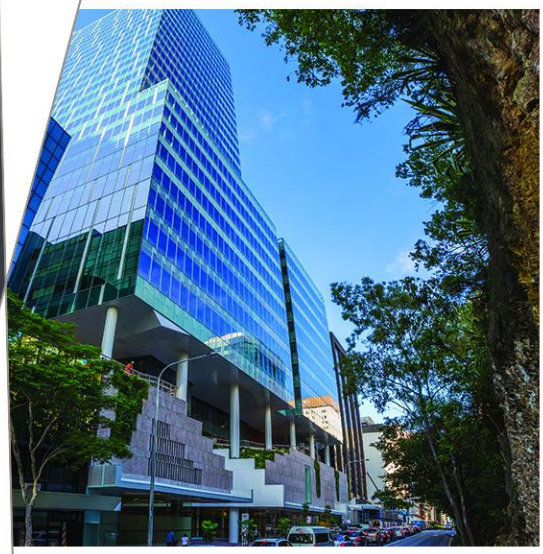
Future Year Modelling Report

St Leonards and Crows Nest Station Precinct Traffic and Transport Study

80018096



Prepared for

Department of Planning, Industry and Environment

13 July 2020

Cardno

Contact Information

Cardno (NSW/ACT) Pty Ltd
ABN 95 001 145 035

Level 9 - The Forum
203 Pacific Highway
St Leonards NSW 2065
Australia

www.cardno.com
Phone +61 2 9496 7700
Fax +61 2 9439 5170

Document Information

Prepared for	Department of Planning, Industry and Environment
Project Name	St Leonards and Crows Nest Station Precinct Traffic and Transport Study
File Reference	80018096-001 St Leonards Future Year Report FINAL.docx
Job Reference	80018096
Date	13 July 2020
Version Number	2

Document History

Version	Effective Date	Description of Revision	Prepared by	Reviewed by
1	08/07/2020	Draft	Jackie Liang	Chris Slenders Ivo Pais
2	13/07/2020	Final	Jackie Liang	Chris Slenders Ivo Pais

Table of Contents

Tables

Figures

1 Introduction

1.1 Background

St Leonards and Crows Nest are neighbouring suburbs approximately five kilometres north of Sydney CBD. The precinct is a major hub on the Sydney's north shore with a mix of low, medium and high density residential dwellings, commercial centres, high density office space, educational and recreational spaces, and health services.

The precinct is well-connected to the rest of Sydney by roads including the Pacific Highway and Warringah Freeway. Public transport services include the T1 North Shore and T9 Northern Line train services and local buses to Sydney, Chatswood and the Northern Beaches among other destinations. Sydney Metro City and Southwest project, due for completion in 2024, includes a new metro station at Crows Nest that will provide direct connections to and from major destinations including the CBD, Hill District and Bankstown.

The Department of Planning Industry and Environment (DPIE) [1] has been working in consultation with local councils including North Sydney, Lane Cove and Willoughby, Transport for New South Wales and NSW Health Infrastructure to finalise the St Leonards and Crows Nest 2036 Plan. The Plan outlines new jobs, open space, infrastructure and homes for St Leonards and Crows Nest. The future performance of the precinct is contingent on the level of planned development, maximisation of active and public transport and the implementation of constrained parking provision and policies for future development.

Cardno was engaged by DPIE to develop a detailed traffic and transport analysis to assist in the planning investigations for the St Leonards and Crows Nest Station Precinct. The scope of works for this project includes the development of a purpose-built microsimulation traffic model using the Aimsun software package. The model was used to identify existing traffic issues and propose ways of managing future traffic demands in the area, while considering Movement and Place principles and interventions outlined in the draft St Leonards and Crows Nest 2036 Plan (draft 2036 Plan). Cardno has developed, calibrated and validated a Base Model for the project which was submitted to DPIE and Transport for NSW along with a report documenting the development procedure[2]. This model replicates the existing (2016) traffic conditions and provides a basis for the assessment of future year scenarios discussed in this report. **Figure 1-1** shows the extent of the precinct area for the traffic study.

The future year scenarios developed by Cardno will assist DPIE in understanding the impact of proposed interventions on the traffic network performance. This understanding will inform decisions about the future traffic network capacity and additional infrastructure required to support these interventions.

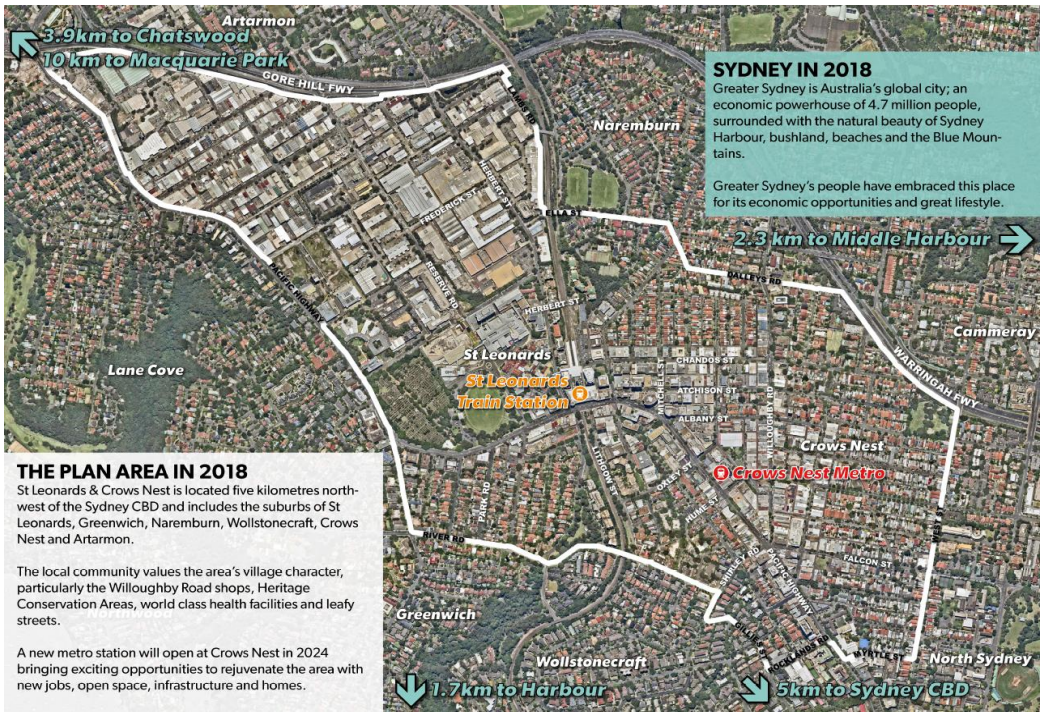


Figure 1-1 St Leonards and Crows Nest Planning Study Area

[1] The New South Wales Department of Planning and Environment (DP&E) until 2019.
[2] *Base Model Development Report* (Cardno, 18 May 2020).

1.2 Report Outline

The structure of this report is:

- **Section 1 – Introduction:** outlines the background, project objective, scope of works and study area
- **Section 2** – **Future demand development:** outlines the methodology and policies regarding the development of the demand used in the future modelling
- **Section 3 – Future network assumptions:** outlines the assumptions and infrastructure changes within the future models
- **Section 4 – Base operational results:** provides the network performance, travel time results and density plots of the base model
- **Section 5 – Future operational results:** provides the network performance, travel time results and density plots of the future models
- **Section 5 – Results comparisons:** compares the base operational results with the future operational results
- **Section 6 – Conclusions**: summarises the findings of the study

1.3 Scope of Work

To assist DPIE in achieving the modelling objectives for this study, Cardno provided the following works:

- Utilise previously conducted traffic surveys from 2016 and 2018 to model traffic behaviour in the precinct during typical AM and PM conditions
- Review strategic model land use assumptions and travel patterns for existing and future years
- Establish traffic growth and mode shift trends for future year scenarios
- Review untested transport infrastructure works identified in the Draft 2036 Plan;
- Develop a microsimulation traffic model using Aimsun of the precinct to:
  - Assess existing conditions and provide a platform for future year assessment
  - Assess future year conditions based on background traffic growth, development growth and proposed infrastructure upgrades from the Draft 2036 Plan.

This scope of work represents a 'stress test' of initiatives proposed in the St Leonards Crows Nest Plan. Further modelling will be required as part of rezoning proposals, including the assessment of 'do nothing' or 'do minimum' cases for future year conditions.

1.4 Study Area

The study area presented in **Figure 1-2** includes the suburbs of Artarmon, St Leonards, Naremburn, Crows Nest, Wollstonecraft. The study area is bound by the Gore Hill Freeway in the north, Pacific Highway in the east, River Road in the south and West street in the east. These areas are overseen by the Councils of North Sydney, Lane Cove and Willoughby**.**

Figure 1-2 St Leonards, Crows Nest and Artarmon Study Area

1.4.2 Key Roads

The major roads within the study network are shown in **Table 1-1**.

Table 1-1 Key Roads

Road	Description	Posted speed limit (km/h)	Key place uses	Key movement uses
Pacific Highway	The portion of Pacific Highway in the study area was substituted by Warringah Freeway and Gore Hill Freeway as the national highway. This portion of Pacific Highway is a state road that travels from the north-western end of the study area to south-east and connects to or provides connectivity to all other major roads in the study area. Outside of the study area, Pacific Highway connects the Sydney CBD to the northern border of New South Wales. The road within the study area has 11 signalised intersections between Alexander Street to Hotham Parade.	60	Residential, Bulk retail, Medical, Education, Transport Interchange, small retail, restaurants.	Significant regional north-south corridor for several bus routes and private vehicles. More freight uses in Artarmon, less so south of Falcon Street.
River Road	River Road runs parallel to Pacific Highway on the southern boundary of the study area. The modelled area includes the section of River Road bound by Greenwich Road and Shirley	50	Residential, recreational.	Regional east west link. 261 bus route. Moderate difficulty cycleway.
Greenwich Road	Greenwich Road provides connectivity between Pacific Highway and River Road within the study area. The road serves as the main connectivity in and out of the suburb of Greenwich.	50	Residential	Pacific Highway to River Road connector. Moderate difficulty cycleway. Residential access.
Herbert Street	Herbert Street runs north-south and intersects with the Pacific Highway in the centre of the study area. The road separates the St Leonards Train station and the Hospital Precinct. High volumes of pedestrians cross Herbert street to access the public transport facilities, hospital precinct and commercial sections.	50	Health, Residential, Commercial, Industry, St Leonards interchange.	Local connector between Artarmon and St Leonards. Moderate difficulty cycleway. Night bus route/ rail replacement route. Community buses.
Chandos Street	Chandos Street runs along the northern border of the study area and provides connectivity from the St Leonards Train Station to the Warringah Freeway via Brook Street. The road intersects with many other major roads such as Oxley Street, Christie and Willoughby Road.	50	Commercial/ Office, Restaurants/ Café, Residential.	Warringah Freeway to Pacific Highway connector.

Road	Description	Posted speed limit (km/h)	Key place uses	Key movement uses
Christie Street	Christie Street runs north-south and provides connectivity between Pacific Highway and Chandos Street. The street also provides access to drop off and pick-up areas on the eastern side of the St Leonards Train Station.	50	Commercial.	Chandos Street to Pacific Highway connector. Moderate to hard cycleway.
Albany Street	Albany Street runs east-west and provides connectivity between Pacific Highway to Willoughby Road and Alexander Street.	50	Retail (High Street function near Pacific Highway), Commercial, Residential.	Local access road to Crows Nest. Can be used as an east-west link.
Willoughby Road	The road experiences high volumes of pedestrian movement due to the presence of shops and restaurants. Willoughby Road has several wombat crossing treatments and bus stop blisters.	50 40 in Crows Nest village.	Significant place function. Crows Nest Village high street shopping and dining. Commercial and residential.	Several north-south bus routes. Local access.
Alexander Street	Alexander Street is a north-south route and provides access from Pacific Highway to the Warringah Freeway via Chandos / Brook Street. The road also intersects with other major roads such as Falcon Street, Albany Street and also provides access to Willoughby Road.	50	Crows Nest Village high street shopping. Residential.	North-south local connector.
Falcon Street	Falcon Street is a major east-west route and provides access from Pacific Highway to Miller Street, Warringah Freeway and Military Road. Falcon Street also intersects with Alexander Street and experiences a high volume of pedestrian movements due to the shopping district and public transport stops near Pacific Highway.	60	South end of Crows Nest village. Residential, education, recreation. Retail pockets at some intersections.	Regional east-west connector. Freight route. Several bus routes.
Shirley Road	Shirley Street provides connectivity between Pacific Highway and River Road.	50	Residential	Regional east-west connector. 261 bus route.
Hume Street	Hume Street intersects with Pacific Highway and provides access to Willoughby Road via Clarke Street. The road runs along the south-east border of the future Sydney Metro Crows Nest Station site. The road is currently closed due to Sydney Metro Construction activities.	50	Retail, future Crows Nest Metro station access.	Local access.
Oxley Street	Oxley Street intersects with Pacific Highway, Albany Street and Chandos Street. The road runs along the north-west border of the future Sydney Metro Crows Nest Station site.	50	Commercial, retail residential.	Local access.

1.5 Modelling Objectives

The purpose of the traffic and transport study is to ensure that transport planning and supporting infrastructure accommodates land use plans across the precinct. For the traffic assessment, Cardno developed a microsimulation model using Aimsun to evaluate the traffic impacts, while examining options to improve pedestrian permeability on the precinct's transport network. The models allowed a detailed assessment of the interventions proposed in the Draft 2036 Plan and identify opportunities to improve accessibility and reduced congestion.

The main modelling objectives of the study are:

- Evaluation of existing traffic and transport conditions across the precinct to provide insight into the existing performance and highlight current deficiencies
- High level consideration of movement and place objectives as they vary across the road network and precinct;
- Quantify and assess the impact of proposed development on the surrounding transport network
- Investigate the impacts of improved pedestrian crossing opportunities throughout the precinct
- Investigate planned initiatives to support increased pedestrian movement to the planned Crows Nest Metro station,
- Identify infrastructure opportunities to support growth across the precinct
- Identify opportunities to encourage mode shift to active and public transport by implementing parking provision policies and public transport infrastructure improvements
- Provide guidance to DPIE and other state and local agencies regarding the traffic and transport implications for the surrounding area

1.6 Reference Material

1.6.1 Reference documents

The following documents have been referenced throughout the study and in the preparation of this report:

- *North District Plan* (Greater Sydney Commission, March 2018)
- *St Leonards and Crows Nest Economic Feasibility Review* (DPIE, March 2018)
- *Road Network Plan Report Pacific Highway: Warringah Freeway to Pennant Hills Road* (Roads and Maritime Services, May 2018)
- *St Leonards and Crows Nest Station Precinct Strategic Transport Study* (Cardno, September 2018)
- *Draft St Leonards and Crows Nest 2036 Plan* (DPIE, October 2018).

1.6.2 Strategic models

Cardno received strategic models from Transport Performance Analytics (TPA):

- *St Leonards Sydney Transport Model (STM) Cordon Map* (TPA, 23 May 2018)
- *Public Transport Project Model (PPTM)* (TPA) for:
  - 2016 TZP16: TfNSW land use projections (23 May 2018)
  - 2026 DPIE project case land use (16 August 2018)
  - 2036 DPIE project case land use (16 August 2018).

1.7 Stakeholders

The stakeholders relevant to this study include:

- The Department of Planning, Industry and Environment
- Transport for New South Wales
- NSW Health Infrastructure
- Lane Cove Council
- North Sydney Council
- Willoughby Council.

2 Future Year Demand Development

This section outlines the demand development procedure used to estimate the traffic demands for the future horizon years.

2.1 Future Policies

This section provides an overview of the context and rationale behind future policies that will affect the traffic demands in the precinct.

2.1.1 Public transport

Sydney has experienced a surge in population over the past decades. *The Greater Sydney Regional Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018) proposes three major focus centres for Sydney's future growth and employment – the Eastern Harbour City, the Central River City (Parramatta) and the Western Parkland City (Campbelltown, Liverpool and Penrith). The Plan envisages that most residents will live within 30 minutes of their jobs, education and health facilities, and other services.

The St Leonards and Crows Nest Precinct is well-serviced by public transport infrastructure. The Draft 2036 Plan aims to make use of the best future transport planning practices to align St Leonards and Crows Nest with the Greater Sydney Commission future strategy for a 30-minute city. The new Crows Nest Metro Station, due for completion in 2024, will leverage the increase in employment opportunities and residential capacity. Growth in the precinct will realise its potential as a major centre in the Eastern Harbour City. Changes to existing land uses in the precinct will increase trips and change travel behaviour. Future demand forecasts are based on a focussed approach to influence commuters towards active and public transport.

The strategic models used for the demand forecasting mechanism (EMME) are maintained by Transport Performance Analytics (TPA). The Sydney Strategic Travel Model (STM) is a planning tool used for generating travel demands and trip distribution. The Public Transport Project Model (PTPM) is a refined mode-choice model used for assessing public transport projects and simplified mode share. The STM projects traffic growth and the PTPM projects public transport mode share and mode shift.

The Crows Nest Metro Station is expected to be the key factor in influencing mode shares within the precinct. The PTPM model outputs suggest that an average increase of four to six per cent for rail mode share is expected following opening.

2.1.2 Active transport

Active transport including walking and cycling are healthy and sustainable modes of travel. They contribute to better social cohesion, reduced traffic congestion, lower road transport costs and improved liveability. The need to encourage pedestrian and active transport within the precinct is paramount to maximising the benefits of Sydney Metro and the Draft 2036 Plan interventions.

The Sydney Coordinated Adaptive Traffic System (SCATS) prioritises road traffic over pedestrians. Adaptive signals are designed to maximise the throughput for cars which usually increases the wait time for pedestrians. This impacts pedestrian level of service and the attractiveness of active transport. Shorter wait times have been shown to encourage more walking, reduce the risk of jaywalking and decrease pedestrian casualties with studies in America, Canada, New Zealand and Europe indicating that the number of illegal crossings by pedestrians increases with average wait times exceeding one minute[3]. The Draft 2036 Plan includes interventions to maximise all-direction crossing opportunities and green times at signals for active transport users in the precinct.

As part of the base model calibration and validation process, pedestrian crossings points at signalised intersections or zebra crossings were accounted for based on the data available. For signalised intersections, this was quantified by reviewing SCATS historical data to determine the signal phasing adopted and the frequency the pedestrian phases were activated. For zebra crossings, the number of pedestrians (if known) was added to the model and the consequent impact to traffic automatically reproduced by the simulation. For locations where pedestrian flows were not available, the traffic speed was manually reduced in the road segments adjacent to the crossings to account for the overall impact to traffic operation across the two hours. Other types of crossings (such as refuge islands) do not feature pedestrian priority and as such these have no impact to the traffic network.

As part of the development of future year traffic models, it was assumed that pedestrian demands would increase throughout the precinct, especially in the vicinity of the future Sydney Metro station. To account for this, it was conservatively assumed that pedestrian phases at signalised intersections would be called on all traffic signal cycles.

[3] *Reducing Pedestrian Delay at Half Signals in the City of Portland, OR* (City of Portland Bureau of Transportation, n.d.)
Reducing Pedestrian Delay at Traffic Signals (NZ Transport Agency, April 2011)
Walking Action Plan (Transport for London, July 2018).

2.1.3 Parking provision

Limiting parking and/or charging for parking can be a tool to influence private vehicle travel demand, reduce congestion and reinforce sustainable travel goals by facilitating mode shift towards active and public transport modes. This relies on the capacity of the active and public transport network to absorb additional trips, and a willingness by residents, employees and visitors to consider travel modes other than private vehicles.

Projections for development in the precinct show significant growth in employees and residents over the next 20 years. An increase in public and private parking provision proportional to the growth forecasted would place significant strain on the road network. It is expected that policies will need to be implemented to constrain parking provision within new developments to help encourage mode shift.

2.2 Future years and scenarios

Future modelling was undertaken for two horizon years (2026 and 2036) for the AM and PM peak as agreed with DPIE.

2.3 Land Use Assumptions

The initial strategic modelling assessment consisted of comparing TZP16 land use projections and DPIE project case land use assumptions, which have different projections for the planning horizons of 2026 and 2036. The next sections summarise land use information assumed for the traffic and transport study.

2.3.1 SGS Modelling

Modelling completed by SGS for the St Leonards and Crows Nest Economic Feasibility Review (SGS Report March 2018) provides an estimate for the changes to land use demands. SGS have refined the TfNSW 2016 Land Use (TfNSW LU16) model to reflect proposed land use changes in the St Leonards and Crows Nest study precinct in accordance with the 'high' jobs target by 2036 as defined in the Great Sydney Commission Draft North District Plan. The SGS project case land use reflects the impacts due to the Sydney Metro project, employment shift and housing distribution.

A total of 6,800 new dwellings and approximately 10,000 additional employment opportunities are included in the land use assumptions. A summary comparison (between the SGS forecast and TfNSW LU16) for the study precinct is shown below in **Table 2-1.** The detailed population and employment breakdown by zone is provided in **Table 2-2**.

