6 Technical considerations

6.1 Traffic and transport

6.1.1 Existing transport network

The road network in the study area can be categorised into the follow functions:

- Arterial roads
- Collector roads
- Local roads

In addition to the above functional classification, RMS has an administrative classification for the funding and management of the State's road network. This classification comprises:

- State classified roads (main roads, highways and motorways), which are under the care, control and management of RMS.
- Regional roads which are partly funded by RMS but under the care and control of relevant local councils.
- Other roads which are under the care and management of relevant local councils.

Within the study area, the arterial roads are managed by RMS. The remaining collector and local streets are under the care and control of Hawkesbury City Council.

Table 5 - Functional road hierarchy

Road class	*Description*	*Through traffic*	*Speed limit (km/h)*
Arterial road	Regional road in urban areas, forming the principal corridors for transport movements. Typical traffic volumes greater than 15,000 vehicles per day (vpd)	Yes	70-100
Sub-arterial road	Provide links from arterial roads to areas of development or carry traffic from one part of a subregion to all parts of the region. May relieve traffic on arterial roads in some circumstances. Typical traffic volumes between 5,000 and 20,000 vpd	Some	60-80
Collector roads	Provide links from sub-arterial or arterial roads to the local road system in developed areas. Typical traffic volumes between 2,000 and 10,000 vpd	Little	40-60
Local roads	Provide direct vehicular access to the development or development precinct and connect to the collector, sub-arterial or arterial road network. Low volumes, usually less than 2,000 vpd	No	40-50

Source: RMS Network Planning Practice Notes and Austroads

Table 6 provides a description of the roads that form the corridor which is under investigation as part of this study.

Table 6 - Description of existing road network

Road	*Description*
March Street	March Street is a classified State road under the care and control of RMS. It continues into Kurrajong Road, northwest from its intersection with Bosworth Street. March Street comprises a single carriageway with a two-lane, two-way configuration and parallel parking provision on both sides for the majority of its length. It has a posted speed limit of 60 km/h. At its signalised intersection with Bosworth Street, March Street widens to two lanes in each direction, through the removal of the parking provision, for a length of approximately 77 metres on the eastbound departure and 50 metres on the westbound approach. The intersection of March Street and West Market Street is giveway-controlled, with March Street as the major priority approach. At its signalised intersection with East Market Street, March Street has a left-turn bay of approximately 50 metres on the south-eastbound approach and a second lane of approximately 50 metres on the north-westbound approach. The departure on the north-western side of East Market Street comprises a short second lane of approximately 40 metres. March Street is a dedicated B-double and 4.6 metre high vehicle route.
Kurrajong Road	Kurrajong Road is a classified State road under the care and control of RMS. It continues into March Street southeast from its intersection with Bosworth Street. Kurrajong Road comprises a single carriageway with one lane in each direction for the majority of its length. It has a posted speed limit of 60 km/h from approximately 300 metres south-east of its intersection with Old Kurrajong Road (Yarramundi Lane) to North Richmond and a posted speed limit of 80 km/h from approximately 300 metres south-east of its intersection with Old Kurrajong Road (Yarramundi Lane) to Richmond. The intersection of Kurrajong Road and Old Kurrajong Road (Yarramundi Lane) is a four-way, giveway-controlled intersection with all movements allowed. The intersection of Kurrajong Road and Chapel Street is a four-way, giveway-controlled intersection with all movements allowed. At its intersection with Bosworth Street, Kurrajong Road widens to two lanes in each direction (south-eastbound approach and north-westbound departure) for a length of approximately 55 metres. Kurrajong Road is a dedicated B-double and 4.6-metre high vehicle route.
Bells Line of Road	Bells Line of Road is a classified State road under the care and control of RMS. It continues into Kurrajong Road at the Richmond Bridge. It comprises a single carriageway with one lane in each direction for the majority of its length. Within the study area, it has a posted speed limit of 60 kilometres per hour. Bells Line of Road has a signalised intersection with Grose Vale Road/ Terrace Road. Right-turn bays are provided into Grose Vale Road and Terrace Road, with lengths of approximately 40 metres and 58 metres (including taper), respectively. A left-turn lane of approximately 130 metres is provided into Grose Vale Road. A second departure lane of approximately 170 metres is provided on Bells Line of Road, south-east of its intersection with Grose Vale Road and Terrace Road. A channelised giveway controlled intersection is located at Bells Line of Road and Pitt Lane. A left-turn lane of approximately 155 metres and a right-turn bay of approximately 70 metres are provided from Bells Line of Road into Pitt Lane. Bells Line of Road is a dedicated B-double and 4.6 metre high vehicle route.

