Appendix 11 – Parramatta Road Corridor Precinct-Wide Traffic and Transport Study

March 2022

Contents

Precinct-wide transport study and its relationship to Council's Planning Proposal:

PRCUTS Implementation Plan 2016-2023 requires that '*prior to any rezoning, a traffic and transport study be prepared for the Corridor'*. To fulfill this requirement, IWC and DPE jointly commissioned Cardno consultants to carry out a transport study analysing the transport network implications of proposals contained in the PRCUTS, in combination with the numerous adjacent infrastructure projects, including WestConnex.

This study was commissioned to Cardno in 2018 and finalised in March 2022 through a series of iterations over the period of four years. This study has a primary focus on IWC precincts of Camperdown, Leichhardt and Taverners Hill. The report includes four sub-reports:

- *Context Report* which provides a comprehensive background analysis of the land use and transport in the area to inform future recommendations;
- *Future Modelling Report* which investigates the traffic network along the Parramatta Road Corridor including an AIMSUM hybrid traffic simulation model;
- *Parking Policy and Rate Review* which provides car parking recommendations in the key precincts to achieve sustainable mode share;
- *Transport Plan* which sets the vision for Parramatta Road Corridor and provides set of recommendations including the Implementation Plan.

Cardno have generally used the PRCUTS' principles and its assumptions to set the framework for Transport Plan's recommendations. The Transport Plan in its final set of recommendations adopts many aspects of the PRCUTS, including its vision:

"Incremental renewal of the Corridor will occur over the long term to deliver a high quality, multi-use Corridor with improved transport choices, better amenity, and balanced growth of housing and jobs."

In order to achieve this vision, it will be essential to implement a comprehensively integrated approach to transport, public domain, land use and urban design. An important first step in this process is the establishment of measures which will encourage a mode shift away from private car use and so creating a more "liveable" environment in the Corridor.

Working from this baseline, Council has used both PRCUTS and this Transport Study to inform this Planning Proposal's provisions. There has, however, been a slight divergence in the final outcomes, as the study's modelling was primarily focused on traffic.

While the modelling carried out in association with this plan is driven predominantly by traffic-based circumstances, it is considered to provide an adequate baseline for the establishment of mode share targets for the three Inner West Precincts (Leichhardt, Taverners Hill and Camperdown).

Based on this modelling it will be essential to achieve a minimum mode shift in private car use, from 79% in 2019 to 71% in 2036 (a 10% reduction of existing car use).

However, noting that this mode shift is required purely to achieve acceptable movement along the corridor, to achieve the desired liveability PRCUTS proposes a 30% mode shift away from private car use, as an average improvement across the three Inner West Precincts. Consequently, this Planning Proposal's key mode shift target is to reduce private car use by a minimum of 10%, and up to 30% between 2019 and 2036.

Based on experience in Australia and around the world, Council considers that sustainably-based Corridor activation leading to more liveable environments in inner city areas, requires the inclusion of significantly enhanced public transport. Consequently, Council does not agree with numerous road network capacity increases recommended in the study and is unlikely to accept these unless these enhance public and active transport outcomes.

That said many of the strategies and actions recommended in the Transport Plan are strongly supported by Council, including, but not limited to, proposals such as:

- Implement an enhanced public transport solution in the corridor which achieves the following outcomes:
  - Safety;
  - Place-making benefits;
  - High capacity;
  - High frequency;
  - Reliability;
  - Travel time efficiency; and
  - Streetscape improvements.
- Develop a travel behavioural change plan.
- Initiate public domain improvements along Parramatta Road and on adjacent side streets.
- Provide gateway treatments at key intersections.
- Construct missing links in the walking and cycling network, including completing a cycle route immediately to the north of, and parallel to, Parramatta Road.
- Install continuous footpath treatments across the mouth of numerous streets in the Corridor.
- Work with the State Government to provide an enhanced local bus network and increased frequency of services along Parramatta Road.
- Examine reasons for crash clusters at specific intersections.
- Rationalise of parking controls, both kerbside and on-street, including the introduction of a maximum rate for on-site provision and the use of unbundled parking where practical.
- Develop controls to better accommodate the needs of freight and servicing within the Corridor.

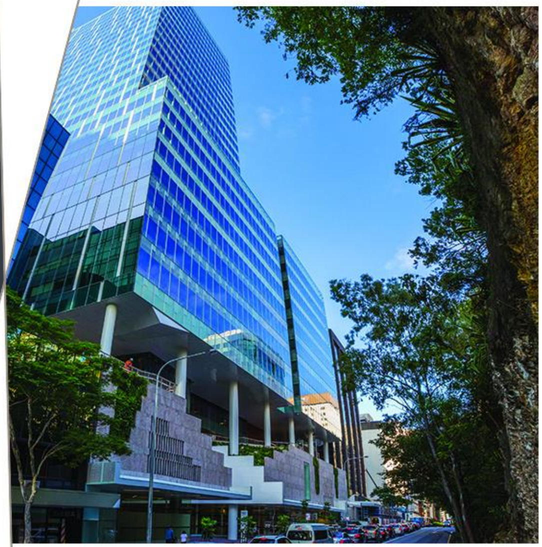
This Planning Proposal has used many of the Transport Plan's strategies and actions to cater for increased population and residents, while enabling the creation of a more liveable environment. Intrinsically this means that private car dependence must be reduced in relation to both local journeys and travel along the Corridor, to and from points beyond the Inner West LGA.

In moving forward, it will be essential for Council, DPE and TfNSW to work together to:

- Prioritise the actions recommended in the Transport Plan;
- Examine funding sources for the actions;
- Create a formal agreement on processes to implement the Plan's actions;
- Establish and agreed set of criteria linking population and employment growth with public transport improvements.

Council is keen to continue working with the State Government to introduce both local and regional measures to realise the outcomes of PRCUTS vision of a healthier, more sustainable and more liveable Corridor.

Transport Plan context Report:– Camperdown, Leichhardt and Taverners Hill



Parramatta Road Corridor Urban Transformation Strategy

80018116

Prepared for

Department of Planning, Industry & Environment and Inner West Council

10 March 2022

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5	10/03/2022	Final 03	Elizabeth Muscat Ivo Pais	Ivo Pais

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Appendices

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1 Report structure

This report has been structured with key information in Part 1 which is supported by review and analytics documented in Part 2. The structure outline is shown in **Table 1-1**.

Table 1-1 Report structure

Part 1: Introduction, summary of findings, issues, opportunities and considerations and options.	
Introduction	Report purpose Background summary of the project and it need. Study precincts including mapping
Population	A review of the existing population and forecast in 2026 and 2036.
Summary of findings	This summarises the findings and transport implications of works documented in Part 2 of this report.
Summary of transport issues and opportunities	Tabulated issues and opportunities as identified in Part 2.
Considerations and options	Discussion of potential ways to manage the transport network to support access and movement for PRCUTS.
Part 2: Background review analysis and case studies.	
State government document summary	A summary of relevant documents from the Greater Sydney Commission, Urban Growth NSW, specifically the Parramatta Road Corridor Urban Transformation Strategy (PRCUTS) and Transport for NSW documents.
Local government document summary	Relevant Inner West Council documents which have implications for PRCUTS areas.
Emerging travel trends and technology	Desktop review of emerging transport technology which may have implications and benefits for the study area and are consideration for transport options and planning.
Land use – existing conditions	A high level summary of existing land uses in the PRCUTS areas of Camperdown, Leichhardt and Taverners Hill.
Travel demand	Findings of data analysis based on Transport for NSW Household Travel Survey and Australian Bureau of Statics Census, Journey to Work data.
Transport network – existing conditions	A review of the existing transport network infrastructure and services. This is categorised into the categories of connectivity and movement, active transport, public transport, road network, freight network, crash analysis, and parking.
Road space reallocation case studies	Selected example case studies where road space for general traffic has been reallocated as a result of either an alternative road being provided or broad reaching policy changes to improve place.

2 Introduction

2.1 Purpose

This transport context report is a supporting sub- report that documents the background review of documents, data and existing conditions to inform recommendations and actions for the Transport Plan.

It tables a summary of findings, issues, opportunities and initial considerations.

This study focuses on Parramatta Road precincts within the Inner West Council (IWC) Local Government Area (LGA).

2.2 Background

Opened in 1811, Parramatta Road is one of the oldest roads in New South Wales. Parramatta Road Corridor is a key east-west link between the Sydney CBD and Parramatta, spanning 20 kilometres from Granville to Camperdown.

Parramatta Road was formally a destination in itself, with people visiting for its adjacent businesses and shopping offerings.

Parramatta Road's function as a vehicle movement corridor has gradually taken priority over its place function from previous decades. This has had a reductive effect on its place value and attraction and it can no longer be described as a vibrant high street.

Parramatta Road serves an important function within regional Sydney for public transport and freight vehicles as well as general traffic.

The NSW government has recognised that Parramatta Road and surrounding land uses are not achieving their full potential, and a multitude of studies over the years have proposed various options and solutions to improve conditions.

The Parramatta Road Urban Transformation Strategy (PRCUTS) proposes approximately 27,000 new dwellings along the Parramatta Road corridor between Granville and Camperdown. There are also 50,000 new jobs planned along the corridor.

For IWC PRCUTS precincts, there is forecast to be an additional 10,000 residents and employees in the period 2016 – 2036.

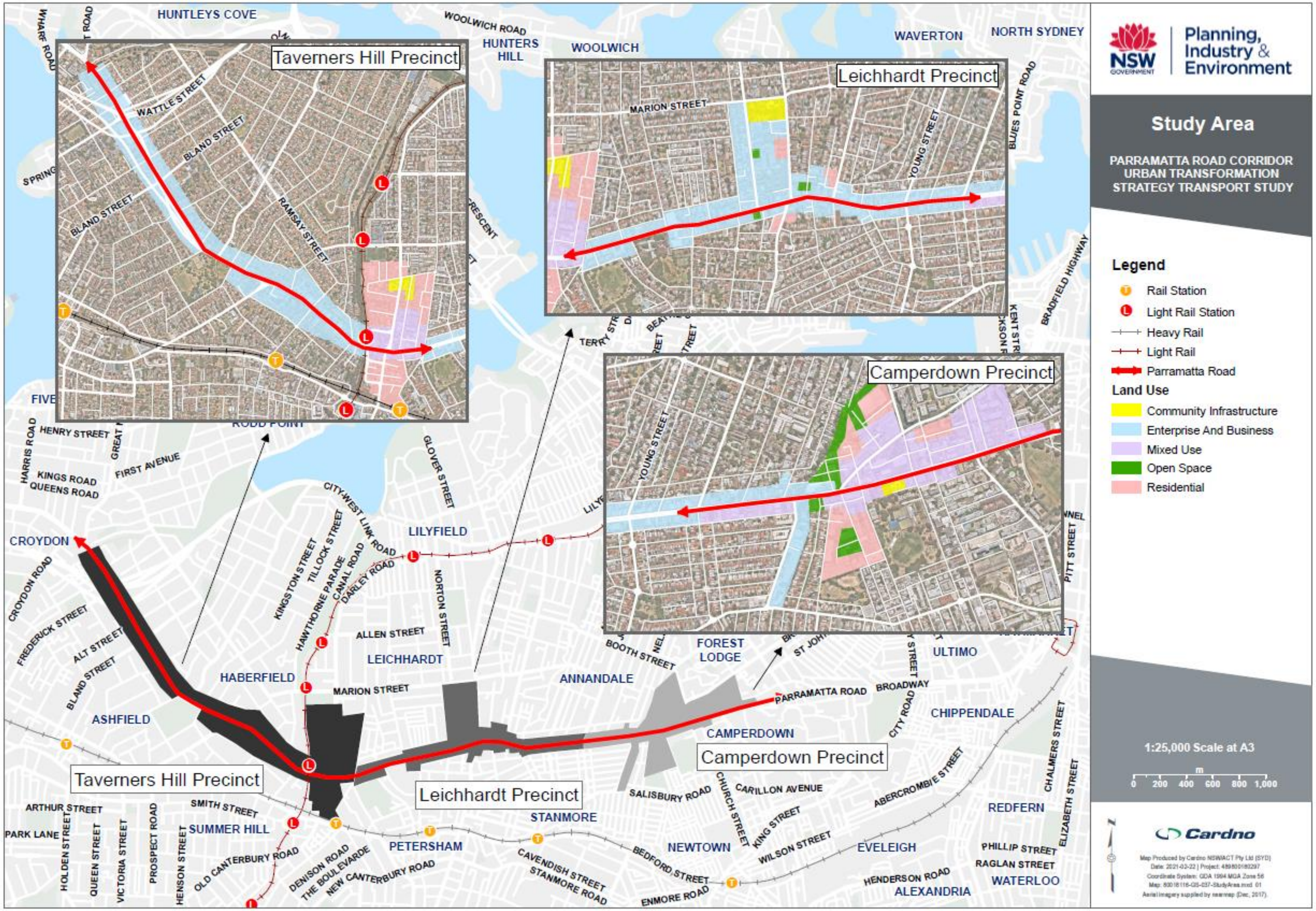
The opening of WestConnex in 2023 will provide the option for some through-traffic to redistribute off Parramatta Road. This will open up opportunities to reimagine how people move along the corridor and the land uses it can support.

The Parramatta Road Urban Corridor Transformation Strategy (PRCUTS) brings together the elements of successful place making to provide a strategy to support population and employment growth, land use and place making and transport to improve the attractiveness and liveability of the corridor and surrounding areas.

2.3 Study precincts

This study has a primary focus on IWC precincts of Camperdown, Leichhardt and Taverners Hill shown in **Figure 2-1**.

Figure 2-1 PRCUTS IWC study precincts



3 Population

The key determinate of transport needs is the population it serves. The following section outlines the 2016 population and the forecast to 2036.

3.1 Residents and employment

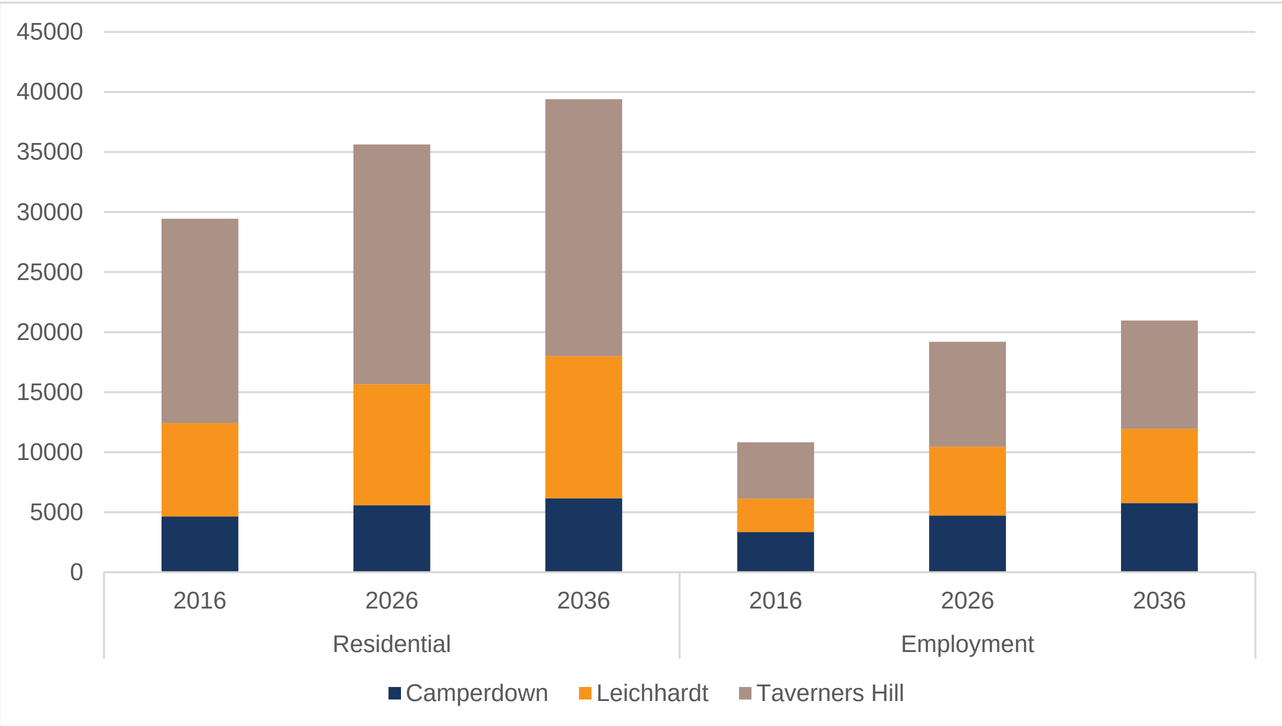
DPIE commissioned a PRCUTS land-use projections review in 2021 to assess the land use in IWC PRCUTS precincts more broadly for traffic modelling analysis. While this review assumed precinct boundaries slightly different to those shown in **Figure 2-1**, it provides a good indication of projected changes to residential and employment numbers. The population and employment forecast is as outlined in **Table 3-1** and graphed in **Figure 3-1**.

Table 3-1 PRCUTS IWC study area residential and employment population

Precinct	Population			Employment		
	2016	2026	2036	2016	2026	2036
Taverners Hill	17,018	19,964	21,409	4,705	8,732	9,025
Leichhardt	7,786	10,075	11,834	2,766	5,748	6,172
Camperdown	4,637	5,589	6,159	3,354	4,716	5,767
Total	**29,441**	**35,628**	**39,402**	**10,825**	**19,196**	**20,964**

Data source: PRCUTS land use review, SGS, 31/05/2021

Figure 3-1 Population – residential and employment forecasts



Data source: PRCUTS land use review, SGS, 31/05/2021

The data in **Table 3-1** and **Figure 3-1** shows that Taverners Hill will continue to house the most residents and employment.

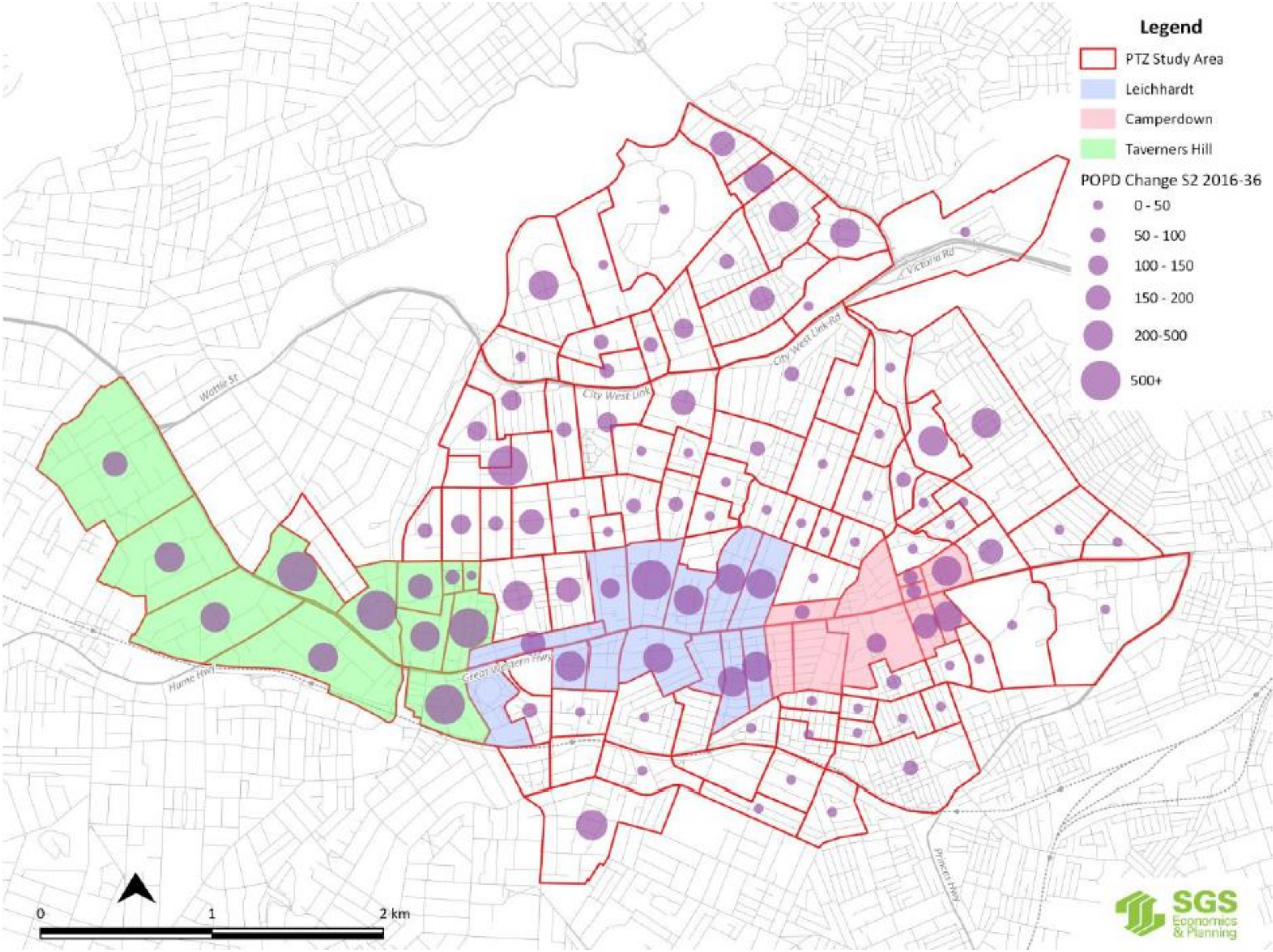
By 2036, it is anticipated the PRCUTS IWC areas will accommodate approximately 39,400 residents and 22,300 workers. Between 2016 and 2036, the transport network must facilitate the movements for an additional:

> 10,000 residents	> 10,000 employees (some of which will be residents)

The population and employment analysis (*PRCUTS land use review, SGS, 31/05/2021*) and calculations is provided in **Appendix A**. This shows the difference between previous forecasts and the additional growth PRCUTS brings over previous land use forecasts.

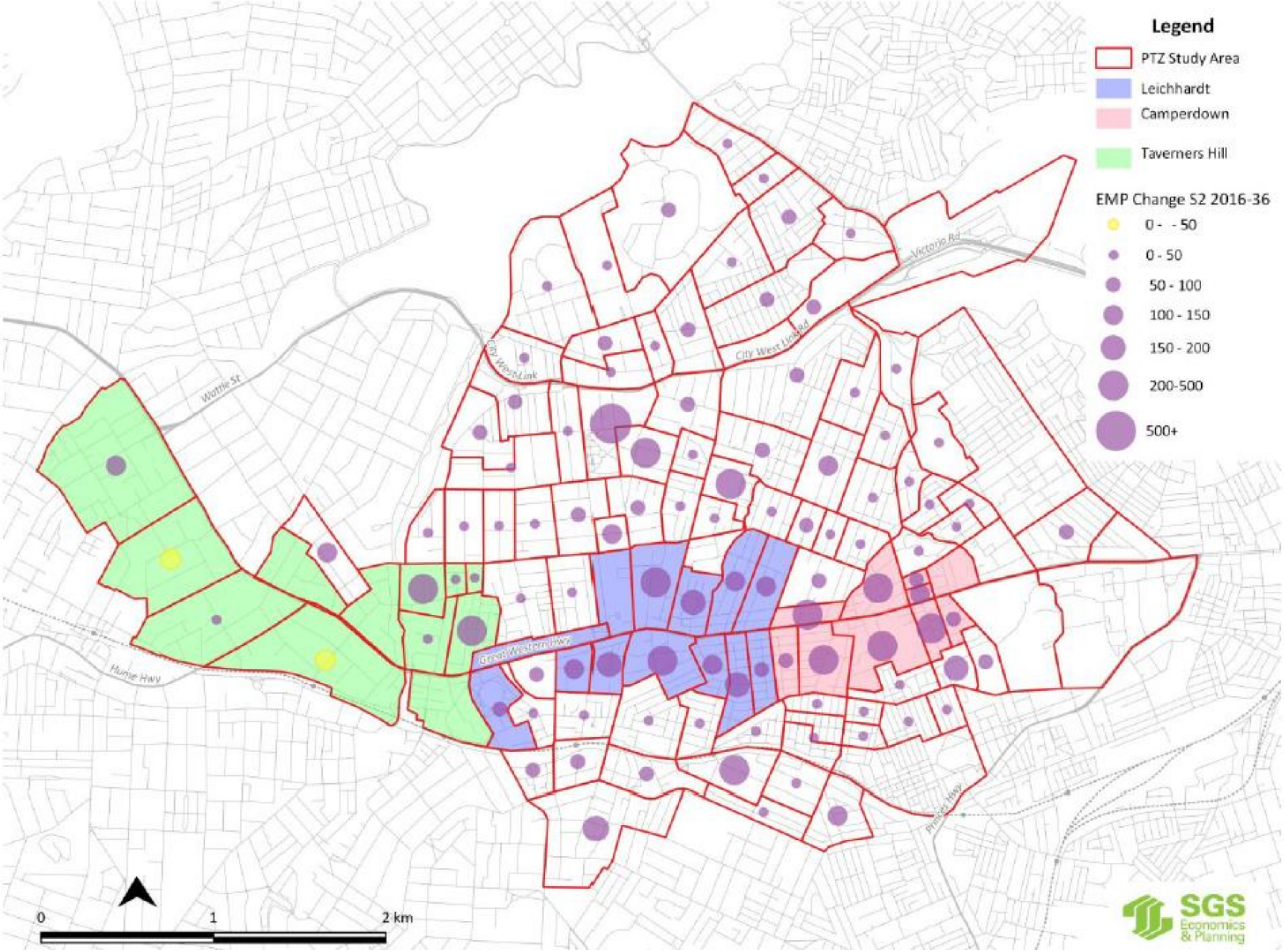
Residents and employment projects are shown in **Figure 3-2** and **Figure 3-3**.

Figure 3-2 Residential projection (2016 – 2036)



Source: PRCUTS land use review, SGS, 31/05/2021

Figure 3-3 Employment projection (2016 – 2036)



4 Summary of findings

Vision and principles

Vision

"Incremental renewal of the Corridor will occur over the long term to deliver a high quality, multi-use corridor with improved transport choices, better amenity, and balanced growth of housing and jobs."

The vision must continually be referred to for all recommendations to ensure that recommendations give effect to the vision and principles.

Transport implications

> Support increased travel demand through a changed mode split with increasing pedestrian, cycling, public transport share and reduce car mode share.
> Increased sustainability and accessibility for all.
> Contribute to affordable living conditions.
> High and easy connectivity.
> High frequency and serving north-south demands as well as east-west.
> Leverage and enhance existing transport infrastructure and services
> Support and improve desired place making outcomes.

Land use

Intensification of land uses in IWC PRCUTS precincts are forecast to result in a change (from 2016 – 2036) of:

> 10,000 more residents
> 10,000 more employees.

These will generate additional trips across the transport network in addition to growth in population and employment from surrounding precincts.

Travel demand

There will be higher travel demand.

Inner West residents make approximately 3.6 trips on a typical weekday, therefore an extra 10,000 people would result in approximately 36,000 trips across the transport network on a typical weekday.

Based on a general assumption that 80 per cent of employees may attend work on a typical day, an extra 16,000 trips would occur on typical working days travelling to/ from work plus any lunch time trips or other business generated trips throughout the day.

The volume of additional trips highlights the necessitates the need to shift trips away from private vehicles to walking, riding and public transport. Therefore, the conditions, issues and opportunities for pedestrians, cycling and public transport are key considerations for providing a functional and safe transport network for PRCUTS and surrounds.

Pedestrians

> There are limited crossing opportunities on Parramatta Road.
> Footpath quality varies from good to poor (narrow/ uneven).

Cycling

> Variable standard bicycle network.
> No safe opportunity along Parramatta Road and parallel routes have many turns.

Roads

> High crash rates are noted due to high vehicle volumes and congestion.

> High traffic demand during peak periods resulting in traffic congestion.

Public transport

- Shared infrastructure with general traffic results in reduced reliability of road based public transport.
- Some challenges with feeder bus routes to better service heavy and light rail stops.
- Public transport frequency can limit the attractiveness of planning a multi-modal public transport trip.
- The existing high frequency network needs to be promoted and identify opportunities for turn up and go routes (very high frequency routes).

Deliveries and Freight

- Increasing competition with general traffic on the road network kerbside space for small parcel/ package delivery.
- Freight trips can be leveraged for a benefit of reduced private car trips.
- Increasing residential and employment populations generate increased delivery demand.

Parking

Car parking is examined in detail in a separate car parking note. In summary

- Car parking takes up space and this needs to be considered against the opportunity cost for other uses of the space.
- Car parking increases the cost of development. In multi-deck car parks, one car parking space can easily cost $50,000 and this cost must be borne by the users a given site/ locality through the purchase price or lease costs.

Amenity

The impact on amenity, streetscape and liveability will be considered particularly noting opportunities to improve:

- Landscaping, tree planting and shading, with a strong preference given to WSUD;
- Increased footpath widths and improved footpath surfaces/pavement treatments;
- Buffering of pedestrians from traffic;
- Provision of all-weather cover, ideally in the form of awnings which are sympathetic to the existing urban fabric;
- Air quality and noise;
- Public art and place-making.

5 Summary of transport issues and opportunities

Categorised transport-related issues and opportunities are outlined in the following tables. The location-specific issues and opportunities are shown in **Figure 5-1**.

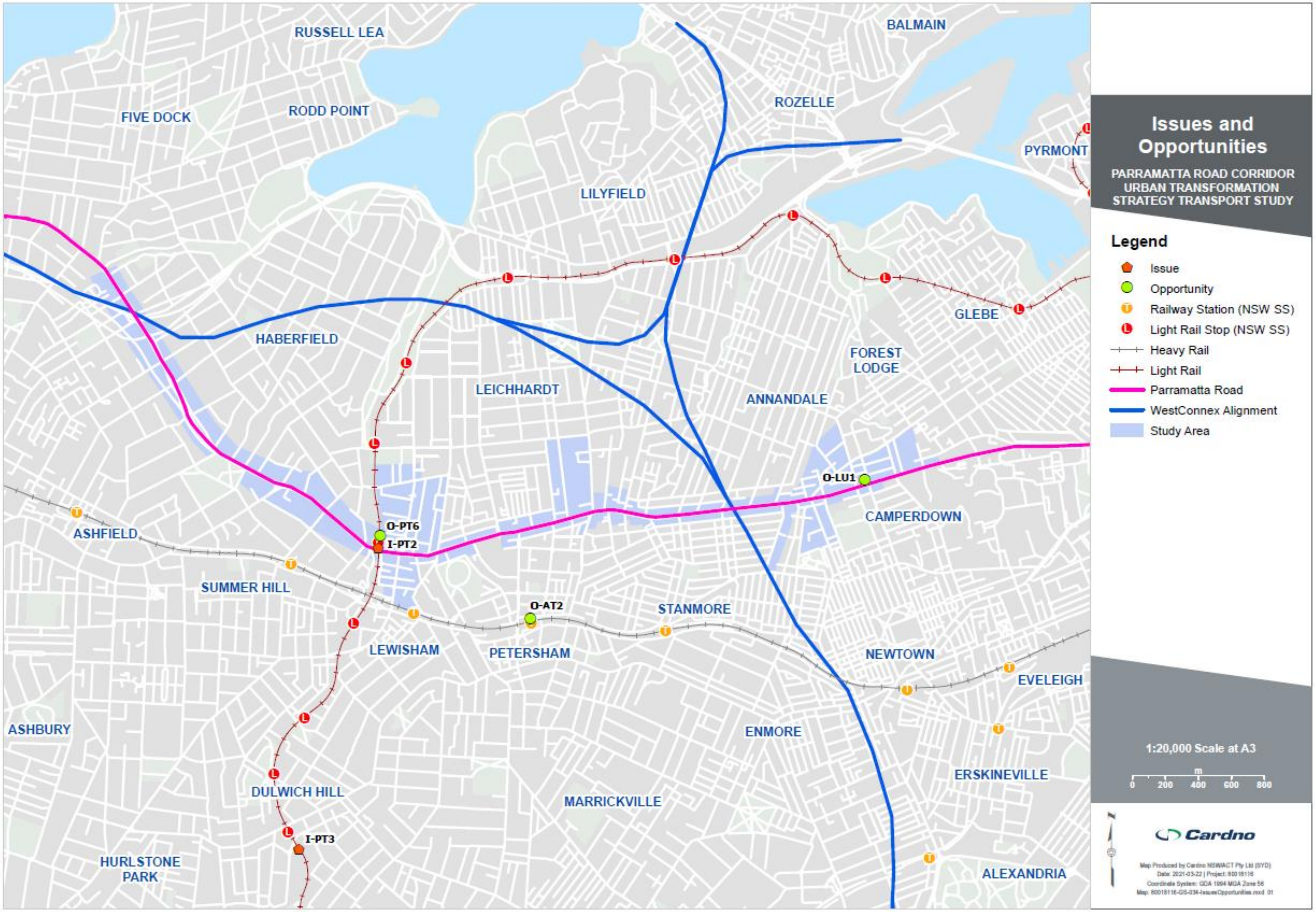
5.1 Issues

Category	#	Issue
People	I-P1	Growing population (20 per cent growth between 2017 and 2036) and aging population (52 per cent increase of population aged 65 years and over by 2036) generating demand for new and improved infrastructure.
Land use integration	I-LU1	Parramatta Road is a barrier for permeability, and poses a safety hazard, particularly for pedestrians and cyclists.
Active transport	I-AT1	Disconnected cycling infrastructure and high-speed roads such as Parramatta Road are a barrier for north-south active transport.
	I-AT2	Non-car modes of travel have low levels of connectivity to adjacent neighbourhoods and local centres.
	I-AT3	Kerbside bus lanes, traffic volumes and speeds discourage use of Parramatta Road as a cycling corridor and parallel routes have turns and are less legible.
Public transport	I-PT1	Mixed traffic lanes reduce bus reliability, speed and thus attractiveness and route capacity.
	I-PT2	Poor interchange between light rail and bus at Taverners Hill.
	I-PT3	Light rail infrastructure (single track in each direction) restricts the ability to increase frequency to and from Dulwich Hill.
	I-PT4	Legibility and complexity of existing bus routes.
	I-PT5	Missing north-south connectivity of public transport network, causing rail travel needing to pass through Redfern or Central before travelling along the north-south axis.
	I-PT6	Bus network is Sydney city centric, 11 out of 15 routes begin and end in there.
Roads and freight	I-R1	Congestion on roads, including Parramatta Road, particularly on weekday peak periods and weekends affecting travel times and reliability of buses.
	I-R1	Proximity with Port Botany and forecasted growth of freight activity increasing heavy vehicle pressure on road network.
Parking	I-Pa1	Publicly accessible parking demand is high in activity areas and residential streets.
	I-Pa2	There is an equity issue between land uses that service their own parking needs on-site as to sites that utilise on-street parking. I.e. the residential parking scheme subsidises users that forgo the cost of providing their own parking.
	I-Pa3	On-street parking limits opportunities to provide the space for other uses including trees, vegetation, runoff filtration, wider paths, separated cycleways.
	I-Pa4	Provision of car parking in new multi-level development cost in the order of $50,000 per space, which results in increased development costs which is passed on to new residential and employment land uses.
	I-Pa5	There is a relationship between the high provision of car parking and increased traffic generation.