Table 2-1 Comparison between SGS Land Use and TfNSW LU16 (TZP16) Forecasts

Study Precinct Total									
	2016			**2026**			**2036**		
	SGS	TfNSW LU16	**Diff**	SGS	TfNSW LU16	**Diff**	SGS	TfNSW LU16	**Diff**
Population	15,604	15,604	**0**	17,952	18,783	**-831**	26,417	25,273	**+1,144**
Employment	47,097	47,097	**0**	50,499	50,499	**0**	63,498	54,230	**+9,268**

Compared to the TfNSW LU16 model, the SGS model indicates slower population growth from 2016 to 2026 in the study precinct. A higher growth is expected from 2026 to 2036 with the precinct ultimately containing 1,144 additional residents compared to the TfNSW LU16 forecasted population.

SGS modelling shows no difference in employment volumes and growth compared to TfNSW before 2026. However, beyond 2026, SGS forecast show increased employment across all travel zones in the study precinct with the largest growth occurring at the Royal North Shore Hospital.

The overall comparison of the population and employment demographic by travel zone shows Mater Misericordiae Hospital and North Sydney Girls Highway School population halving by 2026 under the SGS land use assumptions.

Table 2-3 and **Table 2-4** show growth per travel zone at the 2026 and 2036 design years as modelled by SGS, and graphically represented in **Figure 2-1** and **Figure 2-2**

Table 2-2 SGS Land Use and TfNSW LU16 (TZP16) Population and Employment Summary

TZ CODE	TZ	SGS Population			SGS Employment			TfNSW Population			TfNSW Employment		
	NAME	2016	2026	2036	2016	2026	2036	2016	2026	2036	2016	2026	2036
1838	Artarmon	2	3	3	4,151	4,268	4,716	2	2	2	4,151	4,268	4,408
1832	St Leonards Park Rd and River Rd	1,664	1,798	5,192	2,278	2,414	2,773	1,664	2,324	5,183	2,278	2,414	2,568
1843	Royal North Shore Hospital	1,289	1,345	1,345	10,342	10,882	16,273	1,289	1,291	2,142	10,342	10,882	11,424
1844	St Leonards	3,648	5,360	6,893	14,058	15,020	17,594	3,648	4,786	5,792	14,058	15,020	16,102
1841	Artarmon Industrial Area Western End	11	14	14	5,549	5,830	6,650	11	12	12	5,549	5,830	6,158
1842	St Leonards Station	1,426	1,727	1,936	843	911	1,092	1,426	1,526	1,573	843	911	994
1915	Mater Misericordiae Hospital	2,226	1,201	2,588	2,035	2,398	3,542	2,226	2,430	3,421	2,035	2,398	2,807
1911	Wollstonecraft Rose and Macleod Plaza Crows Nest	1,679	2,629	3,692	2,617	2,917	3,575	1,679	2,119	2,581	2,617	2,917	3,248
1949	North Sydney Girls High School South	566	113	491	1,496	1,680	2,121	566	709	730	1,496	1,680	1,875
1914	North Sydney Girls High School North	680	801	925	548	633	849	680	768	798	548	633	721
1912	Crows Nest	1,190	1,412	1,591	1,846	2,037	2,457	1,190	1,367	1,444	1,846	2,037	2,233
1910	Crows Nest Plaza	1,223	1,549	1,746	1,336	1,510	1,856	1,223	1,448	1,595	1,336	1,510	1,693
Study Precinct Total		**15,604**	**17,952**	**26,417**	**47,097**	**50,499**	**63,498**	**15,604**	**18,783**	**25,273**	**47,097**	**50,499**	**54,230**

Source: NSW Department of Planning & Environment, July 208, and Transport for New South Wales LU16 (TZP16), May 2018. (Last Revised by Cardno August 2018)

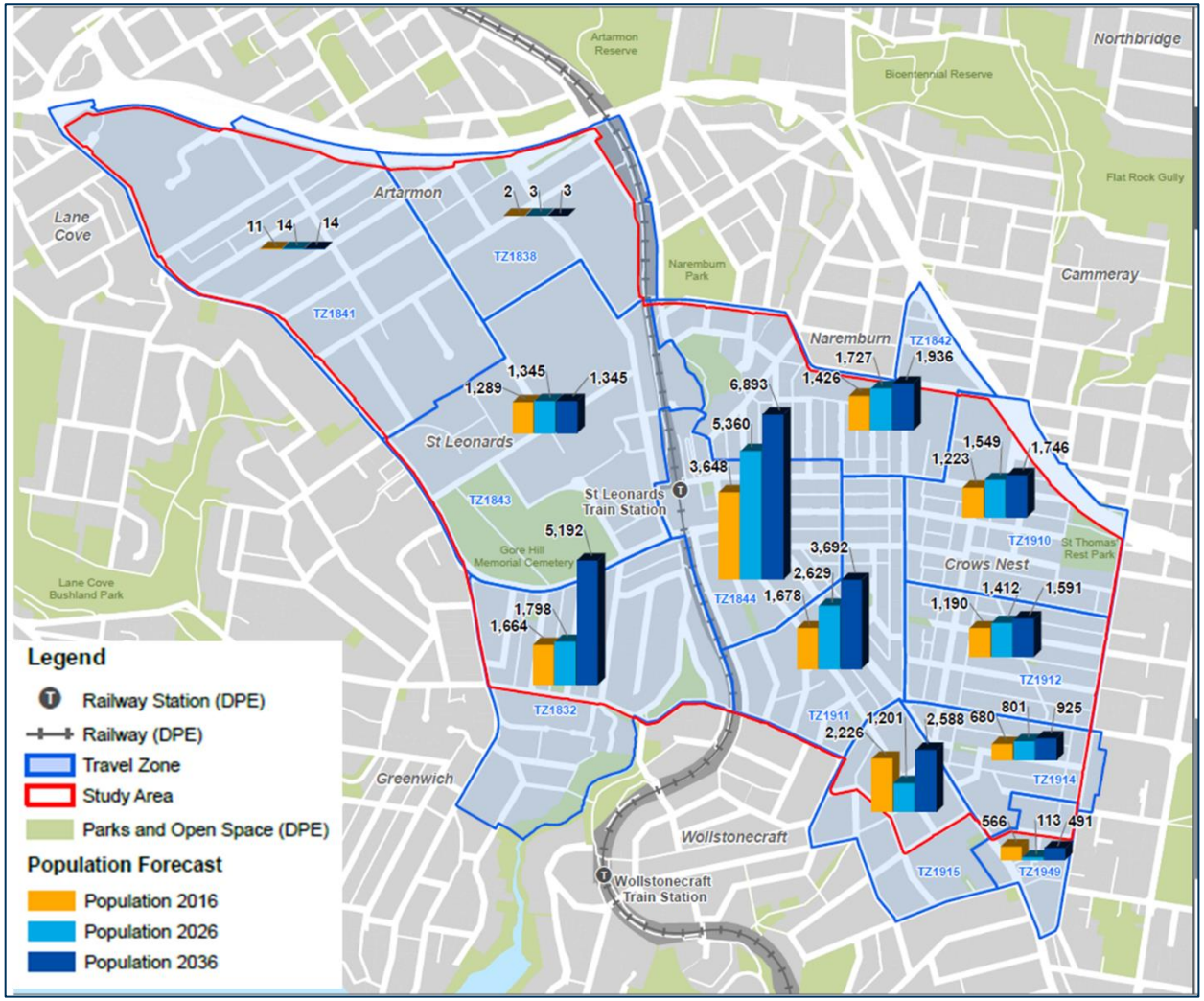


Figure 2-1 SGS Land Use (Population)

Table 2-3 SGS Land Use Population Growth Rates per Annum

TZ CODE	TZ NAME	Population Growth 2016 - 2026	Population Growth 2016 - 2036
1838	Artarmon	2.5%	1.2%
1832	St Leonards Park Rd and River Rd	0.8%	5.9%
1843	Royal North Shore Hospital	0.4%	0.2%
1844	St Leonards	3.9%	3.2%
1841	Artarmon Industrial Area Western End	2.5%	1.2%
1842	St Leonards Station	1.9%	1.5%
1915	Mater Misericordiae Hospital	-6.0%	0.8%
1911	Wollstonecraft Rose and Macleod Plaza Crows Nest	4.6%	4.0%
1949	North Sydney Girls High School South	-14.9%	-0.7%
1914	North Sydney Girls High School North	1.6%	1.5%
1912	Crows Nest	1.7%	1.5%
1910	Crows Nest Plaza	2.4%	1.8%
Study Precinct Total		1.4%	2.7%

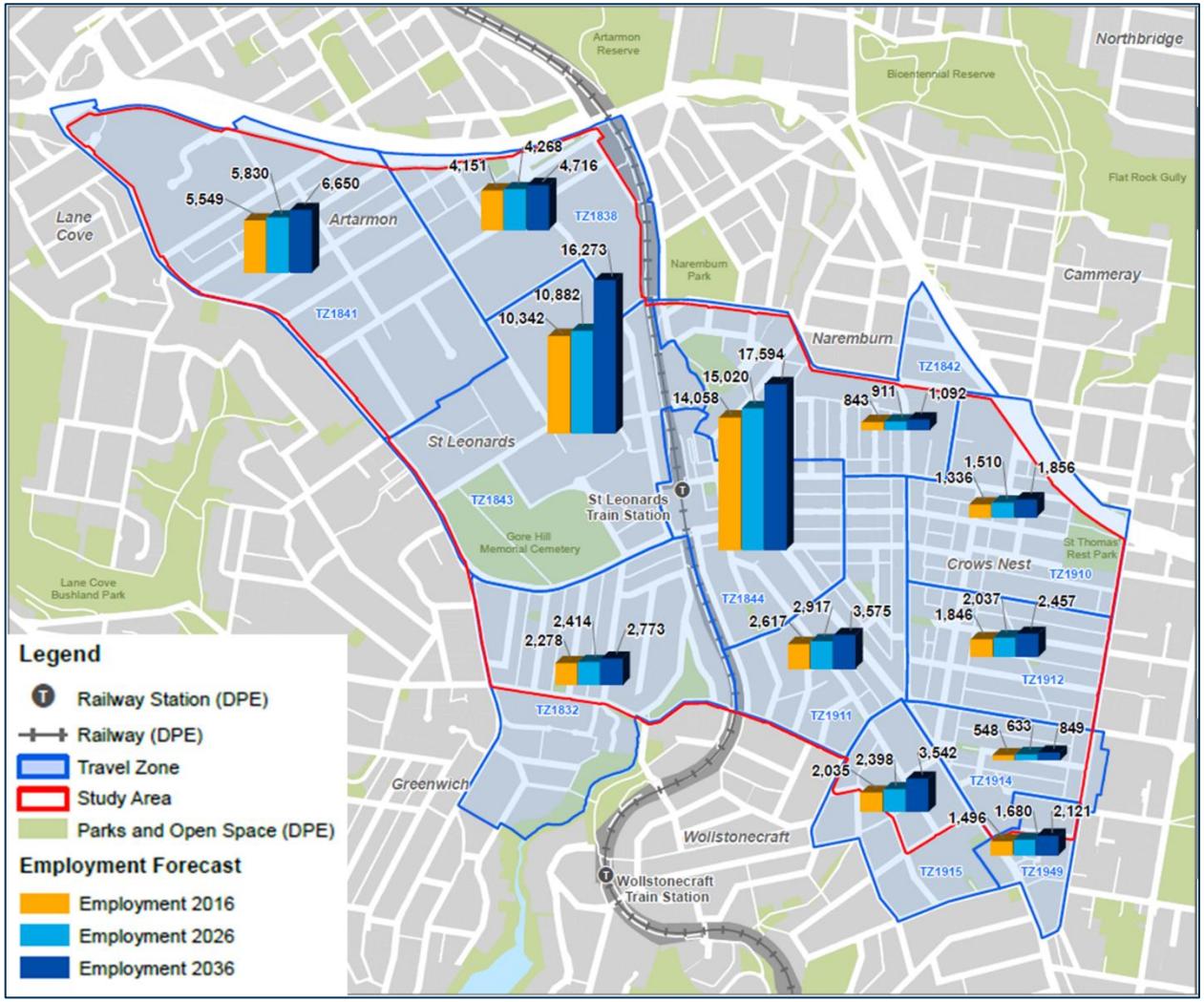


Figure 2-2 SGS Land Use (Employment)

Table 2-4 SGS Land Use Employment Growth Rates per Annum

TZ CODE	TZ NAME	Employment Growth 2016 - 2026	Employment Growth 2016 - 2036
1838	Artarmon	0.3%	0.5%
1832	St Leonards Park Rd and River Rd	0.6%	0.7%
1843	Royal North Shore Hospital	0.5%	2.0%
1844	St Leonards	0.7%	0.8%
1841	Artarmon Industrial Area Western End	0.5%	0.7%
1842	St Leonards Station	0.8%	0.9%
1915	Mater Misericordiae Hospital	1.7%	2.0%
1911	Wollstonecraft Rose and Macleod Plaza Crows Nest	1.1%	1.0%
1949	North Sydney Girls High School South	1.2%	1.2%
1914	North Sydney Girls High School North	1.4%	1.5%
1912	Crows Nest	1.0%	0.9%
1910	Crows Nest Plaza	1.2%	1.0%
Study Precinct Total		1.4%	0.7%

2.4 Strategic Models (EMME) Road Network Future Assumptions

The Beaches Link, Western Harbour Tunnel (WHT) and Sydney Metro consist of the main transport infrastructure improvements in Sydney relevant to the study area's transport network. Other infrastructure improvements included in the strategic models are summarised in **Table 2-5**

Table 2-5 2026 and 2036 Future Major Projects and Infrastructure Assumed in STM and PTPM TfNSW strategic models

Major Infrastructure	Included in 2026	Included in 2036
Road projects	NorthConnex and WestConnex (Stage 1A, State 1B, Stage 2 and Stage 3) North West Priority Growth Centre (Showgrounds Road, Schofield Road Stage 2, Schofield Road Overpass, Schofield Road Stage 3, Memorial Avenue, Windsor Road, Garfield Road, Riverstone Overpass and other minor road upgrades) South West Priority Growth Centre (Bringelly Road, Camden Valley Way, Narellen Road, The Northern Road and other minor road upgrades) Western Sydney Employment Area (Horsley Drive) M12 (M7 to The Northern Road) Supporting road upgrades for Western Sydney Airport **Western Harbour Tunnel and Beaches Link**	NorthConnex and WestConnex (Stage 1A, State 1B, Stage 2 and Stage 3) North West Priority Growth Centre (Showgrounds Road, Schofield Road Stage 2, Schofield Road Overpass, Schofield Road Stage 3, Memorial Avenue, Windsor Road, Garfield Road, Riverstone Overpass and other minor road upgrades) South West Priority Growth Centre (Bringelly Road, Camden Valley Way, Narellen Road, The Northern Road, Edmondson Avenue, Cowpasture Road and other minor road upgrades) Western Sydney Employment Area (Horsley Drive and *Werrington Arterial*) M12 (M7 to The Northern Road) Supporting road upgrades for Western Sydney Airport **Western Harbour Tunnel and Beaches Link** *Southern Connector Motorway*
Rail/ light rail projects	**Sydney Metro City & South West terminating at Bankstown station.** Sydney CBD and South East Light Rail project Parramatta Light Rail Stage 1 - (project includes a light rail service between Westmead and Carlingford) The Sydney CBD and South East Light Rail project includes two light rail services: (Circular Quay to Randwick & Circular Quay to Kingsford).	**Sydney Metro City & South West terminating at Bankstown station.** Sydney CBD and South East Light Rail project Parramatta Light Rail Stage 1 - (project includes a light rail service between Westmead and Carlingford) The Sydney CBD and South East Light Rail project includes two light rail services: (Circular Quay to Randwick & Circular Quay to Kingsford).
Bus Priority / New Bus Services	No major bus assumptions related to the study precinct were identified.	No major bus assumptions related to the study precinct were identified.

The only differences between the 2026 and 2036 future transport infrastructure assumptions consist of the inclusion of Werrington Arterial within the Western Sydney Employment Area and Southern Connector Motorway Project. These two infrastructure projects do not have significant impact on the St Leonards and Crows Nest area.

2.5 Demand Development Methodology

2.5.1 Future Origin and Destination (OD) Matrix Estimation

The Sydney Traffic Forecasting Model (STFM) was interrogated to provide 2026 and 2036 demand matrices including background growth. The demand modelling procedure consisted of the following steps:

- The 2016, 2026 and 2036 strategic model demands were derived from the STFM model using land use assumptions from the SGS economic review study
- 2016, 2026 and 2036 strategic model demands were extracted from the STFM model
- The trip growth for the future years were calculated by subtracting the 2016 STFM matrix
- No reductions were considered for zones with negative growth
- The STFM matrix was disaggregated into the Aimsun zone system
- The 2016 demand profile was applied to the 2026 and 2036 matrices for 15-minute time intervals.

The same procedure was completed for both peaks (AM and PM) for light vehicles, rigid trucks and articulated trucks. The procedure is summarised in **Figure 2-3**.

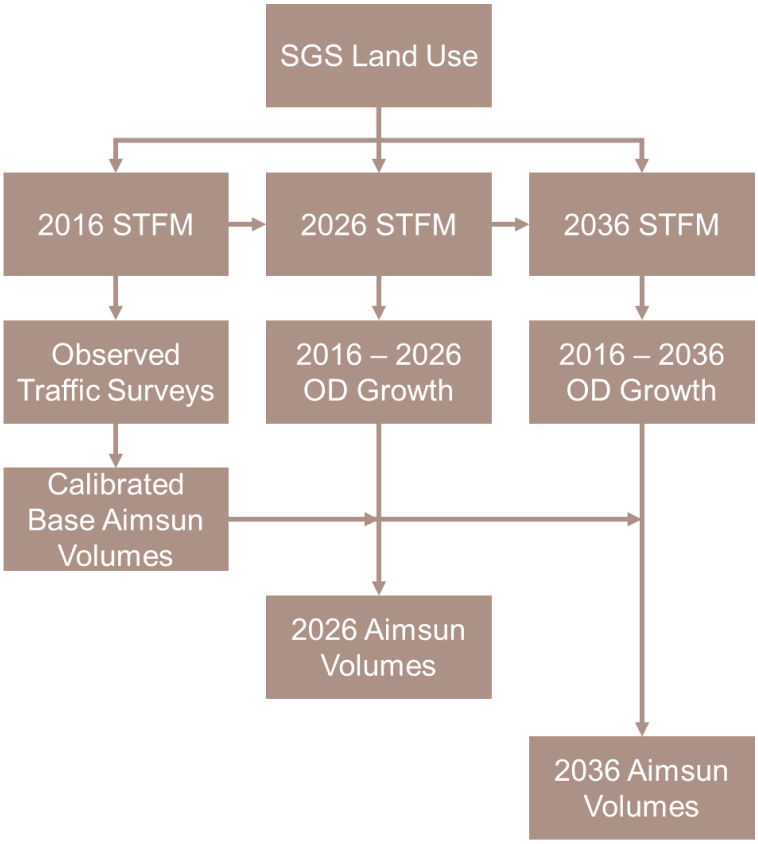


Figure 2-3 Future Traffic Demand Matrices Estimation Methodology

The STFM OD matrix totals are summarised in **Table 2-6**.

Table 2-6 STFM OD Matrix Totals (2 Hours)

Demand (vehicles)	AM			PM		
	2016	2026	2036	2016	2026	2036
Light Vehicles	29,827	33,637	38,554	32,146	35,180	40,181
Rigid Trucks	1,323	1,703	1,960	943	1,196	1,373
Articulated Trucks	272	342	395	179	220	245
Total	31,421	35,681	40,909	33,268	36,597	41,799

The annual linear growth rates per annum (p.a.) are summarised in **Table 2-7**.

Table 2-7 STFM OD Matrix Growth Rates

Growth Rate (per annum)	AM			PM		
	2016-2026 (10yr)	2026-2036 (10yr)	2016-2036 (20yr)	2016-2026 (10yr)	2026-2036 (10yr)	2016-2036 (20yr)
Light Vehicles	1.28%	1.46%	1.46%	0.94%	1.42%	1.25%
Rigid Trucks	2.87%	1.51%	2.41%	2.69%	1.48%	2.28%
Articulated Trucks	2.58%	1.56%	2.28%	2.31%	1.11%	1.84%
Total	1.36%	1.47%	1.51%	1.00%	1.42%	1.28%

3 Future Network Assumptions

3.1 Future Modelling Years and Scenarios

Cardno proceeded with future modelling investigations following a review of the base model by TfNSW. Two future year scenarios (2026 and 2036) were modelled. The traffic demand for each design year was developed as per the methodology outlined in **Section 2.** The future years are also in line with the STFM strategic model being utilised within NSW.

Future year scenarios were assessed with the pre-identified road upgrades under the draft 2036 Plan. Do-nothing and Do-minimum models were not prepared for comparison purposes.

The design years and scenarios assessed are summarised in **Table 3-1**.

Table 3-1 Summary of Assessment Scenarios

Design Horizon Year	Development Scenario	Modelling Analysis	
		Weekday AM	Weekday PM
2016	Existing / Base Case	✓	✓
2026	With Draft 2036 Plan upgrades	✓	✓
2036	With Draft 2036 Plan upgrades	✓	✓

3.2 Modelled Time Periods

Two time periods were modelled, consisting of the two busiest morning and evening peak hours and is in line with the traffic modelling peaks identified in the base model development. The modelled peak hour periods were determined from the traffic survey data (i.e. the hours with the highest traffic demand). In addition to the peak-period (comprising 2 hours), a 'warm-up' period of 60 minutes was added before the first modelled peak hour. The warm up period pre-loads the network prior to the start of the simulation period and ensures that traffic is already using the network before extracting modelling results.

