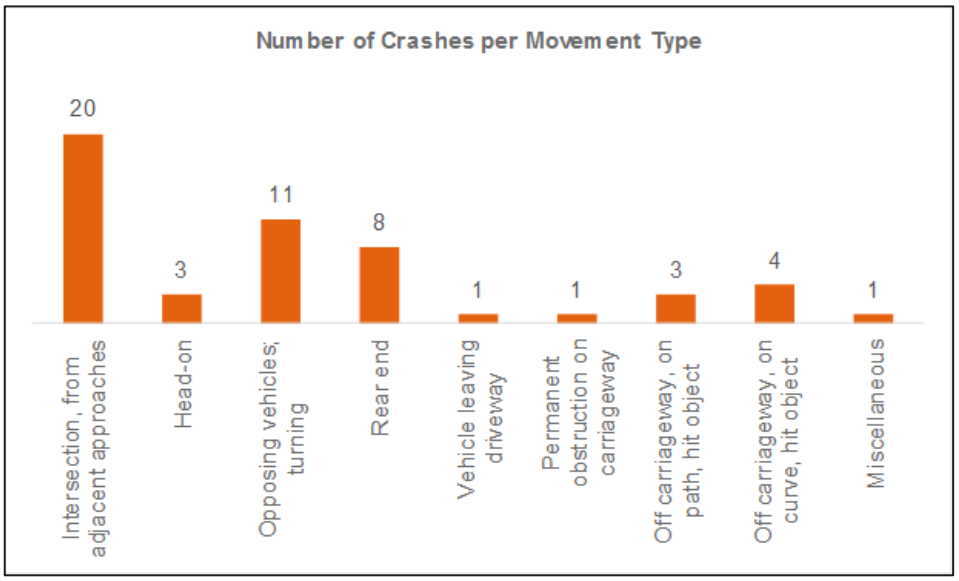


Figure 2-7 Number of Cashes by Movement Types

Figure 2-8 shows crash locations on Bridge Street and approach roads. Figure 2-8 indicates that crashes are mostly located at intersections. Particularly crash-prone locations are:

- Freemans Reach Road and Wilberforce Road intersection;
- Bridge Street and George Street intersection; and
- Bridge Street and Macquarie Street intersection.

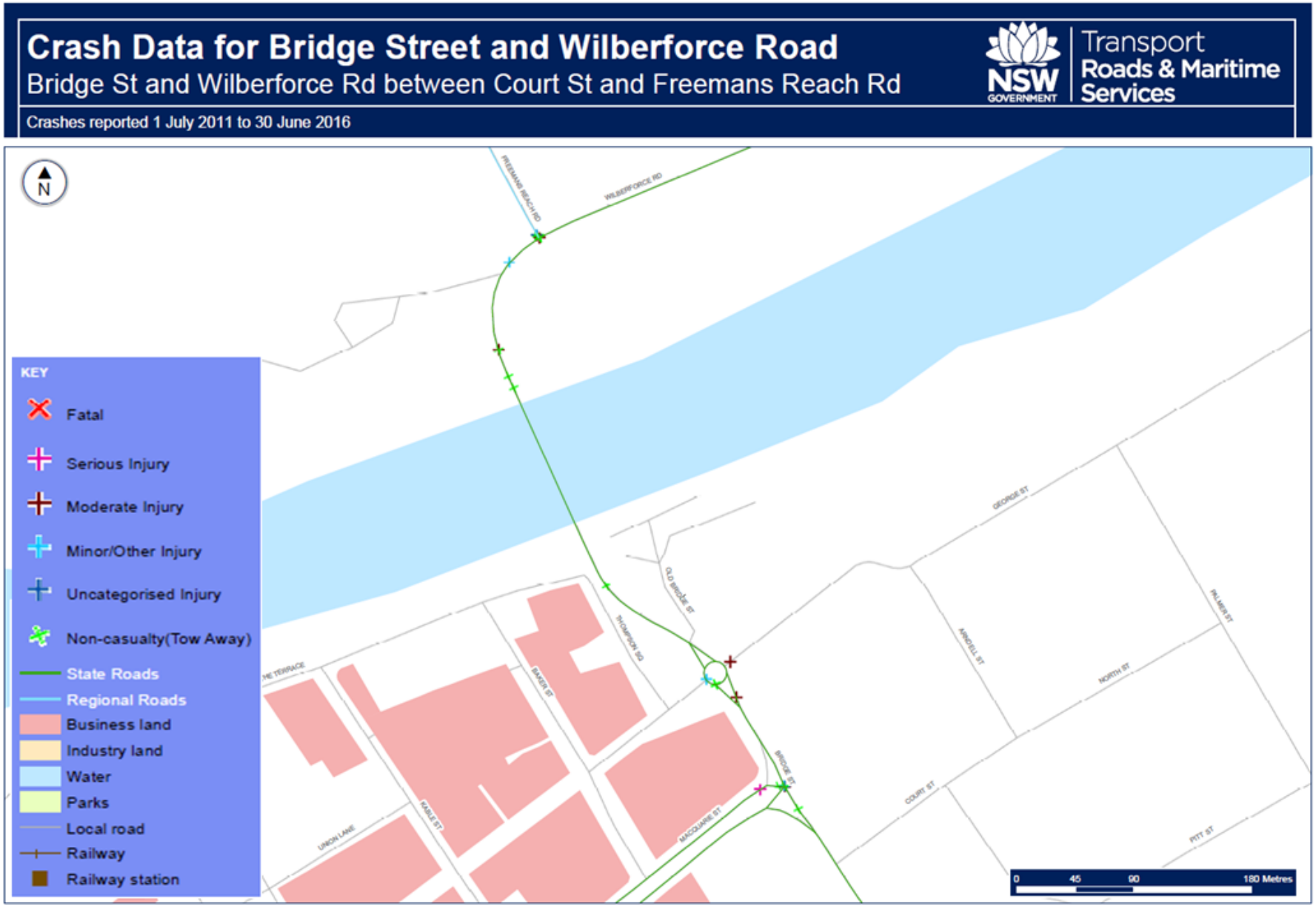


Figure 2-8 Spatial Distribution of Crashes on Bridge Street and Approach Roads

3 Existing Road Network Performance

This chapter establishes existing transport network performance in the study area. Results of the new 2017 traffic survey are summarised in this section, and formed the basis of the SIDRA model and level of service assessment.

3.1 Traffic Surveys

The 2017 traffic survey was undertaken by Matrix in March 2017 to satisfy the needs and purpose of the study. It included:

- Daily automatic traffic counts;
- Intersection turning movement counts;
- Queue length surveys; and
- Travel time surveys.

3.1.1 Mid-block traffic counts

Daily mid-block traffic survey was conducted on the Windsor Bridge for a continuous seven-day period between 24 March 2017 and 30 March 2017. The mid-block data was collected to identify the thirteen Austroads standard vehicle classes.

3.1.2 Intersection counts and queue length surveys

Intersection turning movement counts and queue length surveys were conducted on 28 March 2017 (Tuesday) for two hours in the AM (07:00-9:00) and two hours in the PM (16:00-18:00).

The survey was conducted for the following four intersections:

- Wilberforce Road / Freemans Reach Road;
- Bridge Street / George Street;
- Bridge Street / Macquarie Street; and
- Bridge Street / Court Street.

3.1.3 Travel time and speed surveys

Travel time surveys were conducted on 28 March 2017 (Tuesday) for two hours in the AM (07:00-9:00) and two hours in the PM (16:00-18:00).

The survey was conducted for one bi-directional route:

- Bridge Street / Wilberforce Road (between 500 metres south of Court Street / Bridge Street intersection and 500 metres east of Freemans Road / Wilberforce Road intersection)

Figure 3-1 below shows the survey locations for midblock counts, intersection counts, queue length and travel time surveys.

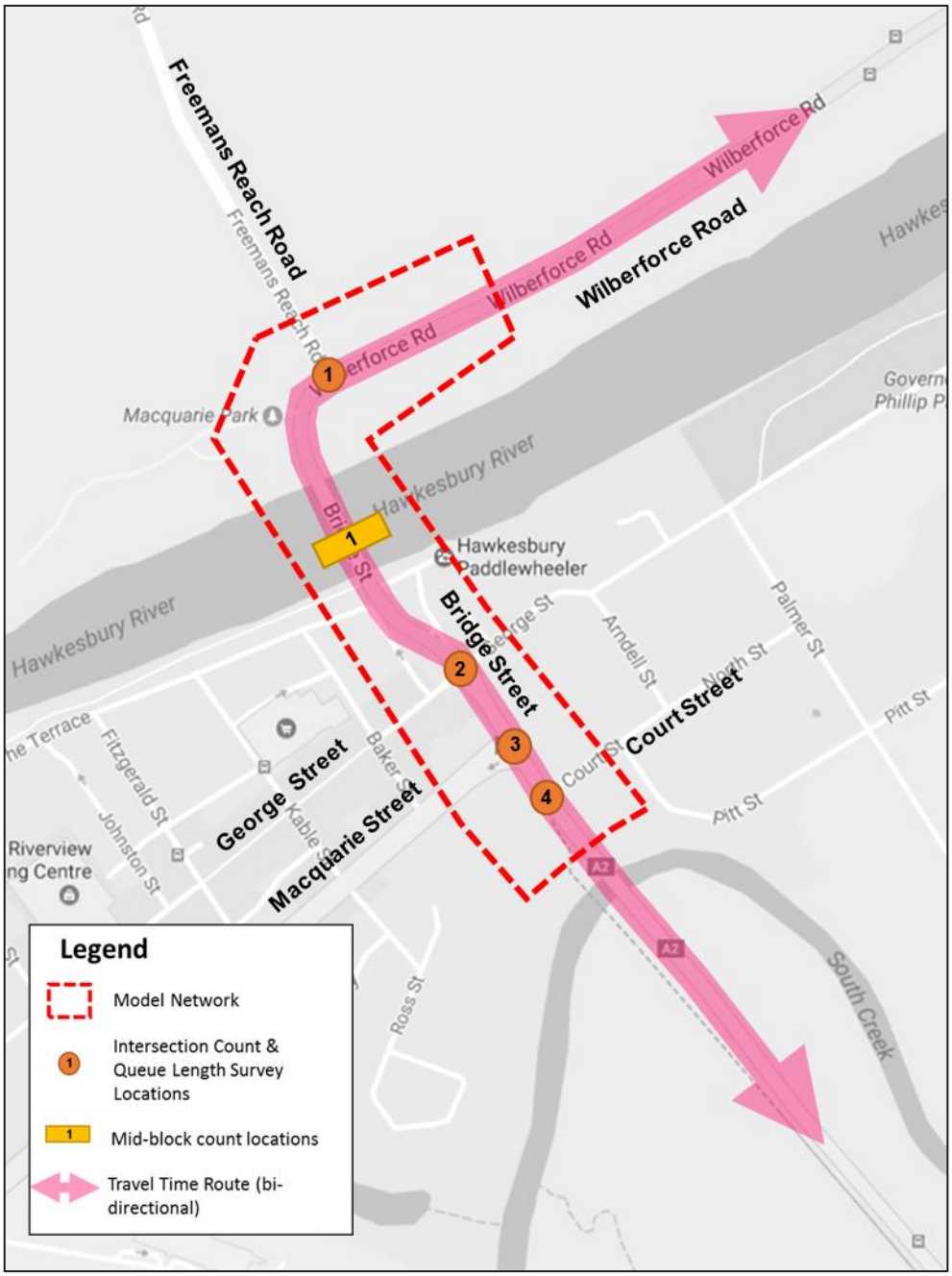


Figure 3-1 Traffic Survey Locations

3.2 Traffic Results

This section quantifies the current 2017 daily and peak hour traffic flows on Windsor Bridge and adjoining intersections within the study area. The peak hour intersection turning movements for AM and PM are used to estimate the current level of service at modelled four intersections.

3.2.1 Daily Traffic Volumes on Windsor Bridge

The 2017 midblock count represents data obtained from the March 2017 traffic survey. Table 3-1 shows the daily 2017 traffic volumes counted on Windsor Bridge (Bridge Street over Hawkesbury River).

Table 3-1 Daily traffic volume on Windsor Bridge in 2017

Day	Total Vehicles	Heavy Vehicles	Heavy Vehicle %
Monday	21,000	2,300	11%
Tuesday	21,400	2,400	11%
Wednesday	22,300	2,600	12%
Thursday	21,200	2,300	11%
Friday	21,900	2,200	10%
Saturday	17,800	1,300	8%
Sunday	15,800	1,000	6%
Average weekday (5 days)	21,600	2,400	11%
Average weekly (7 days)	20,200	2,000	10%
Average weekend (2 days)	16,800	1,200	7%

The daily traffic volumes are shown for average weekly (7 days) and average weekday (5 days) including heavy vehicles.

- Currently (2017), Windsor Bridge (Bridge Street over Hawkesbury River) carries between 21,000 and 22,300 vehicles per day on weekday (Monday to Friday) with average of 21,600 vehicles per day;
- Based on averaged weekday (5 days), Windsor Bridge carries about 2,400 heavy vehicles per day representing about 11per cent of total volumes; and
- Weekend (Saturday and Sunday) traffic is significantly lower than weekday traffic, being about 22 per cent lower than weekday average (5 days).

Figure 3-2 shows the 2017 average weekday volume on Windsor Bridge.

Figure 3-2 Average Daily Traffic (Weekday) in 2017

3.2.2 Heavy Vehicle Volumes

According to the Austroads vehicle classification system, heavy vehicles include trucks with two or more axles, buses, semi-trailers and B-doubles.

Table 3-2 below summarises the 2017 daily heavy vehicles counted on Windsor Bridge. Based on average weekday data, the number of heavy vehicles recorded on Windsor Bridge is about 2,400 vehicles per day, representing about 11 per cent of the total vehicles.

Table 3-2 Daily Traffic Volumes (vehicles) on Bridge Street and Wilberforce Road in 2017

Road Section	Average Daily Traffic	Heavy Vehicles	% Heavy Vehicles
Windsor Bridge (Bridge Street)	21,600	2,400	11%

3.2.3 Hourly Traffic Variation

Hourly traffic variations on Windsor Bridge were analysed for seven days (Monday to Sunday) to establish peak hour traffic patterns throughout the day. Figure 3-3 shows hourly traffic variations for seven days for the March 2017 traffic survey.

The following points are noted in relation to peak hour traffic on the Windsor Bridge (Bridge Street over Hawkesbury River):

- The AM peak spreads over three hours between 6am and 9am, with traffic building up sharply between 7am and 8am when it reaches its peak;
- The PM peak also spreads over three hours between 3pm and 6pm, with traffic volumes gradually starting to build up around 3pm. The peak is reached at 5pm before it starts to decline sharply. The hour between 4pm and 5pm shows the predominant PM peak; and
- In the morning peak hour traffic direction is southbound towards Rouse Hill/Parramatta. This is mirrored in the afternoon peak with a similar volume of traffic heading northbound towards Wilberforce.

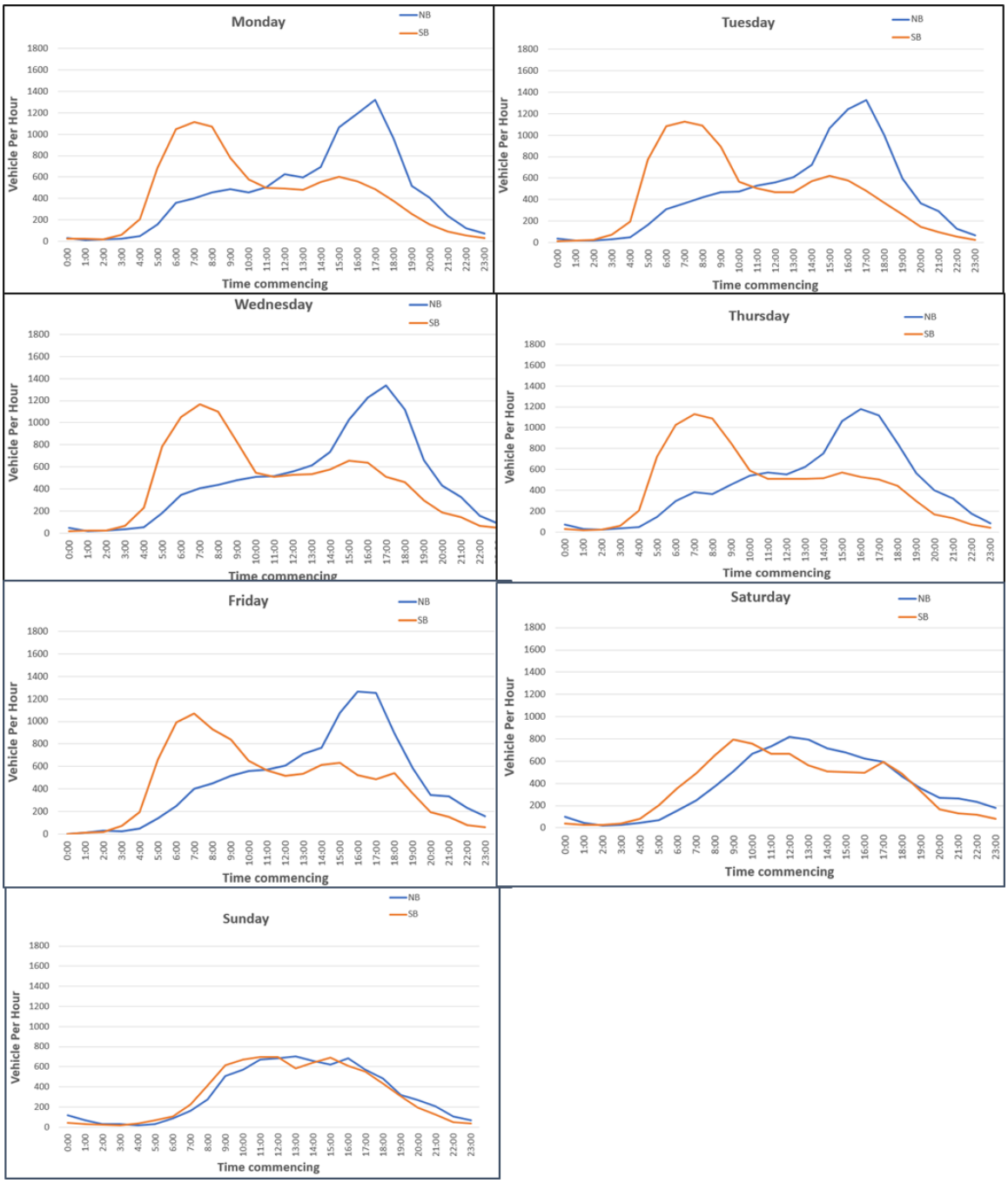


Figure 3-3 Hourly Traffic Profile – 7–day

3.2.4 Average Travel Speeds

The 2017 survey data shows that average travel speeds on Windsor Bridge are between 20 and 40 km/h; lower than the posted speed limit of 60 km/h.