5.2 Opportunities

Category	#	Opportunity
Movement and Place	O-MP1	Identify greening opportunities in all transport network upgrades to achieve a “60% tree canopy cover over all pedestrian spaces (footpaths, trafficable pedestrian areas).”
	O-MP2	Enhance streetscapes through water-sensitive urban design (WSUD).
	O-MP3	Provide outdoor seating to encourage activation of street frontages and enhance the pedestrian environment.
	O-MP4	Consider gateway treatments at each precinct through the provision of space for murals by local artists on side streets at key intersections to local centres and to create a sense of neighbourhood identity.
Land use integration	O-LU1	Leverage on development of the Camperdown Triangle for creating more vibrant streets and stimulating local economy.
	O-LU2	Opportunity to enhance night time economy in the precincts through reliable night time public transport and welcoming streetscapes.
	O-LU3	Enhance permeability for all modes of travel across the precincts by introducing new north-south laneways south of Parramatta Road and east west laneways north of Parramatta Road.
	O-LU4	Consider temporal changes where regular road closures of low volume streets could be used for activation by outdoor dining, street markets and active travel.
	O-LU5	Consider use of existing at-grade off-street car parks as market places or community “nodes”.
Active transport	O-AT1	Improve connections across roads and side streets with initiatives such as continuous footpaths.
	O-AT2	Improve connectivity between Leichhardt Precinct and Petersham Station via existing active transport network particularly in the north-south alignment.
	O-AT3	Provide new cycle connections as planned under the Parramatta Road Urban Amenity Improvement Program.
Public transport	O-PT1	New public transport services providing critical north-south connectivity across Parramatta Road.
	O-PT2	Enhance integration between light rail, heavy rail and bus services.
	O-PT3	Ensure all bus stops are DDA compliant and provide shelter and seating.
	O-PT4	Provide on-demand or turn-up-and-go bus services to improve the public transport catchment to light and heavy rail services.
	O-PT5	Reallocate road space on Parramatta Road for high-frequency mass transport (such as GETS). Consider providing this along the centre of the road.
	O-PT6	Develop direct access to Taverners Hill LRS from Brown Street.
Roads and freight	O-R1	WestConnex to maximise diversion of heavy vehicle through-traffic (except dangerous goods vehicles) for improved freight efficiency and local safety.
	O-R2	WestConnex provides opportunities to transform Parramatta Road as a pedestrian friendly space, recognising “Traffic Evaporation” theory, where road space can be taken away to reduce traffic demand.
	O-R3	Reduce speed limits to support place making and improve safety for pedestrians and cyclists.
Parking	O-Pa1	Reduced provision of car parking provides positive enforcement of shift to sustainable modes.

Figure 5-1 Issues and opportunities



6 Considerations and options

6.1 Parramatta Road

Parramatta Road can be described as in environmental, economic and urban decline. It is the major historical east-west artery of metropolitan Sydney and has been overwhelmed by heavy traffic, excessive noise and declining commercial spaces in recent years. Vacant buildings, pollution and large volumes of freight vehicles have contributed to the corridor becoming less pleasant and less attractive for all road users.

Parramatta Road currently accommodates:

> A major bus corridor;

> A high amount of vehicle traffic over a day, especially during peak periods;

> High levels of congestion along the corridor during peak periods;

> Limited north-south movement opportunities as signals are prioritised for east-west movement; and

> Car parking during off-peak periods.

Redevelopment of the area through planning and infrastructure investment will assist in overcoming the challenges discussed above.

6.1.1 Long list of considerations/ options

The long list of options is tabled to show a potential consideration for discussion only. Not all can be selected, as some options preclude or negate the need for other options.

The long list of opportunities and options to manage the PRC road space are outlined in **Table 6-1**. The treatments included in this table are generally applicable to all streets within the PRCUTS precincts, wherever practical. These are actions for IWC, DPIE and TfNSW to review and decide on.

Table 6-1 Parramatta road corridor long list of options

Initiative	Benefit	Impact	Consideration
Place-making			
Streetscape improvements: ▪ Landscaping ▪ Public art ▪ Street furniture ▪ Pavement treatments ▪ Lighting ▪ Water sensitive urban design	Improved place value and amenity, making the corridor attractive and comfortable for pedestrians. Street trees and landscaping provide shade, improve air quality and reduce the heat island effect. Providing spaces for murals at key intersections will support local Inner West artists and function as gateways to local centres. This would create a sense of place and neighbourhood identity.	Reduction in footpath width due to landscaping and benches in the verge.	Benches, bins and pot plants are currently provided. Footpath pavements are inconsistent and of varying quality and condition and can form components of urban realm improvement projects.
Active transport			
Continuous footpath treatment	Improved amenity and comfort for pedestrians who have increased priority. Attractiveness of active travel is increased.	Slower vehicle speeds (the intended effect) for vehicles turning off Parramatta Road which may cause traffic issues.	Continuous footpath treatments are raised, physical traffic management devices and are appropriate for intersecting streets with low traffic volumes.
Pedestrian countdown timer	Reduction in the risk of pedestrian and vehicle conflict. Pedestrians know exactly how much time they have to safely complete their crossing.	Cost and complexity to signalised intersection.	Pedestrian countdown timers work best at intersections where pedestrians are the only people on the road with a green light (no simultaneous turning movements for vehicles).
Separated cycleway	Provides a safer, dedicated space for cycling along Parramatta Road and throughout the corridor. The corridor would form a major and direct east-west link for commuters, students, food delivery riders and recreational cycling linking with the GreenWay. Provides a buffer/ calming effect between vehicle movements and the pedestrian realm on one or both sides.	Reduced space for: ▪ Motor vehicle traffic; and ▪ Car parking.	Unlikely to be supported by motorists or local businesses that perceive front of business parking opportunity as a key metric to support business viability. Sydney has a well-documented history of opposition of providing dedicated cycling space at the expense of motor vehicle space. A separated cycleway for Pyrmont Bridge Road is to be delivered under the Parramatta Road Urban Amenity Improvement Program.
Signalised bicycle crossings	Introducing signalised bicycle crossings of Parramatta Road and key side streets (where possible) contributes to a safer and more attractive experience for cyclists, especially for less experienced / more vulnerable groups.	Vehicle delays at the intersection level due to the modified signal phasing. Cost and complexity to signalised intersection.	Detailed analysis will be required at the intersection level to assess feasibility, quantify possible impacts and optimise signal phasing.
Introducing pedestrian phases on all legs of all intersections	Improved amenity and comfort for pedestrians who have more direct routes. Attractiveness of active travel is increased.	Vehicle delays at the intersection level due to the modified signal phasing.	Detailed analysis will be required at the intersection level to assess feasibility, quantify possible impacts and optimise signal phasing.

Initiative	Benefit	Impact	Consideration
		Cost and complexity to signalised intersection.	
Public transport			
Full-time / turn up and go mass transit lane (i.e. Bus Rapid Transit, trackless trams)	Dedicated road space for mass transit improves journey reliability, capacity and efficiency of the mass transit vehicle. This can also make a difference to the number of vehicles and resourcing required. Mass transit is a highly effective method of carrying a high volume of people in a limited space. It is more efficient than private vehicle traffic while simultaneously having lower environmental and amenity impact. GETS/ trackless trams are relatively quick and inexpensive to implement, have minimal disruption to the local economy during construction and have a higher speed, capacity and ride quality than Bus Rapid Transit (BRT).	Reduces road space for general traffic. Can limit on-street car parking opportunities.	A highly effective way of moving a high amount of people along the corridor. This requires planning to ensure it is an attractively positioned transport offering that people want to use. Centre running (rather than kerbside running) design can help improve efficiency of public transport along the corridor by removing conflict with left turning vehicles and bicycles - thus enhancing public transport service time reliability. However, it introduces complexities for right turns and requires passengers to cross the road before/after using the public transport service. Consideration can be given to investigate opportunities to introduce "turn-up-and-go" public transport services and/or introduce B-Signals to enhance public transport priority along the corridor.
Improved pedestrian/passenger storage on the footpaths adjacent to major public transport stops	Improved amenity and comfort for public transport passengers. Attractiveness of public transport and active travel is increased.	Could conflict with other uses of footpath width	Smart design can be incorporated to increase placemaking opportunities and improve amenity.
Traffic management			
Optimised signal timings / modified signal phasing to improve pedestrian and/or public transport	Reduction in delay for pedestrians crossing Parramatta Road and improve public transport travel times / reliability. Improve attractiveness of sustainable travel modes.	Longer travel times for vehicles.	Excessive pedestrian delay can result in severance of communities. Connectivity across Parramatta Road for pedestrians is currently weak. Public transport priority contributes to increased attractiveness and improved travel times.
Examine opportunities for alternative heavy vehicle routes including reduced heavy vehicle tolls on WestConnex to encourage heavy vehicles to use WestConnex	WestConnex will provide a motorway bypass opportunity for some through-traffic. It is anticipated that the majority of freight traffic that currently passes along Parramatta Road between Port Botany and Western Sydney will re-divert trips to WestConnex.	Houses have been lost. Motorways have been documented to induce traffic demand. Entry and exit locations to WestConnex are likely to have high traffic demands.	WestConnex is likely to provide an initial benefit to the locality. Historic evidence of major road projects and bypasses indicate that traffic volumes can return to normal unless interventions are made to the bypassed road.

Initiative	Benefit	Impact	Consideration
	The WestConnex Strategic Business Case suggests traffic volumes along IWC portions of Parramatta Road will be similar to 2012 volumes in 2031.		
Co-ordinated traffic signals	Optimised traffic flow and capacity. Improved level of service.	Delays to side street traffic. Does little to reduce demand along Parramatta Road.	Signals are already co-ordinated and optimised for east-west flow. Parramatta Road has reached its capacity during peak periods and other interventions must be considered to maintain a functional corridor in the future.
Tidal flow lane management	Use lane management to increase the number of lanes in the peak movement direction, improving traffic flow and capacity. May provide the opportunity to select a dedicated mass transit lane. Often has a lower capital cost than alternative capacity increasing measures such as widening.	Increased resourcing to manage the road network. Removal of medians increases the chance of collisions of vehicles travelling in the opposite direction, unless a moveable median was selected. Effectiveness reduced where heavy right-turn movements must be accommodated.	This would require removal of all fixed central medians and installation of moveable barriers or overhead lane control signals with illuminated pavement markers. A directional split of traffic flow of at least 70/30 favouring the peak direction is generally necessary before tidal flow operation is justified.
No right turn movements at congestion points	More green time for through traffic. Signalised intersections have less phases.	Limits road network connectivity and accessibility. This can lead to vehicles first turning left and circulating in local streets to undertake an at-grade loop movement to position themselves at a signalised through point to get to the far side of Parramatta Road.	No right turns are already implemented at multiple intersections. Detailed analysis should be carried out to determine whether additional right term prohibitions will result in rat running through residential areas>
Right turn lanes at signalised intersections	Improved access to and from side-streets in more locations. This would distribute right turn movements along the corridor and reduce the through-movement function of the corridor. This would require increased signalisation which could be used to provide additional pedestrian crossings along the corridor.	Increased traffic demands on residential streets. This may reduce through capacity on Parramatta Road.	This could be done in conjunction with more signalised intersections. There are limitations associated with right turn lanes given how road widening is not supported from a place making perspective.
Reduced speed limit	Reduce the severity and potential occurrence of crashes for all road users and improve amenity adjacent to the carriageway.	Longer travel times which may reduce road capacity.	Dynamic speed management (variable speed limits) could vary the speed limit throughout the day/ week. While reduced speed limit is likely to result in longer travel time for vehicles it can help maintain or improve reliability and predictability of public transport travel times. This is aligned with the high level of pedestrian activity that will

Initiative	Benefit	Impact	Consideration
			materialise over time along the corridor due to increased residential population, employees and visitors combining with reactivated frontage uses.
Clearways	Additional road capacity through a parking lane and no delays from drivers undertaking parking movements.	No convenient on-street parking is available to support local businesses during clearway operation periods.	Initiative already implemented during peak periods in some areas. Clearways may be acceptable during peak periods however it is equally important to maintain kerbside parking outside peak periods.
Variable Message Signs (VMS)	Improved road efficiency and enhanced safety. Electronic signs assist with traffic and incident management.	Fully automated systems require the integration of incident detection systems with message selection and deployment for the management of incidents, congestion and impact of adverse weather conditions.	VMS are already implemented along the PRC: ▪ Before Dalhousie Street (westbound) ▪ After Ross Street (eastbound)
Travel demand management			
Tolls	Toll revenue could be used to fund transport initiatives along Parramatta Road and would likely reduce traffic demand.	Expensive to implement and requires on-going management.	Unpopular, unlikely to be supported by the majority of motorists unless there was a linked scheme to reduce WestConnex tolls for certain trips. Could be developed as a scheme where short trips are free and long trips are tolled.
Kerbside Management			
Improved kerbside management recognising the numerous competing elements in relation to land use, vehicle flow, freight and service delivery, pedestrian amenity, temporal demand and safety	Efficient kerbside management has the potential to achieve and effective balance of the competing demands by recognising the temporal changes in demand.	Use of the kerbside for purposes other than traffic flow has the potential to reduce traffic speeds in the through-lanes, however in the light of the numerous competing uses this may ultimately prove to be beneficial	In order to achieve a revitalization of the corridor it is essential that the placemaking benefits of efficient kerbside management be recognised. - Use of the kerbside lane for parking has the ability improved pedestrian amenity on the footpaths by buffering pedestrians from through traffic - Use of the kerbside lane for Loading on deliveries has the potential to improve the built form of frontage uses - Use of the kerbside lane for through traffic may increase traffic speeds and so reduced safety and increase vehicle noise, In so doing reduce the overall amenity of the corridor.

Background review analysis and case studies

The following sections of this report provide summaries of a range of state and local government documents, existing land use, existing transport network conditions and case studies of road space reallocation.

These were used to inform the:

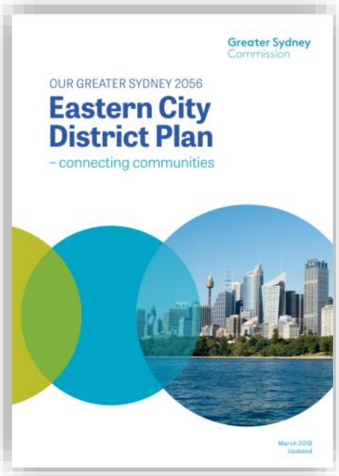
> Summary of findings.

> Summary of transport issues and opportunities.

> Considerations and options.

7 State government document summary

7.1 Eastern City District Plan, Greater Sydney Commission, 2018

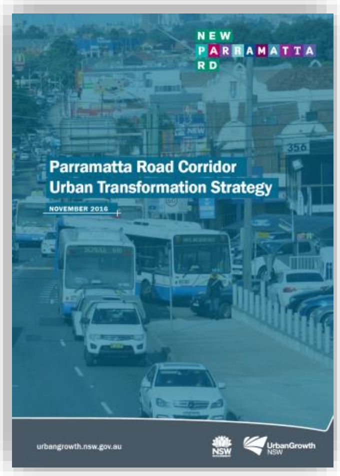


The Greater Sydney Commission (GSC) is implementing The Greater Sydney Region Plan (the Regional Plan) through five district plans, which detail district-specific directions, place-based outcomes, and the actions to achieve these. The relevant district plan covering the Inner West is the *Eastern City District Plan* (the District Plan).

The District Plan describes how integrated land use and transport planning can help achieve the 30-minute city through increasing development density near transit corridors. It sets a housing supply increase for the Inner West of 5,900 new dwellings between 2016 and 2021, around 14,000 more people which is the third largest housing target for the District Plan.

The key infrastructure elements committed to in the District Plan that would impact the Parramatta Road Corridor (PRC) include Sydney Metro West and Parramatta Road public transport improvements.

7.2 Parramatta Road Corridor Urban Transformation Strategy, UrbanGrowth NSW, 2016



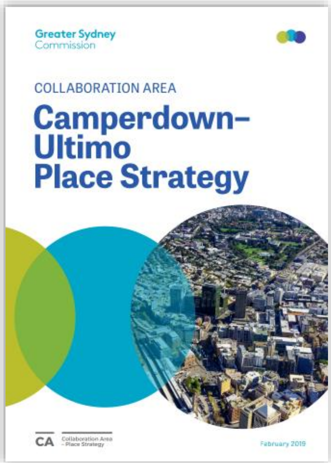
The *Parramatta Road Corridor Urban Transformation Strategy* (PRCUTS) represents the NSW Government's 30-year plan to guide amplified land use functions and support urban revitalisation along the PRC. It presents the long-term infrastructure, commercial and housing delivery programs for the PRC, with an emphasis on place-based planning and liveability. It plans for an estimated 56,000 additional residents in 27,000 new homes and 50,000 new jobs focused within eight Precincts.

The Strategy is supported by a suite of technical documents prepared for UrbanGrowth NSW as part of the Parramatta Road Corridor Urban Transformation Program:

Table 7-1 PRCUTS supporting documents

Document	Description
Parramatta Road Urban Transformation Precinct Transport Report	The first step in developing transport plans for each of the eight Precincts to support urban transformation in the PRC over the short-, medium- and long-term.
Parramatta Road Corridor Implementation Plan 2016 – 2023	A prioritised set of actions to facilitate transformation of the Corridor in the short term.
Parramatta Road Corridor Planning and Design Guidelines	Suggested land use and built form controls to guide future development.
Parramatta Road Corridor Urban Amenity Improvement Plan	A program of urban amenity improvements attached to $198 million of government funding to deliver tangible public domain improvements to the Corridor aligned with its staged redevelopment.
Parramatta Road Corridor Infrastructure Schedule	A prioritised and costed list of future infrastructure including open space, transport, traffic community, health and education facilities required to support the long-term growth in the Corridor.

7.3 Camperdown Ultimo Collaboration Area Place Strategy, Greater Sydney Commission, 2019



The *Camperdown-Ultimo Collaboration Area Place Strategy* informs public and private policy and investment decisions through identification and recognition of complex, challenges and issues faced by the Collaboration Area and identification of growth priorities. The following priorities under the theme of "connectivity" are particularly relevant to this study:

1. Integrate and connect the Collaboration Area within and beyond its edges;
2. Improve local transport options and amenity within the Collaboration Area; and
3. Promote smart technology, drive innovation and connect locally globally.

The following action items under the three overarching priorities are relevant to this Transport Study:

> **Action 1:** Develop a strategy for transport investigations and initiatives, underpinned by the principles of movement and place, to enhance safety, accessibility and permeability within and surrounding the Collaboration Area by prioritising pedestrian, safety and amenity, encouraging cycling, and planning for public transport, freight movements and parking.

> **Action 2:** Advocate for better connections between Greater Sydney's collaboration areas, innovation clusters and health and education precincts, including transport, technology, utility and digital networks, and information sharing.

> **Action 3:** Advocate for a mass transit system that strengthens connections between the Collaboration Area and Greater Sydney's economic corridors.

> **Action 4**: Advocate for a Sydney Metro West station in Camperdown activity node.

> **Action 7**: Improve public transport, pedestrian and cycling connectivity between the three activity nodes:

- Haymarket to Camperdown along the Ultimo axis;
- Camperdown to Eveleigh along the Darlington axis (particularly Redfern Station to University of Sydney); and
- Haymarket to Eveleigh.

> **Action 8:** Implement a pilot project along Broadway and Parramatta Road to reallocate road space and prioritise pedestrians between Central Station and key land uses on the Ultimo axis, while achieving an acceptable level of service for vehicles at the gateway to the Harbour CBD.

> **Action 9**: Identify shared partnership transport solutions to optimise connectivity within the Collaboration Area.

> **Action 11:** Consider piloting a Smart Places program in the Collaboration Area.

7.4 Camperdown Collaboration Area (Tech central) Place Based Transport Strategy, Transport for NSW, 2021

The Place-based Transport Strategy recognises the need to enhance Parramatta Road to be a safe, convenient, and connected movement corridor for all road users. The future of Parramatta Road requires a high-quality public transport solution to ensure accessible, frequent, and reliable services that enhance efficient movements along the corridor.

The implementation of a connected metropolitan cycling network will support access between the Tech Central node and surrounding areas. In addition, the Strategy recommends the creation of a better pedestrian environment along and across Parramatta Road with wider footpaths, increased dwell space and improved priority for walking at traffic signals, recognising its key role in connecting the Camperdown and Haymarket nodes.

7.5 Parramatta Road and Victoria Road Integrated Transport Strategic Business Cases, Transport for NSW 2021 (ongoing)

TfNSW are preparing Parramatta Road and Victoria Road Integrated Transport Strategic Business Cases with the aim to provide enhanced public transport, active transport and public domain opportunities along Parramatta Road.

The outcomes of this Strategic Business Case will be made available in 2022. TfNSW will continue to engage with DPIE and Council to ensure that the outcomes of Strategic Business Case are aligned with vision and recommendations of this Transport Study/Plan.

7.6 Future Transport Strategy 2056, Transport for NSW

Future Transport 2056 (FT56) was released in early 2018, with the objective of ensuring that the Greater Sydney area is prepared for rapid changes in technology and innovation, in order to create and maintain a world class, safe, efficient, and reliable transport system over the next 40 years. It outlines a comprehensive strategy that focuses on how people and goods will be transported around the state, including details of the proposed infrastructure and initiatives.

The vision is built on six outcomes:

> Customer Focused;
> Successful Places;
> A Strong Economy;
> Safety and Performance;
> Accessible Services; and
> Sustainability.

With respect to tying land use and transport planning, Future Transport notes that *'The best places take time and strong partnerships to develop and flourish. Integrated land use and transport planning can activate public spaces, corridors and networks, and positively impact the delivery of health, education and local government services. Transport can improve the liveability and character of places across the state, achieve wider benefits from investment and encourage more desirable patterns of development'* (p. 6).

This statement is particularly relevant to the PRC with respect to integrating transport infrastructure and land use planning to enable the desired transport mode splits.

Parramatta Road is identified as a 'committed initiative' being the beneficiary of a 'major infrastructure upgrade'. The strategy notes that Parramatta Road is subject to public transport improvements in the 0 to 10-year timeframe.[1]

7.6.1 Greater Sydney Service and Infrastructure Plan

The *Greater Sydney Services and Infrastructure Plan* focuses on specific policy, service and infrastructure initiatives to support the strategic direction of Future Transport 2056.

The Plan discusses a number of specific Eastern City infrastructure initiatives. These include the following initiatives which are relevant to this study:

> WestConnex;
> Sydney Metro West;
> Parramatta Road public transport improvements;
> Priority Cycleway links in inner Sydney, including the Inner West GreenWay; and
> Inner Sydney Regional Bike Network within 10km of the Harbour CBD.

[1] Future Transport 2056, p.103

8 Local government document summary

8.1 Inner West Community Strategic Plan, Inner West Council, 2018

The *Inner West Community Strategic Plan* (CSP) was produced by Council with active community input to identify a high-level vision of how the Inner West Council might best evolve socially to satisfy community needs over the next two decades. The Plan's implementation will involve collaboration with key stakeholders and Council has committed to reporting back to the community every four years on progress.

This transport study can help to give effect to the CSP. Relevant strategic directions, outcomes, strategies and indicators are reproduced in **Table 8-1**.

Table 8-1 Community Strategic Plan, strategic directions, outcomes and strategies

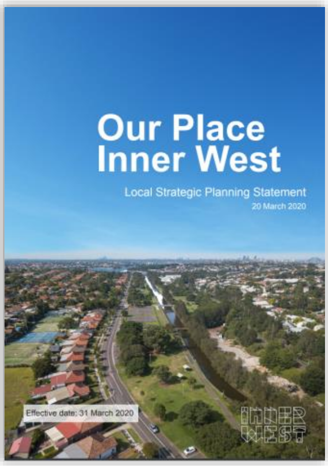
Strategic directions	No.	Outcome	Strategies	Indicators
1: An ecologically sustainable Inner West.	1.1	The people and infrastructure of Inner West contribute positively to the environment and tackling climate change.	Provide the support needed for people to live sustainably. Develop planning controls to protect and support a sustainable environment. Provide green infrastructure that supports increased ecosystem services.	Residential energy consumption.
	1.4	Inner West is a zero emissions community that generates and owns clean energy.	Develop a transport network that runs on clean renewable energy.	
	1.5	Inner West is a zero waste community with an active share economy.	Support people to avoid waste, and reuse, repair, recycle and share.	
2: Unique, liveable, networked neighbourhoods.	2.1	Development is designed for sustainability and makes life better.	Identify and pursue innovative and creative solutions to complex urban planning and transport issues. Develop planning controls that protect and support a sustainable environment and contribute to zero emissions and zero waste community.	Community satisfaction with managing development in the area. Community satisfaction with long-term planning for Council area. Satisfaction with safety of public spaces. Satisfaction with access to public transport. People who travel to work by public transport. Satisfaction with Cycleways. Satisfaction with maintaining footpaths. Community satisfaction with management of parking.
	2.3	Public spaces are high-quality, welcoming and enjoyable places, seamlessly connected with their surroundings.	Plan and deliver public spaces that fulfil and support diverse community needs and life Ensure private spaces and developments contribute positively to their surrounding public spaces Advocate for and develop planning controls that retain and protect existing public and open spaces	
	2.5	Public transport is reliable, accessible, connected and enjoyable.	Advocate for improved public transport services to, through and around Inner West. Advocate for, and provide, transport infrastructure that aligns to population growth.	
	2.6	People are walking, cycling and moving around Inner West with ease.	Deliver integrated networks and infrastructure for transport and active travel. Pursue innovation in planning and providing new transport options. Ensure transport infrastructure is safe, connected and well maintained.	

Strategic directions	No.	Outcome	Strategies	Indicators
3: Creative communities and a strong economy.	3.3	The local economy is thriving.	Strengthen economic viability and connections beyond Inner West. Promote Inner West as a great place to live, work, visit and invest in.	Satisfaction with Council support of local jobs and businesses.
	3.5	Urban hubs and main streets are distinct and enjoyable places to shop, eat, socialise and be entertained.	Pursue a high standard of planning, urban design and development that supports urban centres.	
4: Caring, happy, healthy communities.	4.1	Everyone feels welcome and connected to the community.	Foster inclusive communities where everyone can participate in community life. Empower and support vulnerable and disadvantaged community members to participate in community life.	Satisfaction with support for people with a disability. Walkable open space within 400 metres of all residents. Satisfaction with provision of services for older residents.
	4.3	The community is healthy and people have a sense of wellbeing.	Provide the facilities, spaces and programs that support wellbeing and active and healthy communities.	
	4.4	People have access to the services and facilities they need.	Plan and provide services and infrastructure for a changing and ageing population.	
5: Progressive local leadership.	5.2	Partnerships and collaboration are valued and recognised as vital for community leadership and making positive change.	Collaborate with partners to deliver positive outcomes for the community, economy and environment.	Satisfaction with Council's community engagement. Satisfaction with the community's ability to influence Council's decision making. Community satisfaction with long term planning for council area. Overall satisfaction with Council's performance.

8.2 Inner West Local Strategic Planning Statement, Inner West Council, 2020

The *Inner West Local Strategic Planning Statement* (LSPS) outlines the vision:

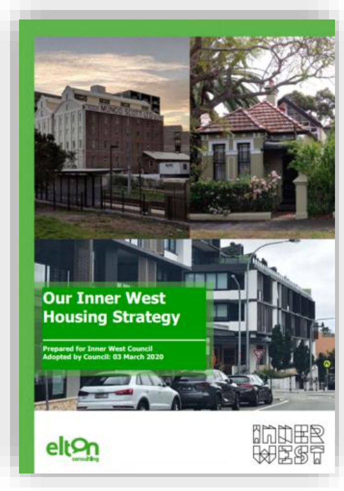
"A place of creative, connected, sustainable and productive neighbourhoods – as vibrant, innovative and diverse as our community".



This is supported by fourteen planning priorities. Key planning priorities that the transport study are most related to and can help give effect to include:

> **Priority 1**: Adapt to climate change;
> **Priority 2**: Inner West is a zero emissions community;
> **Priority 6**: Plan for high quality, accessible and sustainable housing growth in appropriate locations integrated with infrastructure provision and with respect for place, local character and heritage significance.
> **Priority 7**: Provide for a rich diversity of functional, safe and enjoyable urban spaces connect with and enhanced by their surroundings.
> **Priority 8**: Provide improved and accessible sustainable transport infrastructure.
> **Priority 9**: A thriving local economy; and
> **Priority 11**: Provide accessible facilities and spaces that support active, health communities.

8.3 Inner West Local Housing Strategy, Inner West Council, 2020



The *Inner West Local Housing Strategy* is a high-level strategy providing direction for the provision for housing for communities within the LGA. It is an evidence-based study that informs the LSPS, LEP and DCP.

This Strategy aligns with Council's and the community's vision for housing and state government strategic plans and shows how Council will meet the requirements of the District Plan. It also:

> Identifies the unique housing needs of Inner West's current and future residents;

> Develops an approach to boost housing supply, diversity and affordability responding to local needs while enhancing the character of local neighbourhoods;

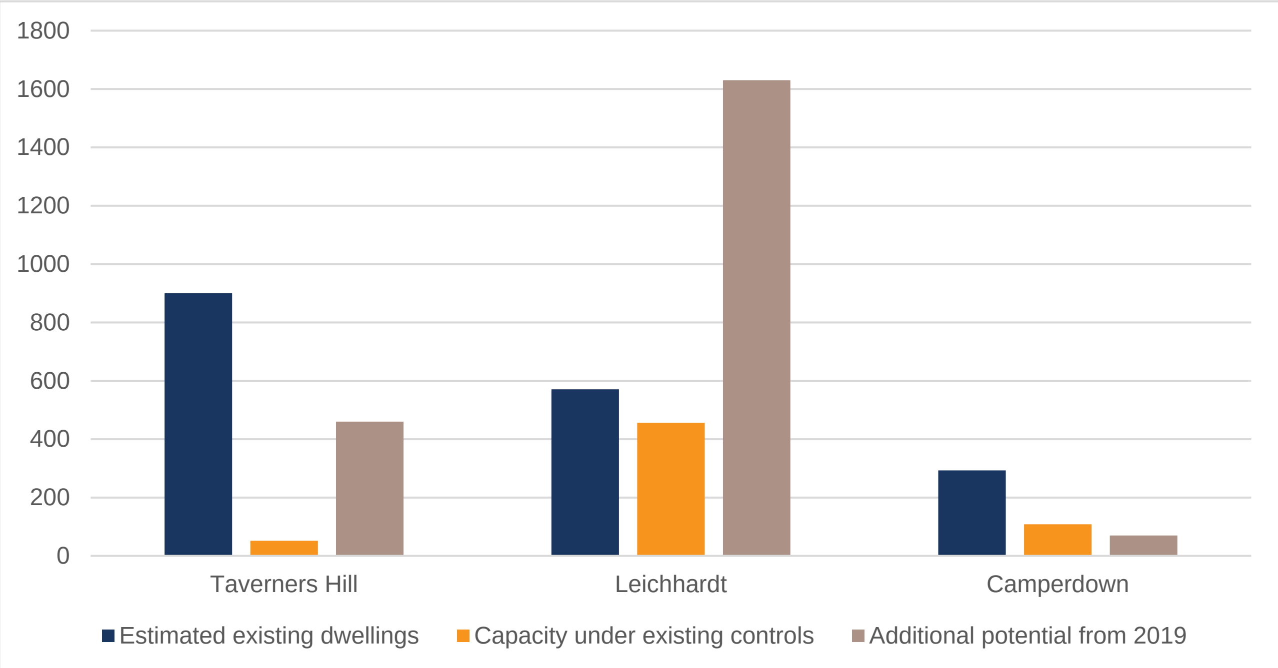
> Provides for population and housing growth;

> Aligns growth and infrastructure; and

> Supports the role of centres and informs Affordable Rental Housing mechanisms and strategies to increase affordable housing supply in the LGA.