The time periods are outlined in **Table 3-2**.

Table 3-2 Modelled Time Periods

	Warm Up	Peak
AM	6:30am – 7:30am	7:30am – 9:30am
PM	3:45pm – 4:45pm	4:45pm – 6:45pm

3.3 Infrastructure Upgrades

As a starting point, the network geometries for 2026 and 2036 modelling horizons were assumed to be consistent with the infrastructure list contained in the St Leonards and Crows Nest 2036 Draft Plan, NSW Department of Planning and Environment, July 2018. Any exceptions or modifications to this list are stated in this document.

The draft 2036 Plan proposes upgrades within the study precinct to improve access in line with the 2036 vision for the area. Upgrades include changes to existing intersections, new infrastructure and decreased prioritisation of private vehicles at intersections. It is assumed that these infrastructure changes will be supplemented with amended parking policies area wide to introduce constrained parking in new developments.

The proposed upgrades impacting the study area are listed in **Table 3-3** and correspondingly numbered in **Figure 3-1**.

Table 3-3 List of Proposed Upgrades in the Model Network

#	Location	Description
1	Intersection on Herbert Street near RNSH and Railway Bridge.	New Pedestrian Crossing treatment.
2	Intersection of Canberra Avenue and River Road.	New signalised intersection and crossing.
3	Intersection of Willoughby Road and Atchison Street.	New pedestrian treatments to existing intersection.
4	Willoughby Road south of Holtermann Street.	New pedestrian crossing.
5	Sergeants Lane and Christie Street Intersection.	Kerb outstand.
6	Intersection of Oxley Street and Pacific Highway.	Pedestrian crossing, north west leg. Introduce a right-turn for south bound vehicles.
7	Intersection of Oxley Street and Nicholson Street.	Intersection upgrades for pedestrian and cyclists.
8	Intersection of Nicholson Street and Shirley Road.	Provide intersection treatment for pedestrians or cyclists crossing Shirley Road (refuge/signals).
9	Intersection of Chandos Street and Christie Street.	Pedestrian crossing treatments.
10	Intersection of Chandos Street and Atchison Street intersections with Mitchell Street.	Pedestrian crossing treatments.
11	Intersection of Chandos Street and Oxley Street.	Pedestrian crossing treatments.
12	Intersection of Chandos Street and Willoughby Road.	Pedestrian crossing (signalised), north leg.
13	Pacific Highway near Portview Road.	Signalised pedestrian crossing.
14	Intersection of Pacific Highway and Reserve Road.	Signalised pedestrian improvement.
15	Intersection of Pacific Highway and Herbert Street.	Signalised pedestrian improvement.
16	Intersection of Pacific Highway and Christie Street.	Signalised pedestrian improvement.
17	Intersection of Pacific Highway and Albany Street.	Signalised pedestrian improvement.
18	Intersection of Pacific Highway, Shirley Road, Willoughby Road and Falcon Street.	Signalised pedestrian improvement.
19	St Leonards Station.	Improved pedestrian and cyclist facilities, kiss and ride areas, and taxi zones.
20	Bus stop between Oxley Street and Hume Street (east side).	Relocate bus stops near Sydney Metro Station.
21	Bus stops between Hume Street and Shirley Street (west side).	Consolidate two bus stops near Sydney Metro Station.
22	Intersection of Oxley Street and Clarke Street.	New pedestrian crossing.
23	Intersection of Oxley Street and Atchison Street.	New pedestrian treatment.
24	Intersection of Oxley Street and Albany Street.	New pedestrian crossing legs.

Figure 3-1 Future Year Road Network Upgrades Location

4 Base Model Operational Results

This section details the modelling results of the base (2016) scenario. Development and calibration results from the base scenarios are documented in the '*St Leonards Base Model Development Report, May 2020'*. The results presented in this section establishes the base reference case for comparative assessment with future scenarios.

4.1 Data Inputs

The 2016 base model was developed using the following inputs:

- Traffic signal operations (cycle times, phase times and offsets) based on SCATS History Files, SCATS Region LX file
- Peak hour volume data from intersection traffic survey counts from Thursday 17th November 2016 and supplemented with data from Tuesday 15th May 2018
- Travel time data obtained from TomTom Traffic Statistics
- Public transport operations obtained from the GTFS Feed.

4.2 Model Specifications and Assumptions

The traffic model was developed to replicate the road conditions observed at the time of the data collection. The settings and parameters of the 2016 base model are as follows:

- Aimsun version 8.4.0 Thu May 2019 (afba3b3059 x64 Python 2) was used to develop the St Leonards microsimulation model
- The vehicle experiment results were calculated from SRC using vehicle paths derived from the DUE assignment
- Signals were coded as actuated using timings derived from provided SCATS data
- The peak hours were identified using survey data and the peak hours are:
  - AM 2-hour peak: 7:30am to 9:30am
  - PM 2-hour peak: 4:45pm to 5:45pm

4.3 Existing Conditions Performance

4.3.1 Network Statistics

The network statistics for the calibrated/validated 2016 base model are shown in **Table 4-1**. The network performance indicates that the AM peak is currently the more critical peak with a higher volume of vehicles.

Table 4-1 Base Model Network Performance

Network Performance Measurements	2016 Base Model	
	AM Peak	PM Peak
All vehicles		
Total traffic demand (vehicles)	25,781	21,141
Total vehicle kilometres travelled in network (kilometres)	39,635	39,555
Total vehicle travel time (hours)	1,915	1,796
Total delay (hours)	1,165	1,043
Total vehicles arrived	24,991	20,499
Total number of stops	68,962	96,335
Average per vehicle in network		
Average vehicle kilometres travelled in network (kilometres)	1.6	1.9
Average time travelled in network(minutes)	4.6	5.3
Average number of stops	2.8	4.7
Average speed (kilometres per hour)	24.9	26.6
Unreleased vehicles		
Unreleased demand (vehicles)	7	4
Per cent of total traffic demand	0%	0%

4.3.2 Travel Times

The travel times and speeds in the 2016 base model for the routes specified in **Figure 4-1** are provided in **Table 4-2** and **Table 4-3** for the AM and PM peak respectively. The results indicate that there are reduced travel speeds on Pacific Highway between Albany Street and Park Lane for the northbound direction and between Albany Street and Alexander Street for the southbound direction in both the AM and PM peaks. These reductions in travel speeds are attributed to the closely located signals along the route.

Figure 4-1 Travel Time Routes (2016 Base)

Table 4-2 Travel Time and Speeds – AM Peak (2016 Base)

Route	Direction	Modelled Time			
		7:30am to 8:30am		8:30am to 9:30am	
		Travel Time (mm:ss)	Speed (km/h)	Travel Time (mm:ss)	Speed (km/h)
Route 1: Pacific Highway between Hotham Parade and Bruce Street					
Bruce St – Falcon St	Northbound	0:41	31	0:43	30
Falcon St – Albany St	Northbound	1:04	35	1:11	31
Albany St – Park Ln	Northbound	2:00	22	2:09	20
Park Ln – Westbourne St	Northbound	1:03	35	0:56	39
Westbourne St – Hotham St	Northbound	1:34	42	1:19	44
Bruce St – Hotham St	**Northbound**	**6:21**	**28**	**6:28**	**27**
Hotham St – Westbourne St	Southbound	1:52	38	1:52	37
Westbourne St – Herbert St	Southbound	2:12	25	2:08	26
Herbert St – Albany St	Southbound	0:53	31	0:58	28
Albany St – Bruce St	Southbound	2:33	25	2:53	21
Hotham St – Bruce St	**Southbound**	**7:21**	**25**	**7:51**	**23**

Table 4-3 Travel Time and Speeds – PM Peak (2016 Base)

Route	Direction	Modelled Time			
		4:45pm to 5:45pm		5:45pm to 6:45pm	
		Travel Time (mm:ss)	Speed (km/h)	Travel Time (mm:ss)	Speed (km/h)
Route 1: Pacific Highway between Hotham Parade and Bruce Street					
Bruce St – Falcon St	Northbound	0:47	27	0:50	24
Falcon St – Albany St	Northbound	1:18	29	1:01	38
Albany St – Park Ln	Northbound	1:35	27	1:30	29
Park Ln – Westbourne St	Northbound	1:06	32	1:21	27
Westbourne St – Hotham St	Northbound	1:53	35	1:44	39
Bruce St – Hotham St	**Northbound**	**6:40**	**27**	**6:26**	**27**
Hotham St – Westbourne St	Southbound	1:45	38	1:37	41
Westbourne St – Herbert St	Southbound	3:47	25	2:13	24
Herbert St – Albany St	Southbound	0:54	27	0:59	23
Albany St – Bruce St	Southbound	2:25	19	2:55	16
Hotham St – Bruce St	**Southbound**	**7:06**	**25**	**7:43**	**23**

4.3.3 Density

The density plots for the 2016 base model are shown in **Figure 4-2** and **Figure 4-3** for the AM and PM peak. The densities are calculated and represented based on “vehicles per kilometre’.

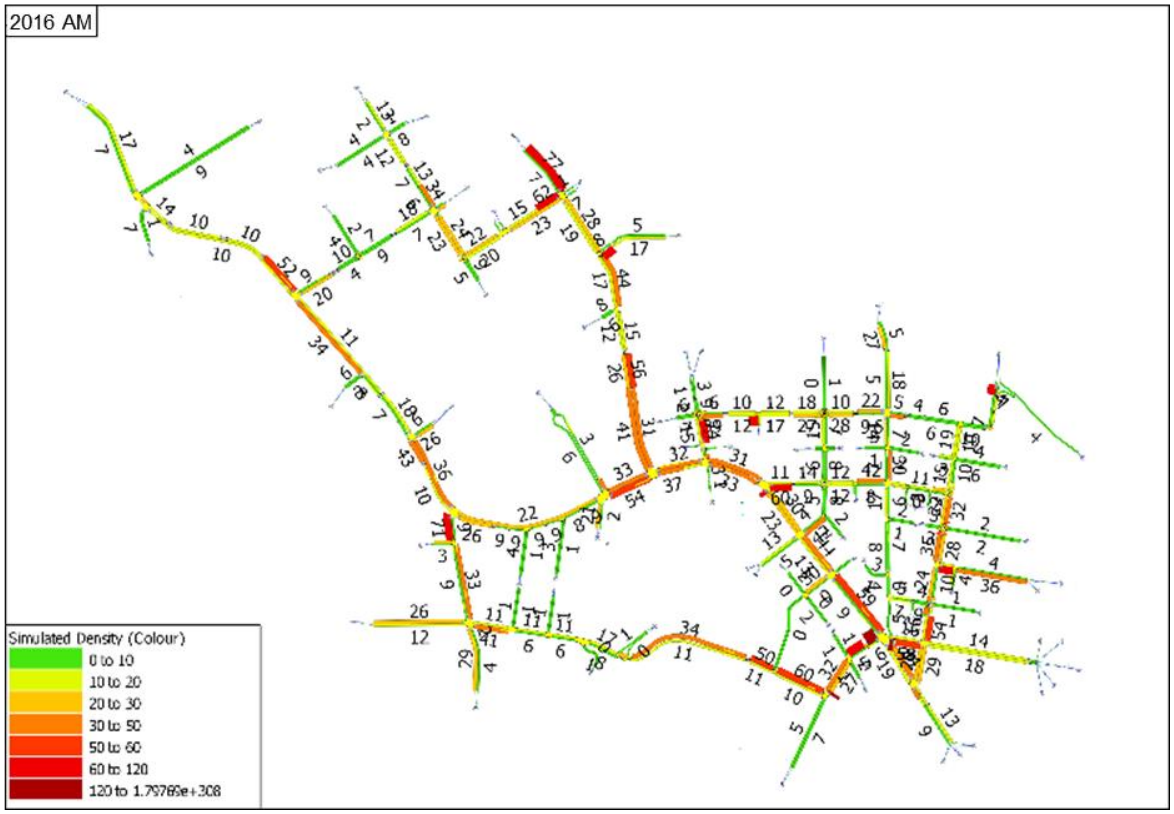


Figure 4-2 Density Plot – AM Peak (2016)

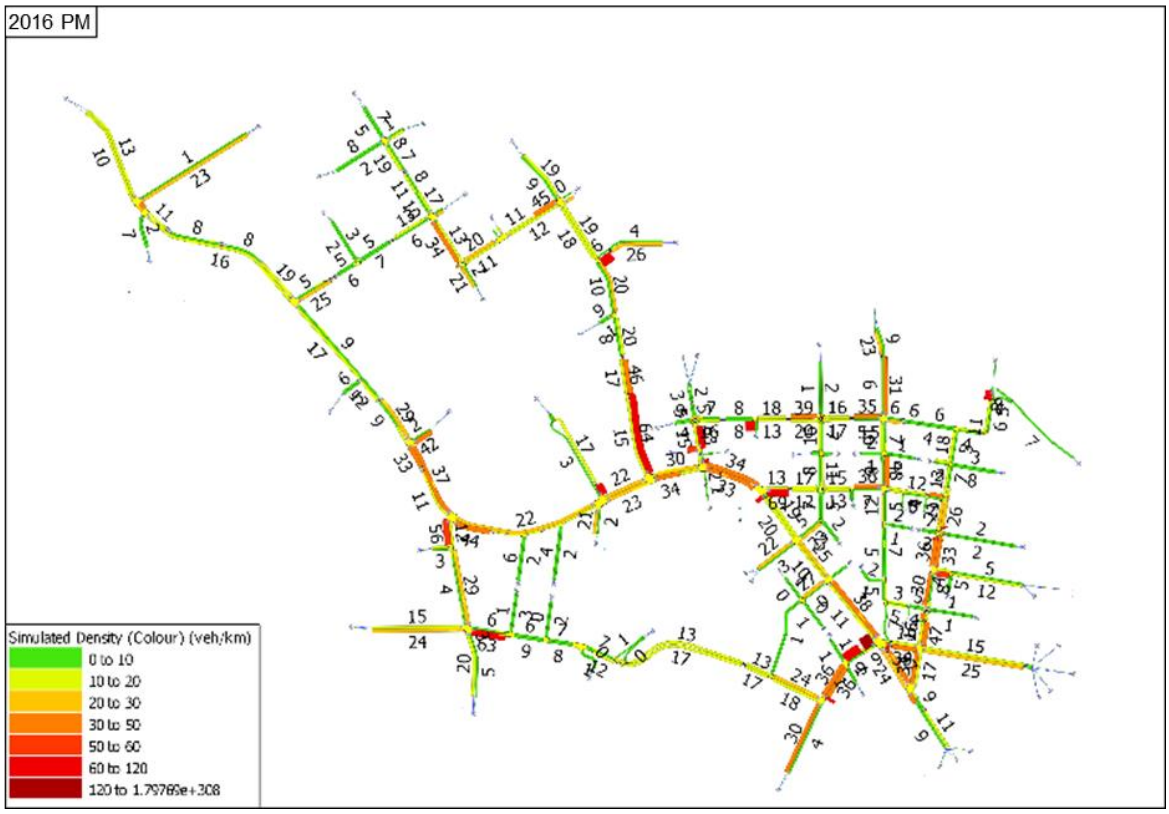


Figure 4-3 Density Plot – PM Peak (2016)

5 Future Year Operational Results

5.1 Inputs and Assumptions

The 2026 and 2036 future year models were developed using the 2016 model as a base. Traffic demand was increased to reflect the forecasted land use changes within the precinct and background traffic growth.

5.1.1 Demand Input

The 2026 and 2036 future models contain traffic growth on top of the 2016 base model demands. The methodology used to estimate the traffic growth is detailed in **Section 2**. The total number of trips for each scenario (for the full 2 hours) is summarised in **Figure 5-1**.

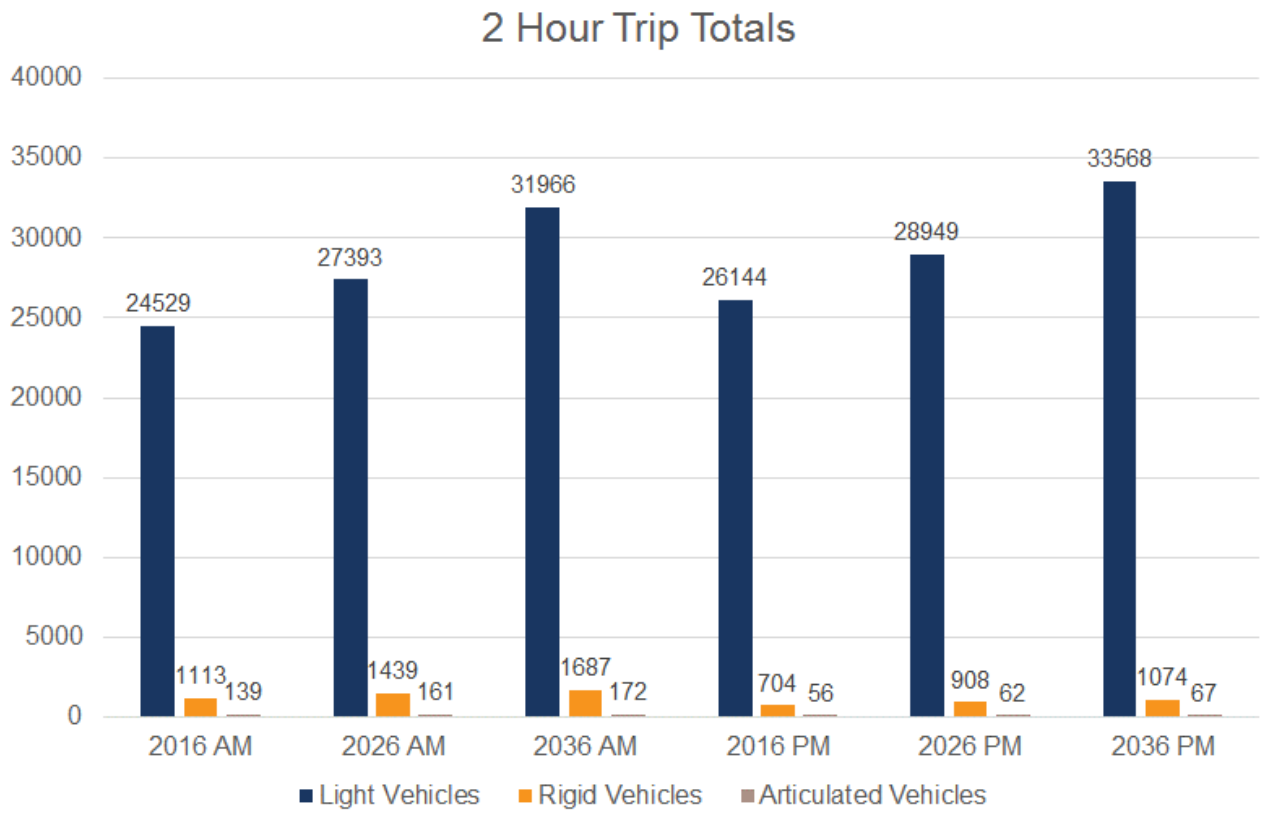


Figure 5-1 Traffic Demands

5.1.2 Public Transport

It has been assumed that the bus services and frequencies in the future year scenarios remain unchanged from the 2016 base model.

5.1.3 Road Network

The 2026 and 2036 future model network were modified to include the 2036 Draft Plan infrastructure upgrades as outlined in **Section 3.3**. Some upgrades were not included in the model as there was no impact to the traffic network or insufficient detail was available. The list of upgrades and commentary for each intervention is summarised in **Table 5-1** and the locations shown in **Figure 5-2**. **Tables 5-2** to **5-13** illustrate each of the upgrades included in the 2026 model.

Further upgrades for the 2036 network were required, in addition to the 2036 Draft Plan, in order to accommodate the 2036 traffic demand. These upgrades are summarised in **Table 5-14** and the locations shown in **Figure 5-3**. **Table 5-15 to 5-19** illustrate each of the upgrades included in the 2036 model.

Table 5-1 Future Year Model Infrastructure List (from the draft 2036 Plan)

#	Locations (2036 Draft Plan Reference)	Description (subject to further investigation and detailed design)	Included in the model?	Modelling interim outcome
1	Intersection on Herbert Street near RNSH and Railway Bridge (P1)	New pedestrian crossing treatment. Existing zebra crossing converted to signalised crossing.	Yes	Operates satisfactorily in 2026 By 2036, there is a potential to cause queue spillback in the AM peak to the Pacific Highway depending on the timing and frequency of the signalised crossing.
2	Intersection of Canberra Avenue and River Road (P4)	New signalised intersection and crossing. Signalised crossing implemented to facilitate a north-south movement to the west of Canberra Avenue / River Road. East-west movement south of the intersection would also be signalised	Partially	Operates satisfactorily in 2026 / 2036 Partially included in the model as the model does not include the southern leg of the intersection.
3	Intersection of Willoughby Road and Atchison Street (P5)	New pedestrian treatments to existing intersection. Pedestrian refuge (north) and raised crossing with speed bumps (east, like Burlington Street)	Yes	Operates satisfactorily in 2026 / 2036
4	Willoughby Road south of Holtermann Street (P5)	New pedestrian crossing. Midblock speed humps	Yes	Operates satisfactorily in 2026 / 2036
5	Sergeants Lane and Christie Street Intersection (P6)	Kerb outstand. Kerbside widening on Sergeants Lane to allow for safer pedestrian movements and storage for signalised crossing	Yes	Operates satisfactorily in 2026 / 2036
6	Intersection of Oxley Street and Pacific Highway (P7)	Pedestrian crossing, north west leg. This improves pedestrian connectivity and capacity near the (under construction) Crows Nest Metro Station. Pedestrian crossing on north west leg and a dedicated right-turn for southbound vehicles on Pacific Highway within the existing carriageway due to reallocation of road space. The right turn movement from Pacific Highway into Oxley Street westbound is anticipated to reduce through movements on the Crows Nest local road network.	Yes	Operates satisfactorily in 2026 / 2036 Right turn lane queues in 2036: AM – Max: 9 vehicles, Mean: 3 vehicles. PM – Max: 9 vehicles, Mean: 3 vehicles.

