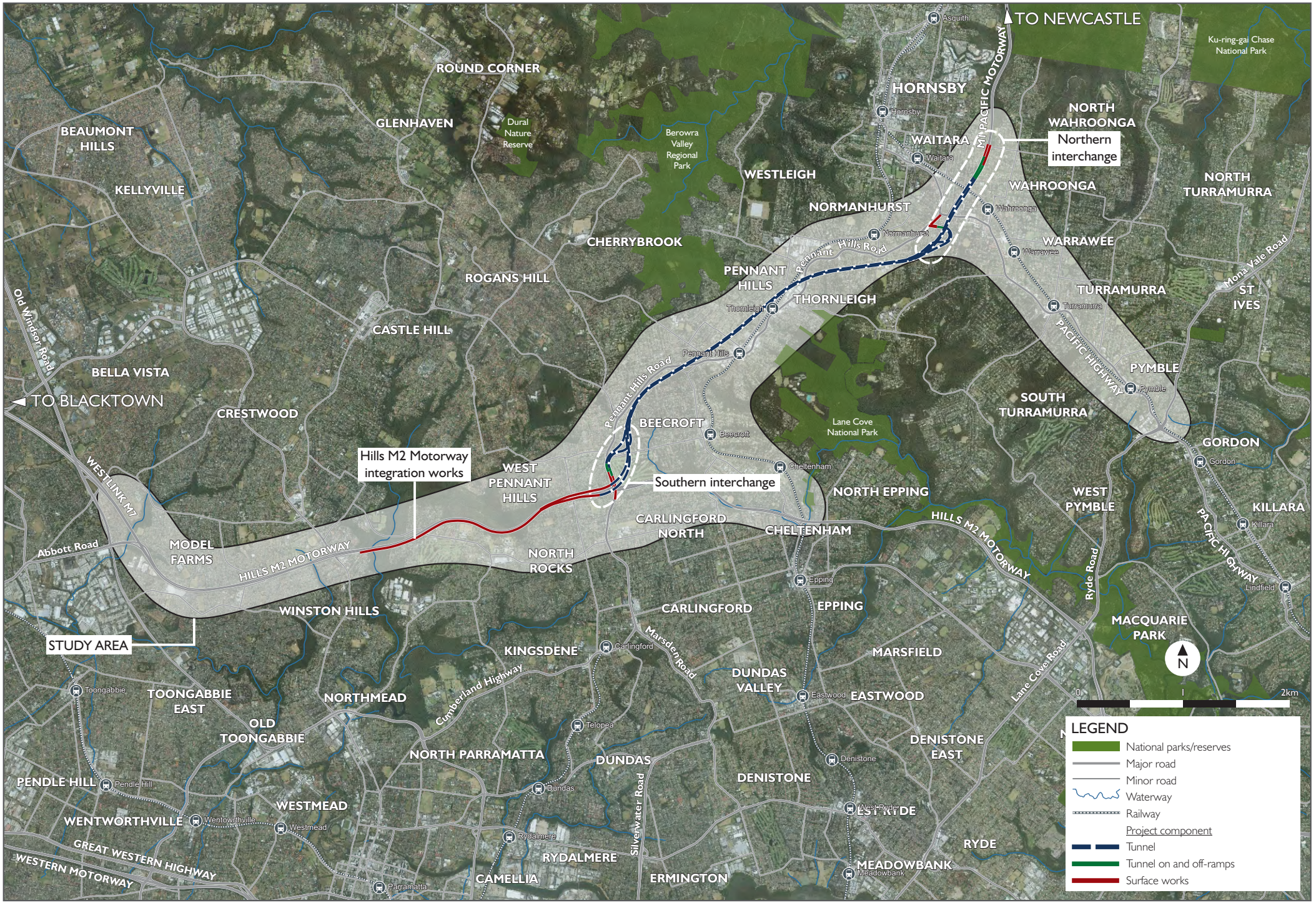

Figure 3-1 Study area

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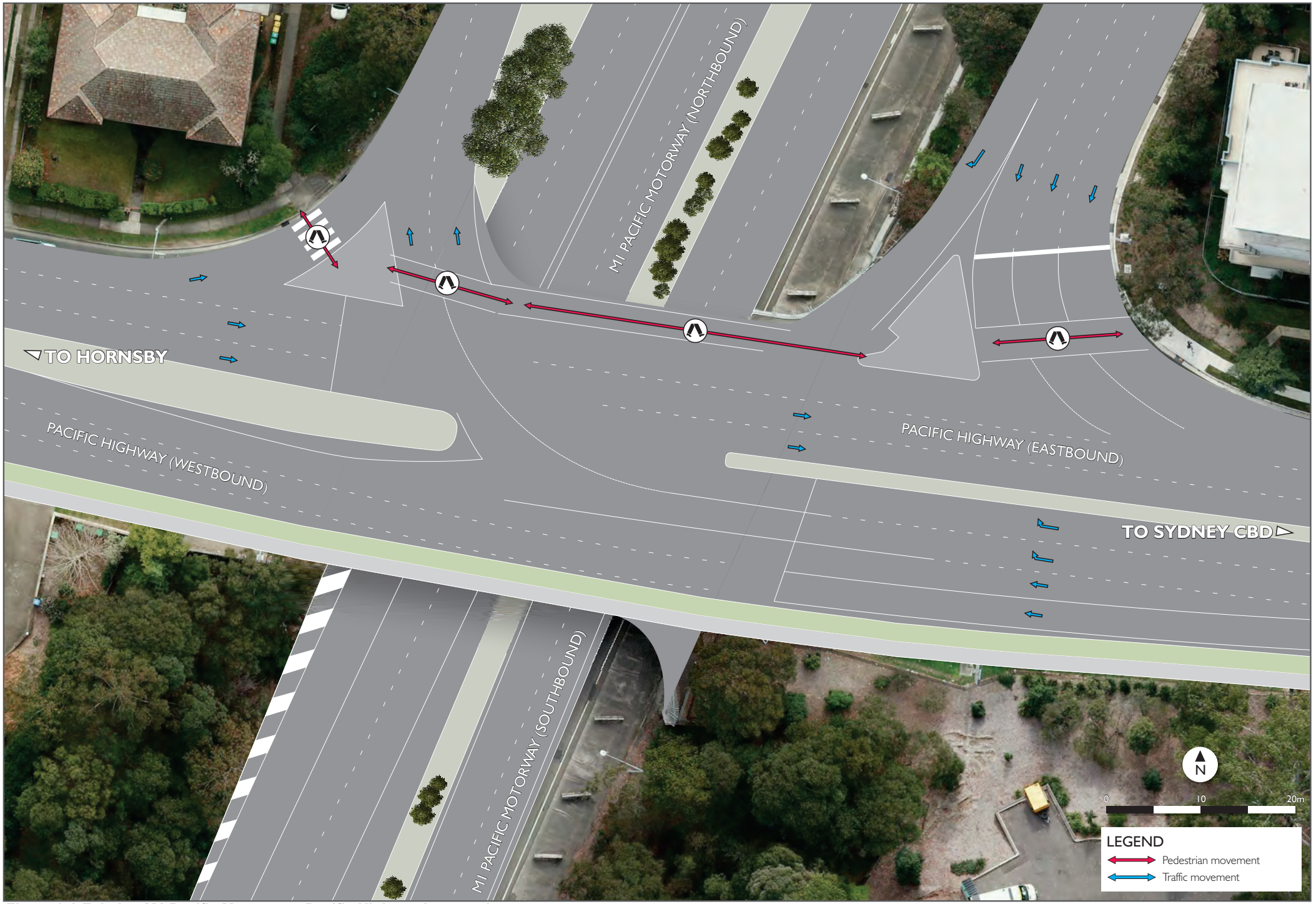

Figure 3-2 Existing M1 Pacific Motorway - Pacific Highway Intersection

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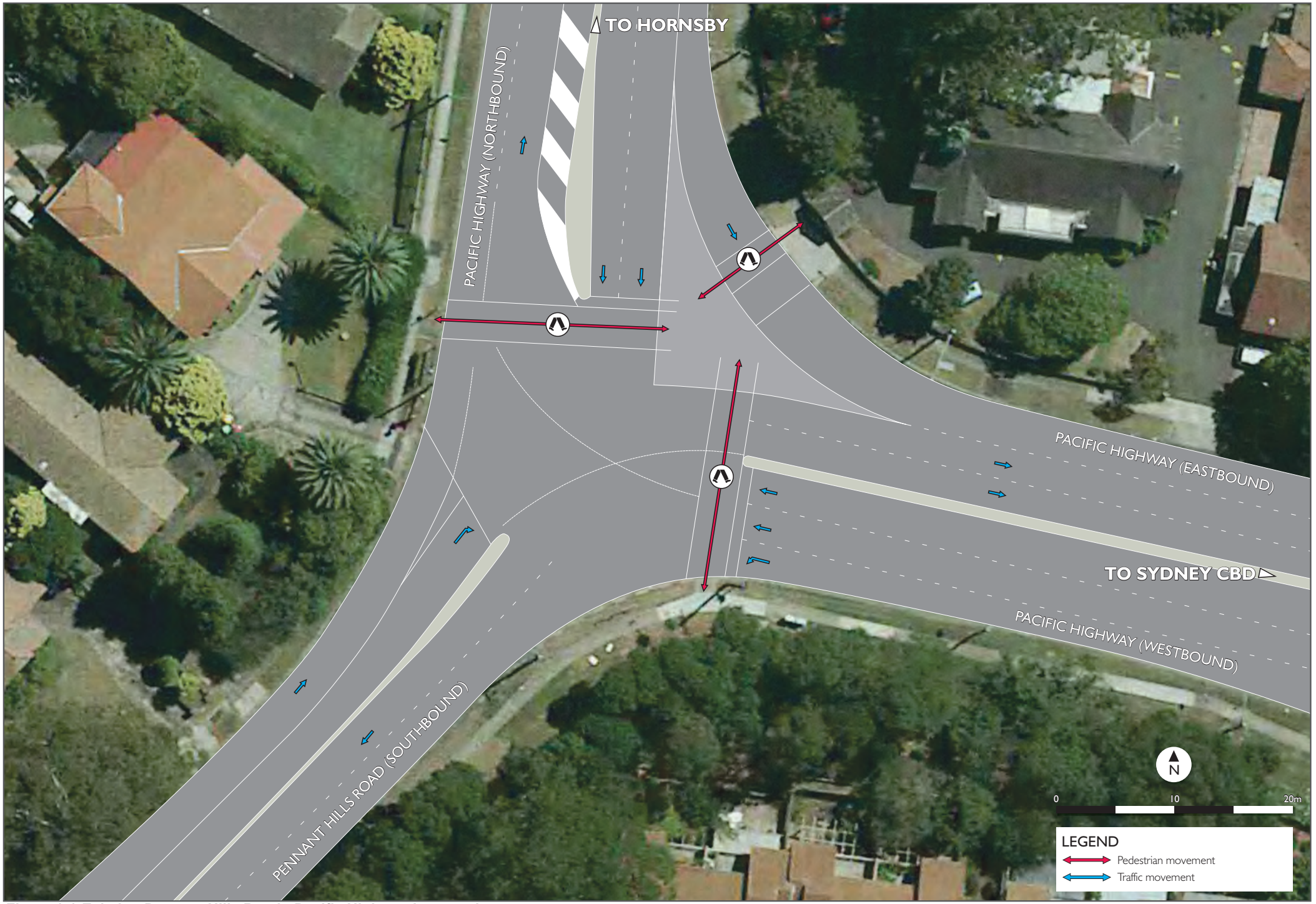