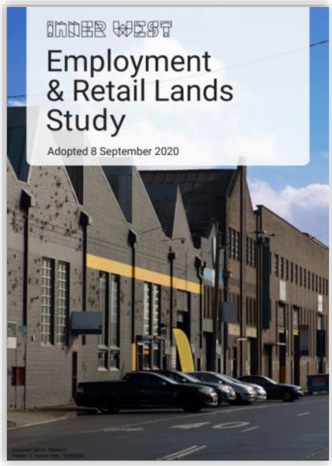
The Strategy identifies significant potential development capacity from 2019 in Leichhardt, with some capacity for additional dwellings in Taverners Hill and Camperdown as shown in **Figure 8-1**. It is noted that this is dependent on rapid mass transit on Parramatta Road, within the existing road configuration. Additional development capacity has been identified in Leichhardt from 2026 dude to the impacts of Sydney Metro West on the rail network.

Figure 8-1 Investigation areas from 2019 for additional housing in 2021-2026



Source: Inner West Local Housing Strategy, Inner West Council, 2020

8.4 Employment & Retail Land Study, Inner West Council, 2020



The *Employment & Retail Land Study* (EaRLS) provides a review of employment and retail land uses and their future potential in the IWC. It aims to facilitate the management of the Inner West employment lands and commercial centres, prioritising actions for productive commercial and industrial land uses to drive job growth and thriving economies.

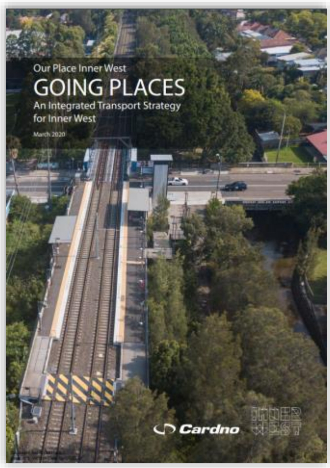
The review and analysis of PRCUTS impacted land identifies inaccuracies in PRCUTS dwelling and employment numbers and that without details of the method and assumptions used in the PRCUTS projects, an independent critical review is difficult.

Council undertook and independent analysis of existing land use and floor space and has examined future land use scenarios based on strategic figures and what is likely to be feasible based on, existing planning controls, PRCUTS proposed planning controls and spatial analysis.

Key issues identified in the study relating to the PRC include:

- Loss of industrial and urban services land as well as flexible and affordable employment floor space under PRCUTS in all three precincts; and
- Greater Sydney Commission and Inner West Council policy positions have changed since the adoption of PRCUTS for the Camperdown precinct. Camperdown-Ultimo Collaboration Area Place Strategy (2019) recommends the following actions:
  - Safeguard business zoned lands from conversions which allow residential uses;
  - In support of establishing biotechnology hub in the triangles between Parramatta Road, Mallett Street and Pyrmont Bride Road; and
  - Safeguard existing and potential innovative and research activities from unrelated commercial activities until the master plan is produced for the precinct.

8.5 Inner West Integrated Transport Strategy, Cardno & Inner West Council, 2020



Going Places: An Integrated Transport Strategy for Inner West aims to address the transport challenges faced by the Inner West LGA and provides strategies and actions of integrated nature to support the Council in achieving its transport vision.

Going Places states the below vision for future transport which is focused on sustainable transport modes:

"Growing numbers of Inner West residents, workers and visitors prefer to walk, cycle and use public transport because it is safe, convenient, enjoyable and healthy.

Inner West transitions to environmentally sustainable transport.

Everyone is connected to their community and local services, and can access educational, retail, cultural and recreational districts, as well as jobs and services across local and regional areas.

The transport network enhances local economic vitality, with freight and goods movements are separated from people by space and/ or time."

The strategy is highly relevant to this study with future plans that would have direct implications on PRCUTS. It outlines several key projects including:

- Parramatta Road Revitalisation;
- Plan and Build Inner West Pedestrian Network;
- Plan and Build Inner West Cycle Network;
- The GreenWay and The Green Grid;
- Grid Bus Network;
- Increased support for efficient goods delivery;
- Innovative Mass Transit for Parramatta Road;

8.5.1 Parramatta Road revitalisation

IWC previously commissioned the *Parramatta Road Transport Opportunity Study*. This study outlined an opportunity for a road-based mass transit system with dedicated road space to provide a high quality, frequency and capacity service along the Parramatta Road corridor as a means to support a high capacity movement function for people instead of vehicles. The Inner West Integrated Transport Study provides further recommendations including:

> 24-hour dedicated mass transit lane with additional space at stops for customers;

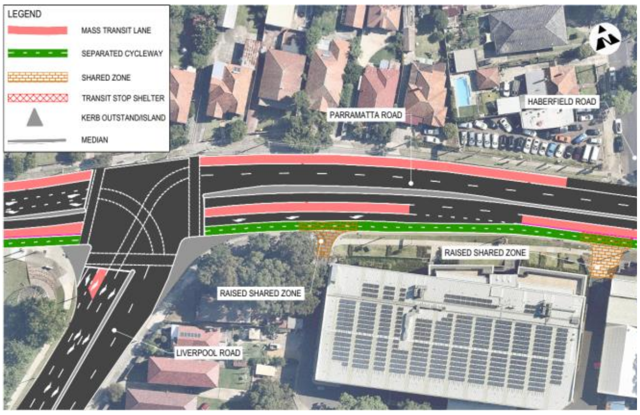
> Plantings and car parking at mid-block locations; and

> Separated cycle facilities and opportunities for site-specific footpath widening.

Concept layouts from west to east are shown in **Figure 8-2**.

Figure 8-2 Parramatta Road concept layouts

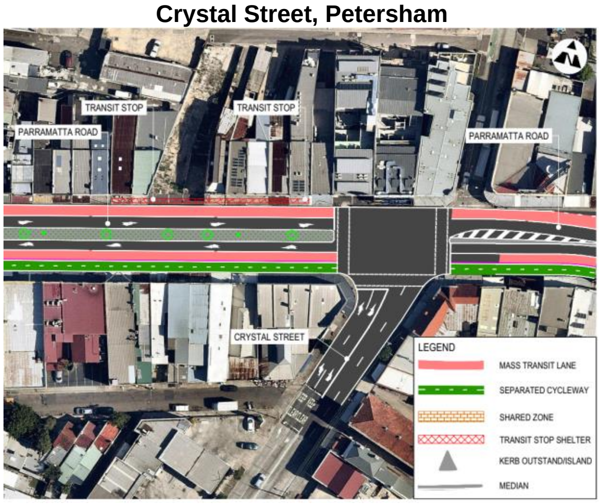
Liverpool Road, Ashfield



Taverners Hill Light Rail Stop

Norton Street, Lechhardt

Crystal Street, Petersham



Pyrmont Bridge Road, Annandale

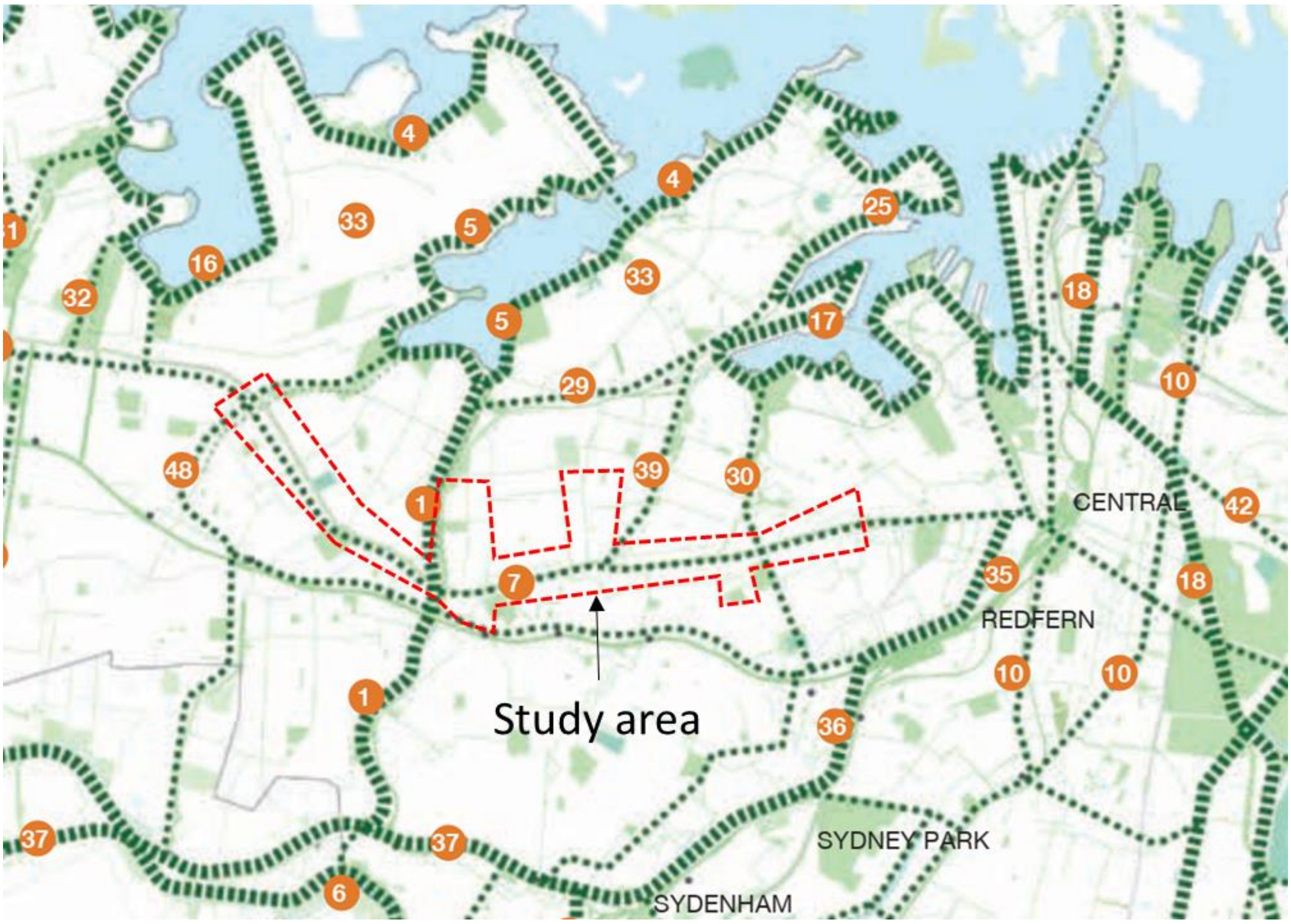
8.5.2 The GreenWay and The Green Grid

The Sydney Green Grid, which includes all of metropolitan Sydney, was developed in recognition of the importance of natural land uses the environment and people. Some Green Grid corridors also provide the opportunity to be part of and integrate with active transport links.

PRCUTS IWC precincts have several existing or proposed projects with active transport opportunities as numbered in **Figure 8-3**. These include:

- 1 – The Greenway and Hawthorn Canal;
- 7 – Parramatta Road Urban Renewal Corridor;
- 30 – Johnsons Creek and Harold Park;
- 39 – Whites Creek and Whites Creek Lane, Leichhardt; and
- 48 – Cooks River Secondary Green Links: Ashfield to Canterbury (from Iron Cove Creek).

Figure 8-3 Green Grid



Base image source: Central District, Sydney Green Grid Spatial Framework and Project Opportunities, Tyrrell Studio, 2017

8.5.3 Inner West Pedestrian Network and Cycle Network

The Inner West Strategic Pedestrian and Cycle Network identifies a priority mesh network that covers the entire IWC and connects people from where they live to places they need and want to be. The strategic pedestrian and cycling network was developed to align with the Green Grid and Greenways.

These priority networks have interfaces with the study area and will be used to align recommended actions.

A schedule of the strategic networks as they interface with PRCUTS Inner West precincts is outlined in **Table 8-2**. Map extracts of the strategic pedestrian and bicycle network are shown in **Figure 8-4** and **Figure 8-5**.

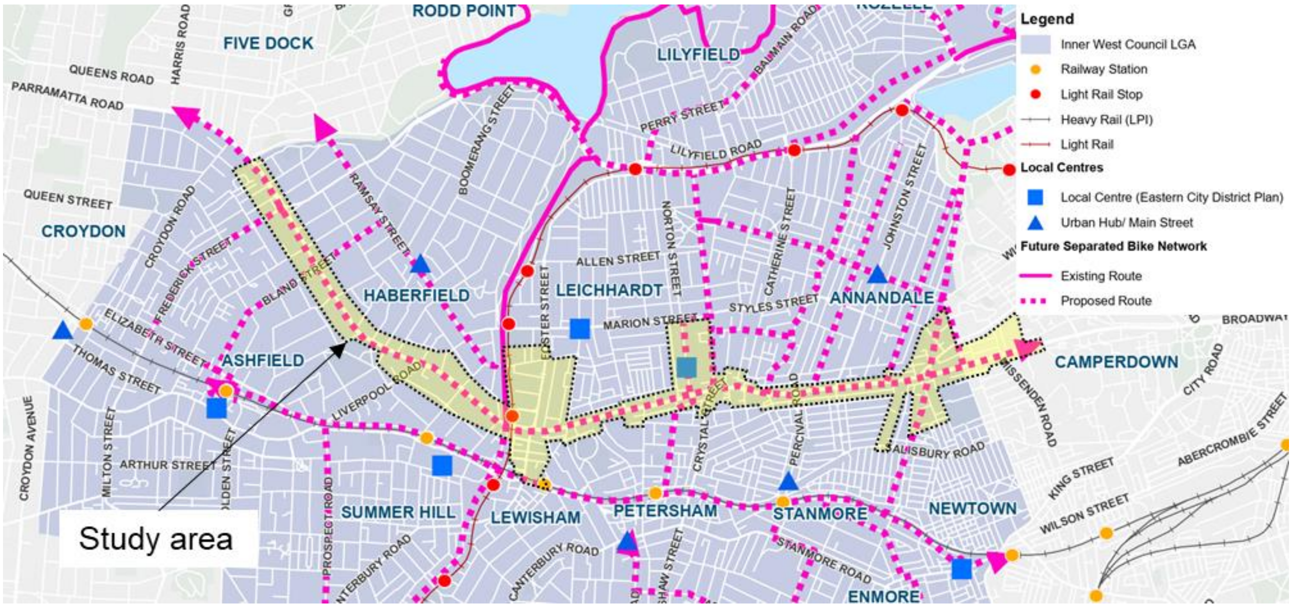
Table 8-2 Strategic pedestrian and bicycle network

Precinct	Location	Side of Parramatta Road	Strategic pedestrian network	Strategic bicycle network
Taverners Hill	Parramatta Road	Both	Yes	Proposed
	Iron Cove Creek	North	Proposed	No
	Wattle Street	North	Yes	Yes
	Fedrick Street	South	Yes	Proposed
	Bland Street	Both	No	Proposed
	Dalhousie Street	North	Yes	No
	Liverpool Road	South	Yes	No
	Sloane Street	Both	Yes	No
	Greenway	North	Yes	Yes
	Greenway	South	Proposed	Proposed
	Flood Street	North	Yes	No
Taverners Hill/ Leichhardt	West Street	South	Yes	No
Leichhardt	Palace Street	South	Yes	No
	Railway Street	South	No	Proposed
	Renwick Street	North	No	Proposed
	Norton Street	North	Yes	Proposed
	Balmain Road	North	Yes	Proposed
	Catherine Street	North	Yes	No
	Whites Creek Lane	North	Proposed	Proposed
	Percival Road	South	Yes	No
	Annandale Street	North	Yes	Proposed
Leichhardt/ Camperdown	Johnston Street	North	Yes	No
Camperdown	Nelson Street	North	Yes	Proposed
	Johnstons Creek	North	Proposed	Proposed
	Denison Street	South	Yes	No
	Booth Street	North	No	Proposed

Figure 8-4 Strategic pedestrian network – existing and proposed

Base image source: Our Place Inner West Going Places, An Integrated Transport Strategy for Inner West, Inner West, 2020

Figure 8-5 Strategic bicycle network – existing and proposed



Base image source: Our Place Inner West Going Places, An Integrated Transport Strategy for Inner West, Inner West, 2020

8.5.4 Grid Bus Network

The existing bus network is complex due to the large number of routes traversing through the Inner West which reduces the convenience, propensity for a customer to use multiple services. This can also result in buses bunching on key corridors.

The Grid Bus Network proposes Transport for NSW simplify the bus network into a mesh/ grid system comprising of north-south and east-west routes. This would ideally serve higher capacity networks such as rail and an improved mass transit service on Parramatta Road.

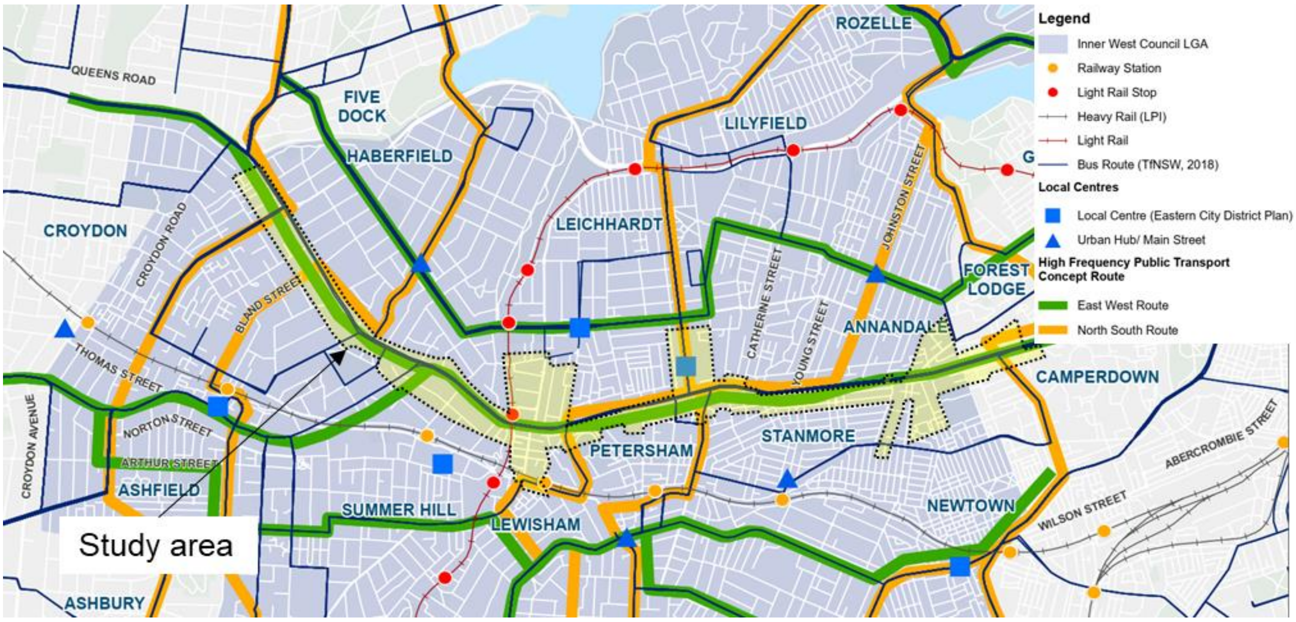
For the PRCUTS IWC precincts, this would mean:

> Rationalisation of existing bus services along Parramatta Road replacing multiply routes with a single high capacity and frequency service and improved integration with Taverners Hill light rail stop;
> A north south route linking the Balmain peninsula to Dulwich Hill via Lewisham train station;
> A north south route linking Drummoyne to Hurlstone Park via Ashfield Station;

> A north south route linking Rozelle to Marrickville via Petersham train station.

The proposed grid bus network is shown in **Figure 8-6**.

Figure 8-6 Grid bus network



Base image source: Our Place Inner West Going Places, An Integrated Transport Strategy for Inner West, Inner West, 2020

8.5.5 Increase support for efficient goods delivery

Council recognises the economic benefits and needs for the movement of goods. With increased online shopping culture as well as business needs, space for deliveries provides a higher value benefit.

The project identifies a kerbside hierarchy which will apply to PRCUTS precincts. This has been identified by factors that support sustainability, the economy and the highest number of beneficiaries. This is outlined in **Table 8-3**.

Table 8-3 Kerbside space use hierarchy

Priority	Use	Rationale
Higher	Bicycle and personal mobility devices	Space is made for sustainable transport device parking
	Public transport stops	A higher priority is given to the provision of public transport stops.
	Service vehicle zones Mail zones Truck zones Loading zones	Provision of servicing space is given a high priority to support safe conditions for workers and supporting the economy.
	Taxi/ rideshare zones	Space provided for safer pick up and drop off which supports people who do not own a private car.
	Car share zones	Provide spaces to support residents without a car and workers who do not drive to work and may be required to undertake workday trips. Car share has many beneficiaries throughout the day and week.
	Motorbike parking	Provides a benefit to more people per a given area.
Lower	Private vehicle parking: Accessible parking Electric vehicle parking Non-electric vehicle parking	Private vehicle parking occupies a considerable space and benefits fewer people. Accessible parking takes highest priority in this category to support equity.

8.5.7 Innovative Mass Transit for Parramatta Road.

The strategy examines potential options for mass transit along Parramatta Road including:

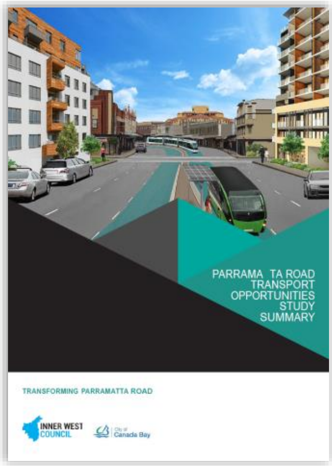
- High-Spec buses;
- Bus Rapid Transit;
- Guided Buses;
- Optically-Guided Trams; and
- Trams or Light Rail Vehicles.

The strategy states service must have the following benefits:

- Features to identify the service and attract passengers to use it;
- High frequency and comfort; and
- Easy to understand service.

Inner had previously undertaken a detailed mass transit study along Parramatta Road which is described in the next section.

8.6 Parramatta Road Transport Opportunities Study Summary, Inner West Council & City of Canada Bay Council, 2017



This study was developed in response to PRCUTS and the potential reduction of traffic on Parramatta Road due to WestConnex and the approval condition of WestConnex which is to convert two lanes on Parramatta Road between Burwood and Haberfield. The study was conducted to examine the existing carriageway of Parramatta Road and provide recommendations on the public transport opportunities on the Corridor.

The study examines various options and configuration of public transit options including light rail, bus rapid transit, guided electric transit system and bike sharing.

The study recommended Guided Electric Transit System (GETS) emerged as the preferred option for Parramatta Road, feasible for operation form 'Day-One 'of WestConnex Stage 3. It recommended centre-running dedicated lanes for the GETS which supports accessible transport and kerbside parking of other vehicles.

GETS is also scalability for a spine and spur network with first and last mile infrastructure in the future. The system can:

- Be accommodated within the corridor between Strathfield and Sydney City;
- Innovative image which can encourage confidence in developers and future residents and hence, promote revitalisation of the Corridor; and
- Cost effective while providing sufficient capacity, frequency and flexibility.

9 Emerging travel trends and technology

Emerging travel trends and technology are likely to impact the need and the way people travel in future. New transport technologies and innovations provide an opportunity to improve the transport network by providing benefits through improving safety, accessibility, mobility, sustainability and productivity.

Consideration must be given to technologies that help to give effect to the vision of PRCUTS and being award of when and what technology may have negative impacts. The Inner West Council Transport Strategy outlines a number of initiatives. **Table 9-1** updates and summarises the emerging technology and megatrends as they could apply to PRCUTS IWC precincts.

Table 9-1 Emerging technologies and megatrends

Transport technology/ innovation	Source/ status & timing	Location	Key details	Implications PRCUTS IWC precincts
Mobility as a Service (MaaS)	Discussed in Future Transport 2056. *No official policy as yet.*	Global.	Application-based services would market and integrate transport modes including, rideshare, car share or public transport.	Easier to use transport network, reducing reliance on private vehicles within precincts.
E-bikes	Online	Global.	Bicycles with batteries and electric motors to assist when pedalling is not desirable.	Advances in technology are making these vehicles cheaper and more accessible to all. Additional bike volumes on the local transport network for local and through movements needs to be considered and accommodated for. This could have safety implications for pedestrians or users without the right support and application of safety and risk reduction initiatives. Additional parking opportunities will need to be provide in the public domain and new development.
E-scooters	Online	Global.	Scooters with batteries and electric motors to assist when desirable.	Currently illegal to ride on footpaths and roads in NSW. Nonetheless, a change in policy would allow E scooters to become a convenient tool for short local trips to shops and transit nodes. Scooters also take up less space than bicycles when parked on footpaths. Consideration of safety and parking opportunities as per bikes.

Transport technology/ innovation	Source/ status & timing	Location	Key details	Implications PRCUTS IWC precincts
Intelligent transport systems and infrastructure	Online/ Ongoing	Global.	Applying computing power and data to improve transport networks. Real-time vehicle position. Traffic management software and infrastructure. Integration of systems to support multi-modal systems.	Efficient management of transport through PRCUTS and providing customers timely information to inform optimal travel choices.
Track-free trams or Guided Electrical Transit System (GETS)[2]	IWC – aspirational. *No committed timeframe and dependent on State Government funding assistance.*	Global Interest, already running in China and parts of Europe.	These vehicles look like a light rail vehicle but run on rubber tyres and are electrically powered. They can run autonomously with laser guided tracking along a set path on normal roads. Control can be assumed by human intervention if required, usually to help divert it from its normal passage during disruption. Vehicles are designed to run at 70 kilometres an hour, at high frequency. Capacity is dependent on configuration, with a typical unit able to accommodate 300 customers.	It has similar benefits to trams but far lower costs and time required for implementation. Potential as high capacity mass transit on Parramatta Road, providing opportunity for pedestrian friendly vibrant streets.
Electric buses	Online	Global. Transit System trial to begin mid 2019	Buses with electric motors, powered by batteries. Buses typically have capacity for 50 – 100 customers depending on configuration.	Quieter public transport movements with cleaner air and lower running costs on existing bus routes.
Smart shuttles	Trials underway by TfNSW at Sydney Olympic Park and regional NSW.	Global.	Vehicles carry up to 14 people and follow variable route corridors with the ability to react to customer needs.	Existing public transport service and coverage likely to negate the need for Smart Shuttles.
On demand public transport	Trials underway by TfNSW in the Northern Beaches, and The Hills Shire Council in Metro Station Precincts. .	Global.	Buses made available by online bookings, mostly to reach local transit nodes as a 'last mile' service. Generally used to fill in public transport service coverage gaps.	Existing public transport service and coverage likely to negate the need for On Demand buses.

[2] https://theconversation.com/why-trackless-trams-are-ready-to-replace-light-rail-103690

Transport technology/ innovation	Source/ status & timing	Location	Key details	Implications PRCUTS IWC precincts
Automated freight delivery methods	Connected and Automated Vehicles Plan 2019 by NSW Government	Global.	Artificial intelligence will drive vehicles for us, pre-empt changes in traffic, provide opportunity for centrally control traffic routing cognisant to the environment. More efficient use of road space and reduction in circulating vehicles if multiple deliveries are undertaken with one vehicle.	These have the potential to provide smaller sized deliveries to homes and businesses and could include read to eat food delivery. These may be undertaken on footpaths and would require standards to manage safety and space.
Rideshare	Implemented	Global	Rideshare technology has disrupted the taxi industry. It provides the convenience of users being able to request a point to point service from a mobile device.	Reduces the need to own and use a private vehicle, particularly for shorter trips. More kerbside space is required in conspicuous locations to support safe pick-up and drop-off access to services.
Electric vehicles (EV)	Electric and Hybrid Vehicle Plan (2019), NSW Government. Future Transport 2056. *Initiatives for Investigation (0-10 years).*	Global.	Embraces the growing availability of electric and hybrid vehicles. Roll-out of electric vehicle charge points as necessary to facilitate the future of electric vehicle use.	Opportunities to trial charging points in local centres and in new developments. New development should consider the need to easily add infrastructure to charge electrical vehicles.
Connected and autonomous vehicles (CAVs)	Connected and Automated Vehicles Plan 2019 by NSW Government	Global.	Artificial intelligence will drive vehicles for us, pre-empt changes in traffic and tune in to the movements of all around them. It is quite possible that private ownership of cars will become a thing of the past, replaced by rideshare fleet memberships. Shared CAVs would likely allow for a more efficient use of existing road space and parking spaces, reduce traffic volume, improve network efficiency and improve road safety by removing human error.	This could make some car parking redundant into the future. Consideration should be given providing less car parking and readapt able car parking space in development.

10 Land use – existing conditions

This section summarises existing land use characteristics in Taverners Hill, Leichhardt and Camperdown and discusses future plans in each precinct. Core and frame areas of each precinct are shown in **Figure 10-3.**

10.1.1 Camperdown

The Camperdown Precinct spans across the Inner West and the City of Sydney LGA's. The Camperdown Core Precinct falls wholly in the Inner West.

10.1.1.1 Camperdown Core Precinct

The Camperdown Core Precinct is bounded by Johnston Creek, Mallet Street north of Parramatta Road and Australia Street, Cardigan Lane and Derby Street south of Parramatta Road. The Precinct is strategically located near the Sydney CBD, University of Sydney and Royal Prince Alfred Hospital.

The Camperdown core precinct comprises primarily of industrial areas to the north and south of Parramatta Road. A number of bulky goods are located on Pyrmont Bridge Road and a small number of high street retail front the southern side of Parramatta Road.

Proximity to the city and university, availability of light industrial spaces and good arterial road access has supported employment of researchers and creatives in businesses such as design studios and start-ups. A large proportion of industrial buildings located between Mallet Street, Pyrmont Bridge Road and Parramatta Road were demolished to accommodate the WestConnex construction.

Camperdown is shown in **Figure 10-1** and **Figure 10-2**.

Figure 10-1 Camperdown Hotel

Figure 10-2 Parramatta Road, Camperdown

10.1.1.2 Camperdown Frame Area

The Camperdown Frame Area is an approximately 1.3-kilometre long corridor on Parramatta Road that connects between Johnston Street in the west and Missenden Road to the east. The frame areas support a variety of retail businesses including homeware stores, furniture shops, automotive shops, hardware stores and eateries.

10.1.1.3 PRCUTS planned future

PRCUTS and the Camperdown-Ultimo Collaboration Area Place Strategy (CUCAPS) are in alignment with developing Camperdown as a health, education and innovation precinct. Leveraging on Camperdown's proximity with the Sydney CBD, University of Sydney and Royal Prince Alfred Hospital, an opportunity exists to support tech start-ups, innovative and creative industries to expand the research and knowledge-based activities in the precinct. This includes a biotechnology hub in the 'Camperdown Triangle', which consists of land bound by Parramatta Road, Mallett Street and Pyrmont Bridge Road. The site is currently a WestConnex dive site.

The CUCAPS and the IWC Employment and Retail Land Study (EaRLS) are in support of safeguarding business zone lands from being converted into residential lands and safeguarding existing and potential innovative and research activities from unrelated commercial activities. This will be done through:

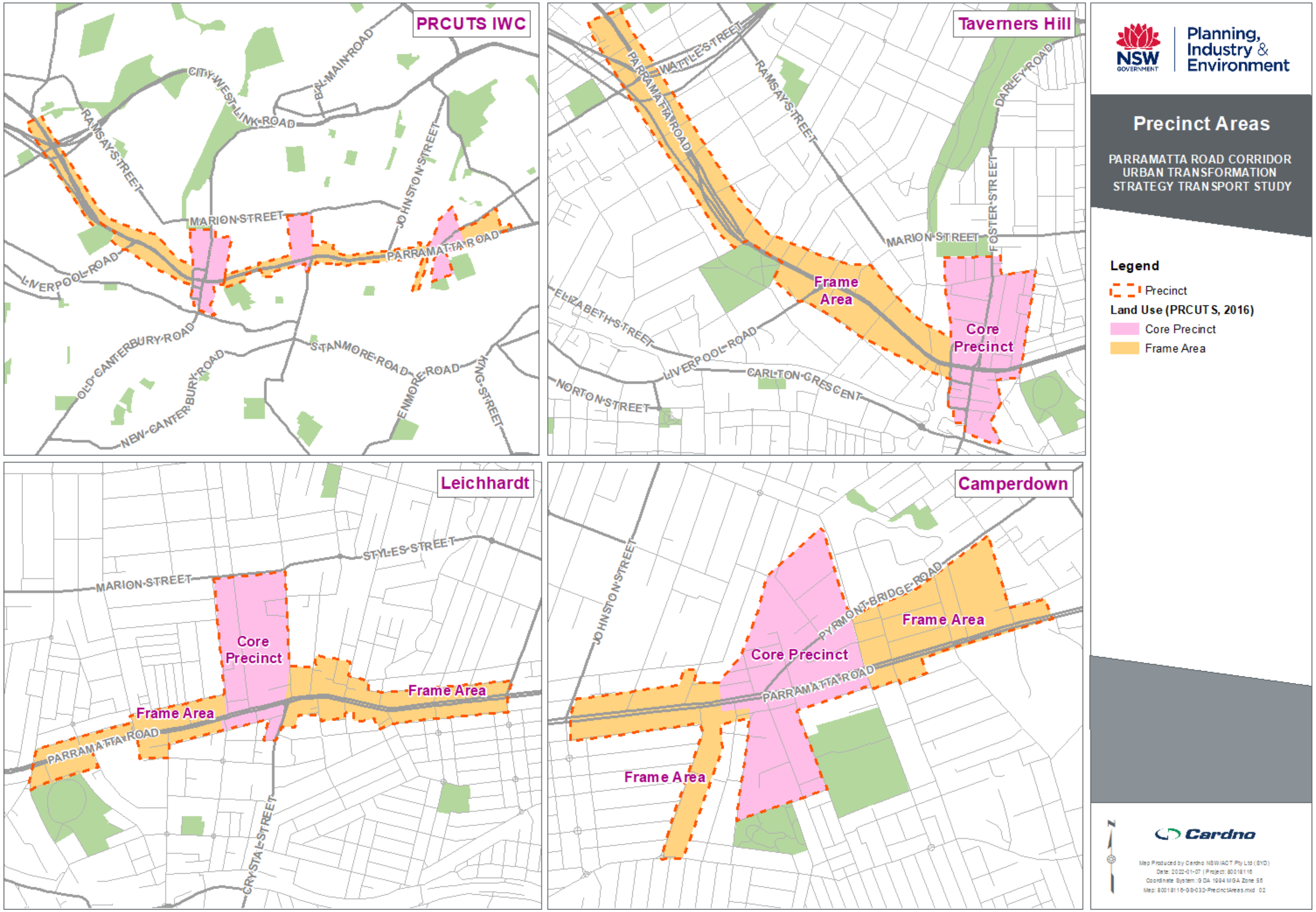
> Maintaining existing light industrial zone to allow for affordable employment options; and

> A pilot project that introduces a minimum percentage requirement for affordable space in new developments to encourage innovative and creative industries.