#	Locations (2036 Draft Plan Reference)	Description (subject to further investigation and detailed design)	Included in the model?	Modelling interim outcome
7	Intersection of Oxley Street and Nicholson St (P7)	Intersection upgrades for pedestrians and cyclists. Midblock elevated speed bumps	Yes	Operates satisfactorily in 2026 / 2036
8	Intersection of Nicholson Street and Shirley Road (P8)	Provide intersection treatment for pedestrians or cyclists crossing Shirley Road (refuge/signals). Elevated crossing and speed bumps on Shirley North Approach, after the keep clear area	No	A zebra crossing on Shirley Road is not legally possible given its four lane cross section. A signalised crossing would be difficult to coordinate with the Pacific Highway / Falcon Street intersection, adjacent driveways and intersections.
9	Intersection of Chandos Street and Christie Street (P10)	Pedestrian crossing treatments. Upgrade roundabout to signals and allow pedestrian crossing	No	There is no net traffic improvement by implementing signals as the queues regularly extend from the Pacific Highway to this intersection and beyond. Signalising the intersection may require land acquisition for a small benefit to pedestrians and no benefit to the traffic network.
10	Chandos Street and Atchison St intersections with Mitchell Street (P10)	Pedestrian crossing treatments. The full extent of Mitchell Street is not included in the model due to the corridor function (local road typically accommodating low volumes).	No	It is noted that the upgrade has been recently installed and is already operational. No traffic issues anticipated as forecast volumes on Mitchell are likely to cope with this infrastructure change
11	Intersection of Chandos Street and Oxley Street (P10)	Pedestrian crossing treatments. Refuge on north and south approaches can be considered subject to parking bans	No	Refuge islands would maintain priority for vehicles over pedestrians and therefore there is no impact to the traffic network.
12	Intersection of Chandos Street and Willoughby Road (P10)	Pedestrian crossing (signalised), north leg.	Yes	The intersection is already experiencing delays and failing to perform at acceptable LOS at present. The introduction of the additional pedestrian crossing constrains signal phasing time allocated to traffic. Some deterioration of existing performance is prevalent due to the additional pedestrian phase and increased volumes but the crossing can be accommodated without causing the intersection to fail.
13	Pacific Highway near Portview Road (R1)	Signalised pedestrian crossing.	Yes	Operates satisfactorily in 2026 / 2036
14	Intersection of Pacific Highway and Reserve Road (R2)	Signalised pedestrian improvement. Signalised pedestrian crossing on the west approach.	No	Not implemented as it is not feasible to add new crossing on eastern side given the congestion and traffic volumes using this intersection. New pedestrian crossing on eastern side would require changes to the signal phasing reducing green time on Pacific Highway and/or Reserve Road.
15	Intersection of Pacific Highway and Herbert Street (R3)	Signalised pedestrian improvement. Signalised pedestrian crossing on the east approach.	No	Not implemented as the model indicates that the additional crossing on eastern side would not be feasible due to the traffic volumes. The crossing would require significant changes to the signal phasing and reduce time for traffic.

#	Locations (2036 Draft Plan Reference)	Description (subject to further investigation and detailed design)	Included in the model?	Modelling interim outcome
16	Intersection of Christie and Pacific Highway (R4)	Signalised pedestrian improvement. Pedestrian and cycleway crossing on the west approach	No	Not implemented as an additional western crossing would not be feasible as it would impact signal timing, reducing time for traffic on Christie Street or Pacific Highway.
17	Intersection of Pacific Highway and Albany Street (R5)	Signalised pedestrian improvement. Kerb widening on Albany Street to shorten crossing distance	No	More information is required to model the suggested kerb extension (outstand). The intersection may support a small kerbside extension on the north side of Albany St by approximately 2m. Traffic turning into Albany Street already use this section as “wide single lane”. However, the feasibility of the kerb extension is subject to a swept path analysis to confirm that heavy vehicles would be able to safely turn into Albany Street. No impact to traffic flows.
18	Intersection of Pacific Highway, Shirley Road, and Falcon Street (R7)	Signalised pedestrian improvement. Alteration of five-way intersection to support vehicular traffic movement.	No	Layout for proposed geometry and treatments are required. This intersection is part of a complex coordination with two other intersections in close proximity to each other and is constrained and causing significant congestion on Falcon Street and Shirley Road. Consideration should be given to upgrading this intersection as it constitutes the main pinch point for traffic within the modelled network. However, it is not clear what a feasible upgrade would consist of.
19	St Leonards Station (6)	Improved pedestrian and cyclist facilities, kiss and ride areas, and taxi zones.	No	No impacts to the traffic network are anticipated provided that these upgrades are delivered via changes to kerb side parking regulations (e.g. – taxi zones / kiss and ride zones) or improvements to pedestrian and cycling infrastructure next to the station (i.e. – no change to the road network).
20	Bus stop between Oxley Street and Hume Street (east side) (1)	Relocate bus stops near Sydney Metro Station.	No	Small capacity improvements to traffic would be achieved in the model. It has not been included in the model conservatively to account for the potential increase in bus stoppage time from increased patrons due to Sydney Metro.
21	Bus stops between Hume Street and Shirley Street (west side) (2)	Consolidate two bus stops near Sydney Metro Station.	No	As above
22	Intersection of Oxley Street and Clarke Street (8)	New pedestrian crossing. Raised pedestrian crossing with speed bumps all approaches	Yes	Operates satisfactorily in 2026 / 2036
23	Intersection of Oxley Street and Atchison Street (9)	New pedestrian treatment. Raised pedestrian crossing with speed bumps all approaches	Yes	Operates satisfactorily in 2026 / 2036
24	Intersection of Oxley Street and Albany Street (7)	New pedestrian crossing legs. Elevated pedestrian crossing with speed bumps all approaches	Yes	Already existing. Operates satisfactorily in 2026

Figure 5-2 Future Model Infrastructure Upgrade Locations

Table 5-2 Upgrade #1 – Herbert Street

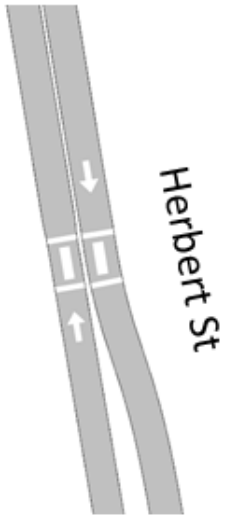
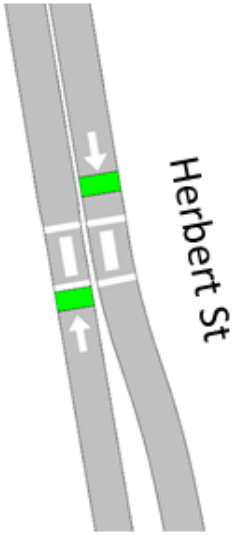
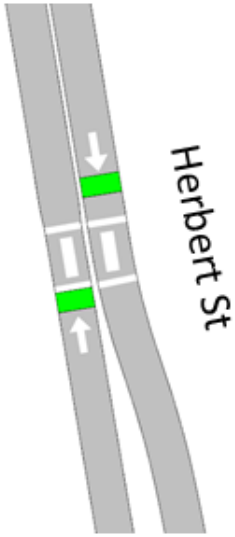
2016	2026	2036
		
	• Convert zebra pedestrian crossing to signalised pedestrian crossing	• No further changes from 2026

Table 5-3 Upgrade #2 – Canberra Avenue / River Road

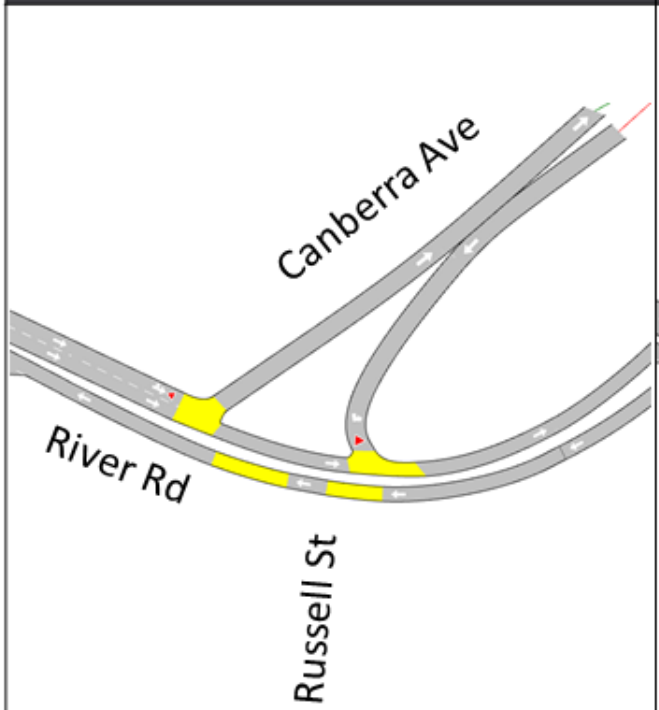
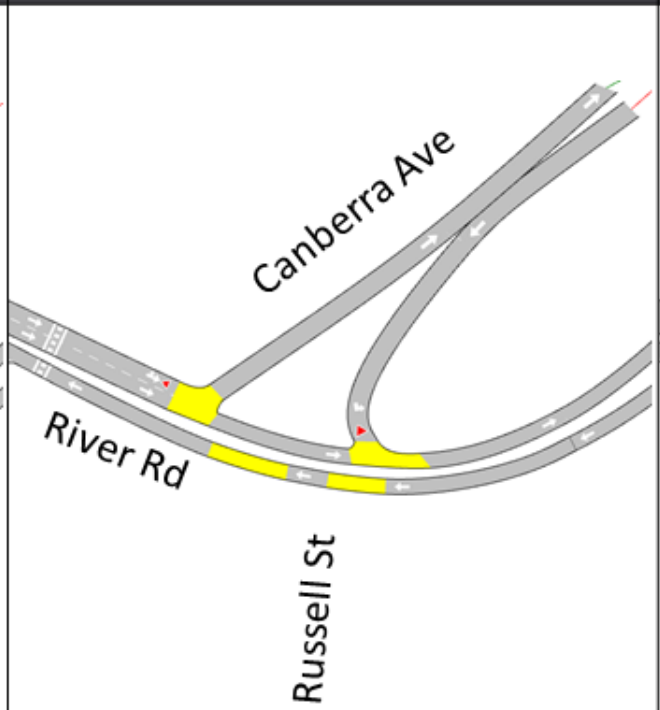
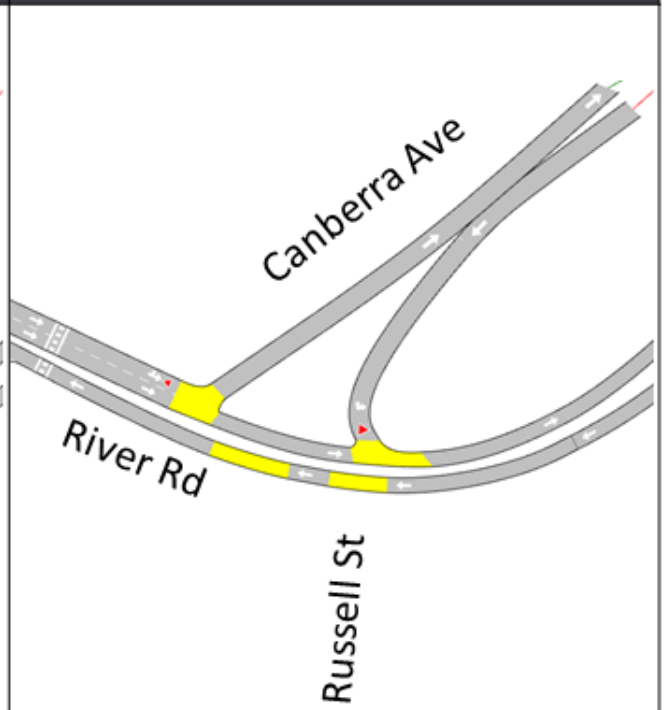
2016	2026	2036
		
	• New signalised crossing to the west • Signalised crossing on Russell Street	• No further changes from 2026

Table 5-4 Upgrade #3 – Willoughby Road / Atchison Street

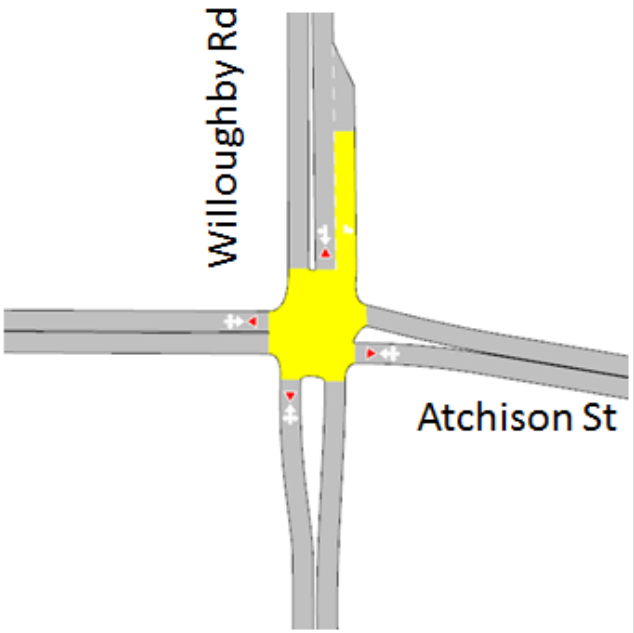
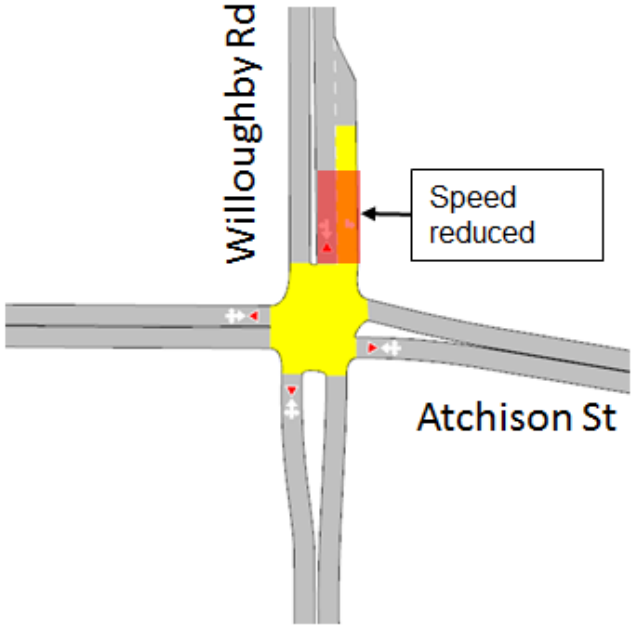
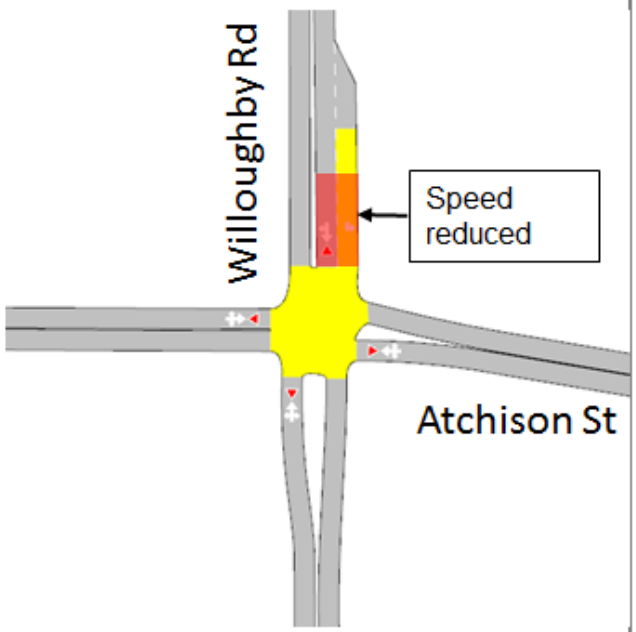
2016	2026	2036
		
	• Pedestrian refuge (north – no impact to model) • Raised crossing with speed bump	• No further changes from 2026

Table 5-5 Upgrade #4 – Willoughby Rd (south of Holtermann St)

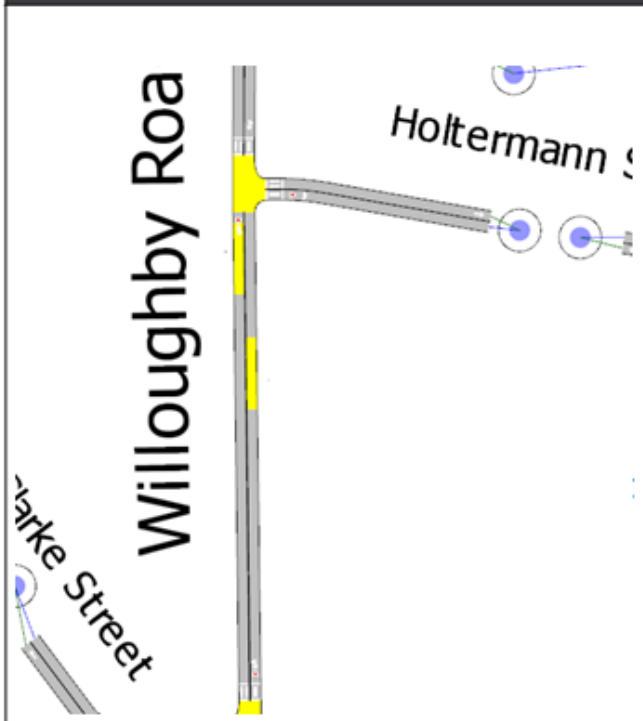
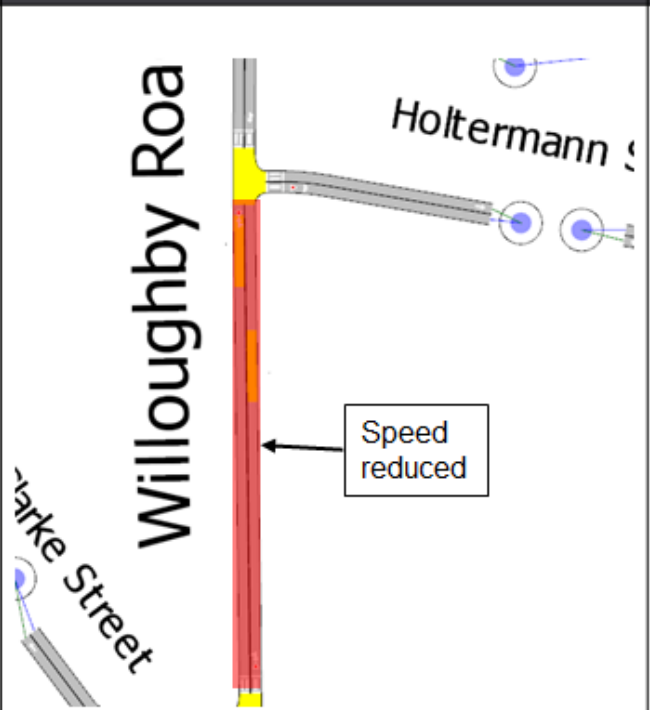
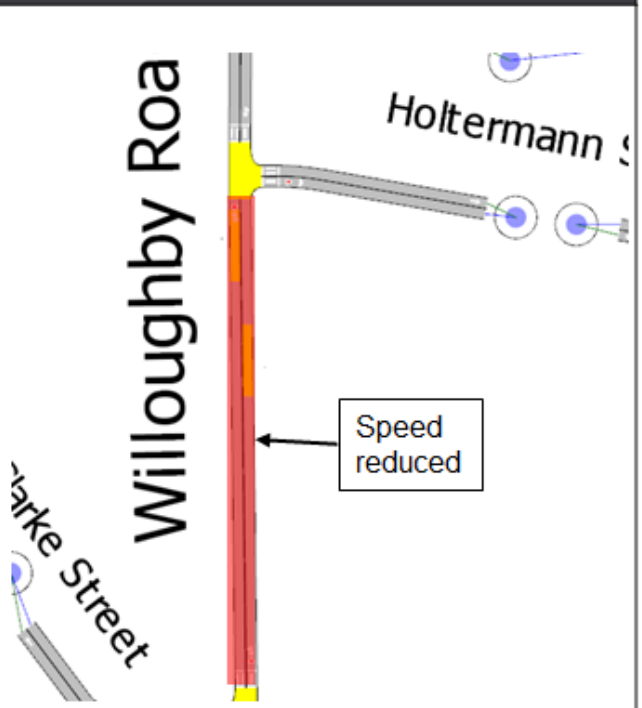
2016	2026	2036
		
