Meriton Properties

128 and 130-150 Bunnerong Road, Pagewood

Transport Impact Assessment

Rev A | 7 April 2017

Job number 237575

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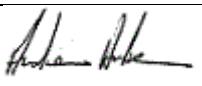
		Signature			
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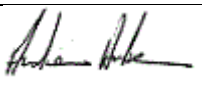
		Signature			
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Traffic modelling report

1 Introduction

1.1 Background

Meriton Properties (Meriton) commissioned Arup to undertake traffic and transport analysis for the proposed 128 and 130-150 Bunnerong Road, Pagewood site. An L-shaped parcel (10.35ha) known as 130-150 Bunnerong Road, Pagewood was approved as a concept masterplan in 2014. A Development Control Plan (DCP) including a site specific chapter has been prepared (refer to Chapter 9D – British American Tobacco Australasia, of the Botany Bay DCP 2013).

The intended outcome of the Planning Proposal is to amend the *Botany Bay Local Environmental Plan 2013* (BBLEP 2013) as follows:

- Rezone the subject site from part IN1 General Industrial and part R3 Medium Density Residential to R4 High Density Residential.
- Increase the maximum floor space ratio (FSR) development standard from 1:1 to 2.3:1.
- Increase the maximum height of buildings development standard to part 28m and part 65m.

A concept plan illustrating the type of development facilitated by the Planning Proposal has been prepared by Hassell. The concept plan contemplates a high-density residential development with buildings of 8-20 storeys oriented around a network of internal roads and public open space. The plan also provides for the non-listed heritage buildings in the north-east of the site to be retained and dedicated to Council in recognition of their heritage value. The development will accommodate approximately 2,068 dwellings and allowance has been made for 1,000m^2 retail floor space, 100-place childcare centre and potential for 2,000m^2 of community uses within the retained historic buildings.

The subject site is located within a broader site known as 128 and 130-150 Bunnerong Road, Pagewood. The site is within the Bayside Local Government Area (LGA) and is legally described as Lots 1 and 2 in DP 1187426 (see **Figure 1**).

The broader site was previously occupied by industrial uses associated with the manufacturing operations of British American Tobacco Australasia (BATA). Lot 1 was excised from the larger site, remaining for reduced industrial uses while the remaining portion of the site was rezoned in June 2013 to support mixed use development, including high density residential uses.

The Planning Proposal request relates to the whole of Lot 1 in DP1187426 (Lot 1) and the northern portion of Lot 2 in DP118746 (Lot 2) and covers an area of approximately 8.95ha. The site has frontages to an internal road (Meriton Boulevard) to the south, Bunnerong Road to the east, Banks Avenue to the west and Heffron Road to the north.

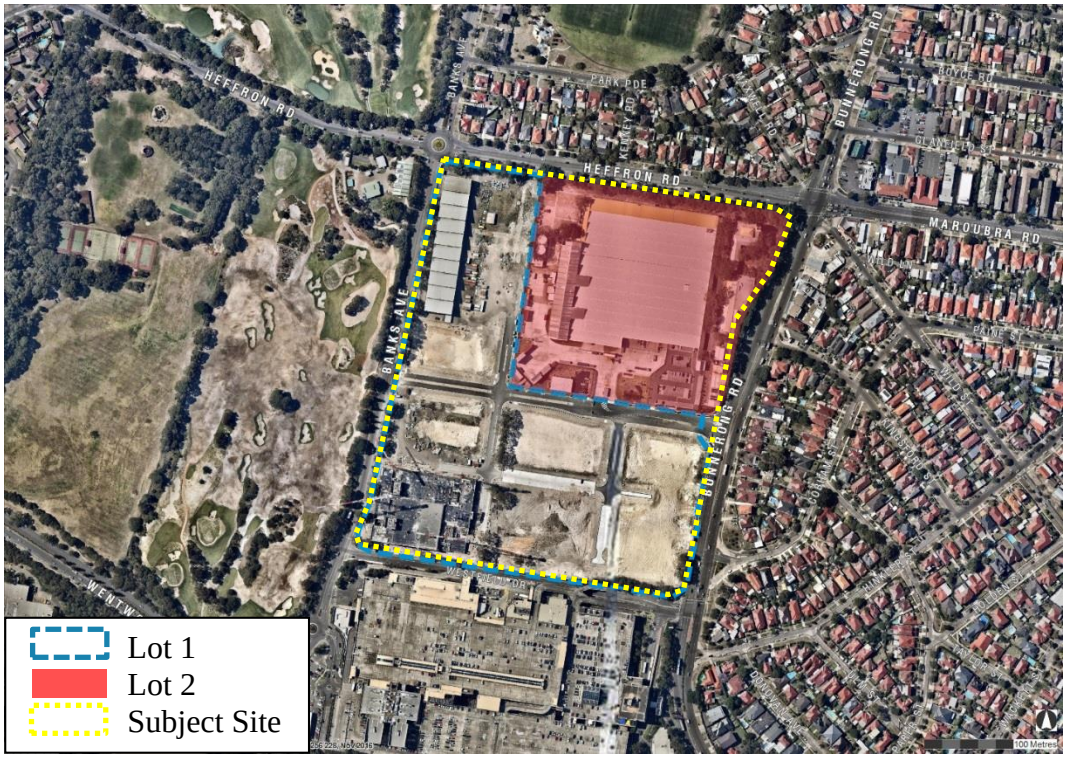


Figure 1: Location plan

This report has been prepared for review by Roads and Maritime in response to letter dated 25 August 2015 to determine the necessity for road upgrades on surrounding roads. The traffic models used and described within this report and supporting reports are submitted together with this report.

This report references the previously prepared documentation for the remainder of the BATA site including:

- Colston Budd Hunt and Kafes and supplementary PB report dated March 2012
- Arup Traffic Impact Assessment dated 24 July 2014
- Arup S34 Conference Report dated 5 May 2015

1.2 Report scope

This transport report supports the rezoning application related to 128 Bunnerong Road, Pagewood and the northern portion of 130-150 Bunnerong Road, Pagewood and will outline the following:

- Existing transport conditions
- Forecast traffic generation
- Road network impacts
- Parking provision
- Access arrangements
- Public transport availability
- Pedestrian and cycle linkages

2 Existing site context

2.1 Site description

The proposed development site relates to 128 Bunnerong Road, Pagewood and the northern portion of 130-150 Bunnerong Road, Pagewood which is shown in Figure 2. The site is located within the Bayside Council local government area. The overall site is bound by Heffron Road to the north, Meriton Boulevard to the south, Bunnerong Road to the east and the north-south street No.1 to the west. The site is located some 8kms south of the Sydney CBD and 1km west of Maroubra Junction and located within the Bayside Council Local Government Area. Adjacent land uses include:

- Approved concept masterplan for 2,223 residential units, four child care centres and 5,000m^2 retail at 130-150 Bunnerong Road, Pagewood;
- Westfield Eastgardens shopping centre to the south of the site;
- Existing low-density residential development to the north and east of the site; and
- Bonnie Doon Golf Club to the west of the site across Banks Avenue.

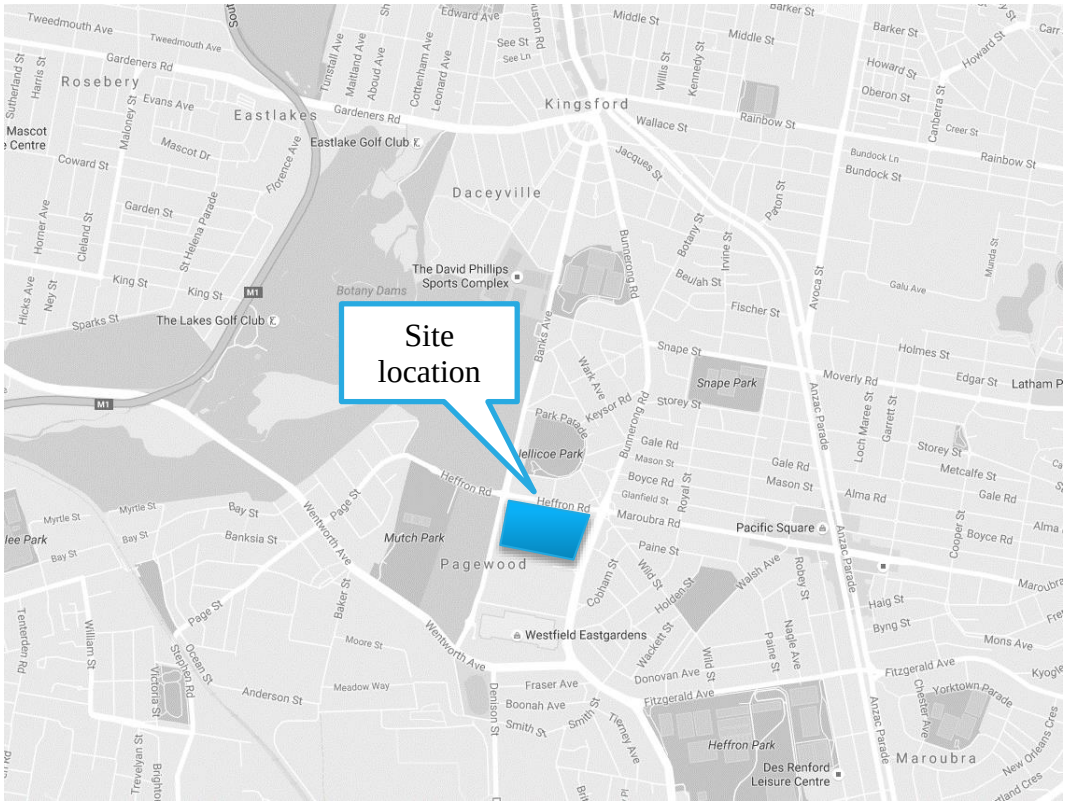


Figure 2: Site location plan

The site was previously used by the British American Tobacco Australia (BATA) as a production facility and contains a large warehouse. There are also some heritage buildings on the northeast corner of the site. The site has staff car parking and loading areas suitable for B-double vehicles. Existing vehicular access to the BATA site is provided from Meriton Boulevard, which is accessed from Bunnerong Road as a left-in / left-out priority intersection.

In 2008, BATA lodged a proposal to rezone part of the site to allow medium density residential development plus other non-residential uses which was approved in June 2013. The site has been subdivided into two lots under DA 11/272. Lot 1 which is located in the north east corner of the site was retained by BATA for its reduced operation. The approved rezoning of the site is as follows:

- Zone IN1 for industrial use within the BATA retained site at 128 Bunnerong Road;
- Zone B4 mixed use and Zone R3 medium density residential for 130-150 Bunnerong Road.

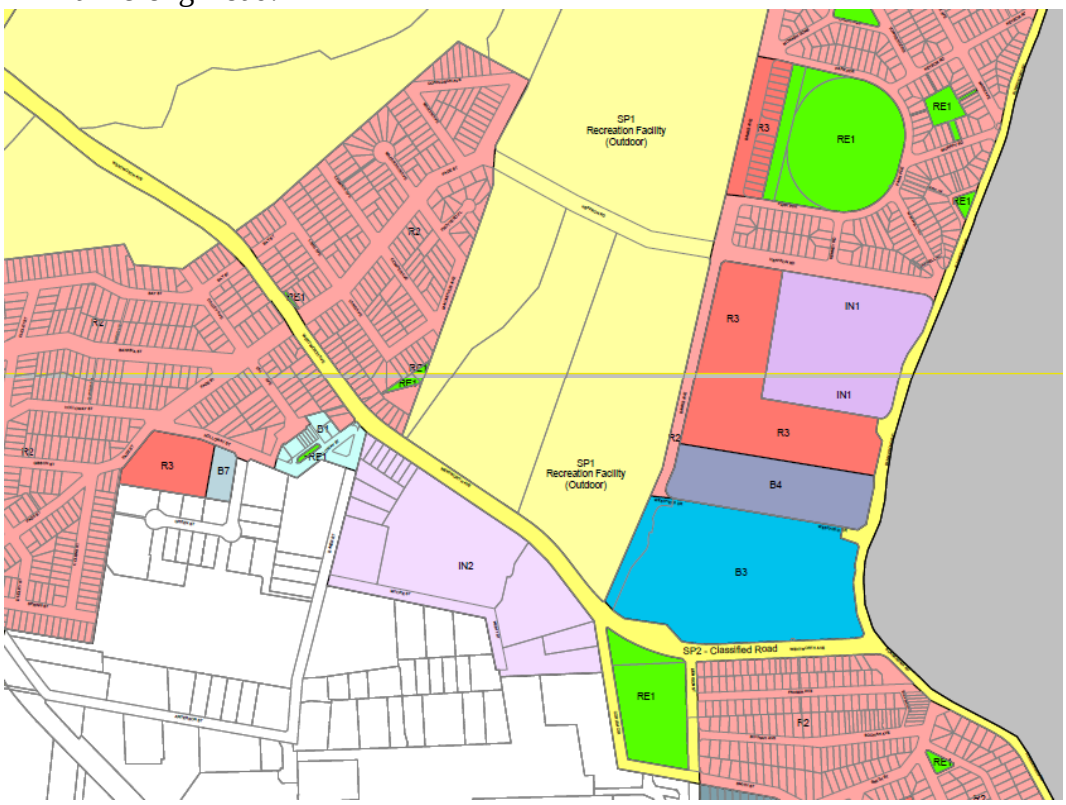


Figure 3: Current Botany Bay LEP zoning

2.2 Road network

The main roads surrounding the site are Bunnerong Road to the east, Wentworth Avenue to the south, Banks Avenue to the west and Heffron Road/Maroubra Road to the north.

Bunnerong Road is a north-south state road connecting La Perouse to Kingsford Nine Ways. It generally has three traffic lanes in each direction and a speed limit of 60km/h. Bunnerong Road is a major bus corridor with buses connecting to the Sydney CBD, La Perouse and Matraville.

Wentworth Avenue, (located further south to the site) is a state road with three traffic lanes in each direction. It serves as a major connection between Mascot and Eastgardens. Wentworth Avenue has a speed limit of 70km/h.

Westfield Drive is a private road located between Banks Avenue and Bunnerong Road and provides access to both the Westfield Eastgardens and the approved 130-150 Bunnerong Road, Pagewood masterplan site.

Banks Avenue is a local road connecting Eastgardens to Kingsford. It has generally has two traffic lanes in each direction and has a speed limit of 50km/h.

Heffron Road and Maroubra Road are regional roads that connect Banksmeadow to Maroubra. Heffron Road generally has one traffic lane and one parking lane in each direction and Maroubra Road is a multi-lane divided road. In the immediate vicinity of the site Heffron Road has a speed limit of 50km/h. Bus services also operate on Heffron Road and Maroubra Road.

There are also internal roads being constructed as part of the approved masterplan site, which include a series of public and private roads. The public roads include Meriton Boulevard which runs east-west through the site between Bunnerong Road and Banks Avenue, a local street east-west street north of Meriton Boulevard and two north-south streets.

2.3 Public transport

The site has good access to public transport. The main public transport servicing the site are buses. A number of major bus routes operate on nearby roads as shown in Table 1. Bus stops are located on Bunnerong Road near Heffron Road (northeast of the site) and at the Westfield Eastgardens bus terminal (southeast of the site).

Table 1: Bus services

Bus route	Frequency
Route 301, Eastgardens to City – Circular Quay via Mascot, Eastlakes, Roseberry, Zetland, Waterloo and Surry Hills	Every 30 minutes throughout the day in both directions of travel
Route 302, Eastgardens to City – Circular Quay via Kingsford, Kensington, Waterloo and Surry Hills	Every hour throughout the day in both directions of travel
Route 310 Port Botany and Eastgardens to city	Every 20 minutes throughout the day in both directions of travel
Route 316, Eastgardens to Bondi Junction via South Maroubra, Maroubra Beach, South Coogee, Randwick Junction and Waverley	Every 20 minutes throughout the day in both directions of travel
Route 317, Eastgardens to Bondi Junction via South Maroubra, Maroubra Beach, South Coogee, Randwick Junction and Waverley	Every 30 minutes throughout the day in both directions of travel
Route 353, Eastgardens to Bondi Junction via Maroubra, Maroubra Beach, South Coogee, Coogee, Clovelly and Waverley	Every 30 minutes throughout the day in both directions of travel
Route 391, La Perouse and Little Bay to City via Bunnerong Road	Every 30 minutes throughout the day in both directions of travel
Route 392, La Perouse and Little Bay to City via Bunnerong Road	Every 30 minutes throughout the day in both directions of travel
Route 400 Burwood to Bondi Junction	Every 30 minutes throughout the day in both directions of travel
Route 410 Rockdale to Bondi Junction	Every 15 minutes throughout the day in both directions of travel. Only operates during the AM and PM peak periods

2.4 Active transport

2.4.1 Cycling

There are a number of cycle facilities surrounding the development site, consisting mainly of on-road facilities or shoulders. These include an off-road facility along Wentworth Avenue and on-road marked cycle lanes on Heffron Road / Page Street and Banks Avenue. A map of surrounding cycleways is shown in Figure 4.

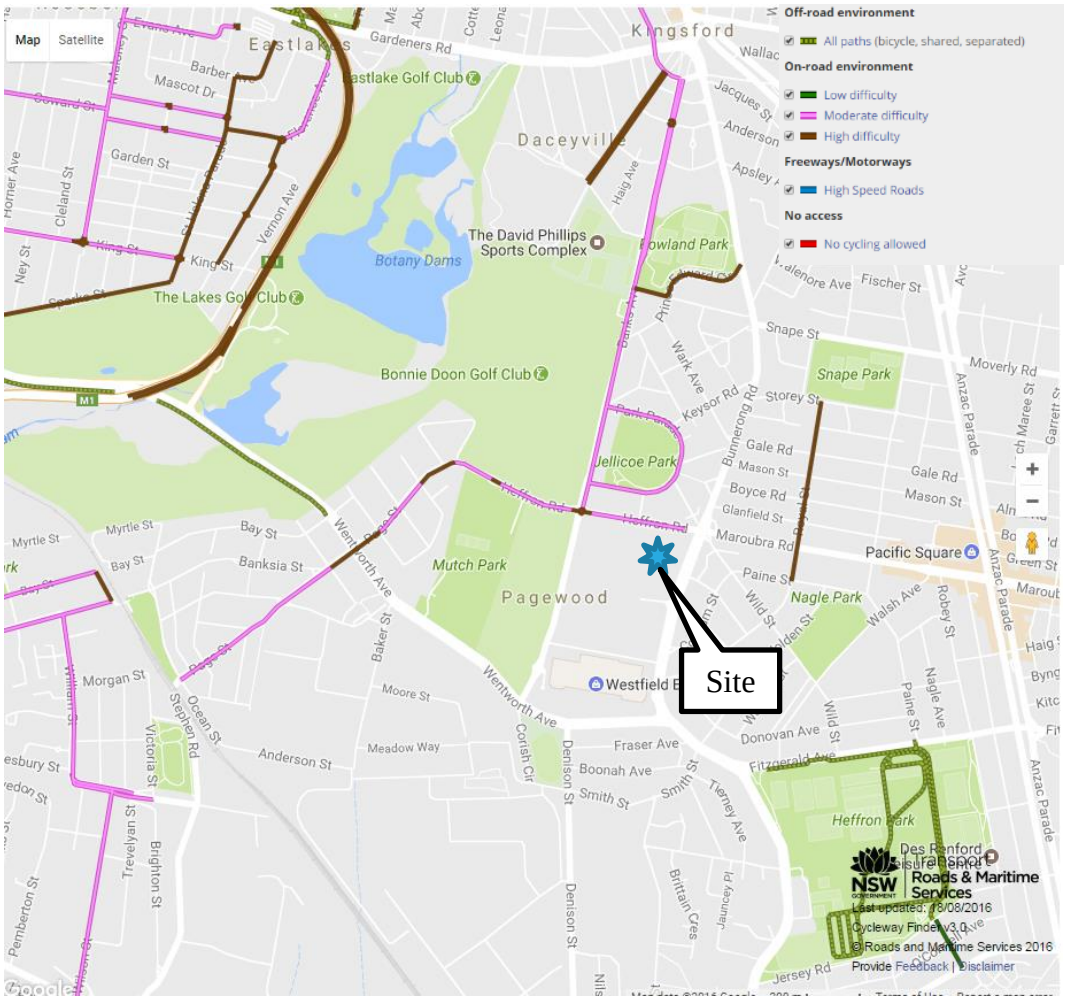


Figure 4: Cycling routes (Source: Roads and Maritime Cycleway Finder)

2.4.2 Walking

Due to the site's close proximity to public transport and local amenities, there is a good network of local footpaths. Footpaths and kerb ramps are provided on both sides of the road on Bunnerong Road, Heffron Road and Westfield Drive. A pedestrian footpath is provided on the eastern side of Banks Avenue.

There are also ample pedestrian crossing opportunities in the area, with multiple signalized pedestrian crossing opportunities on Westfield Drive, Bunnerong Road and Maroubra Road. The local area has wide roads which are shared between cyclists and motorists. An on-road separated cycleway is marked along Heffron Road, north of the site.

Pedestrian connections to surrounding amenities such as shops, transport, parks, sports fields and schools were plotted and then audited. The diagram below shows the most direct and safest connections to these amenities. Main attractors include:

- Pacific Square
- Maroubra Road shops
- Westfield Eastgardens (including bus interchange)
- Nagle Park
- Jellicoe Park
- Heffron Park
- Hensley Athletic Field
- Mutch Park
- Our Lady of the Annunciation Catholic School and Church
- South Sydney High School
- Pagewood Public School
- Future light rail stop at Kingsford

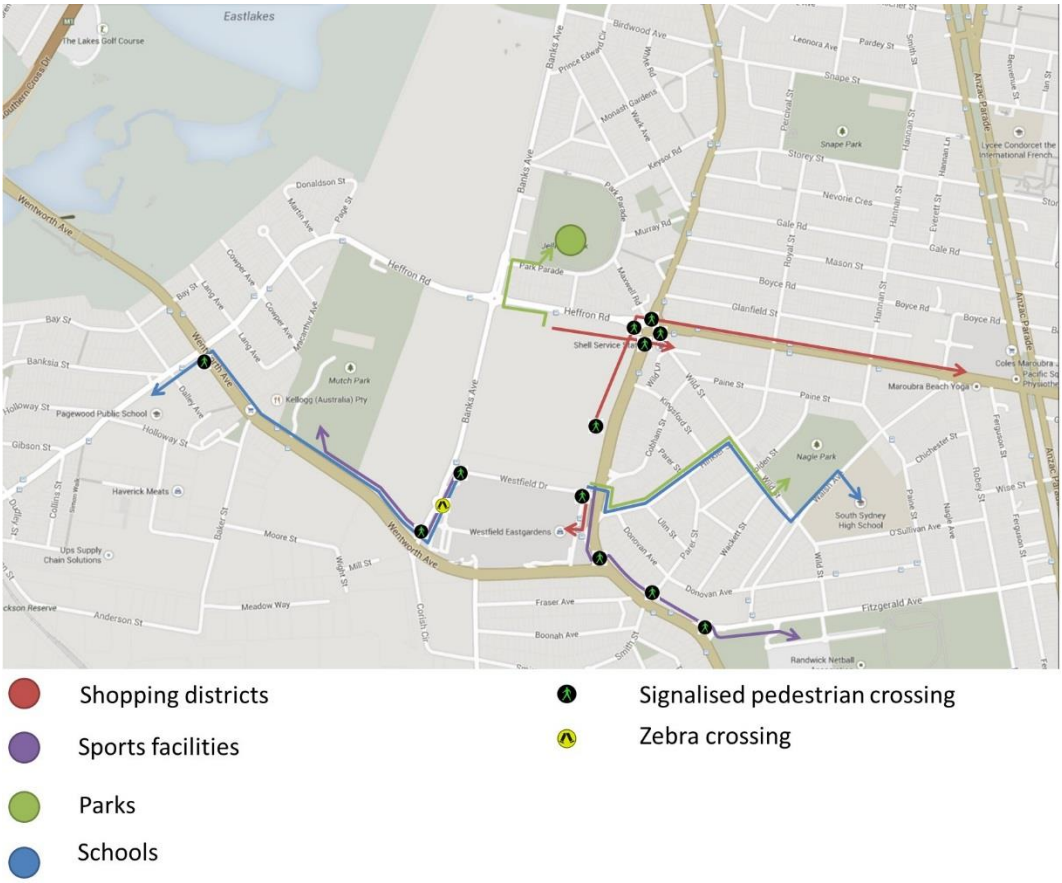


Figure 5: Walking routes from development

2.5 Travel patterns

Mode share patterns at the site were analysed using 2011 Journey to Work (JTW) Census data from the Bureau of Transport Statistics. The JTW data for travel zone 421, 423, 424 and 640 were used to assess the likely mode of peak hour trips approaching/departing the site (as the travel zone containing the site is purely employment). The results of the analysis are presented in Table 2.

Table 2: 2011 Journey to Work (JTW) travel patterns (for travel zones 421, 423, 424 and 640)

Mode	Inbound trips to work	Outbound trips to work
Train	4%	3%
Bus	11%	19%
Car	62%	57%
Walk	5%	6%
Other	3%	4%
Did Not Travel	15%	12%
Total %	100%	100%
Total Trips	4,466	3,622

Source: BTS, 2011

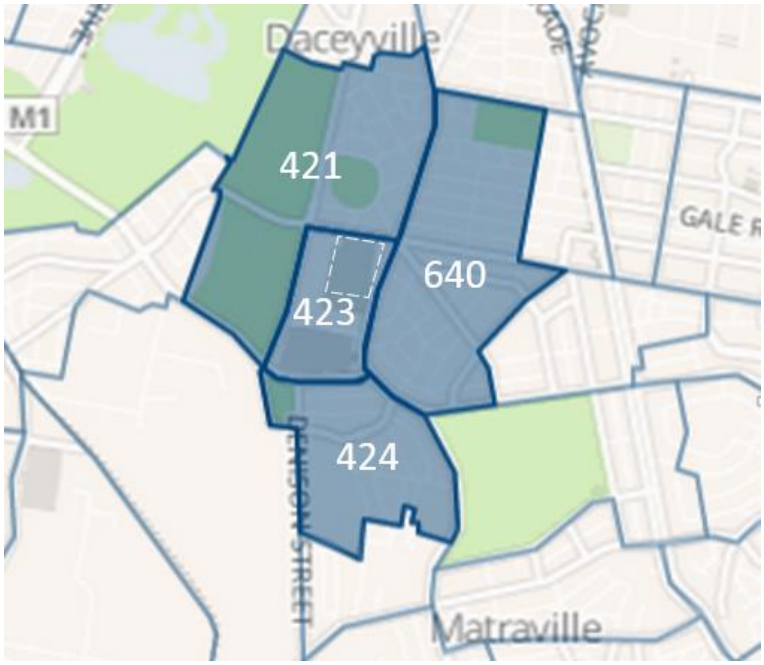


Figure 6: Journey to Work travel zone coverage

The data revealed that outbound trips by local residents rely more heavily on car trip modes (57%), followed by bus (19%). Other modes noted walking (6%) and train (3%).

2.6 Road safety

Crashes were analysed on the surrounding streets of the site over the most recent five year period (from January 2009 – December 2013 inclusive). Overall, there were 123 crashes recorded, of which there were no fatalities, 51 injuries and 72

non-casualty (tow away) crashes. The data also indicates a fairly even distribution of crashes per year as shown in Figure 7.

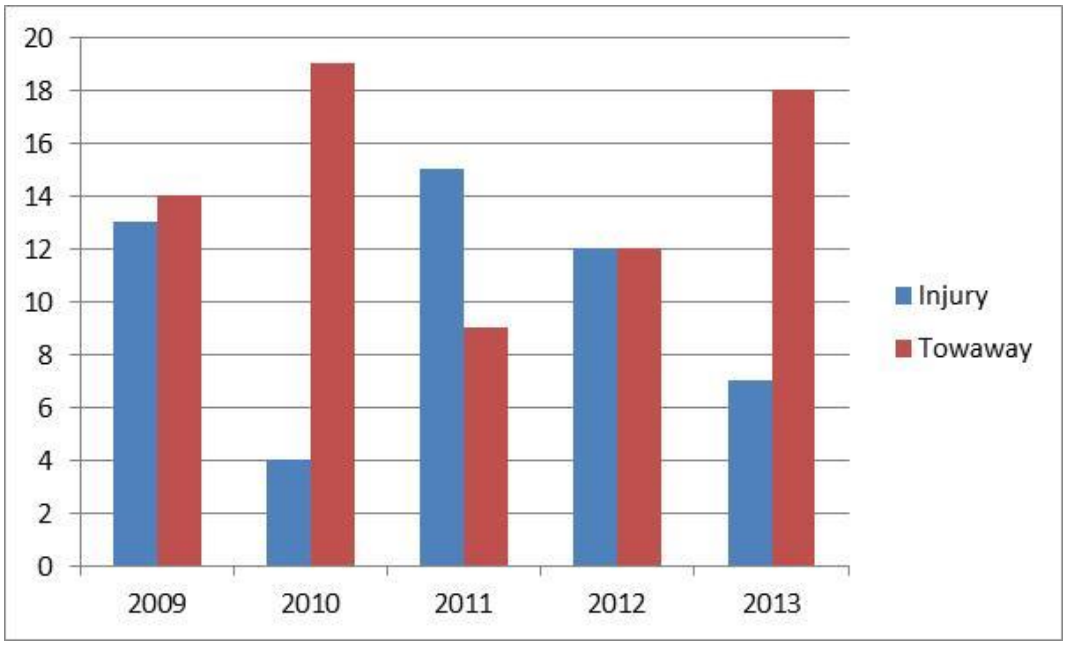


Figure 7: Degree of crashes per year (2008-2013) on surrounding streets

The crash data was sorted into hourly time periods (Figure 8). Crashes were more concentrated in the commuter peak periods. Interestingly, the highest recorded hourly time period were in the PM peak hours (4pm-6pm), likely indicating higher traffic volumes.