In the morning peak the average travel speed on the bridge is 40 km/h in the northbound direction and 20 km/h in the southbound direction. In the afternoon peak, average travel speeds on the bridge are 40 km/h in the northbound direction and 30 km/h in the southbound direction.

3.2.5 Queue Lengths

Queue length surveys on at four key intersections within the study area were for AM peak two hours (7-9am) and PM peak two hours (4-6pm) in March 2017. Appendix A includes queue length survey results for AM and PM peak hour.

3.3 Peak Hour Traffic Volumes on Windsor Bridge

Table 3-3 shows the morning and afternoon peak hour traffic volumes on Windsor Bridge by travel direction in 2017.

Table 3-3 Peak Hour Traffic Volumes on Windsor Road in 2017

Road Section	AM Peak			PM Peak		
	NB	SB	Two-way	NB	SB	Two-way
Windsor Bridge (Bridge Street)	430 (29%)	1,050 (71%)	1,480 (100%)	1,220 (68%)	570 (32%)	1,790 (100%)

In 2017 Windsor Bridge carried about 1,480 and 1,790 vehicles (two-way) per hour in the AM and PM peak hours respectively. The AM peak data suggests substantial traffic (about 71 per cent) in the southbound direction. Conversely, the PM peak data suggests substantial traffic (about 68 per cent) in the northbound direction. The current peak hour directional traffic distribution on Windsor Bridge suggests typical 'tidal flow' distribution.

3.4 Capacity Assessment on Windsor Bridge

The notional traffic capacity of the Windsor Bridge was estimated using Austroads' *Guide to Traffic Management Part 3: Traffic Studies and Analysis.* Figure 3-4 shows hourly traffic distribution for the average weekday on the existing Windsor Bridge.

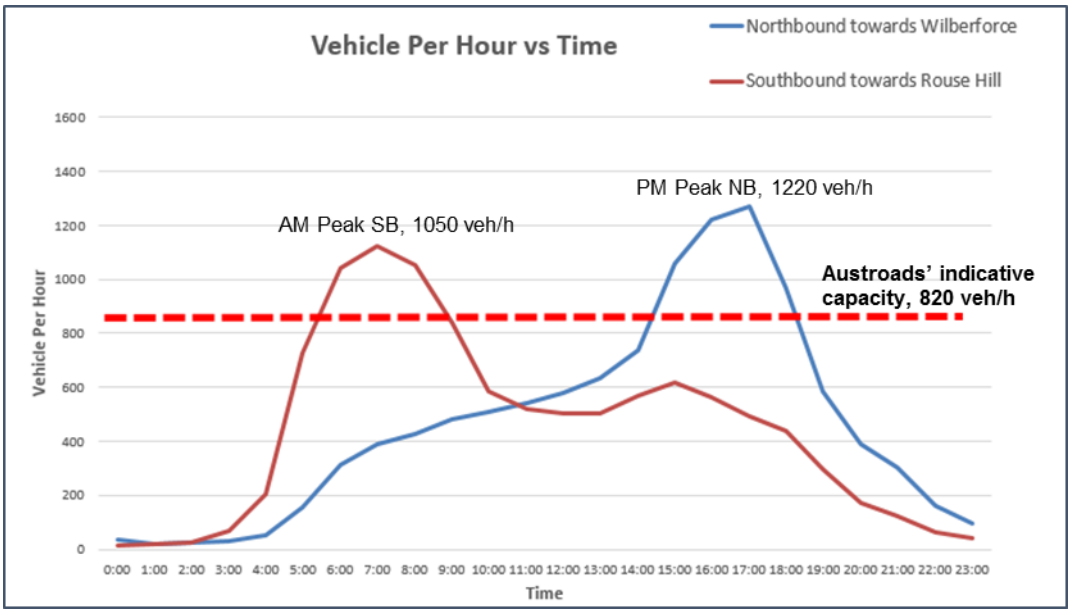


Figure 3-4 Hourly traffic volumes on Windsor Bridge, March 2017

The 2017 traffic data shows that during peak hour the bridge carries between 1,100 and 1,200 vehicles per hour in the peak direction. The Austroads' Guideline has suggested an indicative (notional) capacity of 820 vehicles per hour per lane as bridge traffic capacity. The bridge capacity of 820 vehicles per hour takes into account posted speed reductions for heavy vehicles and upstream and downstream intersection capacity.

The capacity analysis suggests that current traffic on Windsor Bridge exceeds the saturation traffic levels in both the morning (AM) and afternoon (PM) peak periods.

The existing condition analysis for the bridge also suggests the need for additional bridge capacity. Further capacity analysis is documented in Section 3.5 below.

3.5 Existing Intersection Level of Service

The capacity of the section of Bridge Street and Wilberforce Road between Court Street and Freemans Reach Road is strongly influenced by the operation of Windsor Bridge and adjoining key intersections.

Four intersections within the study area were analysed (using SIDRA, version 7 network) to determine the operating performance and level of service including:

- Wilberforce Road / Freemans Reach Road (sign controlled);
- Bridge Street / George Street (roundabout);
- Bridge Street / Macquarie Street (traffic signals); and
- Bridge Street / Court Street (sign controlled).

Figure 3-5 below shows the location of all 4 intersections in the study area.

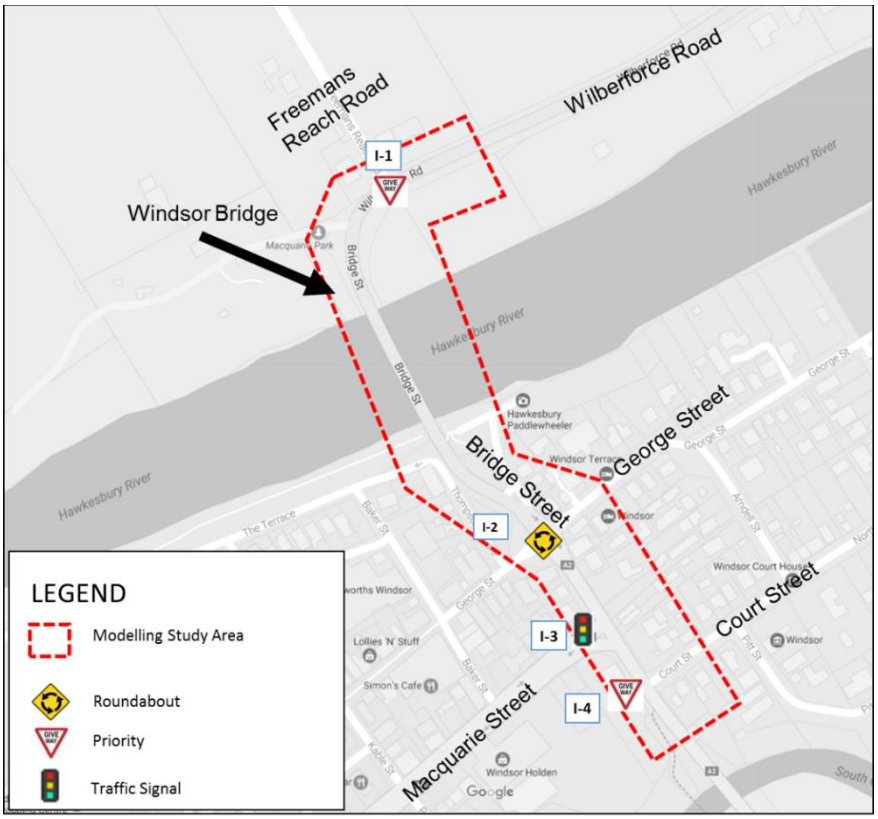


Figure 3-5 Key intersections adjacent to Windsor Bridge

Figure 3-6 and Figure 3-7 showing counted 2017 turning volumes at above intersections for AM peak one hour (8-9am) and PM peak one hour (4-5pm).

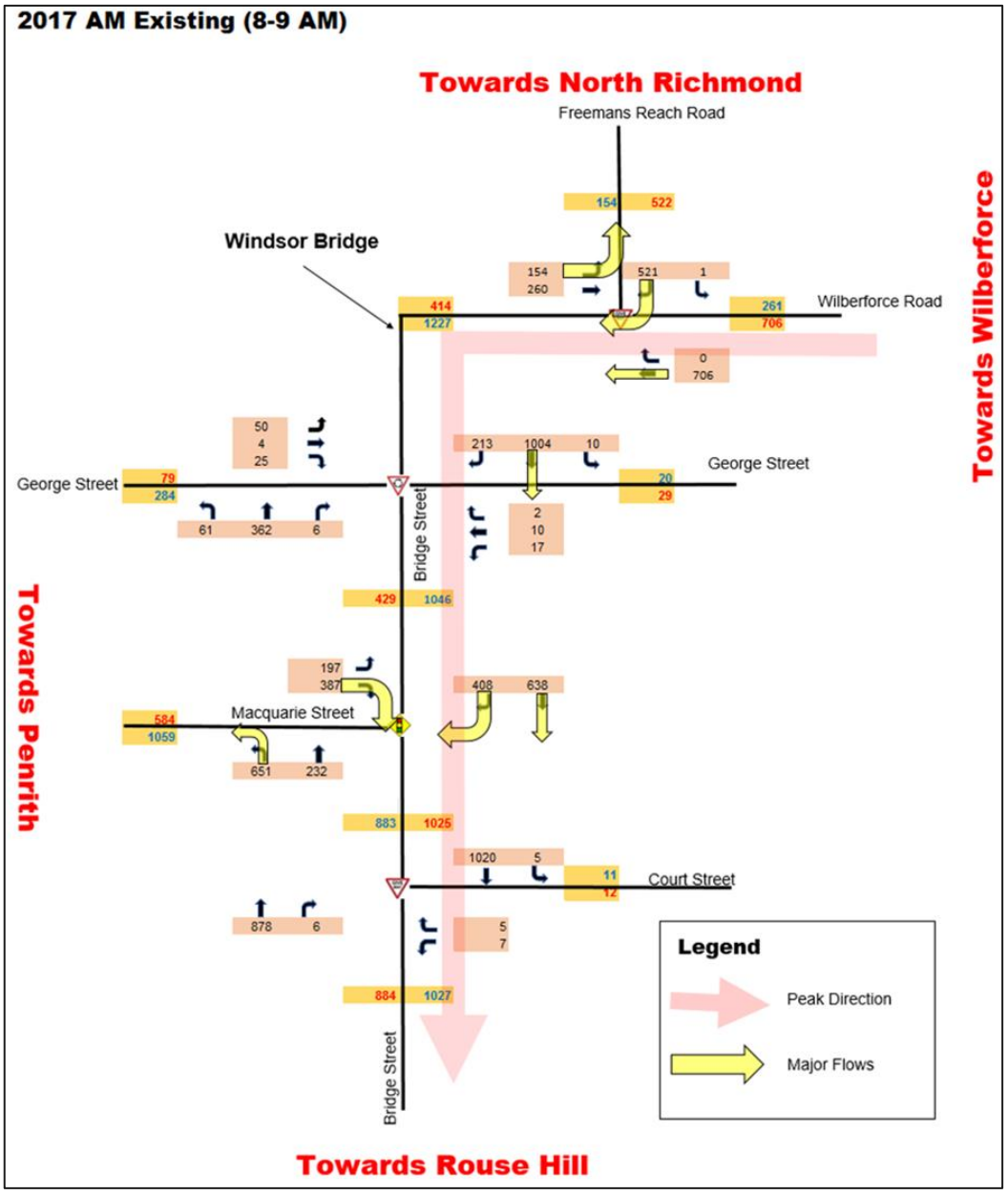


Figure 3-6 Existing Turning Volumes – 2017 AM Peak one hour (8-9am)

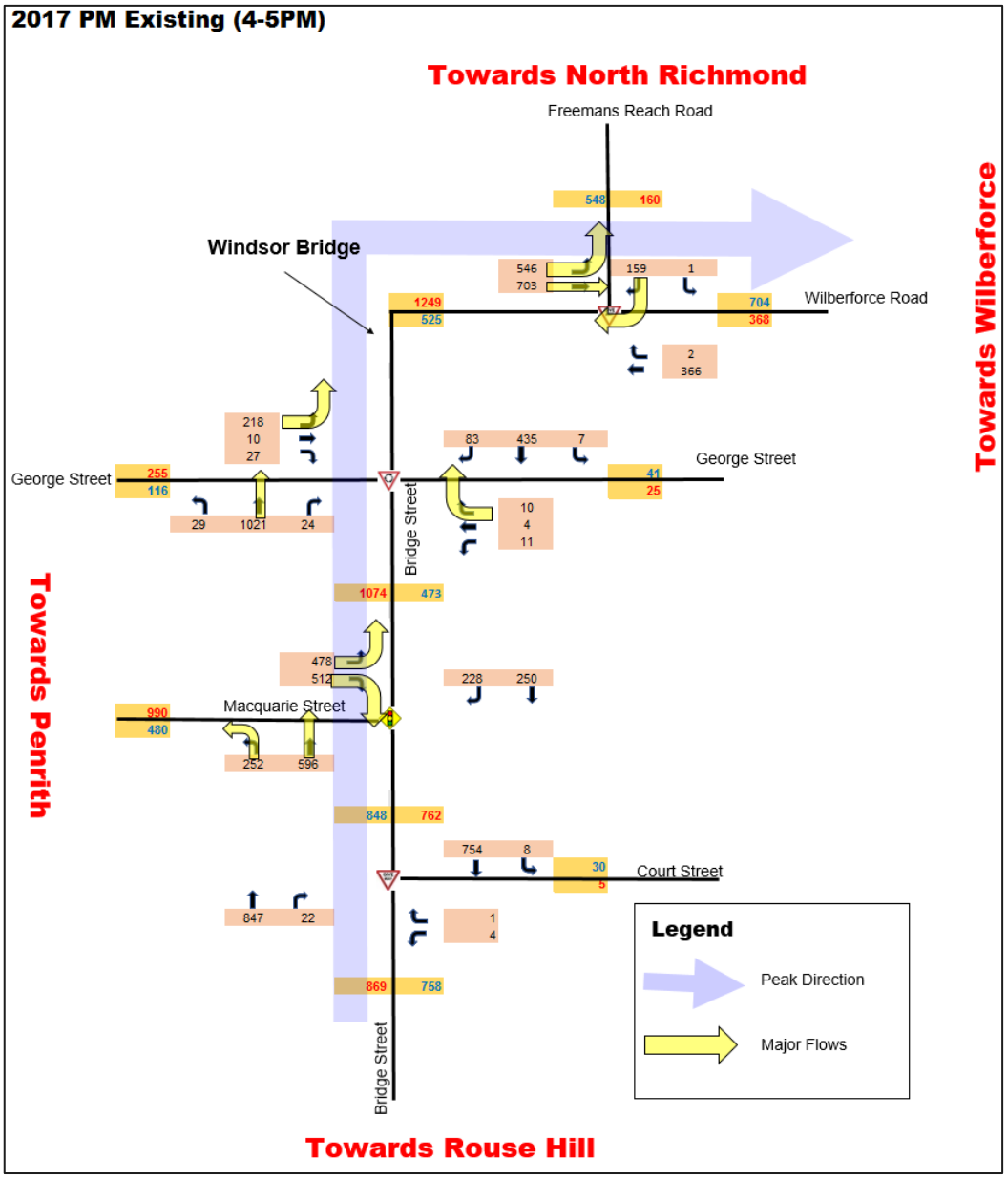


Figure 3-7 Existing Turning Volumes – 2017 PM Peak one hour (4-5pm)

The performance of an intersection is measured by the intersection average delay per vehicle, which in turns leads to a Level of Service measure for the intersection.

Table 3-4 below shows the Roads and Maritime standard level of service criteria for intersection operation.

Table 3-4 Level of Service Criteria for Intersections

Level of Service	Average Delay per Vehicle (secs/veh)	Traffic Signals, Roundabout	Give Way & Stop Signs
A	<14	Good operation	Good operation
B	15 to 28	Good with acceptable delays & spare capacity	Acceptable delays & spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity & accident study required
E	57 to 70	At capacity; at signals, incidents will cause excessive delays Roundabouts require other control mode	At capacity, requires other control mode
F	>70	Unsatisfactory with excessive queuing	Unsatisfactory with excessive queuing

Level of Service (LoS) is reported in accordance with the Roads and Maritime guideline (*Traffic Modelling Guideline, Issue 1.0, RMS, February 21013*). It recommends that for priority intersections such as a roundabouts and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay. With these type of intersection controls (roundabout, Stops and Give way sign controls), some movements may experience high levels of delay while other movements may experience minimum delay. For a signalised intersection LoS criteria are related to the average intersection delay measured in seconds per vehicle.

Table 3-5 below shows the existing 2017 Level of Service at the four analysed intersections.

Table 3-5 Existing Level of Service in 2017

I-D	Intersection	Control	AM Peak		PM Peak	
			Delay (sec)	LoS	Delay (sec)	LoS
I-1	Wilberforce Road and Freemans Reach Road	Priority (1)	59	E	60	E
I-2	Bridge Street and George Street	Roundabout (1)	41	C	97	F
I-3	Bridge Street and Macquarie Street	Traffic Signals (2)	15	B	29	C
I-4	Bridge Street and Court Street	Priority (1)	37	C	22	B

Note: (1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay. (2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

The following points are noted for existing network performance:

- Two intersections north and south of Windsor Bridge currently operate at or over their capacity during peak hour. Wilberforce Road / Freemans Reach Road (sign controlled intersection) currently operates with Level of Service E in the AM and PM peaks (delays of 60 seconds). Bridge Street / George Street (roundabout) currently operates at Level of Service F in PM peak (delays of 97 seconds). The operational issues at both intersections adversely impact the traffic performance on Windsor Bridge during peak hours.
- The Bridge Street / Macquarie Street traffic signals operate with Level of Service between B to C (delays of 15 to 29 seconds) and Bridge Street / Court Street (sign controlled) intersection operates with Level of Service between B to C (delays of 22 to 37 seconds).

Appendix A documents detailed SIDRA results for existing 2017 AM and PM peak traffic conditions.