Figure 3-3 Existing Pennant Hills Road - Pacific Highway Intersection

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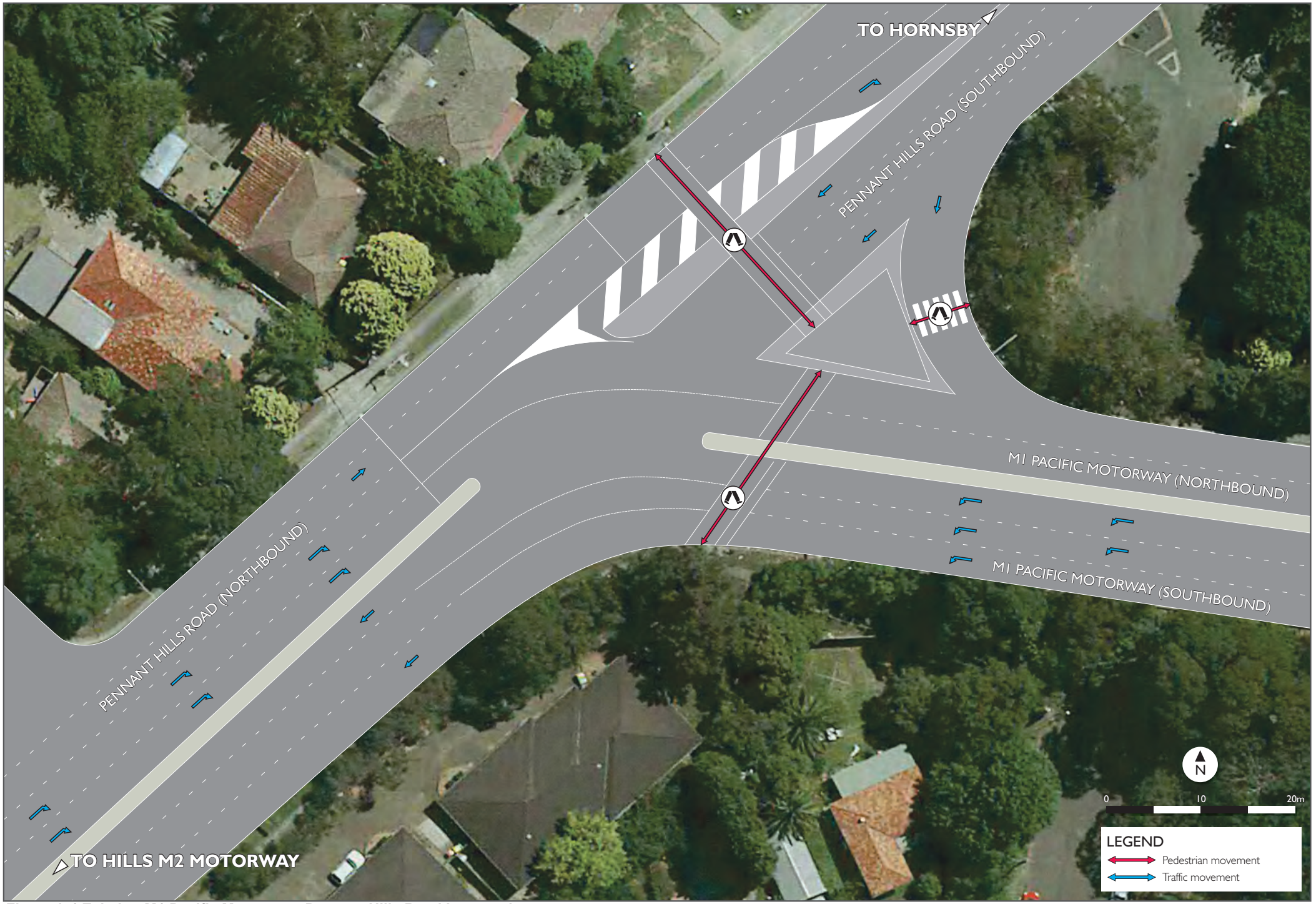

Figure 3-4 Existing M1 Pacific Motorway - Pennant Hills Road Intersection

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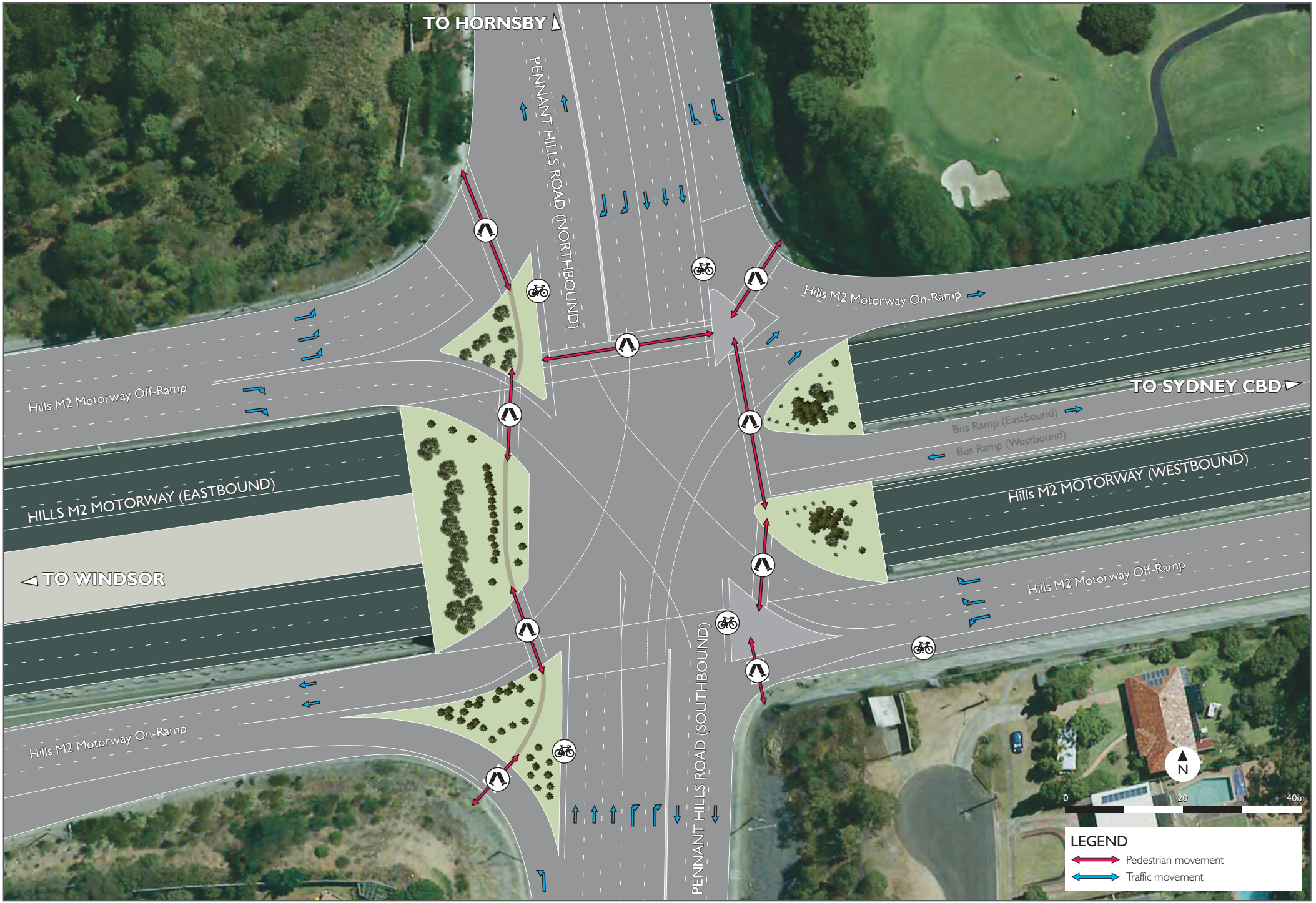

Figure 3-5 Existing Hills M2 Motorway - Pennant Hills Road Intersection

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3.2.2 Modes of travel

Private vehicles are the predominant mode of transport in the project area, which is reflected by higher than average vehicle ownership in The Hills and Hornsby local government areas. The average vehicle ownership per household in The Hills and Hornsby is 2.1 and 1.7 respectively, compared to an average of 1.6 in the Sydney greater metropolitan area.

The *NSW Bureau of Transport Statistics (BTS), Household Travel Survey 2011/12 Summary Report, 2013 Release* provides details of the mode share of average weekday travel demand made from each local government area in NSW. Travel mode shares for The Hills and Hornsby local government areas in comparison with the Sydney greater metropolitan area are shown in **Table 3-2**.

Data from the household travel survey shows that on average 77 per cent of trips on a typical weekday in the project area are car-based compared to an average of 68 per cent in the Sydney greater metropolitan area. The high proportion of people dependent on car travel highlights the importance of efficient routes for vehicles in the area.

Table 3-2 Average weekday travel mode share for The Hills / Hornsby local government areas (2011/12)

Local Government Area	Private vehicle			Rail	Bus	Walk only	Other modes
	Driver	Passenger	Total				
The Hills	58%	24%	82%	2%	6%	9%	1%
Hornsby	50%	21%	71%	9%	4%	14%	2%
Sydney Greater Metropolitan Area	47%	21%	68%	5%	6%	18%	3%

(Source: NSW BTS, Household Travel Survey 2011/12 Summary Report, 2013 Release)

3.2.3 Public transport services

Public transport services are a key method of transport for journeys to work in the area, particularly to the Sydney central business district.

3.2.3.1 Rail services

Table 3-2 shows that in The Hills and Hornsby local government areas, rail passengers represent two per cent and nine per cent of the mode share of average weekday travel respectively. Since the completion of the Epping to Chatswood Rail Link in 2009, services on the Northern Line operate from Hornsby to Epping and onward to Macquarie Park, North Sydney and the Sydney central business district via stops at Normanhurst, Thornleigh, Pennant Hills, Beecroft and Cheltenham. Services further along the Northern Line to Strathfield can be accessed by interchanging at Epping station. Rail services are also provided on the North Shore Line in the north of the project area, from Hornsby to the Sydney central business district via Chatswood and North Sydney.

Rail services in the project area are shown in **Figure 3-6**. Pennant Hills Road is adjacent to Thornleigh and Pennant Hills stations, providing access to these stations.

Figure 3-6 Sydney Trains network map

(Source: Sydney Trains, 2013)

There are eight services operating from the project area to the Sydney central business district in the AM peak, and eight services returning in the PM peak. Services operate with a frequency of approximately 15 minutes all day on weekdays, including inter peak, AM and PM peak hours. Peak train services operating on the Northern Line are shown in **Table 3-3**.

Table 3-3 Sydney Trains services

Line	Major destinations	AM peak services 7am-9am	Frequency	PM peak services 4pm-6pm	Frequency
Northern	Epping, Chatswood, Sydney central business district	8	15 mins	8	15 mins

(Source: Sydney Trains, March 2014)

Sydney Trains publishes annual NSW station entry and exit statistics. The latest data was released in 2012 and is contained in *A Compendium of Sydney Rail Travel Statistics, Eighth Edition, November 2012*.

Station entry and exit barrier counts for the five stations in the project area are summarised in **Table 3-4**. Entry and exit statistics are for 6am-6.30pm and over the corresponding 24 hour period. Thornleigh, Pennant Hills and Beecroft encounter a comparable passenger volume and show a similar tidal profile, with the majority of passengers departing from the station in the AM peak and returning in the PM peak. Normanhurst and Cheltenham handle a smaller volume of passengers compared to the other three stations, and are more evenly balanced between passengers entering and exiting the station in the AM and PM peak periods.

Table 3-4 Station entry and exit barrier counts (2011)

Station	AM peak 6am-9.30am		Inter peak 9.30am-3pm		PM peak 3pm-6.30pm		24 hours	
	In	Out	In	Out	In	Out	In	Out
Normanhurst	760	410	280	150	220	500	1,300	1,300
Thornleigh	1,320	180	410	360	280	1,150	2,120	2,120
Pennant Hills	1,860	570	570	480	750	1,720	3,310	3,310
Beecroft	1,470	130	330	300	200	1,180	2,070	2,070
Cheltenham	680	390	320	80	290	650	1,310	1,310

(Source: NSW BTS, Compendium of Sydney Rail Travel Statistics, 8th Edition V1.1, 2012)

3.2.3.2 Bus services

Table 3-2 shows that in The Hills and Hornsby local government areas, bus passengers represent six and four per cent of the mode share of average weekday travel demand respectively.

Pennant Hills Road is an important bus corridor with a number of bus services operating in the project area, as shown in **Figure 3-7** and **Figure 3-8**. HillsBus operate bus services in the vicinity of Pennant Hills Road, in contract region four, while Transdev operates bus services in contract region 12.

Bus stops are located at regular intervals in both directions, with these services providing connections between a number of centres, including Pennant Hills, Beecroft, Castle Hill, Parramatta and the Sydney central business district via the Hills M2 Motorway. Services to the Sydney central business district which travel along Pennant Hills Road subsequently flow onto the Hills M2 Motorway, which provides quick access from the north west into the Sydney central business district. However, service levels and reliability of bus operations are dependent on traffic conditions on Pennant Hills Road, the Hills M2 Motorway and surrounding local road network.