Road	*Description*
East Market Street	East Market Street is a regional road, which is under the care and control of council with partial funding from RMS. On both approaches to its intersection with March Street, East Market Street comprises two lanes in each direction. March Street is a dedicated B-double and 4.6 metre high vehicle route.
West Market Street	West Market Street is a local road under the care and control of council. It comprises a two-way, two-lane configuration.
Bosworth Street	Bosworth Street is a regional road, on the south western side of March Street, which is under the care and control of council, with partial funding from RMS. On the north eastern side of March Street, Bosworth Street is a local road under the care and control of council. On the north-eastbound approach to its intersection with March Street, Bosworth Street comprises two lanes for a length of approximately 300 metres. The Bosworth Street departure on the south-western side of the March Street intersection comprises two lanes for approximately 150 metres. On the north-eastern side of March Street, Bosworth Street consists of two lanes in each direction for a length of approximately 50 metres, which narrows to one lane in each direction on the approach to its roundabout-controlled intersection with Windsor Street. Bosworth Street is a dedicated B-double and 4.6 metre high vehicle route on the south western side of March Street.
Chapel Street	Chapel Street is a local road under the care and control of council. It comprises a two-way, two-lane configuration.
Old Kurrajong Road (Yarramundi Lane)	Old Kurrajong Road (Yarramundi Lane) is a local road under the care and control of Council. It comprises a two-way, two-lane configuration and has a posted speed limit of 60 km/h. Old Kurrajong Road (Yarramundi Lane) provides access to rural residential properties on the south western side of Kurrajong Road.
Old Kurrajong Road	Old Kurrajong Road is a local road under the care and control of council. It comprises a two-way, two-lane configuration and has a posted speed limit of 60 km/h. Old Kurrajong Road provides access to rural residential properties and Windsor Polo Club on the north eastern side of Kurrajong Road.
Pitt Lane	Pitt Lane is a local road under the care and control of council comprising a one-way, one-lane configuration. It primarily provides access to the North Richmond shopping village car park on the south western side of Kurrajong Road.
Grose Vale Road	Grose Vale Road is a regional road under the care and control of council with partial funding provided by RMS. Grose Vale Road is a two-way, two-lane configuration for the majority of its length. At its signalised intersection with Kurrajong Road/Bells Line of Road, it consists of two lanes in each direction, including a dedicated right-turn lane onto Kurrajong Road. Grose Vale Road has a posted speed limit of 60 km/h with a school zone commencing approximately 70 metres southwest of the intersection with Kurrajong Road.
Terrace Road	Terrace Road is a regional road, under the care and control of council with partial funding provided by RMS. Terrace Road comprises a two-way, two-lane configuration and has a posted speed limit of 60 km/h. Approximately 40 metres from the intersection with Kurrajong Road, Beaumont Avenue intersects with Terrace Road, providing rear access to a number of commercial properties.

6.1.2 Public transport

Figure 21 on page 30 shows the existing bus service routes and bus stop locations in the study area.

Table 7 summarises the frequency of bus service in the study area.

Table 7 - Frequency of existing bus services

Route	Description	Frequency (minutes)			
		AM peak	PM peak	Off-peak	Sunday/ Public Holiday
680	Richmond to Bowen Mountain to Richmond, via Kurrajong, Grose Vale and Grose Wold	Infrequent service	Infrequent service	Infrequent service	Two services only
682	Richmond to Kurrajong, via Bells Line of Road (extends to Berambing)	15 to 30	30	Infrequent service	Two services only
668	Windsor to Richmond, via Wilberforce, Glossadia, Freemans Reach and North Richmond	Infrequent service	60	Infrequent service	Two services only

6.1.3 Pedestrians and cyclists

Figure 22 on page 31 shows the existing and proposed pedestrian and cyclist facilities in the study area.

6.1.4 Traffic modelling

Based on the traffic surveys conducted for the Stage 1 investigations it was identified that Kurrajong Road at Richmond Bridge is approaching capacity in the peak directions. A typical measure used in assessing traffic capacity for a road is to adopt a lane capacity allowance of 1,200 vehicles per lane per hour. Kurrajong Road currently experiences between 1,300 and 1,600 vehicles per hour per direction in peak periods, therefore a long term solution is required to ensure future traffic growth can be accommodated.