	• Speed manually reduced on Willoughby (south of Holtermann St) to account for improved pedestrian crossing opportunities and consequent contribution to a slower speed environment.	• No further changes from 2026

Table 5-6 Upgrade #5 – Sergeants Lane and Christie Street Intersection

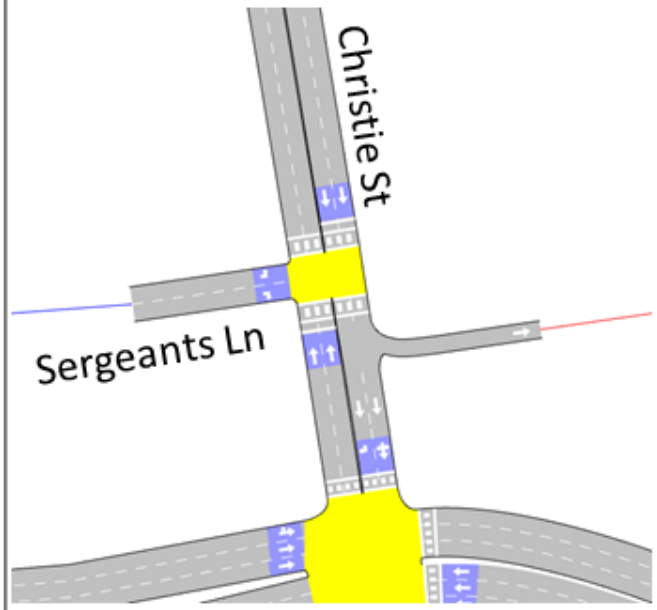
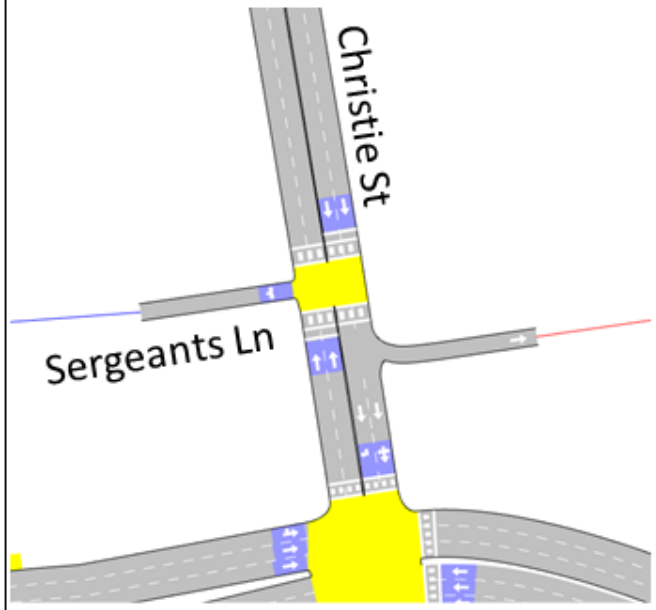
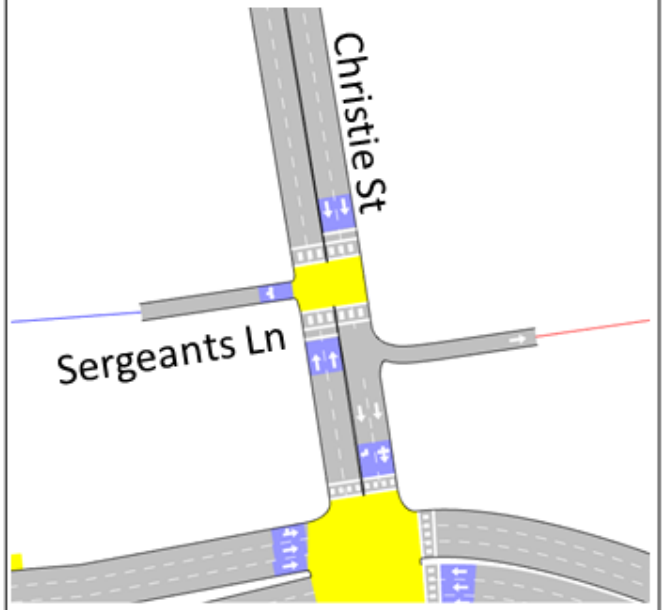
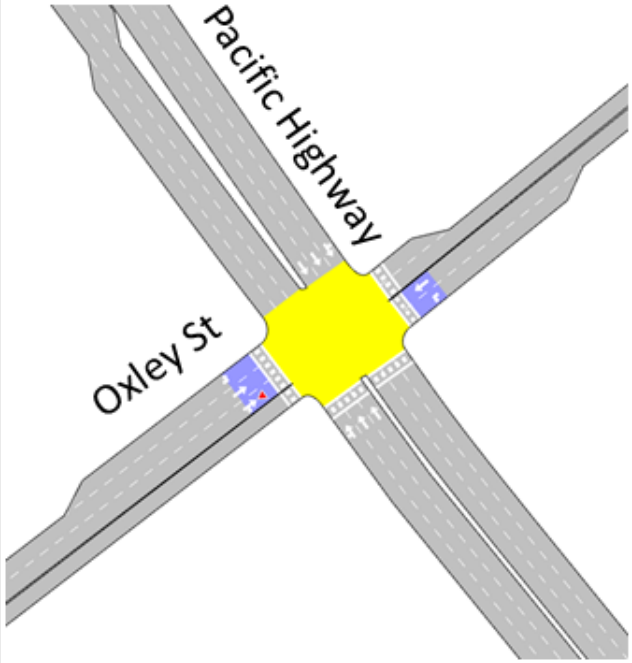
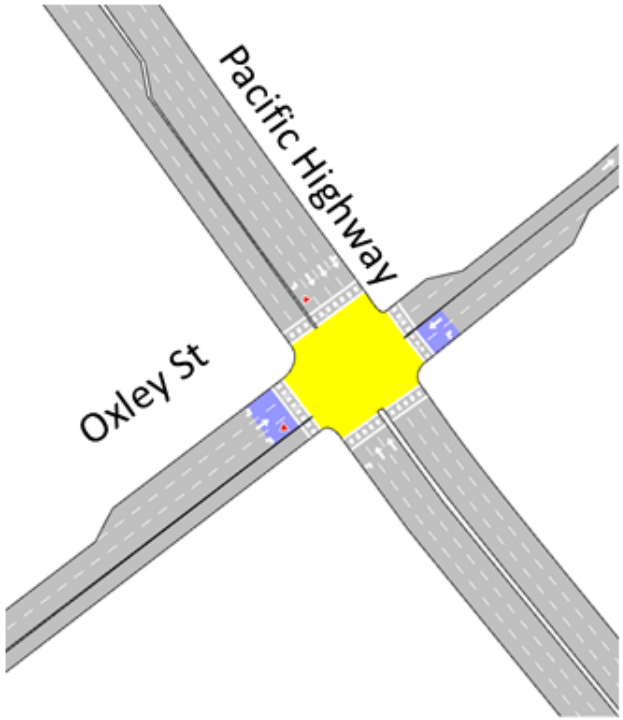
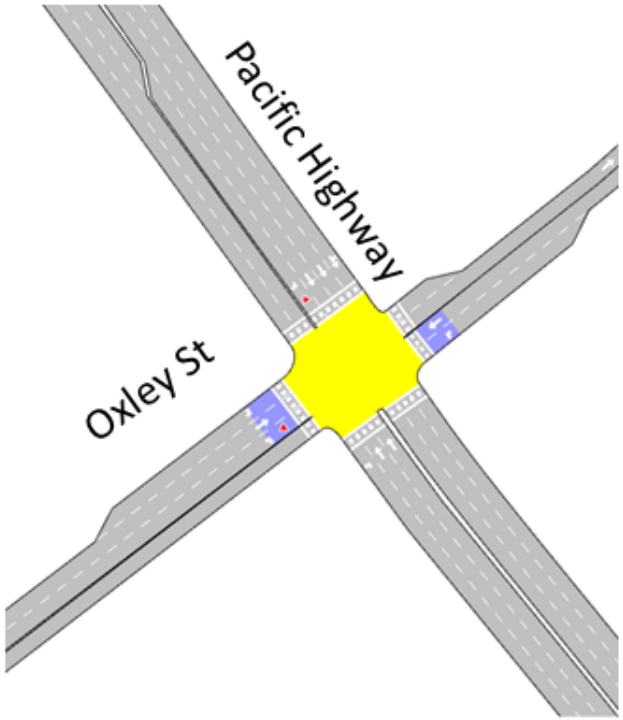
2016	2026	2036
		
	• Sergeants lane reduced to single lane to allow for kerb outstand	• No further changes from 2026

Table 5-7 Upgrade #6 – Oxley Street / Pacific Highway

2016	2026	2036
		

• Existing Cycle:
  • AM: 134s | 136s
  • PM: 132s | 138s
	• Additional Filter RT with RT Bay and reduced northbound departure lane to two lanes
	• Cycle Time:
	  • AM: 134s | 136s
	  • PM: 132s | 138s
		• No further geometry changes from 2026
		• Cycle Time:
		  • AM: 134s | 136s
		  • PM: 132s | 138s

Table 5-8 Upgrade #7 – Oxley Street / Nicholson Street

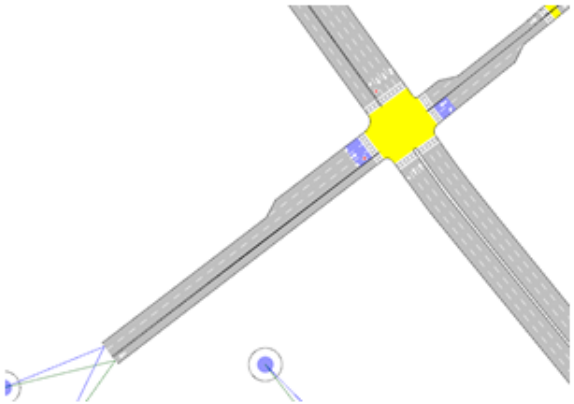
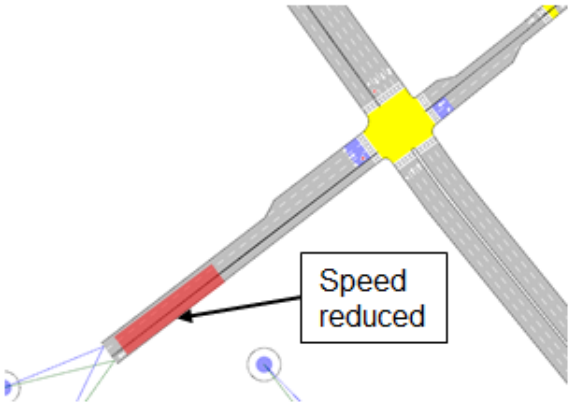
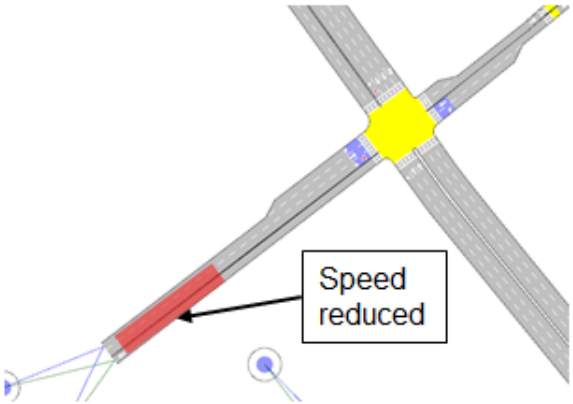
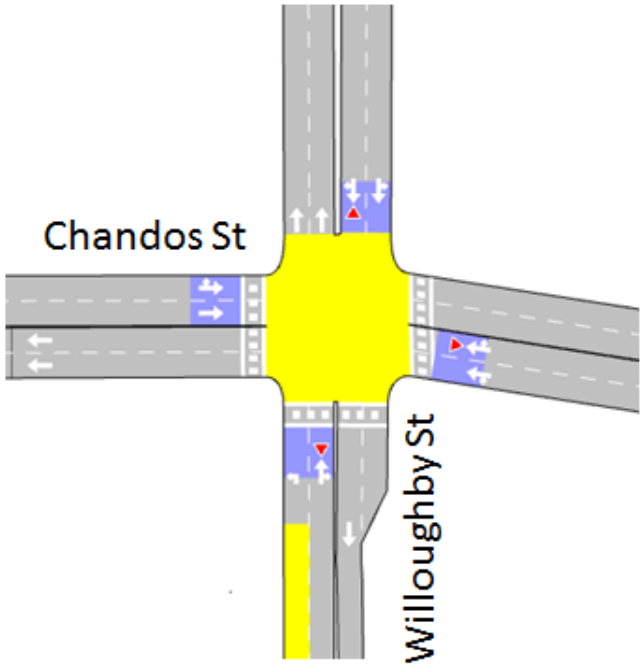
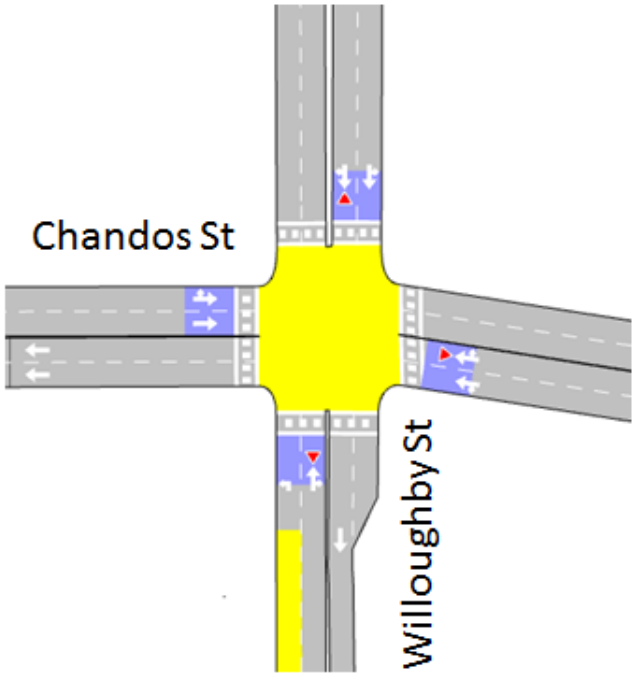
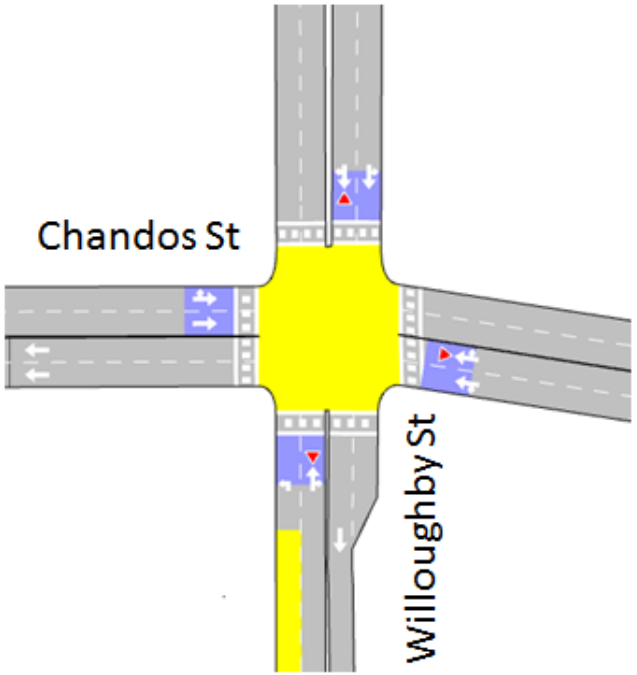
2016	2026	2036
		
	• Midblock elevated speed bumps	• No further changes from 2026

Table 5-9 Upgrade #12 – Chandos Street / Willoughby Street

2016	2026	2036
		

• Existing Cycle Time:
  • AM: 67s | 68s
  • PM: 66s | 69s
	• Pedestrian crossing added to north approach
	• Cycle Time:
	  • AM: 67s | 68s
	  • PM: 66s | 69s
		• No further geometry change from 2026
		• Cycle Time:
		  • AM: 67s | 68s
		  • PM: 66s | 69s

Table 5-10 Upgrade #13 – Pacific Highway near Portview Rd

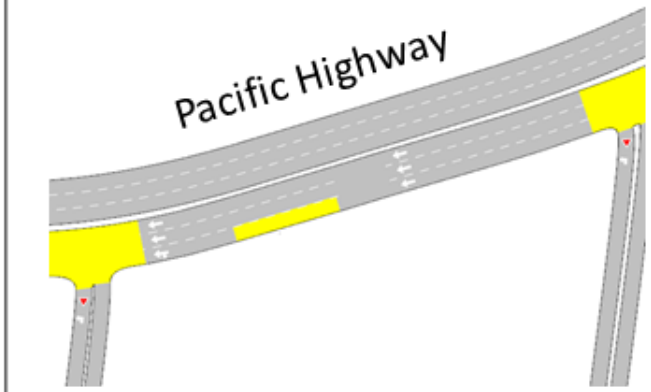
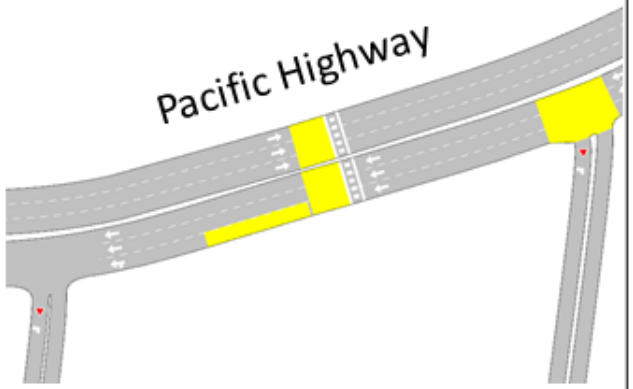
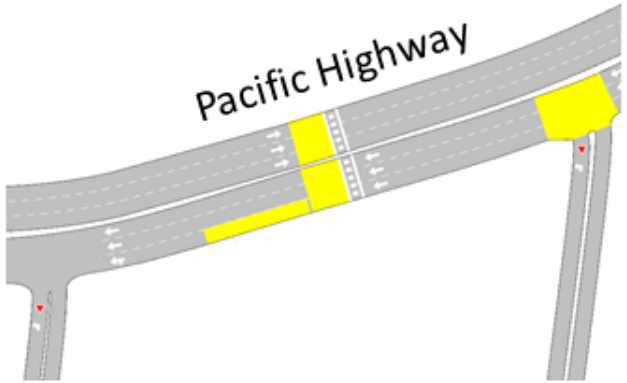
2016	2026	2036
		
	• New signalised pedestrian crossing	• No further changes from 2026

Table 5-11 Upgrade #22 – Oxley Street / Clarke Street

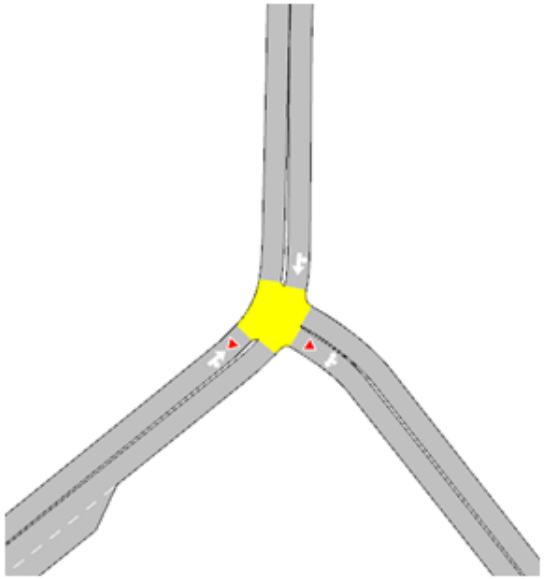
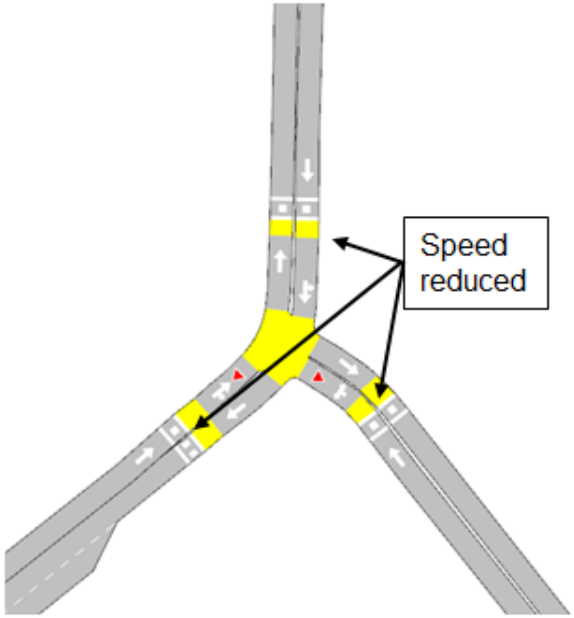
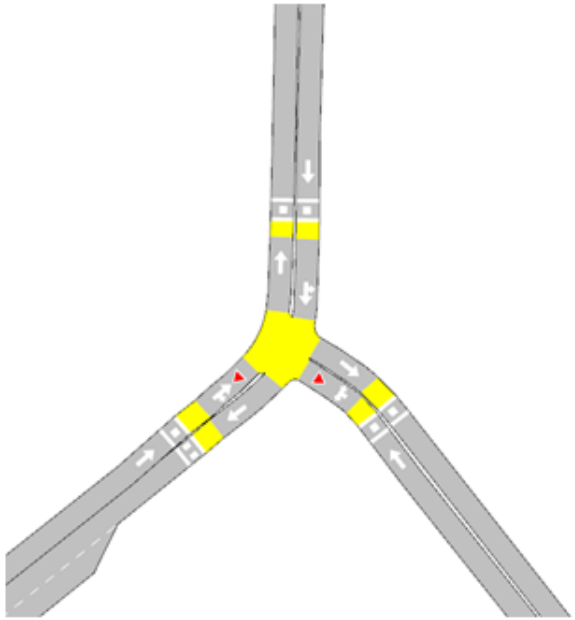
2016	2026	2036
		