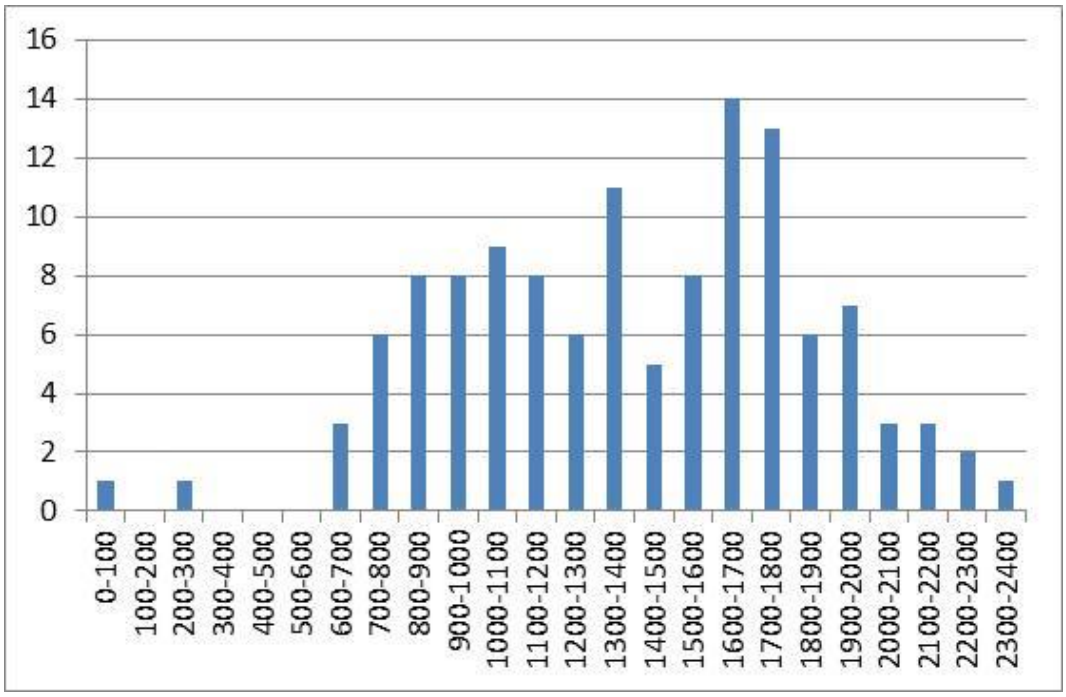


Figure 8: Crashes by time period

The crash data was sorted into days of the week (Figure 9). Crashes were more concentrated in the earlier days of the week, indicating that they were not directly related to shopper peaks (which are Thursdays and weekends).

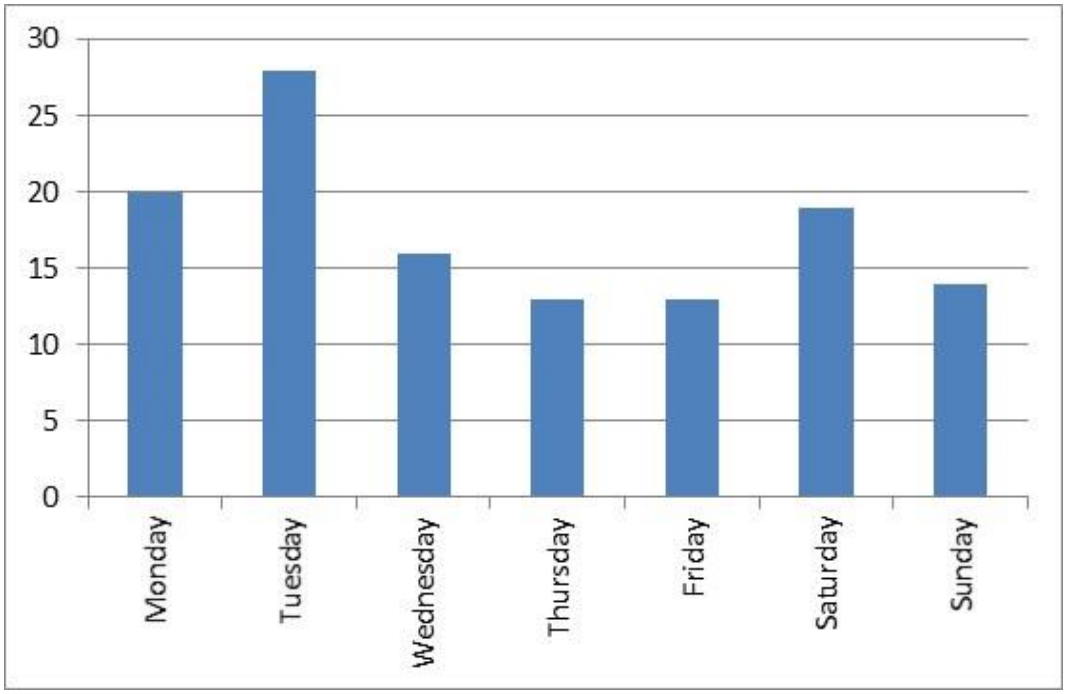


Figure 9: Crashes by day of the week

The crash data was classified into the various road user movement (RUM) codes to analyse crash clustering. The majority of crash types were recorded as vehicles from opposing directions, followed by vehicles in same direction which are common along arterial roads and at intersections (Figure 10).

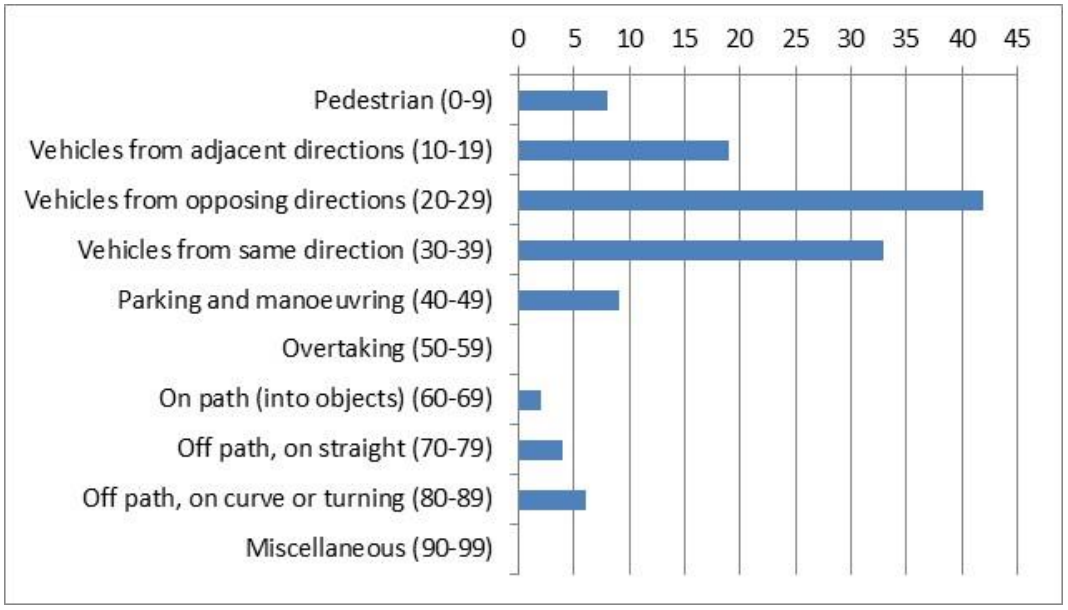
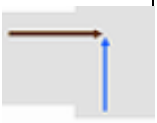
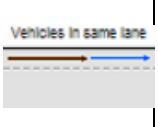


Figure 10: Crash types by road user movement categories

2.7 Crash clusters

Crash clusters for the purposes of this study were defined as three or more crashes with the same RUM code, within 50m of each other. Crash clusters were focused around key intersections and are detailed in Table 3 and Figure 11. There were no recognisable clusters for pedestrians, but crash types were similarly ‘emerging pedestrians’ crash types surrounding the site.

Table 3: Investigation of crash clusters at intersections by road user movements

Primary street	Cross street	Adjacent cross traffic	Adjacent right-thru from right	Same rear end	Opposite right through
					
Bunnerong Road	Heffron Road	**3**		**7**	
Heffron Road	Banks Avenue	**6**		**4**	
Bunnerong Road	Westfield Drive			**3**	**13**
Bunnerong Road	Wentworth Avenue			**3**	**12**
Wentworth Avenue	Banks Avenue		**4**		**6**
Wentworth Avenue	Denison Street				**11**

Bunnerong Road / Heffron Road had a number of rear ends and cross traffic crashes recorded. These were recorded in all approaches, indicating no common contributing factors. These are inherently common at a signalised intersection, considering the current traffic volumes and are not easily treatable without major upgrades. There were a number of rear ends that appeared to occur on the southbound lanes leaving the intersection, perhaps due to driveways and merging from upstream parking along the carriageway.

Heffron Road / Banks Avenue had a large number of cross traffic crashes and rear ends. Similarly, these are inherently common at intersections such as a roundabout (or signalised) intersection and are not treatable without major upgrades. It is likely that a signalised intersection will continue to have these types of crashes, with a reduced rate, but more severity (given increase of traffic speeds). Crashes were more common along Heffron Road, but were spread either side of the intersection at no specific area.

Bunnerong Road / Westfield Drive and **Bunnerong Road / Wentworth Avenue** had a large number of opposite right through crashes, which are treatable given the filter right turn occurring from Bunnerong Road. It is suggested to remove the filer if non-detrimental to traffic flows or amend the sightlines for this approach.

Wentworth Avenue / Banks Avenue had a number of opposing right through and adjacent right through crashes. This is likely resulting due to filter right turns and vehicles running red due to saturation of the turn bay on Wentworth Avenue. More right turn capacity (extra lane) is suggested for Wentworth Avenue to help alleviate traffic volumes and safety at this intersection.

Wentworth Avenue / Denison Street had a large number of right through crashes. This is likely a result of the phase that allows Westfield to exit and filter right turns from Dension Street. No upgrades are suggested without major detriments to the traffic flows.

The crash types identified as clusters are considered common at intersections (where the majority of crashes were recorded). Therefore, as a consequence of the level of traffic on surrounding roads, crashes are fairly typical and there are no further safety upgrades recommended as a result of the assessment.

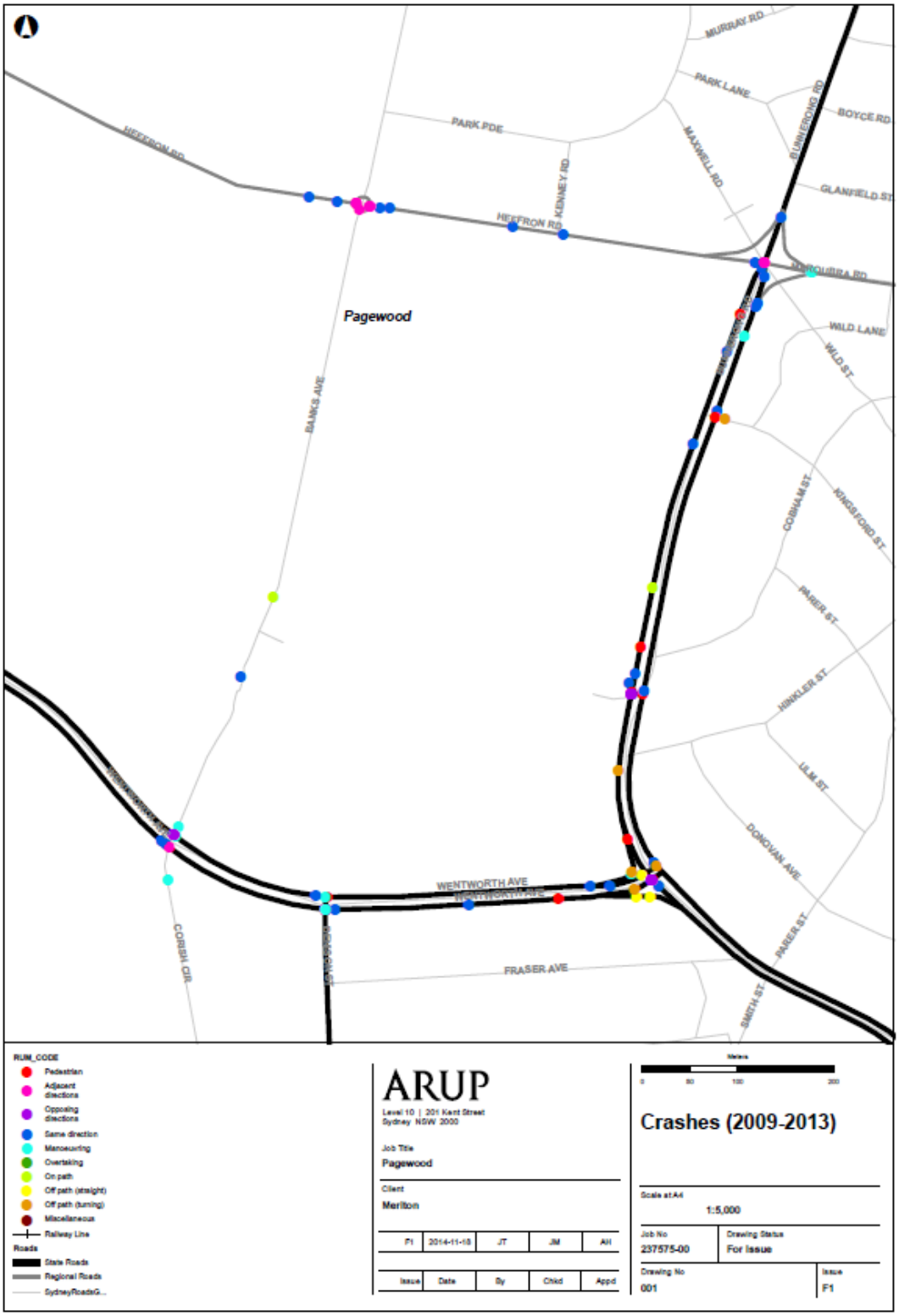


Figure 11: Crash investigation 2008 - 2013

3 Planning context

3.1 Sydney Light Rail

The current Sydney Light Rail is proposed to terminate at Kingsford, which is a 25 minute walk from the site. However, Infrastructure NSW noted that the light rail may be extended to La Perouse via Maroubra Junction in the State Infrastructure Strategy Update. This would place a light rail stop within 15 minutes walk of the proposed site.

Figure 12: Potential Light Rail extension

Meriton in liaison with the former Botany Bay Council and Randwick Council, has also approached the NSW State Government to consider extending the current CBD and South East Light Rail to Maroubra Junction and on to the site. This would service the suburbs of Maroubra, Pagewood, Matraville, Eastgardens and the broader South-East Sydney area. There would also be further opportunities to expand this service beyond the site to the south and west, expanding the potential for cross district transport connections.

3.2 Sydney Metro West

The NSW Government has announced a new underground metro railway line linking the Parramatta and Sydney CBDs, and communities along the way. The Sydney Metro West project addresses Sydney's rapid growth, with the city's population to increase above 6 million in the next 20 years. The new railway is expected to be built largely underground and operational in the second half of the 2020s. The final number of potential stations will be identified following community and industry consultation. Four key precincts to be serviced have initially been identified at:

- Parramatta, where the number of jobs is expected to double over the next 20 years to 100,000.
- Sydney Olympic Park, where 34,000 jobs and more than 23,000 residents will be located by 2030.
- The Bays Precinct, Sydney's new innovation hub where 95 hectares of land is being regenerated.
- The Sydney CBD, allowing easy access to the existing public transport network and Stages 1 and 2 of Sydney Metro, which is currently under construction.

Following the announcement, a consortium proposed value-capture for the project, including connections further west to Badgerys Creek via Westmead and further east to La Perouse via Maroubra. The potential alignments proposed by the consortium are noted in Figure 13 and could have a connection as close as Maroubra to the proposed site.

Figure 13: Potential Metro West alignments (Source Conybeare Morrison, BG&E)

3.3 Previous studies

BATA resolved that a large proportion of their large industrial landholding at Pagewood was superfluous to their future production needs. A draft Master Plan was prepared and submitted to Council in early 2011. Council prepared a site specific DCP to include the rezoning of the surplus part of the site.

A Traffic and Transport Study (CBH&K) was prepared in March 2012 to accompany the draft LEP and this was supported by a Traffic Modelling Assessment (Parsons Brinkerhoff). Scenarios tested for the rezoned site included:

- 35,000m^2 retail with 1,200 residential apartments generating 1,650 to 1,850 peak hour trips during the PM and weekend peaks respectively
- 5,000m^2 retail with 1,500 residential apartments generating 550 to 700 peak hour trips during the PM and weekend peaks respectively

The LEP and DCP documents were subsequently enacted and development consent granted for subdivision of the total site along with alterations, additions and fit-out of production facility buildings on the retained lot. Roads and Maritime has agreed with the above processes subject to a number of conditions including:

- provision of traffic signals at the Bunnerong Road/Access Road intersection with separate right and left turn lanes
- widening of Bunnerong Road (south) to upgrade the Maroubra Road/Heffron Road intersection

3.4 Previously approved intersection upgrades

A number of intersection upgrades were required to permit the development of the approved concept masterplan at 130-150 Bunnerong Road. These includes funded upgrades (either fully or partially by developer) at the following locations:

- Marourbra Road / Heffron Road Bunnerong Road
- Heffron Road and Banks Avenue
- Wentworth Avenue and Page Street

3.4.1 Maroubra Road / Heffron Road and Bunnerong Road

Proposed upgrades to this intersection include additional right turn lanes for the south and north approach of Bunnerong Road (incorporating previous PB modelling advice and additional traffic modelling undertaken by SMEC and Arup). Upgrades would require civil works including relocation of the central median, repaving and widening of the road on the northern approach.

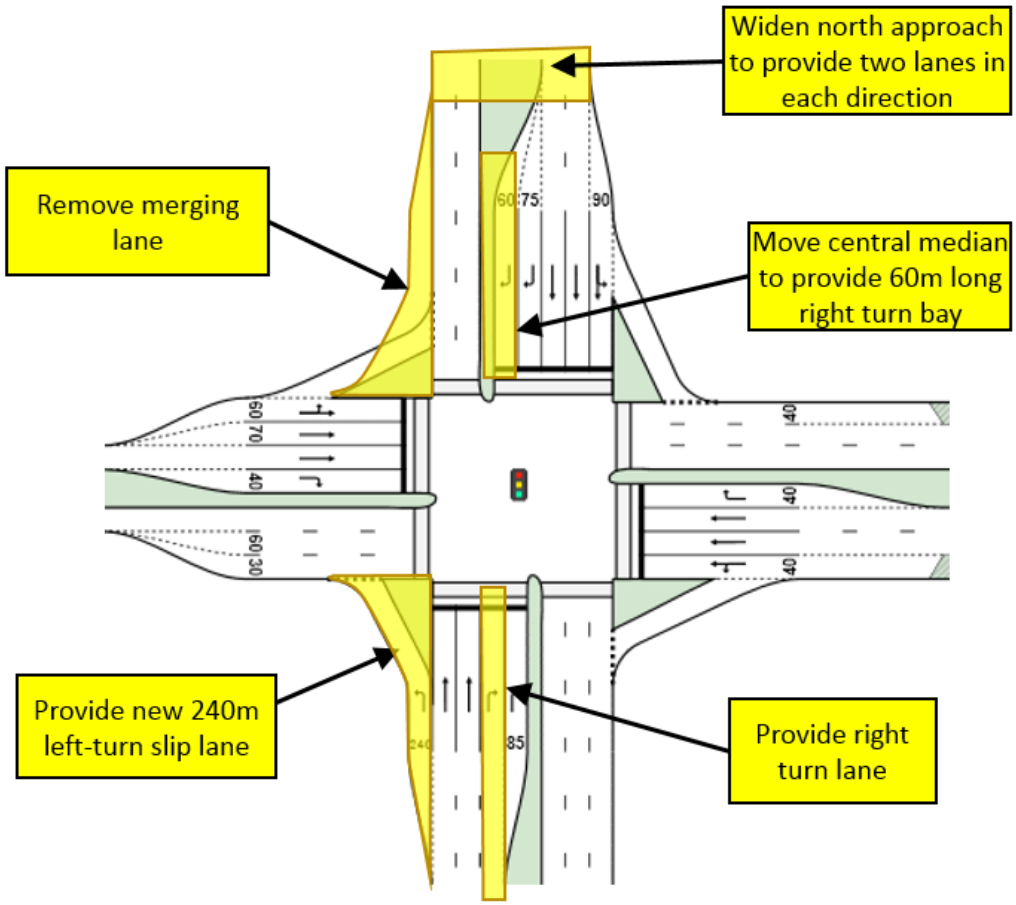


Figure 14: Approved upgrade for Maroubra Road / Heffron Road and Bunnerong Road

3.4.2 Heffron Road and Banks Avenue

The adopted option (by Council preference) was to upgrade the intersection to a two-phase signalised intersection. This would require a new set of signal infrastructure, major civil works to remove the roundabout and approach islands, and reinstatement of kerbs to tighten approaches. An indicative diagram of the upgrades is shown below.

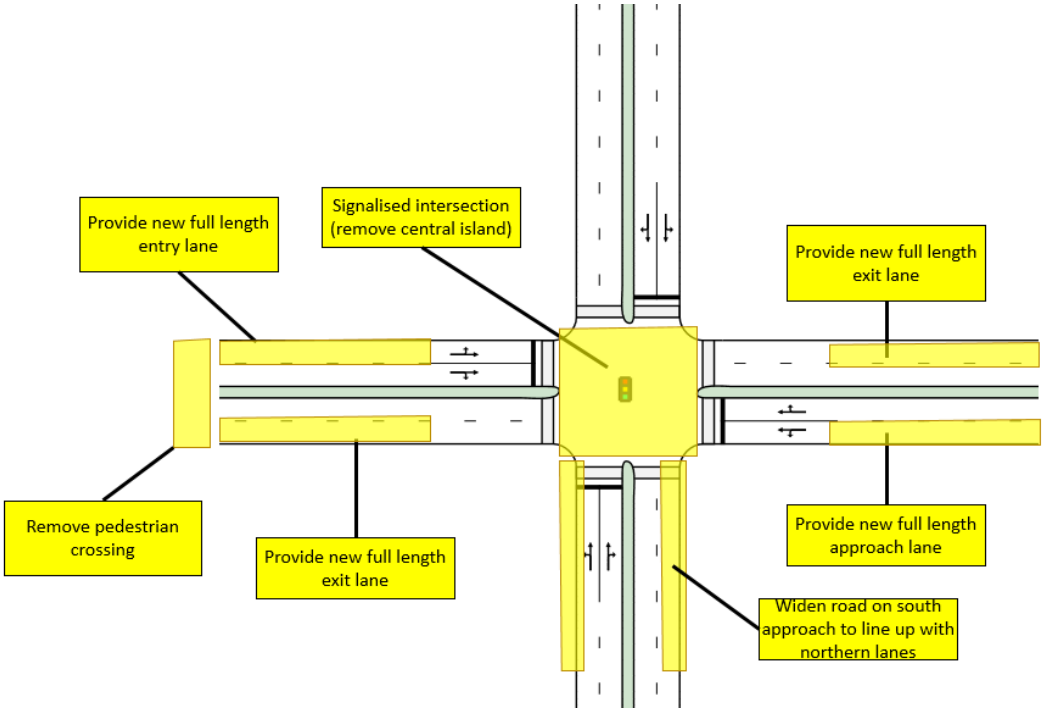


Figure 15: Approved upgrade for Heffron Road and Banks Avenue

3.4.3 Page Street and Wentworth Avenue

Upgrades to this intersection as outlined in the SMEC report (2015) include:

- An additional right turn bay from Wentworth Avenue north approach
- Extension of right turn bays on Page Street west and east
- Extension of two lane section on Page Street east (up to 60m length)
- Left turn slip lane provisions on the west and south approaches.

It is anticipated that upgrades will require major civil works including relocation of the kerb and central median on Wentworth Avenue.

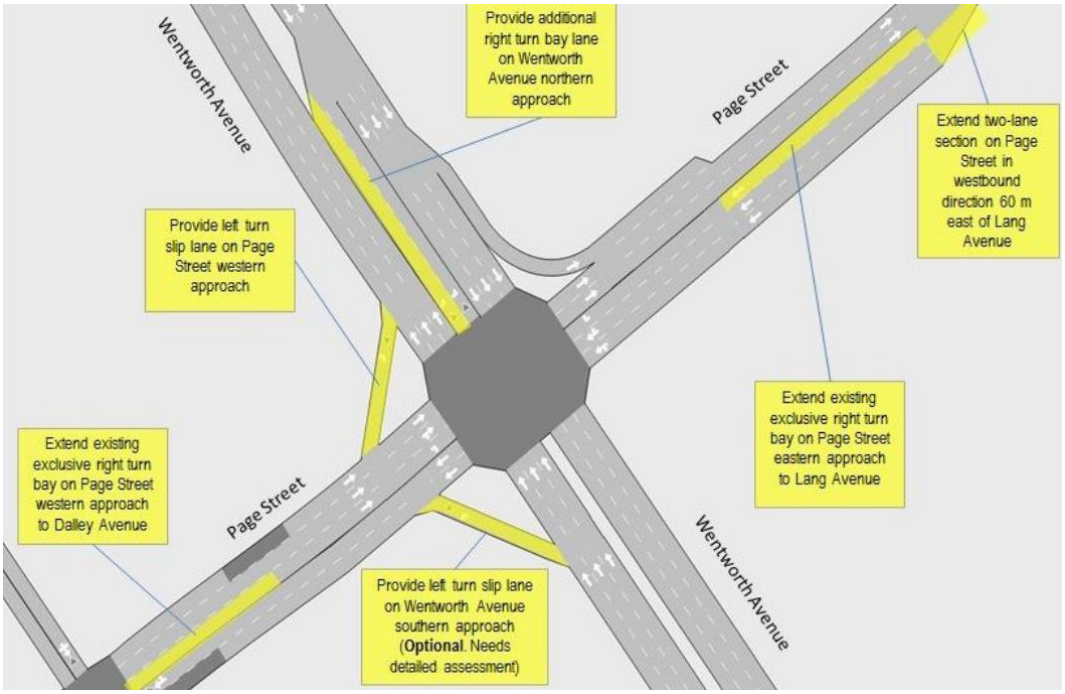


Figure 16: Upgrade to Page Street and Wentworth Avenue

3.4.4 Intersections of Banks Avenue and Wentworth Avenue; and Denison Street and Wentworth Avenue

Upgrade works were discussed with Council for these intersections and there is no scope to provide infrastructure upgrades without significant land acquisition. Previous upgrades were identified in previous reports, but were not addressed in the latest development application submitted by Westfield. Therefore, given that the intersection operates within acceptable level of service parameters with the approved development traffic, there were proposed no proposed upgrades of these intersections.

4 Development proposal

The proposed site incorporates some of the area of the previously approved concept masterplan at 130-150 Bunnerong Road. It is proposed to absorb UB1 and UB2 of the concept masterplan and incorporate these blocks into a new northern precinct.

Both Bayside Council and Meriton have developed schemes for the site, however for the purposes of the traffic and transport analysis, the Meriton option was considered.

Meriton proposes to provide 1,000m^2 retail on the site, one 100-child childcare centre and provide a total of 2,068 residential units with potential for 2,000m^2 GFA of the existing heritage buildings to be retained for community uses dedicated to Council.

As a result, it is proposed that the approved concept masterplan site reduces the residential apartments by 376 dwellings, removes a child care and reduces the retail provision to a total of 1,000m^2 GFA. This equates to an additional 1,692 residential apartments and a net reduction of 3,000m^2 retail against the approved concept masterplan (for 130-150 Bunnerong Road, Pagewood). This scenario was adopted for the traffic and transport analysis.

4.1 Internal site access

The proposed development will utilise the approved concept masterplan internal road network, with some adjustments to the undeveloped portion of the site to accommodate the additional urban blocks. The internal road network will provide separation and access to up to the urban blocks and parklands within the site. The proposed internal road networks are shown in Figure 17 and Figure 18.

Figure 17: Meriton proposed option (Hassell)

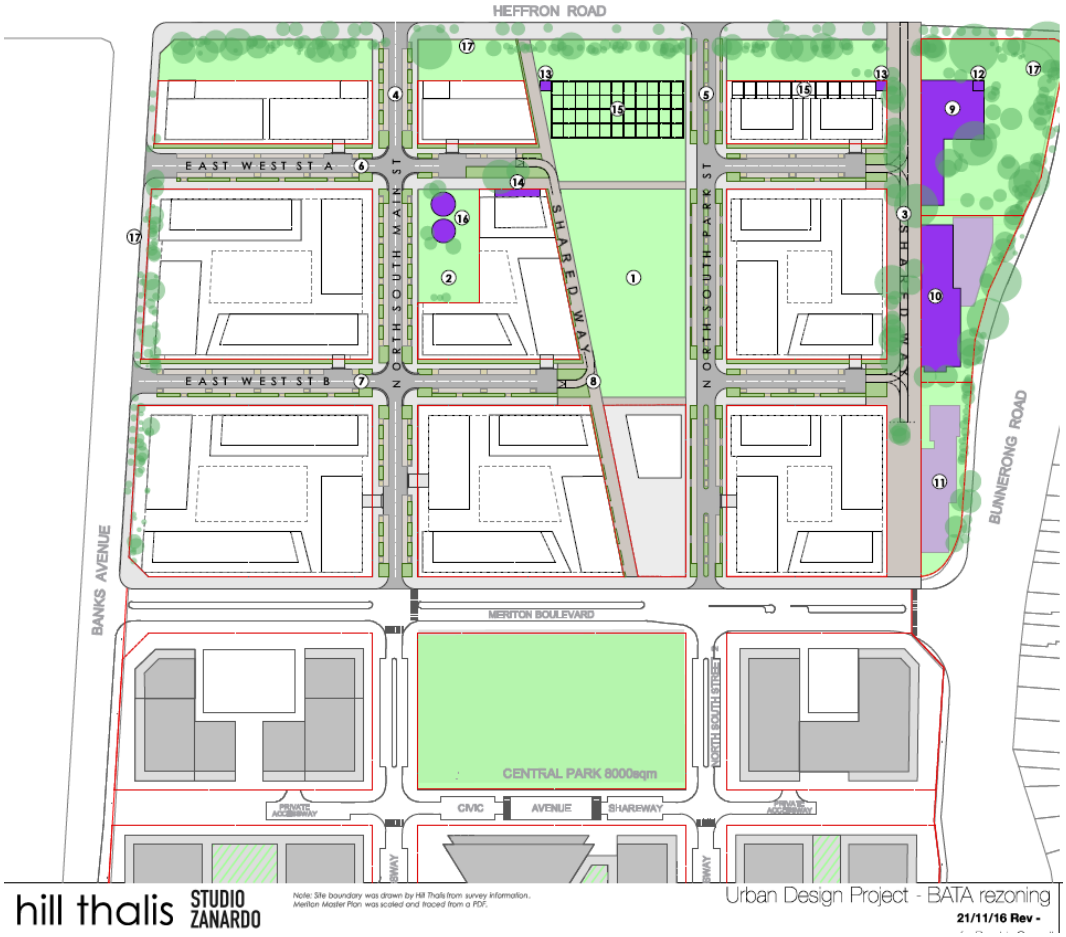


Figure 18: Council preferred scheme

4.2 External site access

The proposed site intends to utilise the following external access arrangements (shown in Figure 19):

- two current approved road accesses from Banks Avenue to the west of the site (unamended);
- the current Meriton Boulevard left in and left out access to Bunnerong Road; and
- an all movements priority accesses to Heffron Road, north of the site.

