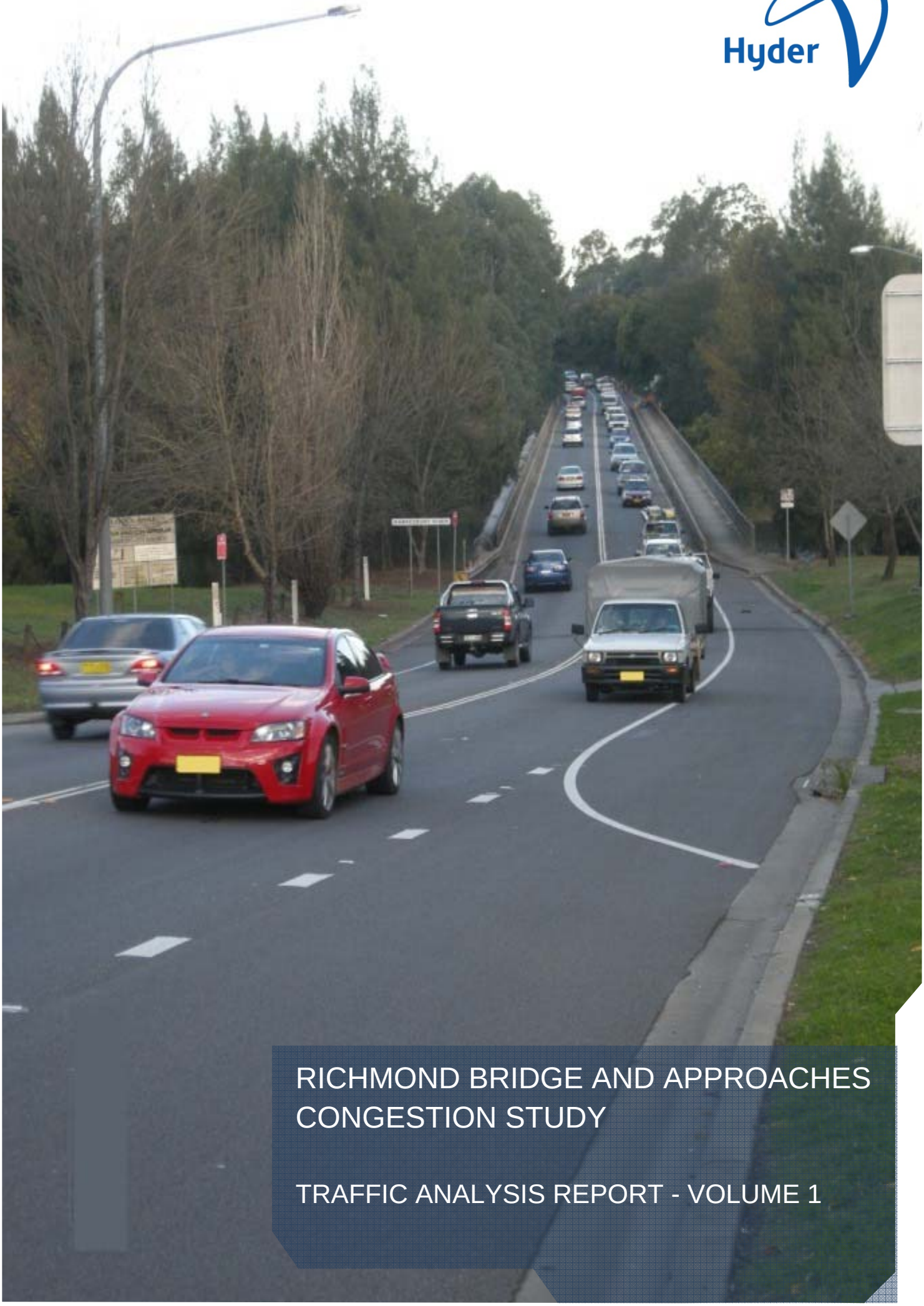
APPENDIX 3

TRAFFIC ANALYSIS REPORT VOLUME 1



RICHMOND BRIDGE AND APPROACHES CONGESTION STUDY

TRAFFIC ANALYSIS REPORT - VOLUME 1

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ROADS AND MARITIME SERVICES

RICHMOND BRIDGE AND APPROACHES CONGESTION STUDY

TRAFFIC ANALYSIS REPORT– VOLUME 1

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REVISIONS

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A-C	15 Nov 2011	Internal reviews	MR, AK, JL	
D	25 Nov 2011	DRAFT for Client's review and comments	MR, AK, JL	MR
E	2 Dec 2011	Incorporates comments from RMS	MR, AK, JL	MR
F	28 Feb 2012	Edited by RMS		
Final	26 March 2012	Final Report	MR	MR
Final	7 April 2012	Minor amendments to Options results in Chapter 5 as per TfNSW comments.	MR	MR

CONTENTS

EXECUTIVE SUMMARY

New South Wales Roads and Maritime Services (RMS) commissioned Hyder Consulting Pty Ltd (Hyder) to develop a road based traffic model to identify network capacity issues that affect the performance of the Richmond Bridge and adjoining approach roads. The Bells Line of Road provides an important link between the Sydney Basin and the Central West Region of New South Wales. It provides a supplementary east-west regional link supporting the Great Western Highway in carrying commuter traffic, and acts as an alternative route. The eastern end of the Bells Line of Road corridor provides access to Richmond and the rapidly growing North-West Growth Sector of Sydney. This section of the route includes the Richmond Bridge which is the only Hawkesbury River crossing serving the entire residential catchment of North Richmond, Kurrajong, Bilpin, Bell and beyond. During the morning and afternoon peak hours this section of Bells Line of Road experiences considerable levels of traffic congestion. Traffic congestion is experienced on the two lane Richmond Bridge (which is one lane each direction) and adjoining approach roads between North Richmond and Richmond.

The purpose of Hyder's study is to assess the performance of Richmond Bridge and section of Bells Line of Road/ Kurrajong Road between Grose Vale Road and East Market Street (the study area). A road based micro-simulation traffic model was developed for the study area. For the micro-simulation model, Hyder used *Paramics* software. For assessing individual intersection capacity, Hyder used *SIDRA* software.

Both Paramics and SIDRA models provided an assessment tool to identify:

- Key network issues that affect the performance of Richmond Bridge and adjoining approach roads.
- Short term options for improvements to traffic flow. Each option was assessed in terms of key traffic factors which are most likely to influence the decisions on the best performing option.

A consultation process involving RMS and key stakeholders constituted an important element of this study. Three stakeholder workshops were undertaken over the course of this project. The stakeholder group was made up of representatives from Roads and Maritime Services (RMS), Transport for NSW and Hawkesbury City Council.