A number of key intersections along the corridor also currently experience significant queuing and delays. The following issues were identified in the Stage 1 investigations, under existing traffic conditions:

- No dedicated right-turn bay is provided for south-eastbound traffic turning right from Kurrajong Road into Bosworth Street. This results in through traffic being blocked at this intersection during the morning peak period.
- The absence of a dedicated right-turn lane from Kurrajong Road into Old Kurrajong Road/Yarramundi Lane blocks through traffic travelling eastbound towards Richmond during the morning peak period. There is a significant amount of traffic turning right at this location.
- The bus stop on Kurrajong Road, east of its intersection with Grose Vale Road and Terrace Road, blocks through traffic travelling towards Richmond. This issue is compounded by the merge from two to one lane.
- Significant queues are experienced by vehicles on the Grose Vale Road approach of its intersection with Bells Line of Road resulting from a high volume of vehicles turning right into Bells Line of Road during the morning peak period.

The traffic and transport investigations completed to date for the corridor study include:

- Modelling undertaken during Stage 1 investigations (Hyder).
- RMS modelling undertaken to inform the Stage 2 investigations.

The above investigations have been considered and supplemented by intersection modelling in order to identify the constraints on the corridor.

6.1.5 Future traffic volumes

Strategic traffic modelling outputs for forecast traffic volumes were prepared for the following scenarios:

1. Base case (assumed implementation of short term options).
2. Richmond Bridge improvements with North Richmond development, 2031 and 2036 AM and PM peak periods.
3. North Richmond development, with construction of Grose River Bridge and Bells Line of Road Option 3 (Southern), 2031 and 2036, AM and PM peak periods.
4. North Richmond development, with construction of Grose River Bridge and Bells Line of Road Option 4 (Driftway), 2031 and 2036, AM and PM peak periods.

These strategic modelling outputs form the basis for determining the number of lanes required for the corridor after 2021. Table 8 and Table 9 summarise the forecast traffic volume outputs (total number of vehicles) from strategic models, for the AM and PM peak periods, respectively for the link between East Market Street, Richmond and Grose Vale Road, North Richmond.

The AM peak period is between 7:00 AM and 9:00 AM and the PM peak period is between 4:00 PM and 6:00 PM.

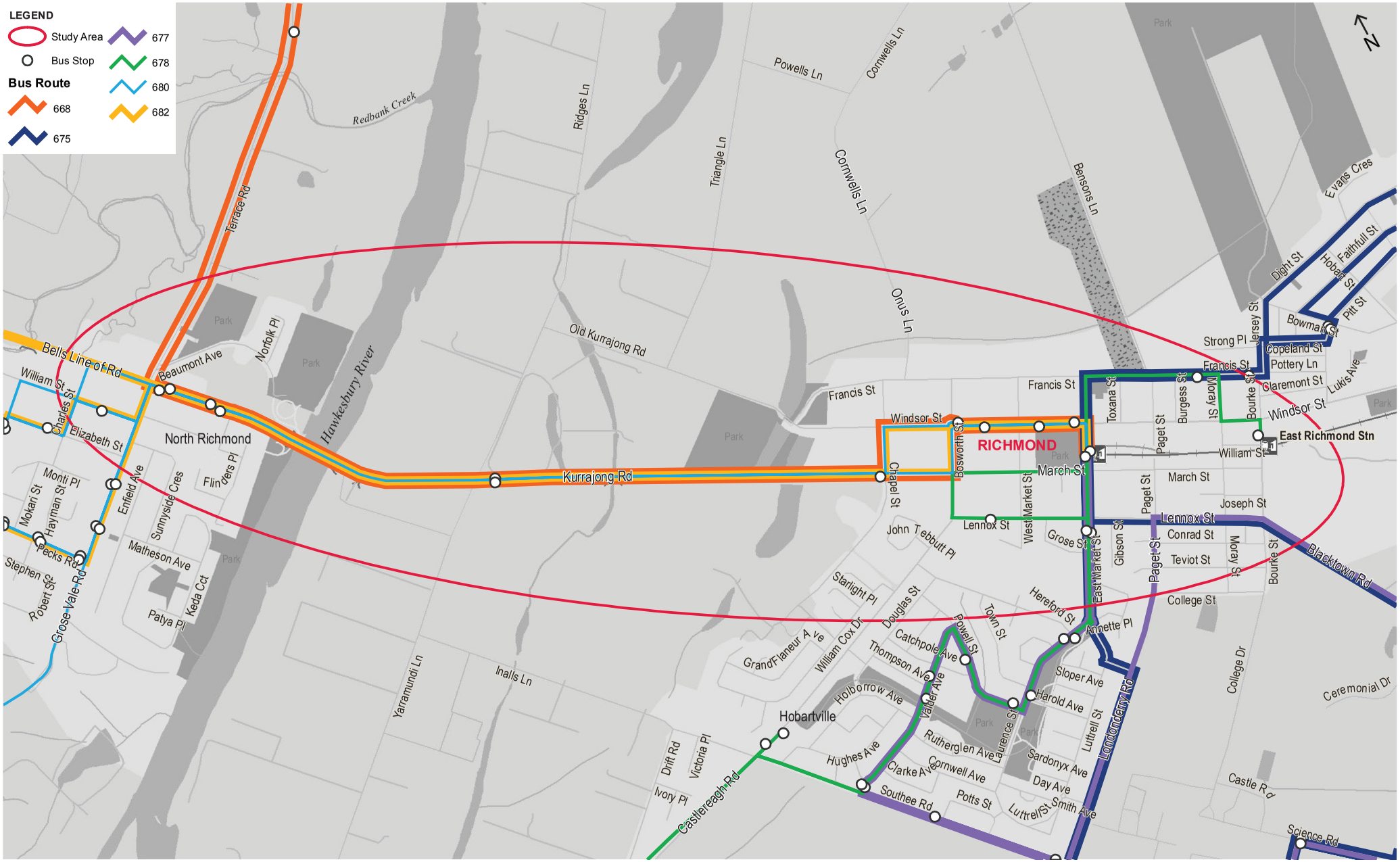
Table 8 - Forecast traffic volumes AM peak period (two hours)