A masterplan is planned to establish Camperdown as a health and education precinct. A $750 million redevelopment of the Royal Prince Alfred Hospital was announced in 2019. The future redevelopment aims to increase jobs and improve health services in the local area. Relocation of the Faculty of Health Sciences, Faculty of Nursing and Midwifery and Central Clinical School at University of Sydney will reinforce the vision of Camperdown as a biotechnology and biomedical hub. The University of Sydney is set to become a more active and dynamic activity node with plans to open up the campuses to the broader community including the Chau Chak Wing Museum opened in November 2020 and a future new gateway to City road.

East of the Camperdown precinct, the Central Station Precinct development will accommodate more than 200,000 additional users within 20 years, and to the north, the Bays Precinct is set to be revitalised with the completion of the Sydney Metro West Station and surrounding development.

Figure 10-3 Core and frame precinct areas



10.1.2 Leichhardt

10.1.2.1 Existing conditions

Leichhardt is a local centre in the Inner West, providing access to essential goods and services near for local residents.

The Leichhardt Core Precinct as defined in PRCUTS is bounded by Renwick Street, Balmain Road, Parramatta Road and Marion Street in addition to a row of properties fronting Crystal Street. The precinct contains residential buildings, restaurant and retail outlets. The precinct's existing activity centre is concentrated on Norton Street, running north-south along the precinct. This is shown in **Figure 10-4** and **Figure 10-5.** Many restaurants and eateries are located along Norton Street and Parramatta Road. The precinct has a specialisation in wedding related retail services, with more than a dozen shops clustered along Parramatta Road.

Key destinations in Leichhardt Core Precinct are:

> Leichhardt Public School;

> Norton Plaza;

> The Italian Forum (Leichhardt Library on the ground floor); and

> Palace Norton Street (Cinema).

Leichhardt Town Hall is located north of the Precinct's northern boundary, Marion Street.

Figure 10-4 The Italian Forum

Figure 10-5 Norton Street

10.1.2.2 Leichhardt Frame Area

The Leichhardt Frame Area extends 1.8 kilometres along Parramatta Road between Flood Street in the west and Johnston Street in the east. On the western end, the Frame Precinct contains industrial warehouse buildings and modern showrooms. East of the Leichhardt Frame Precinct, there contains smaller sized employment centres with mixed urban services and retail. The eastern end also accommodates two council owned carparks: Hay Street car park with 61 spaces and Renwick Street Car Park with 10 spaces. The Italian Forum Car Park has 455 spaces. There is a notable amount of vacant floor spaces within this area. The Corridor also supports a high number of automotive businesses.

Petersham Park accessed via Park Street and West Street provides a public amenity in vicinity of the Frame Precinct. Fort Street High School on Parramatta Road is also a key attractor on the Corridor.

10.1.2.3 PRCUTS planned future

PRCUTS sets the vision for the Leichhardt Precinct to leverage on its existing strengths as a vibrant people orientated area with improved public amenity along Parramatta Road. Existing Improved amenity along PRC including the planned transport projects to improve pedestrian experience will allow for more opportunities in outdoor dining and footpath trading.

The E&RL Study forecasts that an additional 20,065 square metres of office floor space and 11,511 square metres of retail floor space by 2036 will be required on Norton Street. A minimum floor space ratio control for non-residential uses and requirement for ground floor retail to support the forecasted increase in employment will be required.

Leichhardt's night time economy will grow. Markets and street festivals will attract visitors to the area along with the establishment of small bars and late night trading.

Existing light industrial and enterprise corridor zone lanes in Leichhardt will be preserved and protected from conversion to other uses.

The Leichhardt Frame Precinct will benefit from more flexible employment areas, particularly for tenants on ground level, which support a broader range of businesses. A planning response will be developed to achieve renewal of employment floor space while maintaining affordability and urban amenity.

A place-based study is planned to review planning controls for the Leichhardt Precinct in the context of PRCUTS and the former Leichhardt Urban Design and Heritage Studies (2016). As anecdotal evidence has shown that there is currently a low demand for mixed-use development, a feasibility study will be undertaken to ascertain what makes a mixed-use development viable.

10.1.3 Taverners Hill

10.1.3.1 Existing conditions

Taverners Hill is a local centre within the suburb of Leichhardt. The Taverners Hill Core Precinct is a mixed use area with dwellings in a range of densities focused nearer to Parramatta Road.

The precinct supports a range of businesses including car dealerships, offices, automotive repair stores, events specialists, artistic education centres, print shop, a gym and a meat wholesaler, concentrated along Parramatta Road. Residential land uses include apartments, terrace housing and workers cottages.

The active main streets Old Canterbury Road and Tebbutt Street provide north-south connection linking Lewisham Station to Marion Street. Adjacent to Lords Road is an industrial and urban services estate.

Key destinations in and in vicinity of Taverners Hill Core Precinct are:

> Kegworth Public School;
> Leichhardt Community Church;
> Lambert Park Sportsfield; and
> MarketPlace Leichhardt.

Some places in Taverners Hill are shown in **Figure 10-6** and **Figure 10-7**.

Figure 10-6 MarketPlace Leichhardt

Figure 10-7 Parramatta Road, Taverners Hill

10.1.3.2 Taverners Hill Frame Area

The Taverners Hill Frame Area encompasses a 2.4 kilometre section of Parramatta Road between Iron Cove Creek and Hawthorne Canal. The Corridor supports a wide range of retail and services including car dealerships, automotive repair shops, homeware shops, motels and inns. Interchange of Parramatta Road and WestConnex is located west of the precinct.

Key destinations in and in vicinity of Taverners Hill Frame Precinct are:

> NSW Ambulance Haberfield Superstation;
> Uniting Church in Australia;
> Bunnings Ashfield; and
> The Willows Private Nursing Home Pty.

10.1.3.3 PRCUTS planned future

Within the Taverners Hill Precinct, employment land use is expected to be maintained on both sides of Parramatta Road, Tebbutt Street, Upward Street and George Street. Industrial and urban services land in Taverners Hill will also be retained and protected from conversion into residential uses to maintain employment opportunities.

To accommodate increase in population and employment in the future, adoption of increased height and floor space ratio controls along the northern side of Parramatta Road is proposed by IWC. Plans to undertake a detailed precinct planning for Taverners Hill to achieve improved urban design and support site specific redevelopment for employment purposes are underway.

11 Travel demand

The PRC contains some well-established transport networks including road, rail, bus and active transport provisions. The following sections detail the existing conditions and transport services available within the study area.

11.1 Mode share

The Household Travel Survey (HTS) collated by the Transport Performance and Analytics (TPA) division of Transport for NSW provides indicative travel behaviour information from dwellings across the Sydney Greater Metropolitan Area (GMA). Samples of residents provide detailed travel information over a typical weekday. The data is scaled up and uses data from three years of surveys to provide a snapshot of travel patterns of LGAs.

HTS mode estimations for IWC residents in years 2018 – 2019 indicate there were approximately 1,055,000 trips on a typical weekday. These trips are measured by mode, so one trip can be measured as several and this is generally captured by “Walk Linked” trips as part of a multi-modal journey.

A breakdown of the number of estimated trips on a typical weekday in 2018 – 2019 is shown in **Figure 11-1** and the percentage compared with Sydney GMA in **Figure 11-2** .

Figure 11-1 IWC average trips per day/ mode

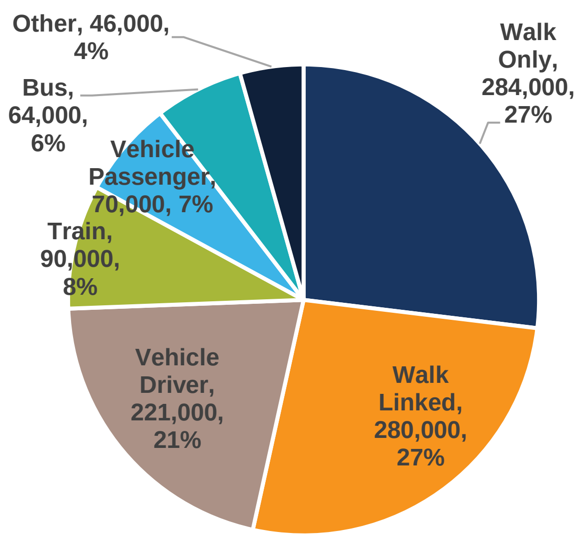
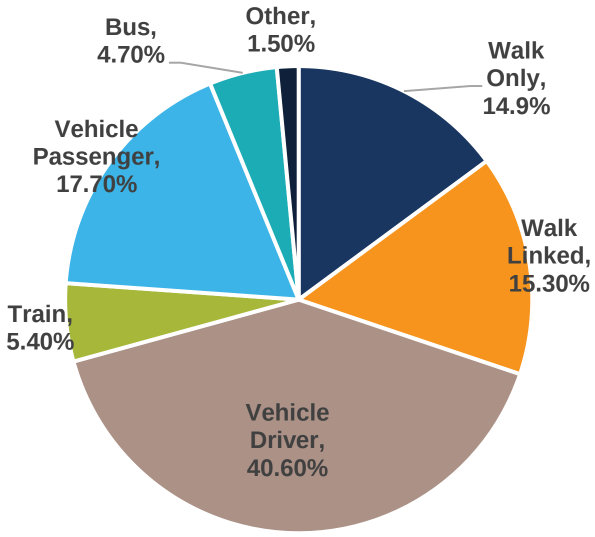


Figure 11-2 Sydney GMA average percentage of trips/ day



Data source: Household Travel Survey 2008/09 – 2018/19 – Data by LGA, TPA, 2021

Figure 11-1 shows that over half of the trips involve walking and this highlights the importance of supporting pedestrians with safe and high quality facilities. A “Walk Linked” trip indicates walking to another mode, i.e. the public transport stop/ station.

Approximately 154,000 public transport (train + bus) trips on a typical weekday, with a portion of the 46,000 trips categorised as “other” likely to be attributed to light rail. This shows that car use (vehicle driver and vehicle passenger) represents the highest portion of motorised travel with just under 300,000 trips.

It is understood that “Other” trips includes cycling trips. It can be anticipated that cycling trips could represent at least 1 per cent of all trips, which would be over 10,000 trips per day.

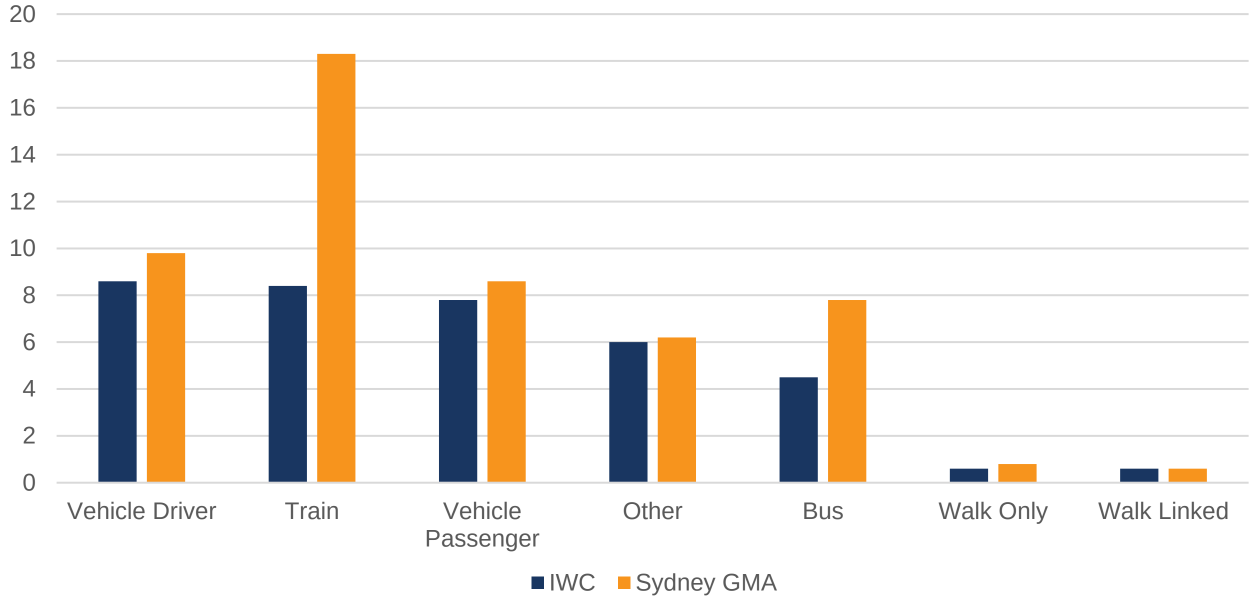
Comparisons to the Sydney GMA shows that the Inner West has higher rates of walking and sustainable transport use.

This information suggests it is important to provide and maintain a high quality walking network to support people within and passing through PRCUTS precincts.

11.2 Average trip distance

Average trip distance for each mode is shown in **Figure 11-3**. This shows the longest average trips for Inner West residents occur in cars and on trains. "Other" trips average six kilometres which aligns with the assumption that many of these represent light rail and bicycle trips. On average, Inner West residents have shorter public transport trips, reflective the location in Sydney. Walking trips represent the shortest trips at approximately 600 metres each.

Figure 11-3 Modal average trip distance



Data source: Household Travel Survey 2008/09 – 2018/19 – Data by LGA, TPA, 2021

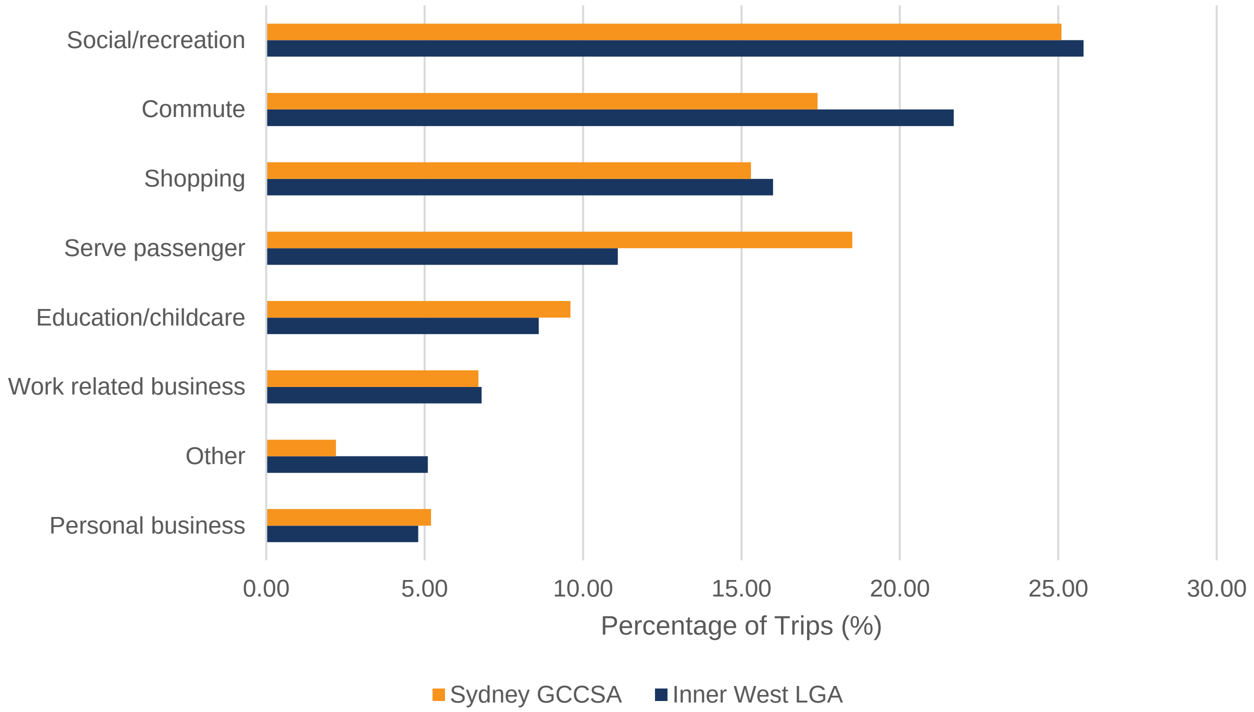
The data indicates that on average, IWC residents travel shorter distances which is indicative that the daily needs of people can be met closer to home. Maintaining land use diversity will continue to support shorter trips, improving liveability for residents.

11.3 Trip purpose

Trip purpose is a subset and aggregate of mode share trips. One trip purpose can utilise multiple modes of travel, as such there are only 722,000 trips identified on a typical weekday. Based on the estimated population of 199,000, each resident makes approximately 3.6 trips per typical weekday.

There are eight trip purpose categories in the data. A comparison on Inner West trip purpose percentage split against the Sydney Metropolitan area is shown in **Figure 11-4**.

Figure 11-4 Trip purpose portion



Data source: Household Travel Survey 2008/09 – 2018/19 – Data by LGA, TPA, 2021

The data shows the most occurring trip purpose is for social/ recreation purposes followed by commuting and shopping. Trip purposes are generally consistent with Greater Sydney. Inner West has a smaller "serve passenger" trip share less people being driven around by others which could be a result of improved public transport and ride share availability.

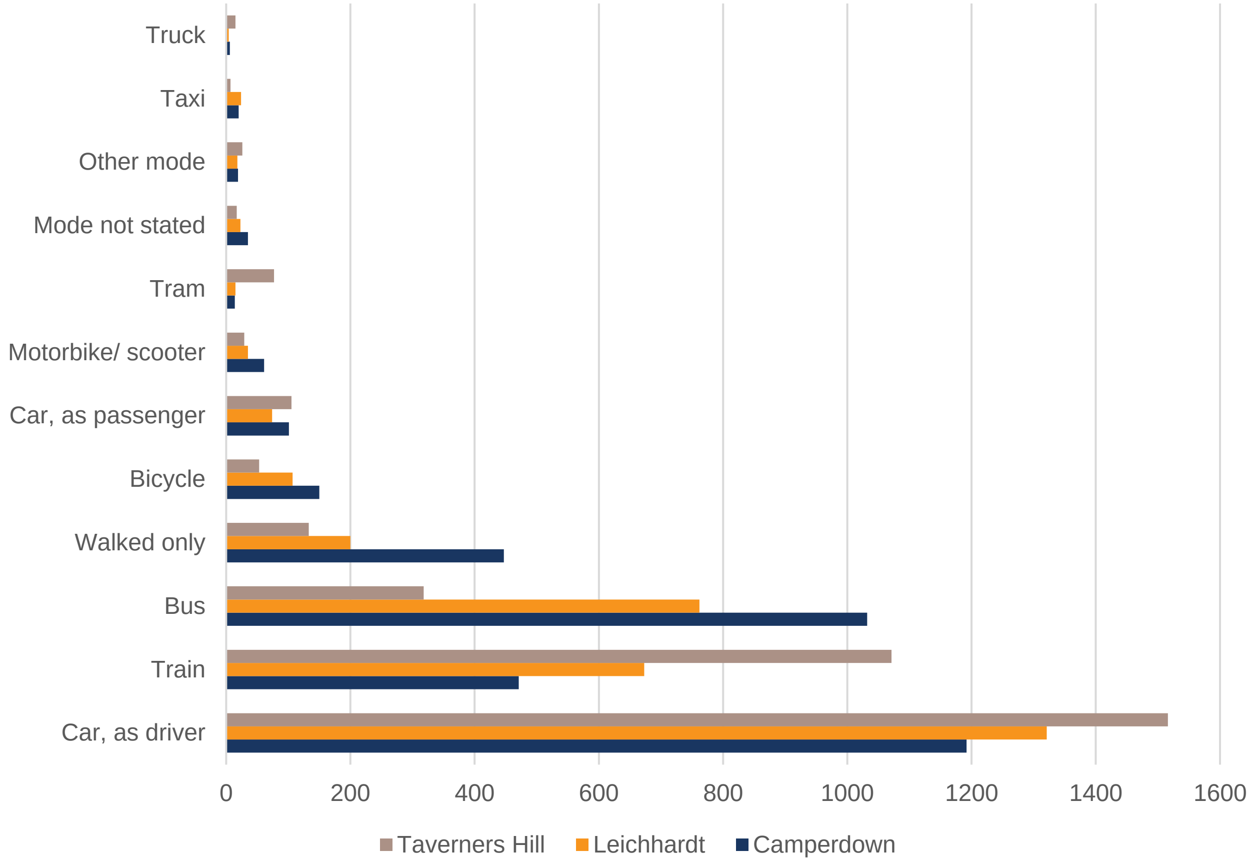
Commuting accounts for approximately 22 per cent of all trips. Due typical business hours and the common times people commute, commuting trips create weekday AM and PM peak periods. Commute trips are discussed in the next section.

PRCUTS transport recommendations must support all trip types, recognising that trips happen throughout the day and despite the network peaks, commute trips represent only 22 per cent of daily trip purposes.

11.4 Journey to work

Journey to work data from Census 2016 has been collated from statistical Area 1 (SA1) geographies selected that best align to the study area. The data indicates that approximately 10,200 commuters commuted from PRCUTS IWC precincts. Public transport combined (train + bus + tram) represents approximately 44 per cent of mode chose which is greater than Car as driver and Car as passenger which represents 42 per cent. This has been graphed in **Figure 11-5**.

Figure 11-5 Journey to work 2016 mode share



Data source: Census, ABS, 2016

Figure 11-5 show that car as driver is the highest mode share from all precincts. The public transport mode share is reflective of the difference in accessibility in each precinct. Train mode share is high in Taverners Hill and lower in Camperdown. Bus use is high in Camperdown and low in Taverners Hill. Most light rail passenger are from Taverners Hill. Bicycles represent 3 per cent and motorcycle and scooters represent 1 per cent of Journey to Work trips. This should be considered and accommodated with on-site provisions for new land uses.

The data demonstrates that active transport links to nearby train stations are important for all precincts and improvements to public transport should be provided to help lower car mode share.

The Transport Plan will use the transport modelling and transformational planning informed by the PRCUTS vision to establish a mode shift target for reduced private car dependency.

12 Transport network – existing conditions

12.1 Connectivity and major movement

The PRC has high capacity east-west connectivity with multiple transport modes available. East-west connectivity is available on either side of Parramatta Road although it is limited within close proximity to the study area. North-south connectivity is limited in capacity and efficiency.

The major east-west movement corridors in and surrounding the PRC are:

> Parramatta Road;
> Marion Street/ Style Street/ Collins Street;
> Main Suburban railway line;
> City-West Link Road;
> Douglas Street/ Salisbury Road;
> Carlton Crescent/ Longport Street/ Railway Terrace/ Trafalgar Street; and
> New Canterbury Road/ Stanmore Road.

The major north-south movement corridors in and surrounding the PRC are:

> L1 Inner West Light Rail.
> Frederick Street/ Wattle Street;
> Dalhousie Street;
> Liverpool Road (Hume Highway);
> Tebbutt Street/ Old Canterbury Road;
> Norton Street;
> Balmain Road,
> Crystal Street,
> Johnston Street;
> Pyrmont Bridge Road;
> Livingstone Road; and
> King Street.

12.2 Active transport

12.2.1 Pedestrian network

Footpaths are generally provided on both sides of the road within most built-up or residential areas. Footpaths provided along Parramatta Road are generally wide (generally between two and four metres in Leichhardt and Camperdown, and between one and three metres in Taverners Hill) and configured in a paved kerb to property line format. Footpath width is generally narrower in laneways. Footpath widths are shown in **Figure 12-1**.

Most of the network contains kerb ramps at intersections, however many of these are misaligned with the kerb ramp on the opposite side of the road.

Shared paths are generally provided as recreational paths. The main shared paths servicing the study area are located along the Hawthorne Canal and around Petersham Park.

12.2.2 Pedestrian walking experience

High traffic volumes and speed along Parramatta Road, as well as obstacles created by utilities and lack of shade contribute to low amenity and pedestrian comfort. Parramatta Road is a major impediment in the pedestrian network, where pedestrian crossing wait times can be longer than one minute and distances between formal crossings are large, shown in **Figure 12-2**. This issue creates a physical barrier that lowers attractiveness for use by foot. Land uses along Parramatta Road are not conducive to creating walking trips, being predominantly retail with several boarded-up frontages. High traffic volumes and speeds also produce noise and air pollution that reduces pedestrian comfort and amenity.

Local roads other than Parramatta Road generally provide a comfortable walking experience. These roads have lower traffic volumes and offer a high level of amenity; separation from traffic, via street parking and landscaping, and trees for shade. Most side streets have a maximum speed limit of 40-50 kilometres per hour.

Figure 12-1 Footpath widths

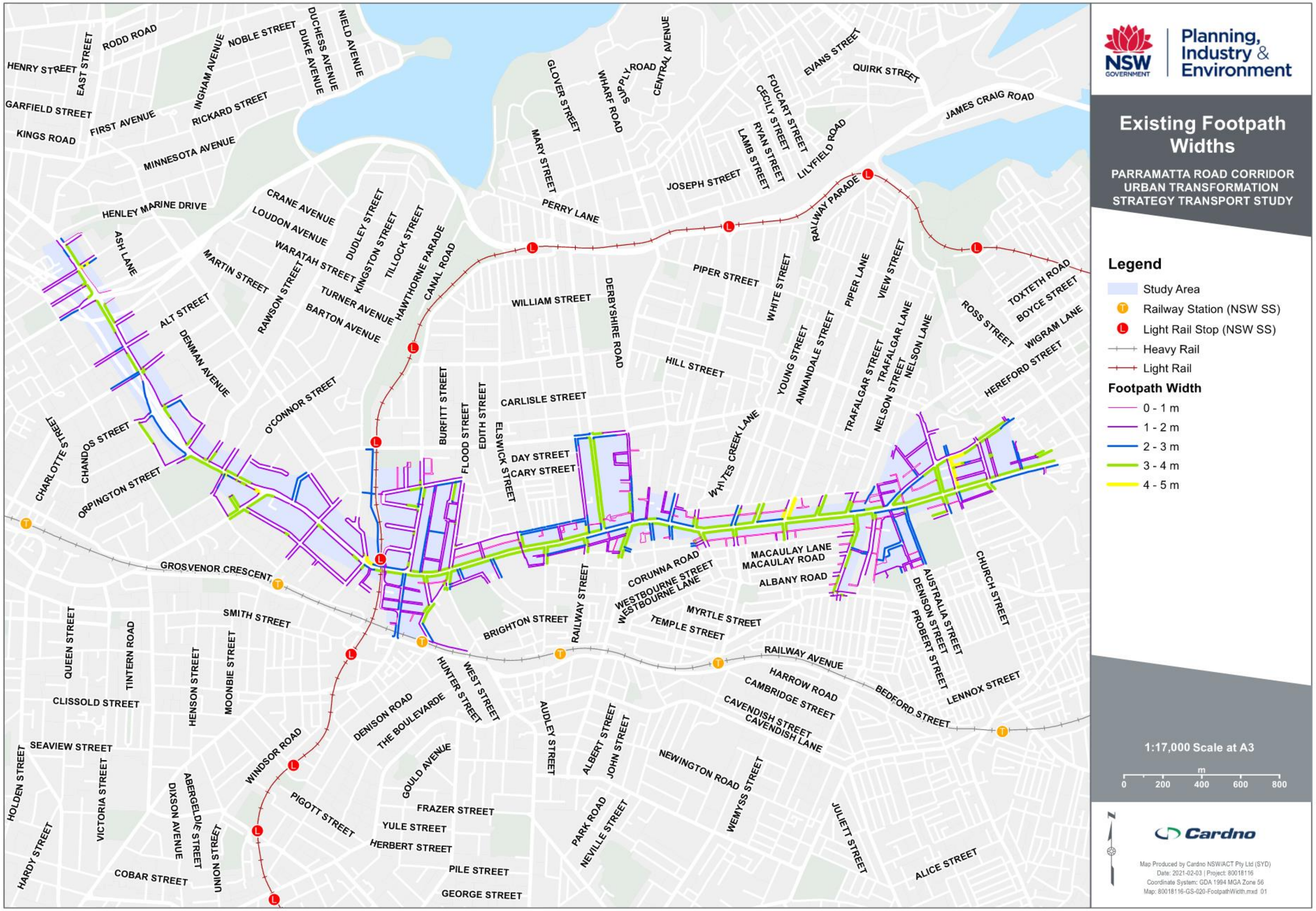
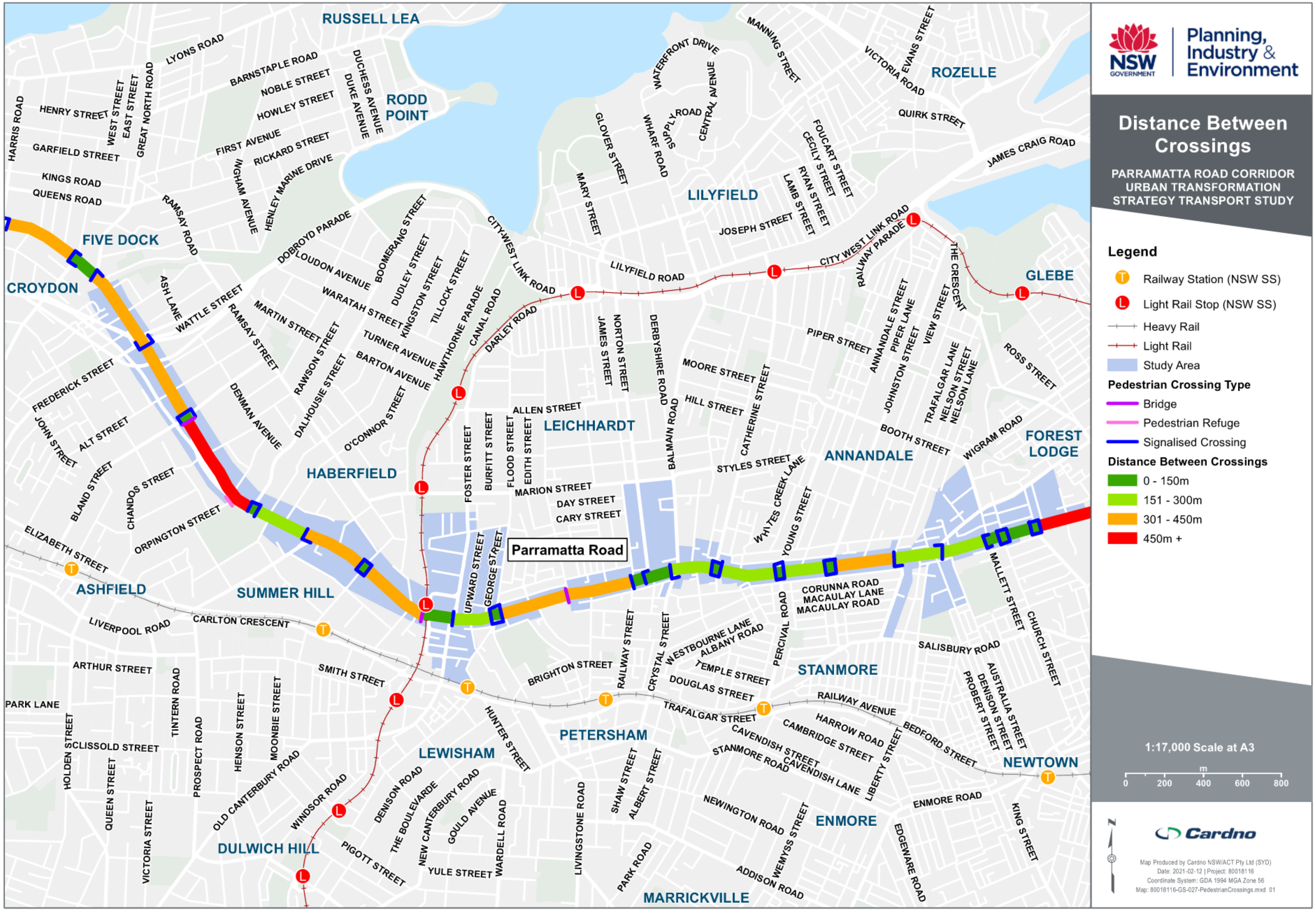


Figure 12-2 Distance between formal pedestrian crossings along Parramatta Road



Taverners Hill precinct

The Taverners Hill precinct includes, and is surrounded by, a number of pedestrian generating land uses including:

> In the north: MarketPlace Leichhardt, Marion Street shops and restaurants, Lambert Park, Kegworth Public School and high-density residential apartments.