These were the adopted access points for the traffic modelling, which create a balanced distribution across the external road network. Other access options were assessed, but this minimum layout forms the best balanced approach as later described in Section 6.6.

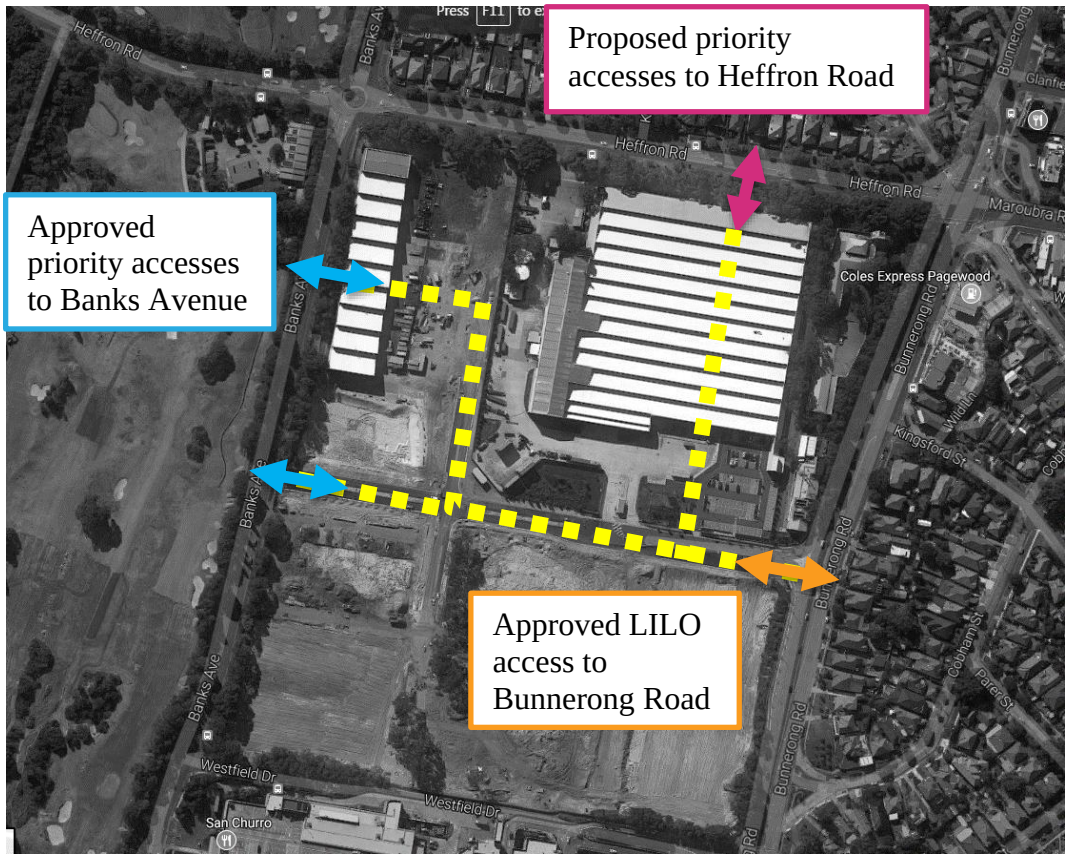


Figure 19: Proposed access arrangements

5 Transport Assessment

5.1 Future mode split

5.1.1 Traffic generation

The traffic generation rates used for the previous Concept Masterplan were adopted, which utilised an adjusted rate from the Roads and Maritime Technical Direction (TDT 2013/04a) and Journey to Work data. The rate for high density residential was determined as a function of the mode share for the development by calculating the peak hour ratios between the sites from the Technical Direction. Given the non-car mode share was 58% for the surveyed sites (in Metropolitan Sydney) and 38% from the JTW data (in Table 2), this resulted in the following peak hour generation rates for the proposed development:

- Weekday AM 0.277
- Weekday PM 0.217
- Weekend Noon 0.246

5.1.2 Forecast mode split

The Roads and Maritime Technical Direction (TDT 2013/04a) and Journey to Work data was utilised to determine the person trips and forecast mode split for the development. It should be acknowledged that demographics will likely be different to the current journey to work dataset, which is focused on a low density established residential area context. The person peak hour trip generation rates that have been adopted for the proposed development are as follows, which are based on the average rates for high density residential developments as outlined in TDT 2013/04a:

- Weekday AM 0.725
- Weekday PM 0.592
- Weekend Noon 0.660

As a result of the traffic generation and person trip generation, the forecast mode splits have been analysed and illustrated in Table 4.

Table 4: Forecast mode split

Mode	AM Peak Hour		PM Peak Hour		Weekend Peak Hour	
	%	Number	%	Number	%	Number
Train	6%	71	5%	60	5%	66
Bus	37%	450	31%	377	34%	416
Car	38%	469	30%	367	34%	416
Walk	12%	142	10%	119	11%	131
Other	8%	95	6%	79	7%	88
Total	100%	1226	100%	1002	100%	1116

The number represent a significant shift to bus modes, which is further discussed in Section 5.4.

5.2 Parking and loading provisions

5.2.1 Car parking

The number of off-street parking spaces are specified by Bayside Council in the Development Control Plan (DCP) 2013. Meriton have proposed parking rates which have been compared to the relevant DCP Part 3A and 9D rates, and the approved Stage 1 concept masterplan rates (summarised below in Table 5.)

Table 5: Minimum car parking rates

Development type	Part 3A/9D BBDCP	Approved Stage 1 masterplan	Proposed rates
Residential flat buildings			
Studio / 1 bedroom apartments	1 space per apartment	1 space per apartment	0.5 space per apartment
2 bedroom apartments	2 spaces per apartment	1.5 space per apartment	1 spaces per apartment
3 bedroom apartments	2 spaces per apartment	2 space per apartment	1.5 spaces per apartment
Visitor parking	1 space per 5 apartments	1 space per 10 apartments	1 space per 10 apartments
Commercial / Retail / Infrastructure			
Shops	1 space per 25m^2	1 space per 40m^2	1 space per 40m^2
Childcare	1 space per 2 employees	1 space per 2 employees	1 space per 2 employees
	1 space per 5 children	1 space per 5 children	1 space per 5 children
	1 pick-up and set-down space per 20 children.	1 pick-up and set-down space per 20 children.	1 pick-up and set-down space per 20 children.

It is considered appropriate to reduce car parking to reduce car mode share from the development. Car parking is a major contributor to car usage and the reduced rates are expected to result in reduced traffic generation. The rates proposed are more aligned to the recommended RTA Guide to Traffic Generating Developments rates which indicate:

- 0.6 spaces for 1-bedroom apartments
- 0.9 spaces for 2-bedroom apartments
- 1.4 spaces for 3+ bedrooms apartments

As a point of comparison, the 2011 Census car ownership in the surrounding suburbs (Botany, Pagewood, Hillsdale, Banksmeadow, Maroubra, Kingsford) for multi-unit dwellings was considered. The car ownership rates (Table 6) are also comparable with the RTA parking rates and subsequently the proposed rates.

Table 6: Car ownership in surrounding suburbs

Units (in area)	No. Units	No. Cars	Required Rate
One bedroom/studio	1245	895	**0.7189**
Two bedroom	5301	5376	**1.0141**
Three bedroom +	1940	2403	**1.2387**
Total	**8493**	**8685**	**1.0226**

The total car parking rates are comparable with the proposed unit mix, given the approximate 1:1 ratio overall as shown in Table 7.

Table 7: Meriton unit mix

Meriton proposed	Indicative unit mix	Cars	Rate
One bedroom/studio	413.6	206.8	0.5
Two bedroom	1447.6	1447.6	1
Three bedroom +	206.8	310.2	1.5
Total	**2068**	**1964.6**	**0.95**

The reduced parking rates are also supported by the good public transport network both planned and under constructions. The potential Light Rail extensions (identified in the NSW Transport Masterplan) and potential Sydney Metro connection may be within walking distance of the site and will further encourage mode shift away from cars and hence the reduced parking rates.

The site is within the Eastgardens and Maroubra district centre and it is expected that there will more services/facilities and transport options in the future to support the surrounding growth and proposed development.

5.2.2 Bicycle parking

The City of Botany Bay DCP states the following in relation to bicycle parking:

*C7 In every new building, where the floor space exceeds 600m² GFA (**except for houses and multi unit housin**g) bicycle parking equivalent to 10% of the required car spaces or part therefore as required in Table 1 shall be provided.*

C8 Residential flat buildings where the floor space exceeds 600m² GFA shall provide secure bicycle storage as per AS 2890.3.

In the absence of specific rates for the provision of bicycle parking in the residential component, the 10% of car parking figure has been adopted consistent with the remainder of the Pagewood concept masterplan site.

5.3 Walk and cycle access

There are changes proposed to the walking and cycling network interface to the site. The extensive provision of walking/cycling facilities provided within the development will be integrated with the number of cycleways surrounding the site, which are shown in the figure below.

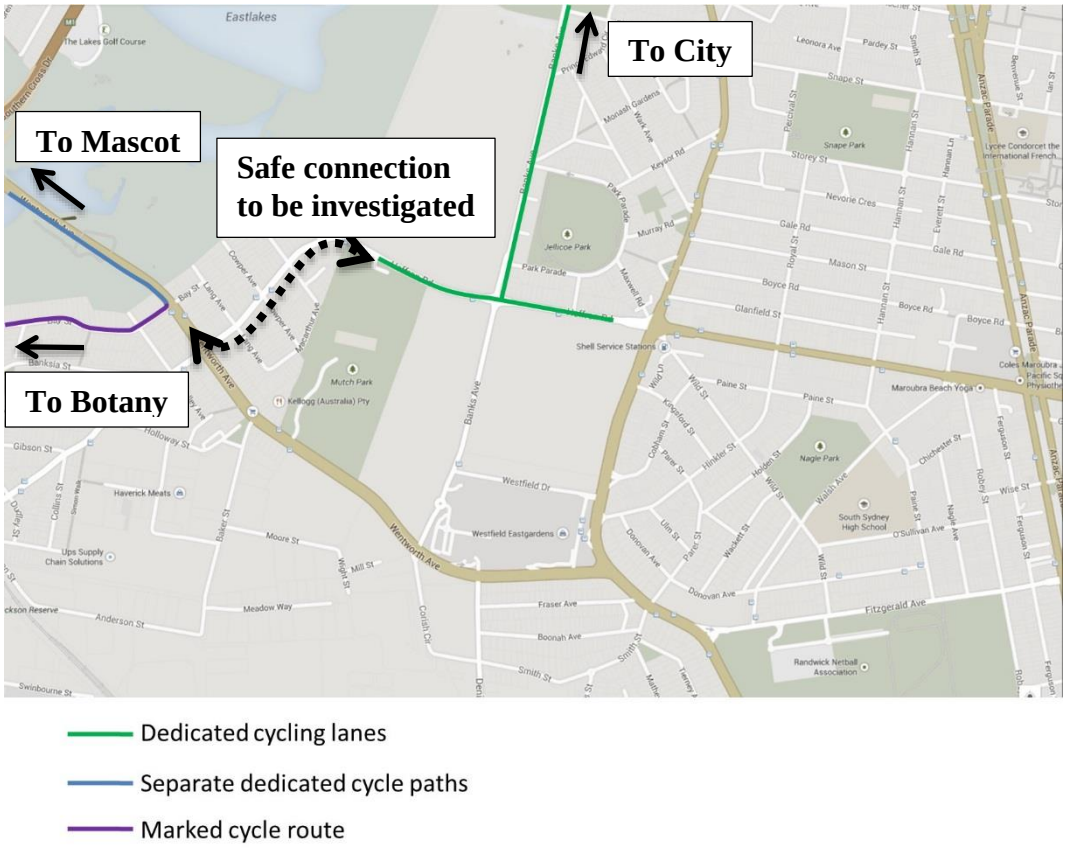


Figure 20: Cycleways surrounding site

The site has some good cycleway connections to the north. The northern route connects directly to the city via Kensington and the western route (from Bay Street) connects to General Holmes Drive and Botany. There are good regional connections to the west as well; however there is a gap along Page Street and limited safe opportunities to cross Wentworth Avenue to the shared path. It is recommended for Bayside Council to investigate this link or prepare a Bike Plan for the area for better regional cycle connections.

Secure bicycle parking is to be provided as a component of the proposed development. Provision of these facilities (along with the site being adjacent to regional shopping facilities) will encourage active travel, such as cycling as a viable mode of transport to the site. This will further contribute to a reduced car mode share of trips.

5.4 Public transport

The following sections outline the current, proposed and potential public transport servicing the site. These are also summarised in Figure 21.

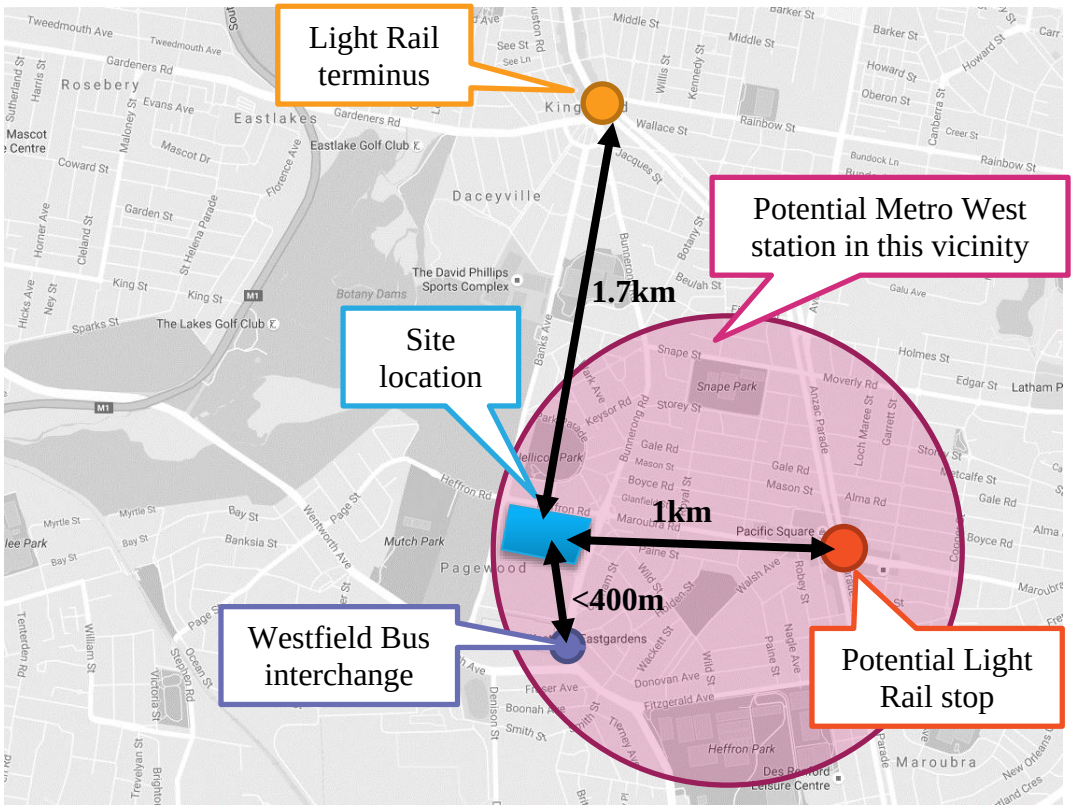


Figure 21: Public transport servicing the development

5.4.1 Bus infrastructure

Using the mode splits for buses established in Section 5.1, this equates to between 334 to 399 people using the bus during peak hours. From site observations, buses were generally 50% full leaving the Westfield interchange, however there may be impacts further towards the destinations such as the City. Therefore, using a bus occupancy of 50 people, this equates to an additional eight bus services during each of the peak hours to service the development. While a number of buses are being rerouted in this area to the Light Rail, it is likely these will need to be supplied towards the City as express services, which will supplement the local feeder services being directed to the Light Rail.

5.4.2 Sydney Light Rail

The current Sydney Light Rail stop under construction at Kingsford terminus is located 1.7km to the north, which may be considered just outside walking distance for most people. However, there will likely be some people who may consider walking within 25 minutes to the stop or cycling for 5 minutes. It is likely that future residents of the site will drive and park at the stop.

5.4.3 Potential Light Rail extension

The government has indicated that Light Rail may be extended to Maroubra Junction in the future, which is within 15 minutes' walk of the site. However, given the distance from the site, there is still expected to be less walk-up of this mode compared to bus and people will likely drive to a commuter car park.

If Light Rail is extended to the site as discussed, patronage of bus is likely to be less and the need for additional services could potentially be mitigated given there will be a mode shift in the surrounding area to Light Rail.

5.4.4 West Metro

As stated in Section 3.2, there are also plans being considered for a West Metro rail line linking the second proposed Sydney Airport at Badgerys Creek to Central and possible extension to the south eastern suburbs. The potential extension may continue near the site and have the potential to attract patronage from the proposed development. This will further encourage less car trips from the development if the station is located within 800m of the site. However, given the uncertainty of the project, no mode split to this mode have been assumed.

5.5 Transport measures

5.5.1 Travel Plans

One of the objectives to reduce the level of private car usage is to favour more sustainable modes of travel such as walking, cycling and public transport. A method of achieving this is personalised marketing strategies to assist in modifying travel behaviour through communicating relevant travel choice information to the community. Marketing would begin through information to be produced by the developer, including:

- Travel information kits for residents (including Travel Access Guides)
- Travel Plans for employees and residents.

5.5.2 Wayfinding

Wayfinding signage would be installed at entry points to allow people to navigate their way around the precinct. Maps would also be installed to allow people to know about the nearby pedestrian and cycle connections.

5.5.3 Car share schemes

Car share schemes are designed to provide a flexible option for people who only require occasional car use and choose not to own a vehicle. They provide access to a vehicle when it is the most suitable mode choice, while avoiding the need and expense of owning a vehicle. They would potentially require lower parking rates than proposed in Section 5.2 to provide sufficient incentive for residents and businesses to reconsider purchasing a first or second vehicle in favour of using the car share vehicle. Without a vehicle sitting in a garage, private car is not the first mode considered, increasing the likelihood that other mode sustainable modes will be chosen.

Successful car share operations are based in metropolitan areas with high-density and mixed-use development, good levels of pedestrian access and constrained parking (fewer car parks or parking that is more expensive). When used in conjunction with public transport, walking, and cycling, car sharing has the ability to be an integral part of the sustainable transport network for urban areas.

Car sharing also has the ability to reduce the total fleet vehicles for an employer and reduce the use of private vehicles for commuting. This trend is supported by current research, such as the Transportation Research Board report that estimated that 'at least five private vehicles are replaced by each shared car' in 2005. Sydney's Go-Get club advertises that its research shows that each car in the scheme gets seven others off the roads.

6 Traffic impact assessment

6.1 Traffic generation

Using the mode splits for cars established in Section 5.1, this equates to the following peak one hour generation rates for the proposed development:

- 0.277 trips per apartment for Weekday AM peak hour
- 0.217 trips per apartment for Weekday PM peak hour
- 0.246 trips per apartment for Weekend Noon peak hour

In addition, child care and retail uses are proposed, which utilise different rates from Roads and Maritime as follows:

- 0.7 trips per child for childcare uses; and
- The following peak hour rates for retail uses:
  - 0.08 / m^2 GFA for AM peak hour trips
  - 0.12 / m^2 GFA for PM peak hour trips
  - 0.16 / m^2 GFA for weekend peak hour trips

Using a two hour conversion factor of 1.6 of the traffic generation rates outlined in Section 5.1, and based on the development yield outlined in Chapter 4, Table 8 outlines the net change of traffic generation relating to 128 Bunnerong Road, Pagewood and the northern portion of 130-150 Bunnerong Road, Pagewood. The net changes are approximately 1,692 additional residential units and a reduction of 3,000m^2 retail uses.

Table 8 Change to development traffic (over two hour peak periods)

Development Type	Original Development Proposal			Proposed Changes		
	AM	PM	WE	AM	PM	WE
Residential	977	765	868	+744	+583	+661
Retail	0	238	317	0	-190	-254
Childcare	222	222	0	-56	-56	0
Warehouse	397	397	0	-397	-397	0
Total	**1,596**	**1,622**	**1,185**	**+292**	**-60**	**+407**

6.2 Traffic modelling methodology

A series of AIMSUM micro simulation traffic models have been created to assess traffic impacts from the proposed development. Further details of the modelling process and results are provided in Appendix A of this report. A series of existing conditions (Year 2016) traffic models were established for the AM, PM and weekend two-hour peak periods for the immediate surrounding road network. Travel time and turning count data was used to calibrate and validate the existing conditions models.

Future year models were created for each of the peak periods for Year 2021 (which is the intended completion year of development) and the 10-year horizon to Year 2031, which were the discussed years to be modelled with Roads and Maritime during a meeting in December 2015. Future year models included

background growth and surrounding key approved developments proposed such as Bunnings, Orica Industrial and Masters, with the following intersection upgrades:

- Page Street / Wentworth Avenue modifications
- Maroubra Road / Bunnerong Road / Heffron Road modification
- Heffron Road signalisation

In total 21 different scenario models were run, three base models, six future year base case models and 12 development models. Table 9 below details each model scenario that was run for an AM, PM and Weekend peak period. For each scenario the intersection Level of Service (LoS), travel time analysis and network performance will be explored.

Table 9 Model Scenarios

Model	Abbreviation	Design Year	Description
Base Model	Base	2016	Calibrated base model exploring existing conditions.
Future Base	FB	2021, 2031	Future base model that includes all likely and currently approved developments. This includes the original Meriton Pagewood proposal. This model will form the benchmark for all future year models.
Proposed Development	PD	2021, 2031	Future options model that includes the changes to the previously proposed Meriton development.
PD with Right Turn from Bunnerong	PDRT	2021, 2031	A modification on the proposed development model to include a right turn in only from Bunnerong Road into Meriton Boulevard.

The model extent included an area from Page Street and Wentworth Avenue to Bunnerong Road between Wentworth Avenue and Maroubra Road. The modelling extent is shown in Figure 22 as previously agreed with Roads and Maritime Services.

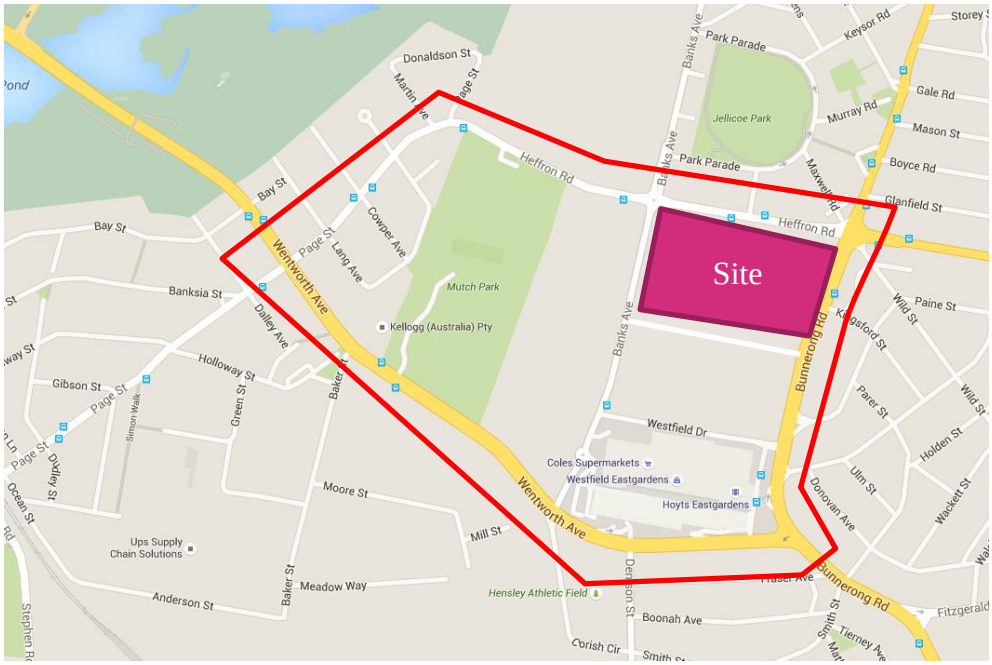


Figure 22: Modelling extents

6.3 Modelling results

In urban areas, the traffic capacity of the major road network is generally a function of the performance of key intersections. This performance is quantified in terms of Level of Service (LOS), which is based on the average delay per vehicle. The results of the surrounding intersections and network are summarised in the Traffic Modelling report in the Appendix. The following sections summarise the future models developed with the development traffic.

6.4 Year 2021

In the AM peak, Wentworth Avenue / Banks Avenue / Corish Circle, Wentworth Avenue / Denison Street and Wentworth Avenue / Page Street intersections have the largest increase in delay as traffic accesses the wider network from the development site increasing the pressure on the side roads. This issue is further exacerbated with the introduction of the right hand turn as it creates an alternative route to Heffron Road. The introduced right turn does however remove the pressure off Wentworth Avenue / Page Street and to a lesser extent, the Banks Avenue / Heffron Road intersection via the alternative route.

Table 10 AM peak Level of Service results

Summary by intersection

	AM							
	Base		FB		PD		PDRT	
	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS
Heffron/Maroubra/Bunnerong	40	C	42	C	43	D	42	C
Bunnerong/Meriton	1	A	2	A	9	A	2	A
Bunnerong/Westfield	8	A	14	A	11	A	12	A
Bunnerong/Wentworth	20	B	22	B	23	B	23	B
Wentworth/Dennison	20	B	25	B	28	B	26	B
Wentworth/Banks/Corish	22	B	25	B	26	B	27	B
Banks/Westfield entrance	5	A	4	A	4	A	4	A
Banks/Westfield	6	A	6	A	6	A	6	A
Banks/Meriton	1	A	2	A	1	A	1	A
Banks/Heffron	14	A	25	B	28	B	26	B
Wentworth/Page	65	E	60	E	70	E	73	F
Banks/access 1			1	A	1	A	1	A
Heffron/Access west					0	A	1	A
Heffron/Access east					2	A	1	A

The issues noted in the AM peak are also experienced in the PM peak period with an intensification of delays around Wentworth Avenue / Banks Avenue / Corish Circle intersection as retail traffic to Westfield Eastgardens intensifies.

Table 11 PM peak Level of Service results

Summary by intersection

	PM							
	Base		FB		PD		PDRT	
	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS
Heffron/Maroubra/Bunnerong	43	D	47	D	41	C	42	C
Bunnerong/Meriton	1	A	11	A	10	A	2	A
Bunnerong/Westfield	12	A	32	C	15	B	18	B
Bunnerong/Wentworth	18	B	24	B	23	B	23	B
Wentworth/Dennison	20	B	34	C	37	C	37	C
Wentworth/Banks/Corish	33	C	94	F	70	E	70	E
Banks/Westfield entrance	6	A	13	A	13	A	19	B
Banks/Westfield	6	A	9	A	7	A	5	A
Banks/Meriton	1	A	2	A	2	A	2	A
Banks/Heffron	16	B	58	E	34	C	36	C
Wentworth/Page	40	C	60	E	61	E	55	D
Banks/access 1			2	A	1	A	1	A
Heffron/Access west					1	A	1	A
Heffron/Access east					1	A	1.2	A

In the weekend peak period, the worst delays are experienced as the intensification of Westfield Eastgardens traffic causes the saturation of the Wentworth Avenue / Banks Avenue / Corish Circle intersection shifting traffic to the Heffron Road corridor, resulting in an increase of delay at the Banks Avenue / Heffron Road intersection. With the introduction of the right hand turn resulting in the further intensification of traffic on Banks Avenue, additional traffic is forced onto Heffron Road / Banks Avenue and the intersection begins to reach saturation point as well.