In 2011, Richmond Bridge carried approximately 26,200 vehicles per day. This included approximately 1500 heavy vehicles (more than 5% of the total traffic). Peak hour traffic volumes on Richmond Bridge were in the order of 1400 to 1500 vehicles in each direction. The traffic analysis suggests that Richmond Bridge is close to saturation traffic levels. During the morning and afternoon peak period, some turning movements at adjoining key intersections with Bells Line of Road/Kurrajong Road also adversely impact the operation of Richmond Bridge's performance. The traffic modelling has identified network operational issues at the following three key intersections:

1 Bells Line of Road/Grose Vale Road (traffic light controlled).

2 Kurrajong Road / Yarramundi Lane / Old Kurrajong Road (sign control).

3 Kurrajong Road/ Bosworth Street (traffic light controlled).

Figure E-1 overleaf shows the location of the key intersections.

Based on modelling investigations, Hyder has identified ten preliminary short term improvement options. In consultation with stakeholders, eight options have been shortlisted for detailed assessment. These are referred to as Options A to H. Each option was assessed in terms of key traffic factors which are most likely to influence any decision regarding the best performing option.

The short term options include minor improvements to road and intersections to maintain an acceptable level of traffic operation. These improvements include intersection widening, banning on-street parking during peak periods and imposing clearway conditions during peak periods. The identified improvement options at the three key intersections (see Figure E1) would improve the major east-west movement of traffic on this section of Bells Line of Road and Kurrajong Road.

The traffic simulation undertaken has enabled an assessment of the eight alternative upgrade Options (A to H) for this section of Bells Line of Road/Kurrajong Road between Grose Vale Road and East Market Street. Each upgrade option was developed to test alternative approaches aimed at improving network efficiency and level of service. The magnitude of this benefit varied between options. Of all options considered, Option H, comprising improvements at Grose Vale Road and Yarramundi Lane intersections along with a peak period clearway condition on Kurrajong Road between Chapel Street and Bosworth Street, would provide a relatively better outcome than other competing options, based on the criteria used. Option H was further assessed for future traffic conditions in years 2016 and 2021. The future year analysis suggested the need for additional improvements at the Bosworth Street intersection after 2016.

The proposed improvements as outlined below and graphically shown in Figure E-2 can be delivered in two stages.

Over the next five years (to 2016) the following improvements (Option 'H' in this study) are recommended:

Bells Line of Road/Grose Vale Road intersection:

- Provision of a westbound shared through/left turn lane on Bells Line of Road, east of Grose Vale Road replacing the existing left turn lane.
- Provision of an additional westbound short through lane on Bells Line of Road, west of Grose Vale Road.
- Provision of a clearway during peak periods between Pitt Lane and Grose Vale Road.
- Banning of eastbound right turns from Bells Line of Road into Grose Vale Road.
- Conversion of the existing eastbound right-turn bay to a second westbound through lane.
- Extension of the eastbound merge (east of Grose Vale Road intersection).

Kurrajong Road / Yarramundi Lane / Old Kurrajong Road intersection:

- Provision of an additional eastbound exclusive right turn bay from Kurrajong Road to Yarramundi Lane.
- Provision of a left turn slip lane out of Yarramundi Lane with an acceleration lane on Kurrajong Road (in the westbound direction).

Kurrajong Road:

- Provision of a clearway on Kurrajong Road between Chapel Street and Bosworth Street during peak periods.

Over the following five years (2016- 2021) additional improvements at the Kurrajong Road/Bosworth Street intersection are proposed:

- Provision of an additional eastbound exclusive right turn bay from Kurrajong Road to Bosworth Street.
- A possible right turn ban from March Street to Bosworth Street (north).

Following 2021, there will be a need to augment Richmond Bridge and approaches to either a three lane configuration (including 'tidal flow') or to four lanes.

In conclusion, the traffic analysis found that proposed improvements would maintain an acceptable level of service to key intersections including Richmond Bridge over the short time period (up to 10 years). The future traffic volumes (in 2021) on Richmond Bridge and this section of Bells Line of Road/Kurrajong Road suggests the need for two through traffic lanes in the peak direction between Grose Vale Road and Yarramundi Lane, hence a tidal flow scheme could be considered. RMS has commenced the investigation of a strategic concept options study for Richmond Bridge and approaches. It is recommended that as part of that study, a tidal flow scheme be further investigated.

REPORT STRUCTURE

The Richmond Bridge and Approaches Congestion Study Traffic Analysis Report is produced in two volumes. This report forms Volume 1.

VOLUME 1- EXECUTIVE SUMMARY AND REPORT

The Traffic Analysis Report – Volume 1 contains the following six chapters providing an assessment of the network performance of the Richmond Bridge and adjoining roads.

Section 1 provides an overview of the project, background information, study objectives, an upper level approach to traffic investigation.

Section 2 provides the regional and local transport context within which the assessment has taken place. This section provides an overview of key transport indicators including historical traffic growth, mode share analysis, crash data and also provides an overview of existing travel patterns in the study area.

Section 3 establishes the existing transport network performance in the study area. Results from traffic surveys are summarised in this section. An assessment of existing network capacity has been undertaken, summarising network deficiency at key roads and intersections.

Section 4 documents an overview of traffic models. Its purpose, model network assumptions, and analysis are included.

Section 5 – describes the eight options and key traffic criteria used to compare the performance for each option. Of the eight modelled options; the best performing option is identified from a traffic perspective.

Section 6 – summarises the key study findings and recommendations.

VOLUME 2 - APPENDICES

Detailed model development, calibration and validation and options results and RMS strategic concept sketches of proposed short term improvements are included in Volume 2 as appendices to Volume 1. The appendices are as follows:

- **Appendix A** RMS' Strategic concept sketches of proposed short term improvements.
- **Appendix B** Existing Traffic Data, SIDRA Analysis.
- **Appendix C** Paramics Model Development, Calibration and Validation;
- **Appendix D** Options Modelling Results (Turning Volumes, SIDRA and Paramics Analysis).