4 Future Traffic Performance of the Project

This section reports traffic growth for the study area road network. The future traffic growth analysis was undertaken using historical traffic growth and forecast traffic volumes obtained from Roads and Maritime's Strategic Traffic Forecasting Model (STFM, EMME model).

Future traffic growth has been reviewed and agreed with Roads and Maritime project team.

4.1 Historical Traffic Growth

The historical traffic growth on Windsor Bridge is estimated using 2012 and 2017 counts. The 2012 counts were sourced from Roads and Maritime's report '*Windsor Bridge Replacement Project, Traffic and Transport Working Paper – Working Paper 4, November 2012'.* The 2017 counts are sourced from the new traffic survey undertaken for this study.

Table 4-1 shows the comparison between 2012 and 2017 average daily traffic counts on Windsor Bridge. The last five year's traffic growth on Windsor Bridge between 2012 and 2017 is also shown.

Table 4-1 Comparison of Total Vehicles for 7-day Traffic – 2012 and 2017

Road Section	Average Daily Traffic			Traffic Growth per Annam
	March 2012	March 2017	Traffic Increase (5 years)	
Windsor Bridge (Bridge Street)	19,100	20,200	1,100 ▲	1.1% ▲

The data shows that between 2012 and 2017 (five year) traffic on Windsor Bridge has grown by approximately 1.1 per cent per annum from 19,100 vehicles per day in 2012 to 20,200 vehicles per day in 2017. Figure 4-1 shows the 24-hour traffic profiles on the Windsor Bridge based on 2012 and 2017 counts.

The 24-hour traffic profile on Windsor Bridge was found to be consistent between 2012 and 2017.

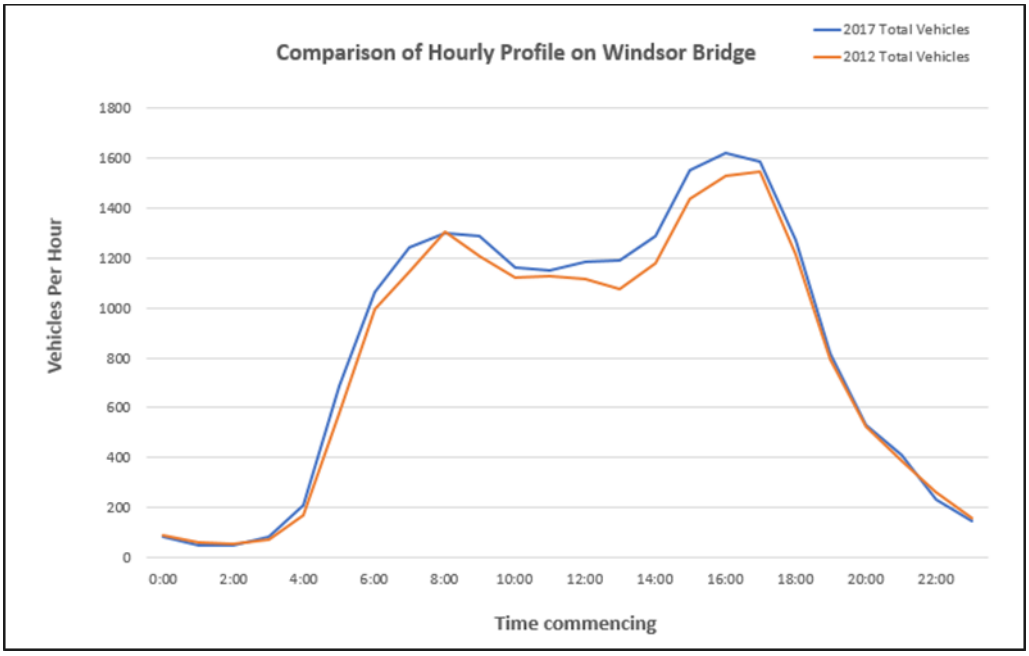


Figure 4-1 Comparison of Hourly Traffic Profile on Windsor Bridge – 2012 & 2017

4.2 Future Traffic Growth

Future traffic growth on Windsor Bridge, Bridge Street and adjoining roads within the study area will be influenced by the combination of passing (through) and local traffic growth. Future traffic growth in the study area was sourced from Roads and Maritime's Strategic Traffic Forecasting Model (STFM, EMME model). Roads and Maritime provided traffic forecasts at key roads for each time period up to 2026 and 2036. Both morning and afternoon peak hour traffic was assessed in the future years.

Future traffic growth assumptions have been reviewed and agreed with Roads and Maritime project team. Table 4-2 shows future traffic growth rates proposed for traffic modelling of the Windsor Bridge Replacement project.

Table 4-2 Proposed Growth Rates for Traffic Modelling Purposes

Road / Location	Growth Rate per Annum (%)		
	2016-2026	2026-2036	2016-2036 (average for 20 years period)
AM Peak			
Bridge Street (Windsor Bridge) and Macquarie Street	1.7%	1.0%	1.3%
George Street and Court Street	0.5%	0.5%	0.5%
PM Peak			
Bridge Street (Windsor Bridge) and Macquarie Street	1.7%	1.1%	1.4%
George Street and Court Street	0.3%	0.3%	0.3%

Table 4-2 indicates the following:

- The future traffic growth rate on Bridge Street (Windsor Bridge) and Macquarie Street will be 1.7 per cent per annum between 2016 and 2026, followed by 1.1 per cent per annum between 2026 and 2036.
- On George Street and Court Street, a lower traffic growth rate was suggested. Traffic volumes on George Street and Court Street would grow by between 0.3 per cent and 0.5 per cent between 2016 and 2036.

4.3 Traffic Implications of the 'Do Nothing' Option

The modelling outcomes from Roads and Maritime's Strategic Traffic Forecasting Model indicates traffic growth between 1.3 and 1.4 per cent per annum on Windsor Bridge until 2036.

Table 4-3 and Table 4-4 below show predicted Level of Service results for 2026 and 2036 traffic conditions for the 'do nothing' case.

Table 4-3 Forecast Level of Service in 2026 – 'Do Nothing'

I-D	Intersection	Control	AM Peak		PM Peak	
			Delay (sec)	LoS	Delay (sec)	LoS
I-1	Wilberforce Road and Freemans Reach Road	Priority (1)	583	F	97	F
I-2	Bridge Street and George Street	Roundabout (1)	49	D	351	F
I-3	Bridge Street and Macquarie Street	Traffic Signals (2)	18	B	153	F
I-4	Bridge Street and Court Street	Priority (1)	51	D	32	C

Note: (1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay. (2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

Table 4-4 Forecast Level of Service in 2036 – 'Do Nothing'

I-D	Intersection	Control	AM Peak		PM Peak	
			Delay (sec)	LoS	Delay (sec)	LoS
I-1	Wilberforce Road and Freemans Reach Road	Priority (1)	500+	F	123	F
I-2	Bridge Street and George Street	Roundabout (1)	63	E	783	F
I-3	Bridge Street and Macquarie Street	Traffic Signals (2)	19	B	376	F
I-4	Bridge Street and Court Street	Priority (1)	70	E	47	D

Note: (1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay. (2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

The model predicts Level of Service F either in the morning or afternoon peak hour at following intersections:

- Wilberforce Road / Freemans Reach Road (I-1);
- Bridge Street / George Street (I-2); and
- Bridge Street / George Street (I-3).

The future Level of Service analysis has found that if no action is taken to improve the traffic conditions on the Bridge Street and Wilberforce Road between Court Street and Freemans Reach Road, the following is likely to occur:

- Major congestion at a number of key intersections during peak periods by 2026 extending throughout a large part of the day
- Of the four key intersections analysed, three intersections showed Level of Service F (over capacity) in 2026 either in morning or afternoon peak periods. In 2036 three intersections showed Level of Service F in either the morning or afternoon peak periods
- Significant delaying and queuing would occur on Bridge Street extending to Wilberforce Road; and
- Road safety would deteriorate on Bridge Street, Wilberforce Road and associated intersections for all road users as traffic increases. The crash analysis indicted a need for safety improvement for both sections of Bridge Street and Wilberforce Road.

Appendix B includes detailed turning volumes for 2026 and 2036 and SIDRA Level of Service results for 2026 and 2036 'do nothing' scenario.

4.4 Future Traffic Volumes on new Windsor Bridge

Traffic volumes on new Windsor Bridge are reported for future years 2026 and 2036. Table 4-5 shows forecast average weekday daily traffic on new Windsor Bridge for 2026 and 2036.

Table 4-5 Estimated Average Weekday Traffic on Windsor Bridge for 2026 and 2036

	Existing			Forecast Average Weekday Traffic (vehicles)					
	2017 Counts			2026			2036		
	NB	SB	Two-way	NB	SB	Two-way	NB	SB	Two-way
Daily	10,800	10,800	21,600	12,500	12,500	25,000	14,000	14,000	28,000
AM peak	430	1,050	1,480	500	1,230	1,730	550	1,360	1,910
PM peak	1,220	570	1,790	1,420	660	2,080	1,590	730	2,320

In 2026, traffic on new Windsor Bridge is projected to be about 25,000 vehicles per day. By 2036, traffic is forecast to grow to about 28,000 vehicles per day.

In the morning, southbound peak traffic on the new Bridge is predicted to be about 1,200 vehicles per hour in 2026 and 1,400 vehicles per hour in 2036.

Similarly, in the afternoon, northbound peak traffic on the new Bridge is predicted to be about 1,400 vehicles per hour in 2026 and 1,600 vehicles per hour in 2036.

4.5 Future Traffic Performance of Concept Design

Future traffic performance of the Concept Design (see Figure 4-2) was assessed for year 2026 and 2036 traffic conditions.

Table 4-6 and Table 4-7 summarise forecast 2026 and 2036 Level of Service results for upgraded network conditions for the AM and PM peak hours, respectively.

Table 4-6 Forecast Level of Service in 2026 – Concept Design

I-D	Intersection	Control	AM Peak		PM Peak	
			Delay (sec)	LoS	Delay (sec)	LoS
I-1	Wilberforce Road and Freemans Reach Road	Roundabout (1)	15	B	17	B
I-2	Bridge Street and George Street	Traffic Signals (2)	17	B	62	E
I-3	Bridge Street and Macquarie Street	Traffic Signals (2)	21	B	56	E

Note: (1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay. (2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

Table 4-7 Forecast Level of Service in 2036 – Concept Design

I-D	Intersection	Control	AM Peak		PM Peak	
			Delay (sec)	LoS	Delay (sec)	LoS
I-1	Wilberforce Road and Freemans Reach Road	Roundabout (1)	17	B	17	B
I-2	Bridge Street and George Street	Traffic Signals (2)	25	B	169	F
I-3	Bridge Street and Macquarie Street	Traffic Signals (2)	25	B	99	F

Note: (1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay. (2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

In 2026, the upgraded network in Concept Design would provide adequate capacity and an acceptable Level of Service B for morning peak traffic condition.

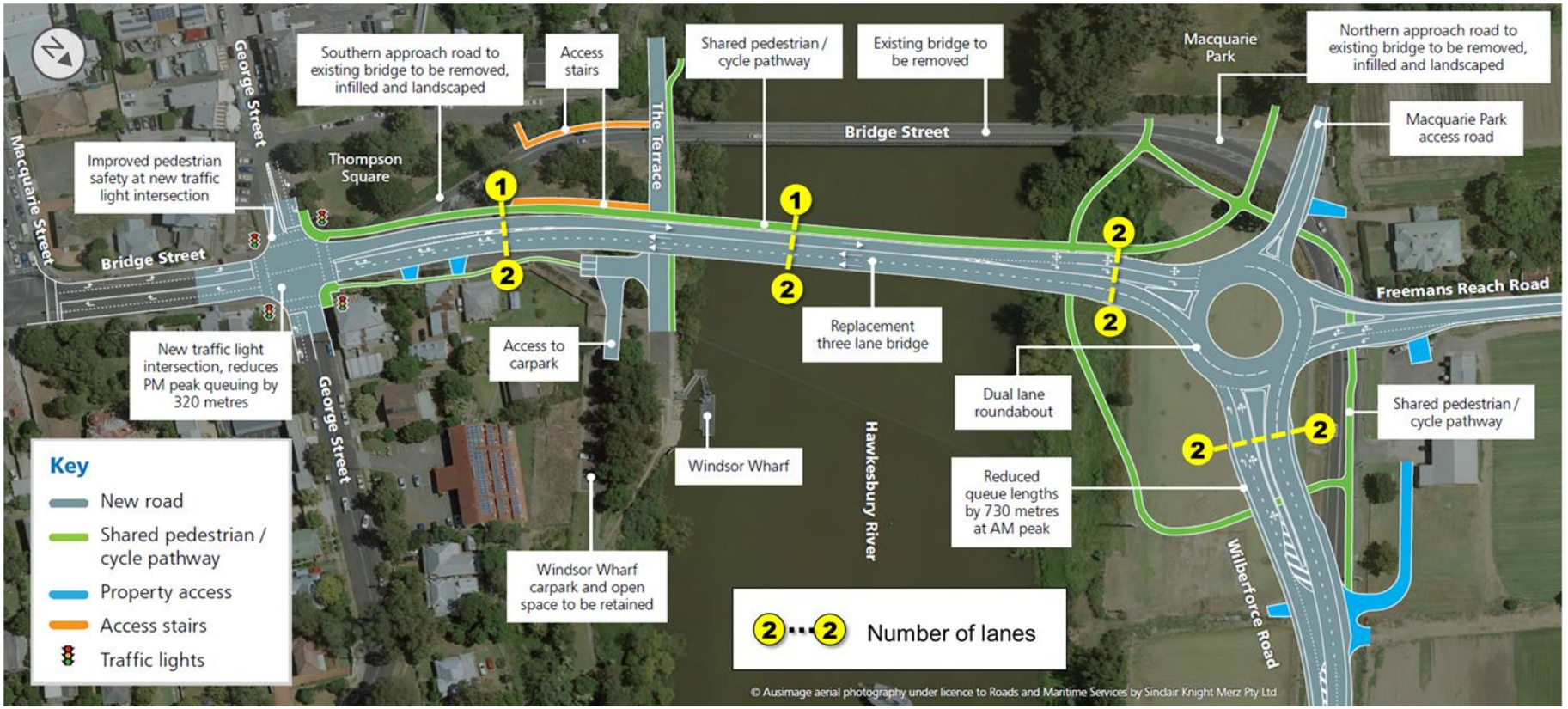
The traffic model predicted Level of Service B at Wilberforce Road / Freemans Reach Road (new roundabout), Bridge Street / George Street (new traffic signals) and Bridge Street / Macquarie Street traffic signals.

In the afternoon peak, the traffic model predicted Level of Service of E at Bridge Street / George Street traffic signals.

In 2036, the Concept Design would provide adequate capacity for the morning peak traffic condition. The traffic model predicted Level of Service B at Wilberforce Road / Freemans Reach Road (new roundabout), Bridge Street / Macquarie Street traffic signals and Bridge Street / George Street (new traffic signals).

In the afternoon peak, the traffic model predicted Level of Service F with delays of more than 169 seconds (2.8 minutes) at Bridge Street / George Street intersection and more than 99 seconds (1.8 minutes) at Bridge Street / Macquarie Street intersection.

Appendix C includes detailed forecast turning volumes and SIDRA Level of Service result for 2026 and 2036 for the Concept Design.



Source: Source: Windsor Bridge Replacement Project Update, December 2016, Roads and Maritime Services

Figure 4-2 Roads and Maritime's Concept Design

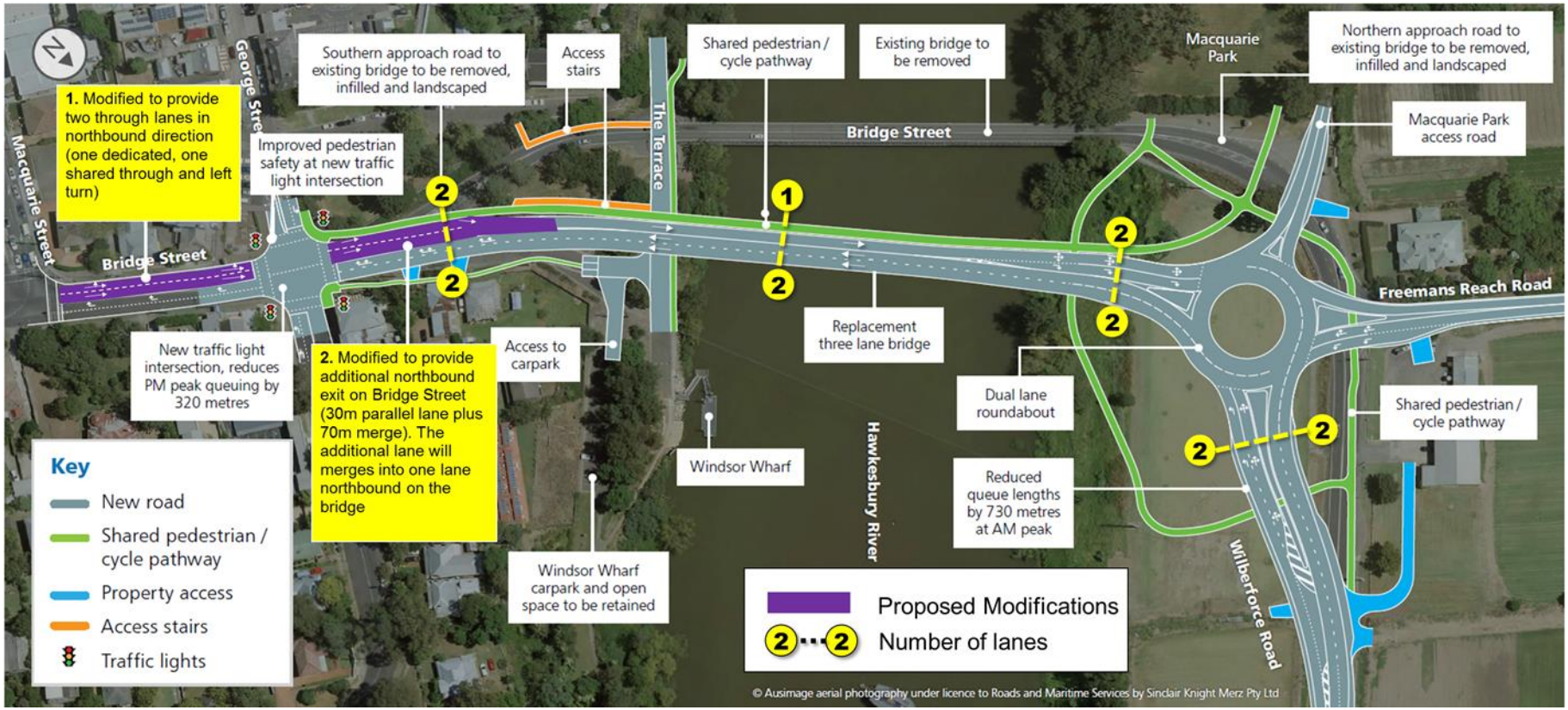
4.6 Proposed Modifications to the Concept Design (Modified Concept Design)

Roads and Maritime have proposed modifications to the Concept Design (referred as the Modified Concept Design) to increase traffic capacity in the northbound direction including:

1. Linemarking modification on the George Street southern approach at George Street / Bridge Street intersection to provide two through lanes in the northbound direction (one dedicated and one shared through and left turn); and
2. Provision of an additional short exit lane (30 metres parallel lane plus 70 metre merge) on the George Street northern approach (Windsor Bridge) at George Street / Bridge Street intersection. The additional lane merges into one lane northbound on Windsor Bridge.