Table 12 Weekend peak Level of Service results

Summary by intersection

	WE							
	Base		FB		PD		PDRT	
	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS
Heffron/Maroubra/Bunnerong	51	D	53	D	47	D	55	D
Bunnerong/Meriton	1	A	2	A	15	B	2	A
Bunnerong/Westfield	13	A	24	B	23	B	24	B
Bunnerong/Wentworth	26	B	30	C	32	C	32	C
Wentworth/Dennison	20	B	38	C	44	D	39	C
Wentworth/Banks/Corish	38	C	94	F	75	F	85	F
Banks/Westfield entrance	9	A	18	B	16	B	14	A
Banks/Westfield	6	A	8	A	9	A	7	A
Banks/Meriton	1	A	3	A	3	A	2	A
Banks/Heffron	16	B	72	F	50	D	103	F
Wentworth/Page	40	C	50	D	52	D	58	E
Banks/access 1			2	A	1	A	1	A
Heffron/Access west					1	A	1	A
Heffron/Access east					2.2	A	3.4	A

In the AM and PM peaks all the intersections along Bunnerong Road remain largely unaffected. However in the Weekend peak these intersections come under increased pressure. The right turn onto Meriton Boulevard does helps alleviate this pressure but causes issues within the network elsewhere.

6.5 Year 2031

The 2031 LoS results further emphasise the Year 2021 results in that the intersections around Eastgardens shopping centre are unable to cope with the increased shopping centre demands. The Year 2031 models were becoming unstable under the future base models and were prone to lockups; as such it was difficult to deduce meaningful/reliable results from the 2031 models.

6.6 Road network impacts

The operational modelling process it was found that the development yields have little impact on the network. In the weekend peak however development traffic has trouble accessing the wider network due to the intensification of retail traffic around Eastgardens. The decoration in performance is established in the future based scenario, without the proposed development traffic and improves slightly across the peak periods with the proposed development.

It was also found that as the road network is expanded and additional connections are added to the wider network, delays increase. This is impart due to the intensification of traffic around Eastgardens from the growth in the retail catchment. This new traffic is using the expanded network for alternative routes increasing turning movements and the associated merging and weaving.

In summary the network operates satisfactorily with the expanded development however it is advisable that the road layout is refined as to minimise new connections onto Banks Avenue and Heffron Road (consistent with the accesses nominated in Section 4.2). It is also recommended to assess possible changes to the network to account for the increased demand to Eastgardens shopping centre as it is retail traffic that has the largest effect on the network.

It is not advisable to include a right turn into Meriton Boulevard even though minimal additional delay is experienced along Bunnerong Road the right turn introduces an alternative route to Eastgardens. Increasing delays along Banks Avenue and Wentworth Avenue as a result.

7 Key recommendations

This transport impact assessment has been prepared for the rezoning of 128 Bunnerong Road, Pagewood and the northern portion of 130-150 Bunnerong Road, Pagewood based on the information available for this study. The rezoning will convert the Precinct to a mixed residential and community precinct. The assessment of the transport network required to support this rezoning has identified a number of influences from the wider Sydney road and light rail networks that could play a key role in determining the magnitude of development within the Eastern Suburbs subregion. The following recommendations are made to assess the impact of these wider regional impacts.

7.1 Arterial road network capacity

The region contains a number of arterial roads, including Wentworth Avenue, Bunnerong Road and Maroubra Road. All of these roads currently experience a level of congestion and are expected to face increased demand in the future. The Sydney Light Rail extension project is likely being considered by government, which may provide additional road capacity in the study area. Its impact on the amount of road capacity in the future and on flows is being investigated by state government.

The region has three main gateways that are mostly operating near capacity, with long delays and queues during peak periods. As a result, some intersections are already being upgraded to cater for development traffic of the 130-150 Bunnerong Road, Pagewood concept masterplan. Others have some spare capacity to accommodate future growth.

The future arterial road network conditions will have a large influence on the amount of traffic that can be generated by the subregion. Upgrades to the arterial road network may cause a re- distribution of trips in the area, changing the balance of traffic that uses each of the three gateway intersections.

Accordingly, there are no upgrades required to the surrounding local or arterial road network as a result of the Planning Proposal.

7.2 Public transport

Public transport surrounding the site is to be accommodated by buses. While a light rail extension has been planned to extend to Maroubra, this is still quite some distance from the site (approximately 1.0km from the site). In addition, the light rail extension adjacent to the site has not yet been approved by government. As such, with the additional residents expected, there may be capacity issues with the public transport system.

The buses servicing the surrounding roads are described in Section 2.3 of the traffic impact assessment. There are approximately 23 bus services during the AM peak hour (of which 7 provide services to the City).

Additional demand may be distributed amongst some of the buses within the area as there was observed capacity on the local routes. However, with the cumulative effects from the approved concept masterplan, Section 5.4 indicates that an extra eight bus services will likely need to be provided so that there is spare capacity retained for the routes further down the lines.

7.3 Development levels

An analysis of the road network capacity has been used to estimate that the road network could sustain development within the 128 Bunnerong Road, Pagewood and the northern portion of 130-150 Bunnerong Road, Pagewood site to the following levels:

- 1,692 additional dwellings across the entire project accommodating approximately 4,400 residents
- 1,000m^2 GFA retail
- Approximately 2,000m^2 GFA of community uses (to be handed to Council)

Other strategies to reduce vehicle trip generation without the need to construct more road upgrades include.

- a more extensive public transport upgrade
- higher public transport frequencies assisted by dedicated public transport priority
- reduced parking rates to encourage the use of alternative modes of transport.

7.4 Summary

This traffic and transport assessment has been undertaken for the proposed rezoning of the 128 Bunnerong Road, Pagewood and the northern portion of 130-150 Bunnerong Road, Pagewood site. The subject site has an area of 8.95ha. A Development Control Plan (DCP) including a site specific chapter has been prepared (refer to Chapter 9D - British American Tobacco Australasia, of the Botany Bay DCP 2013).

The site will have good access to public transport, with buses and light rail (under construction) providing alternatives to car usage. The potential extended transport network and reduced parking rates on the site in comparison to the site specific DCP will also reduce car dependence and result in lesser road network impacts.

Through the operational modelling process it was found that the development yields have little impact on the network. In the weekend peak however development traffic has trouble accessing the wider network due to the intensification of retail traffic around Eastgardens.

This is a broader network issue not generated by the proposed development as the project will have local retail or is within walking distance to the Westfield Centre. Accordingly, the development does not generate the need for any localised upgrades.

Appendix A

Traffic modelling report

Meriton Properties

128 Bunnerong Road, Pagewood

Traffic Modelling Report

Issue | 7 April 2017

Job number 237575

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Document Verification

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Job title		128 Bunnerong Road, Pagewood			**Job number** 237575
Document title		Traffic Modelling Report			**File reference**
Document ref					
Revision	**Date**	**Filename**	Traffic Modelling Draft Report_20170123.docx		
Draft 1	23 Jan 2017	**Description**	First draft		
			Prepared by	Checked by	Approved by
		Name	Tim-R Clark	James-R Turner	James-R Turner
		Signature			
Final	01 Feb 2017	**Filename**	Traffic Modelling Final Report_20170201.docx		
		Description	Final		
			Prepared by	Checked by	Approved by
		Name	Tim-R Clark	James-R Turner	James-R Turner
		Signature			
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Contents

1 Introduction

1.1 Background

The objective of this study was to develop a traffic model suitable for analysing the proposed extension of the Meriton Properties Pagewood development to include the British American Tobacco Australia (BATA) site. The modelling is used to test development yields, assess network impacts and understand access arrangements.

This report also details the option testing that was undertaken to support the expanded Meriton Properties development on the British American Tobacco Australia site. In order to test the traffic and transport implications of potential development options and network changes the base models are to be modified to reflect potential future conditions. The types of changes to the base models that are required include:

- Additional demands due to existing site development approvals, which are expected to be taken up in the near-term
- Possible minor adjustments to road network arraignments
- Potential increases in external traffic passing through the study area

Once the future base model has been established then the incremental demands and network changes associated with the development options will be added to the future base model creating the options models.

1.2 Purpose of this report

This report aims to provide background information relevant to the development of the micro-simulation model, and demonstrate that the model has been developed in accordance with the relevant guidelines. The ultimate goal is to establish confidence that the model is fit-for-purpose for use as part of the subject study only. This is achieved through the presentation of information relevant to the development, calibration and validation of the model including:

- Identification of the network area to be modelled
- Identification of the data used as inputs to the model
- Traffic demand matrix development
- Model validation and calibration

1.3 Software package

The software used for the analysis presented in this report was Aimsun 8.1.1 (R36349x64). Aimsun is an integrated transport modelling software package approved by the RMS that is commonly used for micro and mesoscopic traffic models.

1.4 Site location

Pagewood is located directly to the east of Sydney Airport and 8km south of the Sydney CBD. The University of New South Wales is located immediately to the north with port botany located immediately to the south. There are four wider network connections within the site: Bunnerong Road, Wentworth Avenue, Denison Street and Page Street/Heffron Road.

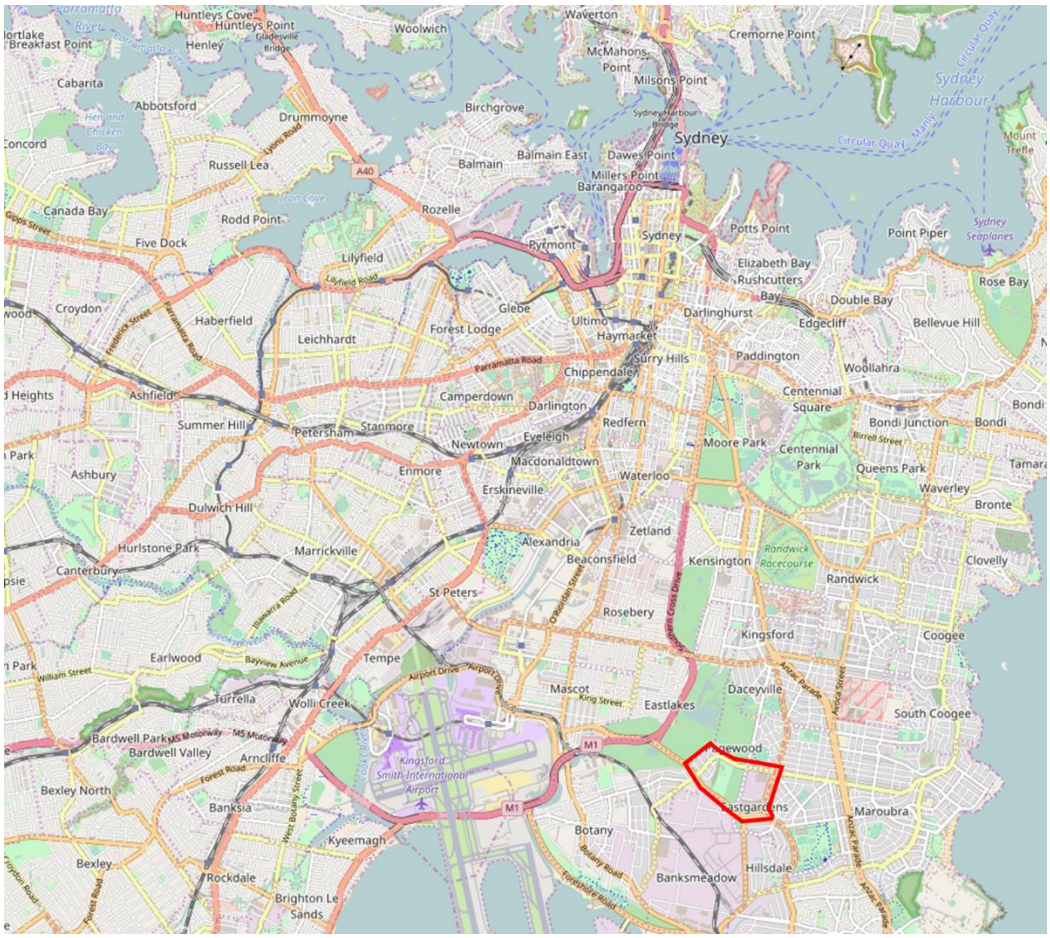

Figure 1 Pagewood location within Sydney (*source: Open Street Maps)*

1.5 Study area

The study area was defined by the major roads surrounding the BATA extension site and is illustrated in Figure 2 below.

Figure 2 Study area definition (*source: google maps*)

The study area includes residential and retail areas, notably the Eastgardens Westfield in the south east corner of the study area. In order to understand how the road network functions, it is crucial to consider the strong freight corridor formed by Wentworth Road running along the southern edge of the study network and Denison Street extending to the south.

1.6 Time periods

In order to select the appropriate time periods to assess, data from the traffic counts were collated across the network with the 15 minute overall demand graphed, see Figure 3. The 15 minute flows were also calculated by surmising the hourly volumes beginning every 15 minutes, see Figure 4, Figure 5 and Figure 6.

This process clearly highlighted the busiest period for the morning, afternoon and weekend peak. As the demand profile was fairly flat for a sustained period of time in the PM and weekend time period a two hour peak was chosen to be modelled. The AM peak for consistency was also modelled as 2 hours.

- AM weekday peak: 7:30 – 9:30am
- PM weekday peak: 4:30 – 6:30pm
- Weekend peak: 11:15am – 1:15pm

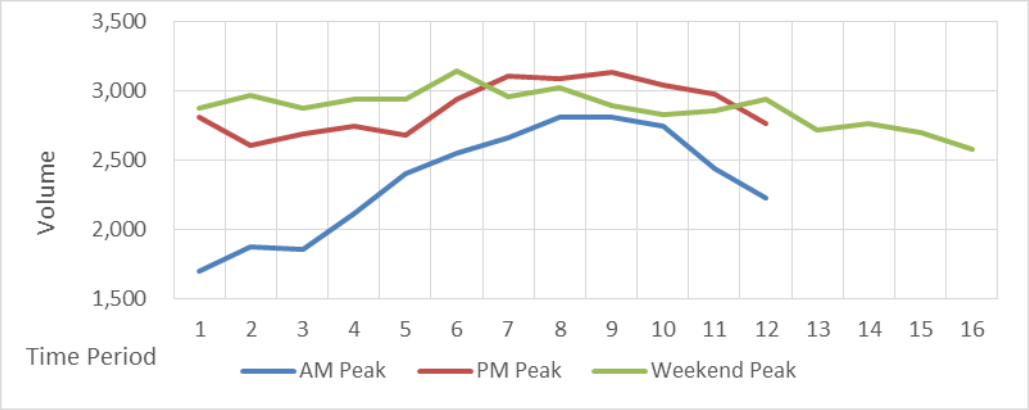

Figure 3 Demand profiling, volume per 15min period

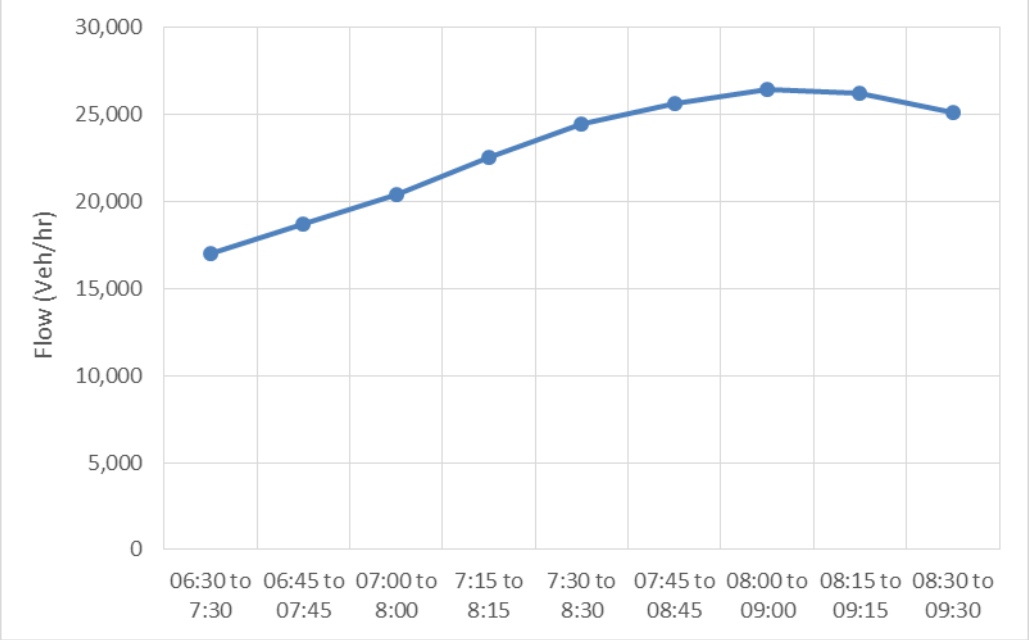

Figure 4 AM Peak identification, 15 min flows

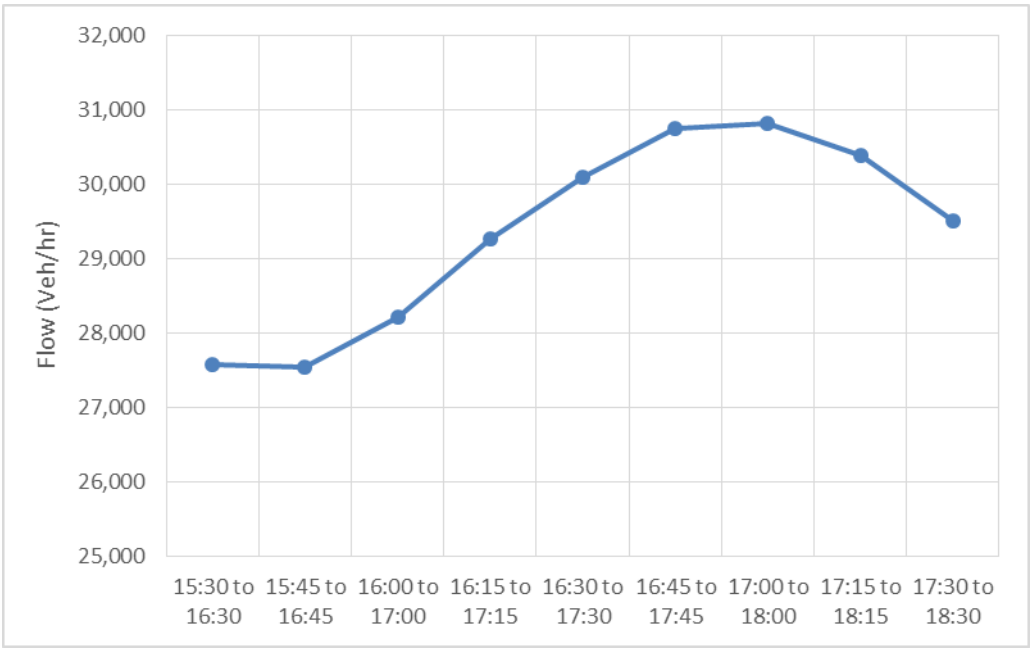

Figure 5 PM Peak identification, 15 min flows

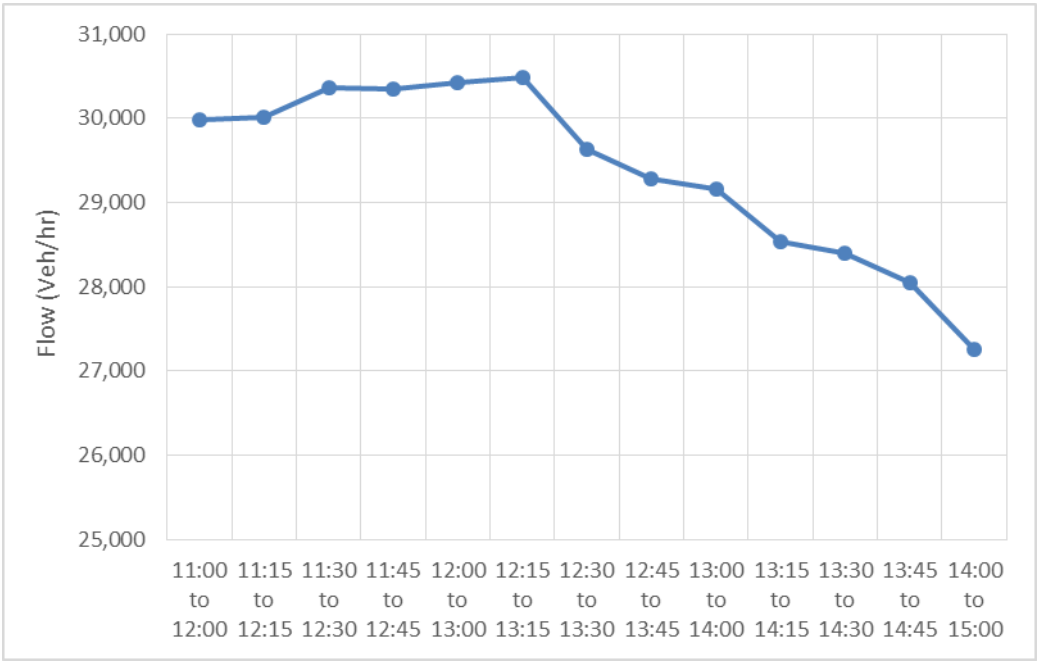

Figure 6 Weekend Peak identification, 15 min flows

2 Data Collection

Developing the model of the study network required the collection of several different data types. This data was used for coding the base model and subsequently during the calibration and validation process. Table 1 below details the types of data collected and their respective uses.

Table 1 Summary of data used in base model

Data type	Description	Location	Date and time	Used for
Intersection counts	Turn counts were undertaken by subconsultants Matrix. This data was recorded in 15minute intervals and categorised into car, truck, bus and pedestrians.	11 intersections across the study area (See Figure 7)	Thursday 18 August, 6:30-9:30am and 3:30-6:30pm Saturday 20 August, 11am – 3pm	Prior matrix and Calibration
Videos of intersections	Videos were used to collect data about average phasing data to use as a starting point for the base model signals.	11 intersections across the study area (See Figure 7)	Thursday 18 August, 6:30-9:30am and 3:30-6:30pm Saturday 20 August, 11am – 3pm	Signal operations
Travel time	Travel time through the model along two routes 1. Page Street – Heffron Rd – Maroubra Rd 2. Wentworth Rd – Bunnerong Rd	2 routes through the study area (See Figure 8)	Thursday 18 August and Saturday 20 August	Model Validation
Site observation	Site visit to study area	Whole study area	Wednesday 16 November	Assessing model operation
TCS plans	Plans from the RTA (now RMS) showing layout and possible phases for signalised intersections	6 signalised intersections in network	NA	Signal operations
Bus network data	Timetabling and routing data for buses operating in study area (See Section 3.3)	Whole study area	Timetables for Nov 2016 used	Creating base model Public Transport demand
Journey to Work data	Data from 2011 census about travel patterns in the area	Wider Pagewood area	2011 Census	Developing trip distribution for prior matrix
RMS guide to traffic generating developments	Information on land use trip generation	Internal network zones	2013 release	Estimating demand in prior matrix

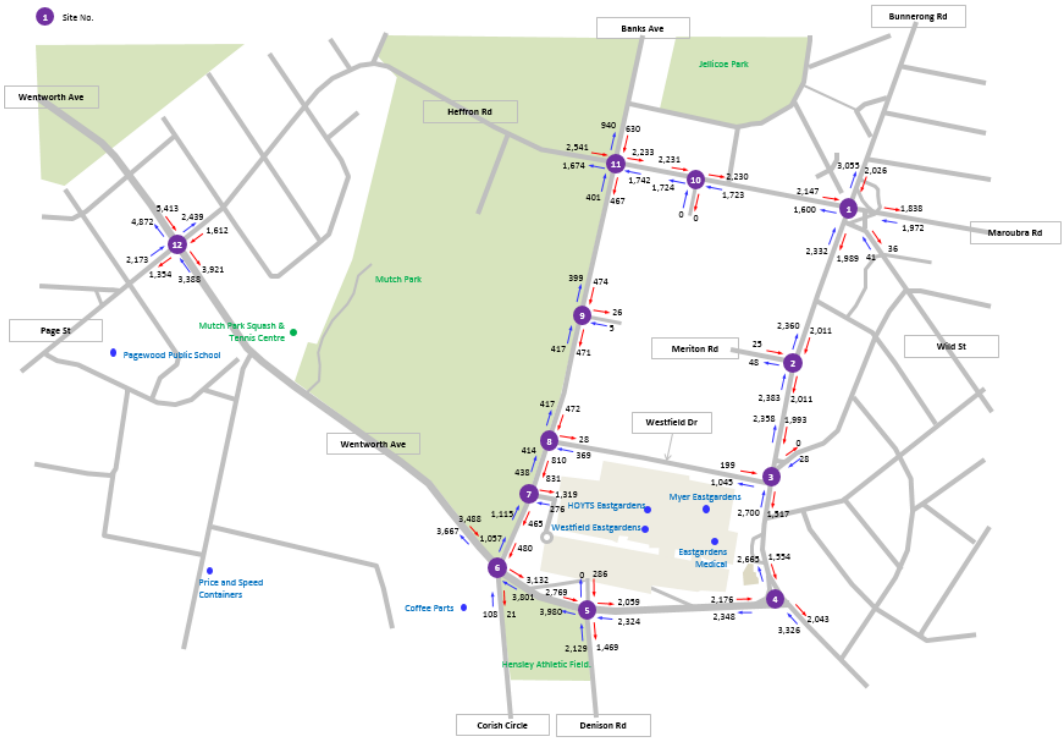

Figure 7 Intersection Count Locations *(source: Matrix traffic and transport data)*

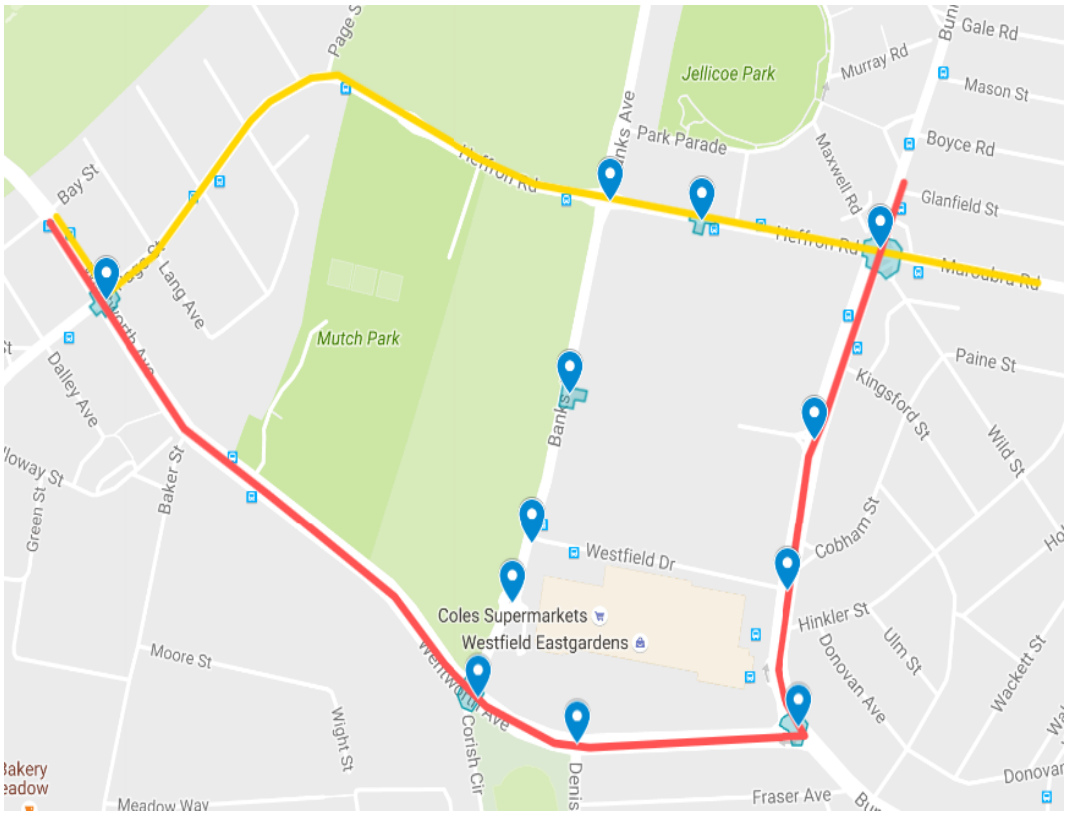

Figure 8 Travel time routes assessed *(source: Matrix traffic and transport data)*

3 Network Development

The network was initially created through the importation of an open street map data file of the study area. The network was then subsequently refined using aerial images from SIXmaps until the required level of detail was obtained.

3.1 Road hierarchy

Three primary road types have been used in the model, sub-arterial (orange), collector (yellow) and local roads (white) as shown in Figure 9. Although not specifically built as sub arterial roads, Page Street and Heffron Road perform a sub-arterial function with regards to network connections. The coding of road types was undertaken primarily for the purpose of static model adjustments and static assignment.

Figure 9 Road Hierarchy

3.2 Travel speeds

Travel speeds within the network have been applied in accordance with posted speeds. These are generally as follows:

- 70km/h along Wentworth Road
- 60km/h along Bunnerong Road
- 50km/h along all residential roads

The default speed distributions within each of these speed categories have been adopted.

Figure 10 Speed ranges within model

3.3 Public transport

Buses are the only form of public transport (excluding taxis) within the study area. Table 2 highlights the bus routes that have been coded within the model. Dead running buses and school buses have not been explicitly coded as it is expected that these services will be captured within the heavy vehicle counts.

The bus interchange at Eastgardens has been coded as a bus only area with a number of buses starting and terminating in this area. Site observations indicated that there was no congestion associated with bus layovers and as such there was no need to explicitly model bus layovers.

Table 2 Bus routes included within the model

Route
301
302
310, X10
316, 317
353
391, 392, X92
400, 410

3.4 Signal operations

Actuated signals have been coded into the model to capture the variability of signal times within Pagewood. A maximum and minimum green time was specified for all phases with some having the ability to be skipped if no demand was present. A gap out parameter of 5 seconds was used with some of the

mainline movements having a reducing gap parameter to account for potentially long green times.

The reducing gap parameter reduces the gap required for gapping out over a specified time period so that phases have the ability to substantially extend the maximum green time only when necessary.