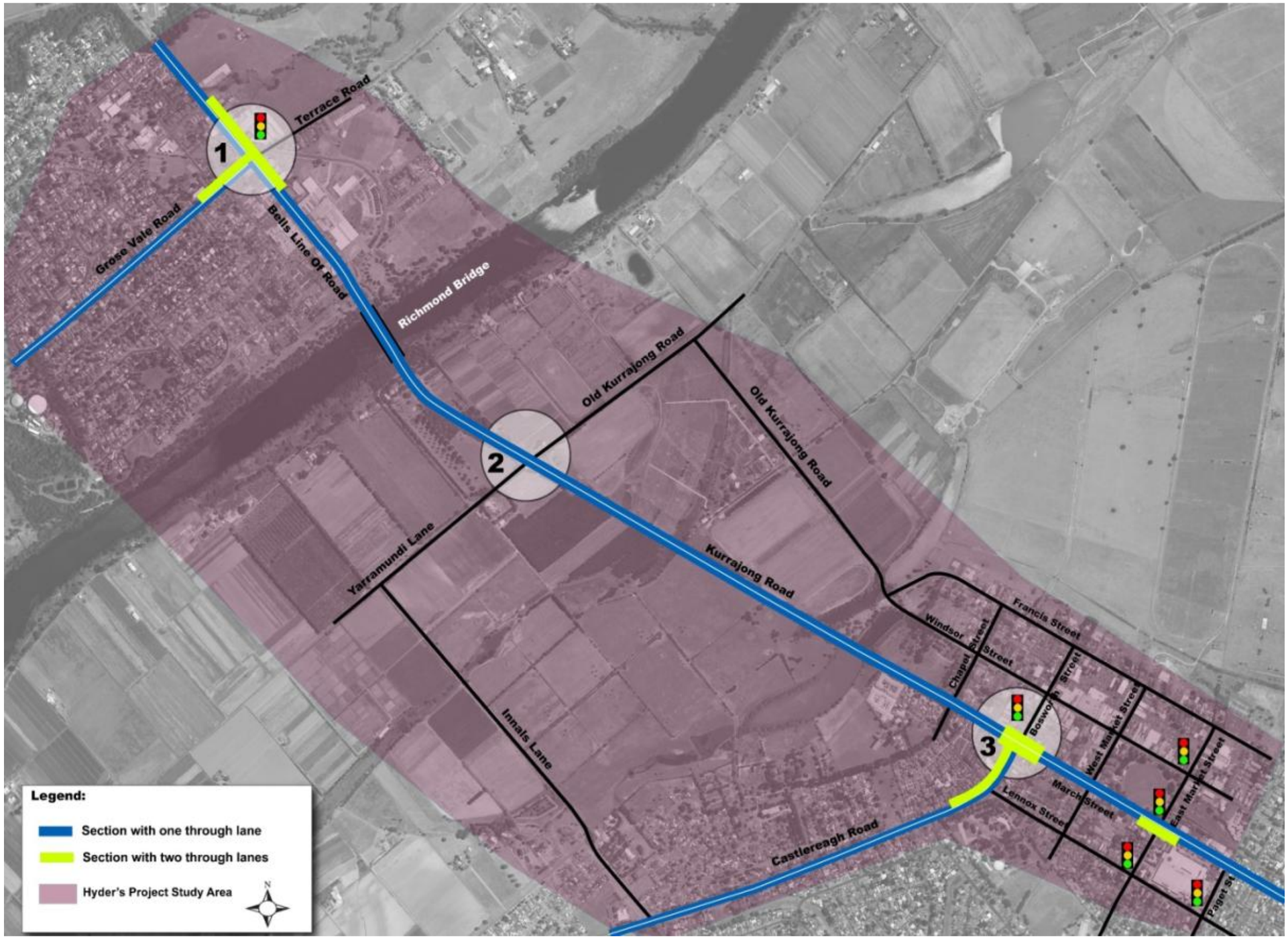

Figure E-1 Study Area and Key Intersections

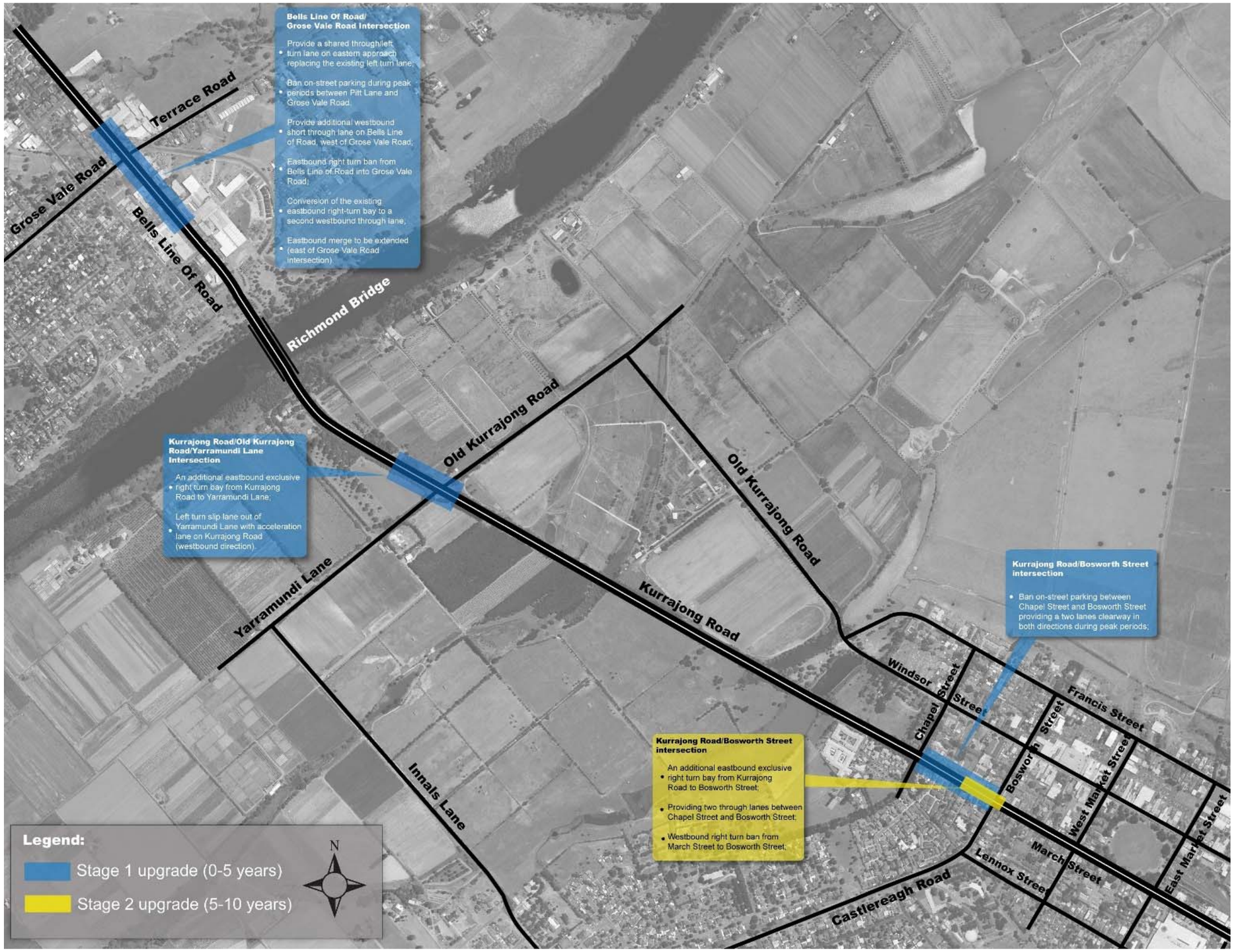

Figure E-2 **Proposed Short term Improvements**

GLOSSARY

AADT	Average Annual Daily Traffic
AM	Morning Peak
BTS	Bureau of Transport Statistics (Now Transport for NSW))
EMME/2	Strategic Transport Modelling Software used by RMS.
GMA	Greater Metropolitan Area
JTW	Journey to Work
LoS	Level of Service
RTA	NSW Roads and Traffic Authority (Now NSW Roads and Maritime Services)
RMS	Roads and Maritime Services
SSTM	Hyder's Sydney Strategic Traffic Model
TZ	Travel Zone
VKT	Vehicle Kilometres Travelled;
VHT	Vehicle Hours Travelled
VPH	Vehicles per Hour
VEH/H	Vehicles per Hour
SIDRA	Intersection Analytical Modelling Software
PARAMICS	Traffic Micro-simulation Modelling Software
PM	Afternoon Peak
Peak Hour	Peak One Hour Traffic Volumes over the Peak Period
TransCAD	Strategic Transport Modelling Software used by Hyder

1 INTRODUCTION

1.1 BACKGROUND

New South Wales Roads and Maritime Services (RMS) commissioned Hyder Consulting Pty Ltd (Hyder) to develop a road based traffic model to identify network capacity issues that affect the performance of the Richmond Bridge and adjoining approach roads. Land use changes in North Western Sydney are putting additional traffic pressure on Richmond Bridge. During peak periods the bridge and adjoining network experience traffic congestion.

The scope of Hyder's study is to examine short term options for improvements to the traffic flow of the section of Bells Line of Road and Kurrajong Road between Grose Vale Road and East Market Street (the study area).

1.2 ROAD NETWORK

Bells Line of Road provides an important link between the Sydney Basin and the Central West Region of New South Wales. As one of the few escarpment crossings, it provides a supplementary east-west regional link supporting the Great Western Highway in carrying commuter traffic, and acts as an alternative route. It also has high tourism significance with botanical gardens, bushwalking trails, lookout points and is one of the most picturesque routes crossing the Blue Mountains.