Scenario	2011		2016		2021		2031		2036	
	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB
1. Base Case	1369	2898	1530	3099	1642	3268	1785	3549	1853	3695
2. Richmond Bridge Improvements with North Richmond development							1908	4239	1961	4386
3. Bells Line of Road (Southern) and Grose River Bridge							913	2615	956	2633
4. Bells Line of Road (Driftway) and Grose River Bridge							755	2178	787	2241

Table 9 - Forecast traffic volumes PM peak period (two hours)

Scenario	2011		2016		2021		2031		2036	
	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB
1. Base Case	2899	1692	3084	1799	3203	1913	3458	2015	3547	2076
2. Richmond Bridge Improvements with North Richmond development							4107	2117	4202	2174
3. Bells Line of Road (Southern) and Grose River Bridge							2241	1335	2321	1384
4. Bells Line of Road (Driftway) and Grose River Bridge							1941	1045	2001	1085

The strategic traffic modelling outputs were used to determine the number of lanes required for the corridor based on forecast traffic volumes. This analysis was based on vehicle/capacity ratios to determine the mid-block Levels of Service (Highway Capacity Manual [HCM], Transportation Research Board, 1994). The lane capacity assumed for the purpose of this analysis is 1,200 vehicles per lane per hour.



Sources - Vector Backdrop Data © 2011 Public Trasnport Data - RMS

Figure 21 Existing bus service routes

Sources - Vector Backdrop Data © 2011 Public Trasnport Data - RMS

Figure 22 Pedestrian and cyclist network

The Level of Service for the corridor is based on the volume to capacity (V/C) ratios for arterial roads (HCM, 1994). The lane capacity assumed for this analysis is 1,200 vehicles per hour per lane. The Levels of Service are summarised in Table 10.

Table 10 - Levels of service for arterial roads, V/C ratios

Level of Service	*Description*	*V/C Ratio*
A	Free-flow conditions with unimpeded manoeuvrability. Stopped delay at signalised intersections is minimal.	0.00 to 0.60
B	Reasonable unimpeded operations with slightly restricted manoeuvrability. Stopped delays are not bothersome.	0.61 to 0.70
C	Stable operations with somewhat more restrictions in making mid-block lane changes than Level of Service B. Motorists will experience appreciable tension while driving.	0.71 to 0.80
D	Approaching unstable operations where small increases in volume produce substantial increases in delay and decreases in speed.	0.81 to 0.90
E	Operations with significant intersection approach delays and low average speeds.	0.91 to 1.00
F	Operations with extremely low speeds caused by intersection congestion, high delay and adverse signal progression.	>1.00

Based on the forecast traffic volumes summarised in Table 8 and Table 9, the minimum number of lanes required during the AM and PM peak periods to obtain an acceptable Level of Service (D or better) are presented in Table 11 and Table 12 respectively. The corresponding Levels of Service are shown in brackets in the tables.