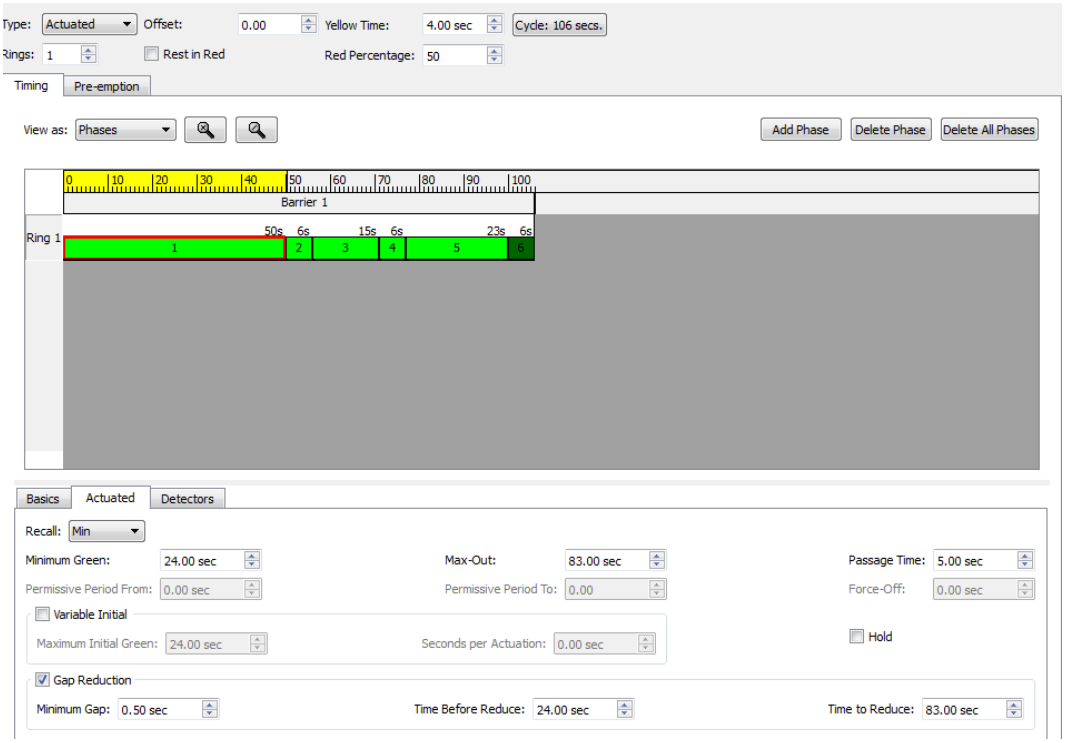

Figure 11 Example of Actuated Signal Coding

Table 3 compares the phase green time proportion for the signalised intersections in the model with observed values. This highlights that the actuated signals, with the exception of 53 phases, are acceptable as per table 11.3 page 105 of the *RMS Modelling guidelines (Roads and Maritime, 2013).*

Three of the phases that lie just outside the criteria do so due to the balance between green times given to the right hand turn and the through movement. This occurs at the Bunnerong Road / Westfield Drive intersection where the right turn starts off as a filter before transitioning to a trailing right turn arrangement. In the weekend peak the through movement is running for a larger proportion of the green time than observed with the right hand turn running for less. In the model, vehicles are finding gaps in traffic during the filter turns while in reality it is more likely that less confident drivers will instead wait for the priority phase as they know this phase is coming. This intersection only shows a 21% difference in green time and as such, this issue is not considered to be significant enough to apply a different signal logic from the other signals. There is a less significant occurrence of this in the PM peak.

The three phase operation in the AM peak at the Wentworth Avenue / Denison Road intersection lies 1% above the required criteria. However as the intersection performs well within criteria for the other two peaks this was not considered significant enough to change the signal logic for all the peaks.

The final signal phase that exceeds criteria is the right hand turn from Wentworth Avenue into Page Street. Similar to the aforementioned issue at Bunnerong Road / Westfield Drive, more vehicles in the model are finding gaps during the filtered right turn than observed on site, again because more conservative drivers are aware of the trailing right hand turn and thus only accept larger than normal gaps. This movement is only 4% above the criteria and again is not considered significant enough to warrant applying different signal logic.

Table 3 Phase Green time proportions, Modelled vs Observed

Intersection	Run	Phase	Modelled	Observed	abs diff
Bunnerong_Westfield	AM	1	81%	82%	1%
		2	5%	11%	5%
		3	14%	15%	2%
	PM	1	62%	52%	10%
		2	12%	25%	13%
		3	26%	22%	3%
	WE	1	63%	45%	18%
		2	11%	32%	21%
		3	26%	25%	2%
Wentworth_Corish	AM	1	64%	54%	10%
		2	6%	11%	6%
		3	22%	24%	3%
		4	8%	10%	2%
	PM	1	59%	49%	10%
		2	13%	17%	3%
		3	21%	30%	9%
		4	7%	5%	2%
	WE	1	48%	51%	3%
		2	18%	17%	1%
		3	26%	29%	2%
		4	8%	4%	4%
Bunnerong_Wentworth	AM	1	48%	50%	1%
		2	14%	18%	3%
		3	37%	33%	5%
	PM	1	51%	48%	4%
		2	9%	17%	8%
		3	40%	36%	4%
	WE	1	49%	44%	4%
		2	17%	19%	2%
		3	34%	36%	3%
Banks_Westfield	AM	1	76%	86%	10%
		2	24%	14%	10%
	PM	1	76%	78%	2%
		2	14%	22%	7%
	WE	1	79%	80%	1%
		2	21%	20%	1%

..Table 3 continued

Intersection	Run	Phase	Modelled	Observed	abs diff
Wentworth_dension	AM	1	46%	53%	7%
		2	16%	20%	4%
		3	38%	27%	11%
	PM	1	48%	58%	9%
		2	15%	12%	3%
		3	36%	30%	6%
	WE	1	48%	54%	6%
		2	13%	13%	0%
		3	39%	33%	6%
Wentworth_Page	AM	1	38%	38%	0%
		2	13%	22%	9%
		3	25%	19%	6%
		4	25%	21%	4%
	PM	1	48%	45%	3%
		2	3%	17%	14%
		3	20%	19%	1%
		4	29%	19%	10%
	WE	1	53%	46%	7%
		2	0%	8%	8%
		3	24%	27%	3%
		4	23%	19%	4%
Bunnerong_Heffron	AM	1	38%	31%	7%
		2	11%	15%	4%
		3	10%	18%	8%
		4	21%	25%	4%
		5	21%	16%	5%
	PM	1	43%	34%	9%
		2	10%	15%	5%
		3	23%	29%	6%
		4	19%	18%	1%
		5	5%	11%	6%
	WE	1	44%	34%	10%
		2	8%	16%	8%
		3	20%	29%	9%
		4	16%	19%	3%
		5	12%	11%	1%

3.5 Priority controlled movements

Priority control movements at intersections as well as right turn filter movements at signalised intersections have had priority rules applied. These priority rules (known as warnings in Aimsun) are consistent with observed signposted and functional priorities in Pagewood. Figure 12 details the gap acceptance parameters used in the model.

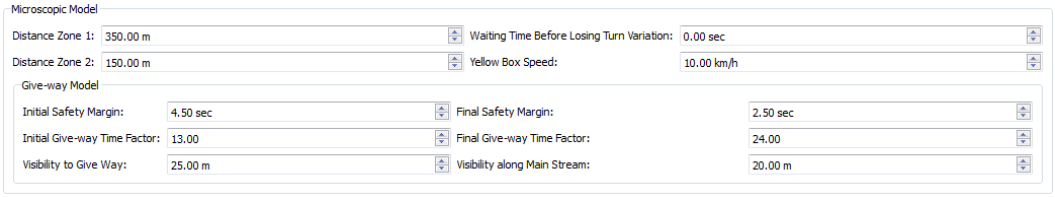

Figure 12 Gap acceptance parameters

The initial safety margin is the initial gap that vehicles will look for. After 58.5 seconds (4.5 * 13.0), vehicles will decrease their gap acceptance linearly to a gap of 2.5 seconds over a 60 second (2.5 * 24.0) period. The visibility to give way (25m) is when vehicles start to look for a gap and visibility along main stream (20m) is the distance into the opposing stream of traffic that vehicles can see.

3.6 Traffic management

Traffic management functions have been used in Aimsun to model lane closures, school zones and traffic calming devices (e.g. chicanes and speed humps). Lane closures have been modelled for Wentworth Avenue westbound in the PM and weekend models to account for parking that is restricted for only park of the simulation period. A speed change has been used to model the school zone on Bunnerong Road that is similarly only active for part of the AM simulation period. A permanent speed change is used for sections along Page/Heffron Road corridor to capture the effects of the traffic calming devices along this corridor. The speed change is representative of the suggested speed of 25km/hr.

3.7 Pedestrian conflicts

Pedestrian right of way conflicts within the model have been coded using the traffic management functionality “Periodic Section Incident”. A periodic section incident will close off a section of road for a specified period of time based on an occurrence rate and an occurrence length. The average arrival interval of a pedestrian at a crossing based of the pedestrian volumes was used for the occurrence rate and the occurrence length was based of calculated crossing times. A standard deviation was applied to both the occurrence rate and length to randomise the closures.

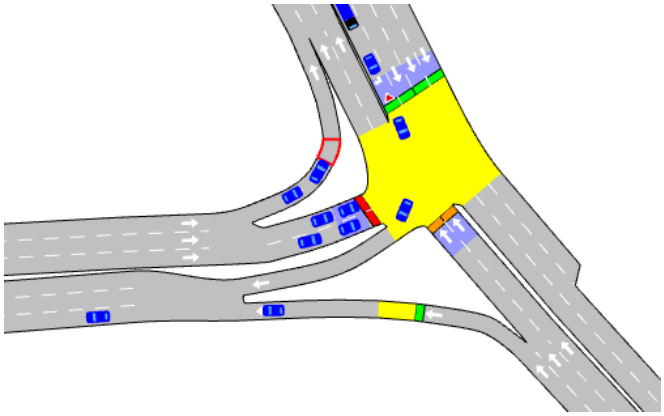

Figure 13 Periodic section incident at the location of a zebra crossing

The effect of pedestrian crossings on signal times was not explicitly modelled due to signals being coded as actuated. However as the green time proportions in the model matched the green time observed it can be deduced that pedestrian effects at signals are being captured.

4 Base Model Development

4.1 Demand development

To model demand in the network, the study area was broken into 29 zones shown in Figure 14. Zones 101 to 114 are internal zones with the Meriton Properties site being covered by zone 108 and the BATA site by 109. Zones 1 through 15 are external zones.

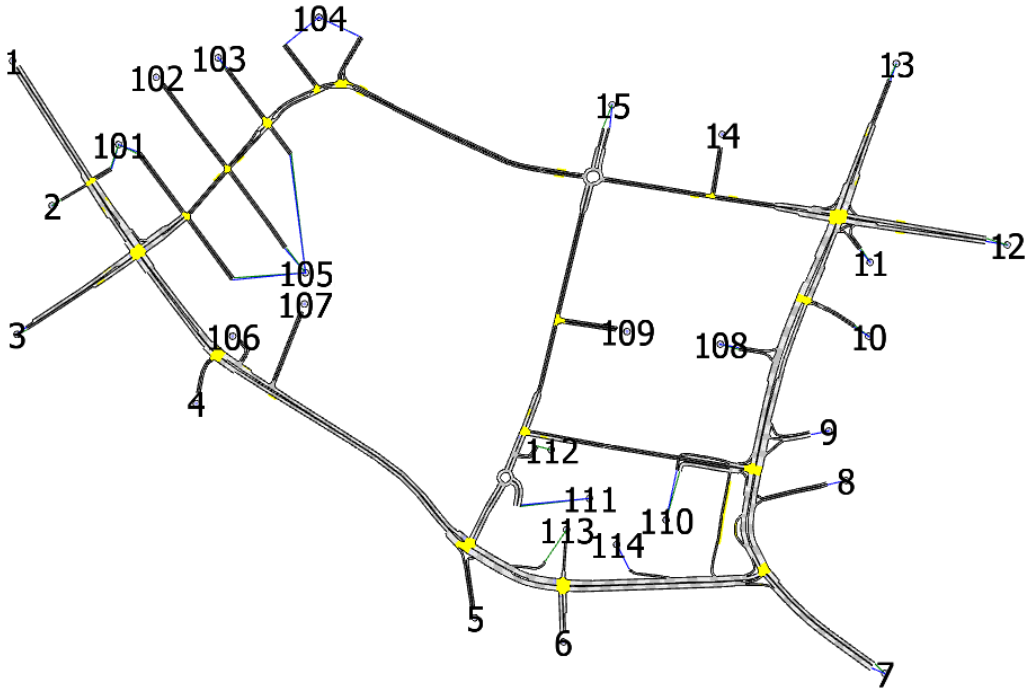

Figure 14 Zones used for demand development

In order to generate the correct matrix pattern traffic from the internal zones was estimated using traffic generation rates based on land use and journey to work information. Estimations were then confirmed and/or corrected using site observations.

External zones were calculated using turn count survey data, by calculation the entering and exiting traffic volumes with major trunk movements deduced using wider network linkages and site observations. Once the total demand for each zone was estimated, a prior origin-destination matrix was constructed.

A static origin destination (OD) adjustment scenario was run on the prior matrix in which the prior OD pairs were automatically adjusted by the modelling software to better match the turning count survey data. A deviation matrix was created also created and applied to restrict the amount of traffic that could be added or removed from particular model zones. This prevents unrealistic zone pair volumes such as unrealistically large weaving trips, which may match the survey data but are extremely unlikely to occur in reality.

After the static OD adjustment was complete the matrices were manually checked for unrealistic zone pairs with some final manual edits being made to increase model calibrations.

The last step in the process was to split the matrices into 8, 15 minute periods to profile the volumes. Table 4 highlights the demand profile used in each peak period.

Table 4 Demand Profile

Time Period	AM	PM	WE
1	12%	11%	12%
2	12%	12%	12%
3	13%	13%	12%
4	14%	13%	13%
5	14%	13%	13%
6	13%	13%	13%
7	12%	13%	13%
8	11%	12%	12%

4.2 Traffic assignment

Traffic was assigned to the network using a combination of static assignment and stochastic assignment. The static assignment method calculated paths and costs based of instantaneous flows using a Frank and Wolfe Assignment engine. The stochastic assignment was based on a c-logit model with the parameters shown in Figure 15.

The combination of 50% static and 50% stochastic allows for a representation of a mix of drivers on the network. 50% being drivers not entirely familiar with the network and less likely to react to changes in traffic with the other 50% being very familiar with the network and likely to change routes based of day to day conditions.

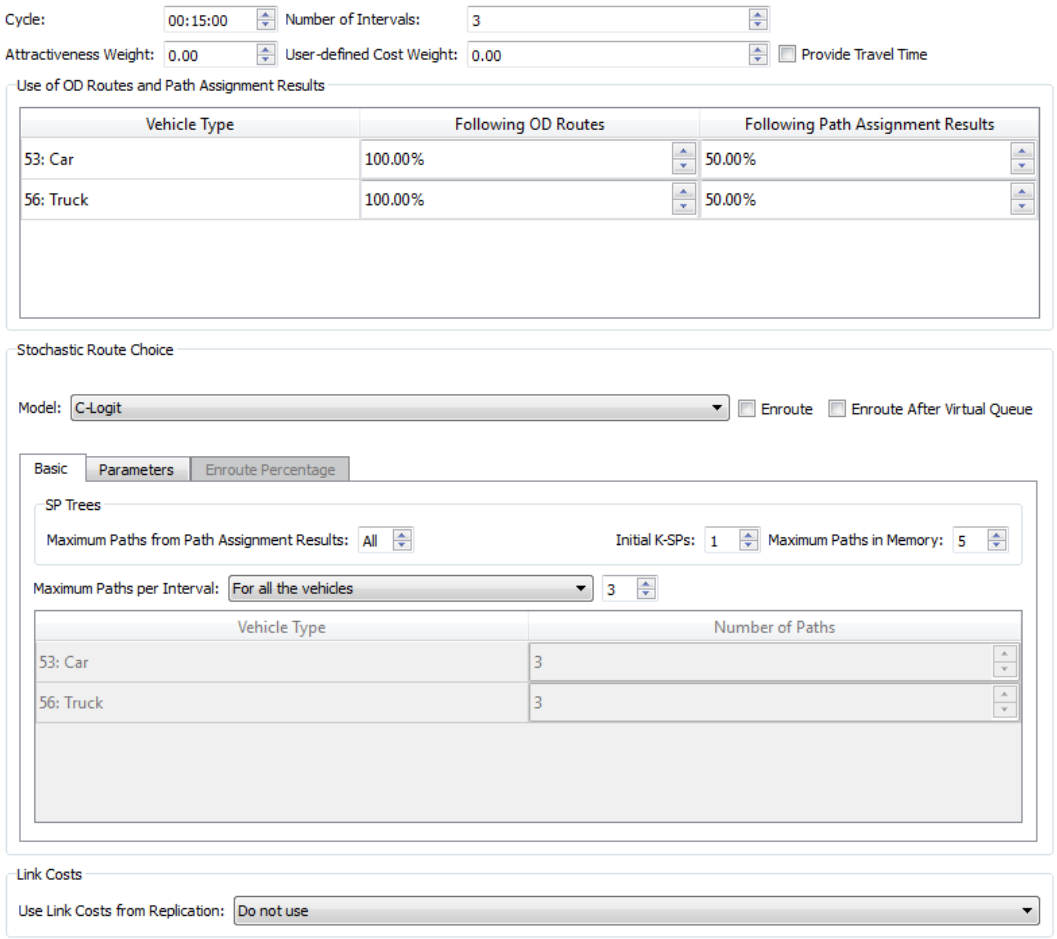

Figure 15 Assignment Parameters

4.3 Model stability

Section 11 of the *RMS Modelling guidelines* provide guidance on calibrating and validating microsimulation traffic models. For the purposes of presenting calibration results, the guidelines suggest comparing vehicle hours travelled for each simulated seed run and identifying the median value. As shown in Table 5, the comparison shows that the median seed for both AM and weekend peak periods is 28 while for the PM peak, the median seed is 560.

Table 5 Total travelled time for each peak period and seed number (medians highlighted)

Seed No.	AM	PM	Weekend
28	**680.91**	708.19	**788.49**
560	726.54	**710.32**	791.36
2849	663.91	715.09	897.73
7771	704.33	706.43	767.67
86524	677.88	738.77	781.10

The median seeds were used for the volume and travel time validation for the corresponding peak periods.

5 Base Model Calibration

Table 11.2 of the *RMS Modelling guidelines* state that the proportion of links within a microsimulation model with a GEH of 5 or lower to be greater than 85% across the whole network. Plots showing the observed volumes compared to modelled volumes using the corresponding median seed simulations are shown in Figure 16, Figure 17 and Figure 18 for AM, PM and weekend traffic respectively.

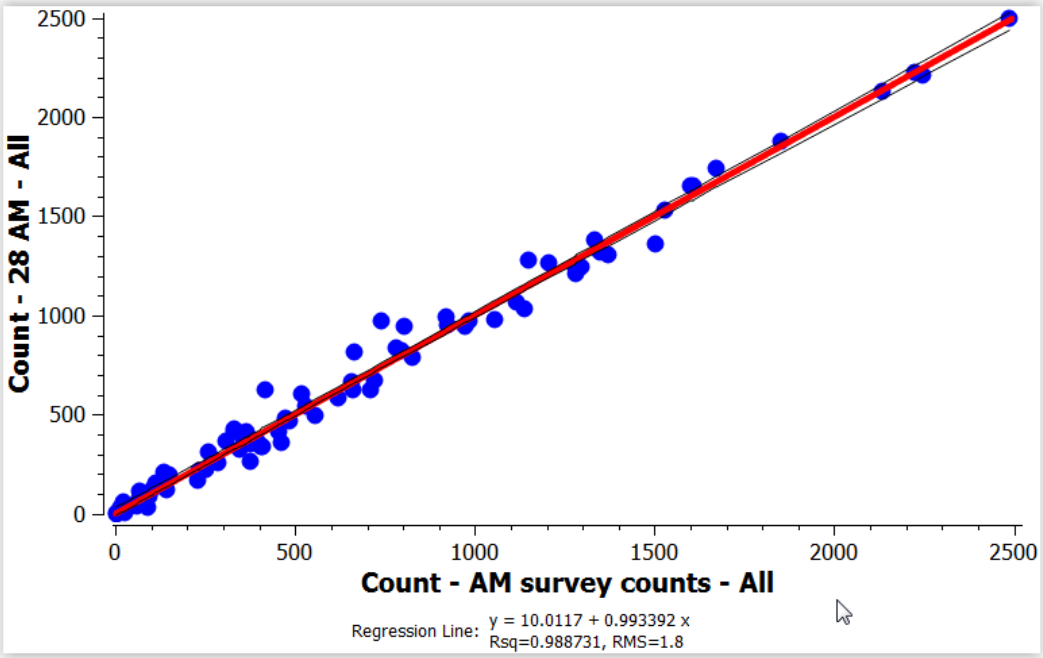

Figure 16 Observed vs modelled plot for AM peak traffic

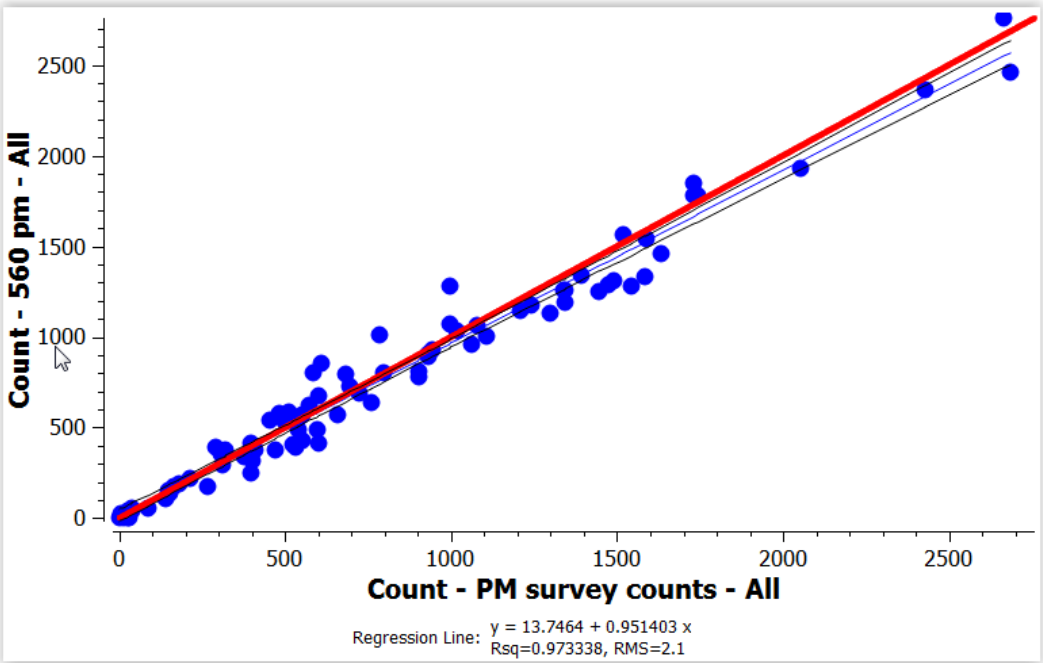

Figure 17 Observed vs modelled plot for PM peak traffic

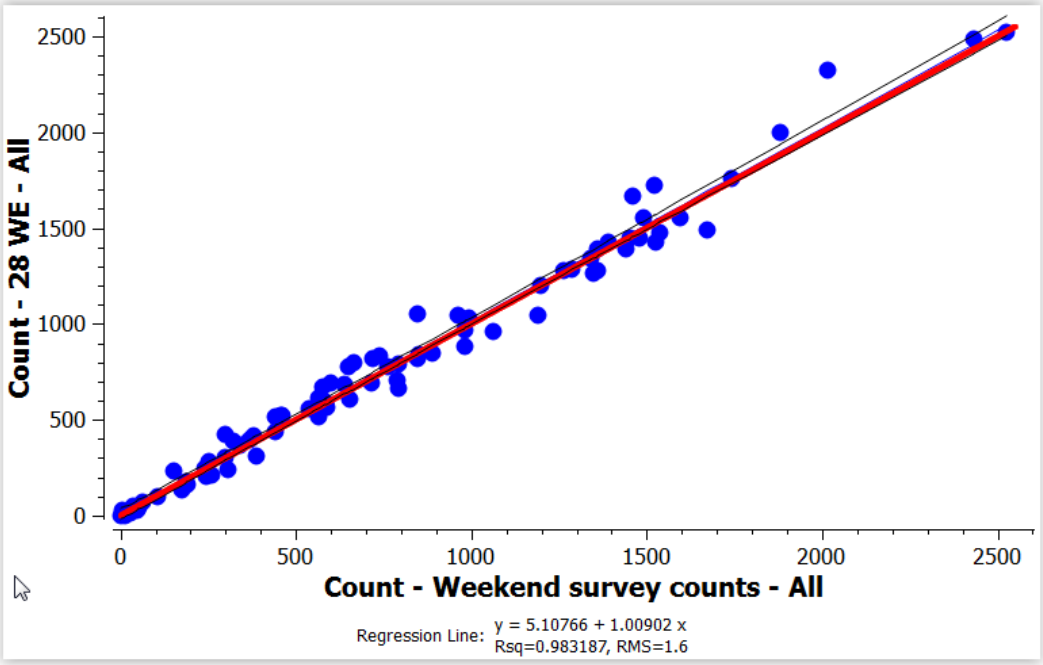

Figure 18 Observed vs modelled plot for weekend traffic

The R squared values are above 97% in all scenarios indicating very good fits between the observed and modelled volumes. The cumulative percent distribution GEH plots are shown in Figure 19, Figure 20 and Figure 21 for AM, PM and weekend traffic respectively.

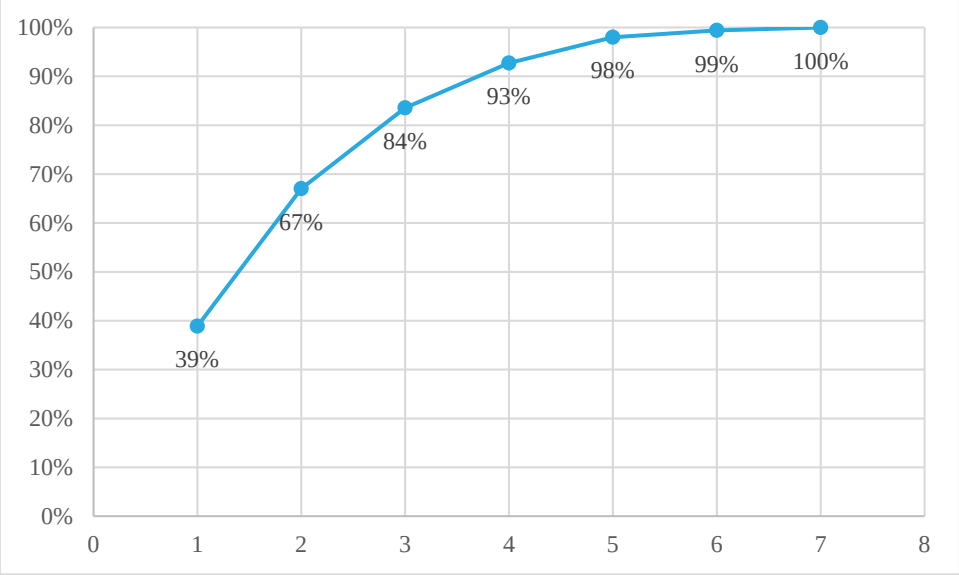

Figure 19 GEH distribution plot for AM traffic

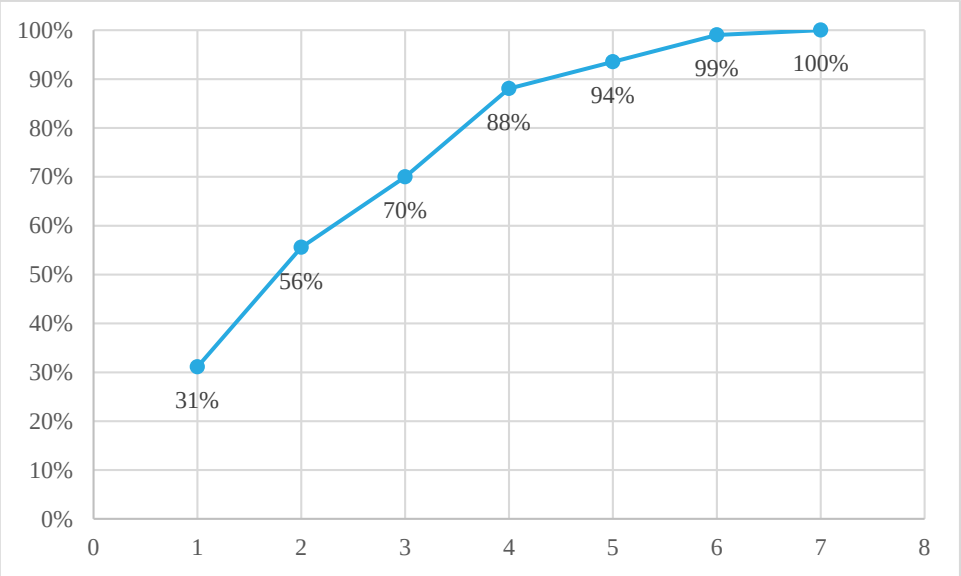

Figure 20 GEH distribution plot for PM traffic

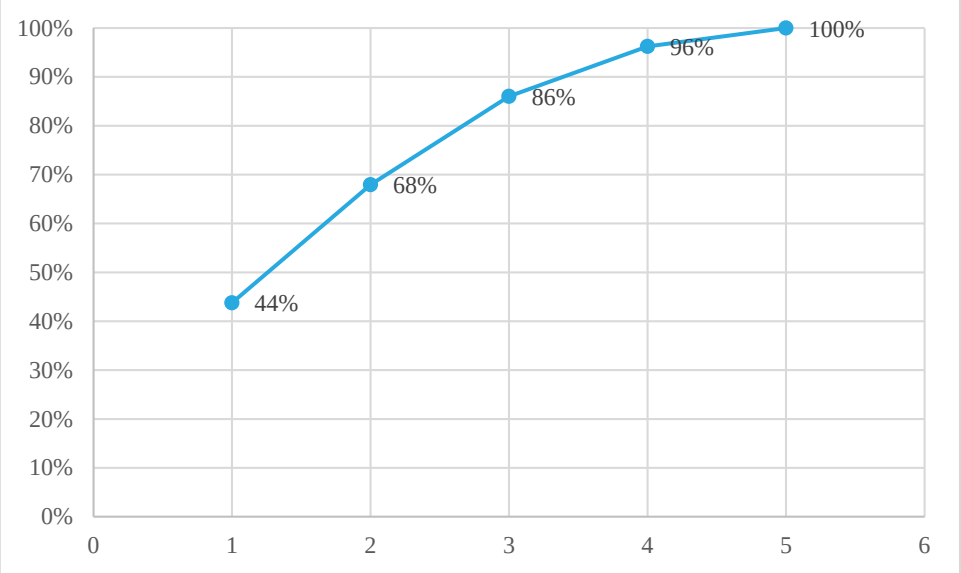

Figure 21 GEH distribution plot for weekend traffic

As shown, the proportion of links with GEH lower than or equal to 5 exceed 85% as suggested by the *RMS Modelling guidelines*. The weekend peak exhibits lower GEH overall compared to the weekday AM and PM peaks due to having lower rat-running movements.