The eastern end of the Bells Line of Road corridor provides access to Richmond and the rapidly growing North-West Growth Sector of Sydney. This section of the route includes Richmond Bridge which is the only Hawkesbury River crossing serving the entire residential catchment of North Richmond, Kurrajong, Bilpin, Bell and beyond. During the morning and afternoon peak hours this section of Bells Line of Road experiences significant levels of traffic congestion. Congestion is experienced on the two lane Richmond Bridge (which is one lane in each direction) and adjoining approach roads between North Richmond and Richmond.

The Australian and NSW Governments are jointly funding the Long Term Strategic Corridor Plan of the Bells Line of Road. When completed, this Plan would guide long term strategic planning along the Bells Line of Road corridor. Figure 1-1 shows Hyder's study area network as well as the geographical scope of the Long Term Strategic Corridor Plan. Figure 1-2 shows the Richmond to North Richmond corridor location map prepared by RMS.

1.3 STUDY OBJECTIVES

The purpose of the traffic modelling investigation is to assess the performance of Richmond Bridge and the section of Bells Line of Road/ Kurrajong Road between Grose Vale Road and East Market Street. A road based micro-simulation traffic model was developed for the study area. For the micro-simulation model, Hyder used *Paramics* software. For assessing individual intersection capacity, Hyder used *SIDRA* software.

Both Paramics and SIDRA models provided an assessment tool to identify:

1 Key network issues that affect the performance of Richmond Bridge and adjoining approach roads.

2 Short term options for improvements to traffic flow. Each option was assessed in terms of key traffic factors which are most likely to influence any decision regarding the best performing option.

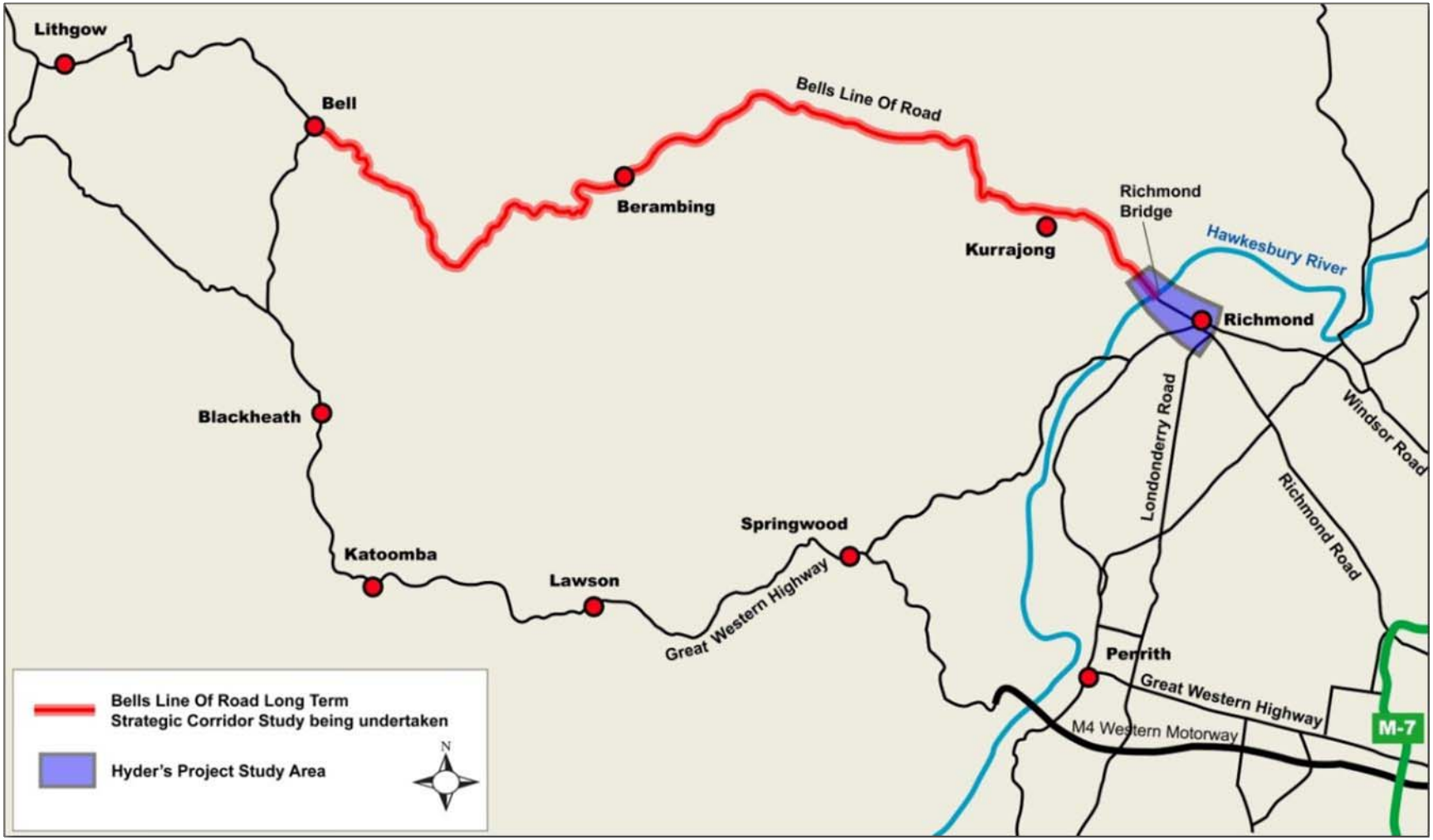

Figure 1-1 Richmond Bridge and Approaches Congestion Study Area in context of the Bells Line of Road Long Term Strategic Corridor Plan