Bus services are likely to change with the construction of the North West Rail Link (NWRL), with many likely to be re-routed to act as feeders for train services.

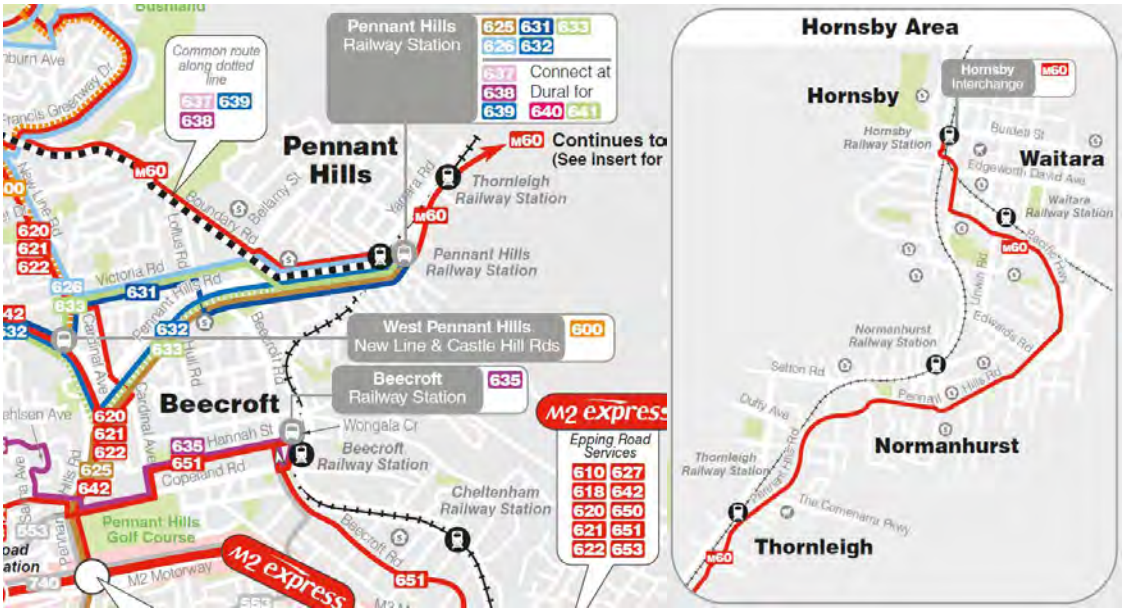

Figure 3-7 HillsBus: The Hills network map

(Source: HillsBus, 2013)

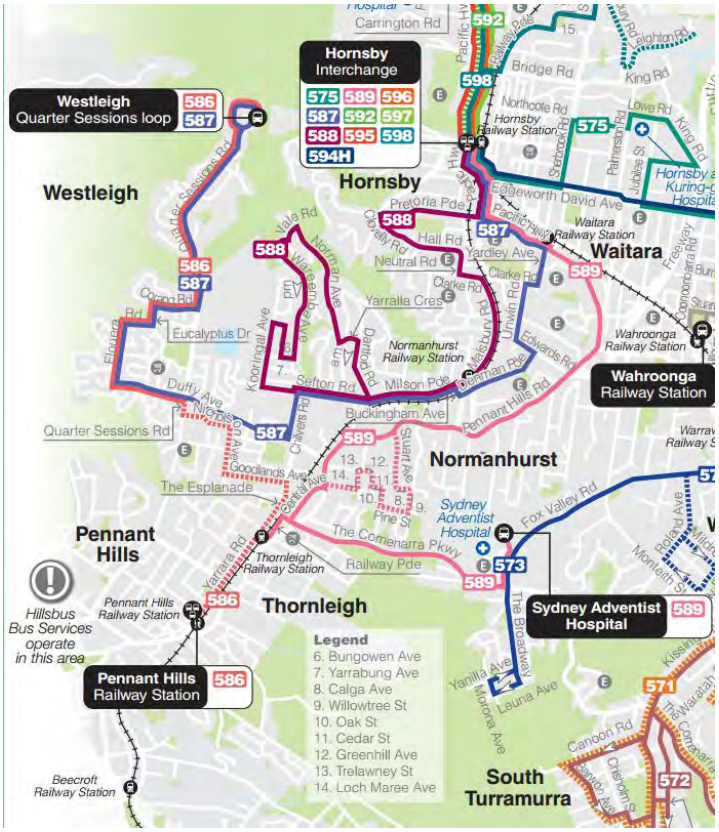

Figure 3-8 Transdev: Hornsby network map

(Source: Transdev, 2013)

The number and frequency of bus services operating along Pennant Hills Road in the AM and PM peak hours are summarised below in **Table 3-5**. The two main services are Route 620 operating from Dural to City via Cherrybrook, Route 642 and 642X operating from Round Corner to City. Each of these routes provides frequent peak services of under 15 minutes in the AM peak, and under 30 minutes in the PM peak.

Table 3-5 Pennant Hills Road bus services

Route	AM peak services (7:00-9:00)	Frequency	PM peak services (16:00-18:00)	Frequency
586 Pennant Hills to Westleigh	5	15-30 mins	3	30 mins
589 Hornsby to Sydney Adventist Hospital	4	60 mins	4	60 mins
620 Dural to City via Cherrybrook	21	4-15 mins	12	5-28 mins
621 Castle Hill – Cherrybrook – West Pennant Hills – Macquarie Park to City	4	32-37 mins	3	30-60 mins
622 Dural via Cherrybrook to Milsons Point	5	20 mins	3	30-55mins
625 Parramatta to Pennant Hills	4	20-45 mins	4	30 mins
626 Dural via Cherrybrook to Pennant Hills	4	20-55 mins	4	18-30 mins
631 Castle Hill to Pennant Hills via Castle Hill Road	2	9 mins	-	-

Route	AM peak services (7:00-9:00)	Frequency	PM peak services (16:00-18:00)	Frequency
632 Castlewood – Castle Hill to Hornsby	5	10-50 mins	6	15-30 mins
633 Castle Hill – West Pennant Hills to Pennant Hills	4	30 mins	4	30 mins
637 Glenorie – Galston – Dural to Castle Hill	1	-	1	-
638 Pennant Hills – Castle Hill to Berrilee	1	-	2	60 mins
639 Pennant Hills to Pitt Town	1	-	2	60 mins
640 Kenthurst to Porters Road	1	-	2	60 mins
641 Rouse Hill to Round Corner	1	-	2	60 mins
642 & 642X Round Corner to City	16	5-15 mins	9	1-25 mins

(Source: HillsBus and Transdev, 2013)

3.2.4 Walking and cycling

Walk only trips in the area represent nine per cent of average weekday travel mode share in The Hills and 14 per cent in Hornsby. The number of people walking in the project area would be increased if people walking to public transport stops were included, meaning infrastructure to support walking trips is more important than indicated. Cycle trips are not represented in the mode share data, although would account for a proportion of the 'other' category, representing one and two per cent in The Hills and Hornsby local government areas respectively. The project would see a benefit to both pedestrians and cyclists, with reduced traffic flows and congestion resulting in a safer area with increased amenity.

Pedestrian footpaths are provided along the length of Pennant Hills Road, with regular crossings via signalised intersections as well as four pedestrian overpasses. With the exception of a short section near the Pennant Hills Road / Castle Hill Road intersection and the Hills M2 Motorway / Pennant Hills Road interchange, there are no dedicated cyclist facilities along this section of Pennant Hills Road. Hornsby Council recognises the Pennant Hills Road corridor as a high difficulty cycle route.

Although the Pennant Hills Road corridor is generally not an inviting cycle route, both The Hills Shire and Hornsby Shire Councils promote sustainable travel and cycling as a means of travelling short distances. However, there are no parallel routes for cyclists to access along the Pennant Hills corridor, leaving cyclists with limited options.

3.2.5 Existing traffic volumes and patterns

3.2.5.1 Mid-block traffic volumes

This section provides details of vehicular traffic flows that have been recorded within the Pennant Hills Road corridor and immediately surrounding road network. As Pennant Hills Road is located within the Sydney metropolitan area, demand will be assessed in typical AM and PM peak hours.

Pennant Hills Road carries large volumes of traffic with two-way annual average daily traffic (AADT) in 2011 of about 80,000 vehicles per day[1]. Publicly available AADT figures up to 2013 were examined to assess traffic growth on Pennant Hills Road[2] and are presented in **Table 3-6**. The figures, where available, show stagnant growth on the Pennant Hills Road corridor, this is attributable to the high levels of congestion during peak periods which limit the rate of potential traffic growth during these times.

[1] Infrastructure NSW, The State Infrastructure Strategy 2012-2032, 2011
[2] From 2005, Roads and Maritime permanent count stations no longer collect traffic data over the whole year.

Table 3-6 Historical Pennant Hills Road AADT (two-way)

Location	2005	2009	2010	2011	2012	2013	% p.a.
near Woodstock Road	-	-	47,500	47,900	46,300	-	**- 1%**
near Copeland Road	-	73,260	-	-	-	-	**-**
near Castle Hill Road	82,700	-	-	-	-	-	**-**
near Beecroft Road	-	59,500	62,600	62,100	62,200	62,000	**1%**

(Source: Roads and Maritime, 2013)

Automatic tube counts were undertaken in early December 2013[3]. **Table 3-7** shows the summarised results of these surveys for AM peak, PM peak, average weekday daily traffic (AWDT) flows and heavy vehicle percentages. A high proportion of heavy vehicles use both the M1 Pacific Motorway and Hills M2 Motorway to transport goods around Sydney, with the M1 Pacific Motorway near Pennant Hills Road recording 21.2 per cent heavy vehicles and Hills M2 Motorway west of Pennant Hills Road recording 13.9 per cent heavy vehicles across the day. Linking these two motorways, Pennant Hills Road is also subject to high volumes of heavy vehicles as shown in **Table 3-7**, with 14.4 per cent recorded north of the Hills M2 Motorway interchange. It is evident that more heavy vehicles use Pennant Hills Road during the AM peak, compared to the PM peak. The proportion of heavy vehicles on the Pacific Highway east of the M1 Pacific Motorway interchange is lower than observed on Pennant Hills Road.

Table 3-7 Weekday traffic flows on Pennant Hills Road (2013) (two-way)

Location	Two-way traffic flows					
	AM Peak		PM Peak		AWDT Flow	
	Veh/h	% heavy vehicles	Veh/h	% heavy vehicles	Veh/day	% heavy vehicles
Pacific Highway, north of Pennant Hills Road	2,290	7.1%	2,620	3.6%	37,200	6.4%
Pennant Hills Road, south of Pacific Highway	1,750	9.1%	1,840	4.0%	26,900	8.0%
Pacific Highway, east of M1 Interchange	4,397	5.3%	4,736	2.3%	26,700	3.1%
Pennant Hills Road, north of M2	5,360	12.3%	5,480	10.3%	79,050	14.4%
Pennant Hills Road, south of M2	3,620	8.3%	3,250	5.3%	47,650	10.4%

(Source: Austraffic, 2013)

Average daily and weekly traffic profiles for the project corridor have been prepared using the automatic tube count data collected. The daily profiles at the southern end of Pennant Hills Road, near the Hills M2 Motorway show high morning and afternoon peak period traffic volumes, with an interpeak period characterised by much lower traffic volumes. The average weekday traffic profiles for Pennant Hills Road, near the Hills M2 Motorway interchange, are presented in **Figure 3-9** and **Figure 3-10**.

[3] While the perception may be that traffic volumes decrease in December, a review of traffic data from six Roads and Maritime count sites was undertaken for the first two weeks in December in the vicinity of Pennant Hills Road, and in all directions except one, the average weekly daily flows (AWDT) for the first two weeks in December were higher than the AADT for the year. Overall, the first two weeks in December showed a slightly higher than average daily traffic volume (approximately two to six per cent higher) when compared to the AADT. Therefore, no factoring of the counts has been considered necessary to account for the surveys being undertaken in early December.

The data indicates that Pennant Hills Road is characterised by traffic volumes which are relatively constant over the week. Many major roads accommodate high traffic volumes on weekdays, with a subsequent decline over the weekend. On Pennant Hills Road however, volumes on the weekend continue at levels experienced on weekdays, with this particularly the case north of the Hills M2 Motorway interchange. Weekly traffic volume patterns are illustrated in the weekly traffic profile, shown in **Figure 3-11** and **Figure 3-12**.