> Around Parramatta Road: Taverners Hill light rail stop, Parramatta Road bus stops, the Louis Hotel and SBG Martial Arts & Fitness.

> In the south: Lewisham Train Station, retirement homes, churches, schools, and Petersham Park.

Key roads in the precinct have footpaths on each side, with the exception of the Brown Street bridge at Taverners Hill, which has a footpath on the east side only. The GreenWay along the precinct's western boundary provides regional walking and cycling connections and provides access to open space north of the precinct. In addition, an east-west active transport link across The GreenWay and light rail line connects Lords Road and Kegworth Street with Hawthorn Parade.

Two mid-block links between Upward Street and George Street are provided as part of the apartment development between these roads.

Leichhardt precinct

Leichhardt is a local centre that attracts high pedestrian numbers and offers high walkability. The Leichhardt precinct consists of a variety of pedestrian generating land uses, supporting a high place function across the road network. These land uses include:

> In the North: parks, playground, churches, medical centres and day care centres.

> Along Norton Street: Leichhardt Library, cafes, restaurants and shops, Leichhardt Public School, Leichhardt Town Hall, The Norton Plaza and The Italian Forum.

> Around Parramatta Road: restaurants, pubs, retailers, gyms and bakeries.

> South of Parramatta Road: Fort Street High School, TAFE NSW Petersham and low density residential housing.

The key roads within the Leichhardt precinct provide footpaths on both sides. The footpath network provides many opportunities for north-south movement within the precinct, however block lengths of up to 450 metres along key streets restrict east-west connectivity.

Camperdown precinct

The Camperdown precinct comprises of pedestrian generating land uses surrounding the Parramatta Road corridor. The key locations include:

> In the north: schools, playgrounds, reserves and medium density residential apartments.

> Around Parramatta Road: University of Sydney, gyms, restaurants and shops.

> In the south: University of Sydney School of Nursing, Camperdown Park and Courts, Royal Prince Alfred Hospital and high density residential housing.

The Camperdown precinct provides effective pedestrian accessibility and manoeuvrability with footpaths on both sides of all key roads. Walking and cycling pathways connecting The Crescent, Minogue Street and Nelson Street link provide a link to streets that are separated by parkland and Johnstons Creek. An additional through-reserve route connects Taylor Street to Chester Street over Johnstons Creek.

There are four signalised intersections with pedestrian crossings provided to cross Parramatta Road. The crossings are separated by irregular intervals, separated by a walking distance of up to 300 metres in some areas of the precinct.

12.2.3 Cycling network

The cycling network consists of mixed traffic routes of varying difficulty and shared paths. Infrastructure on these routes typically includes bicycle road markings and wayfinding signage. The bicycle network is shown in **Figure 12-3**. There are no formal provisions for cycling on Parramatta Road except for a 180metre shared path at Ashfield Park.

12.2.4 Cycling experience

Cycling is popular in the Inner West. Local roads provide safe, comfortable and low speed environments, whereas infrastructure is often disconnected in higher speed environments such as on Parramatta Road. While major roads are often the most direct routes through the study area, they don't provide cycling infrastructure, reducing cyclist safety and amenity in high speed, high volume environments. As such Parramatta Road is currently not suitable for beginner cyclists as a mixed traffic cycling route.

The majority of the cycling network within the three precincts are on-road mixed traffic routes, which does not represent an attractive mode choice for low confidence or beginner cyclists.

Taverners Hill precinct

The Taverners Hill precinct provides a network of on-road and off-road cycling routes. The GreenWay shared path runs along the Hawthorne Canal at the precinct's western boundary. This regional route supports north-south movement through the precinct linking Taverners Hill with Drummoyne to the north and Summer Hill to the south. Flood Street and Foster Street provide an on-road corridor for north-south movement. Flood Street functions as a mixed-traffic cycling route from Marion Street to Lords Road. The remainder of Flood Street provides dedicated cycle lanes, turn markings at intersections and bicycle road markings at regular intervals. This street connects the northern border of the precinct to Parramatta Road. Foster Street runs parallel to Flood Street, offering an alternative north-south mixed-traffic route. South of Parramatta Road, Thomas Street provides a mixed-traffic cycling route from the residential areas near Lewisham train station.

Marion Street and Lords Road function as the precinct's key east-west cycling corridors. Marion Street provides a mixed-traffic route connecting local businesses with Marion light rail stop. The street also includes a bridge providing connection to Haberfield. Lords Road provides a second corridor for east-west movement. This route includes a dedicated bicycle lane, bicycle road markings at regular intervals and an underpass linking Taverners Hill and Haberfield.

Leichhardt precinct

The Leichhardt precinct contains on-road cycling routes. Norton Street currently functions as the precinct's key north-south cycling corridor. This mixed traffic cycling environment connects businesses to Parramatta Road and the precinct's northern border. Balmain Road, which is a one way road, provides a bicycle lane supporting northbound cycling movements parallel to Norton Street. The route offers an alternative link from Parramatta Road into the Leichhardt precinct.

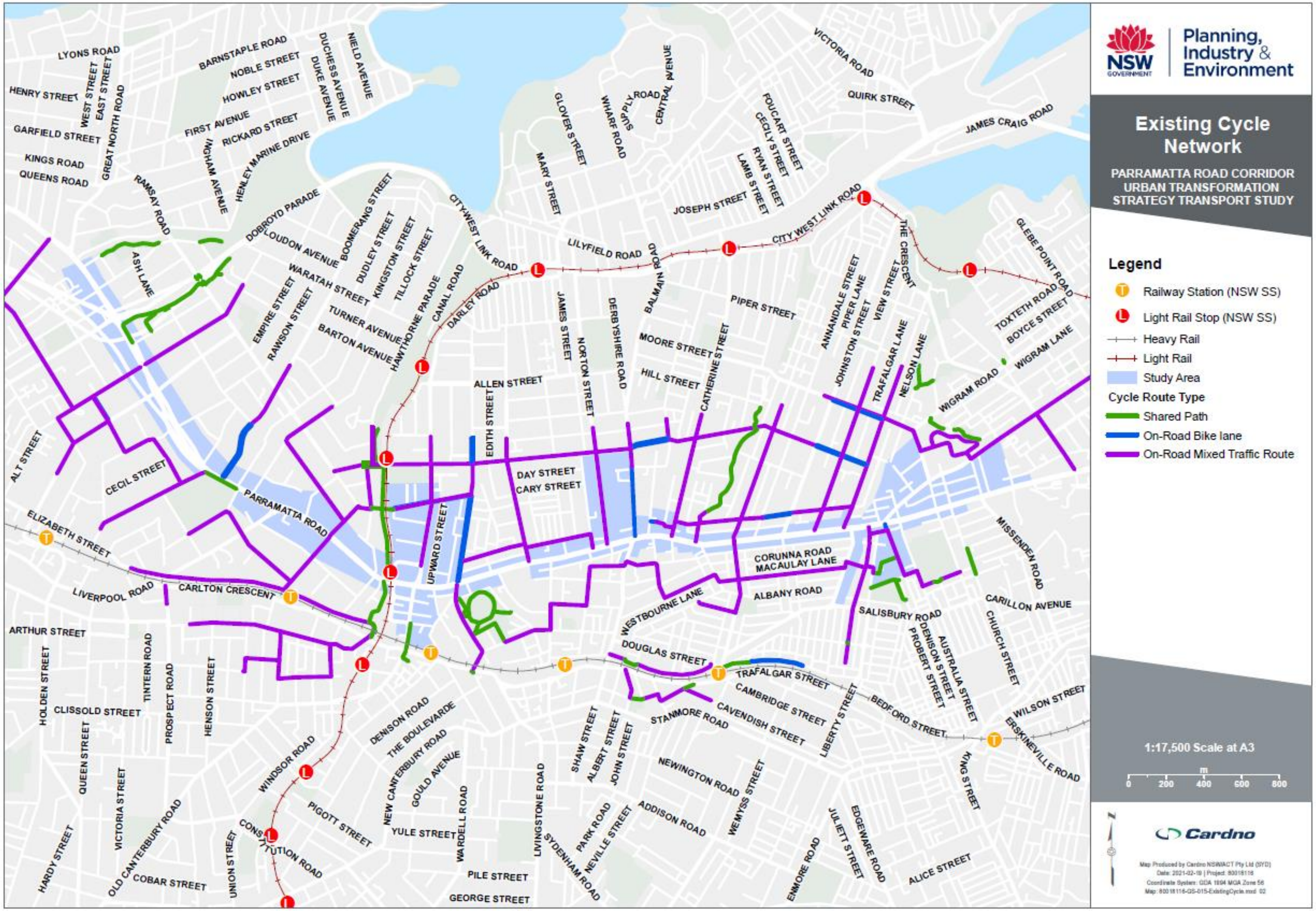
Marion Street provides the key east-west cycle path for the Leichhardt precinct. This mixed-traffic route connects key cycle routes such as Norton Street and Balmain Street, as well as the neighbouring suburbs of Haberfield and Annandale. An additional east-west route is planned for Leichhardt along Dot Lane between Norton Street and Hay Street.

Camperdown precinct

Camperdown has a network of on-road and off-road cycling routes. South of Parramatta Road, Bridge Road and Mallett Street serve as key north-south movement corridors in addition to Nelson Street and Young Street to the north. The mixed-traffic cycling routes connect Parramatta Road to the residential areas within the Camperdown precinct. Additionally, the planned Johnstons Creek shared path will facilitate north-south movement between Wigram Road and Chester Street. This new regional route will connect the Camperdown precinct with the surrounding suburbs of Annandale and Forest Lodge. Although Johnston Street provides no cycling infrastructure, it remains the most popular north-south route according to Strava's heatmap. This informal route will continue to have an increasing importance as Rozelle Railyards Park, The Bays Metro Station, The Bays Precinct and CUCP develop.

Moore Street/ Booth Street provides the key east-west cycling route through the Camperdown precinct. This route provides on-road cycling lanes and sections with mixed traffic. Pyrmont Bridge Road functions as the precinct's key east-west route from Parramatta Road to Glebe and Pyrmont. Currently no cycling infrastructure is provided along the route although a dedicated cycle path is planned between Parramatta Road and Mallett Street.

Figure 12-3 Bicycle network in and adjacent to PRCUTS



12.2.5 Supporting PRCUTS population and employment growth

The active transport network in the IWC PRCUTS precincts is well developed and should be further enhanced to assist in catering for the projected future growth. There is a lack of dedicated separated cycleways which should be provided to increase safety and connectivity and further increase the update of active transport in the Inner West community. The network provides good coverage and is currently not near capacity. Any improvements to the network and supporting infrastructure will enhance the user experience and improve the safety, comfort and attractiveness of active travel. New routes will also provide increased efficiency, reducing travel times. This is important for encouraging a mode shift from private vehicles to active travel into the future as travel demand increases with future development, especially for short trips.

12.3 Public transport

The study area is serviced by heavy rail, light rail and bus. Bus services were commonly full during peak hours prior to the Covid-19 pandemic, with passengers often having to wait long periods before the next service. Further investigation is required by TfNSW in collaboration with Council to understand the impacts of Covid-19 on transport movements, specifically public transport demand, with the aim to agree future planning scenarios for Parramatta Road. The public transport networks in the study area are shown in **0**.

12.3.1 Suburban rail

The study area is serviced by the T2 Inner West and Leppington Line, providing connection east to Sydney CBD and west to Strathfield, Lidcombe, Parramatta and Liverpool. A summary of services is shown below in **Table 12-1**.

Table 12-1 Rail services summary

Station	Precinct	Services per peak hour (7:30am to 8:30am) - eastbound	Services per peak hour (7:30am to 8:30am) - westbound	Services per midday hour (12:00pm to 1:00pm) – each direction	Typical travel time to Central Station (minutes)	Walking distance to Parramatta Road (metres)
Newtown	Camperdown	14	10	8	7	1,300
Stanmore	Leichhardt	11	5	4	10	700
Petersham		10	5	4	12	650
Lewisham	Taverners Hill	10	5	4	14	400
Summer Hill		10	5	4	16	400
Ashfield		15	13	8	14-18	1,000

Source: T2 Inner West & Leppington Line Timetable, TfNSW, accessed 30/03/2021

Ashfield and Newtown are the only stations listed above that accommodate limited stops services.

12.3.2 Light rail

The Taverners Hill Precinct is serviced by the L1 Dulwich Hill Light Rail Line, providing connection south to Dulwich Hill and northeast to Glebe, Pyrmont and Central Station. A light rail stop at Taverners Hill directly services the study area while Lewisham West and Marion are within walking distance from the Taverners Hill precinct. These stops provide a typical travel time of just over 30 minutes to Central Station.

The conversion of the T3 Bankstown Line to Metro will increase the importance of light rail as an access mode to the Metro. There are currently infrastructure limitations that limit the ability to increase light rail frequency to/ from Dulwich Hill. It is understood the DDA compliant interchange will be provided with the introduction of Sydney Metro.

Pedestrian access to the Taverners Hill Light Rail and Marion light rail stops is limited to the western side of the light rail line, where customers must use the stairs provided or use the lift. Passengers alighting and boarding on the Dulwich Hill bound platform must cross over the light rail line from the Central bound platforms.

At Taverners Hill, customer access from the north via Brown Street must cross to the southern side of Parramatta Road via the overpass before crossing back to the northern side via the stairs or lift. A view of the stop from Brown Street is shown in **Figure 12-4**.

Figure 12-4 Taverners Hill light rail stop from Brown Street

Service information for the light rail line is shown below in **Table 12-2**.

Table 12-2 L1 Dulwich Hill Line weekday service information

Direction	Peak frequency	Off-peak frequency	Peak times	Service times
Dulwich Hill to Central	8 minutes	10-15 minutes	6:30AM – 8:53AM	5:50AM – 12:08AM
Central to Dulwich Hill	8 minutes	10-15 minutes	2:25PM – 7:20PM	6:00AM – 12:00AM

Source: L1 Dulwich Hill Line Timetable, TfNSW, accessed 01/02/2021

12.3.3 Bus

The bus network provides good coverage of the study area which is serviced by 15 bus routes, including two express routes and two nightrider routes.

The bus network is Sydney City centric with 11 of the 15 routes commencing and ending in the Sydney CBD. This results in a skewing towards a high number of east-west routes.

Parramatta Road is a major bus corridor in Sydney, and this is particularly the case east of Norton Street. Bus routes servicing Parramatta Road are shown in **Table 12-3** with details listed for eastbound services.

12.3.3.1 Bus stops

Bus stops are provided at all train stations for interchange with the rail network. They are also provided within close proximity to the light rail stops servicing the Taverners Hill precinct.

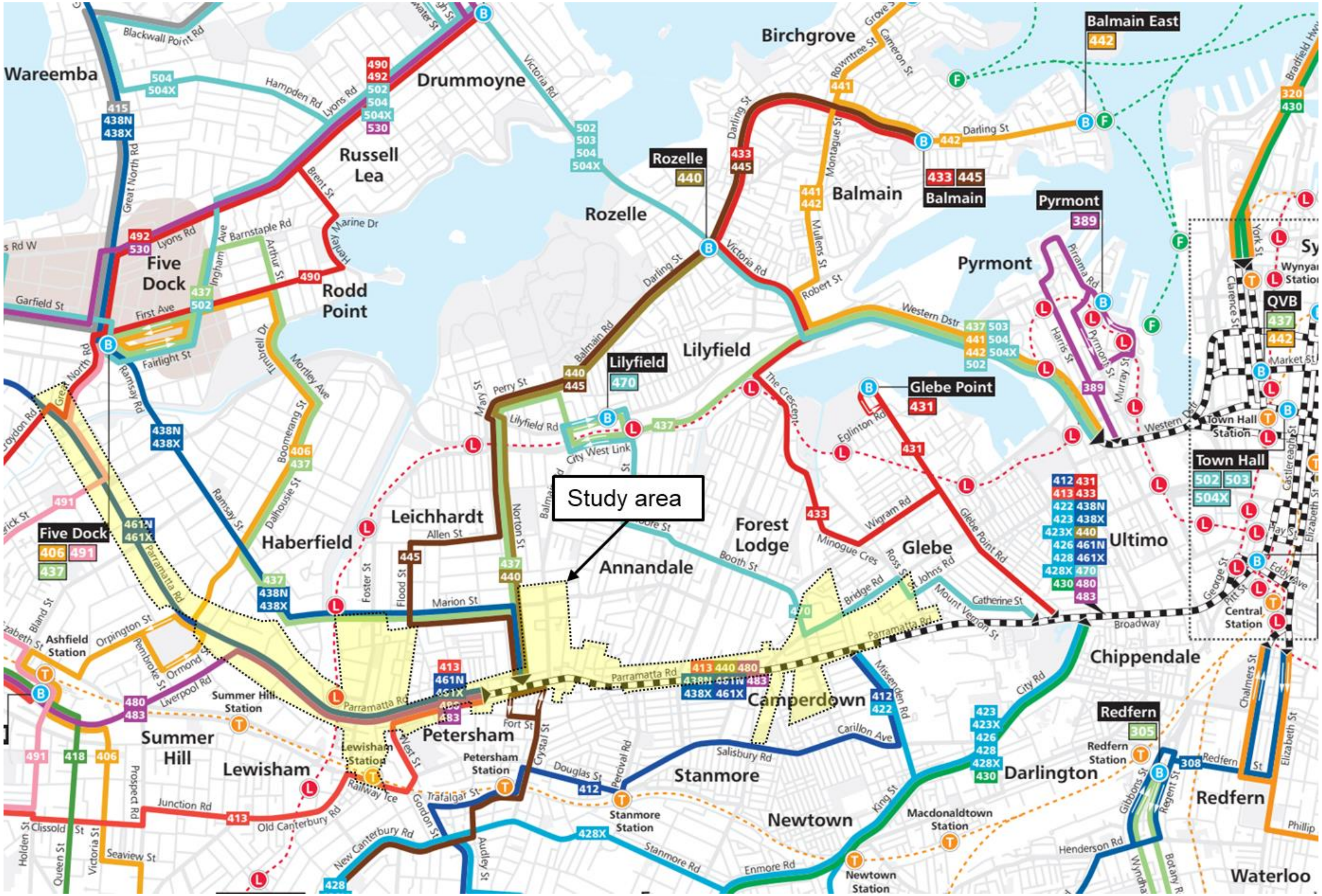
In total, there are 60 bus stops located within and just outside of the PRCUTS precincts study area. Generally, they are in good condition however approximately 50 per cent do not provide all of sufficient shelter, seating, signage and tactile indicators and require improvements. The majority of bus stops that do not provide seating or shelter are located on the western end of the PRC in IWC.

Table 12-3 PRCUTS IWC bus routes

Route	Description	Deviates from Parramatta Road at	Precincts Served Taverners Hill (TH), Leichhardt (L), and Camperdown (C)			Frequency (indicative)		Approximate weekday operating period
			TH	L	C	Peak period	Non-peak period	
370	Leichhardt Marketplace to Coogee	Glebe Point Road, Glebe		Y		8-10 minutes	20 – 30 minutes	5:00AM – 1:00AM
406	Five Dock to Hurlstone Park	Dalhousie Street and Orpington Street	Y			30 minutes	60 – 75 minutes	6:30AM – 12:30AM
412	Campsie to City (Martin Place) via Earlwood and Dulwich Hill	Missenden Road, Camperdown			Y	10-15 minutes	20-30 minutes	5:15AM – 11:45PM
413	Campsie to Central (Pitt Street)	West Street, Lewisham	Y	Y	Y	10-15 minutes	20-30 minutes	5:30AM – 11:30PM
422	Kogarah to Central (Pitt Street)	Missenden Road, Camperdown			Y	10-20 minutes	20-30 minutes	5:30AM – 11:45PM
437	Five Dock to City QVB via City West Link	-	Y			15 minutes	15 minutes	6:00AM – 23:15PM
438X	Abbottsford to City (Martin Place) [Express Service]	Norton Street, Leichhardt		Y	Y	2-5 minutes	10-15 minutes	5:45AM – 9:30PM
438N	Abbottsford to City (Martin Place) [Night Service]	Norton Street, Leichhardt		Y	Y	15 minutes	30-60 minutes	10:00PM – 5:30AM
440	Bondi Junction to Rozelle	Norton Street, Leichhardt		Y	Y	3-8 minutes	10-15 minutes	4:30AM – 1:00AM
445	Campsie to Balmain via Leichhardt Marketplace	Norton Street, Leichhardt and Crystal Street, Petersham.	Y	Y		15 minutes	30 minutes	5:00AM – 12:00AM
461X	Burwood to City (Domain) [Express Service]	Burwood Road, Burwood	Y	Y	Y	6-10 minutes	15-20 minutes	6:00AM – 10:00PM
461N	Burwood to City (Hyde Park) [Night Service]	Burwood Road, Burwood	Y	Y	Y	30 minutes	3 hours	10:30PM – 5:30AM
470	Lilyfield to Martin Place	Derwent Street, Glebe.			Y	10 – 15 minutes	20-30 minutes	5:00AM – 1:00AM
480	Strathfield to Central (Pitt Street) via Homebush Road	Liverpool Road, Ashfield	Y	Y	Y	15-25 minutes	30-60 minutes	5:15AM – 7:00PM
483	Strathfield to Central (Pitt Street) via South Strathfield	Liverpool Road, Ashfield	Y	Y	Y	20 minutes	30-60 minutes	5:45AM – 1:00AM
491	Hurstville to Five Dock	Great North Road and Frederick Street	Y			30 minutes	30 minutes	6:00AM – 21:45PM

Source: Sydney Bus Network timetables, TfNSW, accessed 01/02/2021 and incorporated in the traffic model developed for the project

Figure 12-5 Public transport network

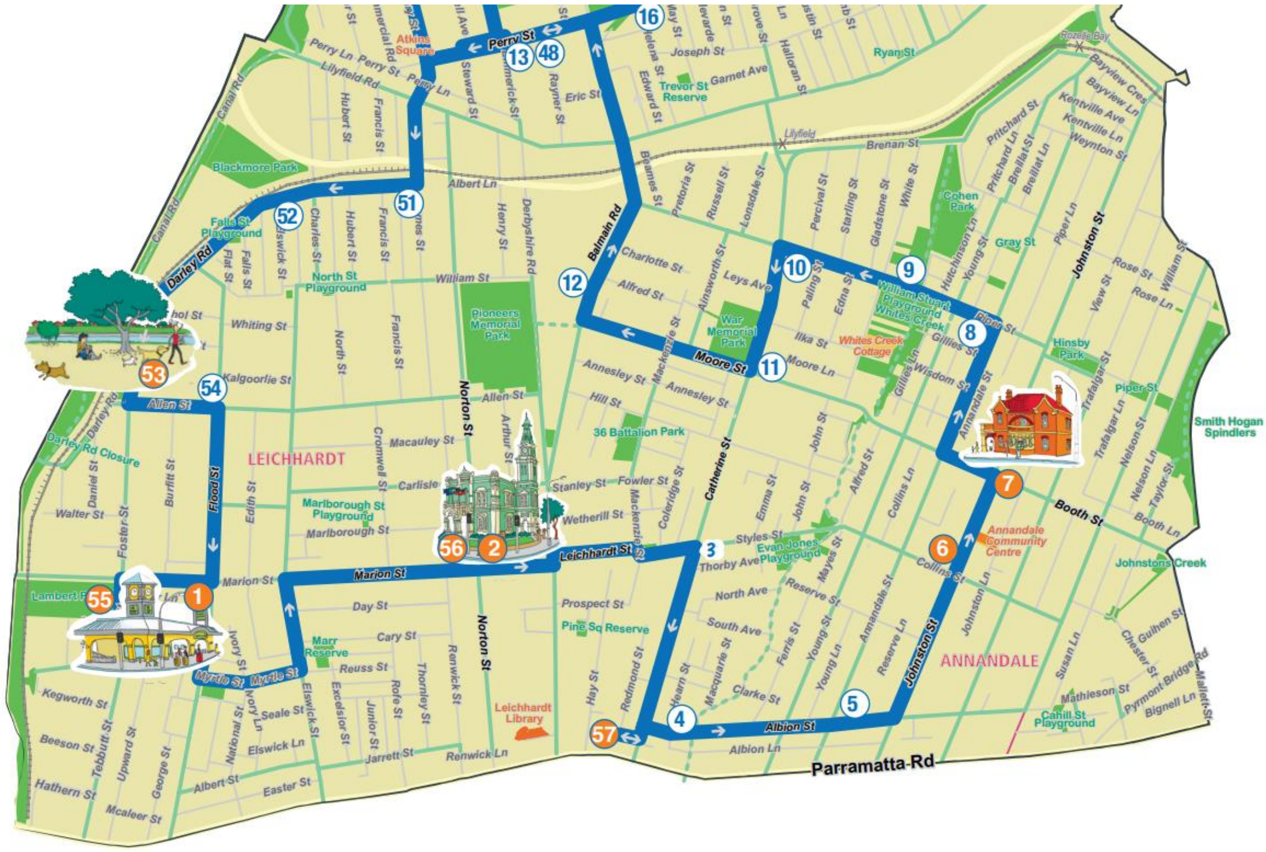


Base image source: https://transportnsw.info/travel-info/ways-to-get-around/bus/bus-operator-maps, accessed 09/02/2021

12.3.4 Community buses

The Leichhardt Local Link is a free community bus connecting between local services such as Leichhardt Park Aquatic Centre, health services, transport services, community facilities, hopping precincts and high streets. The bus runs between 8:30am and 2:45pm on Mondays and Thursdays.

Figure 12-6 Leichhardt Local Link bus route



Source: Leichhardt Local Link, Inner West Council, accessed 01/02/2021

12.3.5 High frequency public transport

High frequency public transport consists of public transport with a waiting time of 15 minutes or less in between services. As shown in **Table 12-3**, not all services include high frequency servicing during peak periods and generally wait times tend to increase to 30minutes on average for most services outside of the peak periods.

The high frequency public transport servicing the study area was analysed for 12-1PM and 9-10PM on a typical weekday. The study area is serviced by nine high frequency bus routes during the 12-1PM period and four high frequency bus routes during the 9-10PM period. Leichhardt and Camperdown precinct are well serviced by high frequency buses, particularly along Norton Street and Parramatta Road. Taverners Hill precinct is mainly serviced by the high frequency light rail and train services.

Figure 12-7 Midday high frequency public transport services 12:00PM – 1:00PM

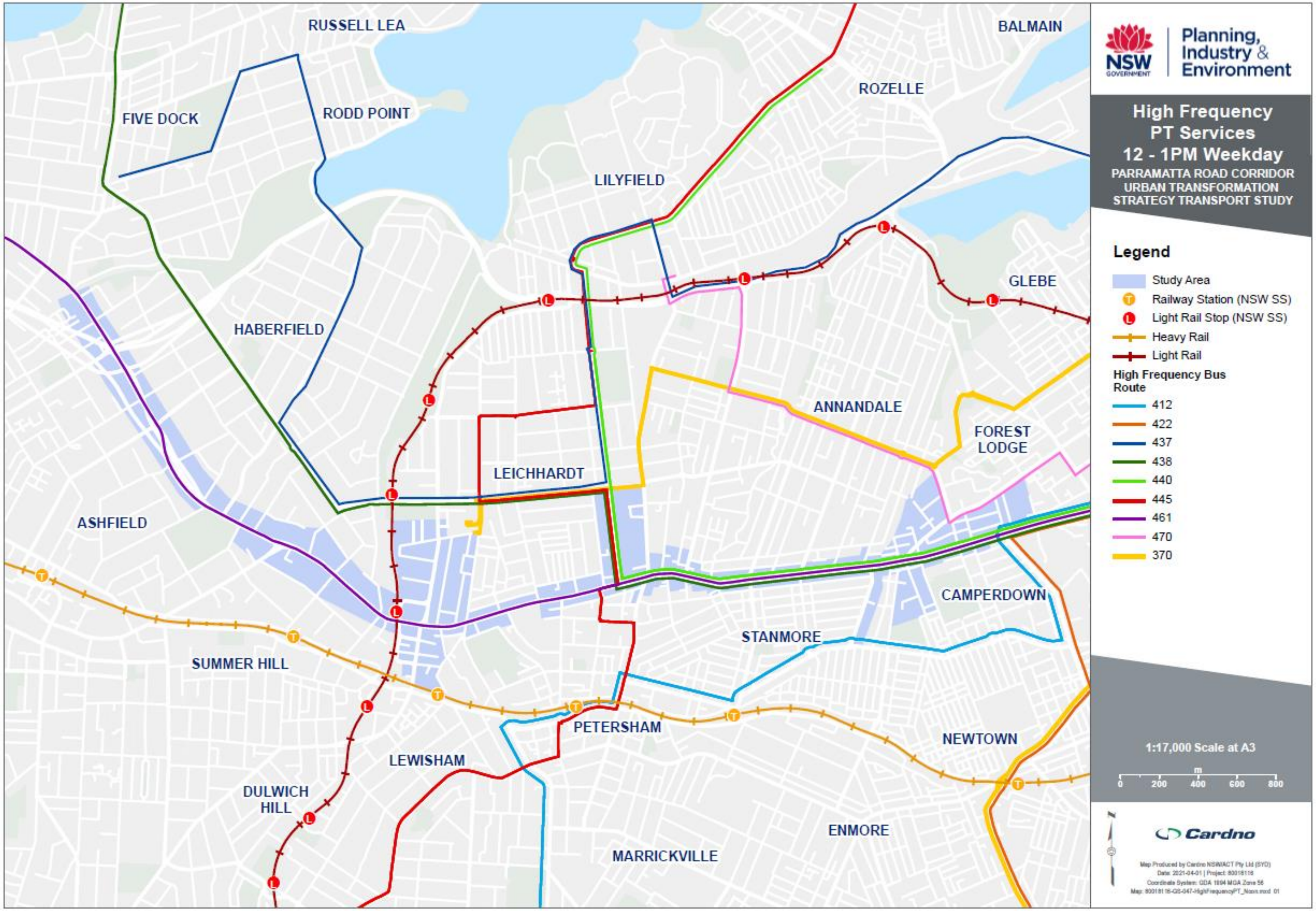
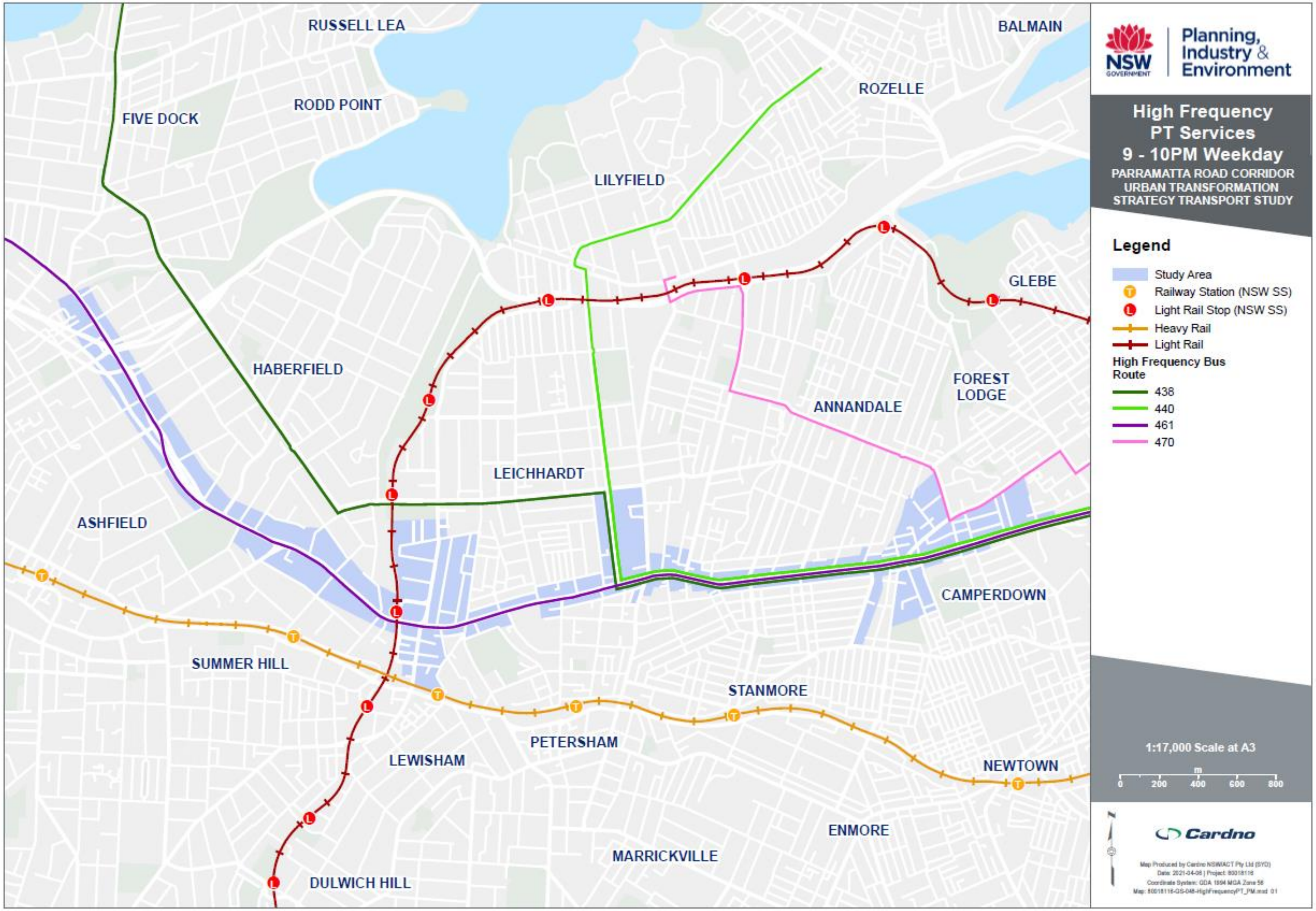


Figure 12-8 Evening high frequency public transport services 9:00PM – 10:00PM



12.3.6 Supporting PRCUTS population and employment growth

The public transport network consisting of heavy rail, light rail and buses provides good connectivity for long-distance trips outside the area east to Sydney CBD, west to Burwood, Strathfield and Parramatta and to other locations within the LGA. Access to heavy rail services is hindered by distance to the PRC. East-west connectivity is strong, however north-south connectivity could be improved to facilitate interchange between public transport services. The interface between the three public transport modes is currently weak. There is potential for bus services to provide a solid link between heavy rail, light rail and Parramatta Road.