To meet possible future demand, the modification allows for future tidal flow arrangements on Bridge Street. This would result in two lanes northbound across the bridge during the afternoon peak.

Figure 4-3 below shows indicative sketch of the Modified Concept Design (with modifications proposed to the Concept Design highlighted in purple).



Note: Proposed modifications to the Concept Design are highlighted in purple.

Figure 4-3 Modified Concept Design (Indicative Sketch)

4.7 Future Traffic Performance of the Modified Concept Design

The traffic performance of the Modified Concept Design was assessed for year 2026 and 2036 traffic conditions.

Table 4-8 and Table 4-9 summarise forecast 2026 and 2036 Level of Service results for the Modified Concept Design for the AM and PM peak hours, respectively. The forecast Level of Service result for the Concept Design is included for comparison.

Table 4-8 Forecast Level of Service in 2026 – Modified Concept Design

I-D	Intersection	Control	Concept Design				Modified Concept Design			
			AM Peak		PM Peak		AM Peak		PM Peak	
			Delay (sec)	LoS	Delay (sec)	LoS	Delay (sec)	LoS	Delay (sec)	LoS
I-1	Wilberforce Road and Freemans Reach Road	Roundabout (1)	15	B	17	B	15	B	17	B
I-2	Bridge Street and George Street	Traffic Signals (2)	17	B	62	E	16	B	20	B
I-3	Bridge Street and Macquarie Street	Traffic Signals (2)	21	B	56	E	20	B	48	D

Note: (1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay. (2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

Table 4-9 Forecast Level of Service in 2036 – Modified Concept Design

I-D	Intersection	Control	Concept Design				Modified Concept Design			
			AM Peak		PM Peak		AM Peak		PM Peak	
			Delay (sec)	LoS	Delay (sec)	LoS	Delay (sec)	LoS	Delay (sec)	LoS
I-1	Wilberforce Road and Freemans Reach Road	Roundabout (1)	17	B	17	B	17	B	19	B
I-2	Bridge Street and George Street	Traffic Signals (2)	25	B	169	F	24	B	30	C
I-3	Bridge Street and Macquarie Street	Traffic Signals (2)	25	B	99	F	23	B	83	F

Note: (1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay. (2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

The Level of Service results in Table 4-8 and Table 4-9 indicate that the proposed modifications to the Concept Design would reduce delays and improve Level of Service at Bridge Street / George Street and Bridge Street / Macquarie Street in the afternoon peak.

In the 2026 afternoon peak, the model predicted that proposed modifications would improve intersection performance at Bridge Street / George Street from Level of Service E with a delay of 62 seconds (Concept Design) to Level of Service B with a delay of 20 seconds (Modified Concept Design). At Bridge Street / Macquarie Street, the proposed modifications would improve intersection performance from Level of Service E with a delay of 56 seconds (Concept Design) to Level of Service D with a delay of 48 seconds (Modified Concept Design).

In the 2036 afternoon peak, the proposed modifications would improve intersection performance at Bridge Street / George Street from Level of Service F with a delay of more than 169 seconds (Concept Design) to Level of Service C with a delay of 30 seconds. At Bridge Street / Macquarie Street intersection, the proposed modification would reduce intersection delay from 99 seconds (Concept Design) to 83 seconds (Modified Concept Design). Travel delay could be improved by a future tidal flow arrangement.

Appendix D includes detailed SIDRA Level of Service result for 2026 and 2036 with Modified Concept Design.

5 Conclusions

Roads and Maritime proposes to replace the existing bridge over the Hawkesbury River at Windsor (known as 'Windsor Bridge'). The project includes a replacement bridge 35 metres north of the existing bridge, modifying the existing intersections and bridge approach roads to accommodate the new bridge location, and providing a shared pedestrian/cycle pathway for access to and across the replacement bridge. The replacement bridge would provide wider lanes and shoulders and greater sight distances in comparison to the existing bridge. Modifications would also be made to the bridge approach roads and existing intersections at Wilberforce Road / Freemans Reach Road, Bridge Street / George Street, Bridge Street / Count Street and Bridge Street / Macquarie Street. All of these factors would contribute to improvements in traffic capacity and safety.

Roads and Maritime has developed a Concept Design for the Windsor Bridge Replacement project between Wilberforce Road and Court Street, Windsor.

A road based traffic model was developed by Arcadis for the study area using SIDRA network version 7.

This report has been prepared to assess the network performance of the Concept Design and identify possible cost-effective improvements.

Currently (as of March 2017), Windsor Bridge carries approximately 21,600 vehicles per day. This includes approximately 2,400 heavy vehicles (more than 11 per cent of the total traffic). The current peak hour traffic volume on the Windsor Bridge is between 1,100 and 1,200 vehicles per hour in each travel direction. Capacity analysis suggests that current traffic demand on the Windsor Bridge (one lane in northbound and one lane in southbound) exceeds the saturation traffic levels in both morning (AM) and afternoon (PM) peak periods. Traffic modelling undertaken for existing condition has identified network operational issues at the following two intersections:

- Wilberforce Road / Freemans Reach Road (sign controlled); and
- Bridge Street / George Street (roundabout).

The Concept Design for the Windsor Bridge Replacement project involves a three lane bridge replacement of the existing Windsor Bridge, providing two lanes in the southbound direction and one lane in northbound direction, new traffic signals replacing the roundabout at Bridge Street / George Street, a new dual lane roundabout replacing priority control at Wilberforce Road / Freemans Reach Road and providing access to Macquarie Park via the western approach.

In year 2026, traffic on the new Windsor Bridge is predicted to be 25,000 vehicles per day. By 2036, traffic is forecast to grow to approximately 28,000 vehicles per day. In the morning, southbound peak traffic on the new bridge is predicted to be about 1,200 vehicles per hour in 2026 and 1,400 vehicles per hour in 2036.

Similarly, in the afternoon, northbound peak traffic on the new bridge is predicted to be 1,400 vehicles per hour in 2026 and 1,600 vehicles per hour in 2036.

Arcadis' modelling assessment on the Concept Design found that:

- The upgraded intersections would provide Level of Service B during morning peak traffic conditions in 2036; and
- In the afternoon peak, the traffic model suggests capacity constraints at both Bridge Street / George Street and Bridge Street / Macquarie Street traffic signals. The Level of Service F is predicted at Bridge Street / George Street and Bridge Street / Macquarie Street traffic signals. The afternoon peak modelling results suggest the need to increase capacity for the northbound traffic.

Two modifications to the Concept Design for Windsor Bridge Replacement are proposed as follows:

- Linemarking modification on the George Street southern approach at George Street / Bridge Street intersection to provide two through lanes in the northbound direction (one dedicated lane and one shared through and left turn lane); and
- Provision of an additional short exit lane (30 metres parallel lane plus 70 metre merge) on George Street northern approach (Windsor Bridge) at George Street / Bridge Street intersection. The additional lane merges into one lane northbound on Windsor Bridge.

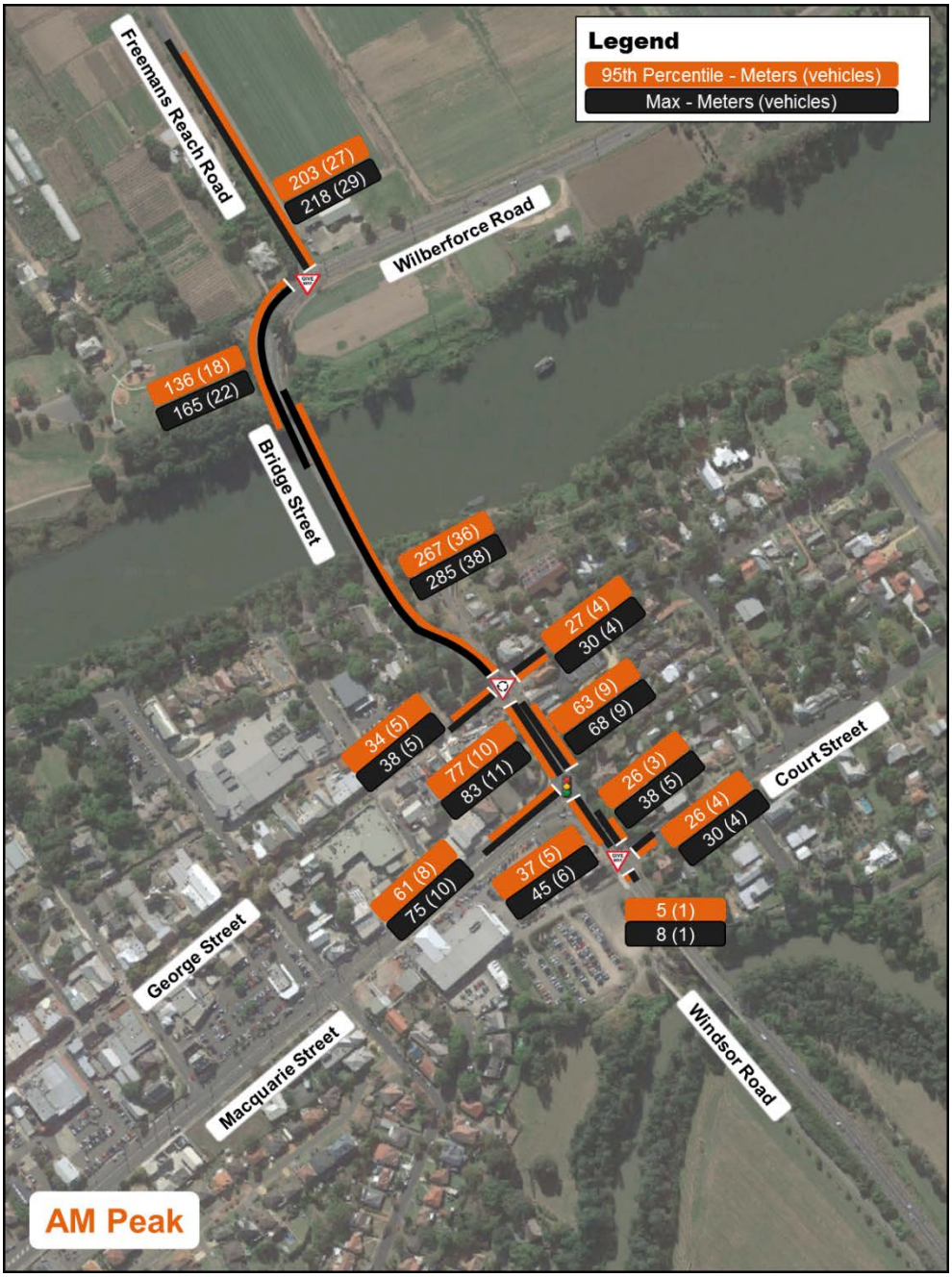
Arcadis' modelling assessment on the Modified Concept Design found that:

- The proposed modifications to the Concept Design (see Figure 4-3) would reduce delays and improve the Level of Service at Bridge Street / George Street and Bridge Street / Macquarie Street in the afternoon peak. The Level of Service B would be achieved in 2026;
- At Bridge Street / Macquarie Street, the intersection Level of Service would be improved to D in 2026; and
- In 2036, the proposed modifications would improve Level of Service to C at the Bridge Street / George Street intersection.

APPENDIX A Detailed SIDRA Analysis Results for 2017 Existing

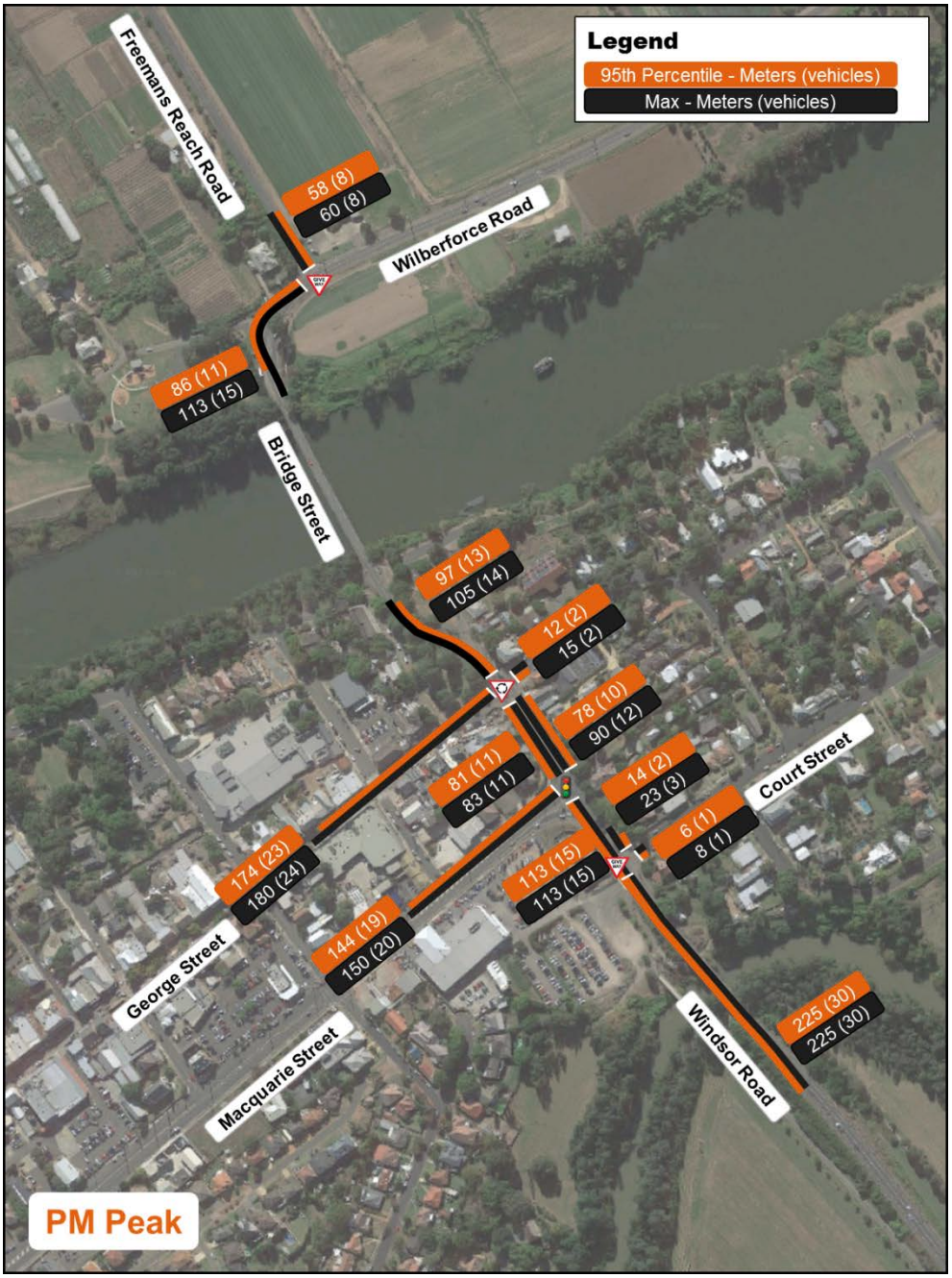
A.1 Existing Queue Length Survey Results (2017)

Figure A-1 and Figure A-2 shows existing (2017) queue length survey results in 95th percentile and maximum queue lengths in meters and number of vehicles for AM and PM peak hour.



Note: Surveyed queue length data was in number of vehicles. An average vehicle length of 7.5 metres was applied to convert vehicles to metres.

Figure A-1 Forecast Turning Volumes 2026 AM Peak (8-9AM)



Note: Surveyed queue length data was in number of vehicles. An average vehicle length of 7.5 metres was applied to convert vehicles to metres.