Table 6 GEH Summary Statistics

Model	**GEH < 5**	**GEH < 10**
AM Peak	98%	100%
PM Peak	93%	100%
WE Peak	100%	100%

6 Base Model Validation

As described in Section 2, travel time data was also collected for two routes. Both routes have the same start and end points: from the Wentworth Avenue / Page Street intersection to Maroubra Road / Bunnerong Road intersection. Route 1 passes via Page Street and Heffron Road while Route 2 passes through Wentworth Avenue and Bunnerong Road as shown in Figure 22.

Figure 22 Location of travel time routes

6.1.1 Travel time results

Table 11.3 from the *RMS Modelling guidelines* suggest that the modelled travel times should be within 15% of the observed travel times. The modelled travel times compared to the observed travel times are shown below for the AM, PM and weekend peaks.

6.1.1.1 AM peak

Modelled and observed travel times along Route 1 and Route 2 in both directions during the AM peak are shown in Figure 23, Figure 24, Figure 25, and Figure 26. Only one route, Route 1 in the east to west direction lies marginally outside the specified criteria. There are a number of on-street parking and driveways along this route that could potentially lead to lower travel speeds than estimated in the model. However, as the model speeds are only marginally outside the criteria and

as congestion increases drivers often behave more aggressively with regards to parking and turning into driveways this issue is not considered significant.

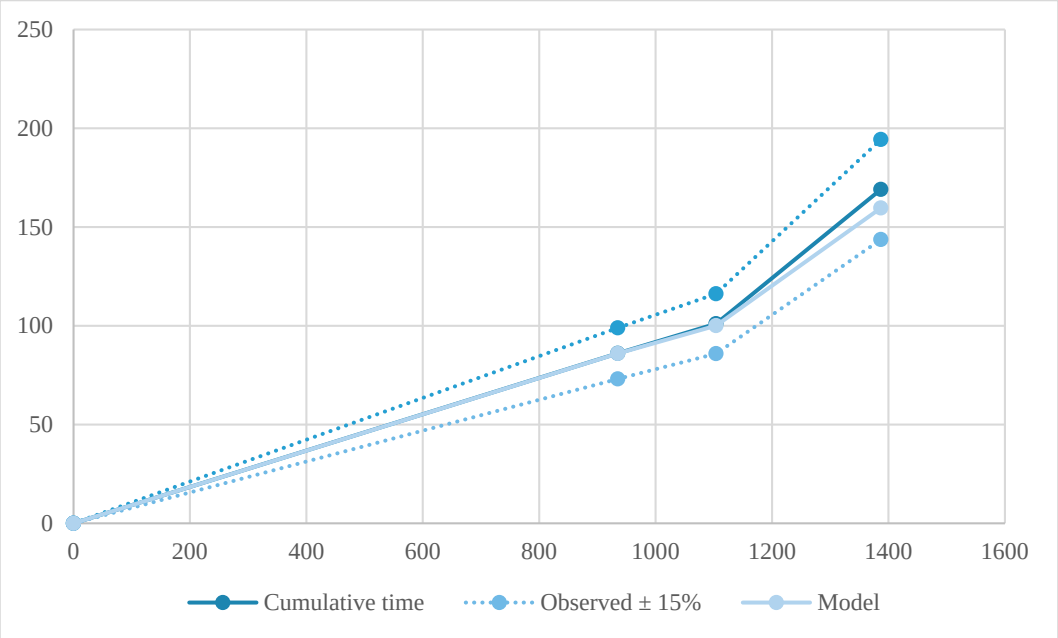

Figure 23 Route 1 - West to East (AM)

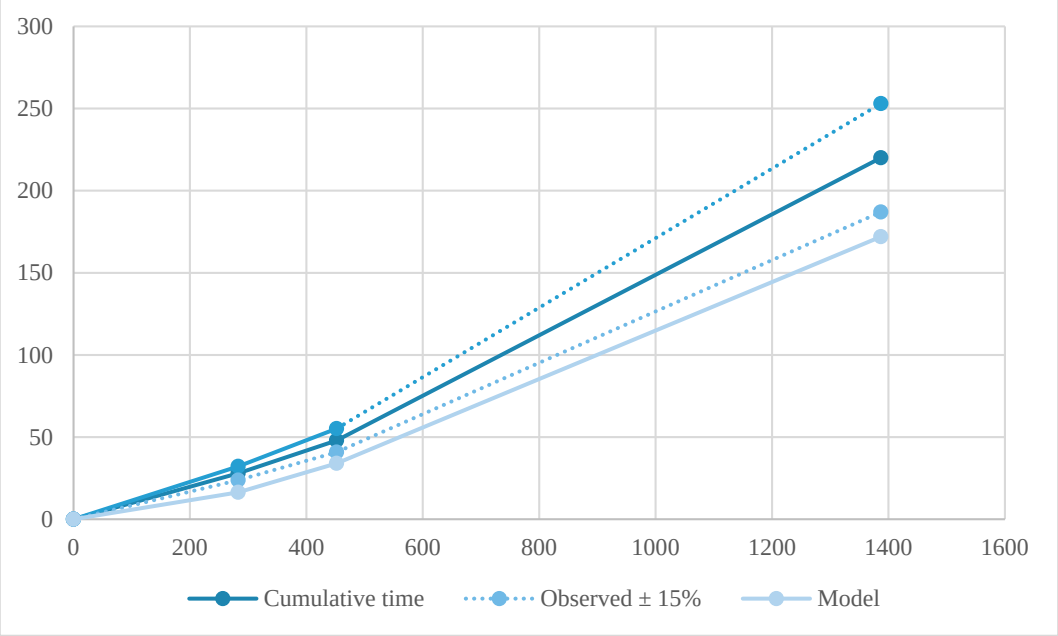

Figure 24 Route 1 - East to West (AM)

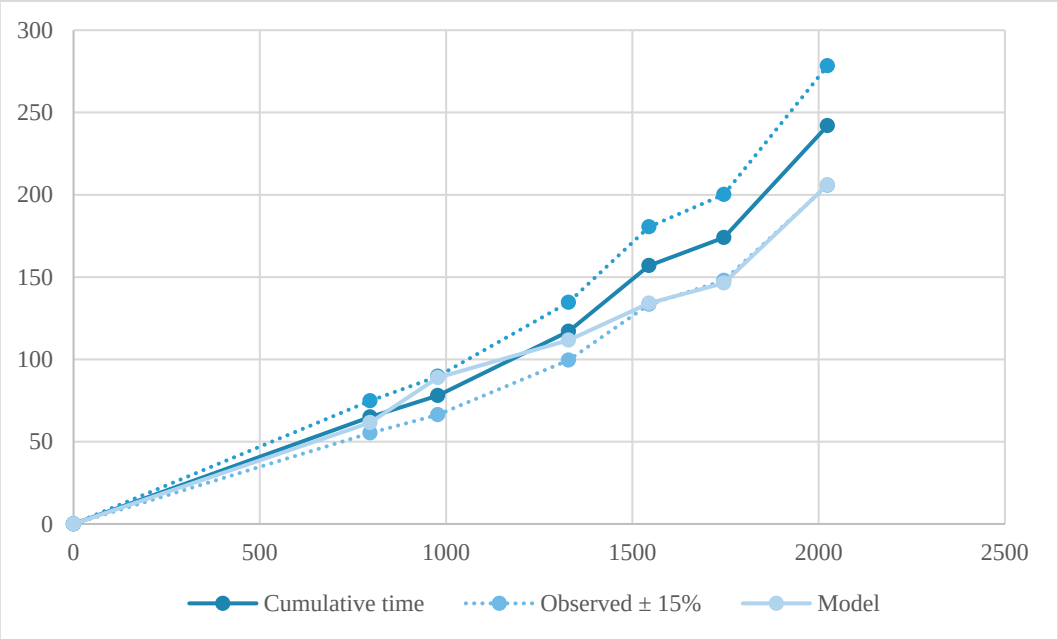

Figure 25 Route 2 - West to East (AM)

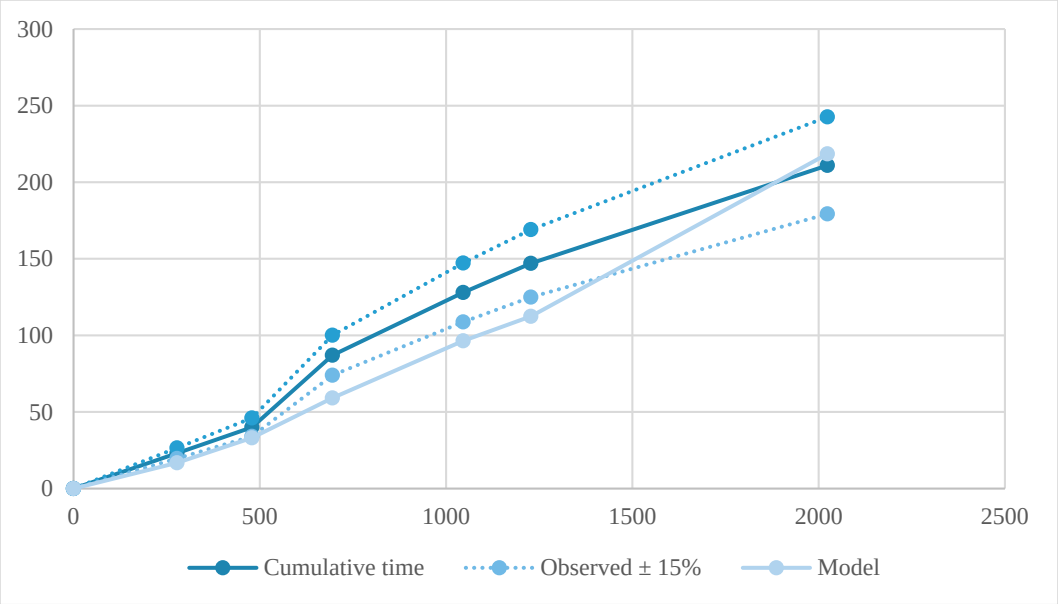

Figure 26 Route 2 - East to West (AM)

Table 7 Route 1 West to East (AM)

				Observed (sec)				Modelled (sec)	
START	END	Section distance	Cumulative distance	section time	Cumulative time	Observed ± 15%	Observed ± 15%	Section time	Cumulative time
1	1	0	0	0	0	0	0	0	0
1	2	935	935	86	86	99	73	86	86
2	3	169	1104	15	101	116	86	14	100
3	4	283	1387	68	169	194	144	60	160

Table 8 Route 1 East to West (AM)

				Observed (sec)				Modelled (sec)	
START	END	Section distance	Cumulative distance	section time	Cumulative time	Observed ± 15%	Observed ± 15%	Section time	Cumulative time
4	4	0	0	0	0	0	0	0	0
4	3	283	283	28	28	32	24	16	16
3	2	169	452	20	48	55	41	18	34
2	1	935	1387	172	220	253	187	138	172

Table 9 Route 2 West to East (AM)

				Observed (sec)				Modelled (sec)	
START	END	Section distance	Cumulative distance	section time	Cumulative time	Observed ± 15%	Observed ± 15%	Section time	Cumulative time
1	1	0	0	0	0	0	0	0	0
1	2	796	796	65	65	75	55	62	62
2	3	182	978	13	78	90	66	27	89
3	4	351	1329	39	117	135	99	23	112
4	5	216	1545	40	157	181	133	22	134
5	6	201	1746	17	174	200	148	12	146
6	7	278	2024	68	242	278	206	60	206

Table 10 Route 2 East to West (AM)

				Observed (sec)				Modelled (sec)	
START	END	Section distance	Cumulative distance	section time	Cumulative time	Observed ± 15%	Observed ± 15%	Section time	Cumulative time
7	7	0	0	0	0	0	0	0	0
7	6	278	278	23	23	26	20	17	17
6	5	201	479	17	40	46	34	16	33
5	4	216	695	47	87	100	74	26	59
4	3	351	1046	41	128	147	109	37	96
3	2	182	1228	19	147	169	125	16	112
2	1	796	2024	64	211	243	179	106	218

6.1.1.2 PM peak

Modelled and observed travel times along Route 1 and Route 2 in both directions during the PM peak are shown in Figure 27, Figure 28, Figure 29, and Figure 30. Similarly as the AM peak only one route lies marginally outside the criteria, Route 1 east to west.

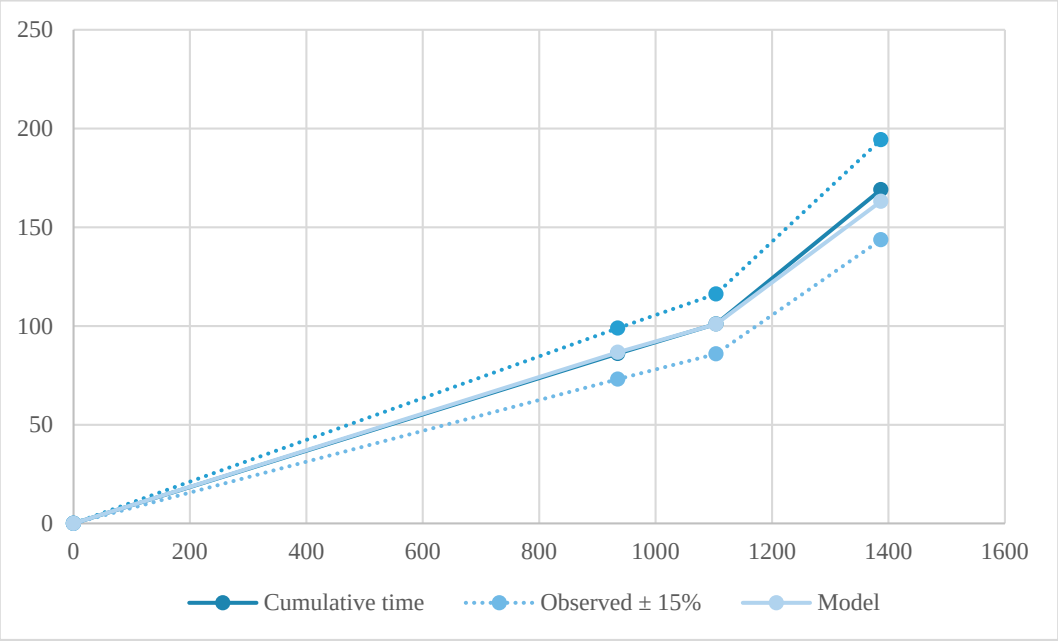

Figure 27 Route 1 - West to East (PM)

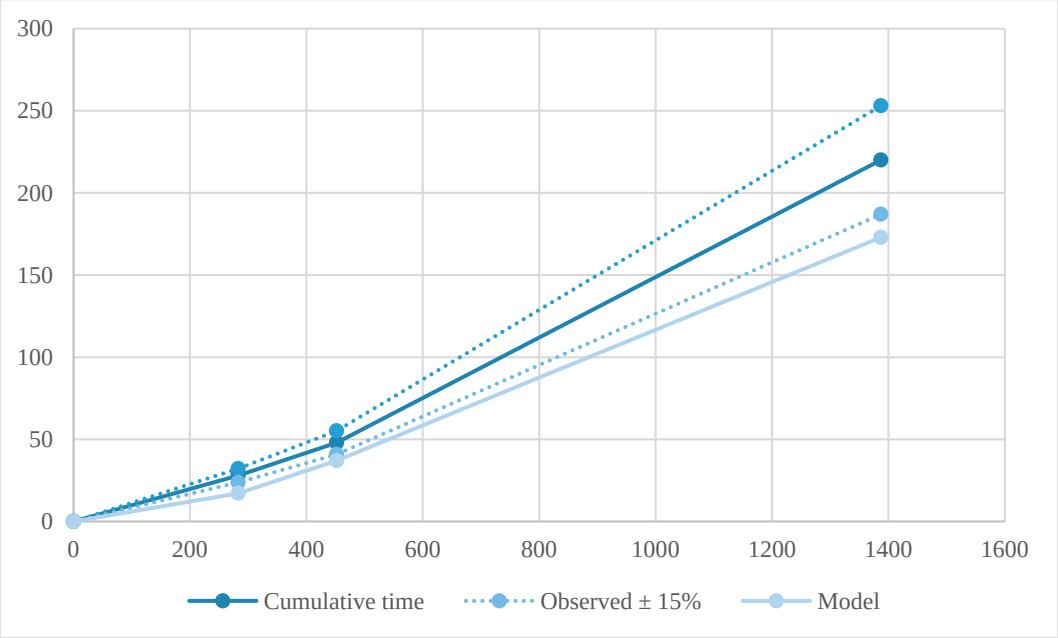

Figure 28 Route 1 - East to West (PM)

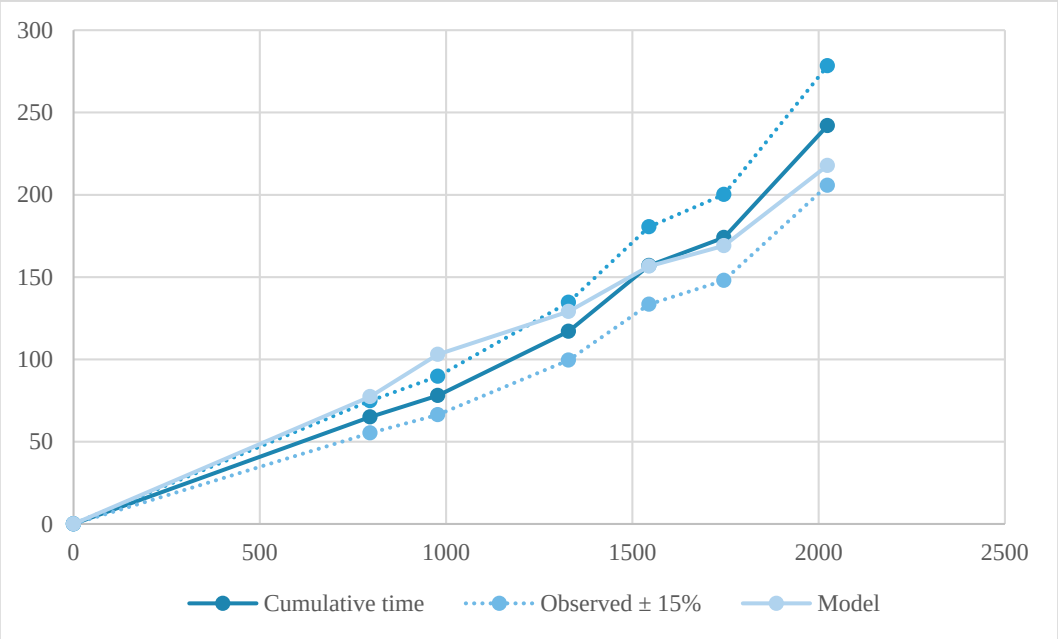

Figure 29 Route 1 - West to East (PM)

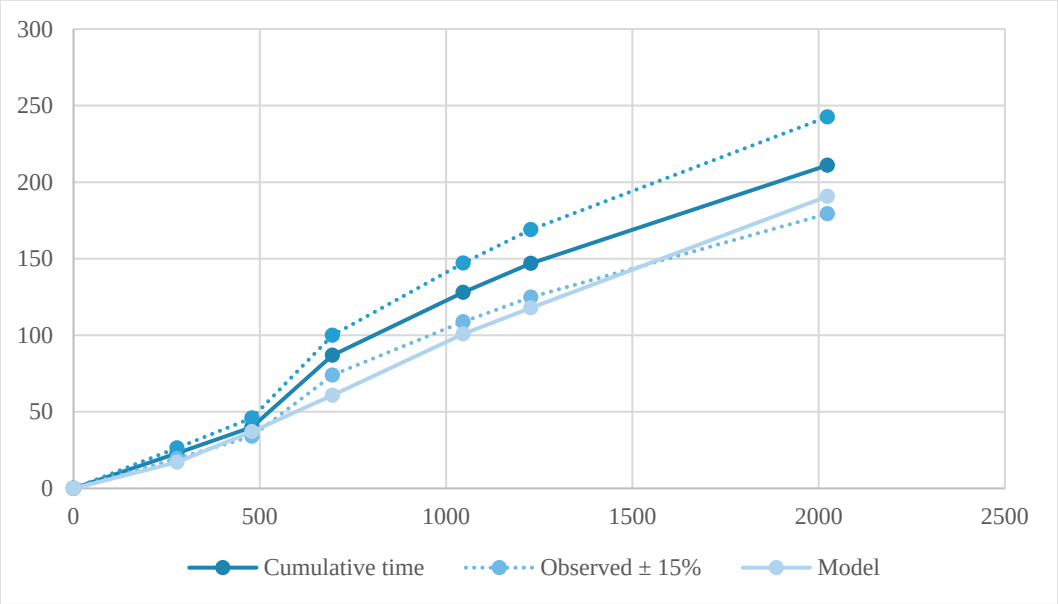

Figure 30 Route 1 - East to West (PM)

Table 11 Route 1 West to East (PM)

				Observed (sec)				Modelled (sec)	
START	END	Section distance	Cumulative distance	section time	Cumulative time	Observed ± 15%	Observed ± 15%	Section time	Cumulative time
1	1	0	0	0	0	0	0	0	0
1	2	935	935	86	86	99	73	87	87
2	3	169	1104	15	101	116	86	14	101
3	4	283	1387	68	169	194	144	62	163

Table 12 Route 1 East to West (PM)

				Observed (sec)				Modelled (sec)	
START	END	Section distance	Cumulative distance	section time	Cumulative time	Observed ± 15%	Observed ± 15%	Section time	Cumulative time
4	4	0	0	0	0	0	0	0	0
4	3	283	283	28	28	32	24	17	17
3	2	169	452	20	48	55	41	20	37
2	1	935	1387	172	220	253	187	136	173

Table 13 Route 2 West to East (PM)

				Observed (sec)				Modelled (sec)	
START	END	Section distance	Cumulative distance	section time	Cumulative time	Observed ± 15%	Observed ± 15%	Section time	Cumulative time
1	1	0	0	0	0	0	0	0	0
1	2	796	796	65	65	75	55	77	77
2	3	182	978	13	78	90	66	26	103
3	4	351	1329	39	117	135	99	26	129
4	5	216	1545	40	157	181	133	28	157
5	6	201	1746	17	174	200	148	12	169
6	7	278	2024	68	242	278	206	49	218

Table 14 Route 2 East to West (PM)

				Observed (sec)				Modelled (sec)	
START	END	Section distance	Cumulative distance	section time	Cumulative time	Observed ± 15%	Observed ± 15%	Section time	Cumulative time
7	7	0	0	0	0	0	0	0	0
7	6	278	278	23	23	26	20	17	17
6	5	201	479	17	40	46	34	20	37
5	4	216	695	47	87	100	74	24	61
4	3	351	1046	41	128	147	109	40	101
3	2	182	1228	19	147	169	125	17	118
2	1	796	2024	64	211	243	179	73	191

6.1.1.3 Weekend peak

Modelled and observed travel times along Route 1 and Route 2 in both directions during the weekend peak are shown in Figure 31, Figure 32, Figure 33, and Figure 34. As with the AM and PM peak only one route lies marginally outside the criteria, route 1 east to west.

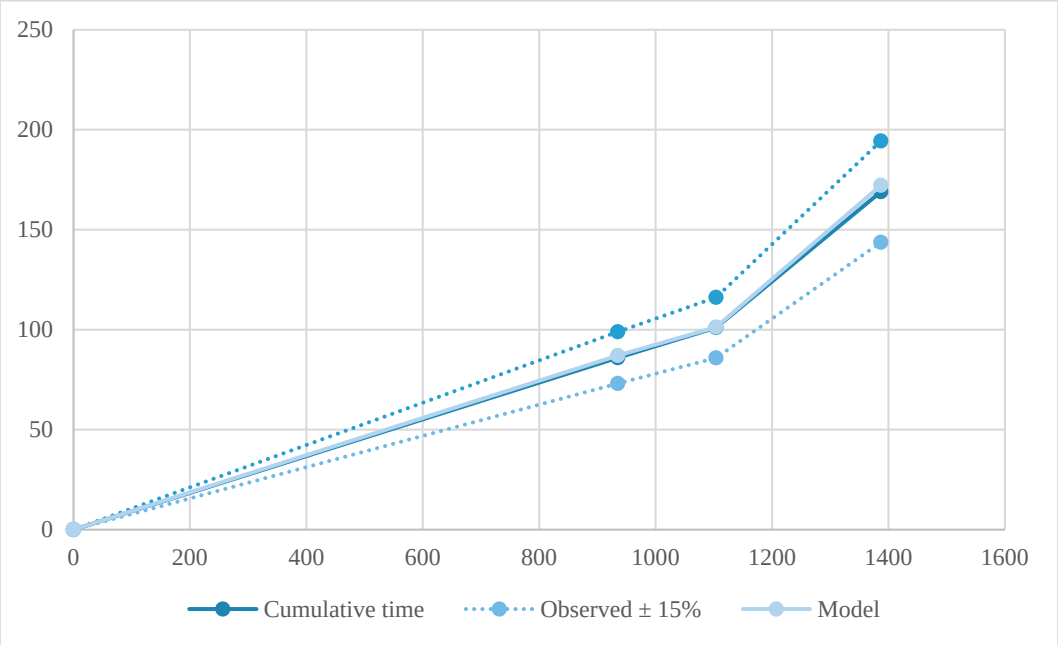

Figure 31 Route 1 - West to East (Weekend)

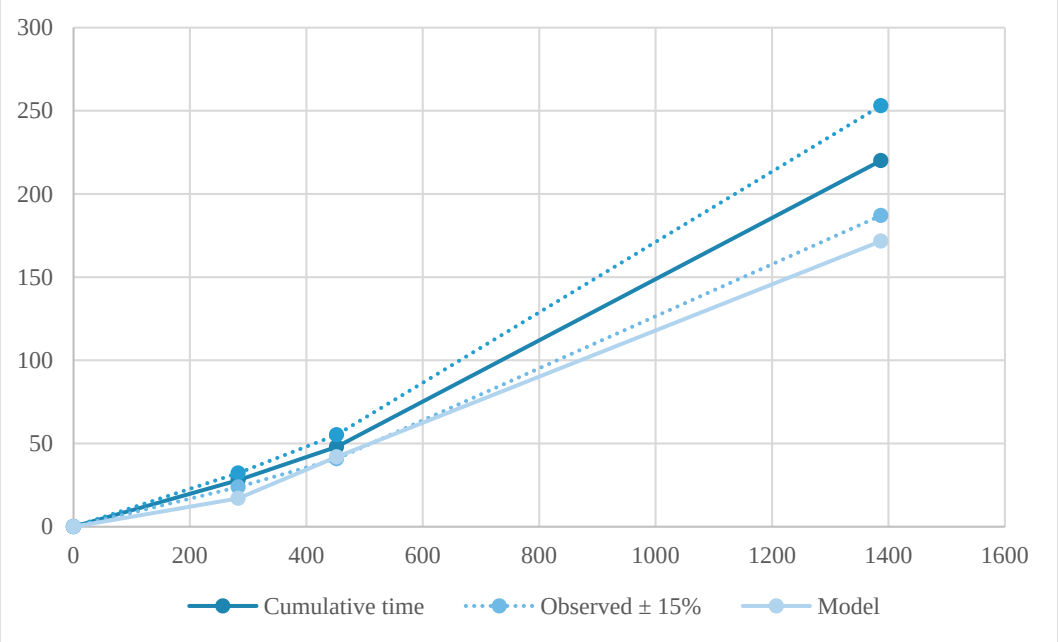

Figure 32 Route 1 – East to West (Weekend)