Due to the constrained nature of existing road network, as well as the vision of providing a revitalised corridor, public transport services will continue to be crucial in the movement of people in and through the area however some network constraints may also limit the ability of existing public transport services to improve sufficiently to cater for the anticipated increased travel demand. Consequently, infrastructure and services should be enhanced to support higher volumes of patrons and routes will need to be rationalised to provide services where they are most required.

High frequency public transport is becoming increasingly important as lifestyles continue to change. COVID-19 has seen more people working from home, creating a more even spread of travel demand throughout the day as opposed to the traditionally concentrated morning and evening peaks. Rapid transit along Parramatta Road would assist in reducing private vehicles trips through traffic evaporation, discussed further in **Section 13.1.1**.

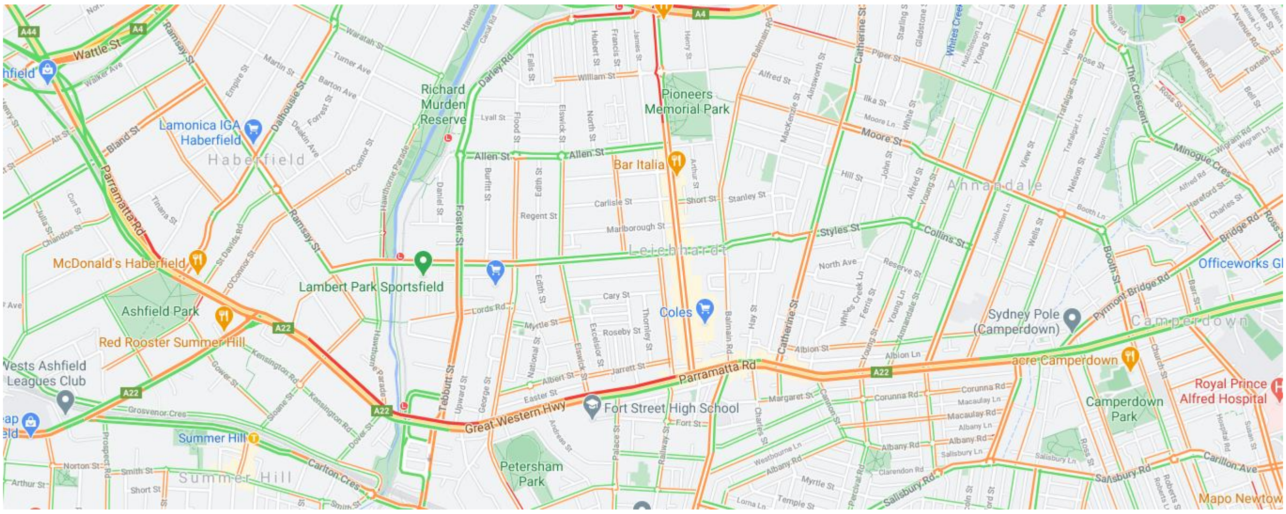
12.4 Road network

The road network generally accommodates multiple modes including pedestrians, cyclists, public transport, freight/ delivery, private vehicles and parking. The road network serves various movement and place functions throughout the study area, accommodating heavy vehicle through movements on arterial corridors such as Parramatta Road, while providing places for people to rest, eat and dwell.

Key characteristics of Parramatta Road and each precinct's road network are described in the following sections, with details of key roads listed in **Section 12.4.6**.

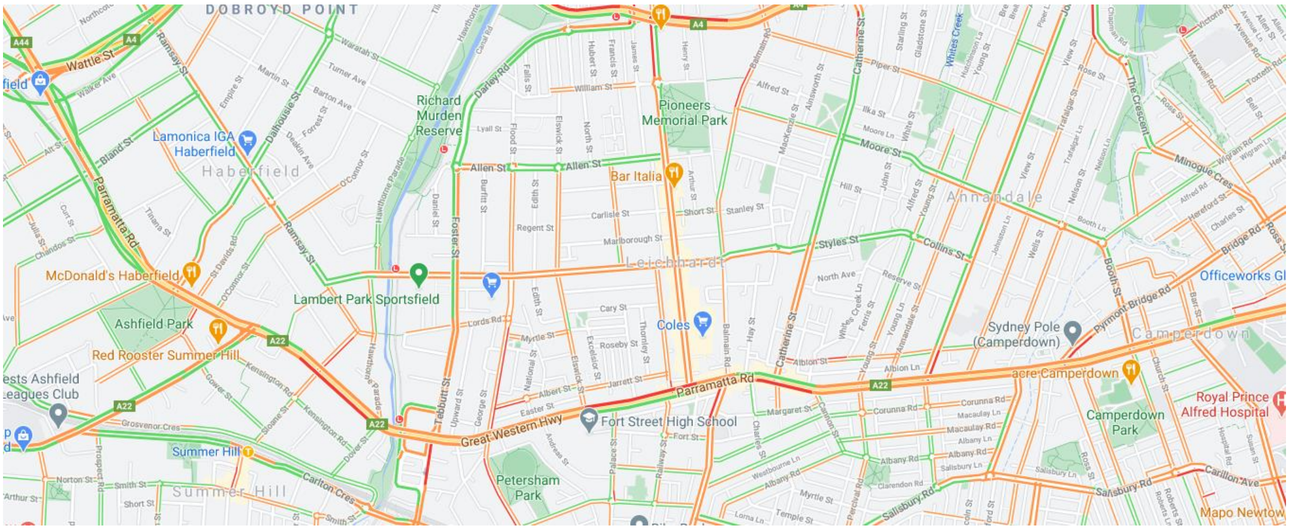
Google Typical Traffic is shown for the typical peak periods of a weekday (Thursday) at 8:00am and 5:00pm, and Saturday 12:00pm in **Figure 12-9**, **Figure 12-10** and **Figure 12-11** respectively.

Figure 12-9 Google typical traffic (Thursday 8:00am)



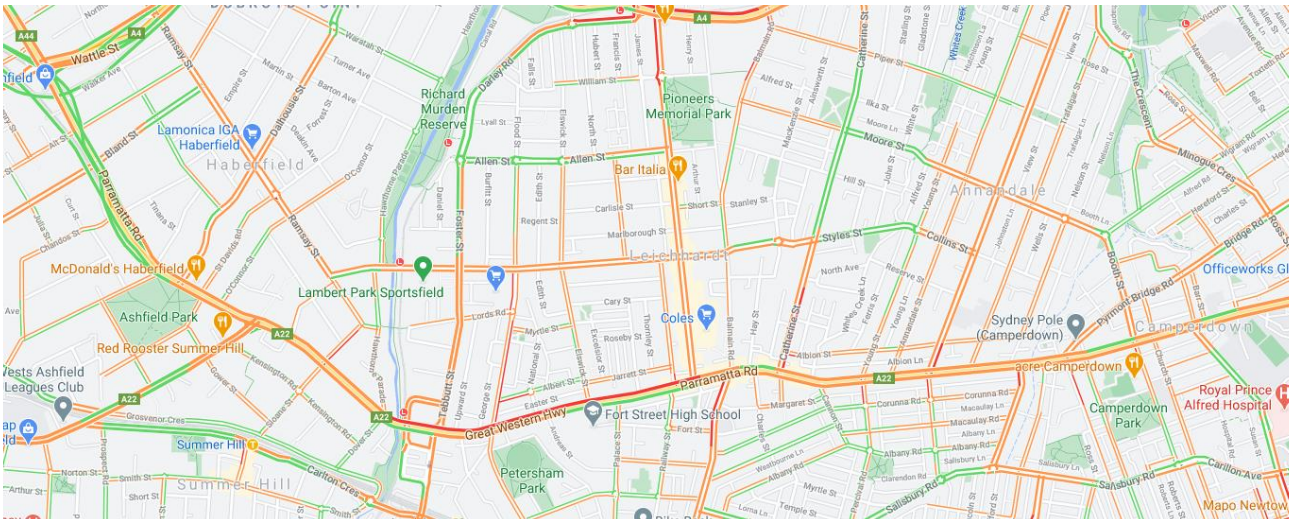
Source: Google typical traffic, accessed 12/02/2021

Figure 12-10 Google typical traffic (Thursday 5:00pm)



Source: Google typical traffic, accessed 12/02/2021

Figure 12-11 Google typical traffic (Saturday 12:00pm)



Source: Google typical traffic, accessed 12/02/2021

All three peak periods exhibit delays on all major roads. The weekday morning peak exhibits delays eastbound along Parramatta Road between Trafalgar Street and Bland Street, with slow vehicle speeds on intersecting streets to the north. The weekday evening peak exhibits delays westbound along Parramatta Road between Sydney CBD and Crystal Street as well as Palace Street and Orpington Street, with slow vehicle speeds on intersecting streets to the north and south. Delays are also experienced eastbound along Parramatta Road during the weekday evening peak. Slow vehicle speeds are seen throughout the network during the weekend peak period with delays on all streets intersecting with Parramatta Road.

12.4.2 Parramatta Road

Parramatta Road, is a one of Sydney's busiest roads for public and private transport, providing an east-west connection between Parramatta and the Sydney CBD, through the centre of the Inner West. Within the Inner West, there are generally three lanes in each direction, including 1.9 kilometres of bus lane in the eastbound direction and 1.3 kilometres in the westbound direction, which accommodates a number bus routes. As a divided road with high traffic volumes and narrow lanes (often less than three metres), the 60 kilometres per hour speed limit is consistent with the current speed limit guidelines.

Current land use along the Parramatta Road corridor includes vehicle-accessed commercial buildings such as showrooms and auto shops, small-scale retail and speciality shops. A high number of driveways in the western section of the Inner West affects amenity for pedestrians and cyclists.

Figure 12-12 Parramatta Road

12.4.3 Taverners Hill precinct road network

The Taverners Hill road network supports regional east-west and north-south trips, as well as access to local destinations and residential areas. Parramatta Road provides the only regional east-west connection through the precinct. The Dulwich Hill Light Rail Line and GreenWay corridor run north-south along the precinct's western boundary, limiting opportunities for additional east-west links to the north until Marion Street. Parramatta Road limits some vehicle movements to and from the precinct as vehicles travelling from the south cannot turn right onto Parramatta Road and vehicles travelling west along Parramatta Road cannot turn right to enter the northern parts of the precinct.

Brown Street includes a bridge providing connection over and across Parramatta Road. The route utilising Foster Street/ Tebbutt Street, Hathern Street, Brown Street, Cook Street/ Barker Street and Old Canterbury Road provides an important north-south connection between City-West Link Road and suburbs south of Parramatta Road such as Lewisham, Dulwich Hill and Marrickville.

Parramatta Road at Taverners Hill is shown in **Figure 12-13**.

Figure 12-13 Parramatta Road at Taverners Hill

The key roads in the Taverners Hill precinct are detailed in **Table 12-4**.

12.4.4 Leichhardt precinct road network

The Leichhardt precinct road network allows regional east-west trips and north-south trips. Marion Street/ Styles Street and Parramatta Road provide east-west connections along the upper and lower boundaries of the precinct. The only locations to turn right into Parramatta Road for vehicles travelling from either the north or south regions of the precinct are at Norton Street (from the north) and Crystal Street (from the south).

Norton Street allows north-south movement between Parramatta Road and City-West Link Road. Balmain Road and Renwick Street provide alternative north-south routes to Marion Street, with Balmain Road/ Derbyshire Road providing a second connection to City-West Link Road and Lilyfield. To the south of the precinct, Crystal Street connects Parramatta Road to New Canterbury Road. Parramatta Road separates the northern and central areas of the precinct from the south. Therefore, north-south movement through the precinct is restricted due to the absence of overpass/underpass infrastructure across Parramatta Road such as Brown Street in the Taverners Hill precinct.

Marion Street intersects Norton Street at the northern boundary of the precinct. These two roads provide links to medical facilities, the local library, public school and local shops. The surrounding roads provide access to residential areas as well as local parks and reserves. Although Norton Street provides a vital north-south route through the precinct, the 470 metre block length along this street restricts local east-west movement. Norton Street is shown in **Figure 12-14**.

Figure 12-14 Norton Street, Leichhardt

The key roads in the Leichhardt precinct are detailed in **Table 12-4**.

12.4.5 Camperdown precinct road network

The Camperdown precinct has a well-connected road network allowing regional east-west trips and north-south trips. Pyrmont Bridge Road/ Bridge Road and Parramatta Road deliver effective east west navigation through the precinct.

Parramatta Road provides limited opportunities to enter the Camperdown precinct. Vehicles travelling eastbound are only able to enter the southern region of the precinct via a right turn at Bridge Street and Missenden Road. Westbound travel on Parramatta Road is more restrictive with the only right turn opportunity at Johnston Street.

Booth Street/ Mallet Street serves as the precinct's key north-south movement corridor. Booth Street joins Moore Street and Catherine Street, providing a vital connection between City-West Link Road and Parramatta Road. Denison Street and Australia Street are key roads providing north-south movement south of Parramatta Road. Both streets allow thoroughfare between Parramatta Road and Salisbury Road. These roads connect a park, playground, childcare and restaurants with medium density housing. The surrounding streets function as low to medium density residential areas, separated by appropriate block sizes permitting efficient movement within the precinct.

Parramatta Road in Camperdown is shown in **Figure 12-15**.

Figure 12-15 Parramatta Road, Camperdown

The key roads of the Camperdown precinct are detailed in **Table 12-4**.

12.4.6 Key roads

The PRC generally accommodates multiple modes including pedestrians, cyclists, buses, freight / delivery, private vehicles and parking.

Roads are managed by an administrative framework of state, regional and local road categories. Classification is based on each road's connectivity and importance to the broader road network. State roads are managed and funded by Transport for NSW, and regional / local roads are managed and funded by councils. Roads that have a high freight task are generally assigned a state road classification. Regional roads perform an intermediate function and due to their network significance, Transport for NSW provides financial assistance to councils for the management of their regional roads.

Key roads within the study area are listed in **Table 12-4**.

Table 12-4 Key roads

Area	Road name	Road classification and number	Managing authority	Speed limit	Description and configuration	Freight network delegation
All	Parramatta Road	▪ State, Highway, 2, Route A22	TfNSW	60km/h	Two to three travel lanes in each direction with a peak hour bus lane and a travel lane converted to parking lane during off peak periods. Right turns are only provided as dedicated turning lanes. A median strip separates traffic for the length of the road.	Primary freight route west of Old Canterbury Road and tertiary freight route to the east.
Taverners Hill	Frederick Street	▪ Regional, Secondary Road, 2064, SR2014	Inner West Council	60km/h	One travel lane in each direction, widening to two lanes at intersections. Unrestricted on street parking available away from intersections and bus stops. One bus service shares road with general traffic.	Tertiary freight route.
	Dalhousie Street	▪ Local Road	Inner West Council	50km/h	One travel lane and one parking lane in each direction. Lanes widened at intersections. Bus services share road with general traffic.	-
	Liverpool Road	▪ State, Highway, 2, Route A22	TfNSW	60km/h -	Generally, two travel lanes in each direction with clearways during peak hour periods. Limited parking is available where road crosses through business precincts.	Tertiary freight route.
	Ramsay Street	▪ State, Main Road, 649 ▪ Regional, Secondary Road, 2013	TfNSW/ Inner West Council	60km/h	Generally, one travel lane in each direction with a dedicated parking lane throughout. Bus services share road with general traffic.	-
	Tebbutt Street/ Foster Street	▪ State, Main Road, 652	TfNSW	50km/h	One travel lane and one parking lane in each direction.	Tertiary freight route.
	Old Canterbury Road	▪ State, Main Road, 652, 664 ▪ Regional, Secondary Road, 2028	TfNSW/ Inner West Council	50km/h	One travel lane and one parking lane in each direction. One bus service shares road with general traffic.	Primary freight route north of train line and tertiary route south of train line.

Area	Road name	Road classification and number	Managing authority	Speed limit	Description and configuration	Freight network delegation
Leichhardt	Crystal Street	▪ Regional, Secondary Road, 2007	Inner West Council	50km/h	Two travel lanes in each direction with second travel lane used as parking lane during off peak periods. One bus service shares road with general traffic.	-
	Norton Street	▪ Local Road	Inner West Council	40km/h	One travel lane in each direction with additional parking lanes. Frequent bus services share roadway with general traffic.	-
	Marion Street/ Collins Street/ Styles Street	▪ Regional, Secondary Road, 2013	Inner West Council	50km/h	One travel lane and one parking lane in each direction. Frequent bus services share road with general traffic.	-
	Catherine Street	▪ Local Road	Inner West Council	50km/h	One travel land and one parking lane in each direction. Angle parking replaces parking lane in some areas. One bus service sharing roadway with general traffic.	-
	Johnston Street	▪ State, Main Road 655, 666 ▪ Regional, Secondary Road 2013	TfNSW/ Inner West Council	50km/h	Two lanes of travel and one parking lane in each direction. Angled parking included in place of parking lane in some areas. Dedicated right turn lanes and medians strips provided at intersections.	-
Camperdown	Moore Street/ Booth Street/ Mallet Street	▪ Unclassified, Regional, 7314	Inner West Council	50km/h	One lane of travel and one parking lane in each direction. Bus services sharing roadway with general traffic.	-
	Douglas Street, Percival Road, Salisbury Road, Carillon Avenue	▪ Unclassified, Regional, 7085	Inner West Council	50km/h	One lane of travel and one parking lane in each direction.	-
	Bridge Street	▪ Local Road	Inner West Council	50km/h	One lane of travel and one parking lane in each direction.	-
	Missenden Road	▪ Unclassified, Regional, 7094	Inner West Council	50km/h	One lane of travel in each direction with one parking lane provided in some areas Bus services share roadway with general traffic.	-
	Pyrmont Bridge Road/ Bridge Road	▪ State, Main Road, 523	TfNSW	60km/h	Two lanes of travel in each direction with one lane functioning as parking lane during off peak periods. Two lanes of traffic merges to one at Bridge Road. One bus service shares roadway with general traffic.	-

12.4.7 Supporting PRCUTS population and employment growth

The road network along the IWC PRC precincts is congested for long periods during the weekday and weekend peaks, especially along Parramatta Road and intersecting arterial roads. High population and employment growth cannot be supported with existing mode share due to lack of capacity and inconsistency with place-making and sustainability objectives. Mode shift towards sustainable modes through provision of sustainable transport infrastructure and prioritisation is essential to reduce demand on the road network and improve network performance.

There is currently very low excess capacity on the road network during peak periods. Additional travel demand generated by future developments will need to be supported primarily by public transport and active transport. Options for the future of Parramatta Road are considered in **Section 6.1**.

12.5 Freight network

The freight network in and surrounding the study area consists of primary, secondary and tertiary routes. The Metropolitan Road Freight Hierarchy on the State Road Network document describes the routes as the following[3]:

> Primary freight routes serve the needs of freight for access interstate and to strategically important ports, airports, industrial areas, freight terminals, intermodal terminals and hubs within Sydney. These roads carry typically high volumes of heavy freight vehicles (>4,000 heavy vehicle AADT).

> Secondary freight routes provide links within regions for significant flows of freight. These roads can carry medium volumes of heavy vehicles (1,000 - 5,000 AADT).

> Tertiary freight routes provide connections from the local road network, serving numerous major business and freight origins and destinations. These roads carry lower volumes of heavy vehicles (<2,000 heavy vehicle AADT).

Parramatta Road is listed as a primary freight route west of Old Canterbury Road and a tertiary freight route to the east. Other tertiary freight routes close to the study area include Frederick Street/ City West Link, Foster Street/ Old Canterbury Road and Liverpool Road as shown in **Figure 12-16**. WestConnex will perform a high freight function and act to redirect through-traffic from Parramatta Road.

Key freight origins, destinations are:

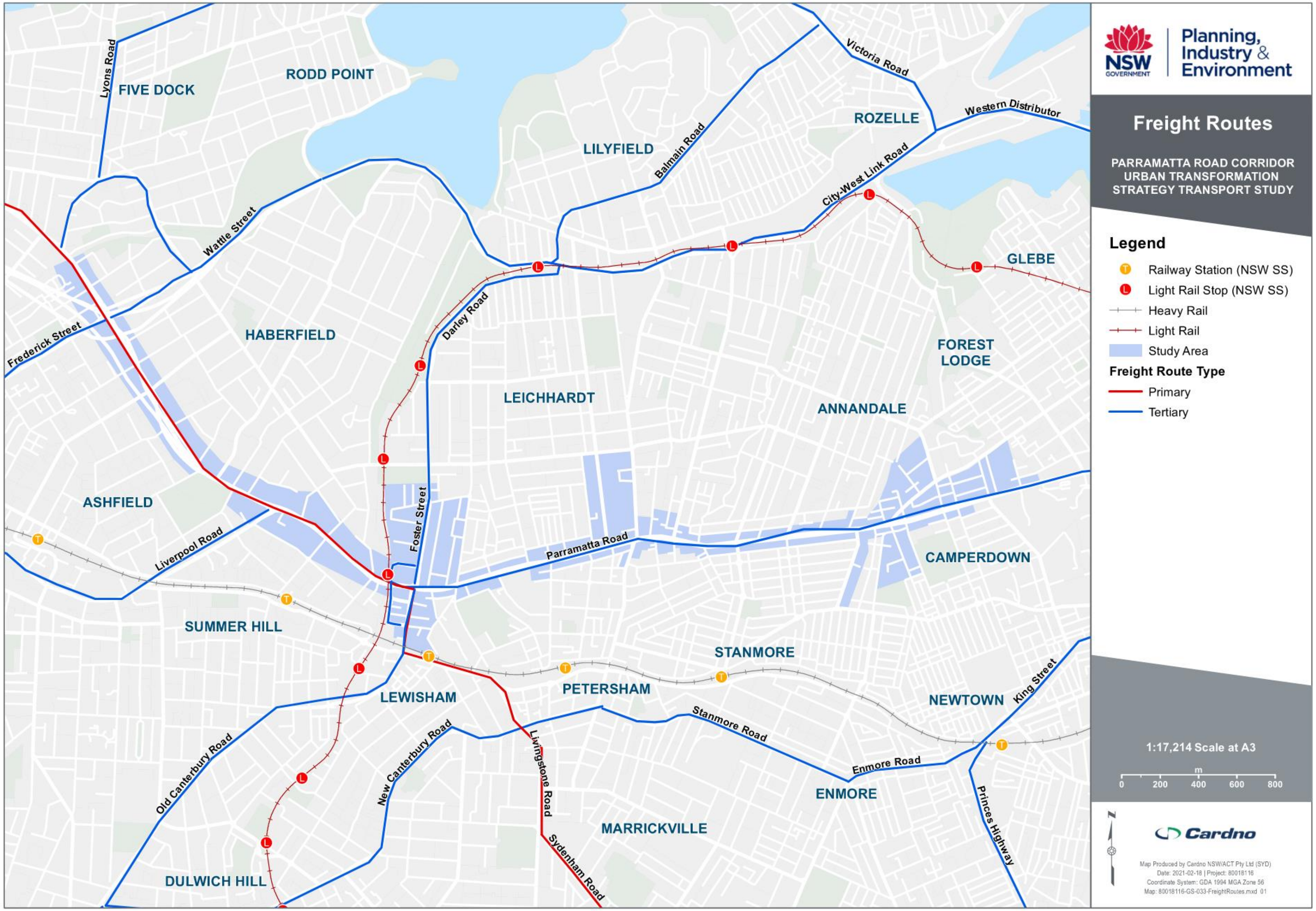
> WestConnex M4 Motorway;

> Bankstown industrial area; and

> Intermodal terminals at Enfield, St Peters, Port Botany.

[3] Metropolitan Road Freight Hierarchy on the State Road Network Practice Note, NSW Government, 2011

Figure 12-16 Freight routes



12.6 Crash history

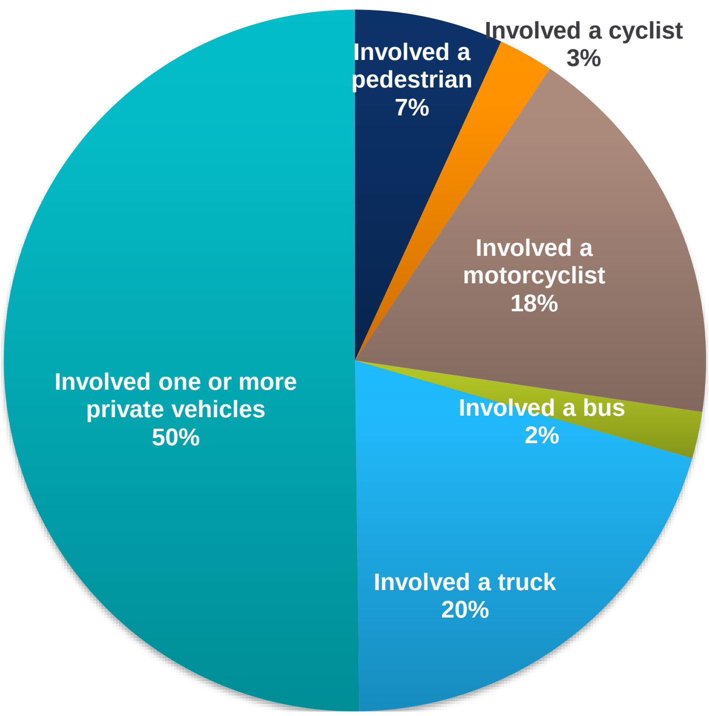
Crash data is reliant on incidents being reported to the NSW police, either through police attendance at a crash scene or reporting by involved parties. It is generally understood that minor collisions without injuries are not reported. As such, analysis of all crashes is not possible. Notwithstanding, crash data does include more serious incidents. This allows analysis to identify trends in accidents and location issues / crash clusters.

Crash data was analysed in the development of the IWC ITS, for the five year period between January 2013 and November 2017. During this period, 513 crashes occurred within 10 metres of the precinct boundaries, including 390 crashes located on Parramatta Road. There was one fatality, 341 injuries and 171 non-casualties.

12.6.1 Crashes by road user and location

The breakdown of crashes by road user are shown in **Figure 12-17**.

Figure 12-17 Crashes within precincts (2013 – 2017)



Pedestrian and cyclist crashes made up 10 per cent of the crashes during this period. The locations of these crashes is shown in **Figure 12-18**.

Within the Inner West LGA, there were six major crash cluster locations along the PRC, ranked in **Table 12-5** and shown in **Figure 12-19**.

Table 12-5 Crash cluster locations

General area	Crash count (2013 – 2017)
Parramatta Road between Wolseley Street and Wattle Street.	65
Parramatta Road between Norton Street and Macquarie Street, and Crystal Street between Parramatta Road and Elswick Street.	64
Parramatta Road between Australia Street and Bridge Road.	40
Parramatta Road between Brown Street and Flood Street.	23
The intersection of Parramatta Road, Northumberland Avenue and Johnston Street.	23
Parramatta Road between Liverpool Road and Dalhousie Street.	22

Figure 12-18 Pedestrian and cyclist crash locations (2013 – 2017)

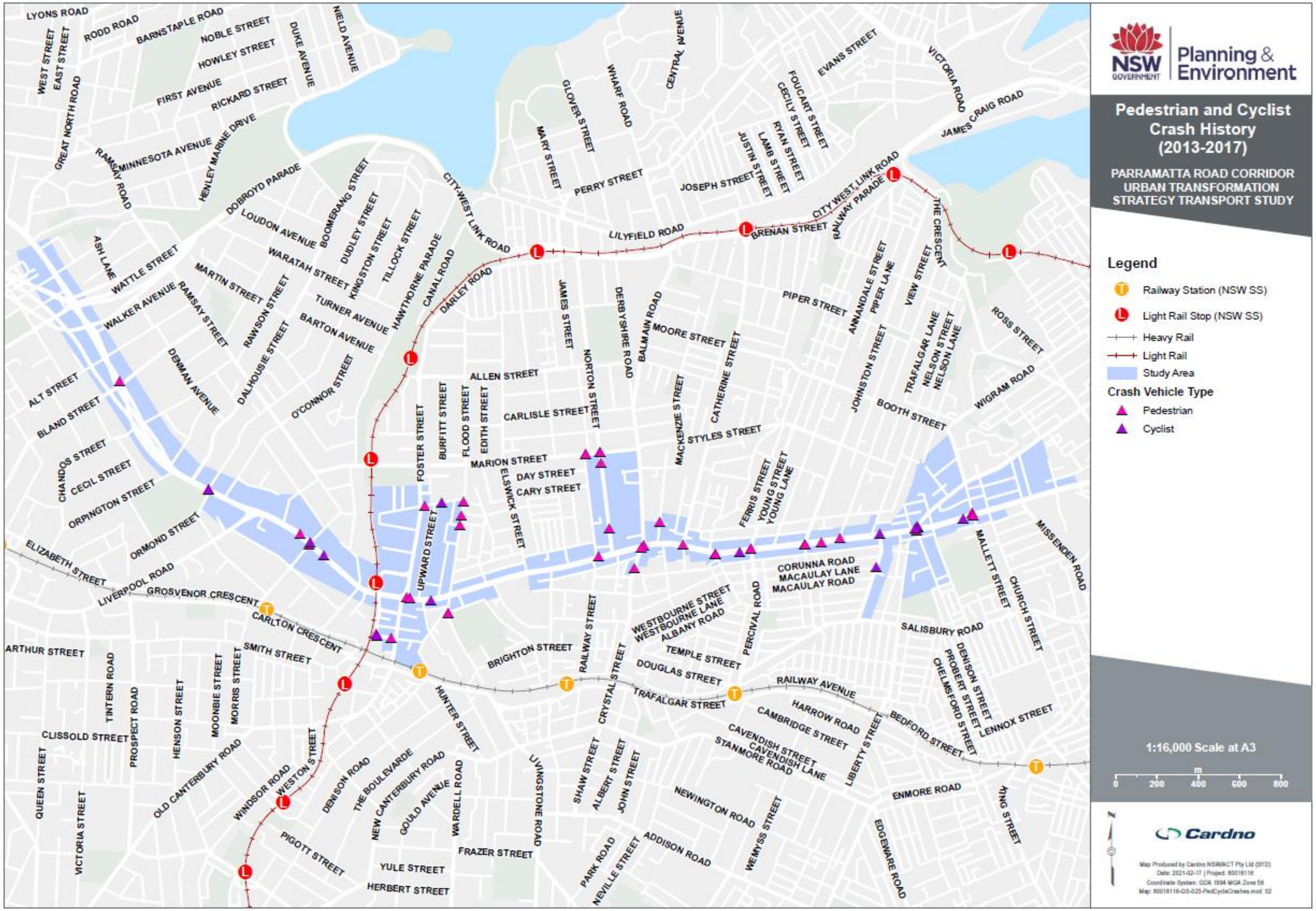
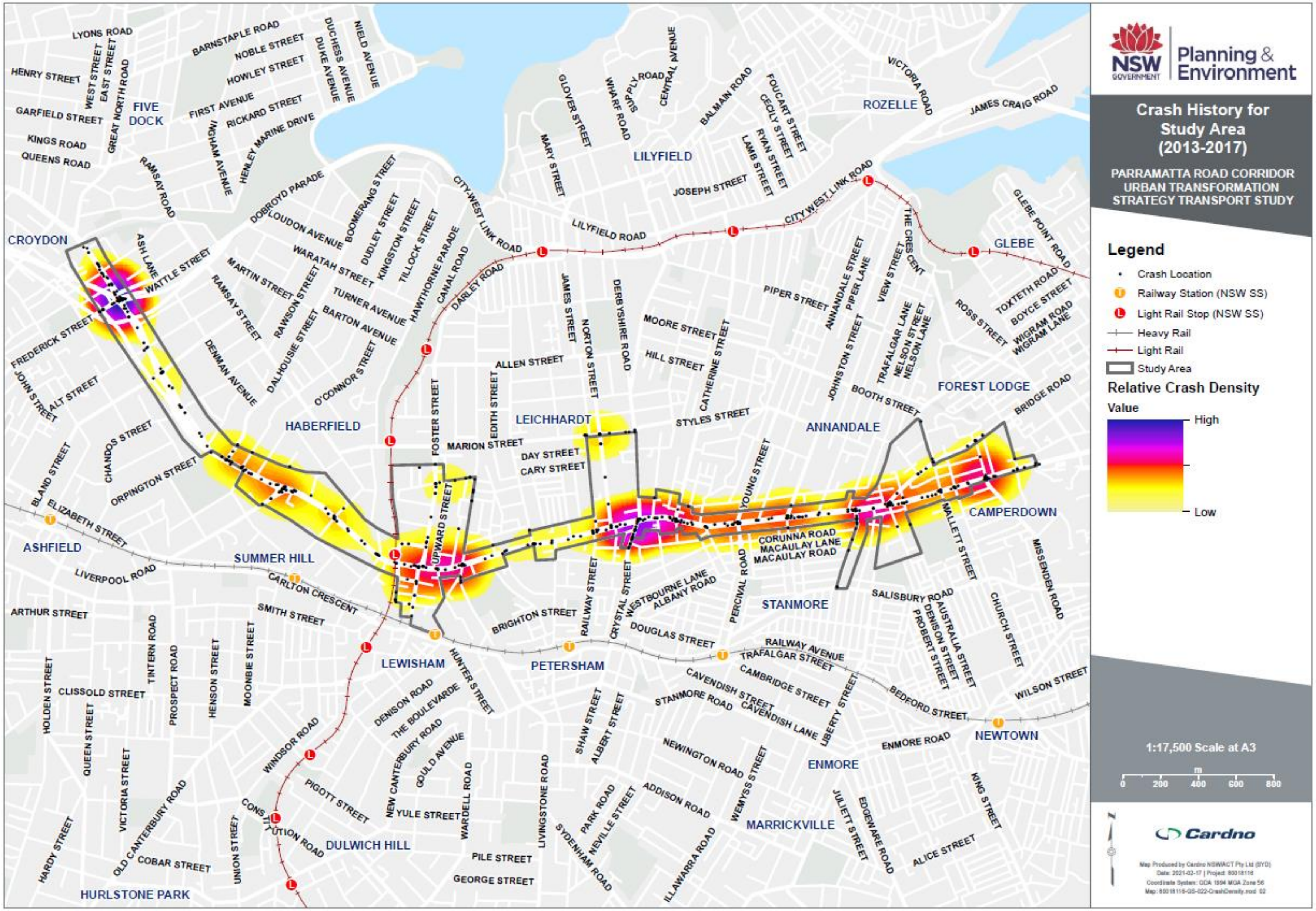


Figure 12-19 Crash cluster locations (2013 – 2017)



12.6.2 Crash type

Each crash type is categorised using a Road User movement (RUM) code from TfNSW. Rear ends were the most common crash type, all of which occurred on Parramatta Road. The top four crash types were:

Table 12-6 Top four crash types by RUM code (2013 – 2017)

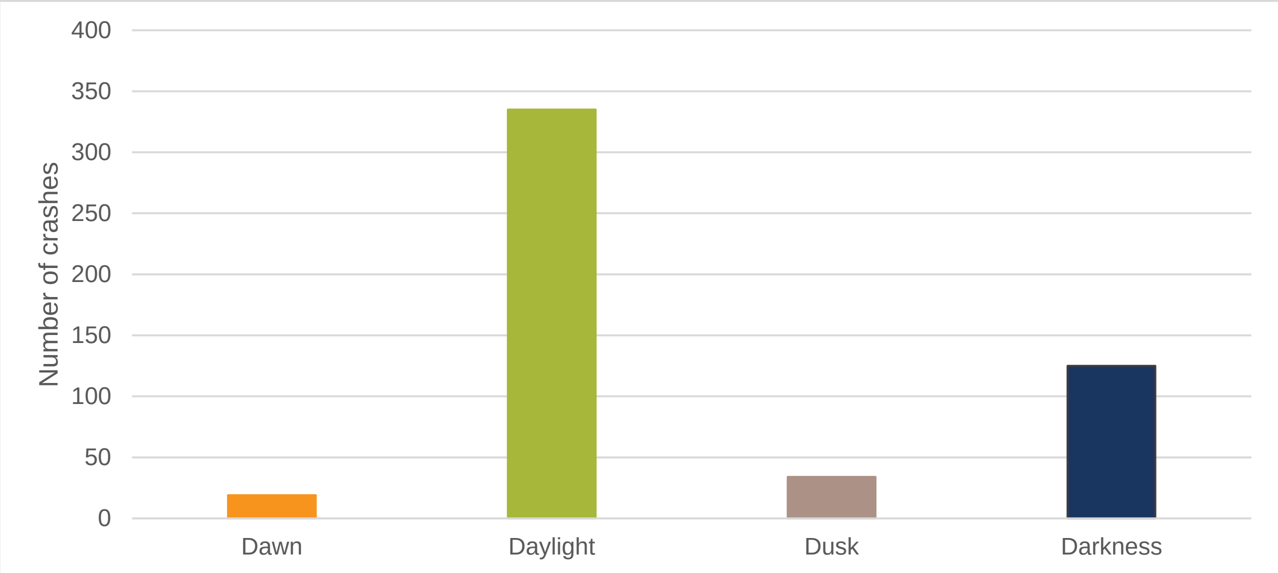
RUM code	RUM description	Number of crashes
30	Rear end	184
21	Right through	40
71	Left off road into object	30
39	Same direction - other	23

The high number of rear end crashes is typical of high traffic volume and congested networks and speed limit arterial roads in an urban environment with a high number of conflict points and signalised intersections.