3.2.5.2 Intersection traffic volumes

Intersection counts were obtained during December 2013 (outside of school holidays) to understand traffic behaviour at many of the key intersections in the project area. These are presented in **Table 3-8**. A number of intersections along the Pennant Hills Road corridor are subject to high traffic volumes, as well as a high proportion of heavy vehicles.

Table 3-8 Intersection count summary (2013)

Intersection / interchange	Light vehicles		Heavy vehicles		Total		HV%	
	AM	PM	AM	PM	AM	PM	AM	PM
Pennant Hills Road / North Rocks Road	4,090	4,540	280	170	4,370	4,710	6.3%	3.8%
Hills M2 Motorway / Pennant Hills Road	5,410	5,780	600	480	6,010	6,260	10.0%	8.3%
Pennant Hills Road / Copeland Road	5,320	5,750	560	470	5,880	6,220	9.6%	8.2%
Pennant Hills Road / Castle Hill Road	4,720	5,790	550	440	5,270	6,230	10.5%	7.6%
Pennant Hills Road / Beecroft Road (S)	5,140	5,510	470	390	5,610	5,900	8.3%	7.1%
Pennant Hills Road / Beecroft Road (N)	6,150	5,890	490	410	6,640	6,300	7.3%	6.9%
Pennant Hills Road / Boundary Road	6,120	6,390	540	450	6,660	6,840	8.1%	7.1%
Pennant Hills Road / Comenarra Parkway	4,510	5,200	590	440	5,100	5,640	11.6%	8.4%
M1 Pacific Motorway / Pennant Hills Road	4,010	4,550	500	380	4,510	4,930	11.0%	8.3%
Pennant Hills Road / Pacific Highway	2,950	3,330	200	100	3,150	3,430	6.3%	3.2%
M1 Pacific Motorway / Pacific Highway	4,450	4,970	240	120	4,690	5,090	5.1%	2.4%

(Source: Austraffic, 2013)

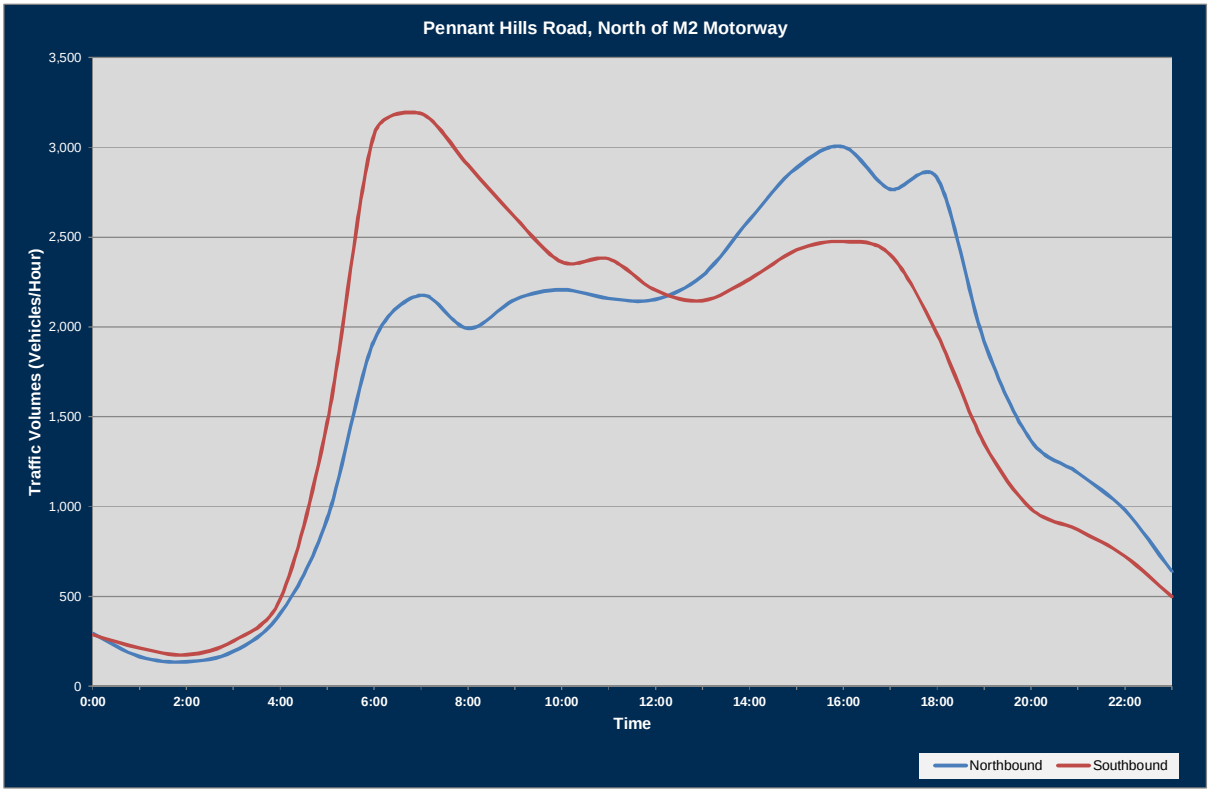

Figure 3-9 Average weekday traffic profile at Pennant Hills Road, north of Hills M2 Motorway

(Source: AECOM, 2014 based on Austraffic, 2013)

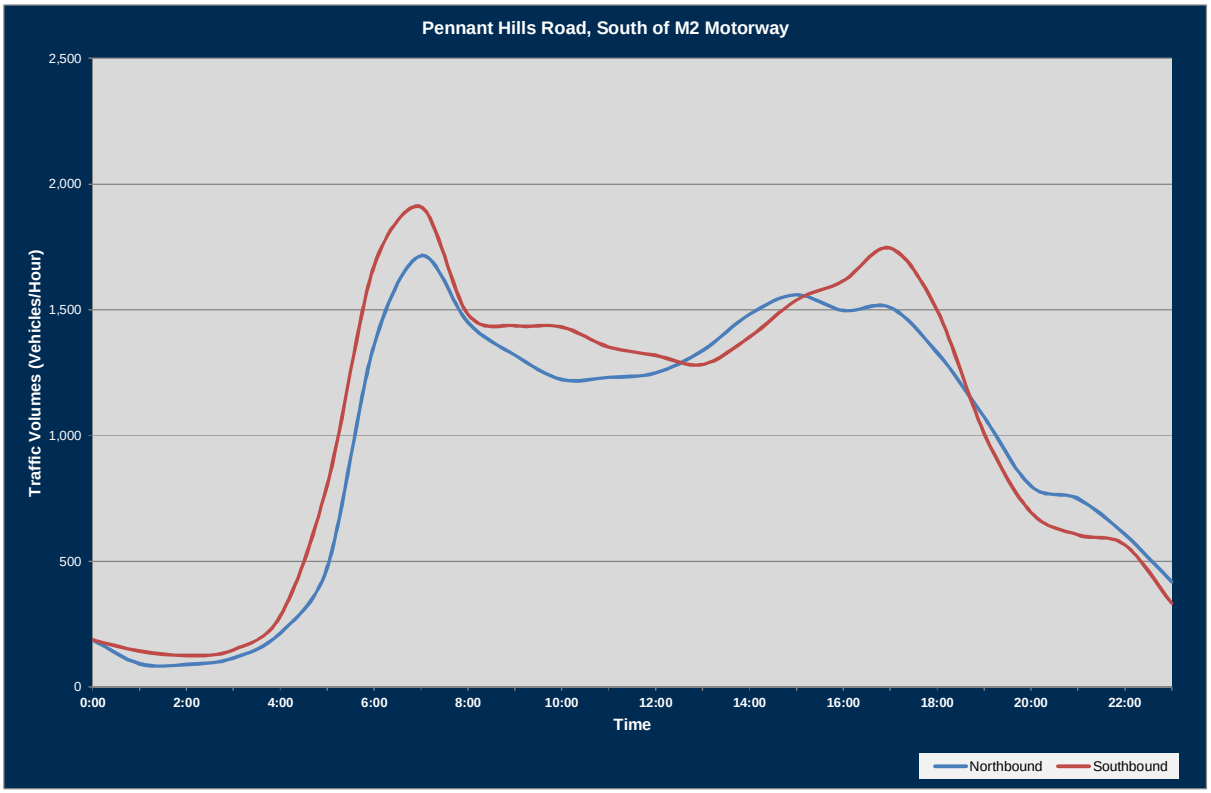

Figure 3-10 Average weekday traffic profile at Pennant Hills Road, south of Hills M2 Motorway

(Source: AECOM, 2014 based on Austraffic, 2013)

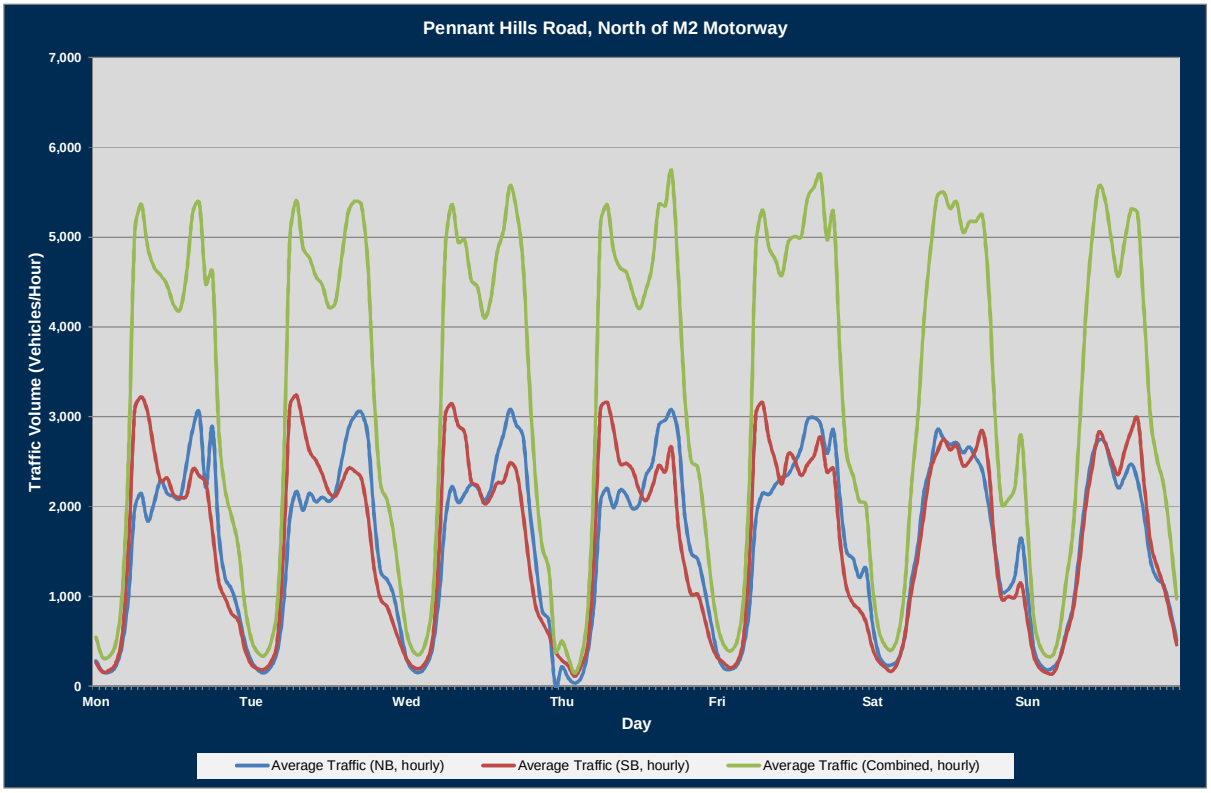

Figure 3-11 Weekly traffic profile at Pennant Hills Road, north of Hills M2 Motorway

(Source: AECOM, 2014 based on Austraffic, 2013)