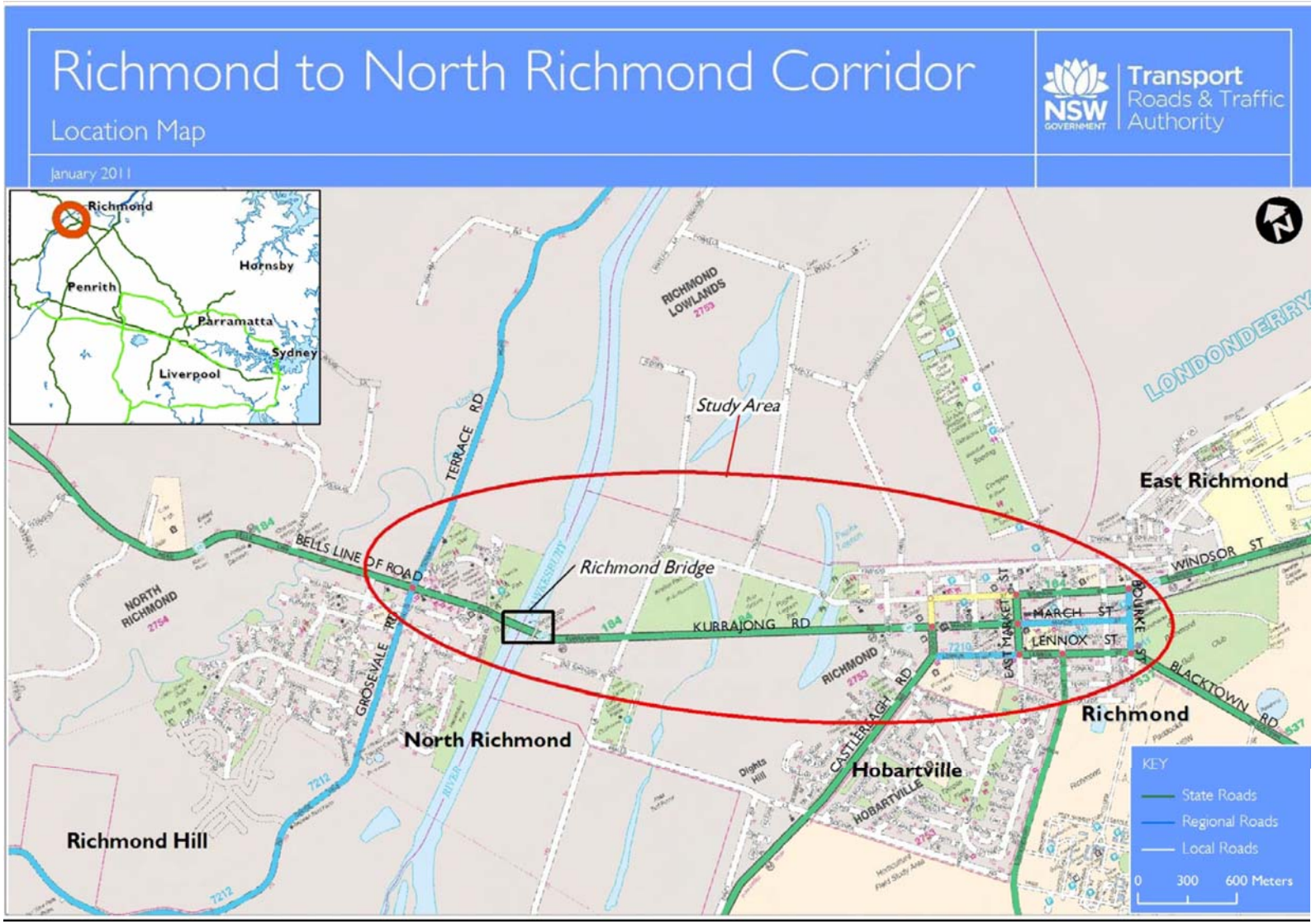

Figure 1-2 Richmond to North Richmond Corridor-Location Map

1.4 APPROACH TO TRAFFIC MODELLING INVESTIGATION

Hyder has developed a comprehensive study approach specifically to achieve key study objectives. It involves identifying the key network operational issues, undertaking a new traffic survey, development of a road based traffic model, calibration and validation of the traffic model and a traffic assessment of short term improvement options.

A consultation process involving RMS and key stakeholders constituted an important element of this study. Three stakeholder workshops were undertaken over the course of this project. The stakeholder group was made up of representatives from following organisations:

- Roads and Maritime Services (RMS);
- Transport for NSW; and
- Hawkesbury City Council.

The outcome of the traffic modelling investigation was presented to relevant representatives from Federal Government.

The traffic study process is shown graphically in Figure 1-3. The key aspects of Hyder's modelling approach include:

- Traffic data, survey and analysis. This stage consisted of reviewing historical and existing data resources and understanding the regional and local traffic context. A new traffic survey was conducted and provided input to model development. Three types of data were collected by traffic surveys, including mid-block counts, intersection turning movement counts and queue lengths.
- Model development, calibration and validation. Traffic models were developed using a two-level methodology - a micro-simulation network model (using *Paramics* software) and a series of intersection models (using *SIDRA* software). The model calibration and validation was undertaken for existing traffic conditions (i.e. 2011). Key network operational issues were identified and confirmed with observed traffic data.
- Options considered and refinements undertaken. Three technical workshops were conducted with RMS and key stakeholders. Based on modelling investigations, Hyder has identified ten (10) preliminary short term improvement options. Through the model refinement process, some of those options are combined. In consultation with stakeholders, eight (8) options have been shortlisted for detailed assessment. These are referred to as Options A to H. All eight options were assessed with regard to improving network operational efficiency over the short term. The eight options were assessed under 2011 traffic conditions for both morning and afternoon peak periods.