12.6.3 Weather and natural light conditions

A total of 59 crashes (11 per cent) occurred during periods of wet weather, and 178 crashes (34 per cent) occurred during hours of dawn, dusk or night. The natural light conditions of crashes based on the time of day are displayed in **Figure 12-20**.

Figure 12-20 Natural light conditions of crashes (2013 – 2017)



The findings of **Figure 12-20** show that adverse light conditions generally are not contributors to crashes. The highest volume of traffic is during daylight hours, reflective of when crashes occur.

12.7 Parking

A separate car parking paper has been prepared to discuss conditions, issues and opportunities for car parking in detail.

General principles regarding car parking are:

> Car parking takes up space and this needs to be considered against the opportunity cost for other uses of the space.

> Car parking increases the cost of development. In multi-deck car parks, one car parking space can easily cost $50,000 and this cost must be borne by the users a given site/ locality through the purchase price or lease costs.

> The amount and availability of car parking has a relationship to traffic generation.

The parking ‘system’ is defined to be all public and private parking, designed for the use of employees, residents or visitors and located on-street or off-street. Through a range of mechanisms, Council has direct control or influence on all aspects of this system.

Public on-street and off-street parking is provided by Council for the benefit of the community, and managed to support specific land uses or functions. The form of management used includes supply restrictions by time, duration or type, as well as demand reduction measures such as paid parking.

Private parking provision is governed by the Council's statutory parking policies. These regulate the supply of parking to meet the broader land use and transport goals for individual precincts and areas.

12.7.1 On-street parking

Publicly accessible on-street car parking is provided throughout the study area. On some key roads, parking is restricted at peak times through clearway management to facilitate additional traffic capacity. Outside of these key corridors, on-street parking is either uncontrolled or managed through short-stay duration restrictions during business hours.

On-street paid parking has been implemented along Norton Street in the Leichhardt precinct to assist with parking demand management. In other areas, parking is managed exclusively through timing and duration restrictions.

12.7.1.1 Permit parking

The Inner West Council Residential Parking Scheme allows residents priority for on-street parking, reflecting concessions towards heritage dwellings constructed without on-site car parking. Parking permits are provided to eligible residents free of charge and is provided to protect parking encroachment from surrounding land uses. This scheme applies in parts of the study area identified in **Table 12-7**.

Table 12-7 Residential Parking Scheme areas

Precinct	Parking Scheme area	Streets with applicable areas
Taverners Hill	Ashfield Area 9	▪ Sloane Street, Hawthorne Parade
	Leichhardt L1	▪ Benson Street
	Marrickville M16	▪ Carrington Street, Thomas Street, Barker Street, Station Street
Leichhardt	Leichhardt L1	▪ Renwick Street
	Leichhardt L2	▪ Renwick Street, Balmain Road
	Leichhardt L3	▪ Norton Street
	Marrickville M5	▪ Queen Street, Charles Street, Phillip Street
Camperdown	Leichhardt A1	▪ Taylor Street, Chester Street, Water Street, Cahill Street, Gordon Street
	Marrickville M1	▪ Cardigan Street, Cardigan Lane

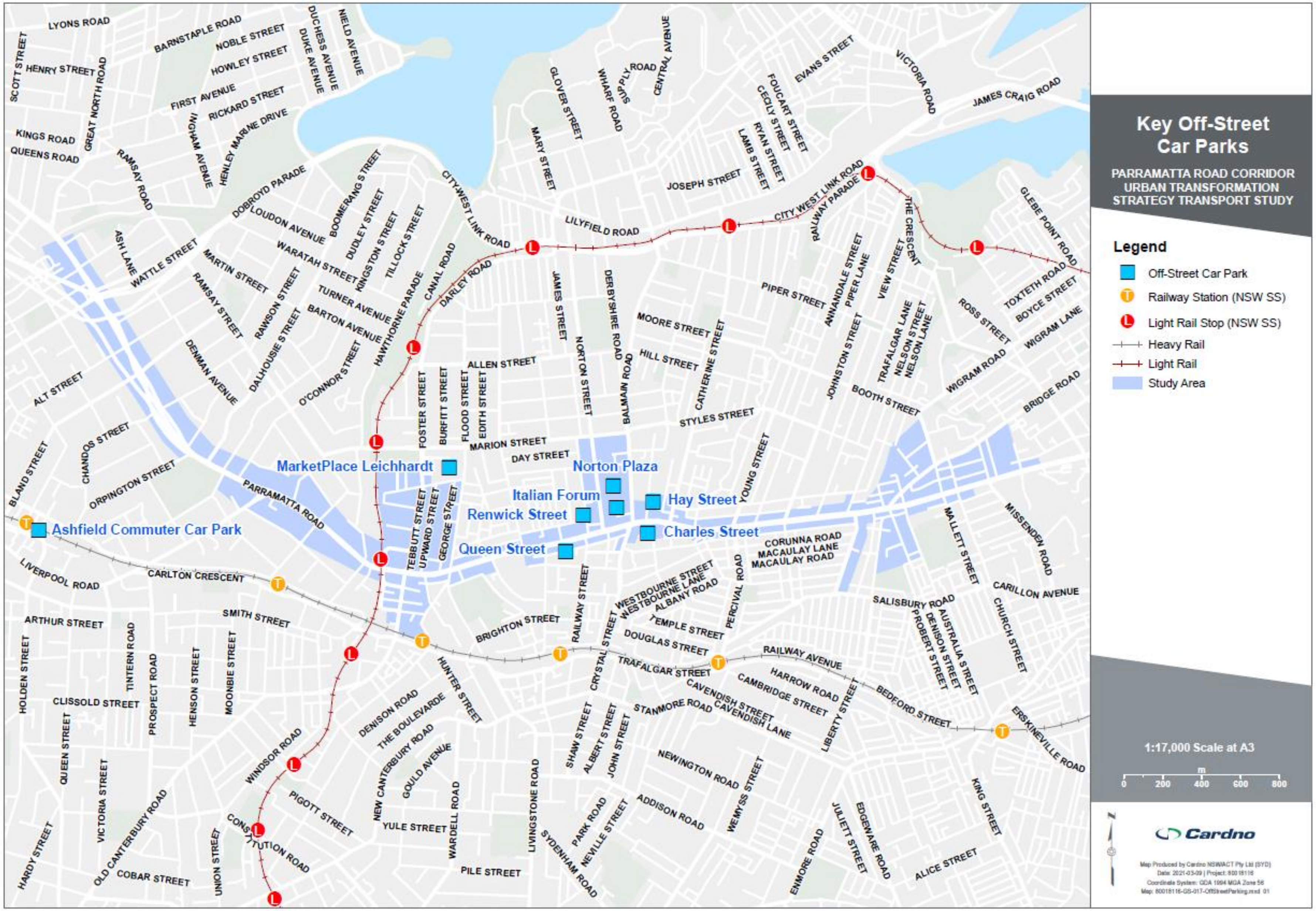
Source: https://www.innerwest.nsw.gov.au/ArticleDocuments/978/Map%20Leichhardt%20Parking%20areas.pdf.aspx, Inner West Council, accessed 02/02/2021

12.7.2 Off-street parking

Inner West Council owns and manages off-street parking across the LGA, supported by the provision of exclusive and publicly available private parking associated with commercial land uses, in accordance with statutory parking policies.

Public off-street car parks are shown in **Figure 12-21**.

Figure 12-21 Off-street car parking



13 Road space reallocation case studies

Historically, major road projects that bypass existing roads in Sydney have been leveraged to improve urban amenities for the community.

Proposals to reduce space for vehicles are often accompanied by alarmist media reports and opposition by motorists. Reallocating road space requires planners to be courageous in decisions to implement this and withstand initial criticism while people change their travel behaviour.

After implementation, these schemes are often celebrated because of the urban environment improvements they bring.

13.1.1 Induced demand versus traffic evaporation

Induced demand is the phenomenon whereby an increase in road capacity generates additional traffic demand. In rapidly growing areas where roads were not designed for the current population, there may be a large amount of latent demand for new road capacity. Once new lanes are opened, new drivers immediately take to the road, quickly clogging them up again. The induced demand is a result of a changed travel choice and can represent mode shift away from alternative modes of transport.

The inverse of this effect is known as traffic evaporation, which results from the strategic removal of road space previously dedicated to motor vehicles. A reduction in road capacity does not completely displace traffic onto alternative routes. It encourages a mode shift to alternate modes of transport which are often more sustainable. Walking or cycling is the usual substitute for shorter journeys, with public transport taking up those travelling longer distances.

The concept of traffic evaporation is relevant to the PRC and its challenges. Issues of congestion may be solved by a reduction in road capacity for motor vehicles, rather than an increase and would need to be supported by improving conditions for alternative modes. This would encourage a mode shift to sustainable transport modes such as walking, cycling, buses, light rail and heavy rail. It also provides an opportunity for road space to be reallocated to support active and public transport modes. Benefits of a reduction in car traffic include reduced street pollution and noise in the short term and safer and cleaner streets in the long term.

13.1.2 Case study: Eastern Distributor

The Eastern Distributor is a six-kilometre motorway which links the Cahill Expressway to Southern Cross Drive. Vehicle drivers had to drive through the residential streets of Darlinghurst and Woolloomooloo on their journey between Cahill Expressway and Southern Cross Drive prior to the completion of the tunnel in 1999.

The opening of the tunnel resulted in a number of changes to the surface streets in the East Sydney/Darlinghurst Area. These changes discouraged through traffic on the surface and improved the accessibility and safety of pedestrian and cyclists by transforming these streets into low speed streets. These changes included:

> Conversion of Crown Street (formerly one-way northbound) to two-way traffic;

> Conversion of Palmer Street (formerly one-way southbound) to two-way traffic;

> Conversion of Bourke Street to two-way traffic; and

> Creation of pedestrian malls through closure of vehicle access from Bourke Street to Oxford Street/ Flinders Street at Taylors Square.

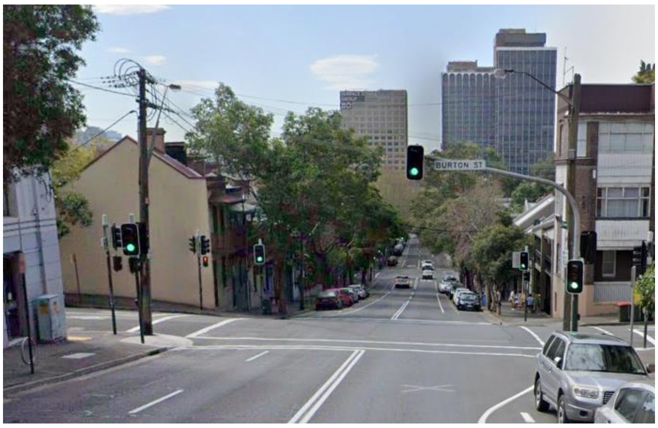
The project resulted in diversion of through traffic onto the Easter Distributor and other routes and the streets have returned to a local access/ residential street function.

A historic photo of Crown Street, Darlinghurst with a one-way traffic condition is shown in **Figure 13-1** and how it looks in 2021 is shown in **Figure 13-2**.

Figure 13-1 Traffic congestion on Crown Street, Darlinghurst in the 1970s

Source: https://www.ozroads.com.au/NSW/Freeways/F7/history.htm, viewed 02/02/2021

Figure 13-2 Crown Street 2021



Source: Google Streetview, viewed 08/03/2021

Several years after the opening, a separated cycleway and further streetscape and amenity improvements were provided on Bourke Street (shown in **Figure 13-3** and **Figure 13-4**), which would not have been possible under its previous role in Sydney's road network.

Figure 13-3 Bourke Street cycleway

Source: Google Streetview, viewed 08/03/2021

Figure 13-4 Taylors Square from Bourke Street

Source: Google Streetview, viewed 08/03/2021

13.1.3 Case study: Lane Cove Tunnel

The Lane Cove Tunnel is a 3.6-kilometre twin tunnel, opened in 2007, which links the Warringah Freeway to the M2 Motorway at Lane Cove River.

Prior to this, Epping Road was the key link between the two roads and accommodated approximately 90,000 vehicle movements per day. Epping Road was generally configured with six-lanes, with the outer lanes being bus lanes and four-lanes for general traffic. The Lane Cove Tunnel project provided the opportunity for space reallocation and amenity improvements to Epping Road in Lane Cove including:

> A new bus interchange on the corner of Longueville Road and Parklands Avenue;

> A new pedestrian bridge across Longueville Road;

> 24-hour bus lanes provided in each direction between Mowbray Road West and Longueville Road;

> A new cycleway and pedestrian pathway was also constructed between Mowbray Road and Pacific Highway;

> Improved street ambience and amenity through tree plantings and new landscaping along Epping Road;

> Reinstatement of right-turn lanes at various intersections.

The Transport for NSW traffic volume viewer indicates that average daily traffic volumes in 2019 where approximately 41,000 vehicles per day, showing a reduction in traffic by more than half. This case shows the benefits and opportunities of a bypassing motorway project on returning streets back to the community.

A typical section of Epping Road is shown aerially in **Figure 13-5** and in **Figure 13-6**. This shows the bus lanes in red and the separated cycleway in (faded) green.

Figure 13-5 Epping Road aerial photograph

Source: Nearmap, viewed 02/02/2021

Figure 13-6 Epping Road

Source: Google Streeview, viewed 02/02/2021

13.1.4 Case study: Champs-Élysées, Paris, France

The Champs-Élysées is a two-kilometre road in central Paris that accommodates eight lanes of traffic including on-street parking, and a separated cycleway on either side of the road. Land uses along the road include restaurants, cafés, luxury retail stores and hotels. The road experiences significant traffic congestion due to being a major tourist attractor.

Plans have been approved to reduce road space for vehicles by half and reallocate it to create an urban garden. This will include a removal of the outer lanes to create wider footpaths and dedicated cycleways as well as the planting of trees and greenery. The changes have been successfully modelled to improve air quality and make the space more people-centred.

Figure 13-7 Champs-Élysées 2021

Source: Google Streetview, viewed 09/03/2021

Figure 13-8 Concept plans for Champs-Élysées

Source: PCA-Stream, 2021

13.1.5 Summary

The case studies for Sydney demonstrate road space reallocation has already occurred successfully in Sydney. Internationally, city leaders are implementing bolder schemes to reduce vehicle traffic on city streets to give the space back to people to use and enjoy.

With the support of alternative transport networks including road or public transport initiatives, road space and functions can be changed to better serve the needs and values of a community.

APPENDIX

A

PRCUTS LAND USE REVIEW

PRCUTS Land Use Review

31/05/21

SGS Economics and Planning Pty Ltd
ACN 007 437 729
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Offices in Canberra, Hobart, Melbourne, and Sydney, on Ngunnawal, muwinina, Wurundjeri, and Gadigal Country

Background and scope

The Department of Planning, Industry and Environment (DPIE) and Inner West Council (IWC) are working to progress traffic modelling for the Parramatta Road Corridor Urban Transformation Strategy (PRCUTS).

To inform that broader work program SGS have been engaged to:

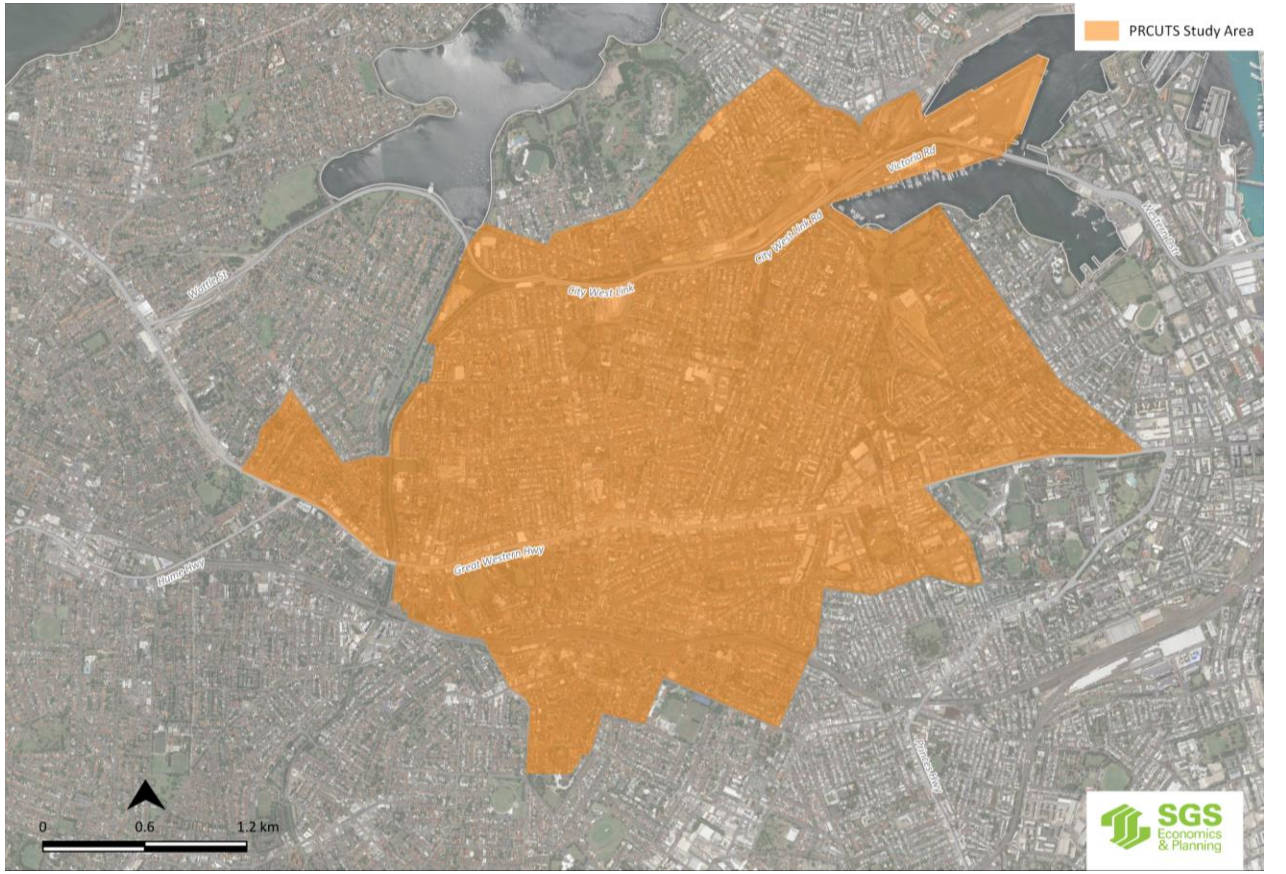
- Rapidly review land use projections and development capacity for the PRCUTS study area and surrounds, and
- from this rapid review and the latest available data, SGS has estimated three revised land use scenarios at a fine grain spatial scale for dwellings, population and employment

Scope limitations

For this rapid review, SGS has relied on existing capacity and development information provided by DPIE, IWC or from other readily available sources. No primarily analysis of capacity was within scope. Where data was not available, assumptions have been made to fill gaps.

Project study area

The project study area is presented in Figure to the right.

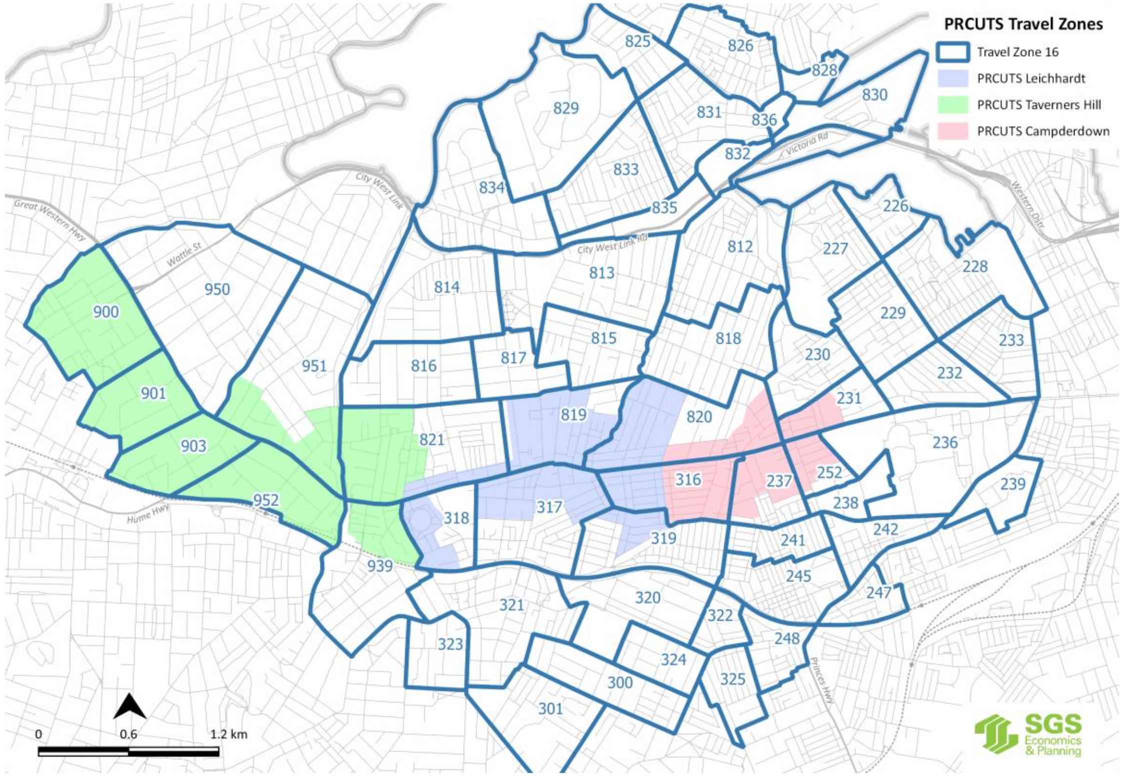


Project geographies

The following key zone geographies were used in the study.

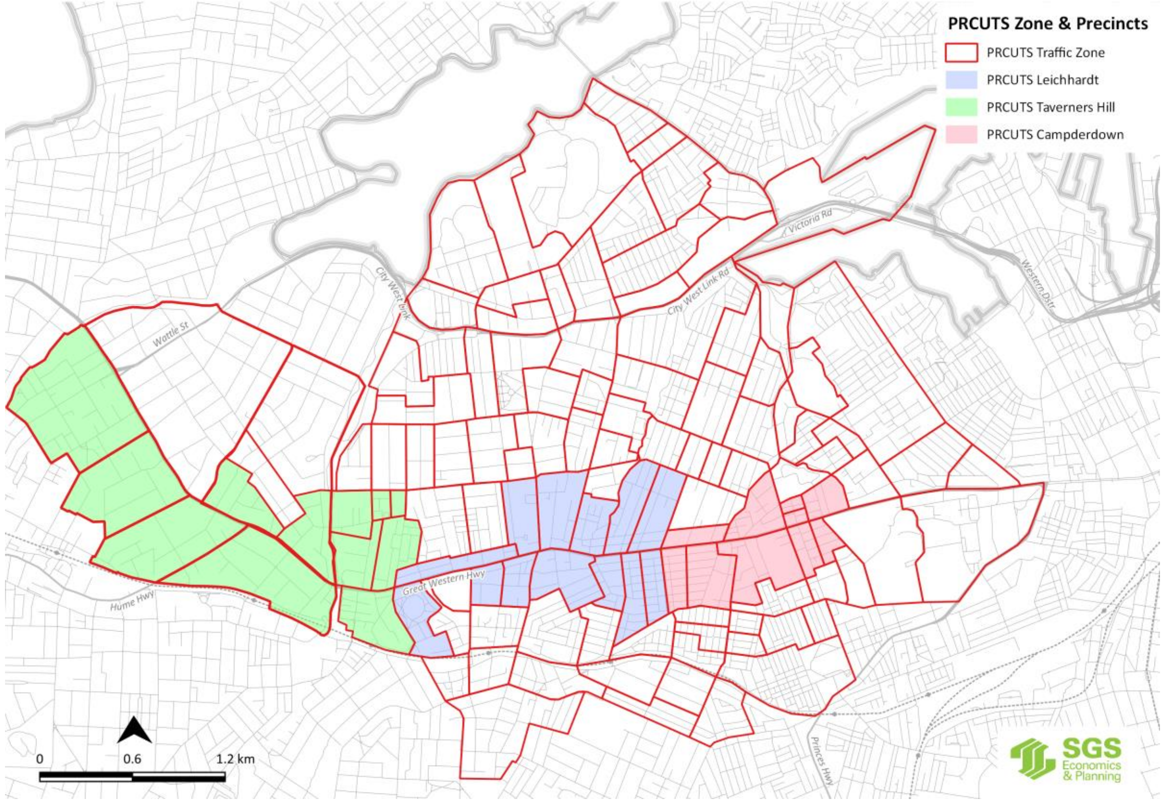
Travel Zones (TZ) (blue)

2016 Travel Zones (TZ) developed by Department of Transport



PRCUTS traffic zones (PTZ) (red)

PTZ geography and base spatial output of project



Land use data variables

The following data variables have been produced:

- Geography:
  - PRCUTS Traffic Zones (PTZ)

- Time periods
  - 2026
  - 2036
  - *The analysis base year is 2016 to align with TZP16 v1.5. An interim base year of 2021 has also been defined to align with current ‘additional’ capacity data.*

- Data variables
  - Residents (count of)
    - Dwellings
    - Population
  - Employment (count of jobs and GFA)
    - Industrial
    - Office
    - Retail
    - Hospital (and hospital beds)
    - Other (i.e. Construction, Arts and Recreation)
  - Schools (count of)
    - Primary students
    - Secondary students
    - TAFE student
    - University students

Data variable definitions

Dwellings and population attributes

Dwellings

= Structural Private Dwellings (SPD)

= Occupied and Unoccupied Dwellings

(Note typically 95 per cent of dwellings are occupied)

Population

= People in Occupied Private Dwellings (POPD)

This excludes *people in non-private dwellings, such as; people in aged care, hospitals, university dorm, corrections facilities*

Broad employment categories

ANZSIC06 Industry	Broad Industry
Agriculture, Forestry and Fishing	Industrial
Mining	Industrial
Manufacturing	Industrial
Electricity, Gas, Water and Waste Services	Industrial
Construction	Other
Wholesale Trade	Industrial
Retail Trade	Retail
Accommodation and Food Services	Retail
Transport, Postal and Warehousing	Industrial
Information Media and Telecommunications	Office
Financial and Insurance Services	Office
Rental, Hiring and Real Estate Services	Office
Professional, Scientific and Technical Services	Office
Administrative and Support Services	Office
Public Administration and Safety	Office
Education and Training	Schools
Health Care and Social Assistance	Hospitals*
Arts and Recreation Services	Other
Other Services	Office

* Adjustment has been made to include education and professionals services employment in the hospital PTZ

Method

The following provides an overview of the method.

Data sources are further discussed on the following page.

Applied equality across all scenarios

Job to GFA by industry assumptions sourced from Urban Growth

Hospital jobs/GFA/beds sourced from TZP16 v1.5, Urban Growth and Hospital annual report

Students by destination sourced from TZP16 v1.5 and location point of interest

TZP 16 v1.5
The base dwelling population and employment by industry from TZP 2016 v1.5 by travel zones

NSW LEP planning Zones

PTZ base land use
TZ data was converted to PTZ using an 'area overlap' concordance. Different LEP planning zones where used to allocate each land use type.

- Res – B4, R1, R2,R3,R4
- Retail – B1, B2, B4
- Com – B1, B2, B5, B6, B7
- Industrial – IN2, SP1, SP2

Scenario 1 Future Capacity (UFM, Cordell Connect)

Manual review and refinement

Scenario 2/3 Future Capacity (UFM (part), Cordell Connect, PRCUTS - endorsed)

50% supply 2026
95*% supply 2036

Manual review and refinement

Scenario 1: Reference Case (without PRCUTS)
Refined land use using existing capacity

Scenario 2: Full development (with PRCUTS)
Full realisation of PRCUTS capacity. Assuming 50% realisation by 2026 and 95% by 2036

Scenario 3: IWC Likely Staging (with PRCUTS)
Land use with PRCUTS and preferred rezoning and staging from IWC (yet to be completed)

** Full development was assumed to be 95% of supply. While any one site could achieve 100% of the capacity it is unrealistic to assume every single property across the entire study area could be built out to their maximum potential within a 20 year horizon or ever. There are a range of development, market, behavioural and other factors which means this is never possible.*

Global conversation assumptions

LEP zones have been used to disaggregate dwellings and employment by type from Travel zones to PTZ.