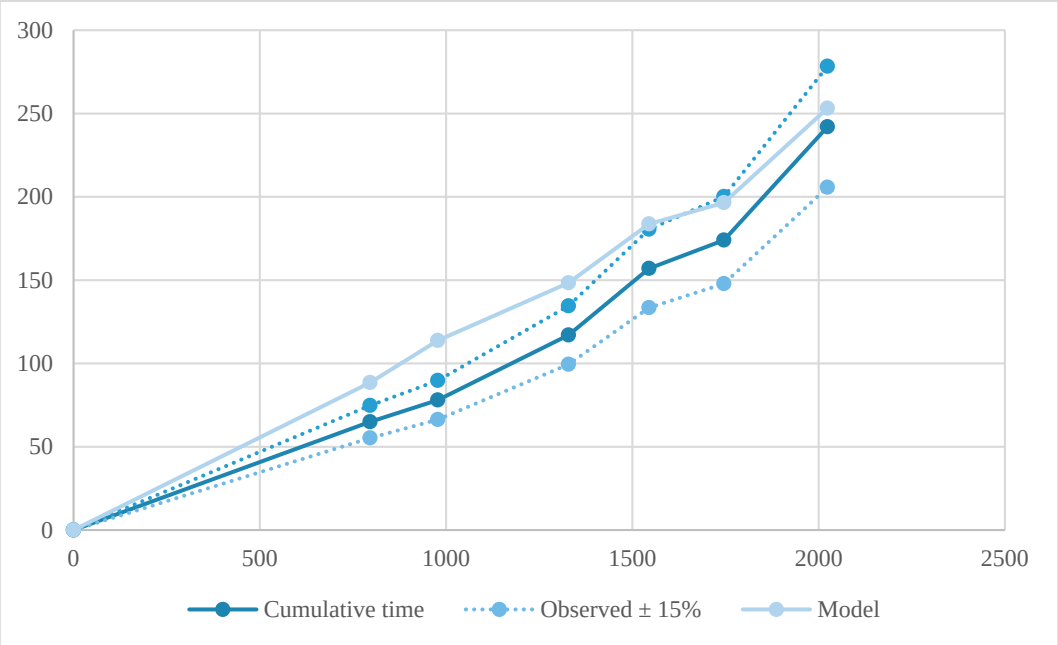

Figure 33 Route 2 - West to East (Weekend)

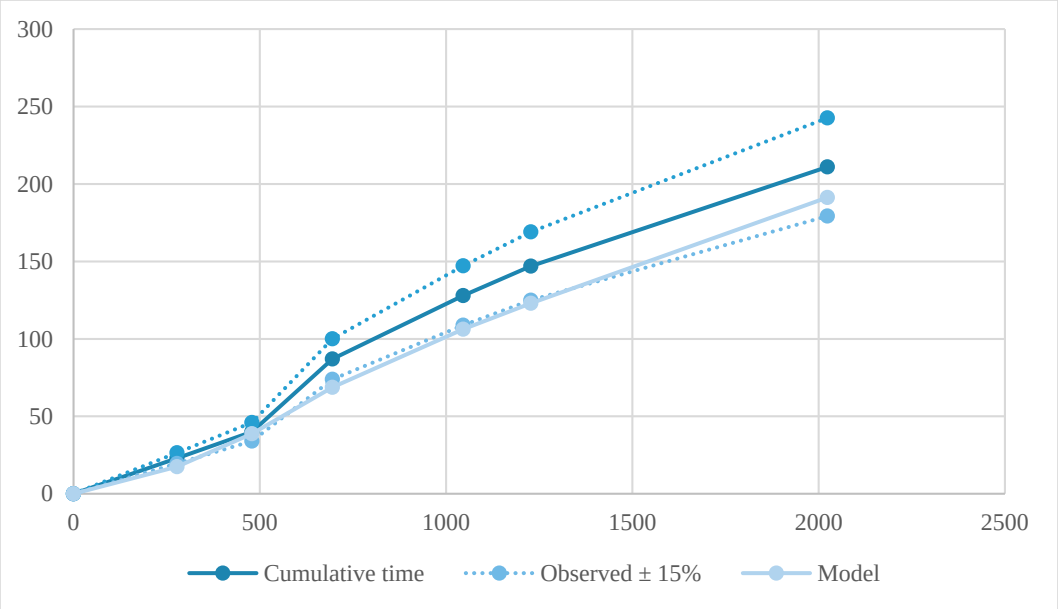

Figure 34 Route 2 - East to West (Weekend)

Table 15 Route 1 West to East (Weekend)

				Observed (sec)				Modelled (sec)	
START	END	Section distance	Cumulative distance	section time	Cumulative time	Observed ± 15%	Observed ± 15%	Section time	Cumulative time
1	1	0	0	0	0	0	0	0	0
1	2	935	935	86	86	99	73	87	87
2	3	169	1104	15	101	116	86	14	101
3	4	283	1387	68	169	194	144	71	172

Table 16 Route 1 East to West (Weekend)

				Observed (sec)				Modelled (sec)	
START	END	Section distance	Cumulative distance	section time	Cumulative time	Observed ± 15%	Observed ± 15%	Section time	Cumulative time
4	4	0	0	0	0	0	0	0	0
4	3	283	283	28	28	32	24	17	17
3	2	169	452	20	48	55	41	25	42
2	1	935	1387	172	220	253	187	130	172

Table 17 Route 2 West to East (Weekend)

				Observed (sec)				Modelled (sec)	
START	END	Section distance	Cumulative distance	section time	Cumulative time	Observed ± 15%	Observed ± 15%	Section time	Cumulative time
1	1	0	0	0	0	0	0	0	0
1	2	796	796	65	65	75	55	89	89
2	3	182	978	13	78	90	66	25	114
3	4	351	1329	39	117	135	99	35	148
4	5	216	1545	40	157	181	133	35	184
5	6	201	1746	17	174	200	148	13	196
6	7	278	2024	68	242	278	206	57	253

Table 18 Route 2 East to West (Weekend)

				Observed (sec)				Modelled (sec)	
START	END	Section distance	Cumulative distance	section time	Cumulative time	Observed ± 15%	Observed ± 15%	Section time	Cumulative time
7	7	0	0	0	0	0	0	0	0
7	6	278	278	23	23	26	20	17	17
6	5	201	479	17	40	46	34	21	39
5	4	216	695	47	87	100	74	30	69
4	3	351	1046	41	128	147	109	38	106
3	2	182	1228	19	147	169	125	17	123
2	1	796	2024	64	211	243	179	68	191

7 Future Demand Development

7.1 Methodology

The future traffic demands that are to be analysed using the traffic micro-simulation model have been developed based on projections of future land uses, increases in population and employment as well as historical growth along traffic corridors. A number of residential and mixed use sites are expected to be developed around the site in the near to medium term, including the currently approved developments on the British American Tobacco Australia (BATA) site. The additional traffic generated by these developments form a baseline future for assessment.

As the main purpose of this study is to analyse the impacts of the changes to development on the BATA site. The additional traffic will be calculated as a change to the original proposed development.

To cross check the demands the proposed floor space and dwelling yields with associated employment and population forecasts are calculated and compared against government forecasts prepared by the Bureau of Transport Statistics for 2021. These checks indicate that the proposed scenarios being used in this study are broadly in line with this separate set of projections.

As the 2031 design year model is also required, a scenario 10 years after completion of the development, the demand for year 2031 are calculated using growth factors. To increase accuracy the growth factors for different regions in the model were determined using a combination of population and employment forecasts. Through traffic movements and shopping centre traffic volumes were increased separately to maintain the separate distribution for these trips.

7.2 Design horizons

Two design year horizons are to be considered for the future year modelling, Year 2021 and 2031. Future baseline models as well development models will be developed for both horizon years. 2021 represents the year of completion and 2031 is the ten year horizon past opening.

7.3 Development of Year 2021 demands

The future base traffic generation involves estimating both the increase in background traffic generation from approved developments, the increase in through trips and the increase in shopping trips to Eastgardens Westfield's. Subsequent options will be tested against this future base case.

Development traffic was then calculated as a change to the future base demands. Through this process public transport and pedestrian demands remained as per the base model as it is unlikely public transport frequencies will increases in the immediate future. Pedestrian demand was modelled using section incidents and an increase in pedestrians will not necessarily lead to a direct increase in conflicts with cars as pedestrians are likely to bunch.

7.3.1 Background traffic growth

At the micro-simulation level of granularity background growth is the traffic generated by the number of residential and mixed use sites in and around the study area that are expected to be developed in the near future.

There are two developments within close proximity to the site, Bunnings and the Orica development site, that along with the currently approved Meriton Properties development, will form the network background growth. It is also assumed that the BATA site under investigation will continue to operate as a warehouse. The background traffic generation is detailed below in Table 19 and Table 20.

Table 19 Meriton Properties Site traffic generation

Land Use	**Size**	**Traffic Generation (2hr)**		
		AM	**PM**	**WE**
Residential	2,222 units	977	765	868
Specialty Retail	5,000 m2	0	238	317
Childcare	4 centres (100 children each)	222	222	0
Warehouse	50,000 m2	397	397	0
Total		1,596	1,622	1,185

Table 20 Adjacent land use changes traffic generation

Land Use	**Size**	**Traffic Generation (2hr)**		
		AM	**PM**	**WE**
Bunnings	14,900m2	400	560	1216
Office	6,000m2	317	317	0
Industrial	60,000m2			
Masters	9,803m2	168	236	512
Total		885	1113	1728

7.3.2 Eastgardens traffic

Changes in population in the Eastgardens Catchment is expected to change access and egress traffic levels and distributions. The Eastgardens trade area extends around 5km to 7km radius from the centre. A 6.5km boundary was drawn around Eastgardens with the catchment being broken up into 4 quadrants whose size depends on network access, see Figure 35. The predicted population increases for the travel zones within each of these quadrants was then assessed to calculate the increase in traffic and any potential change in traffic profile. The largest increase in traffic was experienced to the north and south.

Table 21 Eastgardens growth rates

Quadrant	Population Increase to 2021	Population Increase to 2032 from 2021
North	23%	15%
East	11%	13%
South	20%	14%
West	14%	15%

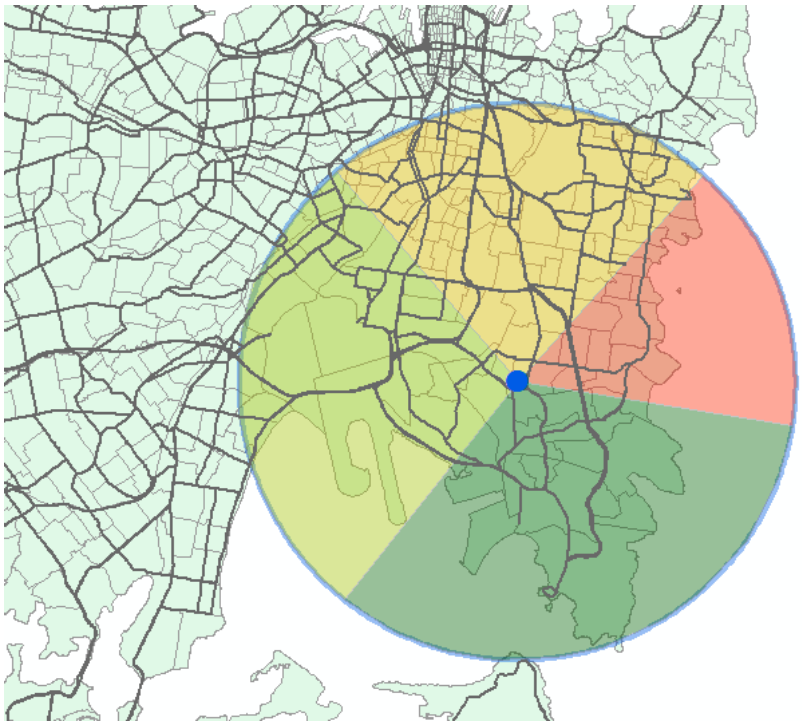

Figure 35 Eastgardens retail catchment

7.3.3 Through traffic growth

The Roads and Maritime traffic volume viewer was used to assess increase in volumes on through movements, trips that start and end in external zones. Data for Wentworth Avenue was only available for two years, see Table 22, where a decrease was observed in the eastbound direction and an increase in the westbound. No data was available for Bunnerong Road with the closest count being located on Anzac Parade north of Lang Road. Given the lack of available information a 1% per annum growth rate was assumed for the trough movements.

Table 22 Wentworth Avenue traffic volumes *source: RMS traffic volume viewer*

	2011	2015	Growth
Wentworth Ave (eastbound)	23,673	21,679	-8%
Wentworth Ave (westbound)	21,550	22,227	+3%

7.3.4 Development traffic

The changes to the development include the removal of the warehouse, the construction of an additional 1,692 residential apartments as well as the removal of 4,000 Gross Floor Area (GFA) of retail bring the total development down to 1,000 GFA of specialty retail. Finally, one child care centre is removed bringing the total for the two stages down to 3 centres. Table 23 below highlights the original traffic generation numbers with the associated changes as a result of the above development traffic.

Table 23 Change to development traffic

Development Type	Original Development Proposal			Proposed Changes		
	AM	PM	WE	AM	PM	WE
Residential	977	765	868	744	583	661
Retail	0	238	317	0	-190	-254
Childcare	222	222	0	-56	-56	0
Warehouse	397	397	0	-397	-397	0
Total	1,596	1,622	1,185	292	-60	407

The traffic generated by both Stage 1 and Stage 2 development is assumed to follow the same distribution as current Journey to Work trips for the surrounding area as documented in the *Arup BATA 2014 Traffic Report*. The zones in the previous model correlate well with zones in the new model being developed and so it is simple to allocate the trips generated by the development to origin-destination pairs.

Zone	Origin/Destination	PM Peak		SAT Peak	
		In	Out	In	Out
1	Wentworth Ave (W)	37%	16%	26%	26%
2	Heffron Road (W)	4%	2%	3%	3%
3	Banks Avenue (N)	4%	2%	3%	3%
4	Bunnerong Road (N)	5%	2%	4%	4%
5	Maroubra Road (E)	4%	2%	3%	3%
6	Bunnerong Road (S)	14%	6%	10%	10%
7	Denison Road (S)	4%	2%	3%	3%
		70%	30%	50%	50%

Figure 36 Development traffic distribution

7.4 Development of 2031 demands

As the 2031 design year horizon is an additional 10 years out (a total of 15 years from the survey data) it is not appropriate to try and account for all potential land use changes. As such to develop demands for the 2031 design hear horizon the Bureau of Transport Statistics population and employment forecasts were used to determine growth factors for all the internal zones between the years of 2021 and 2031.

The growth factors were determined for all travel zones within or immediately adjacent to the site with the exception of the development travel zone, zone D and were used to create a growth factor matrix as opposed to applying a blanket growth factor to all demands. Traffic in the development zone would remain as per the proposed development planes. In the AM and PM peaks a combination of population and employment was used to determine the growth factors with the combination depending on direction of travel. For the weekend peak only population was used.

To account for through trips the 1% per annum growth rate was carried through to 2031 from 2021. Eastgardens traffic was estimated by again looking at the catchment growth, see Table 21. And a heavy vehicle growth factor was calculated based on increase in employment only. Through this process public transport and pedestrian demands remained as per the base model as the future of bus frequencies is uncertain due to the possibility of light rail being extended within the vicinity of Pagewood. Pedestrian demand was modelled using section incidents and an increase in pedestrians will not necessarily lead to a direct increase in conflicts with cars as pedestrians are likely to bunch.

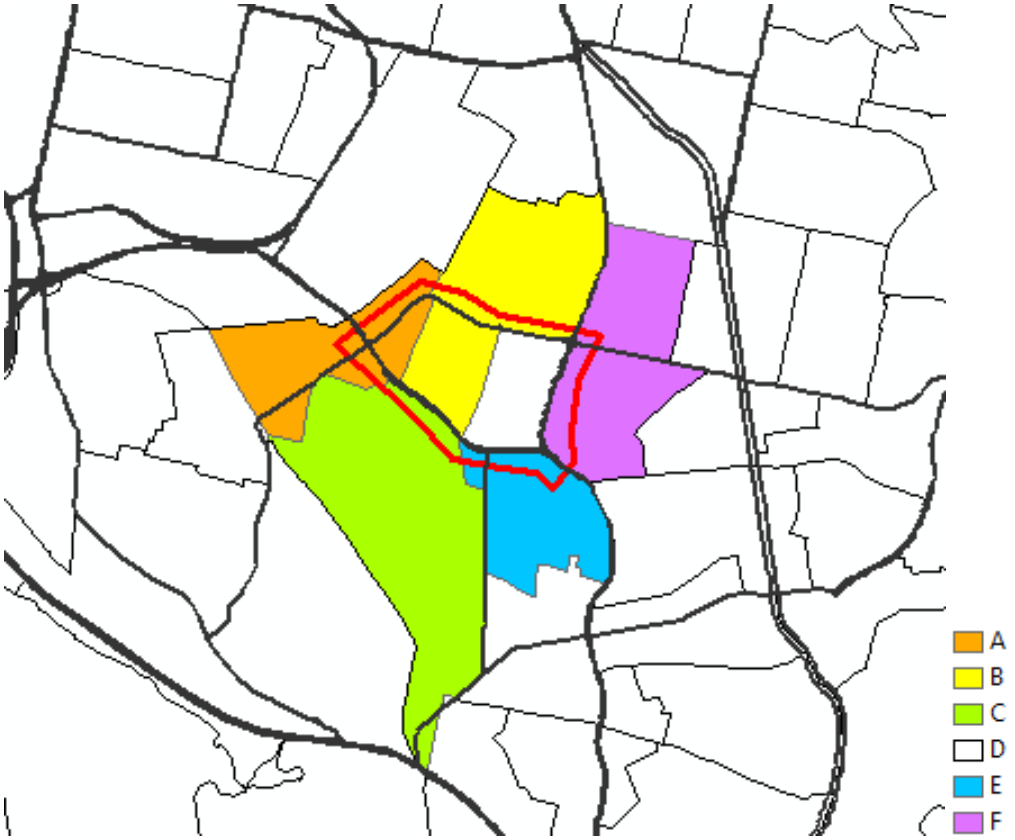

Figure 37 Study area travel zones

Table 24 Travel zones population and employment increases

Travel Zone	Population Increase	Employment Increase
A	6%	8%
B	5%	13%
C	0%	5%
E	46%	10%
F	9%	12%

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	101	102	103	104	105
1	-	7%	-	6%	7%	7%	-	9%	9%	9%	9%	-	-	10%	-	7%	7%	7%	7%	7%
2	7%	-	7%	6%	7%	7%	7%	9%	9%	9%	9%	9%	9%	10%	10%	7%	7%	7%	7%	7%
3	-	7%	-	6%	7%	7%	-	9%	9%	9%	9%	-	-	10%	-	7%	7%	7%	7%	7%
4	4%	4%	4%	-	4%	4%	4%	6%	6%	6%	6%	6%	6%	7%	7%	4%	4%	4%	4%	4%
5	16%	16%	16%	14%	-	15%	15%	18%	18%	18%	18%	18%	18%	18%	18%	16%	16%	16%	16%	16%
6	16%	16%	16%	14%	15%	-	15%	18%	18%	18%	18%	18%	18%	18%	18%	16%	16%	16%	16%	16%
7	-	18%	-	16%	18%	18%	-	20%	20%	20%	20%	-	-	20%	-	18%	18%	18%	18%	18%
8	9%	9%	9%	7%	8%	8%	8%	-	11%	11%	11%	11%	11%	11%	11%	9%	9%	9%	9%	9%
9	9%	9%	9%	7%	8%	8%	8%	11%	-	11%	11%	11%	11%	11%	11%	9%	9%	9%	9%	9%
10	9%	9%	9%	7%	8%	8%	8%	11%	11%	-	11%	11%	11%	11%	11%	9%	9%	9%	9%	9%
11	9%	9%	9%	7%	8%	8%	8%	11%	11%	11%	-	11%	11%	11%	11%	9%	9%	9%	9%	9%
12	-	9%	-	7%	8%	8%	-	11%	11%	11%	11%	-	-	11%	-	9%	9%	9%	9%	9%
13	-	8%	-	6%	7%	7%	-	10%	10%	10%	10%	-	-	10%	-	8%	8%	8%	8%	8%
14	7%	7%	7%	5%	6%	6%	6%	9%	9%	9%	9%	9%	9%	-	9%	7%	7%	7%	7%	7%
15	-	7%	-	5%	6%	6%	-	9%	9%	9%	9%	-	-	9%	-	7%	7%	7%	7%	7%
101	7%	7%	7%	6%	7%	7%	7%	9%	9%	9%	9%	9%	9%	10%	10%	-	7%	7%	7%	7%
102	7%	7%	7%	6%	7%	7%	7%	9%	9%	9%	9%	9%	9%	10%	10%	7%	-	7%	7%	7%
103	7%	7%	7%	6%	7%	7%	7%	9%	9%	9%	9%	9%	9%	10%	10%	7%	7%	-	7%	7%
104	7%	7%	7%	6%	7%	7%	7%	9%	9%	9%	9%	9%	9%	10%	10%	7%	7%	7%	-	7%
105	7%	7%	7%	6%	7%	18%	18%	9%	9%	9%	9%	9%	9%	10%	10%	7%	7%	7%	7%	-

Figure 38 AM peak growth factor matrix

8 Future Network Changes

8.1 Wider network changes

There are three intersection in the network that being upgraded in the immediate future; Bunnerong Road and Heffron Road, Heffron Road and Banks Avenue, Wentworth Avenue and Page Street . The changes are detailed below in Figure 39, Figure 40 and Figure 41.

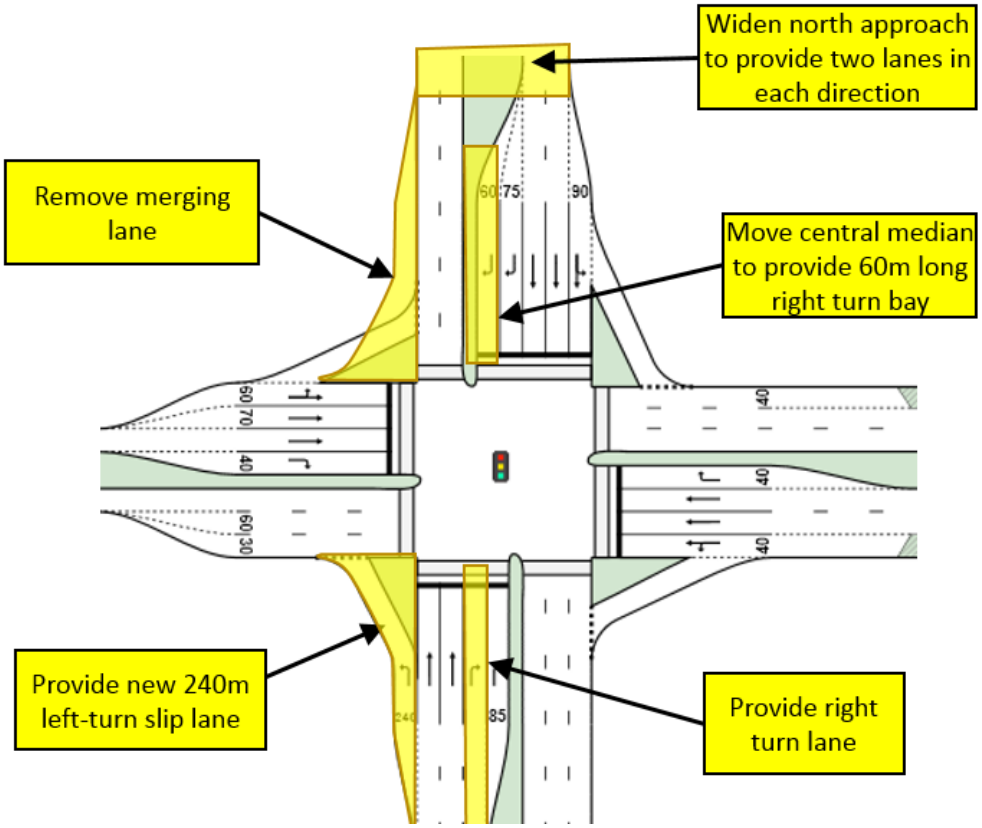

Figure 39 Bunnerong Road / Heffron Road changes, *source: Arup, 130-150 Bunnerong Road, Pagewood Section 34 Conference Report*

There has also been further signal optimisation of all the remaining signalised intersections with the exception of Bunnerong Road / Wentworth Avenue to cater for the increased demand to and from Eastgardens Shopping Centre.

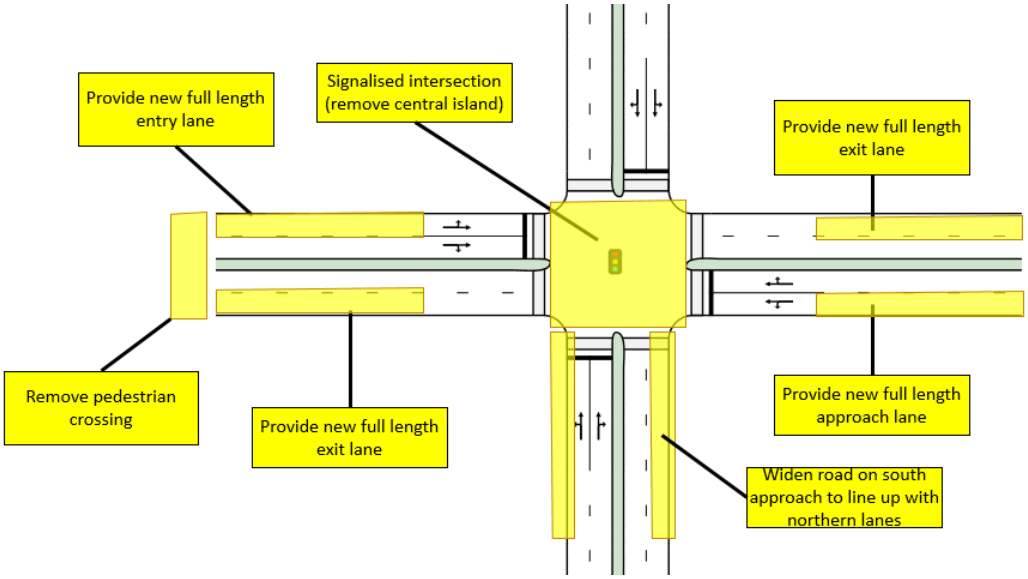

Figure 40 Heffron Road / Banks Avenue changes, *source: Arup, 130-150 Bunnerong Road, Pagewood Section 34 Conference Report*

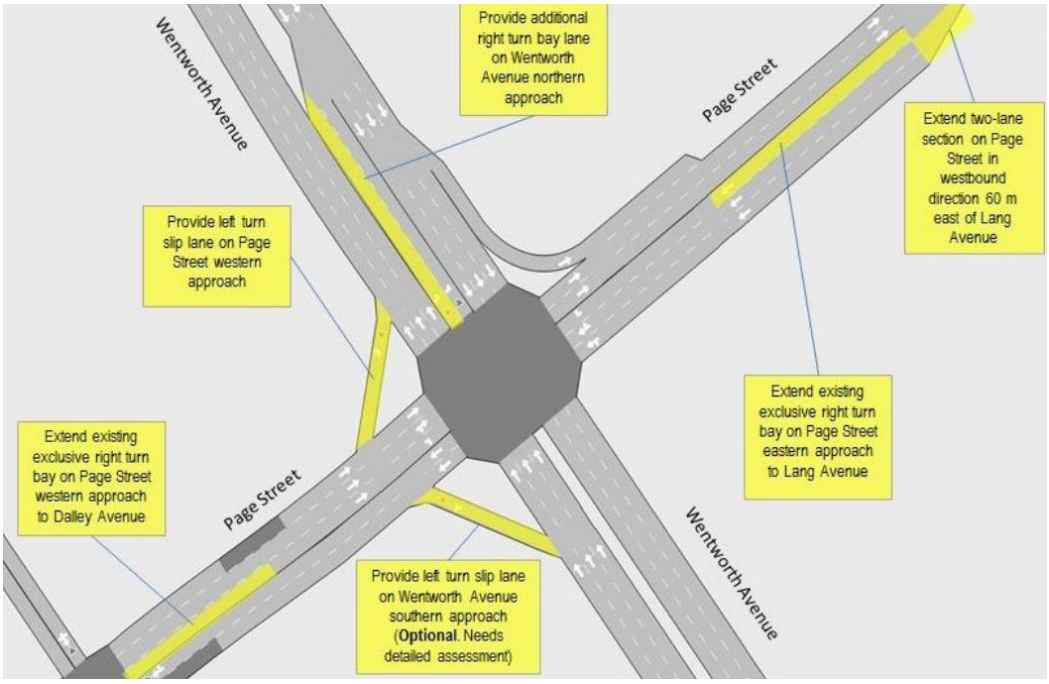

Figure 41 Wentworth Avenue and Page Street *source: SMEC*

Additional changes required as a result of background traffic included the expansion of Wentworth Avenue eastbound (with the removal of unused parking) to three lanes between Page Street and Banks Avenue allowed for the required additional capacity needed to reduce effective green time to the mainline movements.

8.2 Development network changes

8.2.1 Original masterplan

As per the original masterplan outlined in, *130-150 Bunnerong Road, Pagewood Section 35 Conference Report* the following network in the development site was coded as the future base model, see Figure 42.

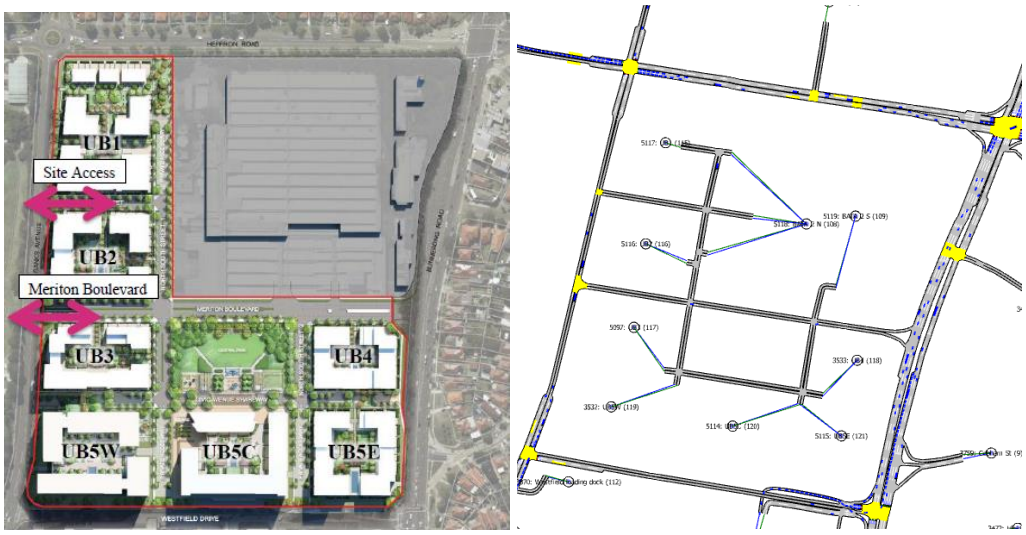

Figure 42 Original Pagewood masterplan

8.2.2 Future network testing

The revised masterplan included an additional access point on Banks Avenue as well as two new additional access points on Heffron Road, see Figure 43. In addition to the revision of the development site a right hand turn into Meriton Boulevard off Bunnerong Road was also tested. Meriton Boulevard remained a left turn out only as a Staged Pedestrian crossing was implemented on the southern side of the intersection with a simple two phase phasing arrangement being used, see Figure 44.