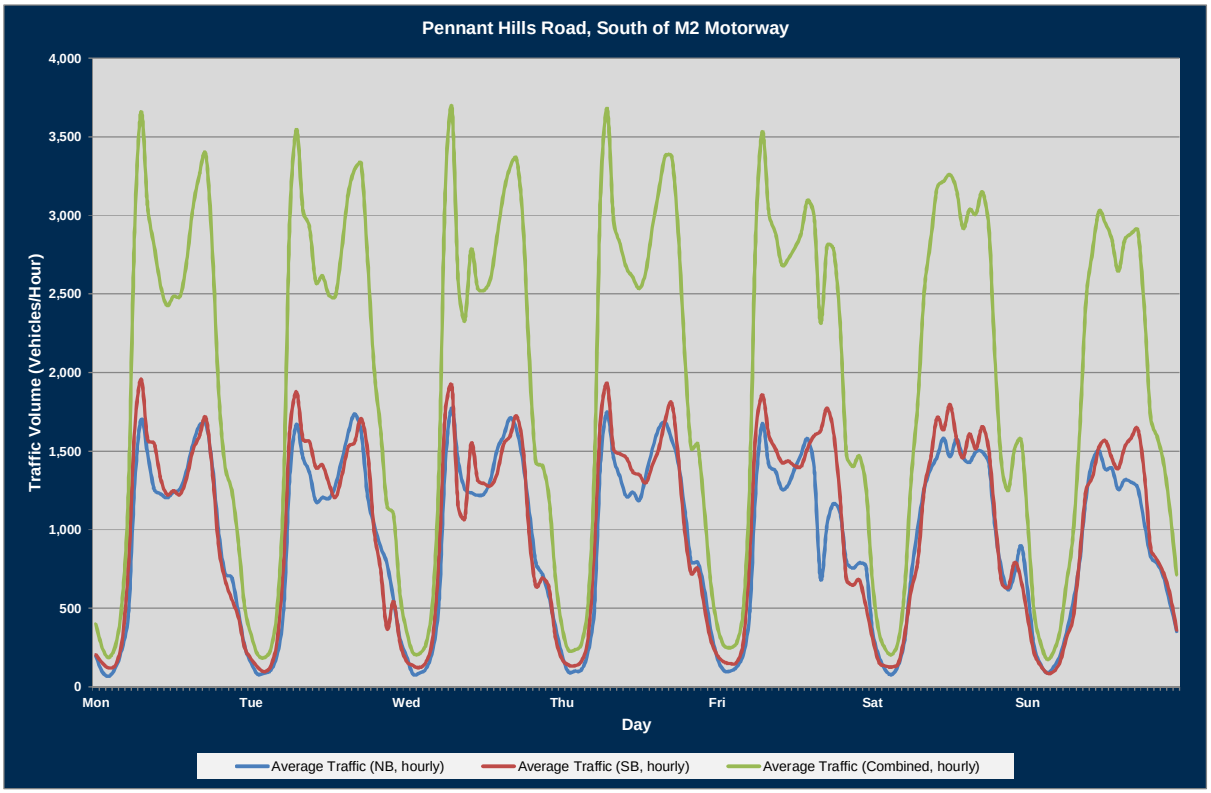

Figure 3-12 Weekly traffic profile at Pennant Hills Road, south of Hills M2 Motorway

(Source: AECOM, 2014 based on Austraffic, 2013)

3.3 Hills M2 Motorway corridor

3.3.1 Route description

The Hills M2 Motorway forms part of the Sydney Orbital Network, which provides a key arterial link between Sydney's north west suburbs and a number of major employment, education and leisure centres, including the Sydney central business district, North Sydney and Macquarie Park.

The Hills M2 Motorway is a divided carriageway motorway consisting of two or three general traffic lanes in each direction and has a posted speed limit of 100 kilometres per hour. The recent Hills M2 Upgrade project (completed in August 2013) included adding an eastbound lane from Windsor Road to Pennant Hills Road and an eastbound lane from Pennant Hills Road, through the Norfolk Tunnel, to Lane Cove Road. In the eastbound direction, between Windsor Road and Beecroft Road, there are now three general travel lanes and one dedicated bus lane.

The Hills M2 Upgrade project also included adding a westbound lane from Beecroft Road to Pennant Hills Road. In the westbound direction, between Beecroft Road and Pennant Hills Road, there are now three general travel lanes and one dedicated bus lane. In the westbound direction between Pennant Hills Road and Windsor Road, there are only two general travel lanes and one dedicated bus lane. A distinct feature of the Hills M2 Motorway is the provision of dedicated bus lanes between Beecroft Road and Windsor Road. These bus lanes allow public transport users to avoid congestion along the corridor, serving to encourage public transport use by making the journey time more attractive to commuters. The bus lanes operate in the centre of the roadway, with median bus stops allowing passenger access via over or under passes.

Along with the Westlink M7 Motorway, the Hills M2 Motorway provides a key link by providing access between the Hume Highway and the M1 Pacific Motorway, effectively linking southern NSW to Sydney and onward to the Central Coast, Newcastle and northern NSW. Due to the role the Hills M2 Motorway plays in linking these key freight links, heavy vehicle volumes along the corridor are high.

3.3.2 Modes of travel

The Hills M2 Motorway borders and traverses nearby the project area discussed earlier in **Section 3.2.2**, with travel behaviour similar in nature.

3.3.3 Public transport services

Public transport is the primary mode of travel for many workers commuting to the Sydney central business district and other major centres from the north western suburbs. A large number of bus services provide both local and express routes to employment and education centres.

3.3.3.1 Rail services

Rail services are not present on, or in the vicinity of, the Hills M2 Motorway component assessed as part of this project.

3.3.3.2 Bus services

A number of bus services operate along the Hills M2 Motorway, providing access between Sydney's north western suburbs and major centres including the Sydney central business district, North Sydney and Macquarie Park. The motorway provides a bus lane in each direction between Windsor Road and Beecroft Road to the east, allowing public transport priority in peak periods when traffic congestion often delays journeys. Bus-only, east-facing entry and exit ramps are also provided at the Pennant Hills Road and Windsor Road interchanges, further enhancing bus priority in peak periods.

The Oakes Road Hills M2 Motorway bus station is located in the median of the motorway at the overpass of Oakes Road, providing direct access for passengers to access public transport, as shown in **Figure 3-13**. There are 15 services which stop at the interchange, with a further ten services joining and leaving the bus lanes at the Pennant Hills Road interchange.

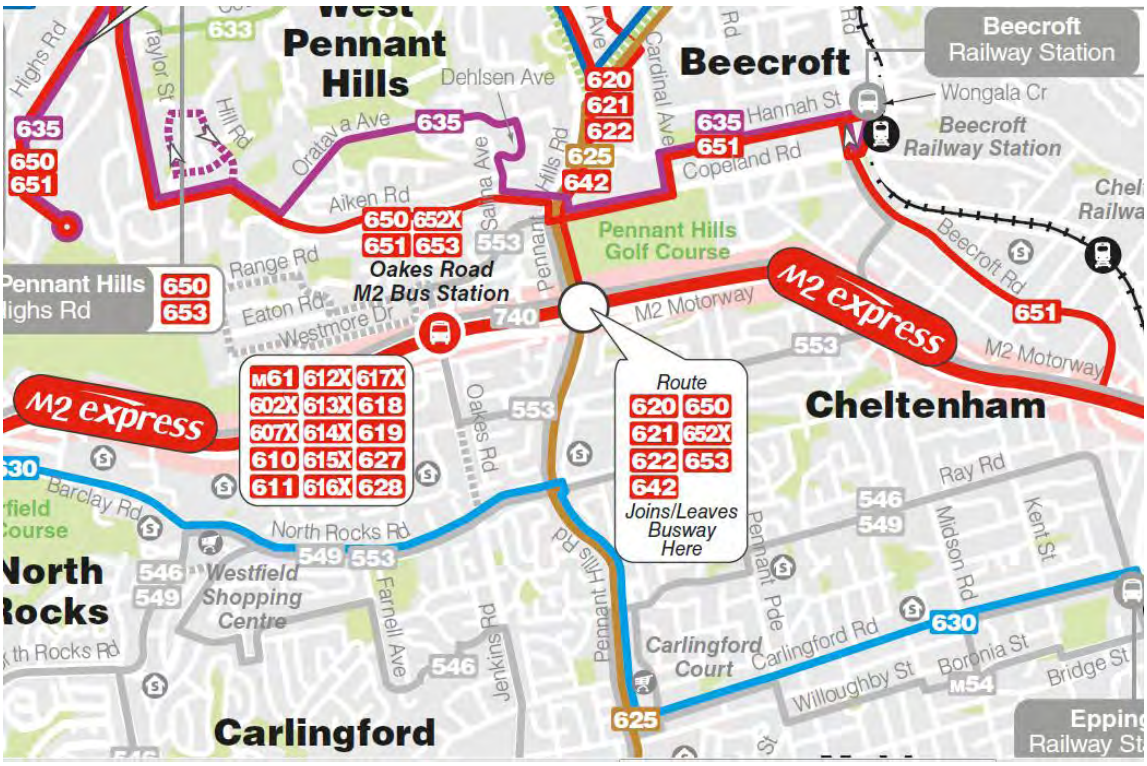

Figure 3-13 Bus network around the Oakes Road M2 Bus Station, at the Hills M2 Motorway and Pennant Hills Road interchange

(Source: CDC Hills Bus, March 2014)

The number and frequency of peak hour bus services stopping at the Oakes Road bus station, or near the Pennant Hills Road interchange for services joining the Hills M2 Motorway at that location, have been identified using available timetable information and are presented in **Table 3-9**. In the morning peak hour between 7am and 8am, 123 services stop at these locations from Sydney's north west en-route to major destinations including the Sydney central business district, North Sydney and Macquarie Park. In the afternoon peak hour between 5pm and 6pm, 93 services stop at these bus stations, travelling towards the north west.

Major bus routes operating along the Hills M2 Motorway with high frequency services include Routes 610, 612, 616X and 620X, with frequencies between three and eight minutes in the morning peak hour and between six and nine minutes in the afternoon peak hour. These services provide a high level of accessibility for commuters, who would be able to arrive at the bus station and access services largely without the need for a timetable.

Table 3-9 Hills M2 Motorway peak hour bus services

Route number	AM peak services (7:00-8:00)	Frequency	PM peak services (17:00-18:00)	Frequency
M61	6	10 mins	4	15 mins
602X	5	12 mins	4	15 mins
607X	6	10 mins	4	15 mins
610X	9	6 mins	9	6 mins
611	5	12 mins	6	10 mins
612X	12	5 mins	9	6 mins
613X	4	15 mins	3	20 mins
614X	6	10 mins	4	15 mins
615X	6	10 mins	4	15 mins
616X	8	7.5 mins	7	8 mins
617X	6	10 mins	5	12 mins
618	4	15 mins	3	20 mins
619	4	15 mins	4	15 mins
620X	9	6 mins	8	7.5 mins
620N	7	8 mins	0	-
621	2	30 mins	2	30 mins
622	3	20 mins	2	30 mins
628	3	20 mins	2	30 mins
642	2	30 mins	1	60 mins
642X	6	10 mins	10	6 mins
650	0	-	1	60 mins
650X	2	30 mins	1	60 mins
652X	6	10 mins	2	30 mins
653	0	-	0	-
740	2	30 mins	2	30 mins
Total peak hour services	**123**		**97**	

(Source: AECOM, 2014; based on Hillsbus, 2014)

3.3.4 Walking and cycling

Due to the Hills M2 Motorway being a closed access road, pedestrians are not permitted to travel on the roadway. Use of the shoulder lane is provided for cyclists in each direction, which provides access along the length of the motorway to local network links. A detour is currently in place for eastbound cyclists between Pennant Hills Road and Delhi Road, North Ryde while works on the Hills M2 Motorway eastbound carriageway occur near Marsfield and Lane Cove Road.

3.3.5 Existing traffic volumes and patterns

The Hills M2 Motorway is a key arterial road in the Sydney Orbital Network, resulting in high peak traffic volumes throughout the week. In the week starting 2 December 2013, traffic surveys were undertaken on the Hills M2 Motorway to monitor existing traffic volumes and patterns in the area. Analysis of traffic data indicated that the corridor experiences a widespread shoulder peak in both the AM and PM peak periods. The AM peak starts relatively early, with traffic volumes increasing rapidly from 6am. The AM peak hour is between 7am and 8am, while the PM peak hour is between 5pm and 6pm, with traffic decreasing after 7pm. These peak hours are the peaks of the peak periods.

Due to the arterial nature of the Hills M2 Motorway, it is influenced by peak direction movements depending on the time of day. In the AM peak, the eastbound direction experiences high traffic volumes as people travel from the north western suburbs to the Sydney central business district and other major centres, such as Macquarie Park and North Sydney. This is reversed in the PM peak, with the westbound direction experiencing high volumes of traffic as people return home.