	• New pedestrian crossing with raised speed bumps on all approaches	• No further changes from 2026

Table 5-12 Upgrade #23 – Oxley Street / Atchison Street

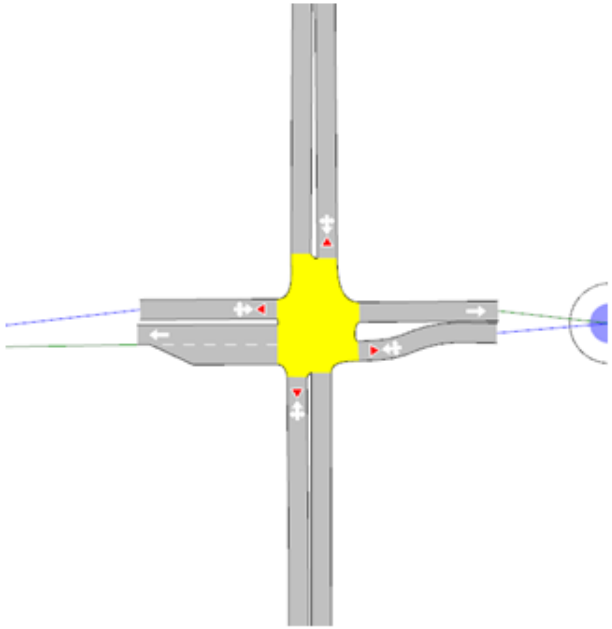
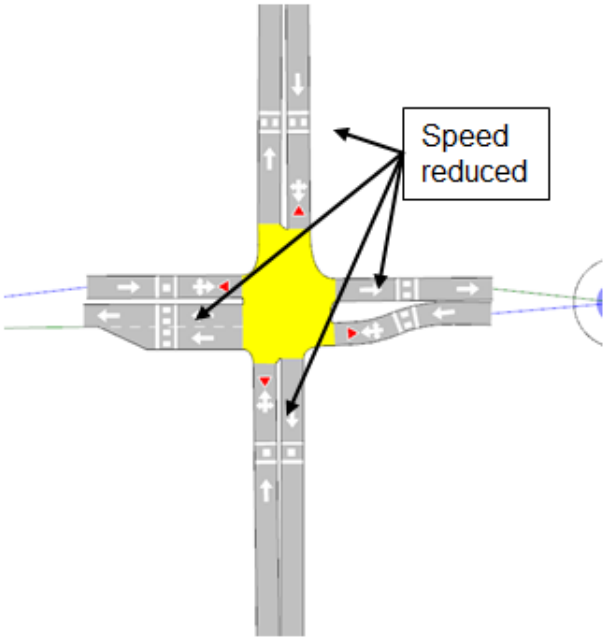
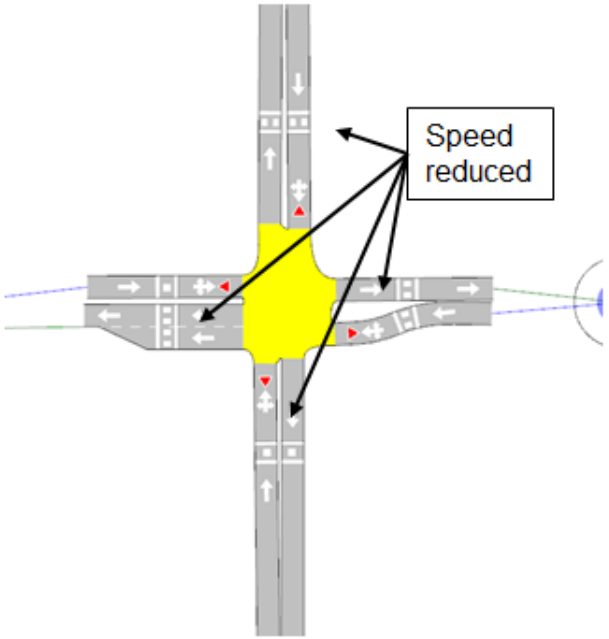
2016	2026	2036
		
	• New pedestrian crossing with raised speed bumps on all approaches	• No further changes from 2026

Table 5-13 Upgrade #24 – Oxley Street / Albany Street

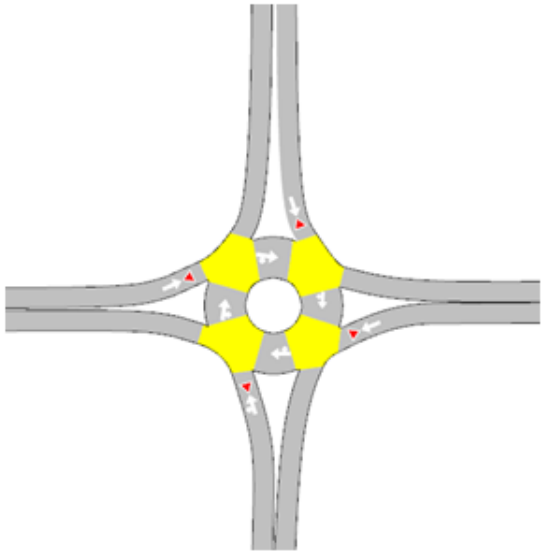
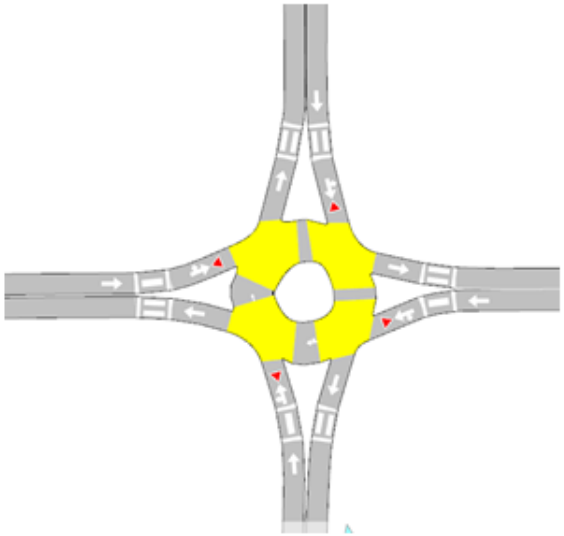
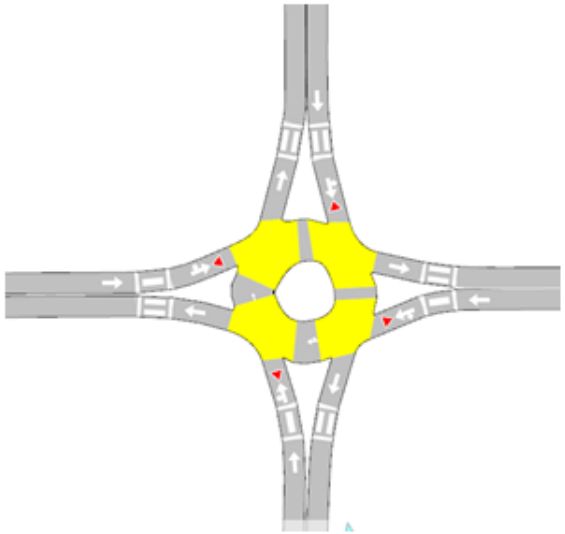
2016	2026	2036
		
	• New pedestrian crossing with raised speed bumps on all approaches • Operational since 2019	• Insufficient capacity in 2036 – refer to upgrade 28

Table 5-14 2036 Additional Upgrades

#	Locations	Description	Upgrade Rationale
25	Chandos Street between Oxley and Willoughby Road	Dual westbound lanes along Chandos Street from Willoughby Road to Mitchell Street (including a dual circulating lane for the westbound direction of the roundabout). This will require the removal of parking in the AM peak (consideration could be given to retain parking in the PM)	There is a heavy westbound traffic in the AM peak along Chandos Street. Without the proposed upgrade, this results in a queue spill back extending as far as the Warringah Freeway interchange and surrounding local roads.
28	Intersection of Oxley Street and Albany Street	Upgrade of the intersection from roundabout to signals. Parking banned between Pacific Highway and Willoughby Road to enable two lanes in each direction. Modifications to the kerbside geometry will be required.	The pedestrian crossings and traffic volume at the roundabout would cause queue spillback into Pacific Highway on the Oxley Street and Albany Street approaches. This would result in significant delays along Pacific Highway. Signalising the intersection will also improve pedestrian access and safety to cater for 2036 traffic conditions. Appropriate green time can be allocated to all traffic movements and pedestrian phases and balanced accordingly (in contrast with an unregulated flow of pedestrians, increased to the proximity to the Metro station, with priority over vehicles)
29	Short lane for the right turn into RNSH on Herbert Street	Removal of 30m of parking in the AM peak to allow for southbound through vehicles to go around right turning vehicles. Parking can be retained in the PM peak.	Herbert Street serves as a critical north-south corridor in 2036. High volumes of northbound traffic cause difficulty for southbound right turning accessing RNSH. Without the dedicated right turn bay, southbound right turning vehicles are likely to block southbound traffic.
31	Greenwich Road midblock between River Road and Pacific Highway	Parking bans in the northbound direction on Greenwich Road in the PM peak. Subject to a road safety assessment on vertical alignment and speeds. There is considerable congestion on Pacific Highway in the AM peak, reducing the effectiveness of the parking bans if it was introduced in the AM peak as well.	Due to the long cycle times at the Greenwich Road / Pacific Highway, storage on Greenwich Road becomes a critical factor in preventing queues from spilling across Greenwich Road / River Road intersection. The removal of parking greatly increases storage capacity of the road in addition to improving queue recovery. Consideration can be given to retain parking in the AM peak.
35	Pacific Highway Clearway	Southbound Clearway along Pacific Highway between Albany Street and Falcon Street (PM peak)	The Clearway would facilitate increased throughput of the intersections along Pacific Highway and would allow for reallocation of green time at the traffic signals for a balance between pedestrian crossings/ side road movement and the highway.

Figure 5-3 2036 Additional Upgrade Locations

Table 5-15 Upgrade #25 – Chandos Street / Oxley Street

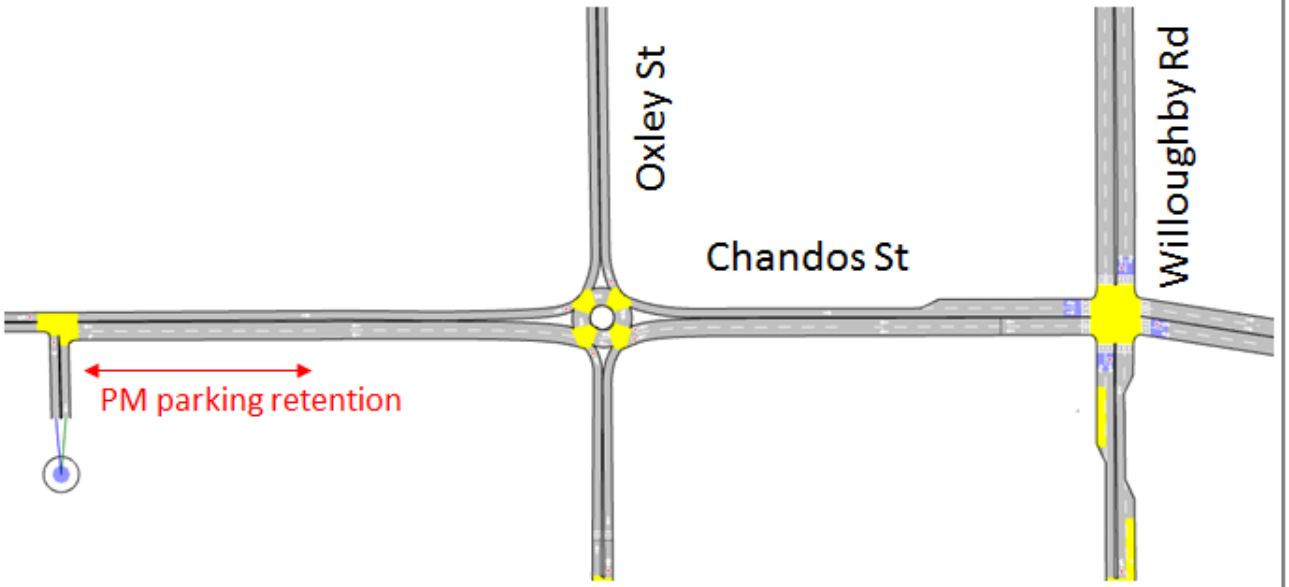
2016 & 2026	2036
	
	• Dual westbound lanes along Chandos Street from Willoughby Road to Mitchell Street (including a dual circulating lane for the westbound direction of the roundabout). This will require the removal of parking. Some parking may be retained in the PM peak.

Table 5-16 Upgrade #28 – Oxley Street / Albany Street

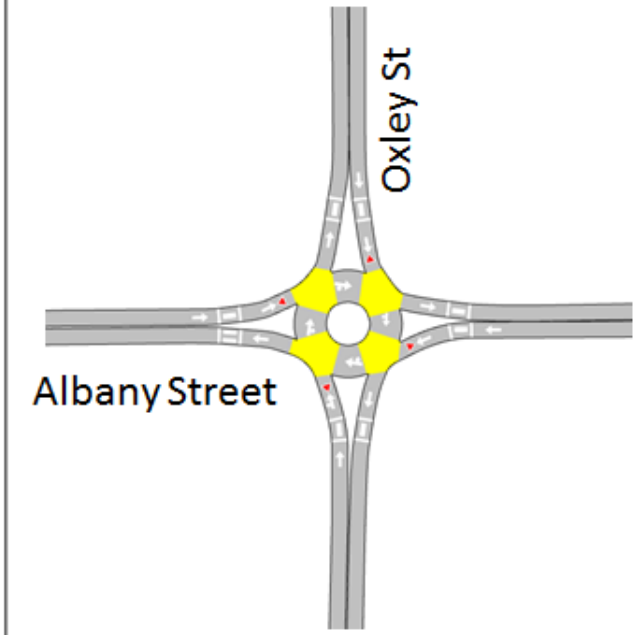
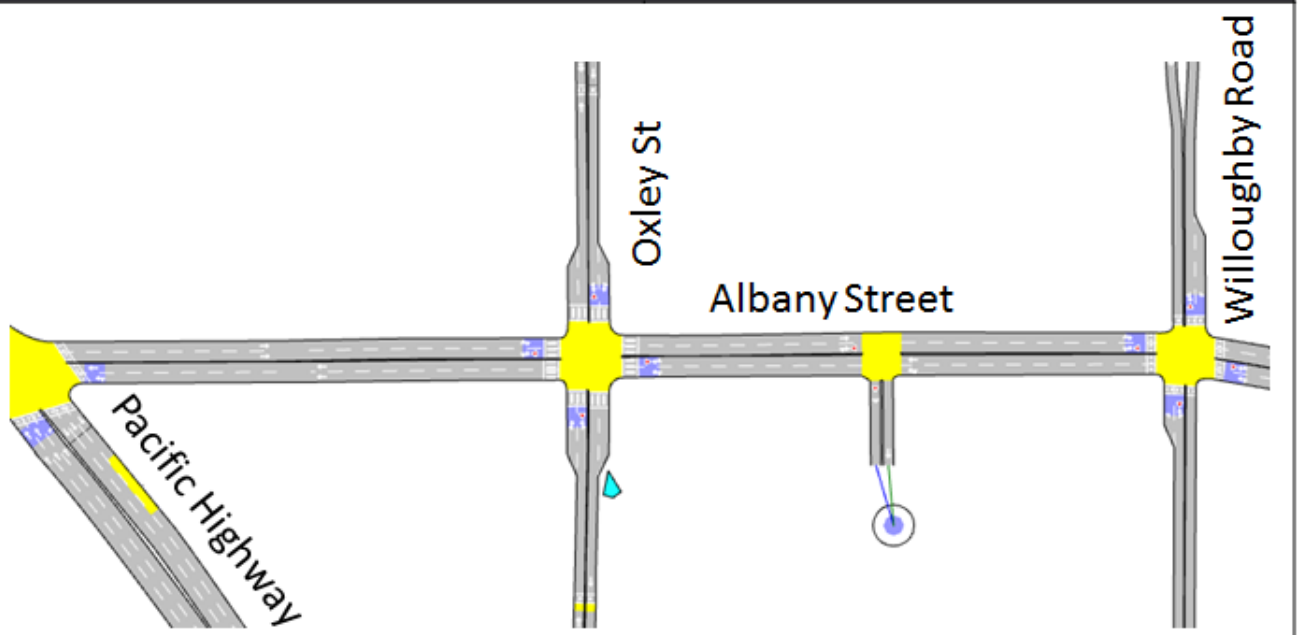
2016 & 2026	2036
	
	• Upgrade of the intersection from roundabout to signals. Parking banned between Pacific Highway and Willoughby Road to enable two lanes in each direction on Albany Street. Modifications to the kerbside geometry will be required.

Table 5-17 Upgrade #29 – Herbert Street / Westbourne Street

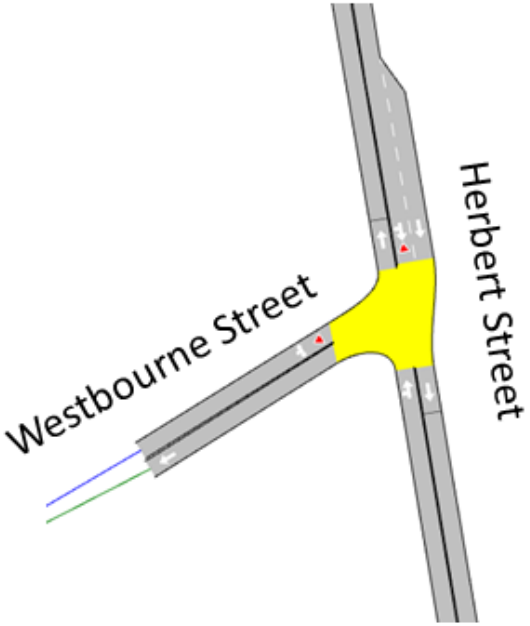
2016 & 2026	2036
	
	• Removal of 30m of parking in the AM peak to allow for southbound through vehicles to go around right turning vehicles. Parking can be retained in the PM peak.

Table 5-18 Upgrade #31 – Greenwich Road

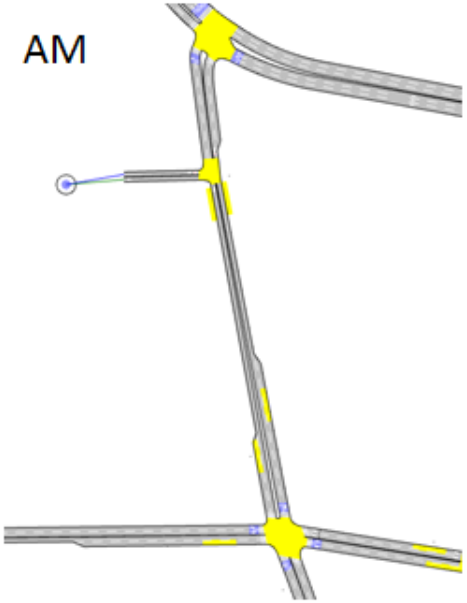
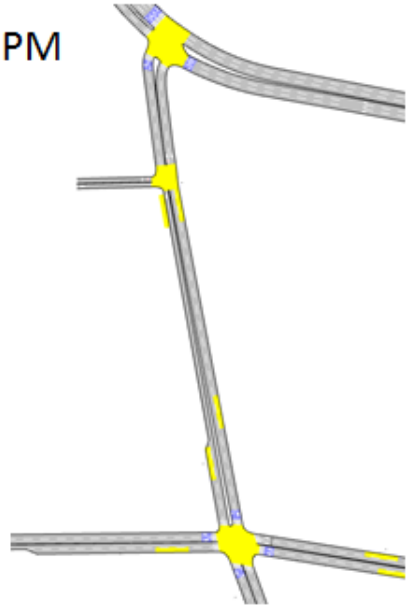
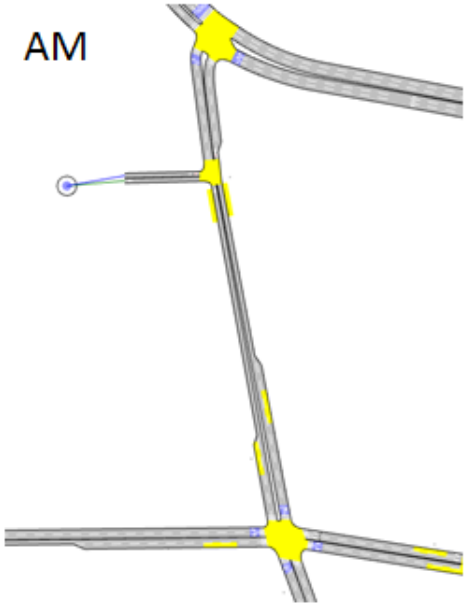
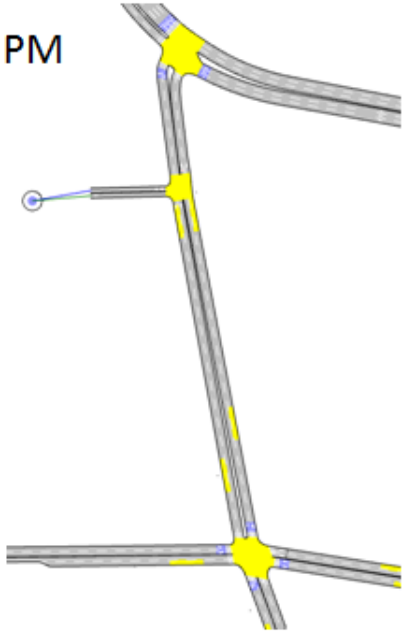
2016 & 2026		2036	
AM 	PM 	AM 	PM 
		• No changes from existing and 2026	• Northbound parking removal

Table 5-19 Upgrade #35 – Pacific Highway Clearway

2016 & 2026	2036
	
	• Clearways (PM) along Pacific Highway between Albany Street and Falcon Street in the southbound direction

5.2 2026 Performance

5.2.1 Network Statistics (2026)

The network statistics for the 2026 future model are summarised in **Table 5-20**.