Traffic Data/Survey and Analysis
Model Development (Paramics, SIDRA)
Model Calibration and Validation
Identify Key Network Issues
Preliminary Options Considered
Stakeholder Workshop 1 (21st of July 2011)
Option Refinements
Options Assessment/Results
Stakeholder Workshop 2 (30th of Aug 2011)
Further Options Assessment
Presentation to Federal Government (7th of Sep 2011)
Stakeholder Workshop 3 (29th of Sep 2011)
Presentation to Stakeholder (20th of Oct 2011)

Figure 1-3 Overview of Hyder's Study Approach

2 REGIONAL AND LOCAL TRANSPORT CONTEXT

The existing traffic and transport conditions in the study area are described within this chapter. It provides the regional and local transport context within which the assessment has been undertaken.

2.1 STUDY AREA

Richmond is located approximately 65 kilometres to the northwest of the Sydney CBD. The study area is geographically subdivided into two by the Hawkesbury River and connected via Richmond Bridge. To the west of the Bridge is North Richmond which is predominantly a residential precinct. To the east is East Richmond which is a mixture of residential, commercial and retail precincts. The RAAF base, located to the east of Richmond, is a major employer. In addition, there are a number of retail units in the main activity area.

The 'Richmond Line' connects Richmond with Sydney and its north-western suburbs via train. The Bells Line of Road/Kurrajong Road that goes through Richmond connects it to the north-western suburbs of Sydney. Access to the western suburbs of Sydney is via Castlereagh Road, Londonderry Road or The Northern Road.

Bells Line of Road also connects Richmond with Kurrajong, located further to the north west of Richmond, via Richmond Bridge. Figure 2-1 shows study area network, through traffic lanes that are available on the section of Bells Line of Road/Kurrajong Road between Grose Vale Road and East Market Street.

Over the years, the steady residential growth in North Richmond and Kurrajong has put additional traffic pressure on Richmond Bridge. During the critical peak periods, intersections on both sides of the Bridge experience major congestion. The two-lane Bells Line of Road on the bridge is also close to capacity.

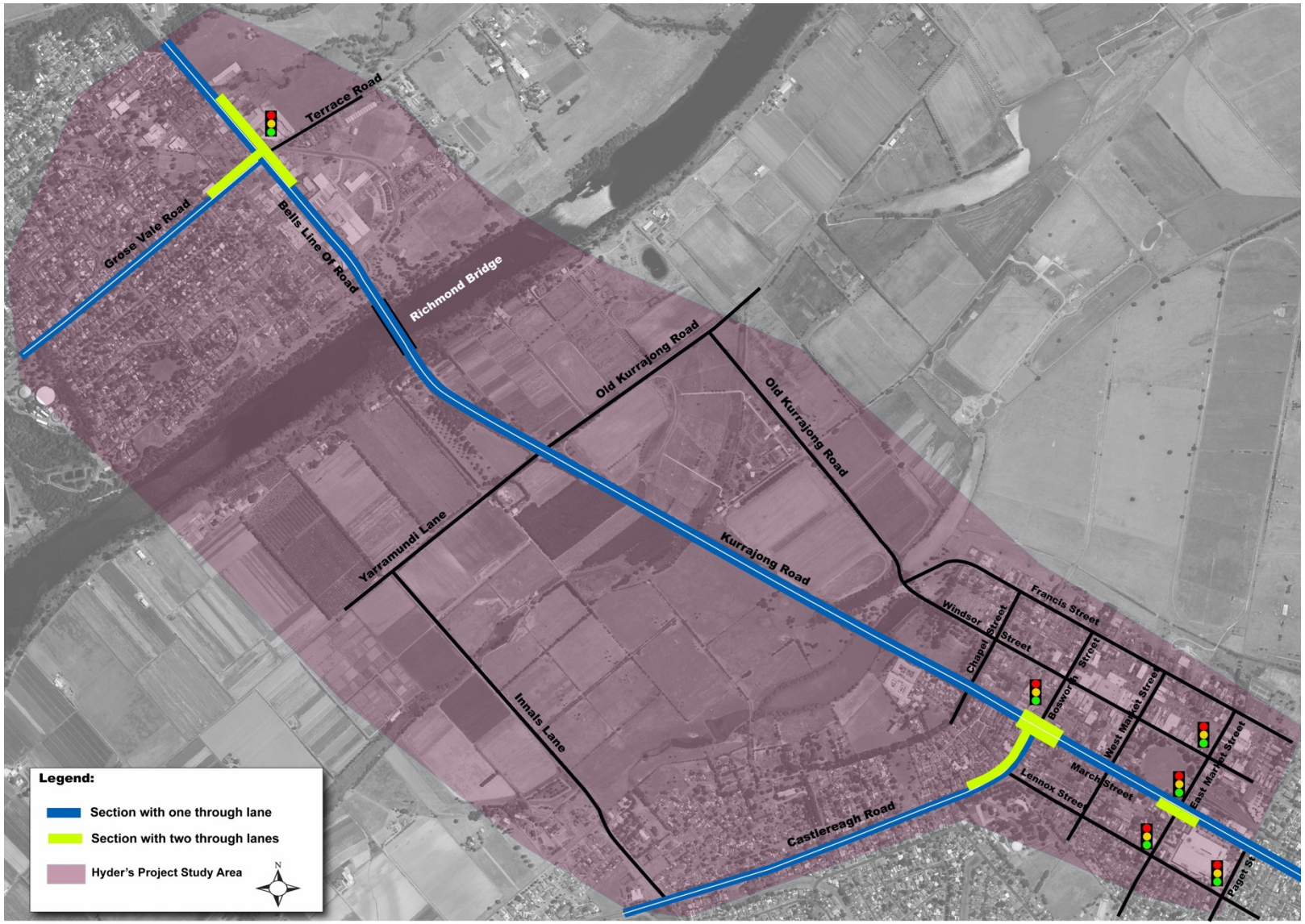

Figure 2-1 Modelling Study Area

2.2 ROAD HIERARCHY

Roads and Maritime Services (RMS), in co-operation with local Councils, defines the functional road hierarchy in an urban area to establish a consistent basis for traffic management. There are three key road categories and their functions are stated as below:

State Roads: Freeways/motorways and primary arterials.

Regional Roads: secondary or sub arterials.

Local Roads: Collector and local access roads.

A generic road hierarchy comprises freeways, primary arterial roads, secondary or sub arterial roads, collector roads and local access roads. The State road network (including the AusLink network) is formed by the primary network of principal traffic-carrying and linking routes for the movement of people and goods within and between major urban centres. Regional roads comprise the secondary network, which together with State roads, provide for travel between smaller towns and districts and perform a sub-arterial function within major urban centres.