Figure A-2 Surveyed Queue Length (95th Percentile and Maximum) – PM Peak

A.2 Level of Service Results (SIDRA) – 2017 Existing

Wilberforce Road / Freemans Reach Road (sign control) - 2017 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	59	E	170
East: Wilberforce Road	8	A	0
West: Bridge Street	3	A	0
Overall (1)	**59**	**E**	

Wilberforce Road / Freemans Reach Road (sign control) - 2017 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	32	C	13
East: Wilberforce Road	60	E	7
West: Bridge Street	3	A	0
Overall (1)	**60**	**E**	

Bridge Street / George Street (roundabout) - 2017 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	6	A	298
East: George Street	41	C	12
South: Bridge Street	9	A	40
West: George Street	11	A	5
Overall (1)	**41**	**C**	

Bridge Street / George Street (roundabout) - 2017 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	6	A	40
East: George Street	13	A	2
South: Bridge Street	6	A	104
West: George Street	97	F	143
Overall (1)	**97**	**F**	

Bridge Street / Macquarie Street (traffic signals) - 2017 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	10	A	78
South: Bridge Street	6	A	27
West: Macquarie Street	37	C	54
Overall (2)	**15**	**B**	

Bridge Street / Macquarie Street (traffic signals) - 2017 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	19	B	74
South: Bridge Street	15	B	98
West: Macquarie Street	46	D	173
Overall (2)	**29**	**C**	

Bridge Street / Court Street (sign control) - 2017 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	4	A	0
East: Court Street	37	C	1
South: Bridge Street	22	B	3
Overall (1)	**37**	**C**	

Bridge Street / Court Street (sign control) - 2017 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	4	A	0
East: Court Street	22	B	0
South: Bridge Street	14	B	32
Overall (1)	**22**	**B**	

Note:
(1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay.
(2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

APPENDIX B Detailed SIDRA Analysis Results for 2026 and 2036 Do Nothing Scenario

B.1 2026 and 2036 Forecast Turning Volumes for the AM peak (8 to 9am) and PM peak (4 to 5pm)

Forecast 2026 AM (8-9 AM)

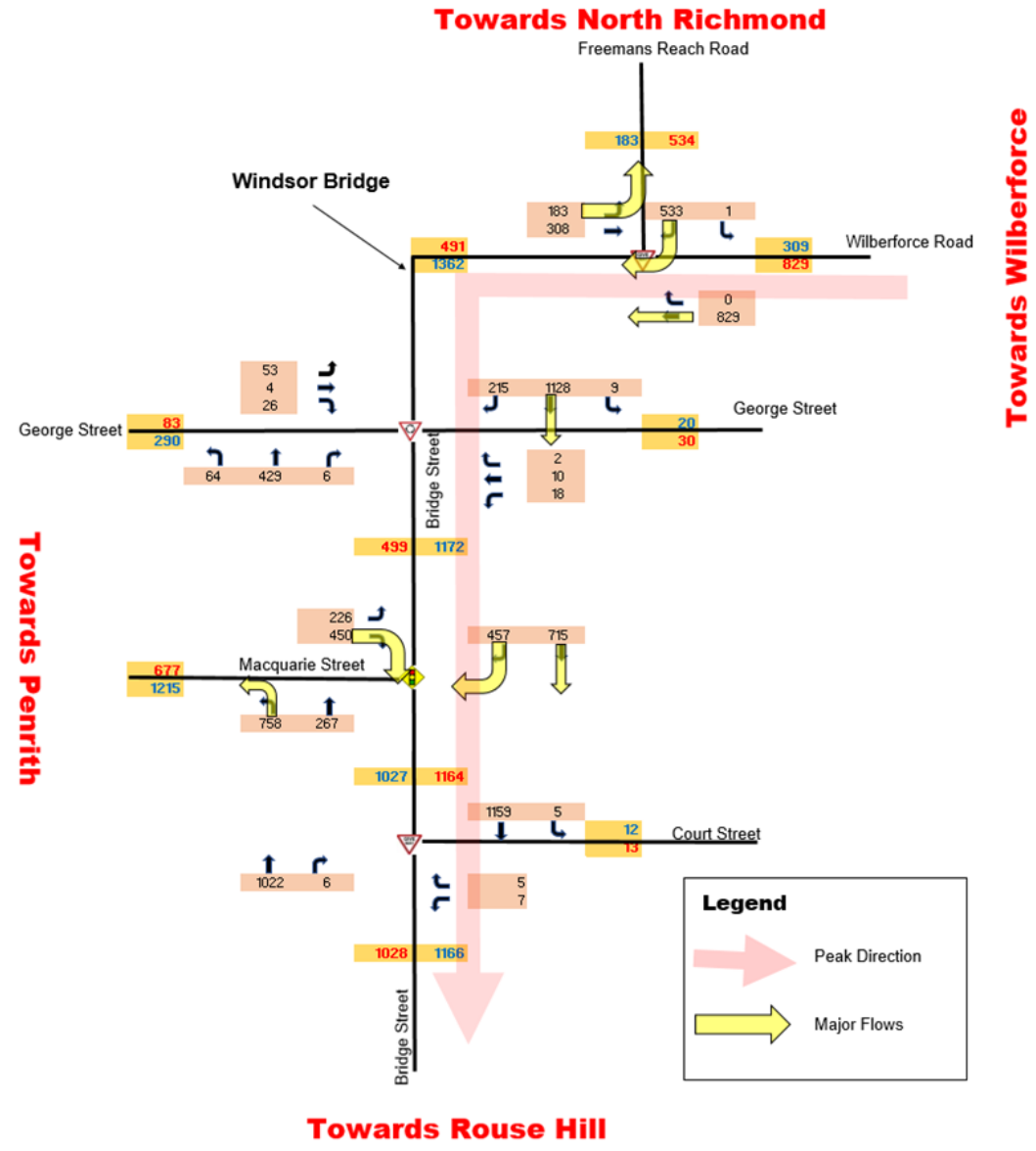


Figure B-1 Forecast Turning Volumes 2026 AM Peak (8-9AM)

Forecast 2026 PM (4-5 PM)

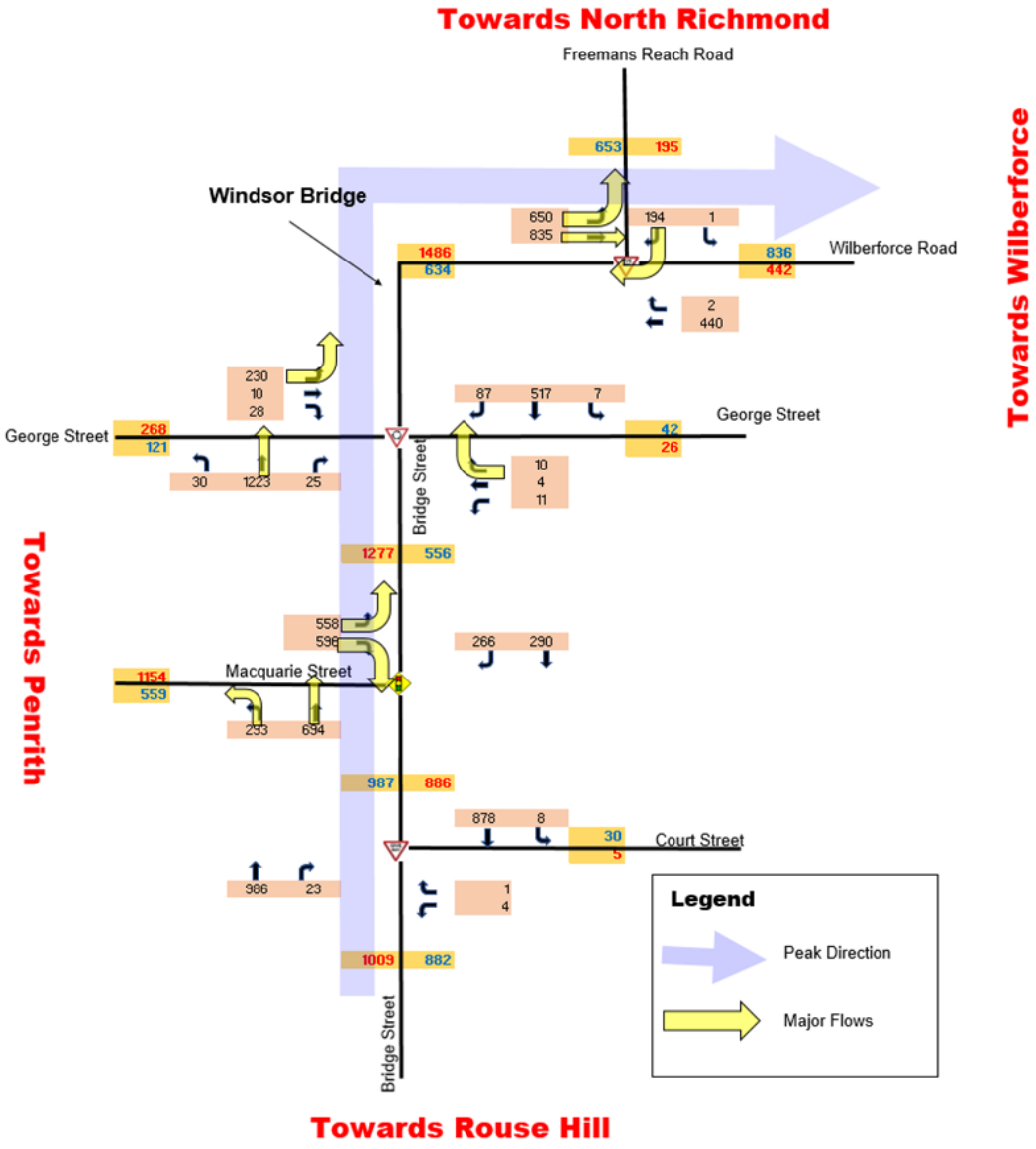


Figure B-2 Forecast Turning Volumes 2026 PM Peak (4-5PM)

Forecast 2036 AM (8-9 AM)

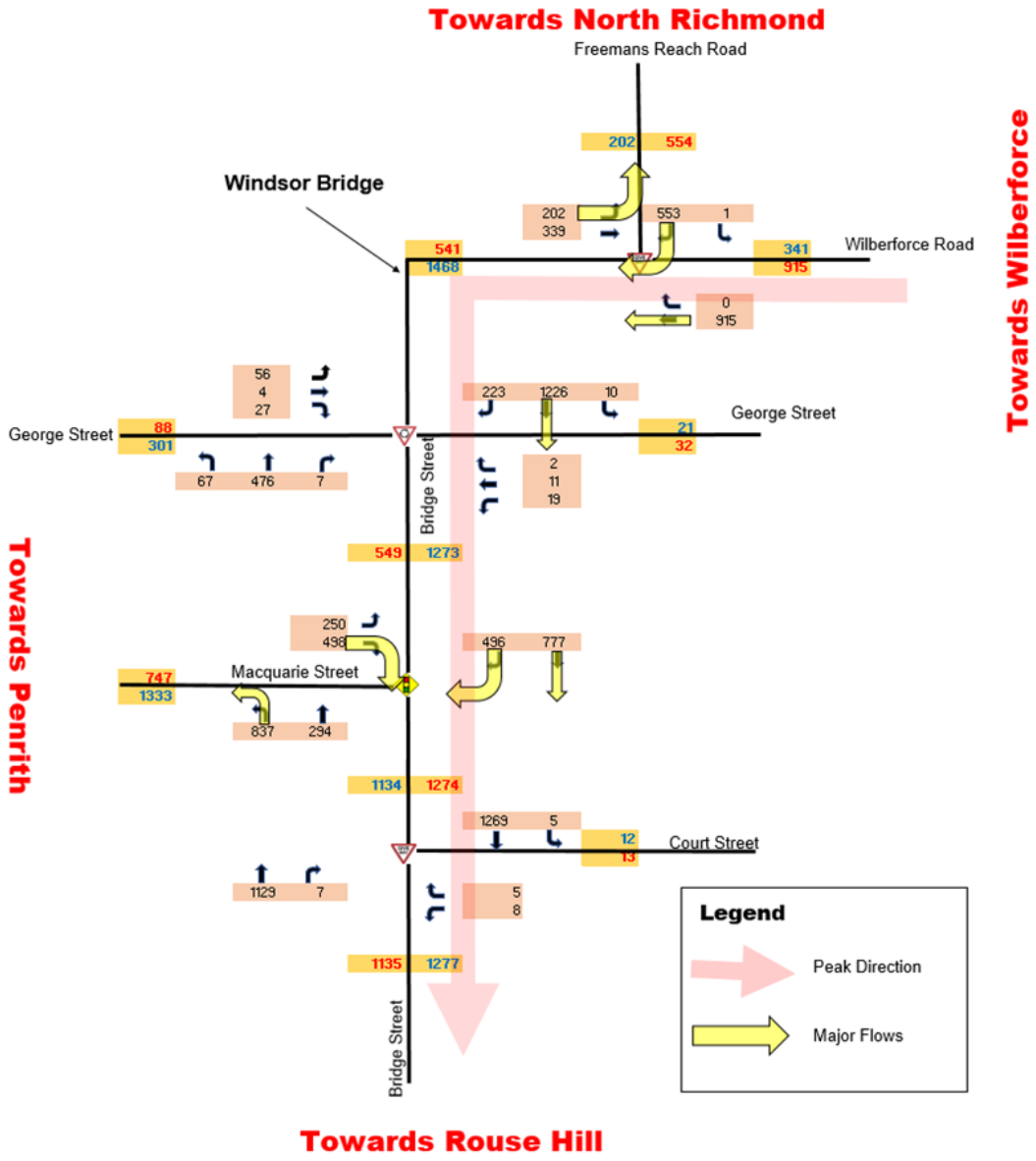


Figure B-3 Forecast Turning Volumes 2036 AM Peak (8-9AM)

Forecast 2036 PM (4-5 PM)

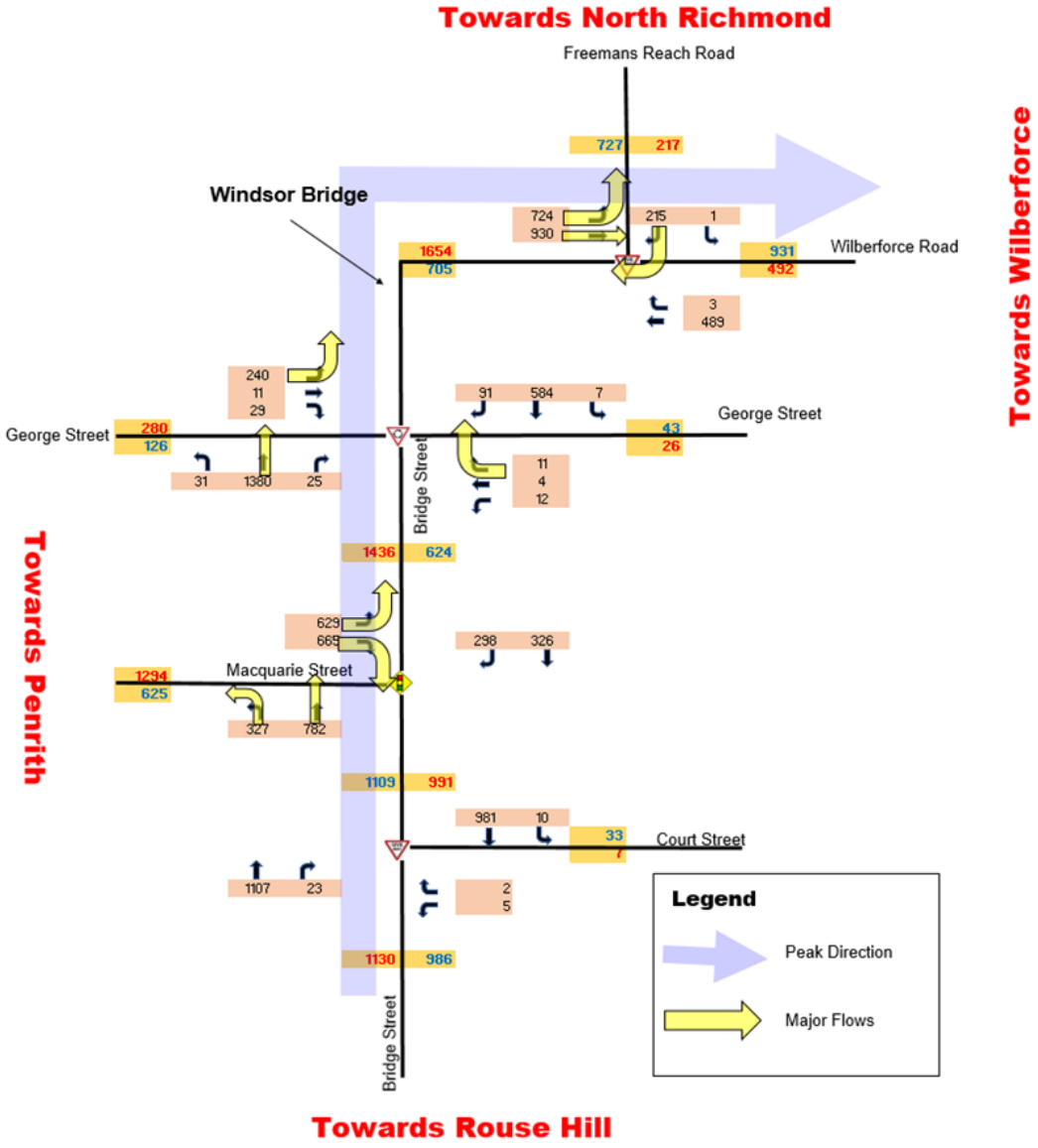


Figure B-4 Forecast Turning Volumes 2036 PM Peak (4-5PM)

B.2 Level of Service Results (SIDRA) – 2026 Do Nothing Scenario

Wilberforce Road / Freemans Reach Road (sign control) - 2026 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	583	F	1200
East: Wilberforce Road	10	A	0
West: Bridge Street	3	A	0
Overall (1)	**583**	**F**	

Wilberforce Road / Freemans Reach Road (sign control) - 2026 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	34	C	29
East: Wilberforce Road	97	F	15
West: Bridge Street	3	A	0
Overall (1)	**97**	**F**	

Bridge Street / George Street (roundabout) - 2026 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	6	A	294
East: George Street	49	D	13
South: Bridge Street	10	A	56
West: George Street	12	A	6
Overall (1)	**49**	**D**	

Bridge Street / George Street (roundabout) - 2026 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	6	A	56
East: George Street	15	B	2
South: Bridge Street	7	A	154
West: George Street	351	F	427
Overall (1)	**351**	**F**	

Bridge Street / Macquarie Street (traffic signals) - 2026 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	17	B	104
South: Bridge Street	9	A	50
West: Macquarie Street	34	C	65
Overall (2)	**18**	**B**	

Bridge Street / Macquarie Street (traffic signals) - 2026 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	25	B	84
South: Bridge Street	348	F	98
West: Macquarie Street	47	D	182
Overall (2)	**153**	**F**	

Bridge Street / Court Street (sign control) - 2026 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	4	A	0
East: Court Street	51	D	2
South: Bridge Street	26	B	4
Overall (1)	**51**	**D**	

Bridge Street / Court Street (sign control) - 2026 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	4	A	0
East: Court Street	32	C	0
South: Bridge Street	17	B	961
Overall (1)	**32**	**C**	

Note:
(1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay.
(2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

B.3 Level of Service Results (SIDRA) – 2036 Do Nothing Scenario

Wilberforce Road / Freemans Reach Road (sign control) - 2036 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres))
North: Freemans Reach Road	1228	F	2061
East: Wilberforce Road	11	A	0
West: Bridge Street	3	A	0
Overall (1)	**1228**	**F**	

Wilberforce Road / Freemans Reach Road (sign control) - 2036 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	123	F	105
East: Wilberforce Road	104	F	186
West: Bridge Street	3	A	0
Overall (1)	**123**	**F**	

Bridge Street / George Street (roundabout) - 2036 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	7	A	350
East: George Street	63	E	15
South: Bridge Street	12	A	75
West: George Street	13	A	7
Overall (1)	**63**	**E**	