Table 5-20 Network Performance Results (2026)

Network Performance Measurements	2026 Model	
	AM Peak	PM Peak
All vehicles		
Total traffic demand (vehicles)	28,993	22,635
Total vehicle kilometres travelled in network (kilometres)	42,695	42,438
Total vehicle travel time (hours)	2,634	2,406
Total delay (hours)	1,936	1,734
Total vehicles arrived	27,439	21,048
Total number of stops	108,778	97,555
Average per vehicle in network		
Average vehicle kilometres travelled in network (kilometres)	1.6	2.0
Average time travelled in network(minutes)	5.8	6.9
Average number of stops	4.0	4.6
Average speed (kilometres per hour)	20.2	22.8
Unreleased vehicles		
Unreleased demand (vehicle)	340	537
Per cent of total traffic demand	1.2%	2.4%

5.2.2 Travel Times and Speed (2026)

The travel times and speeds for the 2026 model are provided in **Table 5-21** and **Table 5-22** for the AM and PM peak respectively.

Table 5-21 Travel Time and Speeds – AM Peak (2026)

Route	Direction	Modelled Time			
		7:30am to 8:30am		8:30am to 9:30am	
		Travel Time (mm:ss)	Speed (km/h)	Travel Time (mm:ss)	Speed (km/h)
Route 1: Pacific Highway between Hotham Parade and Bruce Street					
Bruce St – Falcon St	Northbound	0:43	30	0:42	31
Falcon St – Albany St	Northbound	1:08	33	1:08	38
Albany St – Park Ln	Northbound	1:57	21	2:25	18
Park Ln – Westbourne St	Northbound	1:27	26	1:06	34
Westbourne St – Hotham St	Northbound	1:36	41	1:43	40
Bruce St – Hotham St	**Northbound**	**6:51**	**26**	**7:04**	**25**
Hotham St – Westbourne St	Southbound	1:51	37	1:54	36
Westbourne St – Herbert St	Southbound	2:49	18	4:37	12
Herbert St – Albany St	Southbound	0:54	30	1:03	27
Albany St – Bruce St	Southbound	2:00	29	2:38	22
Hotham St – Bruce St	**Southbound**	**7:36**	**23**	**10:13**	**17**

Table 5-22 Travel Time and Speeds – PM Peak (2026)

Route	Direction	Modelled Time			
		4:45pm to 5:45pm		5:45pm to 6:45pm	
		Travel Time (mm:ss)	Speed (km/h)	Travel Time (mm:ss)	Speed (km/h)
Route 1: Pacific Highway between Hotham Parade and Bruce Street					
Bruce St – Falcon St	Northbound	0:49	26	1:00	18
Falcon St – Albany St	Northbound	1:27	25	1:37	27
Albany St – Park Ln	Northbound	1:29	30	1:44	26
Park Ln – Westbourne St	Northbound	1:26	25	1:18	28
Westbourne St – Hotham St	Northbound	2:04	32	1:52	37
Bruce St – Hotham St	**Northbound**	**7:15**	**25**	**7:31**	**23**
Hotham St – Westbourne St	Southbound	1:45	38	1:39	40
Westbourne St – Herbert St	Southbound	1:58	26	2:03	28
Herbert St – Albany St	Southbound	0:55	26	1:04	21
Albany St – Bruce St	Southbound	2:40	17	3:25	13
Hotham St – Bruce St	**Southbound**	**7:19**	**24**	**8:12**	**21**

5.2.3 Density (2026)

The density plots for the 2026 model are shown in **Figure 5-4** and **Figure 5-5** for the AM and PM Peak.

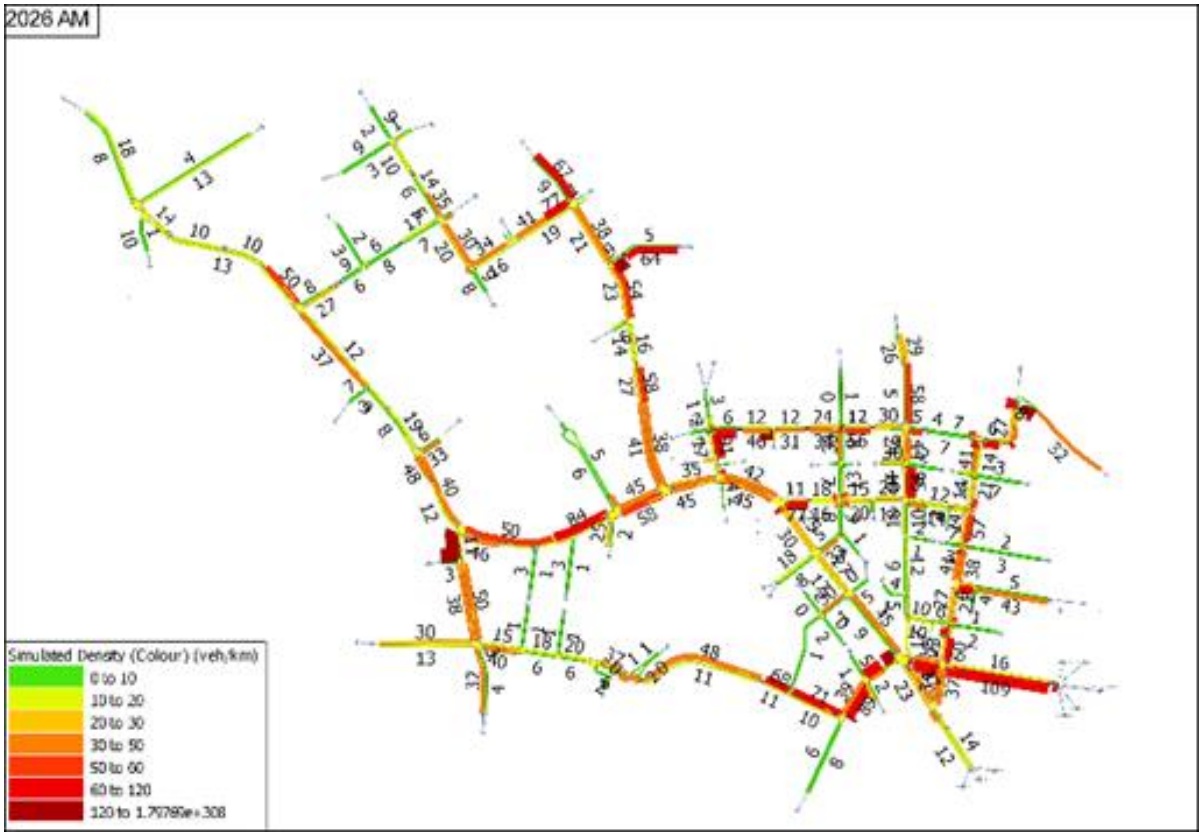


Figure 5-4 Density Plot – AM Peak (2026)

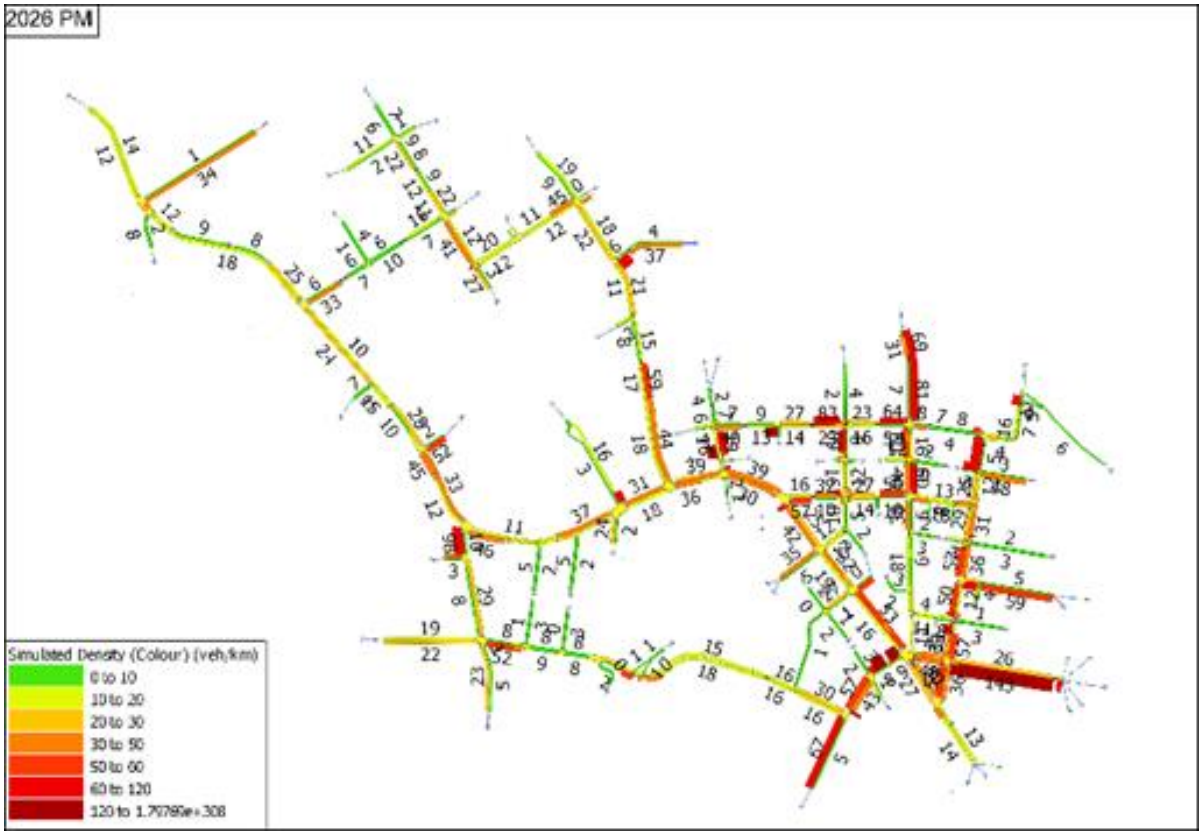


Figure 5-5 Density Plot – PM Peak (2026)

5.3 2036 Performance

5.3.1 Network Statistics (2036)

The network statistics for the 2036 scenario are summarised in **Table 5-23**.

Table 5-23 Network Performance Results (2036)

Network Performance Measurements	2036 Model	
	AM Peak	PM Peak
All vehicles		
Total traffic demand (vehicles)	33,826	26,178
Total vehicle kilometres travelled in network (kilometres)	43,407	44,590
Total vehicle travel time (hours)	3,304	3,445
Total delay (hours)	2,761	2,923
Total vehicles arrived	28,149	21,493
Total number of stops	122,499	130,779
Average per vehicle in network		
Average vehicle kilometres travelled in network (kilometres)	1.5	2.1
Average time travelled in network(minutes)	7.0	9.6
Average number of stops	4.4	6.1
Average speed (kilometres per hour)	18.7	19.11
Unreleased vehicles		
Unreleased demand (vehicles)	3,853	2,709
Per cent of total traffic demand	11.4%	10.3%

5.3.2 Travel Times and Speed (2036)

The travel times and speeds for the 2036 model are provided in **Table 5-24** and **Table 5-25** for the AM and PM peak respectively.

Table 5-24 Travel Time and Speeds – AM Peak (2036)

Route	Direction	Modelled Time			
		7:30am to 8:30am		8:30am to 9:30am	
		Travel Time (mm:ss)	Speed (km/h)	Travel Time (mm:ss)	Speed (km/h)
Route 1: Pacific Highway between Hotham Parade and Bruce Street					
Bruce St – Falcon St	Northbound	0:47	29	0:41	32
Falcon St – Albany St	Northbound	1:16	29	0:51	44
Albany St – Park Ln	Northbound	1:46	22	1:30	28
Park Ln – Westbourne St	Northbound	1:37	22	1:09	34
Westbourne St – Hotham St	Northbound	1:27	44	1:36	42
Bruce St – Hotham St	**Northbound**	**6:11**	**26**	**5:48**	**30**
Hotham St – Westbourne St	Southbound	1:54	37	2:04	34
Westbourne St – Herbert St	Southbound	2:45	20	4:07	14
Herbert St – Albany St	Southbound	0:58	28	1:03	24
Albany St – Bruce St	Southbound	1:41	32	3:02	19
Hotham St – Bruce St	**Southbound**	**7:18**	**24**	**10:16**	**17**

Table 5-25 Travel Time and Speeds – PM Peak (2036)

Route	Direction	Modelled Time			
		4:45pm to 5:45pm		5:45pm to 6:45pm	
		Travel Time (mm:ss)	Speed (km/h)	Travel Time (mm:ss)	Speed (km/h)
Route 1: Pacific Highway between Hotham Parade and Bruce Street					
Bruce St – Falcon St	Northbound	0:49	26	1:22	21
Falcon St – Albany St	Northbound	1:40	25	3:36	16
Albany St – Park Ln	Northbound	1:36	26	1:49	24
Park Ln – Westbourne St	Northbound	1:36	22	1:01	39
Westbourne St – Hotham St	Northbound	2:18	29	2:02	33
Bruce St – Hotham St	**Northbound**	**8:00**	**22**	**9:50**	**18**
Hotham St – Westbourne St	Southbound	1:46	37	1:52	37
Westbourne St – Herbert St	Southbound	2:00	26	2:00	28
Herbert St – Albany St	Southbound	1:01	24	1:16	18
Albany St – Bruce St	Southbound	2:17	20	4:46	11
Hotham St – Bruce St	**Southbound**	**7:25**	**25**	**9:52**	**18**

5.3.3 Density (2036)

The density plots for the 2036 model are shown in **Figure 5-6** and **Figure 5-7** for the AM and PM Peak.

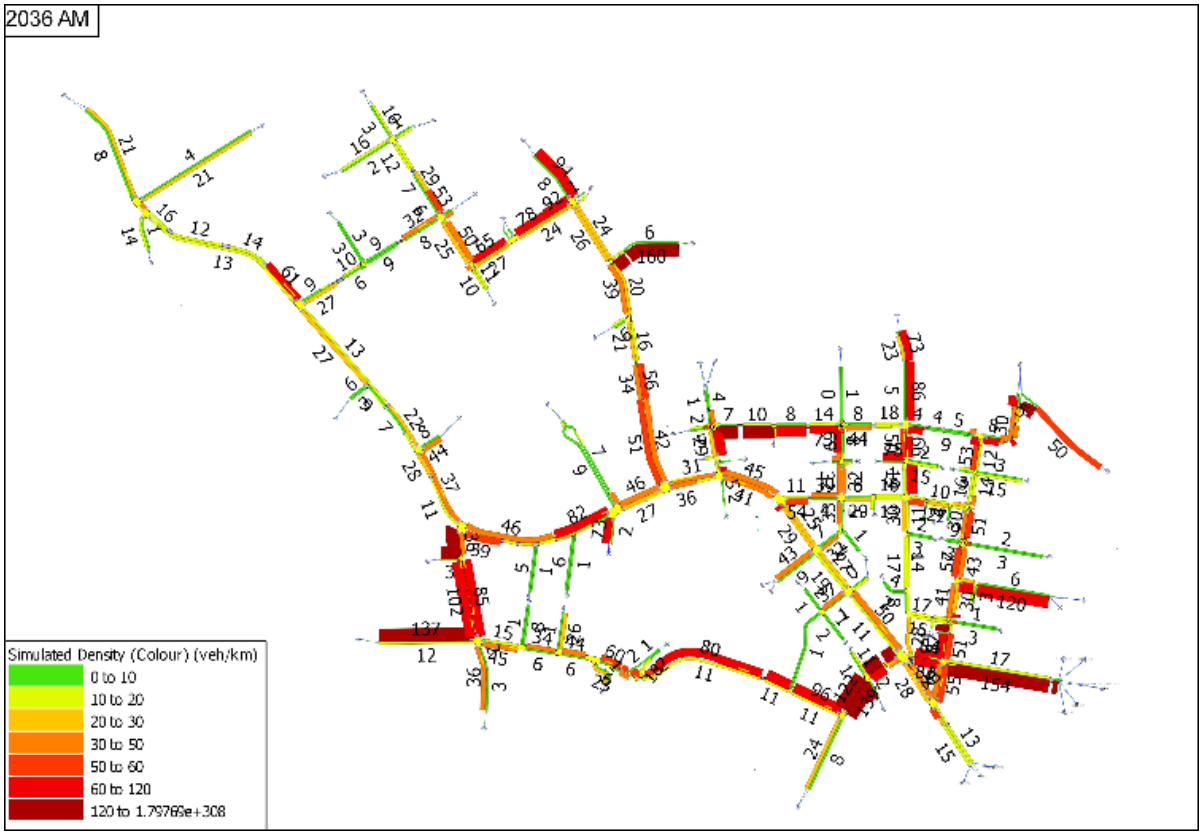


Figure 5-6 Density Plot – AM Peak (2036)

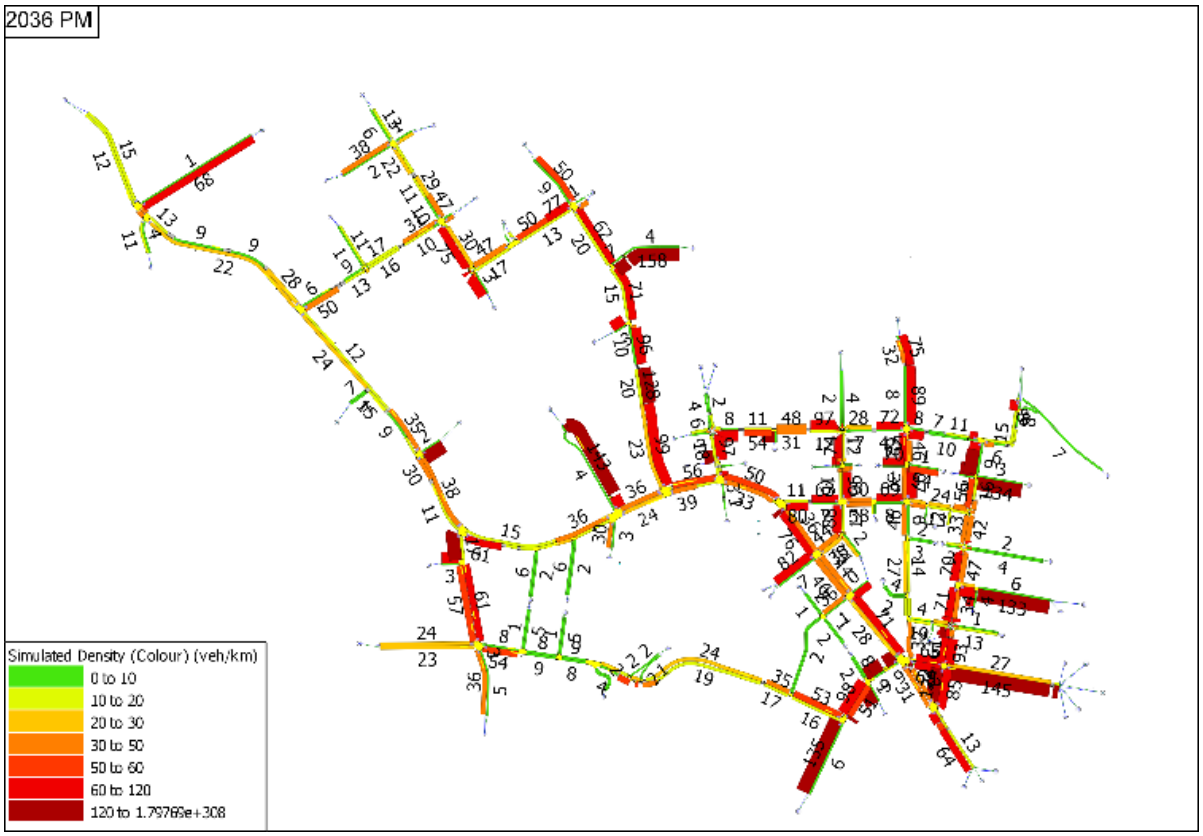


Figure 5-7 Density Plot – PM Peak (2036)

6 Results Comparison

This section describes the comparison of the results outlined in **Section 4** and **Section 5** between the three modelled years (2016, 2026 and 2036).