The road hierarchy allocated to the road network around the Richmond study area is summarised in Table 2-1 and shown graphically in Figure 2-2. The classification criteria are sourced from *NSW Road Classification Review Panel – Final Report 2007.*

Table 2-1 Existing Road Network Characteristics

Road Names	Road Hierarchy	Characteristics
Bells Line of Road / Kurrajong Road / March Street	State Road	It connects East and North Richmond with the north western suburbs of Sydney. This road is generally a two-lane arterial road. On-street parking bays are provided where it has residential frontages.
Castlereagh Road	Regional Road	This is one of the three alternative roads connecting Richmond with the western suburbs of Sydney, including Penrith. The road is generally two-lanes wide. On street parking bays are provided where there are residential frontages.
Londonderry Road	State Road	This is the other alternative route connecting Richmond with the western suburbs of Sydney, including Penrith. The road is generally two-lanes wide. On street parking bays are provided where there are residential frontages.
Yarramundi Lane / Old Kurrajong Road / Inalls Lane	Local Road	These are local roads but traffic between North Richmond and the western suburbs of Sydney, including Penrith, use it as a 'rat run' route to avoid congested intersections on Kurrajong Road further to the south east of Richmond Bridge.

Road Names	Road Hierarchy	Characteristics
Winsor Street / Lennox Street	State Road	March Street splits into two near Richmond Station and provides two alternative routes to the north eastern suburbs of Sydney. The section of road within the study area goes through the major activity centre in Richmond which includes Richmond Market Place and retail frontages. Together with March Street, which is the extension of Bells Line of Road / Kurrajong Road, and four other north south roads including Bosworth Street, East Market Street and Bourke Street, these roads form a grid pattern with a number of closely located intersections.
Bosworth Street, East Market Street, West Market Street and Bourke Street	Local Road	Part of the Richmond activity centre forming a grid with the east-west roads including Windsor Street and Lennox Street.

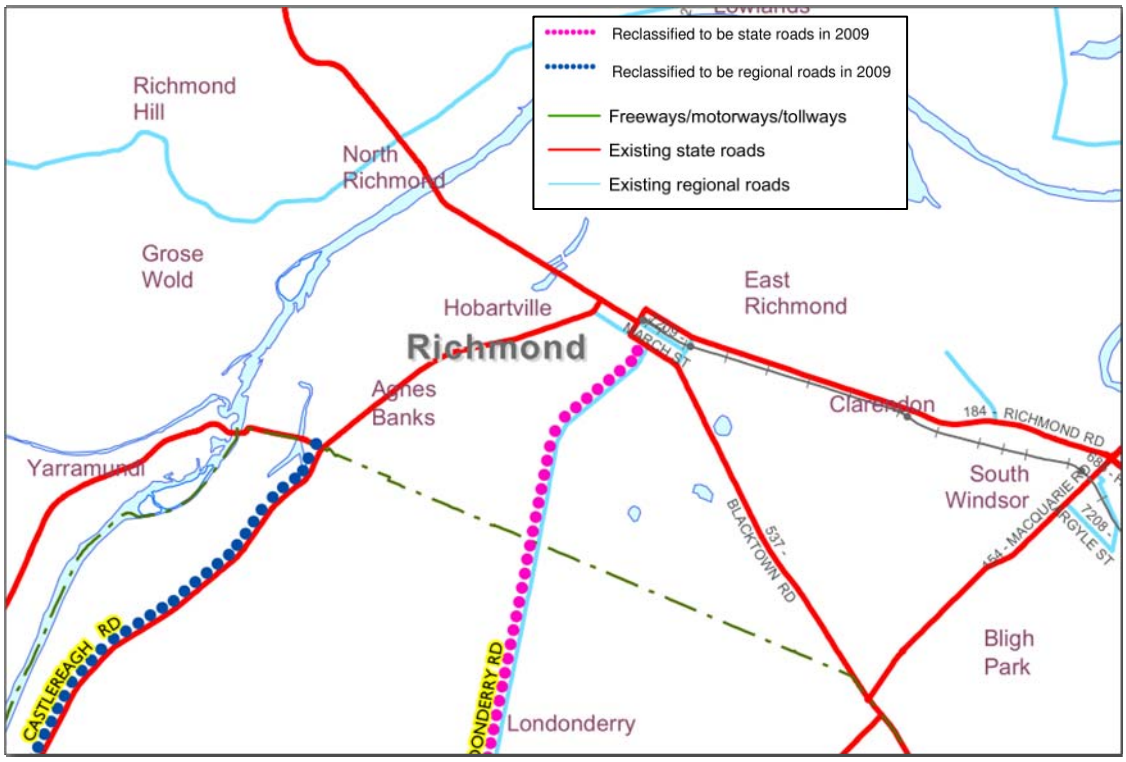

Figure 2-2 Road Hierarchy for the Study Area Network

Note: Local roads are not shown in the map.

Source: RTA May 2009 – Review Panel Final Report Map – Sydney Outer Area

2.3 KEY TRANSPORT INDICATORS

2.3.1 HISTORICAL TRAFFIC GROWTH

Roads and Maritime Services collect traffic volume data at key count locations across the NSW road network. Historical traffic data for Bells Line of Road at Richmond Bridge were obtained from RMS and the Bureau of Transport Statistics (BTS).

Table 2-2 shows historical traffic volumes on Richmond Bridge between 2002 and 2011. Table 2-3 shows historical average growth rates per annum.

The following is of note from the data in Tables 2.2 and 2.3:

- In 2011, Richmond Bridge carried about 27,200 vehicles per day.
- Between 2002 and 2011 Bridge traffic has grown by about 0.7% per annum. Growth has increased to 1.6% per annum between 2008 and 2011.
- The Bridge traffic growth was found to be consistent with regional growth of 1% to 2% per annum observed at other RMS's road survey locations.

Table 2-2 Traffic Trends

AADT/ ADT in Vehicles			Year			
	Count Station	Location	2002 AADT	2005 AADT	2008 ADT (1)	2011 ADT (2)
1	89.044	Richmond Bridge	25,706	25,880	26,010	27,239

Notes:

(1) 2008 data represent 7 days average traffic over one week in June 2008.

(2) 2011 data represent 7 days average traffic over one week in June 2011.

(3) Traffic data for the years 2002 and 2005 were sourced from the RTA. Traffic data in axle pair has been converted to actual vehicle number. It has been assumed that the proportion of trucks with more than two axles represents 5% in the actual traffic mix.

Table 2-3 Annual average traffic growth (%/year)

ID	Road	RTA Count station	Annual Average Growth			
			Between 2002-2005	Between 2005-2008	Between 2008-2011	
1	Richmond Bridge	89.044	▲ 0.2 %	▲ 0.2 %	▲ 1.6 %	
	Average (last 3 years)					▲ 1. 6 %
	Average (last 6 years)					▲ 0. 9 %
	Average (last 9 years)					▲ 0.7 %

2.3.2 COMMUTER MODE SHARE, RICHMOND AREA

The Bureau of Transport Statistics (BTS) has provided journey to work (JTW) data for the Sydney Metropolitan Area (GMA), collected during the 2006 Census. Work trip origin and destinations are coded to the 2006 travel zones.