Bridge Street / George Street (roundabout) - 2036 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	6	A	74
East: George Street	16	B	3
South: Bridge Street	9	A	186
West: George Street	783	F	821
Overall (1)	**783**	**F**	

Bridge Street / Macquarie Street (traffic signals) - 2036 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	18	B	113
South: Bridge Street	9	A	56
West: Macquarie Street	37	C	79
Overall (2)	**19**	**B**	

Bridge Street / Macquarie Street (traffic signals) - 2036 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	27	B	97
South: Bridge Street	914	F	98
West: Macquarie Street	81	F	261
Overall (2)	**376**	**F**	

Bridge Street / Court Street (sign control) - 2036 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	4	A	0
East: Court Street	70	E	2
South: Bridge Street	31	C	7
Overall (1)	**70**	**E**	

Bridge Street / Court Street (sign control) - 2036 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	4	A	0
East: Court Street	47	D	1
South: Bridge Street	21	B	1793
Overall (1)	**47**	**D**	

Note:
(1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay.
(2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

APPENDIX C Detailed SIDRA Analysis Results for 2026 and 2036 with 'Concept Design'

C.1 2026 and 2036 Forecast Turning Volumes for the AM peak (8 to9am) and PM peak (4 to 5pm) with Concept Design

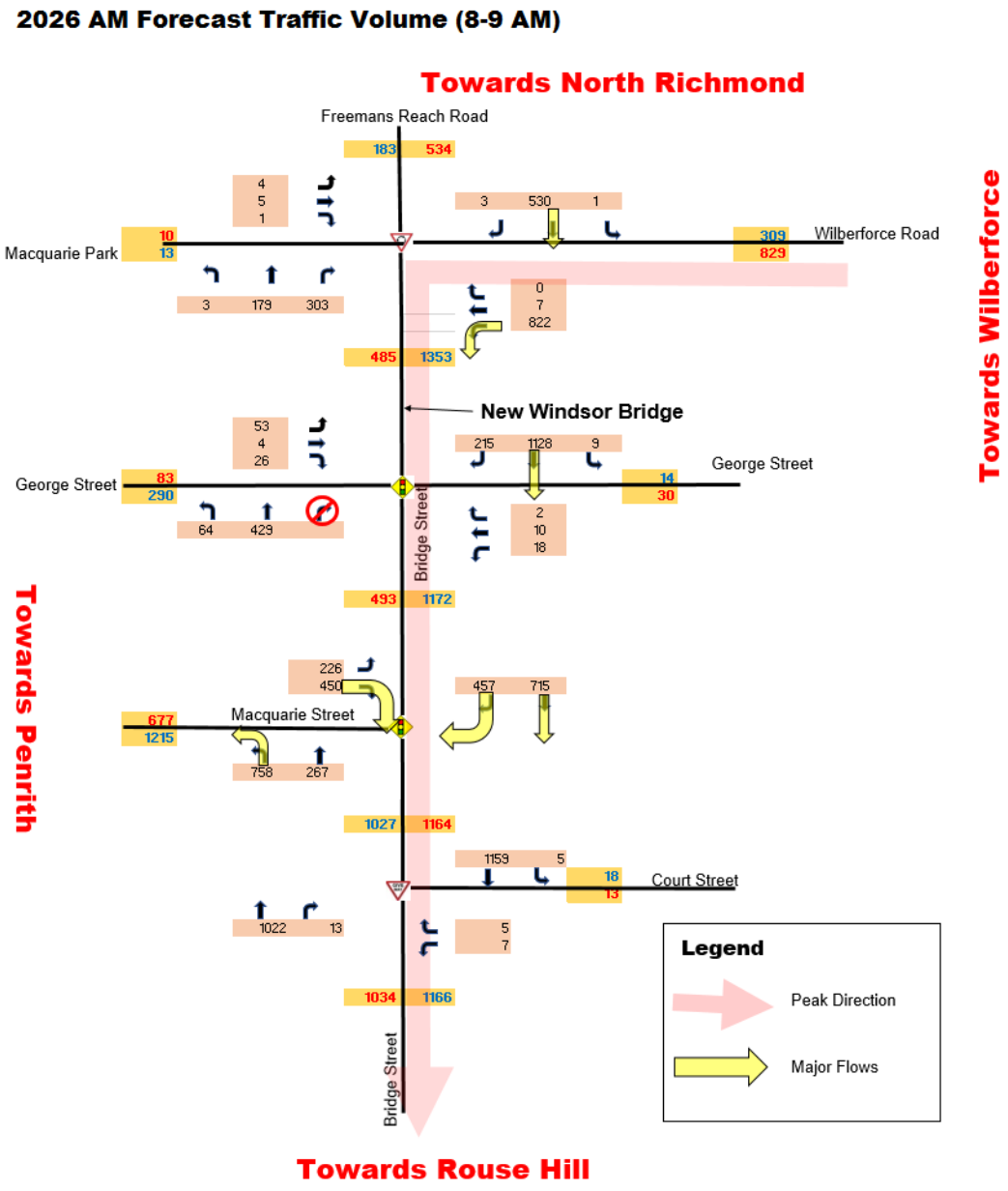


Figure C-1 Forecast Turning Volumes 2026 AM Peak (8-9AM) – with Concept Design

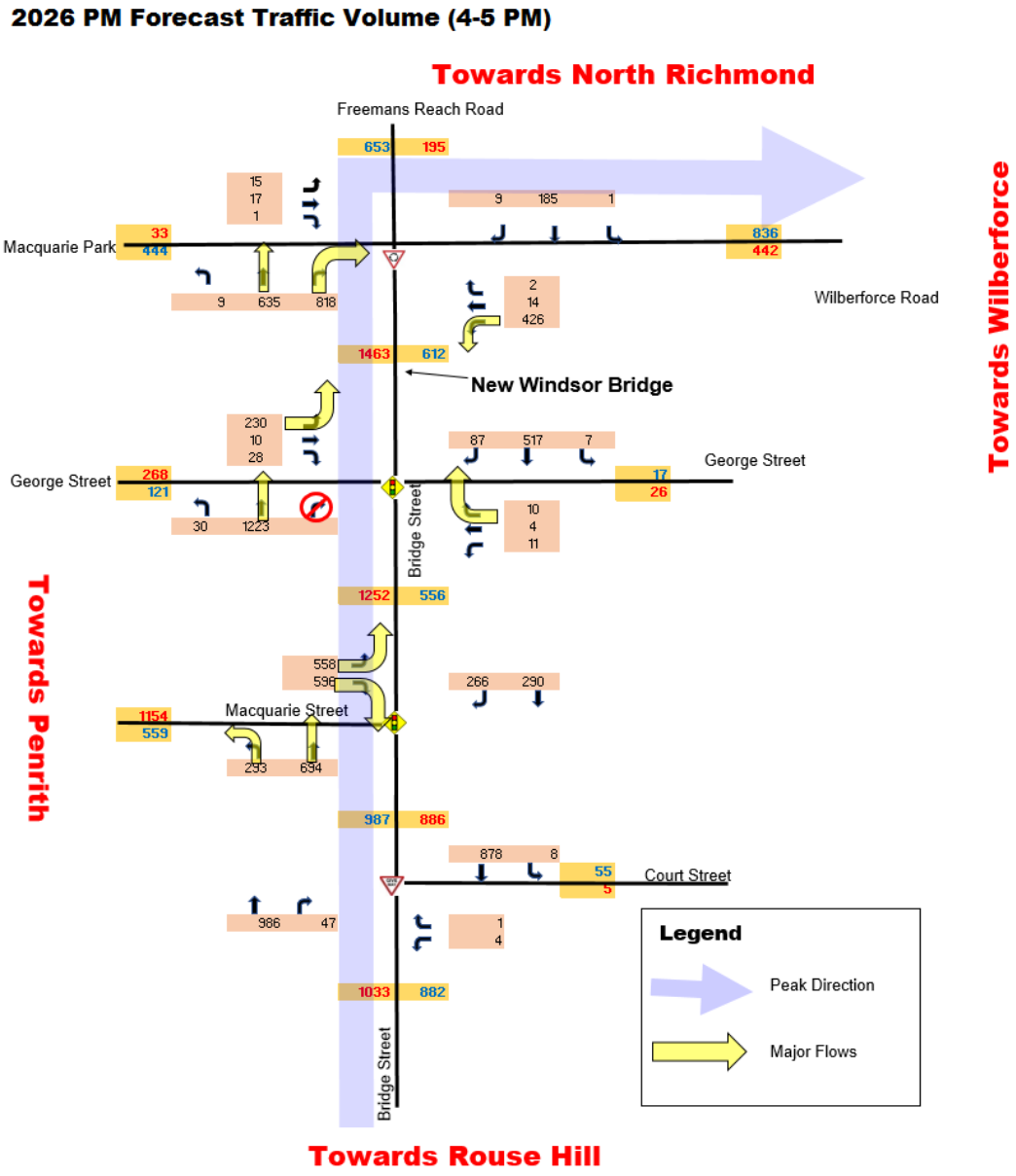


Figure C-2 Forecast Turning Volumes 2026 PM Peak (4-5PM) – with Concept Design

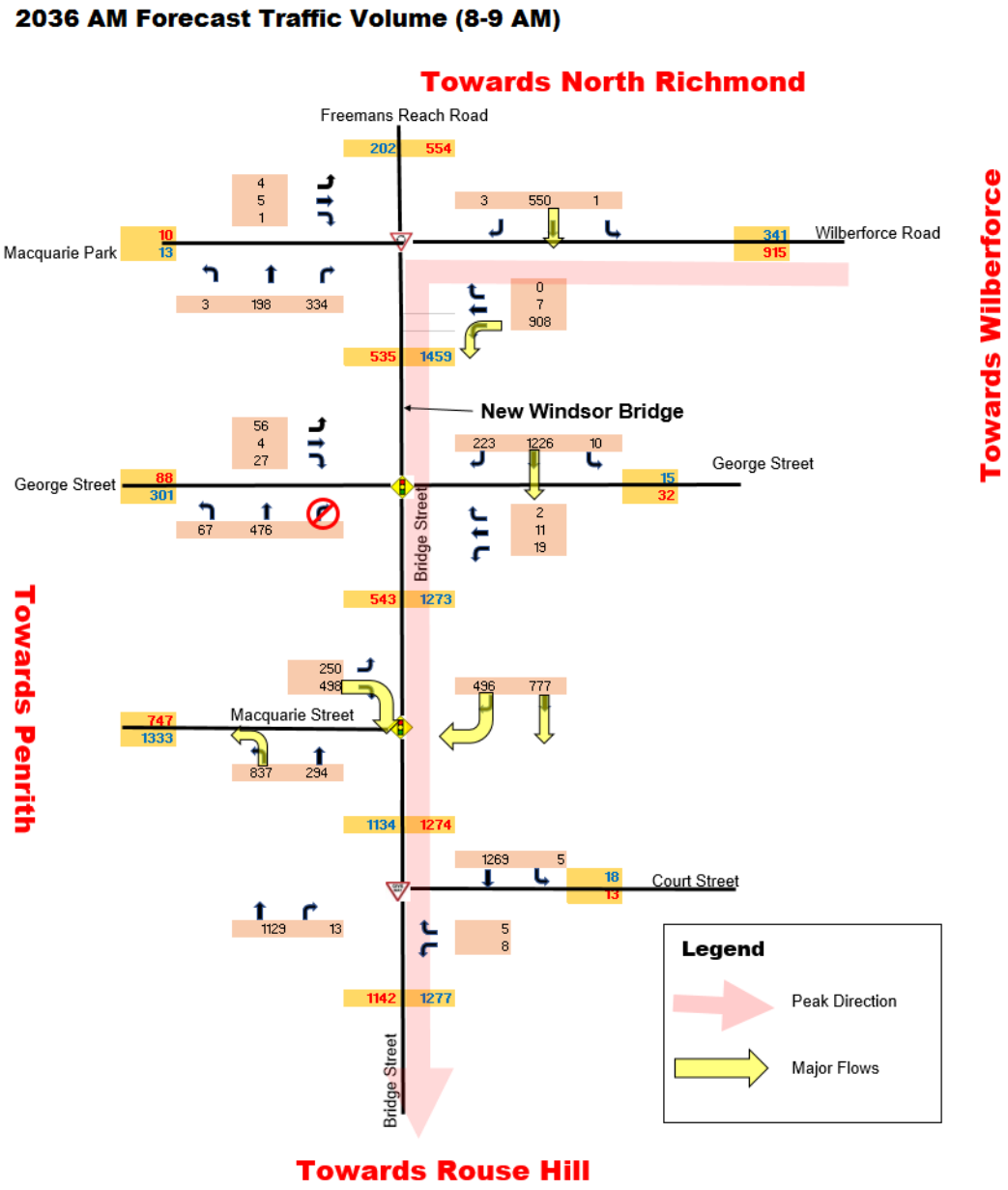


Figure C-3 Forecast Turning Volumes 2036 AM Peak (8-9AM) – with Concept Design

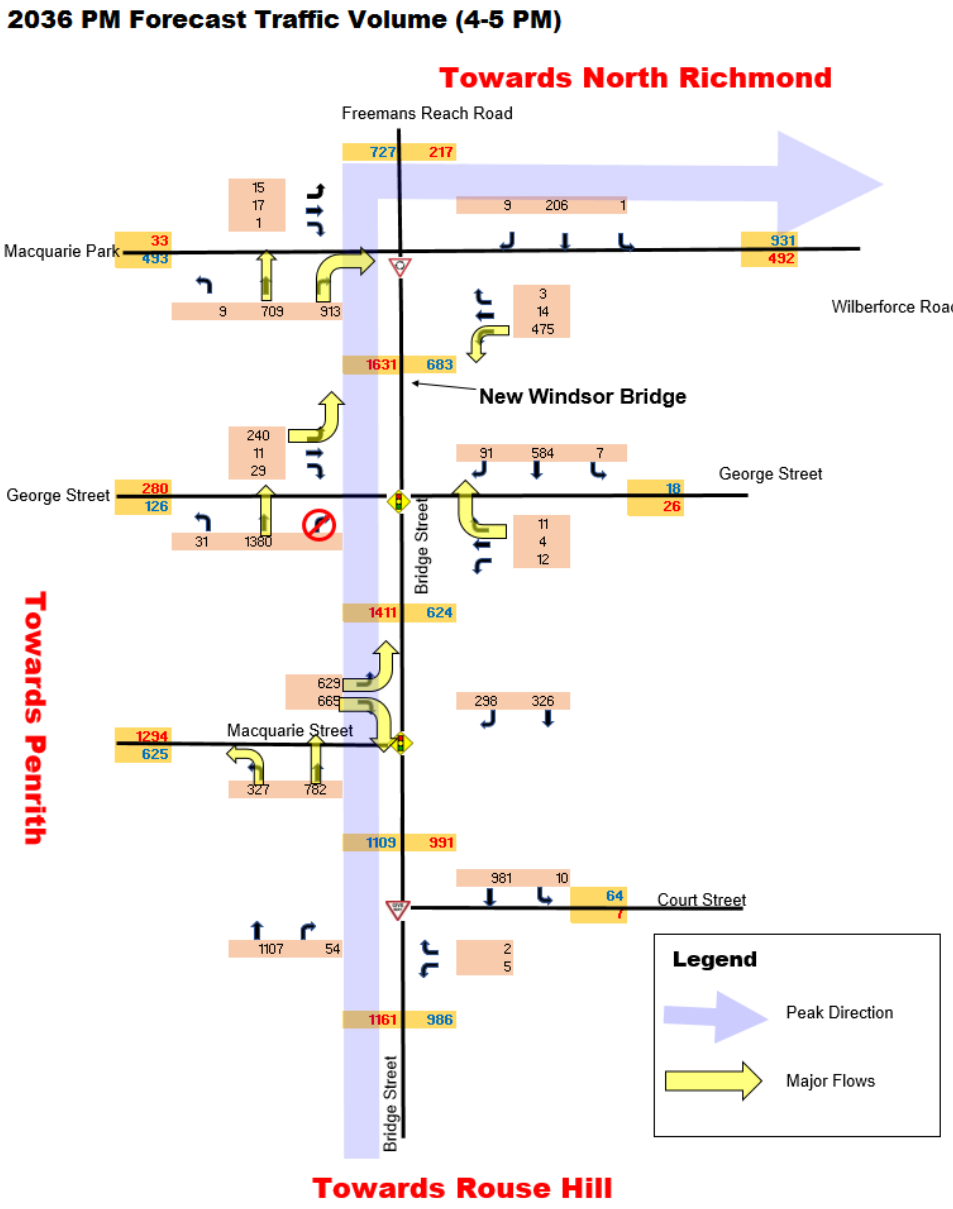


Figure C-4 Forecast Turning Volumes 2036 PM Peak (4-5PM) – with Concept Design

C.2 Predicted Queue Lengths in 2026 and 2036 with Concept Design

Figure C-5 to Figure C-6 show predicted queue lengths (95th percentile) at Wilberforce Road / Freemans Reach Road, Bridge Street / George Street and Bridge Street / Macquarie Street for 2026 AM and PM with Concept Design.