The PM peak is characterised by a greater level of peak spreading than the AM peak. This is likely due to traffic associated with school pick-ups, with a noticeable increase in traffic from around 2pm. Interpeak volumes on the Hills M2 Motorway are considerably lower than in peak hours, with traffic volumes at 12pm around 50 per cent less than those surveyed in the peak hour.

Table 3-10 provides 2013 weekday (Monday-Friday) traffic volumes on the Hills M2 Motorway. The 2013 volumes were collected by tube survey in early December 2013, and averaged over a one week period.

Table 3-10 Weekday (Mon-Fri) traffic volumes on the Hills M2 Motorway (2013)

Location	Direction	AM Peak Hour (vehs/h)	PM Peak Hour (vehs/h)	AWDT (vehs/day)
Between Windsor Road and Pennant Hills Road	Eastbound	4,190	3,220	42,600
	Westbound	2,850	4,170	44,550
	Total (two-way)	**7,040**	**7,390**	**87,150**
Between Pennant Hills Road and Beecroft Road	Eastbound	4,220	2,600	36,650
	Westbound	2,260	4,140	39,450
	Total (two-way)	**6,480**	**6,740**	**76,100**

(Source: Austraffic, 2013)

3.4 M1 Pacific Motorway corridor

3.4.1 Route description

The M1 Pacific Motorway is the major road transport link between Sydney, the Central Coast and the Hunter regions. After it becomes the Pacific Highway, west of Newcastle, it provides the major road transport link to northern NSW and Queensland.

As described in **Section 3.2.1**, the M1 Pacific Motorway in the study area intersects with Pennant Hills Road and also has an interchange with the Pacific Highway, which has north-facing on and off-ramps.

The M1 Pacific Motorway is a divided carriageway motorway. There are two lanes in the northbound direction between the M1 Pacific Motorway / Pennant Hills Road intersection and the M1 Pacific Motorway / Pacific Highway interchange. There are two lanes in the southbound direction between the M1 Pacific Motorway / Pacific Highway interchange and M1 Pacific Motorway / Pennant Hills Road intersection, which flare to three lanes on the approach to the M1 Pacific Motorway / Pennant Hills Road intersection. North of the Pacific Highway interchange, there are three lanes in both directions.

Generally, the motorway has a posted speed limit of 110 kilometres per hour, however between the M1 Pacific Motorway / Pennant Hills Road intersection and the M1 Pacific Motorway / Pacific Highway interchange, a 70 kilometre per hour speed limit applies and between Junction Road and the Pacific Highway, an 80 kilometre per hour speed limit applies.

3.4.2 Public transport services

3.4.2.1 Rail services

The T1 North Shore and Newcastle Line traverse the M1 Pacific Motorway north of Wahroonga station and the Main North Line runs broadly parallel with the motorway from Hornsby, as it heads north up the coast.

3.4.2.2 Bus services

While no metropolitan buses run on the M1 Pacific Motorway, long-distance bus and coach services use the motorway.

3.4.3 Walking and cycling

Due to the M1 Pacific Motorway being a closed access road, pedestrians are not permitted to travel on the roadway. Use of the shoulder lane is provided for cyclists in each direction between Windy Banks Interchange and the M1 Pacific Motorway / Pennant Hills Road intersection.

3.4.4 Existing traffic volumes

Table 3-11 provides the 2013 AM peak hour, PM peak hour and the AWDT traffic volumes on the M1 Pacific Motorway, north of the Pacific Highway interchange. The 2013 volumes were collected by tube survey in December 2013, and averaged over a one week period.

Table 3-11 Weekday (Mon-Fri) traffic volumes on the M1 Pacific Motorway (2013)

Location	Direction	AM Peak Hour (vehs/h)	PM Peak Hour (vehs/h)	AWDT (vehs/day)
North of the Pacific Highway interchange	Northbound	1,680	3,820	36,300
	Southbound	3,660	2,080	36,100
	Total (two-way)	**5,340**	**5,900**	**72,400**

(Source: Austraffic, 2013)

3.5 Westlink M7 Motorway corridor

3.5.1 Route description

Opened to traffic in December 2005, the Westlink M7 Motorway forms part of the Sydney Orbital Network. It provides a key arterial link between the M5 at Prestons in the south with the M4 motorway at Eastern Creek and the Hills M2 Motorway at West Baulkham Hills in the north. The Westlink M7 Motorway connects a number of major employment, residential, leisure and education centres.

The M7 Motorway is a divided carriageway motorway with two lanes in each direction and generally has a posted speed limit of 100 kilometres per hour. Along with the Hills M2 Motorway, it provides a key link by providing access between the Hume Highway and the M1 Pacific Motorway, effectively linking southern NSW to Sydney and onward to the Central Coast, Newcastle and northern NSW. Similar to the Hills M2 Motorway, the Westlink M7 Motorway plays an important role in linking key freight links and heavy vehicle volumes are therefore high.

3.5.2 Public transport services

3.5.2.1 Rail services

Rail services are not present on, or in the vicinity of, the Westlink M7 Motorway component assessed as part of this project.

3.5.2.2 Bus services

Unlike the Hills M2 Motorway, there are no bus facilities on the Westlink M7 Motorway. While no buses run on the Westlink M7 Motorway, bus services operate in the vicinity of the motorway. In the Bella Vista area, services are provided by Busways and CDC Hills Bus. Busways routes T70, 740, 745, and 718 operate in the Bella Vista and Kings Langley regions on alternative routes to the M7 Motorway. This includes Norwest Boulevard and (T70 and 745) and Old Windsor Road (740), as shown in **Figure 3-14**.

In addition, several Hills Bus services operate along these alternate routes to the M7 Motorway as shown in **Figure 3-15**.

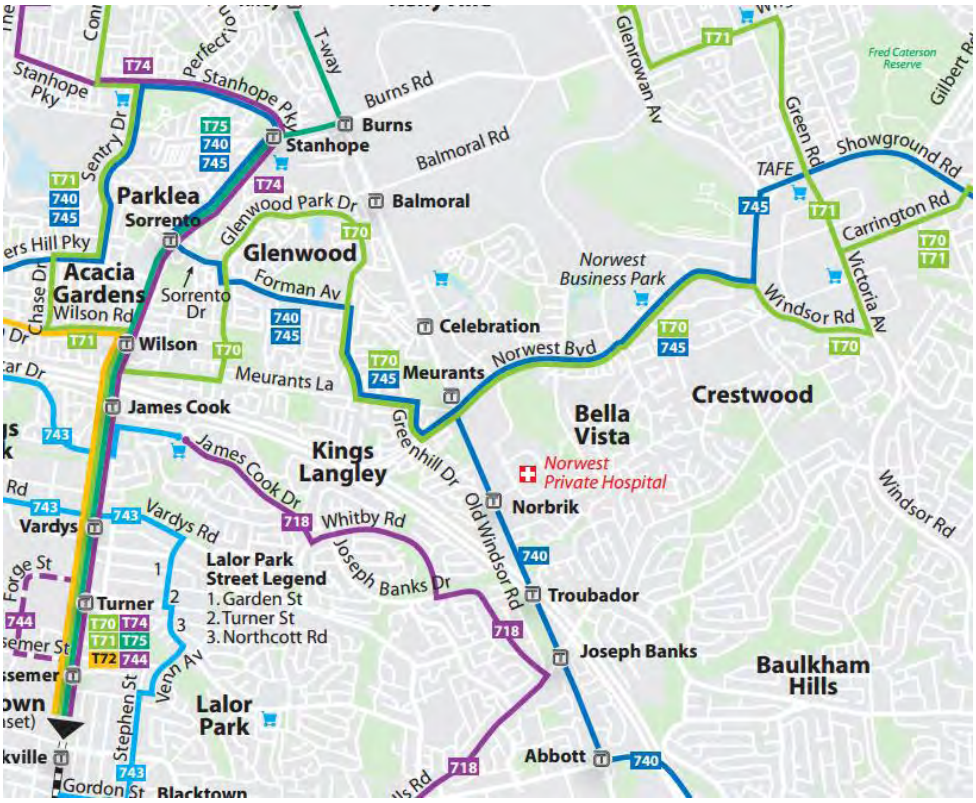

Figure 3-14 Bus network surrounding the Bella Vista area (Source: Busways, March 2014)

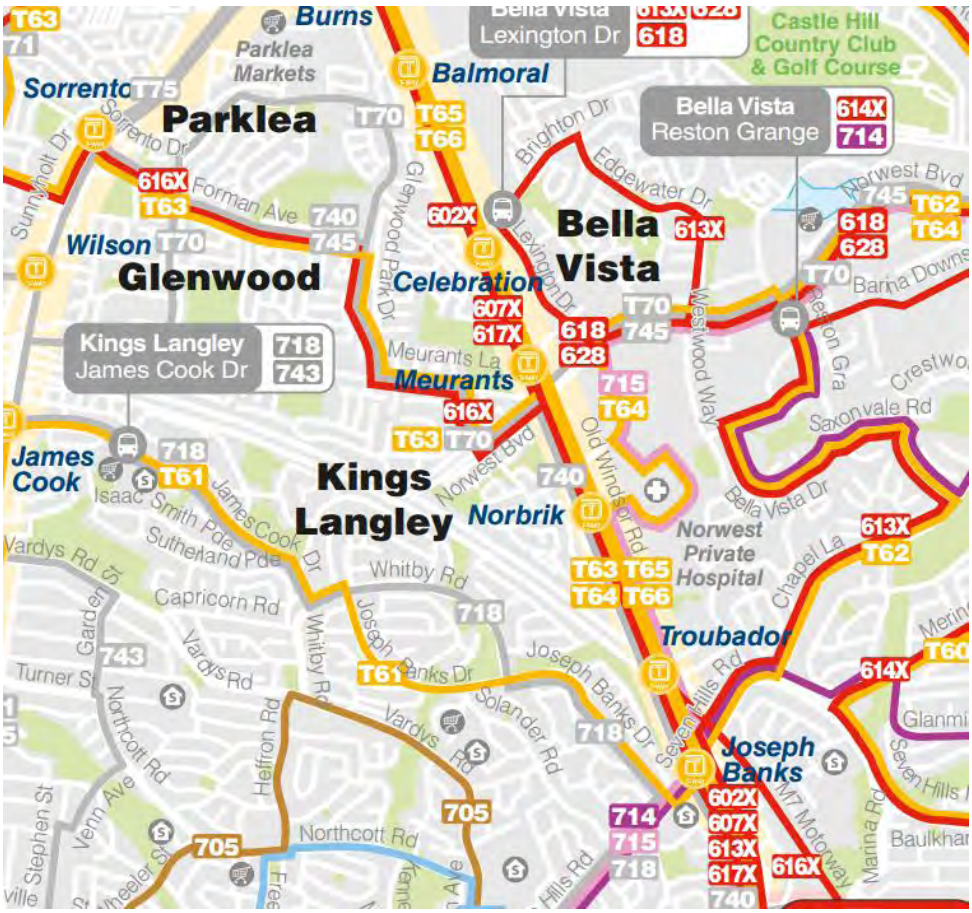

Figure 3-15 Bus network surrounding the Bella Vista area (Source: CDC Hills Bus, March 2014)

3.5.3 Walking and cycling

The Westlink Shared Path runs parallel and traverses the Westlink M7 Motorway providing an off-road facility for cyclists and pedestrians. Just under 40 kilometres long, it connects with the Sydney Cycleway network.

3.5.4 Existing traffic volumes

Table 3-12 provides the 2013 AM peak hour, PM peak hour and the AWDT traffic volumes on two sections of the Westlink M7 Motorway. The section between The Horsley Drive and Old Wallgrove Road was chosen because it has the largest traffic volumes on the Westlink M7 Motorway.

Table 3-12 Weekday (Mon-Fri) traffic volumes on the Westlink M7 Motorway (2013)

Location	Direction	AM Peak Hour (vehs/h)	PM Peak Hour (vehs/h)	AWDT (vehs/day)
Between Old Windsor Road and Hills M2 Motorway	Eastbound	1,490	1,720	23,490
	Westbound	1,520	2,350	24,010
	Total (two-way)	**3,010**	**4,070**	**47,500**
Between The Horsley Drive and Old Wallgrove Road	Northbound	2,660	2,670	35,200
	Southbound	2,680	2,870	35,880
	Total (two-way)	**5,340**	**5,540**	**71,080**

(Source: Transurban, 2014)

4.0 Existing road network performance

In this section, peak period demands are combined with the road and intersection capacity to assess the operational performance of the existing Pennant Hills Road and the surrounding road network.