6.1 Network Performance Comparison

6.1.1 Overview

Table 6-1 summarises the 2016, 2026 and 2036 network performance results. The increased traffic growth over the future year scenarios result in a deterioration of the network operation for private vehicle operation. This is shown by the increased total delay, average time travelled in the network per vehicle, number of stops, unreleased demand and decrease in average speeds

Table 6-1 Network Performance Comparison

Network Performance Measurements	2016 Base Model		2026 Model		2036 Model	
	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
All vehicles						
Total traffic demand (vehicles)	25,781	21,141	28,993	22,635	33,826	26,178
Total vehicle kilometres travelled in network (kilometres)	39,635	39,555	42,695	42,438	43,407	44,590
Total vehicle travel time (hours)	1,915	1,796	2,634	2,406	3,304	3,445
Total delay (hours)	1,165	1,043	1,936	1,734	2,761	2,923
Total vehicles arrived	24,991	20,499	27,439	21,048	28,149	21,493
Total number of stops	68,962	96,335	108,778	97,555	122,499	130,779
Average per vehicle in network						
Average vehicle kilometres travelled in network (kilometres)	1.6	1.9	1.6	2.0	1.5	2.1
Average time travelled in network(minutes)	4.6	5.3	5.8	6.9	7.0	9.6
Average number of stops	2.8	4.7	4.0	4.6	4.4	6.1
Average speed (kilometres per hour)	24.9	26.6	20.2	22.8	18.7	19.11
Unreleased vehicles						
Unreleased demand (vehicles)	7	4	340	537	3,853	2,709
Per cent of total traffic demand	0%	0%	1.2%	2.4%	11.4%	10.3%

6.1.2 Unreleased demand

Unreleased demand consists of the number of vehicles attempting to enter the network but unable to do so due to congestion within the modelled network. The model will continue to attempt to release these vehicles to the network using the pre-determined entry point.

In real life, this would result in a combination of re-routing (as alternative routes become more economically viable / quicker), mode shift (as the delays outweigh the convenience to use private vehicle) and peak spreading (with drivers deciding to complete their trips earlier / later to avoid peak congestion). That is, the actual queue lengths on the extremities of the modelled networks would not reach the hypothetical ranges forecasted by traffic models of this nature based on the number of “unreleased vehicles”. Nevertheless, the unreleased demand is a valuable indicator to help quantify at what point an urban road network becomes saturated and how many trips need to convert to other routes, other modes or other times.

The outputs shown in **Table 6-1** show a modest increase in the number of unreleased vehicles by 2026. A more significant number of unreleased vehicles is shown under 2036 conditions (circa 3,800 and 2,700 in the AM and PM peaks respectively). These are spread across the network and include a combination of trips only passing by the precinct (through trips) and trips generated (starting or finishing) within the precinct. No substantial unreleased demand was observed on either direction of the Pacific Highway. This indicates that no severe impacts to through trips along the Pacific Highway are expected, other than the gradual deterioration of travel times as a result of additional pedestrian crossing requirements / signal phasing changes, the considerable increase in transport demand in the precinct and some modifications to intersection configurations.

Measures to encourage mode shift support improved road network performance and the intended road movement function and place function throughout the precinct. These need to be supported by constrained parking policies to further discourage private vehicle use to travel to/from/within the precinct. It is expected that this type of travel demand measures will assist in absorbing a substantial proportion of the unreleased demand via mode shift. Any residual demand is expected to experience re-routing and peak spreading until the transport network achieves equilibrium.

6.2 Travel Time Comparison

Table 6-2 and **Table 6-3** summarise the 2016, 2026 and 2036 travel time results for the first and second hour of the modelled peak period respectively. The results show that there is a general trend of increased travel times along Pacific Highway in the future years with 2036 having the worst travel times, despite the additional upgrades identified. On the second (worst) hour of the peak, these increase by 2 to 3 minutes (when compared to 2016) to travel the 3km along the Pacific Highway within the modelled network. It is important to note that this is based on a worst case scenario which excludes the additional mode shift that is likely to be achieved with travel demand strategies gradually introduced to the precinct, such as the proposed active transport infrastructure (pedestrian / cycling crossings and connections) and constrained parking policies.

Table 6-2 Travel Time Comparison (1st Hour)

Route	Direction	AM			PM		
		2016 (mm:ss)	2026 (mm:ss)	2036 (mm:ss)	2016 (mm:ss)	2026 (mm:ss)	2036 (mm:ss)
Route 1: Pacific Highway between Hotham Parade and Bruce Street							
Bruce St – Falcon St	Northbound	0:41	0:43	0:47	0:47	0:49	0:49
Falcon St – Albany St	Northbound	1:04	1:08	1:16	1:18	1:27	1:40
Albany St – Park Ln	Northbound	2:00	1:57	1:46	1:35	1:29	1:36
Park Ln – Westbourne St	Northbound	1:03	1:27	1:37	1:06	1:26	1:36
Westbourne St – Hotham St	Northbound	1:34	1:36	1:27	1:53	2:04	2:18
Bruce St – Hotham St	**Northbound**	**6:21**	**6:51**	**6:11**	**6:40**	**7:15**	**8:00**
Hotham St – Westbourne St	Southbound	1:52	1:51	1:54	1:45	1:45	1:46
Westbourne St – Herbert St	Southbound	2:12	2:49	2:45	3:47	1:58	2:00
Herbert St – Albany St	Southbound	0:53	0:54	0:58	0:54	0:55	1:01
Albany St – Bruce St	Southbound	2:33	2:00	1:41	2:25	2:40	2:17
Hotham St – Bruce St	**Southbound**	**7:21**	**7:36**	**7:18**	**7:06**	**7:19**	**7:25**

Table 6-3 Travel Time Comparison (2nd Hour)

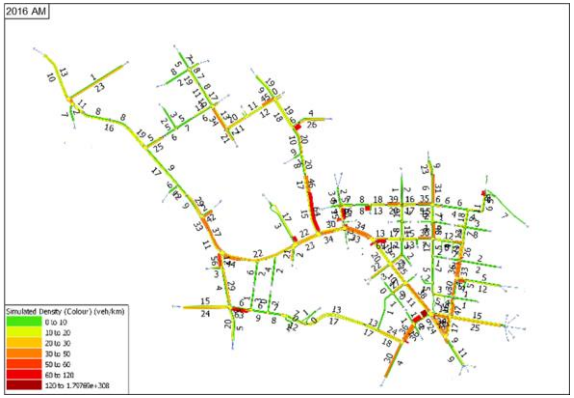
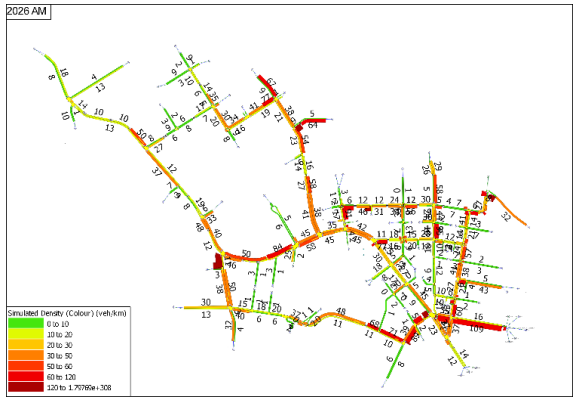
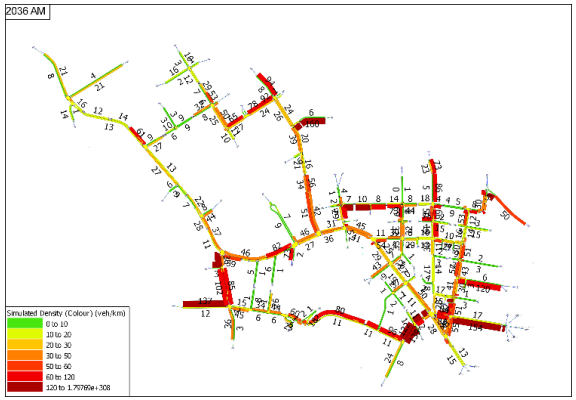
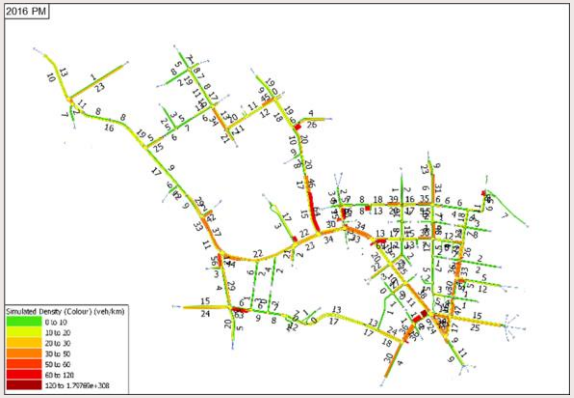
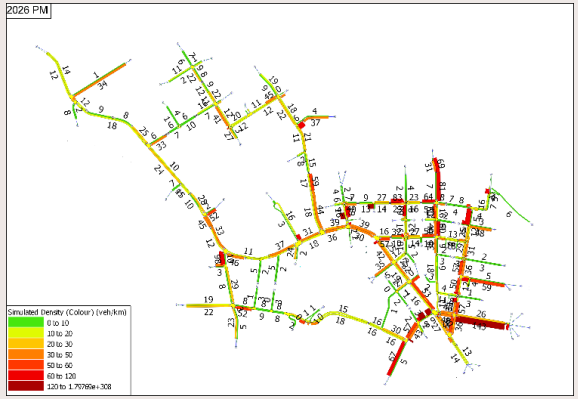
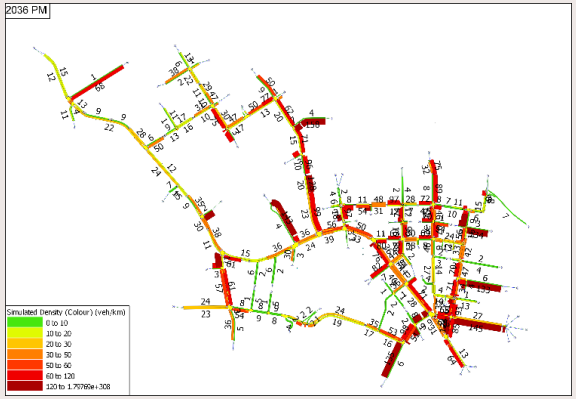
Route	Direction	AM			PM		
		2016 (mm:ss)	2026 (mm:ss)	2036 (mm:ss)	2016 (mm:ss)	2026 (mm:ss)	2036 (mm:ss)
Route 1: Pacific Highway between Hotham Parade and Bruce Street							
Bruce St – Falcon St	Northbound	0:43	0:42	0:41	0:50	1:00	1:22
Falcon St – Albany St	Northbound	1:11	1:08	0:51	1:01	1:37	3:36
Albany St – Park Ln	Northbound	2:09	2:25	1:30	1:30	1:44	1:49
Park Ln – Westbourne St	Northbound	0:56	1:06	1:09	1:21	1:18	1:01
Westbourne St – Hotham St	Northbound	1:19	1:43	1:36	1:44	1:52	2:02
Bruce St – Hotham St	**Northbound**	**6:28**	**7:04**	**5:48**	**6:26**	**7:31**	**9:50**
Hotham St – Westbourne St	Southbound	1:52	1:54	2:04	1:37	1:39	1:52
Westbourne St – Herbert St	Southbound	2:08	4:37	4:07	2:13	2:03	2:00
Herbert St – Albany St	Southbound	0:58	1:03	1:03	0:59	1:04	1:16
Albany St – Bruce St	Southbound	2:53	2:38	3:02	2:55	3:25	4:46
Hotham St – Bruce St	**Southbound**	**7:51**	**10:13**	**10:16**	**7:43**	**8:12**	**9:52**

6.3 Density Comparison

Table 6-4 compares the density plots for the 2016, 2026 and 2036 modelled scenarios. The results indicate the following:

- The network deteriorates over time due to the increased demand and changes to some intersections' configuration and/or signal timings. The key locations of congestion are:
  - The intersection of Pacific Highway / Falcon Street / Shirley Road, with congestion spreading to Falcon Street / Alexander Street and Pacific Highway / Alexander Street. Queues spill back along Falcon Street and Shirley Road to the boundary of the modelled network
  - The intersection of Pacific Highway / Christie Street, in particular Christie Street approach as there is limited storage capacity, creating queues to spill back extending to Chandos Street
  - The intersection of Pacific Highway / Herbert Street has limited throughput for southbound traffic and the future signalised crossing could cause potential queue spill back onto Pacific Highway. The same applies to the other intersections intersecting the Pacific Highway
  - The southbound traffic along Willoughby Road north of the intersection of Willoughby Road / Chandos Street

Table 6-4 Density Comparison

	2016	2026	2036
AM			
PM			

7 Key Findings and Recommendations

Based on road network performance analysis, thirteen of the measures in the Draft 2036 Plan were tested and demonstrated to operate satisfactorily. These provide improved pedestrian connectivity and retain a functional road network during peak demand periods.

Some interventions outlined in the Draft 2036 Plan were found to significantly deteriorate road network performance if implemented and were therefore removed from the models. The key items are listed in **Table 7-1.** Other initiatives could not be tested in the traffic model due to the nature of the proposed upgrades or lack of details to allow inclusion in the traffic models.

Table 7-1 Draft 2036 Plan Upgrades Recommended to be Removed

Location	2036 Draft Plan	Reason
Intersection of Nicholson Street and Shirley Road.	Priority active transport crossing treatment.	Central to two intersections within a complex part of the road network with a four lane cross section and a keep clear zone.
Intersection of Chandos Street and Christie Street (P10)	Signalised intersection to provide time managed priorities for pedestrians and vehicles.	Signalising the intersection would likely require property acquisition and result in marginal improvements for pedestrians / no improvements for traffic
Intersection of Pacific Highway and Reserve Road (R2)	Signalised pedestrian crossing on the west approach.	Detrimental effect on performance of intersection given existing / future traffic demands. The intersection footprint / number of lanes would require a long signal phasing allocation to pedestrian sand cause severe impacts to the Pacific Highway and Reserve Road.
Intersection of Pacific Highway and Herbert Street (R3)	Signalised pedestrian crossing on the east approach.	Detrimental effect on performance of intersection given existing / future traffic demands. The intersection footprint / number of lanes would require a long signal phasing allocation to pedestrian sand cause severe impacts to the Pacific Highway and Herbert Street.
Intersection of Christie Street and Pacific Highway (R4)	Signalised pedestrian crossing on the west approach.	Detrimental effect on performance of intersection given existing / future traffic demands. The intersection footprint / number of lanes would require a long signal phasing allocation to pedestrian sand cause severe impacts to the Pacific Highway and Christie Street.

As part of the assessment, additional initiatives were identified to support road network functionality during weekday peak periods beyond 2026. These generally relate to road space management and parking removal in some key locations (in which case consideration can be given to peak period clearway restrictions instead of permanent removal).

A key recommendation is the signalisation of Oxley Street / Albany Street from its existing roundabout configuration by 2036. This would support safe pedestrian movements at this location and allow functional traffic operation (otherwise constrained by insufficient capacity and a high number of pedestrian flows using zebra crossings).

As a precinct wide consideration, limiting the availability of free, unrestricted parking (on-street or off-street) can be used as a tool to reduce private vehicle demands for trips to / from the precinct. Low off-street parking supply within new developments must be investigated and implemented as much as economically viable. This must be supported by feasible options for other modes such as the gradual improvement of the active transport road network proposed for the precinct.

The modelling results indicate a noticeable increase in the number of unreleased vehicles from 2026 to 2036 operational conditions. Mode shift initiatives will be required to encourage demand onto more space efficient modes of transport, including active and public transport modes. Interventions such as constrained parking provision in new developments, car share schemes and changes in transport technology and employment patterns may contribute to improved efficiency in the transport network.

8 Conclusion

The changes to transport infrastructure documented in the 2036 Draft Plan were tested in the 2026 and 2036 future models to confirm if these can be supported in conjunction with the forecast increase in travel demand. The majority of these measures were found to be feasible in both the 2026 and 2036 horizons. Not all the proposed interventions will have an impact to the traffic network and as such, some of these were not included in the model.

Based on the iterative scenario testing results, it was found that five upgrades originally included in the 2036 Draft Plan are not recommended to be implemented due to the significant impact that this would cause to the traffic network or the complexities associated with the design / operation of these interventions. These are as follows:

- Intersection of Nicholson Street and Shirley Road (the implementation of a pedestrian crossing is not feasible)
- Intersection of Chandos Street and Christie Street (signalising the intersection would likely require property acquisition and result in marginal improvements for pedestrians / no improvements for traffic)
- Intersection of Pacific Highway and Reserve Road (high demands prevent the option to introduce additional pedestrian crossing points. This would constrain signal phasing time allocated to traffic and result in considerable delays along the Pacific Highway and Reserve Road)
- Intersection of Pacific Highway and Herbert Street (high demands prevent the option to introduce additional pedestrian crossing points. This would constrain signal phasing time allocated to traffic and result in considerable delays along the Pacific Highway and Herbert Street)
- Intersection of Pacific Highway and Christie Street (high demands prevent the option to introduce additional pedestrian crossing points. This would constrain signal phasing time allocated to traffic and result in considerable delays along the Pacific Highway and Christie Street)

Due to the increase in travel demand from 2026 to 2036, five additional improvements to the road network capacity were identified to be required by 2036. These are as follows:

- Dual westbound lanes along Chandos Street from Willoughby Road to Mitchell Street (including a dual circulating lane for the westbound direction of the roundabout). This will require the removal of parking in the AM peak (consideration could be given to retain parking in the PM)
- Upgrade of the Oxley Street / Albany Street intersection from roundabout to signals and ban parking on Albany Road between Pacific Highway and Willoughby Road to enable two lanes in each direction
- Short lane for the right turn into RNSH on Herbert Street achieved by removing 30m of parking (to allow for southbound through vehicles to go around right turning vehicles)
- Parking bans in the northbound direction on Greenwich Road between River Road and Pacific Highway in the PM peak. Consideration can be given to retain parking in the AM peak
- Clearways along Pacific Highway between Albany Street and Falcon Street

These recommendations are based on strategic investigations using long term land use and travel demand projections. These should be verified by further modelling once the impacts of Sydney Metro have been realised and travel behaviour evolves towards sustainable travel modes. Other external factors such as the Western Harbour Tunnel and Beaches Link are also expected to influence transport demand and patterns within the precinct. That is, the number of external trips passing through the precinct is expected to change gradually as regional road infrastructure upgrades are added to the network and the demands across the regional infrastructure network are rebalanced. The exact delivery timeframes and consequent impact to private vehicle demand must be considered and monitored given the high proportion of through trips using the precinct and how these interface with locally generated transport demand.

The comparison of the density plots reveal that the infrastructure upgrades implemented in the model can cater for the increase in local trips along the key road corridors and local roads. As the land use and infrastructure changes are implemented, the travel times along the Pacific Highway are forecast to experience small changes (under 1 minute) during the first hour of the peak period. By 2036, in the second hour of the peak, an additional 2minutes and 30seconds are anticipated to be required to travel the full extent of the Pacific Highway included in the model (Hotham Parade to Bruce Street, circa 3 kilometres).

This is a result of the combined increase in local trips associated with the densification in the precinct and growth in through trips (passing the study area via the Pacific Highway).

Some increase in congestion levels is expected at local centres due to the increase in pedestrian demand. However, the additional traffic congestion may be acceptable due to the place value of these locations and need to provide improved active transport infrastructure to encourage mode shift. A perceived gradual reduction of travel speeds / increase in congestion is conducive to a gradual transition to a greater take up of other modes.

Unreleased demand quantifies the number of vehicles attempting to enter the network but unable to do so due to traffic congestion. The model will continue to attempt to release these vehicles to the network using the pre-determined entry point. In real life, this results in a combination of re-routing (as alternative routes become more economically viable / quicker), mode shift (as the delays outweigh the convenience to use private vehicle) and peak spreading (with drivers deciding to complete their trips earlier / later to avoid peak congestion). As such, the queue lengths experienced in real life on the extremities of the modelled networks do not typically reach the hypothetical ranges forecasted by traffic models. Nevertheless, the unreleased demand is a valuable indicator to help quantify at what point the network becomes saturated and how many trips need to convert to other routes, other modes or other time. The model outputs indicate that by 2036, this consists of approximately 3,800 vehicles in the morning peak and 2,700 vehicles in the PM peak.

As the precinct grows and the additional population and employment materialises, policy measures and infrastructure upgrades supporting active and public transport will be required to support a vibrant and economically viable precinct with a balanced transport demand across the various modes. This is also important due to the role of the Pacific Highway as a major north-south corridor in the lower north shore and the need to minimise delays along the corridor. An excessive supply of on-street / off-street parking or insufficient investment in sustainable travel modes would lead to an increased reliance of private vehicle usage by residents and visitors and contribute to a deterioration of the precinct, its viability and significantly impact trips passing by the study area.