Table 11 - Number of lanes required AM peak period

Scenario	*2031*		*2036*	
	WB	*EB*	*WB*	*EB*
2. Richmond Bridge Improvements with North Richmond development	1 (C)	2 (D)	1 (D)	2 (E)
3. Bells Line of Road (Southern) and Grose River Bridge	1 (A)	2 (A)	1 (A)	2 (A)
4. Bells Line of Road (Driftway) and Grose River Bridge	1 (A)	2 (A)	1 (A)	2 (A)

Table 12 - Number of lanes required PM peak period

Scenario	*2031*		*2036*	
	WB	*EB*	*WB*	*EB*
2. Richmond Bridge Improvements with North Richmond development	2 (D)	1 (D)	2 (D)	2 (A)
3. Bells Line of Road (Southern) and Grose River Bridge	2 (A)	1 (A)	2 (A)	1 (A)
4. Bells Line of Road (Driftway) and Grose River Bridge	2 (A)	1 (A)	2 (A)	1 (A)

Table 13 provides a summary of the key outcomes of the traffic and transport analyses completed to date for the study.

Table 13 - Traffic and transport impacts of the strategic concept options

Option	*Description of impacts on corridor*
Richmond Bridge upgraded/ Bells Line of Road and Grose River Bridge are not upgraded	Without Bells Line of Road and Grose River Bridge improvements, Richmond Bridge will be close to capacity in the AM peak by 2036, even with two lanes in the peak direction. If Bells Line of Road and Grose Bridge are not upgraded, Richmond Bridge will require two lanes in each direction (not just the peak direction) by 2036.

The key findings of the traffic and transport assessments completed to date are summarised in Table 14 below. They have been used to inform the option identification and assessment process to identify the short list of strategic concept options.

Table 14 - Key findings of the traffic and transport assessment process

Corridor element	*Key findings*
Richmond Bridge upgraded, though Bells Line of Road and Grose River Bridge not upgraded	Introduction of signalised control at the four give way intersections (West Market Street, Chapel Street, Old Kurrajoing Road/ Yarramundi Lane and Pitt Lane), improves the overall operation of these intersections in 2036
East Market Street	The operation of the intersection of East Market Street improves to an acceptable level by removing the on-street parking along East Market and March Street during the peak periods
Kurrajong Road and Bosworth Street intersection	The operation of this intersection is improved to an acceptable level by removing the on-street parking along Kurrajong Road during the peak periods.
Kurrajong Road and Chapel Street intersection	The operation of this intersection is improved to an acceptable level by installing signalised control and removing the on-street parking along the north-western approach of Kurrajong Road during the peak periods.
March Street and West Market Street, Kurrajong Road and Old Kurrajong Road (Yarramundi Lane) and Kurrajong Road and Pitt Lane intersections	These intersections have been modelled in isolation during the preliminary modelling as being signalised. In the strategic options it has not been proposed to signalise these intersections. It is considered that during the next phase of modelling, once a preferred option is identified, these intersections may need to be signalised to obtain an acceptable level flow through the intersections and along the corridor. The final layouts for these intersections will be confirmed at that time.
Kurrajong Road and Old Kurrajong Road intersection	The configuration of the Kurrajong Road and Old Kurrajong Road/ Yarramundi Lane intersection varies across the options. For Options A, B, and C all existing movements remain with the provision of a dedicated right turn bay on Kurrajong Road for eastbound traffic to access Old Kurrajong Road/Yarramundi Lane. For Option D, the right-turn movement out of the northern approach of Old Kurrajong Road and through movements from both Old Kurrajong Road/Yarramundi Lane approaches would not be possible due to the elevated carriageway along Kurrajong Road. This is likely to impact a low number of vehicles, with a total of approximately 20 vehicles during the AM peak and five vehicles in the PM peak.
Bells Line of Road, Grose Vale Road, and Terrace Road intersection	This intersection requires a significant upgrade. This will be investigated further once a preferred option is identified.