Figure 43 Future proposed masterplan

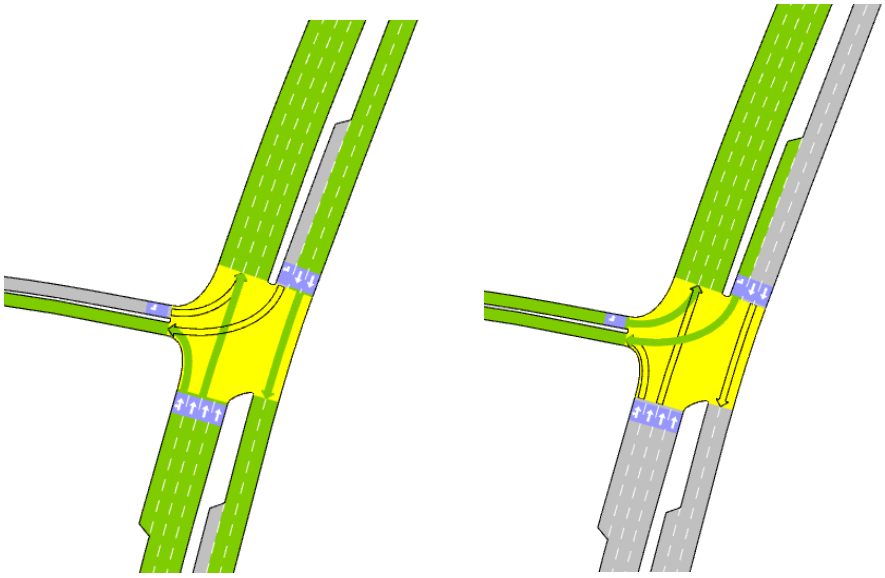

Figure 44 Phasing at new Bunnerong Meriton intersection

The new Bunnerong Road / Meriton Boulevard intersection included an additional right turn only lane southbound of 40m. As traffic out of Meriton Boulevard is now stopped by signals the left turn only lane on the south and acceleration lane on the north have been converted into an additional through lane.

9 Results

In-total 21 models were run, three base models, six future year base case models and 12 development models. Table 25 below details each model scenario that was run for an AM, PM and Weekend peak period. For each scenario the intersection Level of Service (LoS), Travel time analysis and network performance will be explored.

Table 25 Model Scenarios

Model	Abbreviation	Design Year	Description
Base Model	Base	2016	Calibrated base model exploring existing conditions.
Future Base	FB	2021, 2031	Future base model that includes all likely and currently approved developments. This includes the original Meriton Properties Pagewood proposal. This model forms the benchmark for all future year models.
Proposed Development	PD	2021, 2031	Future options model that includes the changes to the previously proposed Meriton Properties development.
PP with Right Turn from Bunnerong	PDRT	2021, 2031	A modification on the proposed development model to include a right turn in only from Bunnerong Road into Meriton Boulevard.

9.1 Intersection Level of Service (LoS)

9.2 Year 2021

Table 26 AM peak LoS results

Summary by intersection

	AM							
	Base		FB		PD		PDRT	
	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS
Heffron/Maroubra/Bunnerong	40	C	42	C	43	D	42	C
Bunnerong/Meriton	1	A	2	A	9	A	2	A
Bunnerong/Westfield	8	A	14	A	11	A	12	A
Bunnerong/Wentworth	20	B	22	B	23	B	23	B
Wentworth/Dennison	20	B	25	B	28	B	26	B
Wentworth/Banks/Corish	22	B	25	B	26	B	27	B
Banks/Westfield entrance	5	A	4	A	4	A	4	A
Banks/Westfield	6	A	6	A	6	A	6	A
Banks/Meriton	1	A	2	A	1	A	1	A
Banks/Heffron	14	A	25	B	28	B	26	B
Wentworth/Page	65	E	60	E	70	E	73	F
Banks/access 1			1	A	1	A	1	A
Heffron/Access west					0	A	1	A
Heffron/Access east					2	A	1	A

In the AM peak, all intersections within the study network are capable to absorbing the increase in demand, with the only exception being Wentworth Road

and Page Street which deteriorates to Level of Service F with the Meriton Boulevard right turn added. This is expected as this intersection forms the gateway to the motorway network via Southern Cross Drive and experiences high volumes already.

Table 27 PM peak LoS results

Summary by intersection

	PM							
	Base		FB		PD		PDRT	
	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS
Heffron/Maroubra/Bunnerong	43	D	47	D	41	C	42	C
Bunnerong/Meriton	1	A	11	A	10	A	2	A
Bunnerong/Westfield	12	A	32	C	15	B	18	B
Bunnerong/Wentworth	18	B	24	B	23	B	23	B
Wentworth/Dennison	20	B	34	C	37	C	37	C
Wentworth/Banks/Corish	33	C	94	F	70	E	70	E
Banks/Westfield entrance	6	A	13	A	13	A	19	B
Banks/Westfield	6	A	9	A	7	A	5	A
Banks/Meriton	1	A	2	A	2	A	2	A
Banks/Heffron	16	B	58	E	34	C	36	C
Wentworth/Page	40	C	60	E	61	E	55	D
Banks/access 1			2	A	1	A	1	A
Heffron/Access west					1	A	1	A
Heffron/Access east					1	A	1.2	A

The weakness in the network for the PM peak period occurs around Wentworth / Banks / Corish, with the intersection deteriorating to Level of Service E and F across the future scenarios. This intersection is the main access point to Westfield Shopping Centre as well as the primary access point to the site from the south. This performs worse in the future base because the combination of the Westfield and onsite retail results in a more pronounced peak. In the future development of the Meriton site, when retail is largely removed, this effect diminishes. A similar effect can be seen at the Banks/ Heffron intersection which is the primary northern access point. Wentworth / Page intersection also experiences some deterioration in the PM peak but this is less pronounced than the effect in the AM peak.

Table 28 Weekend peak LoS results

Summary by intersection

	WE							
	Base		FB		PD		PDRT	
	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS
Heffron/Maroubra/Bunnerong	51	D	53	D	47	D	55	D
Bunnerong/Meriton	1	A	2	A	15	B	2	A
Bunnerong/Westfield	13	A	24	B	23	B	24	B
Bunnerong/Wentworth	26	B	30	C	32	C	32	C
Wentworth/Dennison	20	B	38	C	44	D	39	C
Wentworth/Banks/Corish	38	C	94	F	75	F	85	F
Banks/Westfield entrance	9	A	18	B	16	B	14	A
Banks/Westfield	6	A	8	A	9	A	7	A
Banks/Meriton	1	A	3	A	3	A	2	A
Banks/Heffron	16	B	72	F	50	D	103	F
Wentworth/Page	40	C	50	D	52	D	58	E
Banks/access 1			2	A	1	A	1	A
Heffron/Access west					1	A	1	A
Heffron/Access east					2.2	A	3.4	A

The weekend scenarios display a similar pattern of delay as the PM but with increased delays due to increased retail demand. Similar intersections deteriorate as in the PM peak. Intersections around the Westfield all experience increasing delays in the future scenarios.

Wentworth/Banks/Corish is unable to cope with the increased weekend demand and fails in all future scenarios (as opposed to only the future base in the PM peak). The result of this is a flow on affect to Dennison / Wentworth intersection which also deteriorates.

Worthy of note is Heffron/ Banks intersection where some evidence of "rat-running" is observed where people take unintended routes through the site to avoid signals on the main road network.

In the AM and PM peaks all the intersections along Bunnerong Road remain largely unaffected. However in the Weekend peak these intersections come under increased pressure. The right turn onto Meriton Boulevard does helps alleviate this pressure but causes issues elsewhere.

9.3 Year 2031

The 2031 LoS results further emphasise the Year 2021 results in that the intersections around Eastgardens shopping centre are unable to cope with the increased shopping centre demands. The Year 2031 models were becoming unstable under the future base models and were prone to lockups as such it was difficult to deduce meaningful results from the 2031 models.

9.4 Travel time analysis

Travel time routes were assessed in the 2021 models, Figure 45 below details the location of each route. These travel time routes through the network capture the effect that the development will have on trough trips through the site. Leading to an understanding as to how the development will affect the surrounding network.

Figure 45 Travel time routes

Table 29 AM peak travel time routes

AM	Route 1		Route 2	
	Westbound	Eastbound	Westbound	Eastbound
Base	165	179	210	239
FB	167	188	203	234
PD	172	243	196	243
PDRT	171	237	208	270

Table 30 PM peak travel time routes

PM	Route 1		Route 2	
	Westbound	Eastbound	Westbound	Eastbound
Base	167	181	217	209
FB	161	284	403	403
PD	161	234	261	308
PDRT	155	265	275	343

Table 31 Weekend peak travel time routes

WE	Route 1		Route 2	
	Westbound	Eastbound	Westbound	Eastbound
Base	174	179	257	221
FB	231	209	394	258
PD	271	219	370	283
PDRT	375	222	387	281

Table 29 details the AM peak travel time results where the westbound routes remain largely unaffected. The Eastbound routes (peak direction) increase in delay as the increased developments come online. The right turn onto Meriton Boulevard providing some relief however from the LoS analysis this causes issues elsewhere on the network.

Table 30 shows the PM peak travel time routes. The future base scenario has a doubling of travel time along Wentworth Avenue (Route 2) which is due to delays at Banks / Wentworh / Corish intersection. This improves in the future development scenarios when retail traffic is reduced.

The weekend peak shown in Table 31 shows some rather large increases in travel time for the westbound traffic on route 1. This confirms the previous conclusion that all the development traffic is being pushed onto Heffron Road by the Eastgardens shopping traffic with this being further exaggerated during the introduction of the right hand turn. As Banks Avenue demands more time from the signals there is also an increase in delay on westbound route 2.

10 Summary

In order to assess the impacts of proposed developments, and works identified as part of the study, a micro-simulation model has been developed using software package Aimsun. The model has been calibrated and validated carried out using criteria defined by RMS' Traffic Modelling Guidelines. The key results of the models' calibration and validation against RMS criteria are as follows.

- Intersection turning movements satisfied GEH criteria for each of the three peak periods assessed with 85% of GEH below 5 and 100% below 10.
- The R^2 was greater than 0.9 for each peak period, when plotting modelled and observed traffic flows.
- The travel time routs were generally within approximately 15% or 1 minute with only one route in each peak period being slightly quicker than observed.
- Observations made onsite at areas of congestion were generally comparable to behaviours observed within the model

The input data, model development, calibration and validation is considered to have produced a model that is considered 'fit for purpose' for the type of study being undertaken.

Through the operational modelling process it was found that the development yields have little impact on the network with some increases in delays at intersection. In the weekend peak however development traffic has trouble accessing the wider network due to the intensification of retail traffic around Eastgardens with the associated congestion.

It was also found that as the road network is expanded and additional connections are added to the wider network delays increase. This is impart due to the intensification of traffic around Eastgardens from the growth in the retail catchment. This new traffic is using the expanded network for alternative routes increasing turning movements and the associated merging and weaving behaviour reducing road capacity.

In summary the network operates satisfactorily with the expanded development however it is advisable that the road layout is refined as to minimise new connections onto Banks Avenue and Heffron Road. It is also advisable to assess possible changes to the network to account for the increased demand to Eastgardens shopping centre as it is retail traffic that has the largest effect on the network. It is not advisable to include a right turn into Meriton Boulevard even though minimal additional delay is experienced along Bunnerong Road the right turn introduces an alternative route to Eastgardens. Increasing delays along Banks Avenue and Wentworth Avenue as a result.

Appendix A Turning Movement Summary

Note that all volumes given are for the two-hour peak periods identified in Section 1.6.

Table 32 AM turn count calibration results

Intersection	Turning movement	Observed volume (all veh types)	Modelled volume (all veh types)	GEH
Heffron//Bunnerong	1_NE_NW	268	280	0.5
Heffron//Bunnerong	1_NE_S	472	485	0.4
Heffron//Bunnerong	1_NE_SE	24	3	4.0
Heffron//Bunnerong	1_NE_SW	722	672	1.3
Heffron//Bunnerong	1_NW_NE	249	223	1.2
Heffron//Bunnerong	1_NW_S	983	975	0.2
Heffron//Bunnerong	1_NW_SW	362	413	1.8
Heffron//Bunnerong	1_S_NE	329	428	3.6
Heffron//Bunnerong	1_S_NW	1333	1380	0.9
Heffron//Bunnerong	1_S_SW	104	125	1.4
Heffron//Bunnerong	1_SE_S	21	62	4.5
Heffron//Bunnerong	1_SW_NE	803	945	3.4
Heffron//Bunnerong	1_SW_NW	657	666	0.2
Heffron//Bunnerong	1_SW_S	79	69	0.8
Heffron/Site access	10_E_W	1281	1239	0.8
Heffron/Site access	10_W_E	1601	1651	0.9
Heffron/Banks	11_E_in	1295	1242	1.1
Heffron/Banks	11_E_out	1606	1651	0.8
Heffron/Banks	11_E_thr	454	417	1.3
Heffron/Banks	11_N_in	530	542	0.4
Heffron/Banks	11_N_out	794	820	0.6
Heffron/Banks	11_N_thr	1530	1527	0.1
Heffron/Banks	11_S_in	332	421	3.2
Heffron/Banks	11_S_out	402	343	2.2
Heffron/Banks	11_S_thr	1347	1316	0.6
Heffron/Banks	11_W_in	1851	1877	0.4
Heffron/Banks	11_W_out	1206	1267	1.2
Heffron/Banks	11_W_thr	473	471	0.1
Wentworth/Page	12_E_S	136	210	4.0
Wentworth/Page	12_E_W	2247	2210	0.6
Wentworth/Page	12_N_E	44	36	0.9

Intersection	Turning movement	Observed volume (all veh types)	Modelled volume (all veh types)	GEH
Wentworth/Page	12_N_S	375	267	4.3
Wentworth/Page	12_N_W	740	970	5.6
Wentworth/Page	12_S_E	344	322	0.9
Wentworth/Page	12_S_N	782	835	1.3
Wentworth/Page	12_S_W	367	395	1.0
Wentworth/Page	12_W_E	2487	2497	0.1
Wentworth/Page	12_W_N	974	944	0.7
Wentworth/Page	12_W_S	484	467	0.6
Bunnerong/Westfield	3_E_S	20	12	1.4
Bunnerong/Westfield	3_N_S	1054	980	1.6
Bunnerong/Westfield	3_N_W	519	603	2.5
Bunnerong/Westfield	3_S_N	1672	1740	1.2
Bunnerong/Westfield	3_S_W	394	367	1.0
Bunnerong/Westfield	3_W_N	113	152	2.4
Bunnerong/Westfield	3_W_S	67	114	3.5
Bunnerong/Wentworth	4_N_S	619	584	1.0
Bunnerong/Wentworth	4_N_W	556	495	1.9
Bunnerong/Wentworth	4_S_N	1370	1309	1.2
Bunnerong/Wentworth	4_S_W	1114	1068	1.0
Bunnerong/Wentworth	4_W_N	664	814	3.9
Bunnerong/Wentworth	4_W_S	923	952	0.7
Bunnerong/Denison	5_E_S	149	198	2.6
Bunnerong/Denison	5_E_W	1502	1363	2.6
Bunnerong/Denison	5_N_E	93	89	0.3
Bunnerong/Denison	5_N_S	66	79	1.1
Bunnerong/Denison	5_N_W	58	42	1.6
Bunnerong/Denison	5_S_E	257	313	2.3
Bunnerong/Denison	5_S_W	1279	1207	1.4
Bunnerong/Denison	5_W_E	1148	1278	2.6
Bunnerong/Denison	5_W_S	825	788	0.9
Wentworth/Corish	6_E_N	462	361	3.5
Wentworth/Corish	6_E_S	15	35	2.8
Wentworth/Corish	6_E_W	2222	2222	0.0
Wentworth/Corish	6_N_E	143	123	1.2
Wentworth/Corish	6_N_W	252	226	1.2
Wentworth/Corish	6_S_W	80	73	0.6

Intersection	Turning movement	Observed volume (all veh types)	Modelled volume (all veh types)	GEH
Wentworth/Corish	6_W_E	2132	2128	0.1
Wentworth/Corish	6_W_N	417	627	6.5
Banks/Westfield entrance	7_E_in	230	171	2.9
Banks/Westfield entrance	7_E_out	1136	1036	2.1
Banks/Westfield entrance	7_E_thr	233	217	0.8
Banks/Westfield entrance	7_N_in	710	628	2.2
Banks/Westfield entrance	7_N_out	348	401	1.9
Banks/Westfield entrance	7_N_thr	659	625	0.9
Banks/Westfield entrance	7_S_in	918	990	1.6
Banks/Westfield entrance	7_S_out	374	353	0.8
Banks/Westfield entrance	7_S_thr	89	35	4.8
Banks/Westfield Dr	8_E_N	22	58	4.0
Banks/Westfield Dr	8_E_S	284	257	1.2
Banks/Westfield Dr	8_N_E	3	2	0.4
Banks/Westfield Dr	8_N_S	406	341	2.4
Banks/Westfield Dr	8_S_E	17	33	2.3
Banks/Westfield Dr	8_S_N	309	365	2.2
Banks/Site access	9_E_N	1	3	1.0
Banks/Site access	9_E_S	2	0	1.4
Banks/Site access	9_N_E	2	0	1.4
Banks/Site access	9_N_S	410	342	2.5
Banks/Site access	9_S_E	3	5	0.7
Banks/Site access	9_S_N	329	417	3.2

Table 33 PM turn count calibration results

Intersection	Turning movement	Observed volume (all veh types)	Modelled volume (all veh types)	GEH
Heffron//Bunnerong	1_NE_NW	165	175	0.5
Heffron//Bunnerong	1_NE_S	602	677	2.1
Heffron//Bunnerong	1_NE_SE	31	7	3.9
Heffron//Bunnerong	1_NE_SW	759	636	3.3
Heffron//Bunnerong	1_NW_NE	500	536	1.1
Heffron//Bunnerong	1_NW_S	1634	1462	3.1
Heffron//Bunnerong	1_NW_SW	407	396	0.4
Heffron//Bunnerong	1_S_NE	599	415	5.8
Heffron//Bunnerong	1_S_NW	1209	1148	1.3
Heffron//Bunnerong	1_S_SW	181	188	0.4
Heffron//Bunnerong	1_SE_S	25	2	4.4
Heffron//Bunnerong	1_SW_NE	997	1281	6.0
Heffron//Bunnerong	1_SW_NW	522	406	3.8
Heffron//Bunnerong	1_SW_S	147	153	0.3
Heffron/Site access	10_E_W	1337	1255	1.6
Heffron/Site access	10_W_E	1744	1780	0.6
Heffron/Banks	11_E_in	1343	1255	1.7
Heffron/Banks	11_E_out	1729	1779	0.8
Heffron/Banks	11_E_thr	657	568	2.5
Heffron/Banks	11_N_in	798	805	0.2
Heffron/Banks	11_N_out	682	791	2.8
Heffron/Banks	11_N_thr	1588	1542	0.8
Heffron/Banks	11_S_in	483	576	2.9
Heffron/Banks	11_S_out	553	569	0.5
Heffron/Banks	11_S_thr	1447	1253	3.7
Heffron/Banks	11_W_in	1730	1844	1.9
Heffron/Banks	11_W_out	1390	1339	1.0
Heffron/Banks	11_W_thr	540	490	1.6
Wentworth/Page	12_E_S	321	375	2.0
Wentworth/Page	12_E_W	2429	2359	1.0
Wentworth/Page	12_N_E	37	52	1.6
Wentworth/Page	12_N_S	472	380	3.2
Wentworth/Page	12_N_W	696	730	0.9
Wentworth/Page	12_S_E	399	253	5.7
Wentworth/Page	12_S_N	611	856	6.4

Intersection	Turning movement	Observed volume (all veh types)	Modelled volume (all veh types)	GEH
Wentworth/Page	12_S_W	409	374	1.3
Wentworth/Page	12_W_E	2663	2758	1.3
Wentworth/Page	12_W_N	1079	1063	0.3
Wentworth/Page	12_W_S	402	320	3.1
Bunnerong/Westfield	3_E_S	12	5	1.7
Bunnerong/Westfield	3_N_S	1474	1289	3.5
Bunnerong/Westfield	3_N_W	932	903	0.7
Bunnerong/Westfield	3_S_N	1490	1308	3.4
Bunnerong/Westfield	3_S_W	585	805	5.9
Bunnerong/Westfield	3_W_N	552	431	3.9
Bunnerong/Westfield	3_W_S	398	411	0.5
Bunnerong/Wentworth	4_N_S	1243	1172	1.4
Bunnerong/Wentworth	4_N_W	596	485	3.4
Bunnerong/Wentworth	4_S_N	1299	1129	3.5
Bunnerong/Wentworth	4_S_W	904	811	2.2
Bunnerong/Wentworth	4_W_N	783	1008	5.3
Bunnerong/Wentworth	4_W_S	1585	1329	4.7
Bunnerong/Denison	5_E_S	140	109	2.0
Bunnerong/Denison	5_E_W	1341	1190	3.0
Bunnerong/Denison	5_N_E	310	298	0.5
Bunnerong/Denison	5_N_S	213	220	0.3
Bunnerong/Denison	5_N_W	265	174	4.3
Bunnerong/Denison	5_S_E	152	139	0.8
Bunnerong/Denison	5_S_W	1062	957	2.3
Bunnerong/Denison	5_W_E	1518	1564	0.8
Bunnerong/Denison	5_W_S	943	930	0.3
Wentworth/Corish	6_E_N	531	388	4.7
Wentworth/Corish	6_E_S	6	12	1.4
Wentworth/Corish	6_E_W	2053	1927	2.0
Wentworth/Corish	6_N_E	319	364	1.7
Wentworth/Corish	6_N_W	722	689	0.9
Wentworth/Corish	6_S_W	86	56	2.5
Wentworth/Corish	6_W_E	2683	2457	3.2
Wentworth/Corish	6_W_N	574	623	1.4
Banks/Westfield entrance	7_E_in	1015	1031	0.4

Intersection	Turning movement	Observed volume (all veh types)	Modelled volume (all veh types)	GEH
Banks/Westfield entrance	7_E_out	1542	1280	4.9
Banks/Westfield entrance	7_E_thr	291	391	3.8
Banks/Westfield entrance	7_N_in	930	894	0.8
Banks/Westfield entrance	7_N_out	511	582	2.1
Banks/Westfield entrance	7_N_thr	903	777	3.1
Banks/Westfield entrance	7_S_in	1106	1006	2.2
Banks/Westfield entrance	7_S_out	998	1068	1.5
Banks/Westfield entrance	7_S_thr	308	354	1.8
Banks/Westfield Dr	8_E_N	25	40	1.9
Banks/Westfield Dr	8_E_S	377	336	1.5
Banks/Westfield Dr	8_N_E	7	27	3.4
Banks/Westfield Dr	8_N_S	532	539	0.2
Banks/Westfield Dr	8_S_E	39	42	0.3
Banks/Westfield Dr	8_S_N	453	540	2.8
Banks/Site access	9_E_N	0	4	2.0
Banks/Site access	9_E_S	0	0	0.0
Banks/Site access	9_N_E	0	0	0.0
Banks/Site access	9_N_S	548	566	0.5
Banks/Site access	9_S_E	1	3	1.0
Banks/Site access	9_S_N	482	570	2.7

Table 34 Weekend turn count calibration results

Intersection	Turning movement	Observed volume (all veh types)	Modelled volume (all veh types)	GEH
Heffron//Bunnerong	1_NE_NW	320	385	2.4
Heffron//Bunnerong	1_NE_S	845	1049	4.7
Heffron//Bunnerong	1_NE_SE	35	38	0.4
Heffron//Bunnerong	1_NE_SW	794	664	3.4
Heffron//Bunnerong	1_NW_NE	443	441	0.1
Heffron//Bunnerong	1_NW_S	1594	1552	0.7
Heffron//Bunnerong	1_NW_SW	369	396	1.0
Heffron//Bunnerong	1_S_NE	651	779	3.4
Heffron//Bunnerong	1_S_NW	1538	1475	1.1
Heffron//Bunnerong	1_S_SW	259	211	2.2
Heffron//Bunnerong	1_SE_S	106	99	0.5
Heffron//Bunnerong	1_SW_NE	847	816	0.8
Heffron//Bunnerong	1_SW_NW	461	523	2.0
Heffron//Bunnerong	1_SW_S	174	132	2.4
Heffron/Site access	10_E_W	1358	1275	1.6
Heffron/Site access	10_W_E	1479	1445	0.6
Heffron/Banks	11_E_in	1347	1267	1.6
Heffron/Banks	11_E_out	1451	1446	0.1
Heffron/Banks	11_E_thr	575	671	2.7
Heffron/Banks	11_N_in	738	831	2.3
Heffron/Banks	11_N_out	791	790	0.0
Heffron/Banks	11_N_thr	1288	1287	0.0
Heffron/Banks	11_S_in	564	617	1.5
Heffron/Banks	11_S_out	582	592	0.3
Heffron/Banks	11_S_thr	1340	1345	0.1
Heffron/Banks	11_W_in	1439	1393	0.9
Heffron/Banks	11_W_out	1264	1277	0.3
Heffron/Banks	11_W_thr	640	685	1.2
Wentworth/Page	12_E_S	300	304	0.2
Wentworth/Page	12_E_W	2014	2326	4.7
Wentworth/Page	12_N_E	53	44	0.9
Wentworth/Page	12_N_S	440	512	2.3
Wentworth/Page	12_N_W	716	692	0.6
Wentworth/Page	12_S_E	457	525	2.2
Wentworth/Page	12_S_N	551	557	0.2

Intersection	Turning movement	Observed volume (all veh types)	Modelled volume (all veh types)	GEH
Wentworth/Page	12_S_W	239	247	0.4
Wentworth/Page	12_W_E	2526	2520	0.1
Wentworth/Page	12_W_N	852	843	0.2
Wentworth/Page	12_W_S	246	206	1.9
Bunnerong/Westfield	3_E_S	27	13	2.2
Bunnerong/Westfield	3_N_S	1521	1723	3.5
Bunnerong/Westfield	3_N_W	1189	1042	3.1
Bunnerong/Westfield	3_S_N	1741	1756	0.3
Bunnerong/Westfield	3_S_W	718	821	2.6
Bunnerong/Westfield	3_W_N	790	706	2.2
Bunnerong/Westfield	3_W_S	452	486	1.1
Bunnerong/Wentworth	4_N_S	1359	1394	0.7
Bunnerong/Wentworth	4_N_W	665	799	3.5
Bunnerong/Wentworth	4_S_N	1489	1556	1.2
Bunnerong/Wentworth	4_S_W	890	847	1.0
Bunnerong/Wentworth	4_W_N	961	1047	1.9
Bunnerong/Wentworth	4_W_S	1525	1429	1.8
Bunnerong/Denison	5_E_S	151	232	4.1
Bunnerong/Denison	5_E_W	1390	1424	0.6
Bunnerong/Denison	5_N_E	308	241	2.9
Bunnerong/Denison	5_N_S	187	178	0.5
Bunnerong/Denison	5_N_W	252	280	1.2
Bunnerong/Denison	5_S_E	190	165	1.3
Bunnerong/Denison	5_S_W	847	817	0.7
Bunnerong/Denison	5_W_E	1460	1668	3.7
Bunnerong/Denison	5_W_S	760	777	0.4
Wentworth/Corish	6_E_N	566	515	1.6
Wentworth/Corish	6_E_S	18	12	1.1
Wentworth/Corish	6_E_W	1881	2000	1.9
Wentworth/Corish	6_N_E	340	366	1.0
Wentworth/Corish	6_N_W	652	604	1.4
Wentworth/Corish	6_S_W	63	68	0.4
Wentworth/Corish	6_W_E	2432	2487	0.8
Wentworth/Corish	6_W_N	598	689	2.5
Banks/Westfield entrance	7_E_in	1063	961	2.3

Intersection	Turning movement	Observed volume (all veh types)	Modelled volume (all veh types)	GEH
Banks/Westfield entrance	7_E_out	1674	1489	3.3
Banks/Westfield entrance	7_E_thr	299	422	4.6
Banks/Westfield entrance	7_N_in	981	879	2.4
Banks/Westfield entrance	7_N_out	586	588	0.1
Banks/Westfield entrance	7_N_thr	992	1031	0.9
Banks/Westfield entrance	7_S_in	1198	1203	0.1
Banks/Westfield entrance	7_S_out	982	967	0.3
Banks/Westfield entrance	7_S_thr	380	416	1.3
Banks/Westfield Dr	8_E_N	35	52	1.8
Banks/Westfield Dr	8_E_S	386	309	2.9
Banks/Westfield Dr	8_N_E	7	30	3.8
Banks/Westfield Dr	8_N_S	588	563	0.7
Banks/Westfield Dr	8_S_E	49	30	2.1
Banks/Westfield Dr	8_S_N	536	558	0.7
Banks/Site access	9_E_N	3	2	0.4
Banks/Site access	9_E_S	14	0	3.7
Banks/Site access	9_N_E	0	0	0.0
Banks/Site access	9_N_S	583	592	0.3
Banks/Site access	9_S_E	3	0	1.7
Banks/Site access	9_S_N	564	613	1.4