The assessment uses the following performance indicators:

- Road safety and incidence of traffic crashes.
- Average travel times and speeds.
- Operational assessment of roadways (midblock) and intersections based on average delay and Level of Service (LoS).

The assessment is presented in the following order:

- Pennant Hills Road and Pacific Highway corridor (section 4.1).
- Hills M2 Motorway corridor (section 4.2).
- M1 Pacific Motorway corridor (section 4.3).
- Westlink M7 Motorway corridor (section 4.4).

4.1 Pennant Hills Road corridor and Pacific Highway corridor

4.1.1 Traffic crashes

In the project area, both Pennant Hills Road and the Pacific Highway have a crash history which is broadly consistent with NSW averages. On both routes, fatal crashes have occurred at a lower frequency than average, while injury crashes have occurred on a slightly higher than average frequency. However, even minor crashes have a significant congestion impact due to the high traffic flows and strategic importance of Pennant Hills Road.

Table 4-1 summarises the crash history for this period, including the section where they occurred. Maps of the crash locations can be found in **Appendix A**. In summary, between 1 July 2008 and 30 June 2013:

- On Pennant Hills Road between the Pacific Highway and Hills M2 Motorway / Pennant Hills Road interchange:
  - A total of 980 crashes occurred, including one fatal and 342 injury crashes.
  - Around 50 per cent of total crashes involved rear-end collisions.
  - Heavy vehicles accounted for around 17 per cent of all vehicles involved in crashes.
- On the Pacific Highway between Galston Road and Pennant Hills Road:
  - A total of 186 crashes occurred, with no fatal crashes and 81 injury crashes.
  - Over 40 per cent of total crashes occurred as a result of one or more vehicles making turning movements or at intersections.
  - Around 20 per cent of total crashes involved rear-end collisions.
  - Heavy vehicles accounted for less than ten per cent of all vehicles involved in crashes.

Table 4-1 Crash history (1 July 2008 to 30 June 2013)

Section from	Section to	Section length (km)	Crashes			
			Total	Fatal	Injury	Tow-away
Pennant Hills Road						
Pacific Highway	The Comenarra Parkway	3.2	316	0	123	193
The Comenarra Parkway	Beecroft Road	2.2	348	0	108	240
Beecroft Road	Castle Hill Road	1.6	165	1	54	110
Castle Hill Road	Hills M2 Motorway	1.2	151	0	57	94
Total - Pacific Highway to Hills M2 Motorway		**8.2**	**980**	**1**	**342**	**637**
Pacific Highway						
Total – Galston Road to Pennant Hills Road		**3.6**	**186**	**0**	**81**	**105**

(Source: AECOM, 2014 based on Roads and Maritime Crash Data, 2013)

Crash severity indices provide an assessment of road safety based on the type and number of crashes occurring on a route. Fatal, injury and tow-away crashes carry different weightings; they are determined independently of absolute traffic volumes, and calculated to establish the average level of severity of crashes that occur. **Table 4-2** shows crash severity indices and **Figure 4-1** illustrates the formula used to calculate these indices.

Crash Severity Index =

*[(No. of fatal crashes * 3.0) + (No. of injury crashes * 1.5) + (No. of non-injury crashes)] / Total no. of crashes*

Figure 4-1 Crash severity index calculation

(Source: Roads and Maritime Crash Data, 2013)

The average crash severity index on Pennant Hills Road is 1.18, compared to an average of 1.22 for all crashes reported on public roads in the Sydney Metropolitan Area. This index indicates the Pennant Hills Road corridor has a lower than average proportion of fatal and injury crashes.

The lower than average index could be due to the frequent reduced speed environment of Pennant Hills Road, resulting from traffic congestion during peak hours. The high proportion (50 per cent) of traffic crashes in the corridor involving rear-end collisions also suggests traffic congestion is a significant contributing factor.

The average crash severity index of 1.22 for the Pacific Highway is equal to the Sydney Metropolitan Area average.

Table 4-2 Crash severity indices (1 July 2008 to 30 June 2013)

Section from	Section to	Crash severity index
Pennant Hills Road		
Pacific Highway	The Comenarra Parkway	1.19
The Comenarra Parkway	Beecroft Road	1.16
Beecroft Road	Castle Hill Road	1.18
Castle Hill Road	Hills M2 Motorway	1.19
Total – Pacific Highway to Hills M2 Motorway		**1.18**
Pacific Highway		
Total – Galston Road to Pennant Hills Road		**1.22**
New South Wales | Sydney Metropolitan Area Averages – All roads		
New South Wales (1 Jan 2008 to 31 Dec 2012)		**1.24**
Sydney Metropolitan Area (1 Jan 2012 to 31 Dec 2012)		**1.22**

(Source: AECOM, based on Roads and Maritime Crash Data & TfNSW Centre for Road Safety Data)

Crash rates per 100 million vehicle kilometres travelled (100MVKT) are shown in **Table 4-3**. These crash rates are calculated using the volume of traffic and distance travelled along a route, therefore offering a measure of risk per kilometre travelled. The formula used to calculate this rate is shown in **Figure 4-2**.

Crash rate per 100 MVKT =

*(Total no. of crashes * 100,000,000) / (No. of years * 365 * Length (km) * AADT)*

Figure 4-2 Crash rate per 100 million vehicle kilometres calculation

(Source: Roads and Maritime Crash Data. 2013)

The latest available Roads and Maritime data (for the 12 month period ending December 2013) show average fatality and injury rates across the Sydney Metropolitan Area of 0.2 and 29.4 per 100MVKT respectively.

Table 4-3 shows the average fatality and injury rates on the Pennant Hills Road corridor are 0.1 and 33.2 per 100MVKT respectively, estimated using 2013 traffic volumes. These statistics indicate that the occurrence of fatal crashes on Pennant Hills Road is lower per kilometre travelled than the Sydney Metropolitan Area average, although crashes causing injury occur at a higher than average rate.

Similarly, on the Pacific Highway between Galston Road and Pennant Hills road average fatality and injury rates are 0.0 and 32.0 per 100MVKT respectively. As for Pennant Hills Road, these statistics indicate that the occurrence of fatal crashes is lower but the occurrence of injury crashes slightly higher per kilometre travelled than the Sydney Metropolitan Area average.

Table 4-3 Crash rates per 100MVKT (2013)

Section from	Section to	Section length (km)	2013 ADT (veh)	Crash rate per 100MVKT			
				Total	Fatal	Injury	Tow-away
Pennant Hills Road							
Pacific Highway	The Comenarra Parkway	3.2	63,200	85.6	0.0	33.3	52.3
The Comenarra Parkway	Beecroft Road	2.2	73,100	118.6	0.0	36.8	81.8
Beecroft Road	Castle Hill Road	1.6	66,700	84.7	0.5	27.7	56.5
Castle Hill Road	Hills M2 Motorway	1.2	78,500	87.8	0.0	33.2	54.7
Total – Pacific Highway to Hills M2 Motorway		**8.2**	**-**	**95.2**	**0.1**	**33.2**	**61.9**
Pacific Highway							
Total – Galston Road to Pennant Hills Road		**3.6**	**37,000**	**76.5**	**0.0**	**33.3**	**43.2**
New South Wales | Sydney Metropolitan Area Averages – All roads							
New South Wales (1 Jan 2013 to 31 Dec 2013)		-	-	-	**0.5**	**28.0**	-
Sydney Metropolitan Area (1 Jan 2012 to 31 Dec 2012)		-	-	**68.8**	**0.2**	**29.4**	**39.2**

(Source: AECOM, based on Roads and Maritime Crash Data, TfNSW Centre for Road Safety Data, and Australian Bureau of Statistics Survey of Motor Vehicle Use (SMVU) data)

Table 4-4 provides details of the crash costs for Pennant Hills Road and the Pacific Highway. Average crash costs based on crash severity have been calculated using Roads and Maritime' Economic Analysis Manual (Economic Parameters for 2009). The crash costs presented in this report are based on a 'willingness to pay' approach; willingness to pay values for road safety reflect the accumulated value the NSW community is willing to pay or forgo in exchange for a reduction in the probability of crash related injuries and deaths on NSW roads.

Crashes on Pennant Hills Road between 1 July 2008 and 30 June 2013 cost an estimated total of $150,993,550, or $30,198,710 per annum. The analysis indicates an average crash cost per 100MVKT of $14,670,060 for the four sections analysed.

Crashes on the Pacific Highway cost an estimated total of $34,065,750, or $6,813,150 per annum. The cost of crashes per 100MVKT on the Pacific Highway is estimated to be $14,013,640.

Table 4-4 Crash costs (1 July 2008 to 30 June 2013)

Section from	Section to	Section length (km)	2013 ADT (veh)	Crash cost		
				Total Cost	Average Annual Cost	Cost per 100MVKT
Pennant Hills Road						
Pacific Highway	The Comenarra Parkway	3.2	63,200	$52,002,950	$10,400,590	$14,089,580
The Comenarra Parkway	Beecroft Road	2.2	73,100	$46,236,000	$9,247,200	$15,753,510
Beecroft Road	Castle Hill Road	1.6	66,700	$28,618,500	$5,723,700	$14,693,940
Castle Hill Road	Hills M2 Motorway	1.2	78,500	$24,136,100	$4,827,220	$14,039,550
Total – Pacific Highway to Hills M2 Motorway		**8.2**	**-**	**$150,993,550**	**$30,198,710**	**$14,670,060**
Pacific Highway						
Total – Galston Road to Pennant Hills Road		**3.6**	**37,000**	**$34,065,750**	**$6,813,150**	**$14,013,640**

(Source: AECOM, based on Roads and Maritime Crash Data and Roads and Maritime Economic Analysis Manual (Economic parameters for 2009))

4.1.2 Travel times and speeds

4.1.2.1 Pennant Hills Road corridor

Pennant Hills Road experiences congestion during commuter peak periods and business hours, resulting in low average peak travel speeds, unreliable travel times and disruptions to inter-regional traffic movements. Traffic on Pennant Hills Road between the M1 Pacific Motorway / Pennant Hills Road intersection and Hills M2 Motorway / Pennant Hills Road interchange is reported as operating at an average of 28 kilometres per hour in the inbound direction (southbound) in the AM peak period (6.15am-9am) and 32 kilometres per hour in the outbound direction (northbound) in the PM peak period (2.15pm-6pm), with a travel time range of ten to 24 minutes in the inbound direction (southbound) in the AM peak period and 12 to17 minutes in the outbound direction (northbound) in the PM peak[4].

Additional surveys of travel time and speed on Pennant Hills Road between the M1 Pacific Motorway and North Rocks Road were undertaken during the peak periods and the results are presented in **Table 4-5**. The most congested surveyed time was southbound in the AM peak period, where it took almost 40 minutes to travel the 8.9 kilometre section of Pennant Hills Road at an average speed of 14 kilometres per hour. This occurred between 7am and 8am.

Table 4-5 Speed and Travel Time (2013) – Pennant Hills Road corridor, between the M1 Pacific Motorway / Pennant Hills Road intersection and North Rocks Road

Direction	Distance (km)	Range of Travel Times (min:sec)	Average Speeds (km/h)
AM Peak Period			
Northbound	8.9	13:50-22:10	24-39
Southbound	8.9	17:40-39:10	14-30
PM Peak Period			
Northbound	8.9	14:50-20:00	27-36
Southbound	8.9	14:40-23:00	23-36

(Source: Austraffic; 3 Dec 2013)

[4] Roads and Maritime Services, Key Roads Performance Report, June 2013

4.1.2.2 Pacific Highway corridor

The Pacific Highway corridor suffers a high level of congestion in the peak periods. Traffic on the Pacific Highway between the M1 Pacific Motorway / Pacific Highway interchange and Pacific Highway / Ryde Road / Mona Vale Road interchange is reported as operating at an average of 32 kilometres per hour in the inbound direction (southbound) in the AM peak period (6am-8am) and 21 kilometres per hour in the outbound direction (northbound) in the PM peak period (3.30pm-7pm), with a travel time range of seven to 17 minutes in the inbound direction (southbound) in the AM peak period and nine to 19 minutes in the outbound direction (northbound) in the PM peak period[5].