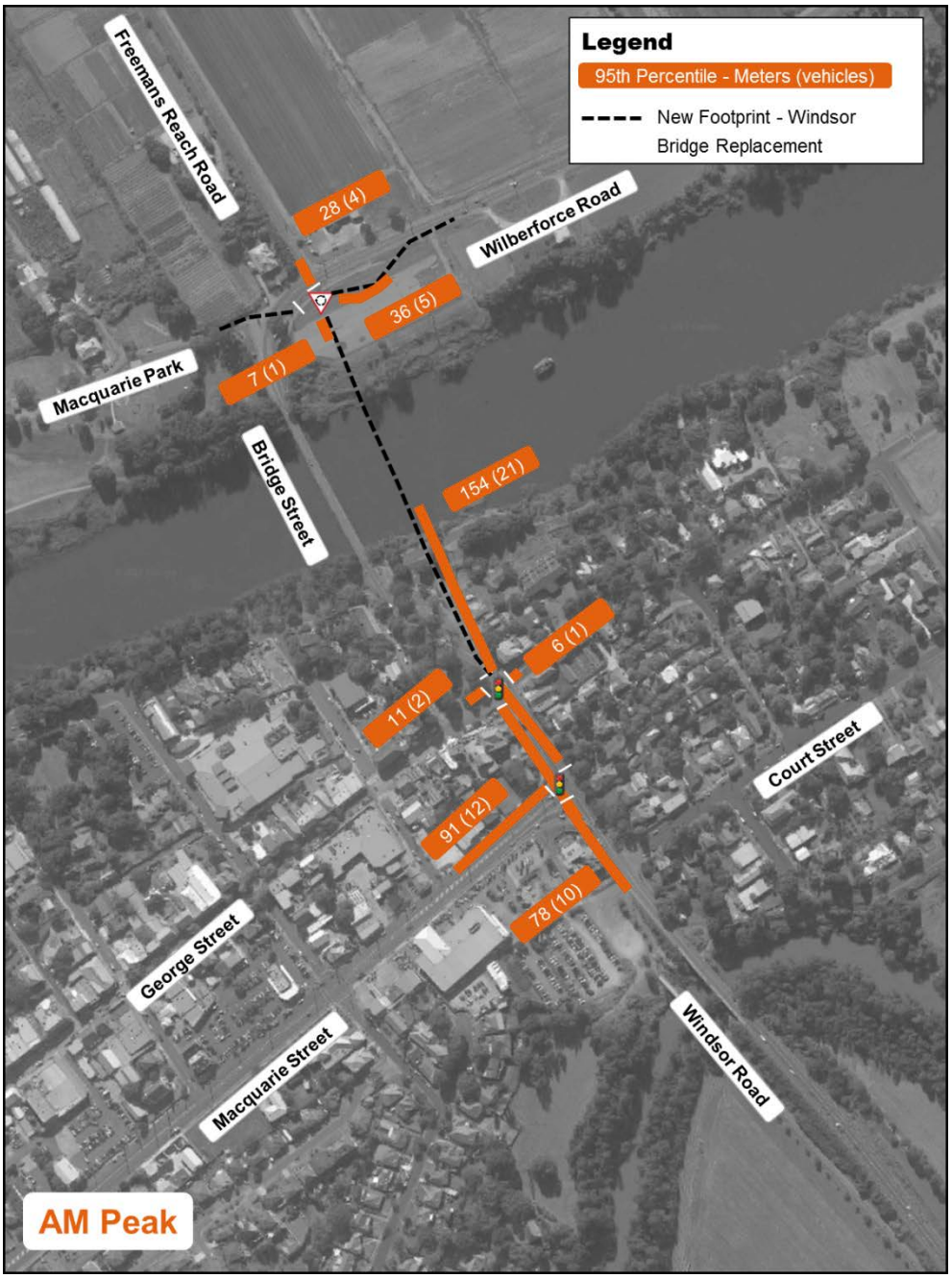


Figure C-5 Predicted 95th Percentile Queue Lengths in 2026 AM Peak with Concept Design

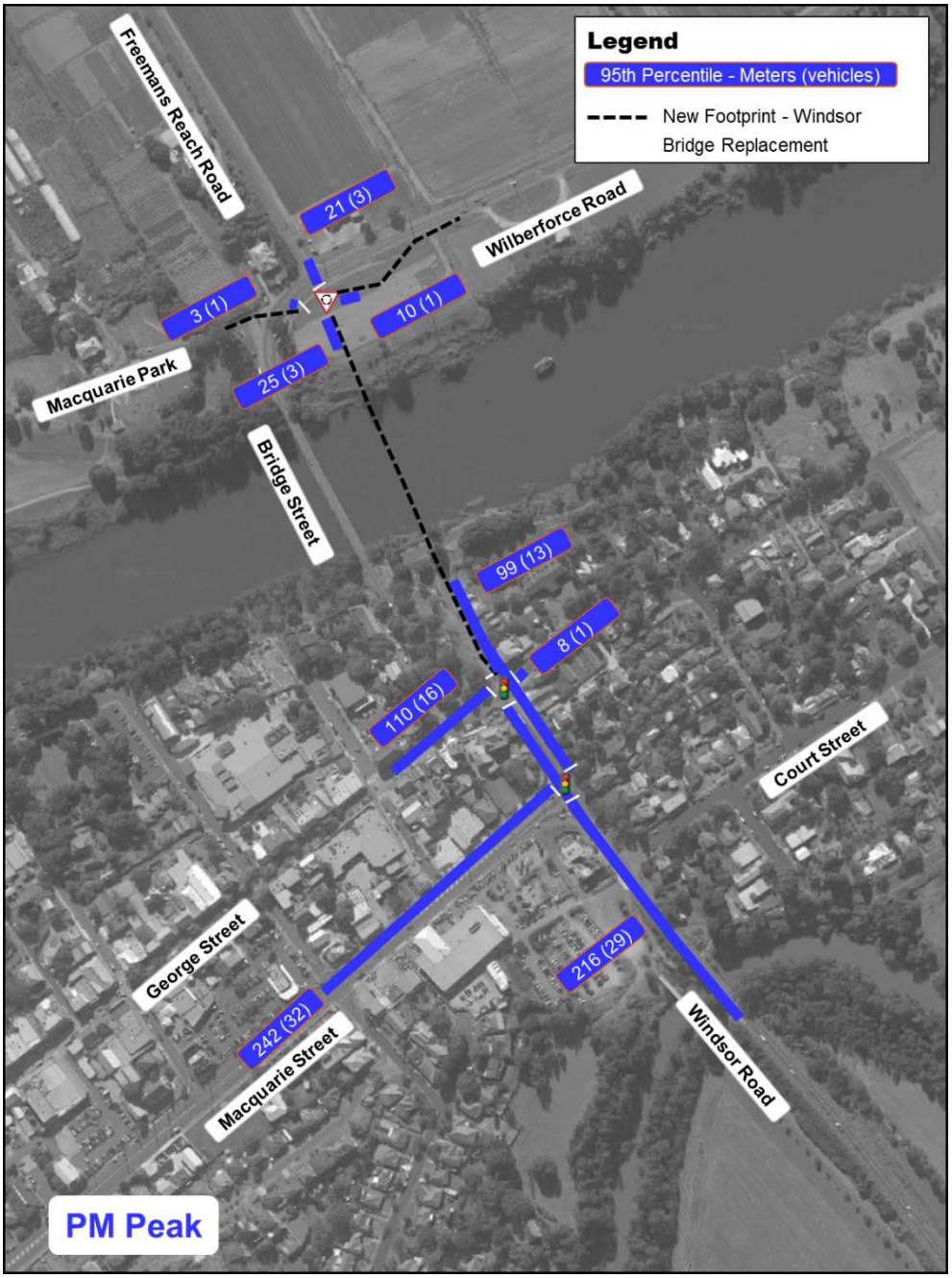


Figure C-6 Predicted 95th Percentile Queue Lengths in 2026 PM Peak with Concept Design

Figure C-7 to Figure C-8 show predicted queue lengths (95th percentile) at Wilberforce Road / Freemans Reach Road, Bridge Street / George Street and Bridge Street / Macquarie Street for 2036 AM and PM with Concept Design.

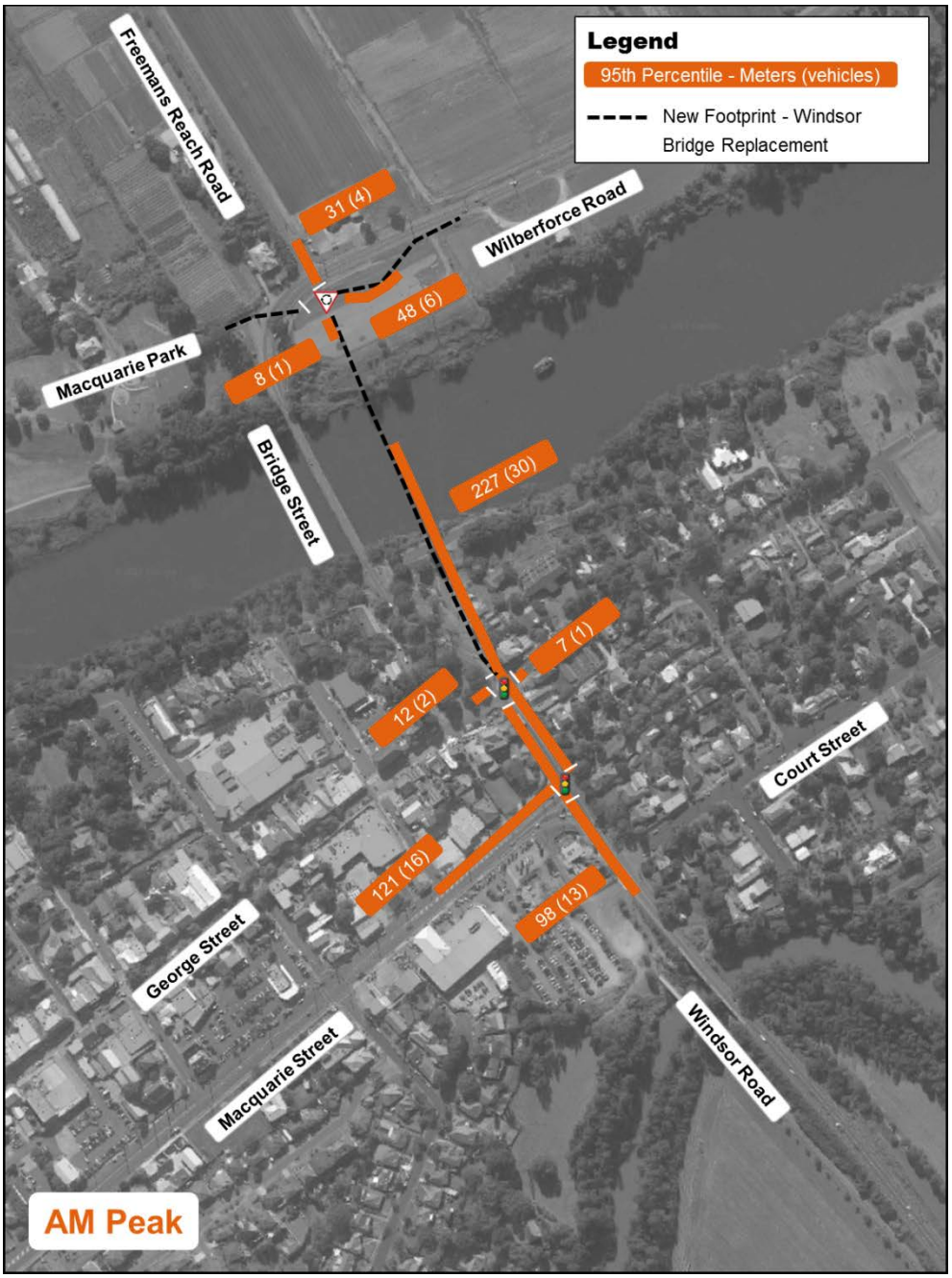


Figure C-7 Predicted 95th Percentile Queue Lengths in 2036 AM Peak with Concept Design

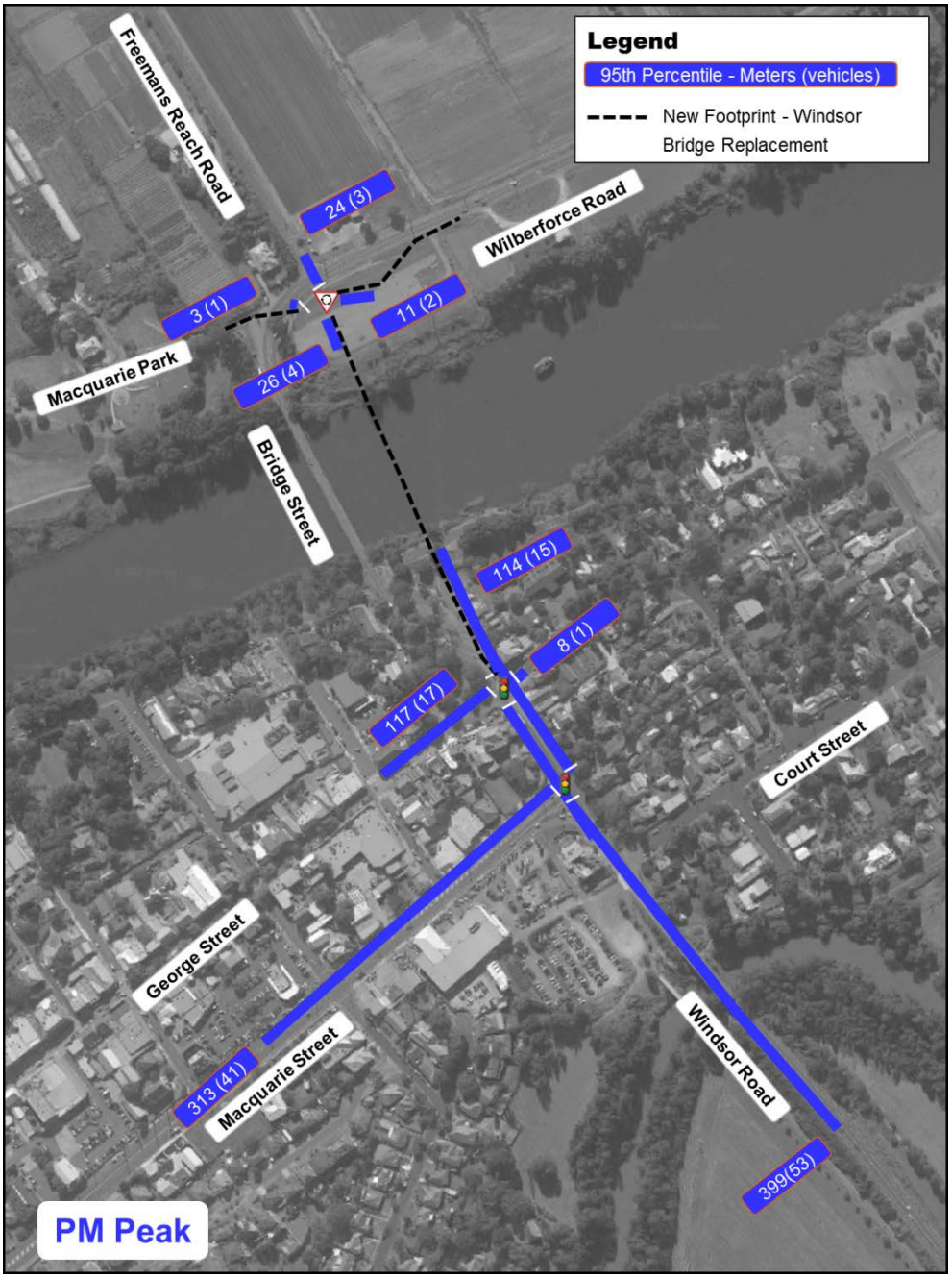


Figure C-8 Predicted 95th Percentile Queue Lengths in 2036 PM Peak with Concept Design

C.3 Level of Service Results (SIDRA) – 2026 with Concept Design

Wilberforce Road / Freemans Reach Road (new roundabout) - 2026 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	11	A	28
East: Wilberforce Road	15	B	36
South: Bridge Street	10	A	7
West: Macquarie Park	11	A	0
Overall (1)	**15**	**B**	

Wilberforce Road / Freemans Reach Road (new roundabout) - 2026 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	17	B	21
East: Wilberforce Road	11	A	10
South: Bridge Street	9	A	25
West: Macquarie Park	17	B	3
Overall (1)	**17**	**B**	

Bridge Street / George Street (new traffic signals) - 2026 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	12	A	154
East: George Street	47	D	6
South: Bridge Street	29	C	122
West: George Street	27	B	11
Overall (2)	**17**	**B**	

Bridge Street / George Street (new traffic signals) - 2026 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	14	A	99
East: George Street	74	F	8
South: Bridge Street	84	F	122
West: George Street	66	E	110
Overall (2)	**62**	**E**	

Bridge Street / Macquarie Street (traffic signals) - 2026 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	12	A	89
South: Bridge Street	15	B	78
West: Macquarie Street	44	D	91
Overall (2)	**21**	**B**	

Bridge Street / Macquarie Street (traffic signals) - 2026 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	35	C	122
South: Bridge Street	75	F	216
West: Macquarie Street	50	D	242
Overall (2)	**56**	**D**	

Note:
(1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay.
(2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

C.4 Level of Service Results (SIDRA) – 2036 with Concept Design

Wilberforce Road / Freemans Reach Road (new roundabout) - 2036 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	11	A	31
East: Wilberforce Road	17	B	48
South: Bridge Street	10	A	8
West: Macquarie Park	11	A	0
Overall (1)	**17**	**B**	

Wilberforce Road / Freemans Reach Road (new roundabout) - 2036 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	17	B	24
East: Wilberforce Road	11	A	11
South: Bridge Street	9	A	26
West: Macquarie Park	17	B	3
Overall (1)	**17**	**B**	

Bridge Street / George Street (new traffic signals) - 2036 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	16	B	227
East: George Street	47	D	7
South: Bridge Street	46	D	122
West: George Street	28	B	12
Overall (2)	**25**	**B**	

Bridge Street / George Street (new traffic signals) - 2036 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	13	A	114
East: George Street	75	F	8
South: Bridge Street	268	F	122
West: George Street	67	E	117
Overall (2)	**169**	**F**	

Bridge Street / Macquarie Street (traffic signals) - 2036 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	12	A	107
South: Bridge Street	19	B	98
West: Macquarie Street	56	D	121
Overall (2)	**25**	**B**	

Bridge Street / Macquarie Street (traffic signals) - 2036 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	37	C	122
South: Bridge Street	181	F	399
West: Macquarie Street	58	E	313
Overall (2)	**99**	**F**	

Note:
(1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay.
(2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

APPENDIX D Detailed SIDRA Analysis Results for 2026 and 2036 with 'Modified Concept Design'

D.1 Predicted Queue Lengths in 2026 and 2036 with Modified Concept Design

Figure D-1 to Figure D-2 show predicted queue lengths (95th percentile) at Wilberforce Road / Freemans Reach Road, Bridge Street / George Street and Bridge Street / Macquarie Street for 2026 AM and PM with Modified Concept Design.