This data is summarized in Table 2.4, below. The following should be noted:

- There is some variation in the pattern of trips exhibited by residents and those arriving to the area for work.
- Walking and cycling comprise a significant number of trips.
- Car (as driver or passenger) is the dominant mode of motorised transport.

Table 2-4 Daily Work Trip Modal Distribution for Richmond

Travel Mode	Core area as home (Outbound trips)	% Core area as Home	Core area as workplace (Inbound trips)	% Core area as Workplace
Car Driver	3,722	64.6%	5,672	68.1%
Car Passenger	286	5.0%	531	6.4%
Train	317	5.5%	91	1.1%
Bus	15	0.3%	26	0.3%
Other (Walking, Cycle,)	499	8.7%	1,398	16.8%
Worked at home/ Did not travel/ Not stated	925	16.0%	612	7.3%
Total	**5,764**	**100%**	**8,330**	**100%**

2.3.3 CRASH DATA

This assessment is based on the crash data supplied by the RMS for the five-year period from 2005 to 2009 inclusive. The data covers crashes reported to the Police, and includes fatal, injury or vehicle damage only accidents. A total of 365 crashes were recorded in the five year period within the study area. Of the total crashes 153 (42%) resulted in casualties. Two crashed resulted in fatalities. Over two third of the total crashes occurred at intersections. About 96 (26%) crashes occurred when a vehicle was hit from behind by the following vehicle. About 74 (20%) crashes occurred when vehicles undertaking turning manoeuvre were hit by other vehicles. Pedestrians were involved in 15 (4%) crashes. About 64 crashes (18) occurred during the hours of darkness. 43 (12%) crashes occurred when the road surface was wet.

Figure 2-3 shows crash locations within study area for the period between 2005 and 2009. Crashes on the map are classified by severity, showing fatal, injury and non-casualty (tow-away) crashes.

The spatial crash distribution indicates that crashes occurred along the major trafficable roads but they are more concentrated at intersections. Some particular crash locations include:

- Kurrajong Road/Yarramundi Lane/Old Kurrajong Road intersection (priority sign control);

- Kurrajong Road/Bosworth Street intersection (traffic light control);
- March Street/East Market Street intersection (traffic light control);
- Castlereagh Road/Innals Lane intersection (priority sign control).

Crash classification by severity showed that between 2004 and 2009, two fatal crashes occurred at Kurrajong Road/Yarramundi Lane/Old Kurrajong Road and Castlereagh Road/Innals Lane intersections.

Other crash locations in the study area showed mixed injury and non-casualty crashes.

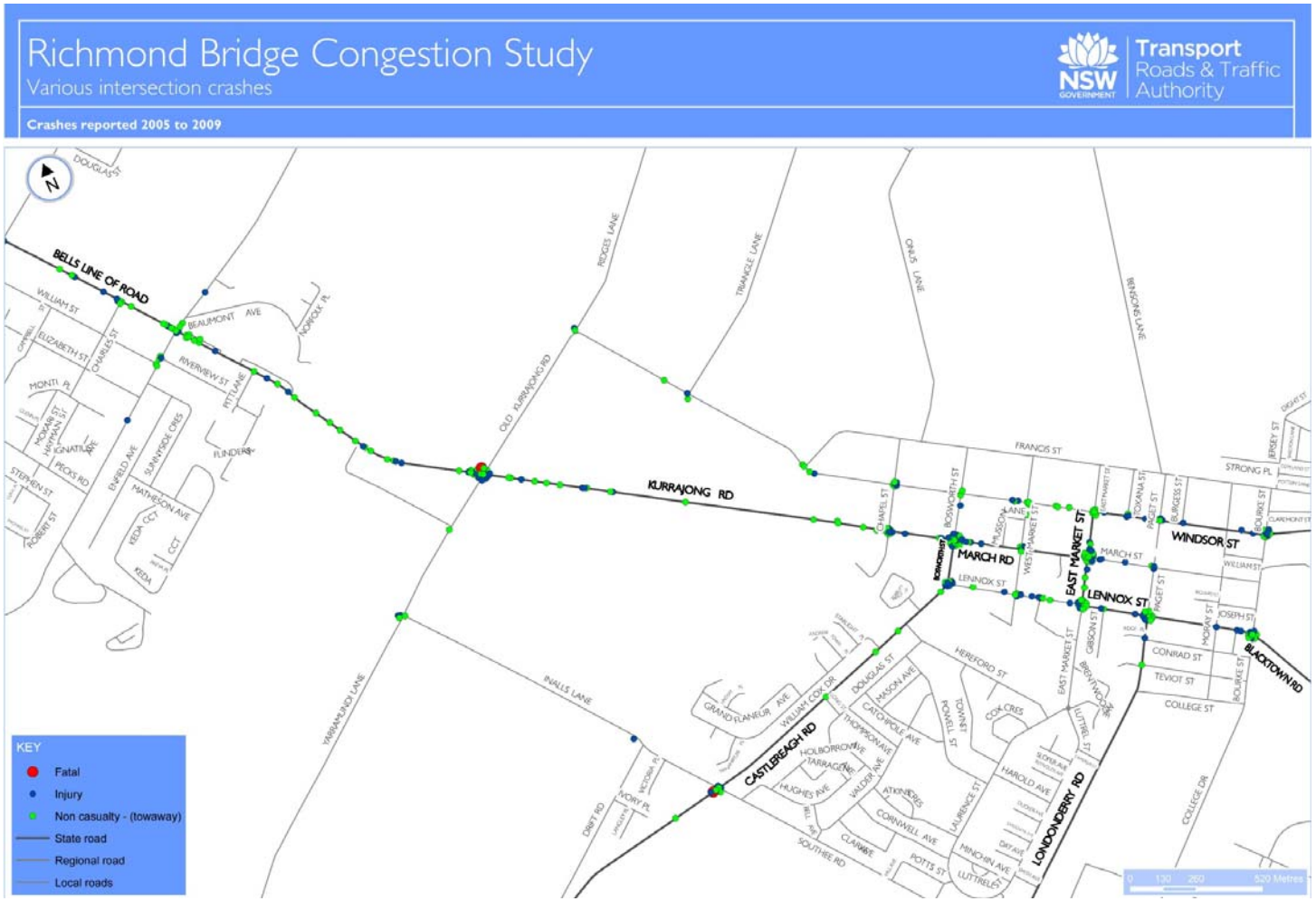

Figure 2-3 Spatial distribution of crashes