To identify the detailed impacts of the preferred option, further traffic and transport investigations need to be undertaken once a preferred option is identified, as detailed in Section 7.2 of this report.

6.1.6 Contra flow traffic management

A contra flow traffic management system is proposed for Option A. It would be in operation in the eastbound direction in the morning (AM) peak and in the westbound direction in the afternoon/evening (PM) peak. During these peak periods two travel lanes would be provided across the bridge in the direction of travel during peak periods.

It is proposed that this system be in operation across the bridge and commence from each approach (approximately 50 metres west of Old Kurrajong Road/Yarramundi Lane on the Richmond side and approximately 120 metres east of Pitt Lane on the North Richmond side).

Several issues in relation to the operation of a contra flow management system will require further consideration should this option be considered. These include but are not limited to:

- Operational cost and maintenance.
- The Workplace Health and Safety (WHS) considerations involved in the set-up/pull-down of the system prior to and following the peak hour period.
- The impact on travel times along the corridor due to the lead time needed for the set-up and pull-down of the system.
- Consideration of a more robust and heavier system (using concrete barriers similar to those used on Victoria Road in Sydney) and the cost (capital, maintenance, operational), space, and loadings on the existing bridge, especially in relation to the serviceable life of the bridge structure.
- The potential need for an on-site traffic crew during the operation of the contra flow in case of an incident on the bridge (where there are only three lanes) and its approaches.
- The relocation of bus stops and consideration of safe crossing points for pedestrians and cyclists across this section of the corridor during the operation of the contra flow.

6.1.7 Road safety considerations

Summary crash statistics collected over the five year period between 2005-2009 are outlined in the Table 15.

Table 15 - Crash statistics

Location	*No. Crashes*	*No. Casualties*	*No. Fatal Crashes*	*No. Injury Crashes*	*No. Non-casualty Crashes*
Yarramundi Lane/Old Kurrajong Road 150 metres south of Inalls Lane and 250 metres north of Kurrajong Road	32	21	1 (3.1%)	12 (37.5%)	19 (59.4%)
March Street, Kurrajong Road, Bells Line of Road between Paget Street (Richmond) and Crooked Lane (North Richmond)	185	96	1 (0.5%)	69 (37.3%)	115 (62.2%)

Yarramundi Lane/Old Kurrajong Road 150 metres south of Inalls Lane and 250 metres north of Kurrajong Road:

- Over 96 percent of crashes were located at an intersection (or up to 10 metres from one).
- 25 percent of crashes were between vehicles from adjacent approaches to an intersection and over 62 percent being rear end crashes.
- Over 81 percent of crashes occurred in dry weather and 75 percent of crashes occurred in daylight hours.

March Street, Kurrajong Road, Bells Line of Road between Paget Street (Richmond) and Crooked Lane (North Richmond):

- 60 percent of crashes were located at an intersection (or up to 10 metres from one).
- Over 41 percent of crashes were rear end crashes, over 17 percent of crashes were between vehicles from adjacent approaches to an intersection and over 17 percent of crashes were from turning vehicles in the opposing direction.
- Over 85 percent of crashes occurred in dry weather and over 77 percent of crashes occurred in daylight hours.

The crashes summarised above are typical to an urban environment generally occurring at intersections and locations where turning vehicle conflict is present. The higher proportion of rear end crashes is also typical to an urban environment and generally reflective of the traffic patterns and congestion currently being experience along the corridor.

Although the above crashes do exist these are generally as a result of the traffic patterns and congestion, as opposed to a direct road safety issue with the corridor or the intersections along it. Although the proposed route options have primarily been developed to address the traffic congestion issue, the improvements will provide road safety benefits achieved through the following design features:

- Traffic signal control at intersections with right turn bays and signal controlled pedestrian crossings.
- Off road shared use path between Chapel Street and the bridge for pedestrians and cyclists, connecting to facilities in Richmond and North Richmond.
- Right turn bay for eastbound access from Kurrajong Road into Old Kurrajong Road/Yarramundi Lane.
- Wire rope safety barrier along divided and elevated carriageways.
- Mid block signalised pedestrian crossing between Pitt Lane and Grose Vale Road.
- Rationalisation of bus stops in North Richmond to provide a single eastbound and westbound bus stop (located in close proximity to the mid block pedestrian crossing).

A road safety audit will also be carried out on the strategic concept design of the preferred option to ensure that the design meets all necessary road design and road safety engineering requirements.