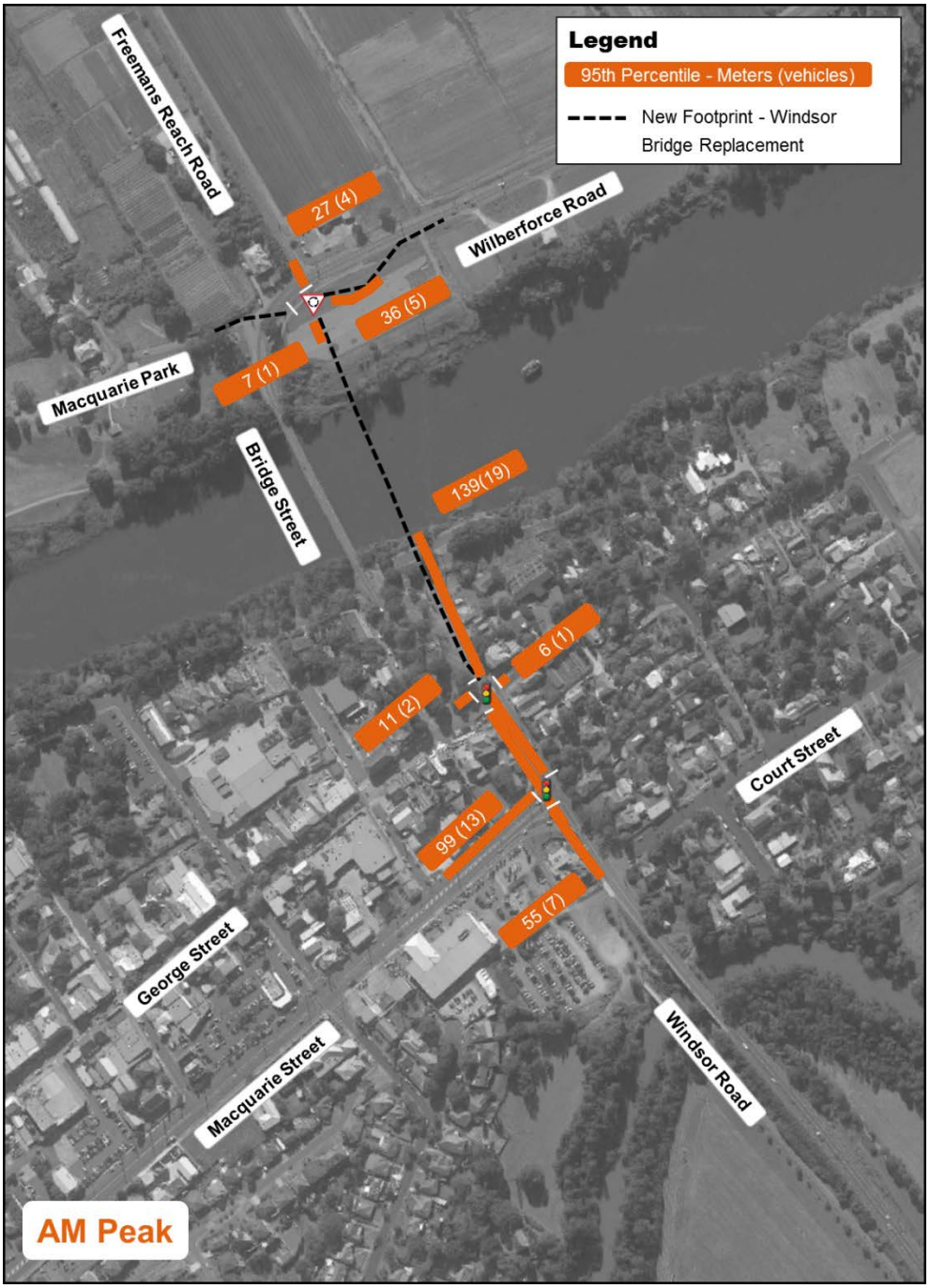


Figure D-1 Predicted 95th Percentile Queue Lengths in 2026 AM Peak with Modified Concept Design

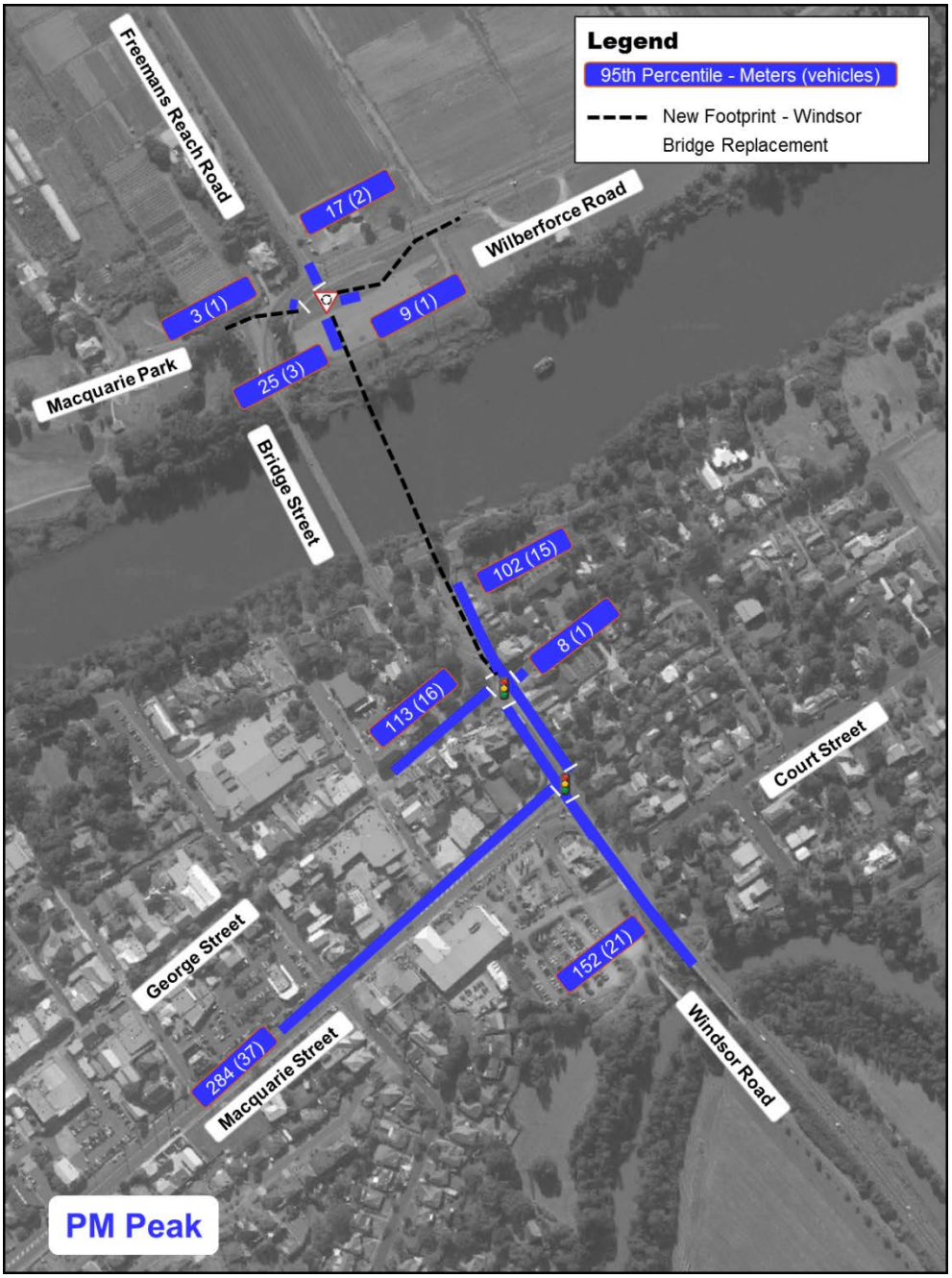


Figure D-2 Predicted 95th Percentile Queue Lengths in 2026 PM Peak with Modified Concept Design

Figure D-3 to Figure D-4 show predicted queue lengths (95th percentile) at Wilberforce Road / Freemans Reach Road, Bridge Street / George Street and Bridge Street / Macquarie Street for 2036 AM and PM with Modified Concept Design.

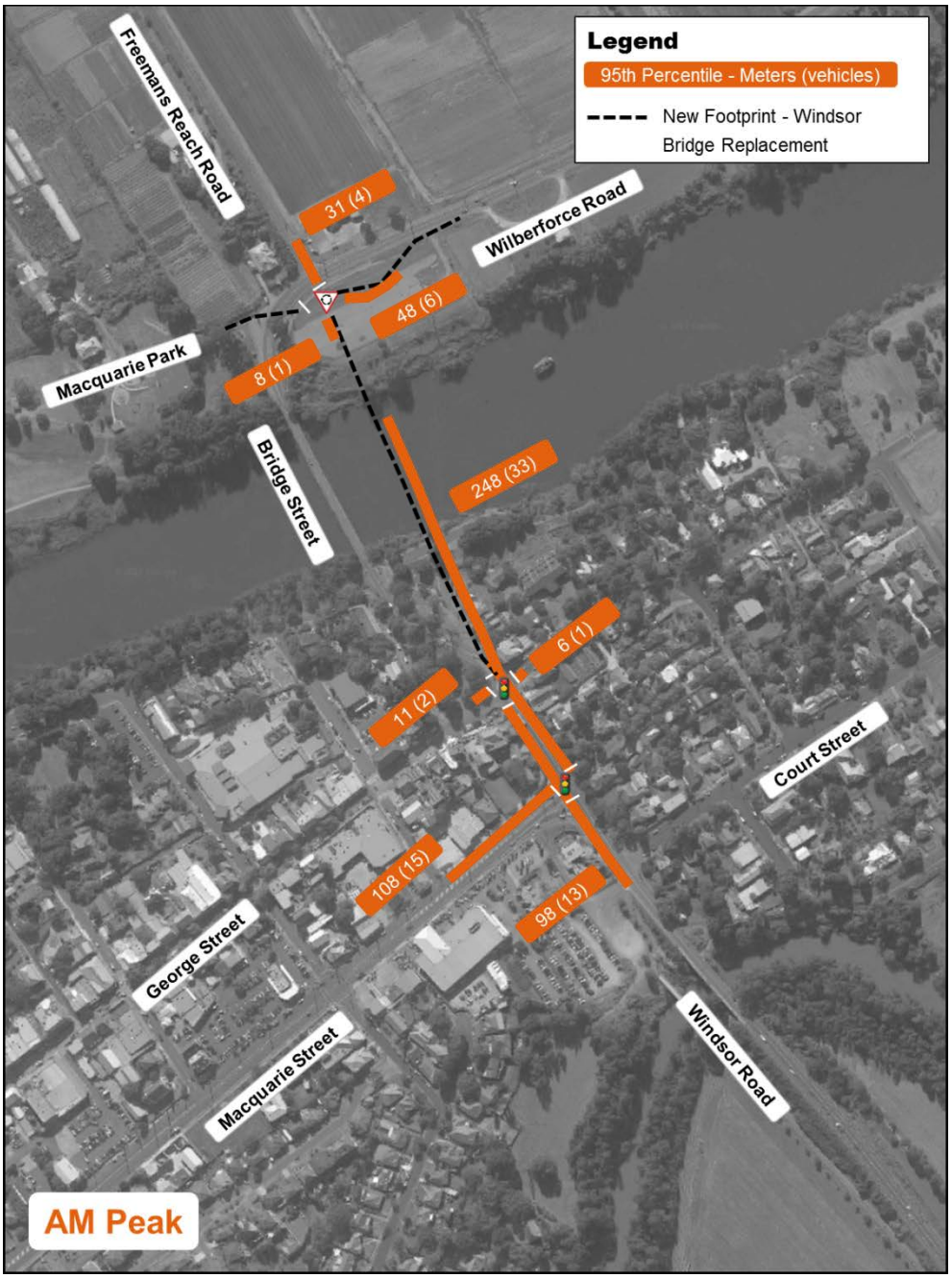


Figure D-3 Predicted 95th Percentile Queue Lengths in 2036 AM Peak with Modified Concept Design

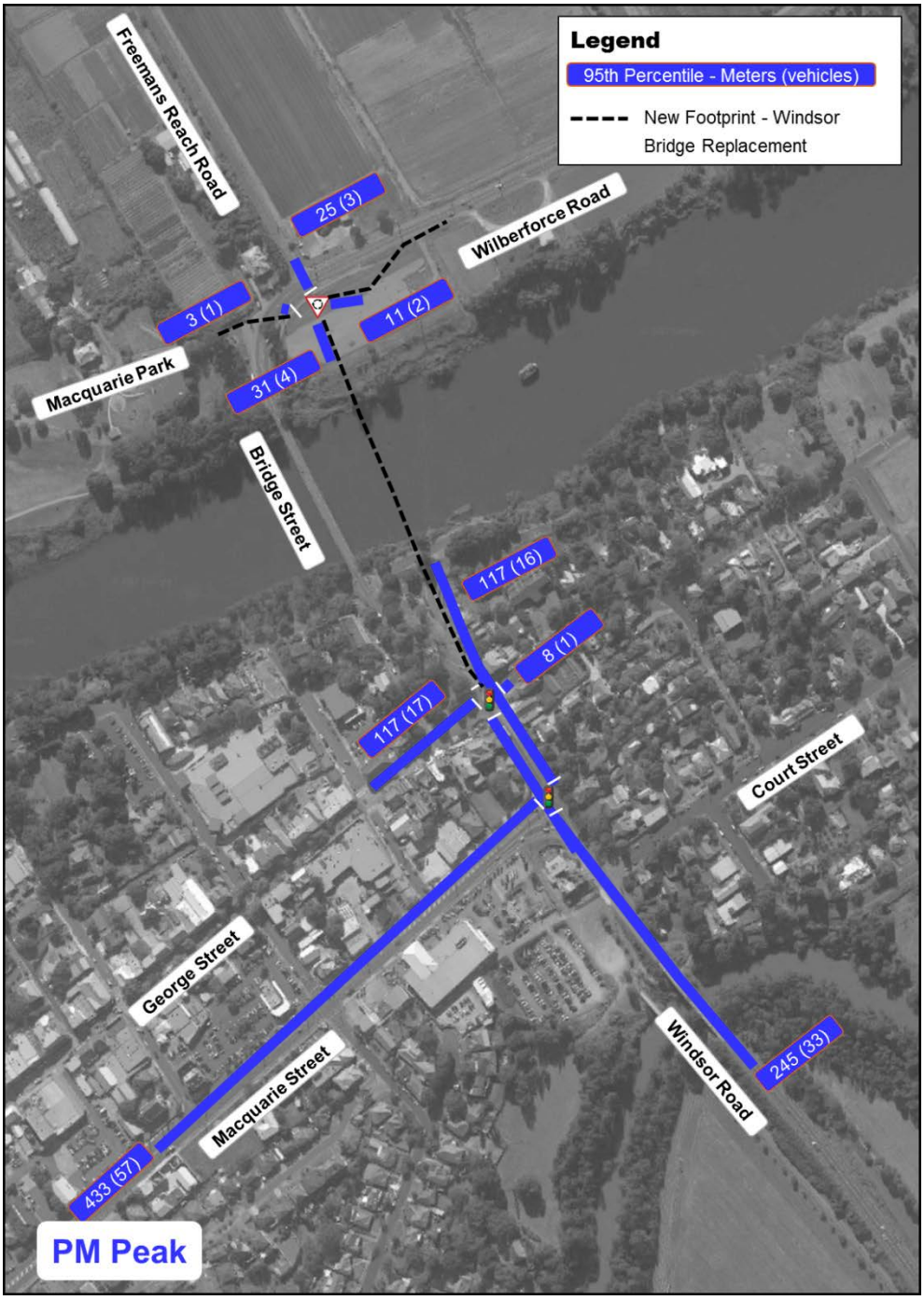


Figure D-4 Predicted 95th Percentile Queue Lengths in 2036 PM Peak with Modified Concept Design

D.2 Level of Service Results (SIDRA) – 2026 with Modified Concept Design

Wilberforce Road / Freemans Reach Road (new roundabout) - 2026 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	11	A	27
East: Wilberforce Road	15	B	36
South: Bridge Street	10	A	7
West: Macquarie Park	11	A	0
Overall (1)	**15**	**B**	

Wilberforce Road / Freemans Reach Road (new roundabout) - 2026 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	16	B	17
East: Wilberforce Road	11	A	9
South: Bridge Street	9	A	25
West: Macquarie Park	17	B	3
Overall (1)	**17**	**B**	

Bridge Street / George Street (new traffic signals) - 2026 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	11	A	139
East: George Street	49	D	6
South: Bridge Street	26	B	122
West: George Street	27	B	11
Overall (2)	**16**	**B**	

Bridge Street / George Street (new traffic signals) - 2026 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	9	A	102
East: George Street	74	F	8
South: Bridge Street	14	A	122
West: George Street	67	E	113
Overall (2)	**20**	**B**	

Bridge Street / Macquarie Street (traffic signals) - 2026 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	11	A	84
South: Bridge Street	12	A	55
West: Macquarie Street	49	D	99
Overall (2)	**20**	**B**	

Bridge Street / Macquarie Street (traffic signals) - 2026 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	31	C	122
South: Bridge Street	35	C	152
West: Macquarie Street	67	E	284
Overall (2)	**48**	**D**	

Note:
(1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay.
(2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.

D.3 Level of Service Results (SIDRA) – 2036 with Modified Concept Design

Wilberforce Road / Freemans Reach Road (new roundabout) - 2036 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	11	A	31
East: Wilberforce Road	17	B	48
South: Bridge Street	10	A	8
West: Macquarie Park	11	A	0
Overall (1)	**17**	**B**	

Wilberforce Road / Freemans Reach Road (new roundabout) - 2036 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Freemans Reach Road	19	B	25
East: Wilberforce Road	11	A	11
South: Bridge Street	9	A	31
West: Macquarie Park	19	B	3
Overall (1)	**19**	**B**	

Bridge Street / George Street (new traffic signals) - 2036 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	17	B	248
East: George Street	46	D	6
South: Bridge Street	40	C	122
West: George Street	27	B	11
Overall (2)	**24**	**B**	

Bridge Street / George Street (new traffic signals) - 2036 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	12	A	117
East: George Street	73	F	8
South: Bridge Street	30	C	122
West: George Street	67	E	117
Overall (2)	**30**	**C**	

Bridge Street / Macquarie Street (traffic signals) - 2036 AM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	13	A	116
South: Bridge Street	19	B	98
West: Macquarie Street	47	D	108
Overall (2)	**23**	**B**	

Bridge Street / Macquarie Street (traffic signals) - 2036 PM

Approach / Road	Average Delay (sec)	LoS	95th Percentile Queue (metres)
North: Bridge Street	38	C	122
South: Bridge Street	70	E	245
West: Macquarie Street	117	F	433
Overall (2)	**83**	**F**	

Note:
(1) Priority intersections such as a roundabout and sign controlled intersections, the Level of Service (LoS) value is determined by the critical movement with the highest delay.
(2) Signalised intersection, LoS criteria are related to the average intersection delay measured in seconds per vehicle.