Surveys of travel time and speed on the Pacific Highway between the M1 Pacific Motorway / Pacific Highway interchange and Pacific Highway / Ryde Road / Mona Vale Road interchange were undertaken during the peak periods and results are presented in **Table 4-6**.

Table 4-6 Average Speed and Travel Time (2013) – Pacific Highway Corridor, between M1 Pacific Motorway / Pacific Highway interchange and Pacific Highway / Ryde Road / Mona Vale Road interchange

Direction	Distance (km)	Range of Travel Times (min:sec)	Average Speeds (km/h)
AM Peak Period			
Northbound	5.4	7:00-10:30	31-46
Southbound	5.4	7:50-15:30	21-41
PM Peak Period			
Northbound	5.4	6:50-14:20	23-47
Southbound	5.4	8:00-13:10	25-41

(Source: Austraffic; 3 Dec 2013)

4.1.3 Operational assessment

Level of service (LoS) is a measure to determine the operational conditions and efficiency of a roadway or intersection. The definition of LoS generally outlines the operating conditions in terms of speed and travel time, freedom to manoeuvre, traffic interruptions, comfort and convenience, and road safety.

4.1.3.1 Definition of roadway level of service

Mid-block traffic volume / capacity (V/C) ratios provide an indication of the saturation level of a segment of roadway, based on theoretical design capacity. These mid-block volume / capacity ratios can be used to provide a corresponding level of service for roadway operation, as detailed in *Guide to Traffic Management – Part 3 Traffic Studies and Analysis* (Austroads, Second Edition, 2013). There are six levels of service for midblock carriageway locations – level of service A to level of service F, with level of service A representing optimum operating conditions (free flow) and level of service F the poorest (forced or breakdown in flow). The range of mid-block volume / capacity ratio ranges which correspond to each level of service vary with differing road conditions and road type classifications.

Table 4-7 details the level of service definitions and corresponding volume / capacity ranges for the road operation conditions which apply to the assessment of the project. Assessment of mid-block level of service for Pennant Hills Road will use the volume / capacity ratio ranges for multi-lane roads, and assessment of the motorways and main alignment tunnels will use the volume / capacity ratio ranges for freeways.

[5] Ibid

Table 4-7 Mid-block level of service definitions and criteria – multi lane roads

LoS	Definition	V/C ratio criteria	
		Multi-lane Roads[1]	Freeways[2]
A	A condition of free flow in which individual drivers are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to manoeuvre within the traffic stream is extremely high.	V/C <= 0.26	V/C <= 0.30
B	In the zone of stable flow where drivers still have reasonable freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort is a little less than with level of service A.	0.26 < V/C <= 0.41	0.30 < V/C <= 0.48
C	Also in the zone of stable flow, but most drivers are restricted to some extent in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience declines noticeably at this level.	0.41 < V/C <= 0.59	0.48 < V/C <= 0.70
D	Close to the limit of stable flow and approaching unstable flow. All drivers are severely restricted in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is poor, and small increases in traffic flow will generally cause operational problems.	0.59 < V/C <= 0.81	0.70 < V/C <= 0.90
E	Traffic volumes are at or close to capacity, and there is virtually no freedom to select desired speeds or to manoeuvre within the traffic stream. Flow is unstable and minor disturbances within the traffic stream will cause breakdown.	0.81 < V/C <= 1.00	0.90 < V/C <= 1.00
F	In the zone of forced flow, where the amount of traffic approaching the point under consideration exceeds that which can pass it. Flow breakdown occurs, and queuing and delays result.	1.00 < V/C	1.00 < V/C

(Source: Austroads, Guide to Traffic Management – Part 3 Traffic Studies and Analysis, Second Edition, 2013)

[1] Where free flow speed is taken as 70 kilometres per hour

[2] Where free flow speed is taken as 100 kilometres per hour

4.1.3.2 Definition of intersection level of service

Average delay is commonly used to assess the operational performance of intersections, with level of service used as an index. A summary of the level of service index is shown in **Table 4-8**.

Table 4-8 Level of service criteria for intersections

Level of service	Average delay / vehicle (secs/veh)	Traffic signals / roundabouts	Give way and Stop signs
A	<14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity and accident study required
E	57 to 70	At capacity; at signals incidents will cause excessive delays	At capacity; requires other control mode
F	>70	Roundabouts require other control mode	At capacity; requires other control mode

(Source: Guide to Traffic Generating Developments, RTA, 2002)

Degree of saturation (DoS) is a measure of assessing the capacity of an intersection using a ratio of intersection traffic volume to intersection traffic capacity between zero and one, with one representing the capacity of the intersection. Intersections are said to reach their practical capacity at a degree of saturation of 0.9. Beyond the practical capacity, any additional traffic would have an increasing impact on delays and the subsequent performance of the intersection.

When a roadway or intersection level of service falls below level of service D, investigations are generally initiated to provide suitable remediation, however constraints in built-up urban areas mean that level of service E and F are regularly experienced by motorists at pinch points on the existing strategic road network in Sydney. These conditions are generally experienced during traffic peak periods. Roads and Maritime have a program of works aimed at relieving congestion at pinch points and improving performance on strategic roads.

4.1.3.3 Roadway level of service

The theoretical mid-block capacity for a single lane on Pennant Hills Road and the Pacific Highway has been adopted as 1,400 passenger car units (PCU) per lane for the peak hour based on urban arterial roads with interrupted flow[6]. Mid-block volume / capacity ratios along the Pennant Hills Road and Pacific Highway corridor under existing (2013) conditions for the AM and PM peak are provided in **Table 4-9**.

Table 4-9 Mid-block traffic volumes and LoS: Existing 2013

Location	Direction	Mid-Block Capacity	Light Vehicles	Heavy Vehicles	V/C	LoS
AM Peak Hour						
Pennant Hills Road, North Rocks Road to Hills M2 Motorway	Northbound	2,800	1,270	150	0.61	D
	Southbound	2,800	1,830	100	0.76	D
Pennant Hills Road, Hills M2 Motorway to Castle Hill Road	Northbound	4,200	2,190	320	0.75	D
	Southbound	4,200	2,910	210	0.84	E
Pennant Hills Road, Castle Hill Road to Beecroft Road	Northbound	4,200	2,370	260	0.75	D
	Southbound	4,200	2,040	200	0.63	D
Pennant Hills Road, Beecroft Road to Comenarra Parkway	Northbound	4,200	3,170	280	0.95	E
	Southbound	4,200	2,980	210	0.85	E
Pennant Hills Road, Comenarra Parkway to Pacific Highway	Northbound	4,200	1,980	260	0.65	D
	Southbound	4,200	2,020	260	0.66	D
Pacific Highway, north of Pennant Hills Road	Northbound	2,800	1,310	70	0.53	C
	Southbound	4,200	1,050	80	0.30	B
Pacific Highway, east of M1 Pacific Motorway Interchange	Northbound	4,200	1,390	100	0.40	B
	Southbound	4,200	2,780	140	0.76	D
PM Peak Hour						
Pennant Hills Road, North Rocks Road to Hills M2 Motorway	Northbound	2,800	1,820	50	0.71	D
	Southbound	2,800	1,610	110	0.69	D
Pennant Hills Road, Hills M2 Motorway to Castle Hill Road	Northbound	4,200	3,320	180	0.92	E
	Southbound	4,200	2,620	280	0.82	E
Pennant Hills Road, Castle Hill Road to Beecroft Road	Northbound	4,200	2,350	160	0.67	D
	Southbound	4,200	2,110	250	0.68	D
Pennant Hills Road, Beecroft Road to Comenarra Parkway	Northbound	4,200	3,400	160	0.92	E
	Southbound	4,200	2,590	280	0.81	E
Pennant Hills Road, Comenarra Parkway to Pacific Highway	Northbound	4,200	2,630	180	0.75	D
	Southbound	4,200	1,980	230	0.63	D
Pacific Highway, north of Pennant Hills Road	Northbound	2,800	1,200	40	0.47	C
	Southbound	4,200	1490	50	0.39	B
Pacific Highway, east of M1 Pacific Motorway Interchange	Northbound	4,200	2,900	70	0.74	D
	Southbound	4,200	1,720	40	0.44	C

[6] Austroads, Guide to Traffic Management Part 3: Traffic Studies and Analysis, Second Edition, April 2013, page 63

During the AM peak hour, Pennant Hills Road between Beecroft Road and Comenarra Parkway is operating near capacity in the northbound direction with a volume / capacity ratio of 0.95. In the PM peak hour, the sections from the Hills M2 Motorway to Castle Hill Road and from Beecroft Road to Comenarra Parkway in the northbound direction operate near capacity, with a volume / capacity ratio of 0.92. It can be expected that these sections in particular would be under pressure with 2019 and 2029 forecast traffic volumes in the 'without project' scenario.

4.1.3.4 Intersection level of service

Table 4-10 provides a summary of the intersection performance level of service at key locations on the Pennant Hills Road corridor under the existing AM and PM peak hour traffic volumes. The analysis provides the average intersection delays and the level of service for the intersection, calculated using LinSig.

Table 4-10 Modelled intersection performance 2013 (AM and PM Peak Hour)

Intersection/Peak	Light Vehicles	Heavy Vehicles	Average Delay	Level of Service
Pennant Hills Road / North Rocks Road				
AM Peak	4,090	280	88.6	F
PM Peak	4,540	170	91.0	F
Hills M2 Motorway / Pennant Hills Road interchange				
AM Peak	5,410	600	45.2	D
PM Peak	5,780	480	86.0	F
Pennant Hills Road / Copeland Road / Eaton Road				
AM Peak	5,320	560	61.4	E
PM Peak	5,750	470	65.4	E
Pennant Hills Road / Aiken Road				
AM Peak	5,070	561	19.8	B
PM Peak	6,091	464	20.9	B
Pennant Hills Road / Castle Hill Road				
AM Peak	4,720	550	13.6	A
PM Peak	5,790	440	27.5	B
Pennant Hills Road / Beecroft Road (South)				
AM Peak	5,140	470	35.8	C
PM Peak	5,510	390	62.5	E
Pennant Hills Road / Beecroft Road (North)				
AM Peak	6,150	490	54.4	D
PM Peak	5,890	410	13.0	A
Pennant Hills Road / Boundary Road				
AM Peak	6,120	540	51.9	D
PM Peak	6,390	450	38.0	C
Pennant Hills Road / Yarrara Road				
AM Peak	4,239	547	43.7	D
PM Peak	5,840	451	39.6	C

Intersection/Peak	Light Vehicles	Heavy Vehicles	Average Delay	Level of Service
Pennant Hills Road / Comenarra Parkway				
AM Peak	4,510	590	67.2	E
PM Peak	5,200	440	82.3	F
M1 Pacific Motorway / Pennant Hills Road				
AM Peak	4,010	490	27.5	B
PM Peak	4,550	380	40.4	C
Pennant Hills Road / Pacific Highway				
AM Peak	2,950	200	58.1	E
PM Peak	3,330	110	50.1	D
M1 Pacific Motorway / Pacific Highway interchange				
AM Peak	4,450	240	42.3	C
PM Peak	4,970	120	55.3	D

The intersection performance results demonstrate the existing Pennant Hills Road corridor experiences significant congestion during the AM and PM peak hour periods. The traffic signals are coordinated to provide priority along the corridor to reduce the average delays to the major through movements in the peak direction; however the results indicate some of the intersections operate close to capacity.

At several key locations, the intersection performance is approaching capacity with movements recording a poor level of service. The delays illustrate capacity constraints within the network under the current geometry and traffic signal phase splits (derived from IDM).

The intersections with an increased number of conflicting movements observe higher average intersection delay. The intersections currently operating at LoS F include:

- Pennant Hills Road / North Rocks Road (both peaks).
- Hills M2 Motorway / Pennant Hills Road interchange (PM peak).
- Pennant Hills Road / Comenarra Parkway (PM peak).

While the remainder of intersections operate at LoS E or better, the poor LoS values indicate they are susceptible to decreases in performance with any increase in demand without improvements to intersection layouts, or where possible, further optimisation of the signal timings. The intersections susceptible to decreases in performance with a relatively small growth in demand include:

- Pennant Hills Road / Copeland Road (both peaks).
- Pennant Hills Road / Beecroft Road (South) (PM peak).
- Pennant Hills Road / Comenarra Parkway (AM peak).
- Pennant Hills Road / Pacific Highway (AM peak).