Residential	Industrial	Office	Retail
B4	IN2	B5	B4
R1	SP1	B6	B1
R2	SP2	B7	B2
R3			
R4			
B4			

* Schools and hospitals were manually identified and aligned to a PTZ

Employment to space assumptions

	Gross Floor Area (GFA) per work ratios	Efficiency rate to estimates Gross Leasable Floor Area (GLFA)
Retail	45 sqm	75%
Industrial	100 sqm	-
Office	20 sqm	-
Other	-	-

Source: Landcom, NSW
https://www.landcom.com.au/approach/sustainability/productive-places/#element-accordion-510

Overview of data sources

The following data inputs where used:

Source	Geographic coverage	Variables	Time	Key figures	Comments
Travel Zone Projections 2016 v1.5 (TZP16 v1.5), DOT	TZ for entire study area	All (SPD, ERP and emp by Ind)	2016, 2020, 2026, 2036	SPD – 44,750 (2036) ERP – 100,600 (2036) Emp – 47,495 (2036)	TZP16 v1.5 growth from 2016 to 2020 used to fill development gap in capacity data. Translated to PTZ using LEP based area overlap
Urban Feasibility Model (UFM), DPIE	PTZ for entire study area	SPD	March 2020 Extract of Feasible Future Capacity under Current LEP	SPD - 3,792 (FD)	Translated to PTZ using LEP based area overlap
Local Environment Plan (LEP) Planning Zones, DPIE	Aligned to PTZ and TZ	-	-	-	
PRCUTS 2016 – Endorsed	Aggregate figures for • Taverners Hill precinct • Leichhardt precinct • Camperdown precinct	SPD, ERP, Emp	Additional from 2020 by 2050	SPD – 1,300 (TH), 1,100 (L), 700 (CD) ERP – 3,300 (TH), 2,100 (L), 1,400 (CD) Emp – 4,100 (TH), 3,250 (L), 2,300 (CD)	Used TZP16 v1.5 and LEP data to spatial distribute precinct totals and employment by industry
Cordell Connect	Entire study area	Capacity	Additional from March 1st 2020 until 2036 (no developments noted completing after 2026)	SPD - 1,490	

Assumed recent development

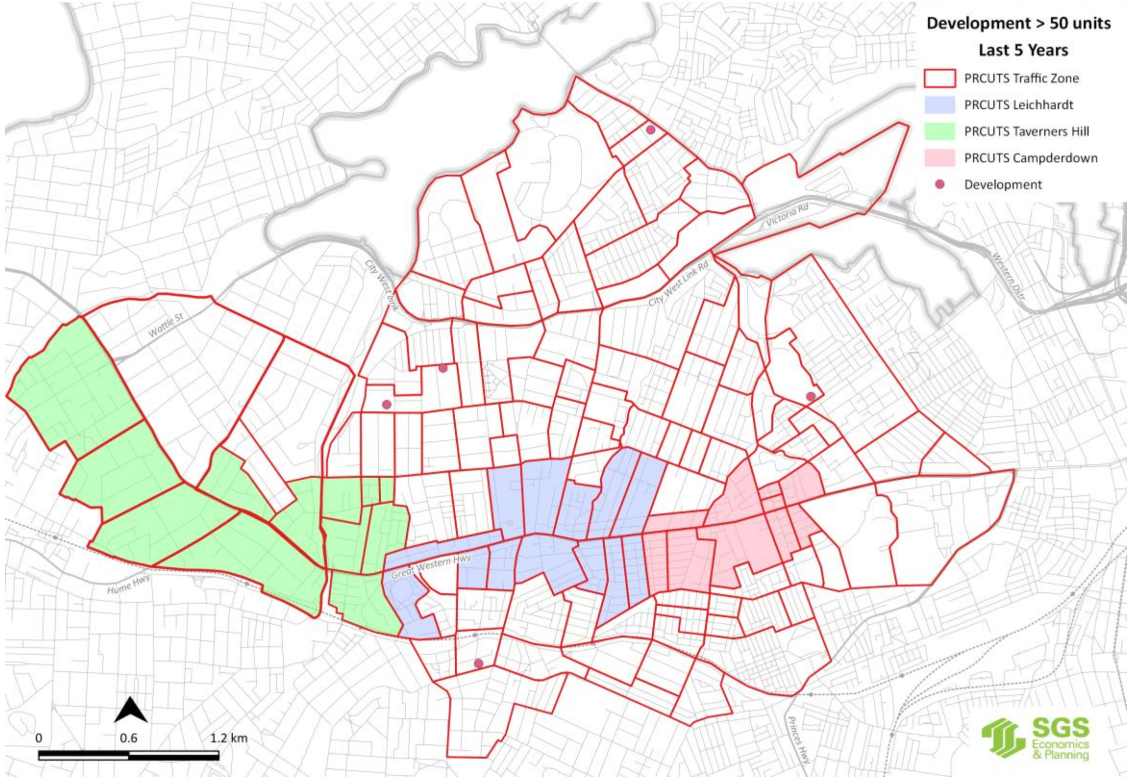
TZP16 v1.5 has been used to estimate recent development since 2016 up to when future capacity/development sources (Cordell/UFM) provide information on additional development

SPD	2016	2020	2016-20
TZP16 v1.5			
Leichhardt	3,687	3,821	135
Camperdown	2,768	2,933	164
Taverners Hill	7,660	8,080	420
Remainder	29,588	30,797	1,209
Total (Entire Study Area)	**43,704**	**45,632**	**1,928**
Total (Traffic Model Area)	37,616	39,483	1,867

Employment	2016	2020	2016-20
TZP16 v1.5			
Leichhardt	2,766	2,926	160
Camperdown	3,354	3,593	239
Taverners Hill	4,705	5,097	391
Remainder	12,294	13,880	1,586
Total (Entire Study Area)	**23,119**	**25,496**	**2,377**
Total (Traffic Model Area)	19,755	21,863	2,107

Some major recent developments during 2016 to 2020 include:

- 4 developments above 50 units over the last 5 years. Combined they represent 925 new dwellings (see map below)
- A further 1,488 units across 34 developments



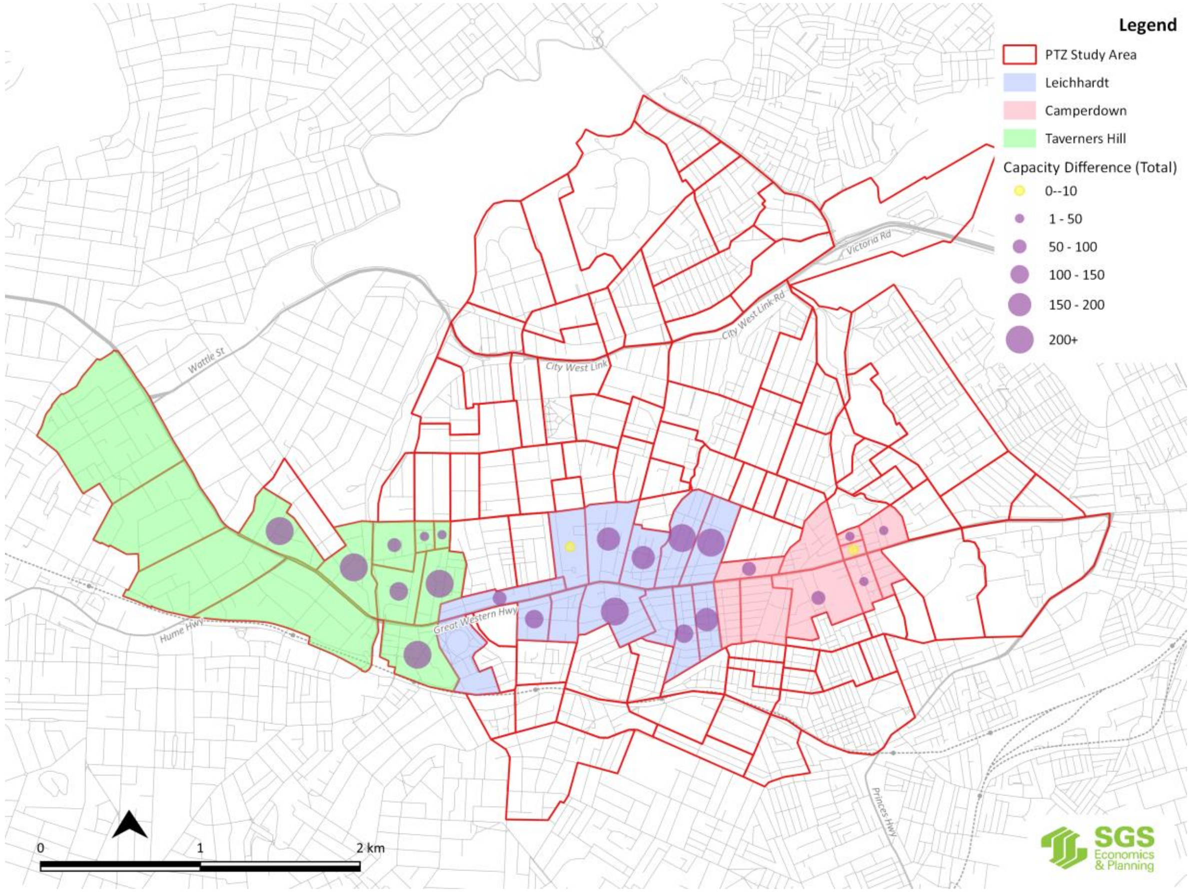
Combined development capacity Inputs

A range of development capacity inputs have been combined:

- S1: Cordell Connect and UFM(under current planning controls)
- S2: Cordell Connect, UFM (under current planning controls outside PRCUTS precincts) and UFM (PRCUTS ‘as corrected’)

SPD	2020-26	2026-36	Total additional from 2020
Scenario 1: Reference Case (without PRCUTS)			
Camperdown	225	189	413
Leichhardt	260	150	410
Taverners Hill	73	73	145
Remainder	2,186	1,137	3,322
Total (Traffic Model Area)	**2,743**	**1,548**	**4,290**
Scenario 2: Full development (with PRCUTS)			
Camperdown	565	496	1,061
Leichhardt	1,180	1,052	2,232
Taverners Hill	813	731	1,544
Remainder	2,202	1,150	3,352
Total (Traffic Model Area)	**4,759**	**3,429**	**8,188**

Difference in capacity inputs between S1 and S2

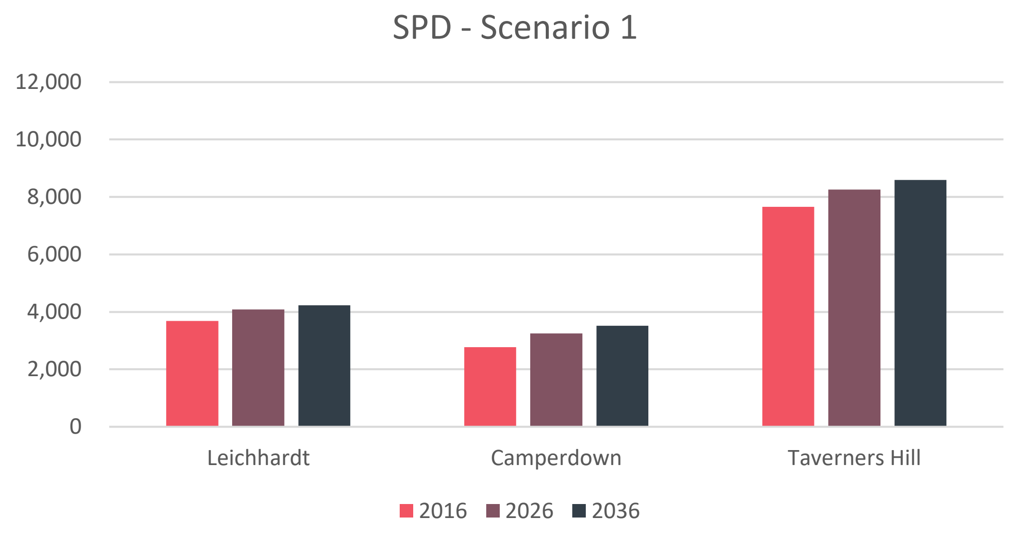


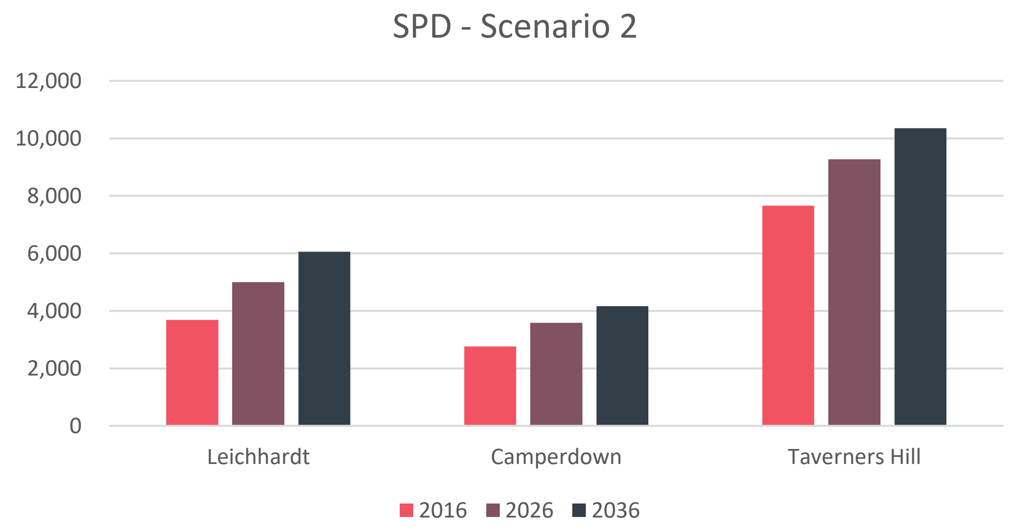
Land use review results

Dwelling scenario overview

SPD	2016	2026	2036	2016-26	2016-36
Scenario 1: Reference Case (without PRCUTS)					
Leichhardt	3,687	4,081	4,231	395	545
Camperdown	2,768	3,245	3,521	476	752
Taverners Hill	7,660	8,257	8,591	597	931
Remainder	29,588	32,883	33,920	3,294	4,332
Total (Entire Study Area)	**43,704**	**48,466**	**50,263**	**4,762**	**6,560**
Total (Traffic Model Area)	*37,616*	*42,226*	*43,773*	*4,610*	*6,157*
Scenario 2: Full development (with PRCUTS)					
Leichhardt	3,687	5,001	6,053	1,315	2,366
Camperdown	2,768	3,585	4,168	817	1,400
Taverners Hill	7,660	9,275	10,350	1,615	2,690
Remainder	29,588	32,867	33,888	3,279	4,300
Total (Entire Study Area)	**43,704**	**50,728**	**54,460**	**7,025**	**10,756**
Total (Traffic Model Area)	37,616	44,227	47,640	6,611	10,024
TZP16 v1.5* *(unaltered - for reference)*					
Leichhardt	*3,687*	*4,024*	*4,123*	*337*	*436*
Camperdown	*2,400*	*2,740*	*3,226*	*340*	*826*
Taverners Hill	*8,600*	*9,651*	*10,007*	*1,051*	*1,407*
Remainder	*29,017*	*32,109*	*36,454*	*3,092*	*7,437*
Total (Entire Study Area)	***43,704***	***48,524***	***53,809***	***4,820***	***10,106***
Total (Traffic Model Area)	*37,616*	*42,284*	*47,319*	*4,668*	*9,703*

** Unaltered TZP16 v1.5 data has been spatially disaggregated and aligned to the study precincts for reference.*

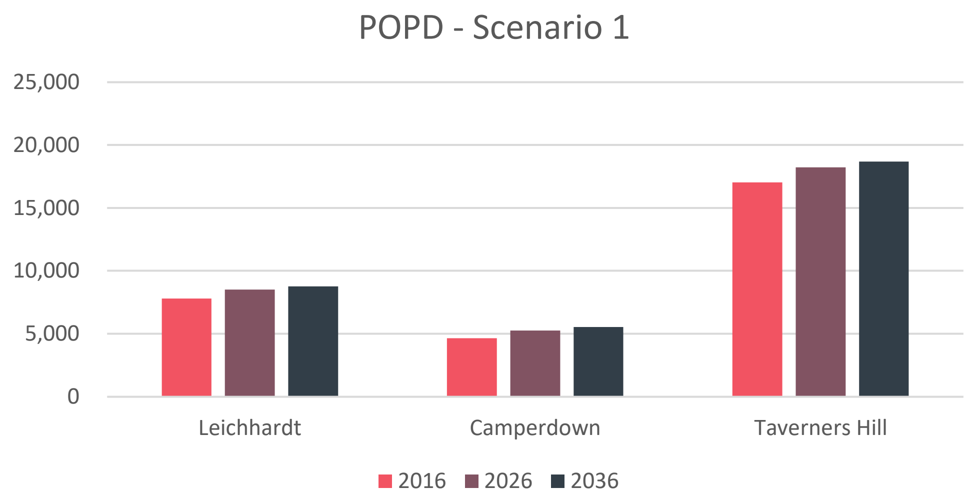


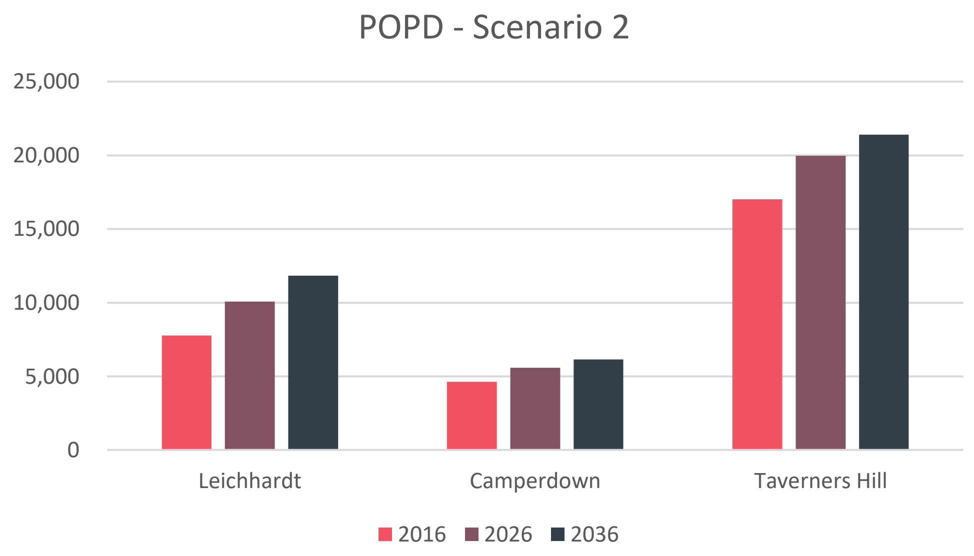


Population scenario overview

POPD	2016	2026	2036	2016-26	2016-36
Scenario 1: Reference Case (without PRCUTS)					
Leichhardt	7,786	8,519	8,769	732	983
Camperdown	4,637	5,247	5,533	611	897
Taverners Hill	17,018	18,211	18,679	1,193	1,661
Remainder	62,459	68,116	69,437	5,657	6,978
Total (Entire Study Area)	**91,900**	**100,093**	**102,419**	**8,193**	**10,519**
Total (Traffic Model Area)	78,130	86,041	88,014	7,912	9,885
Scenario 2: Full development (with PRCUTS)					
Leichhardt	7,786	10,075	11,834	2,289	4,048
Camperdown	4,637	5,589	6,159	953	1,523
Taverners Hill	17,018	19,964	21,409	2,946	4,391
Remainder	62,459	68,093	69,416	5,634	6,957
Total (Entire Study Area)	**91,900**	**103,721**	**108,818**	**11,821**	**16,919**
Total (Traffic Model Area)	78,130	89,226	93,913	11,097	15,784
TZP16 v1.5* *(unaltered - for reference)*					
Leichhardt	7,786	8,356	8,522	570	736
Camperdown	4,177	4,519	4,968	342	791
Taverners Hill	19,402	21,232	21,719	1,830	2,317
Remainder	60,534	65,148	70,682	4,613	10,148
Total (Entire Study Area)	**91,900**	**99,255**	**105,892**	**7,355**	**13,992**
Total (Traffic Model Area)	78,130	85,315	91,653	7,185	13,523

** Unaltered TZP16 v1.5 data has been spatially disaggregated and aligned to the study precincts for reference.*





Persons per Dwelling

POPD per SPD	2016	2026	2036	2016-26	2016-36
Scenario 1: Reference Case (without PRCUTS)					
Leichhardt	2.1	2.1	2.1	1.9	1.7
Camperdown	1.7	1.6	1.6	1.3	1.0
Taverners Hill	2.2	2.2	2.2	2.0	1.4
Remainder	2.1	2.1	2.0	1.7	1.3
Total (Entire Study Area)	**2.1**	**2.1**	**2.0**	**1.7**	**1.3**
Total (Traffic Model Area)	2.1	2.0	2.0	1.7	1.3
Scenario 2: Full development (with PRCUTS)					
Leichhardt	2.1	2.0	2.0	1.7	1.7
Camperdown	1.7	1.6	1.5	1.2	1.0
Taverners Hill	2.2	2.2	2.1	1.8	1.3
Remainder	2.1	2.1	2.0	1.7	1.3
Total (Entire Study Area)	2.1	2.0	2.0	1.7	1.4
Total (Traffic Model Area)	2.1	2.0	2.0	1.7	1.4
TZP16 v1.5* *(unaltered - for reference)*					
Leichhardt	*2.1*	*2.1*	*2.1*	*1.7*	*1.7*
Camperdown	*1.7*	*1.6*	*1.5*	*1.0*	*0.9*
Taverners Hill	*2.3*	*2.2*	*2.2*	*1.7*	*1.4*
Remainder	*2.1*	*2.0*	*1.9*	*1.5*	*1.3*
Total (Entire Study Area)	***2.1***	***2.0***	***2.0***	***1.5***	***1.3***
Total (Traffic Model Area)	*2.1*	*2.0*	*1.9*	*1.5*	*1.3*

** Unaltered TZP16 v1.5 data has been spatially disaggregated and aligned to the study precincts for reference.*

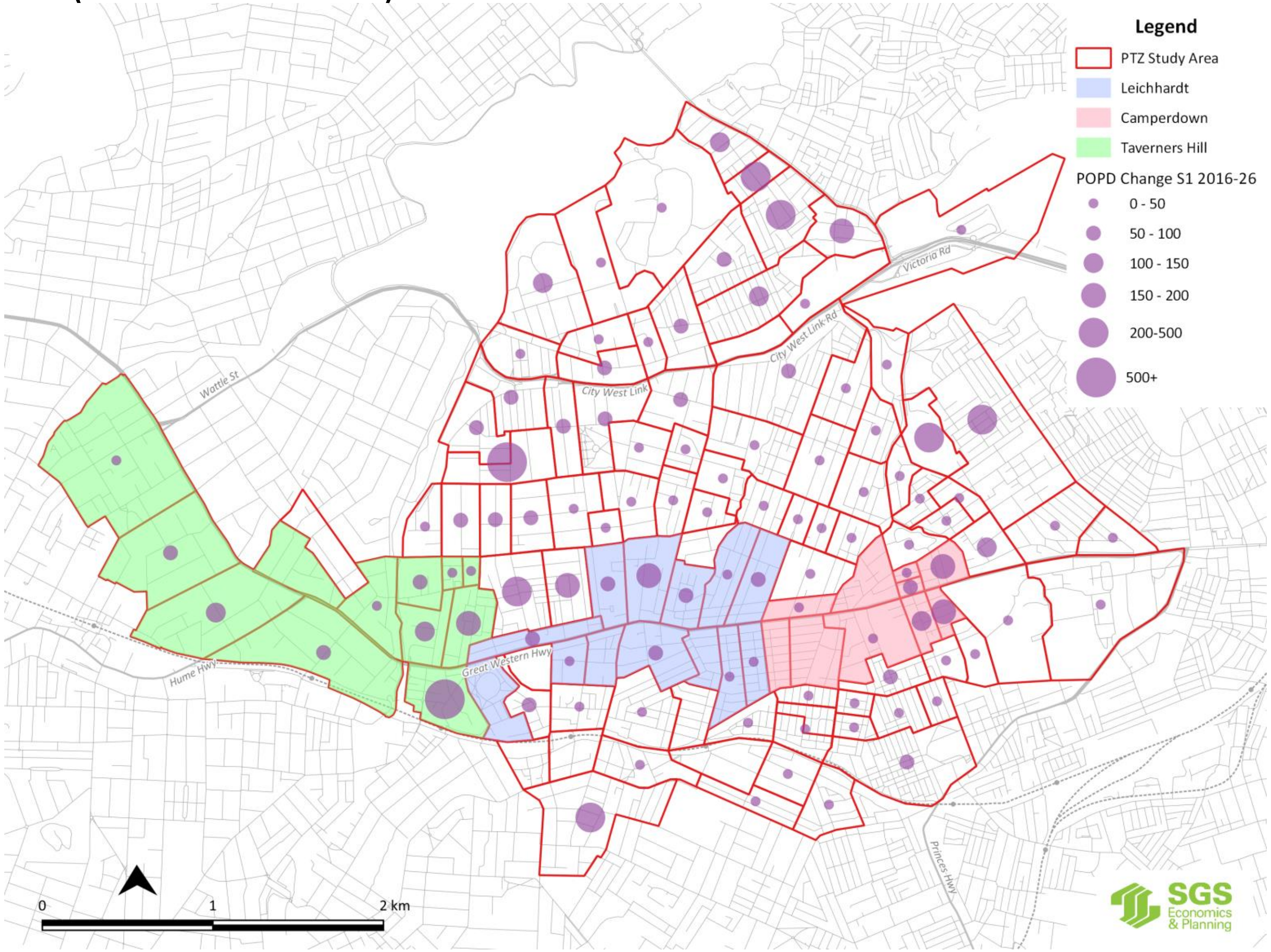
Assumptions:
New dwellings in PCRUTS precincts follow pre-set Persons Per dwellings:

	2026	2036
Leichhardt	1.9	1.9
Camperdown	2.0	2.0
Taverners Hill	2.5	2.5

For PTZ's outside these areas the Persons per Dwelling defaults to the TZ_16 Trend

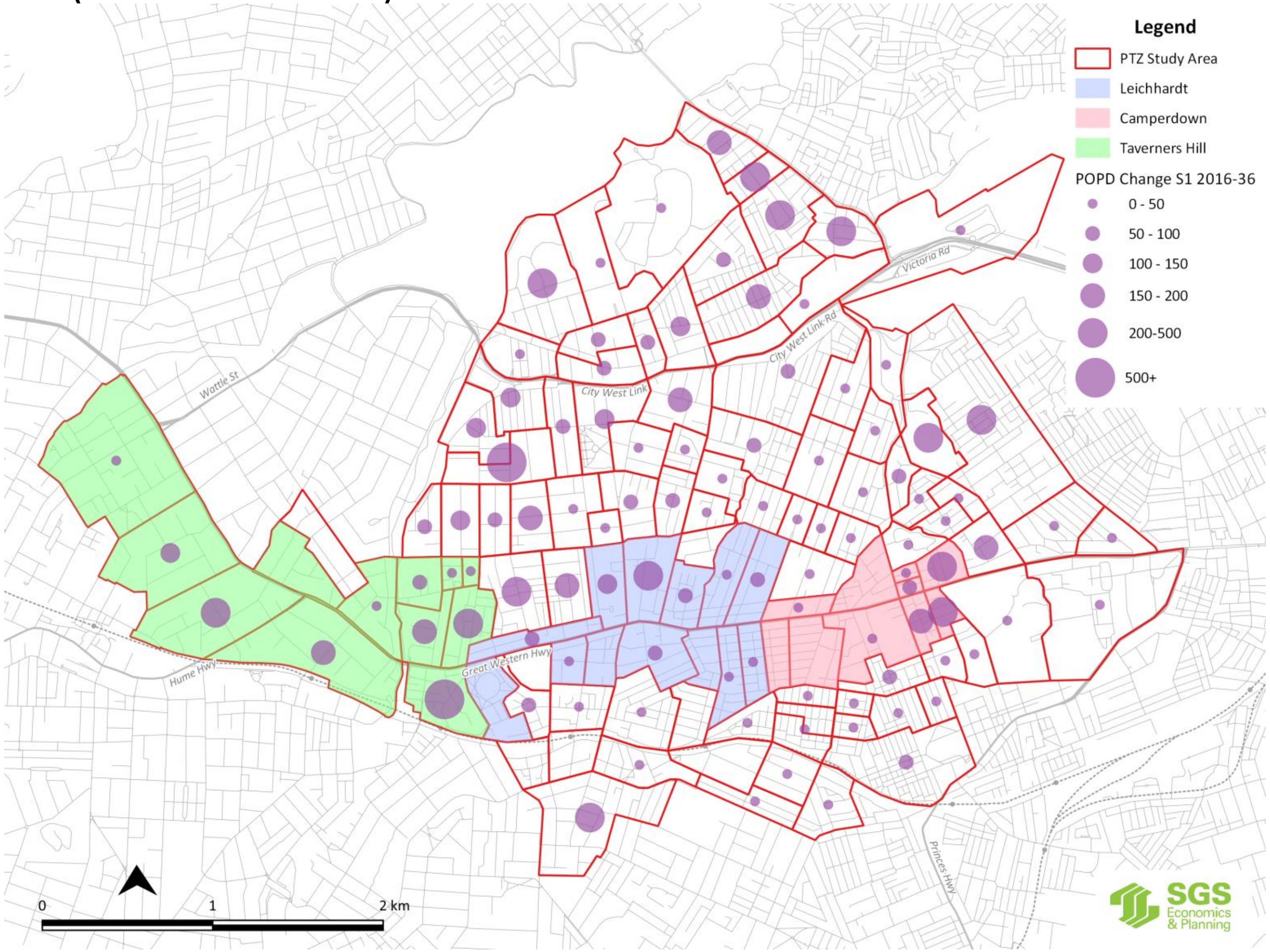
Population Change

2016 to 2026 - Scenario 1: Reference Case (without PRCUTS)



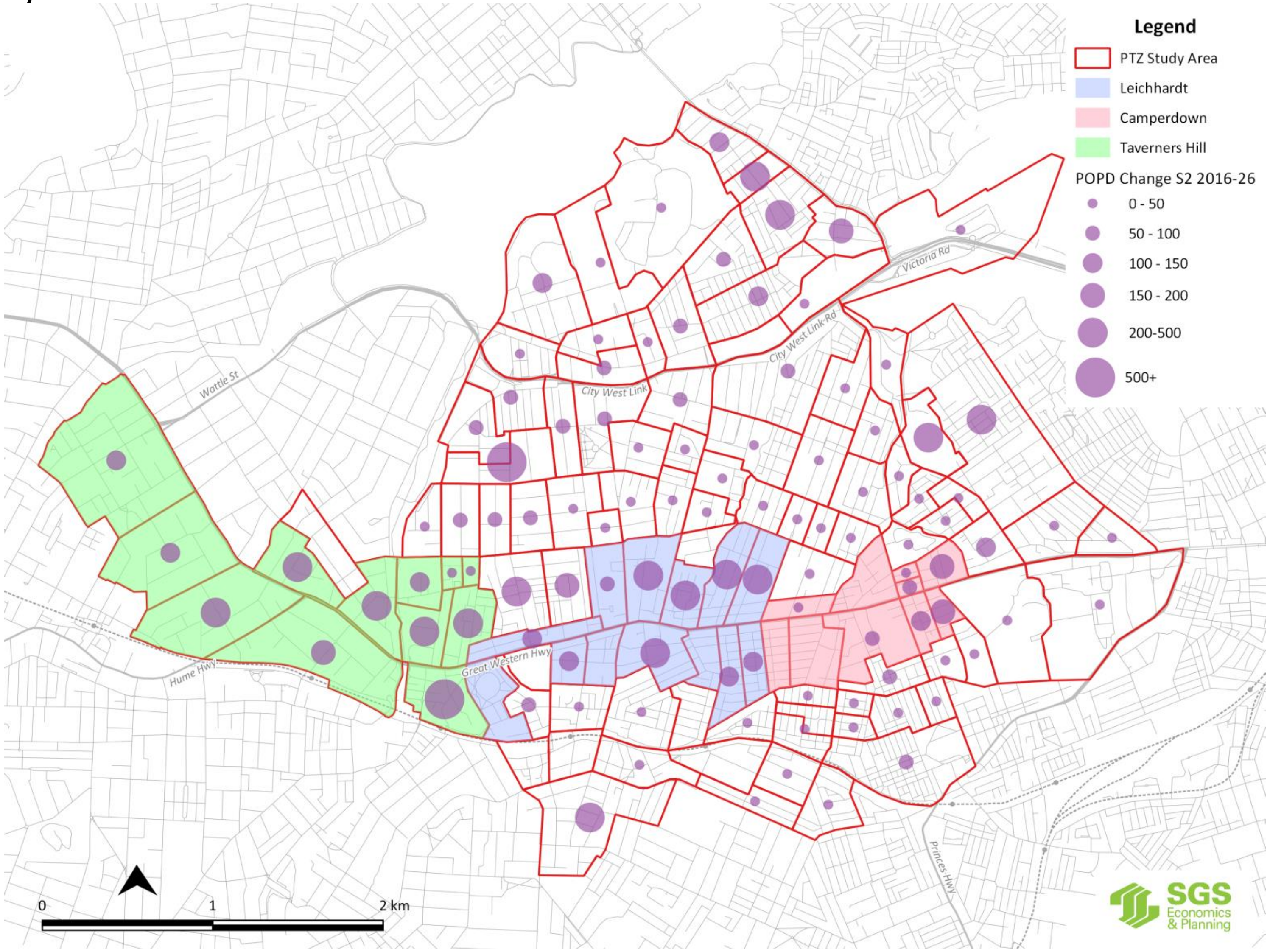
Population Change

2016 to 2036 - Scenario 1: Reference Case (without PRCUTS)



Population Change

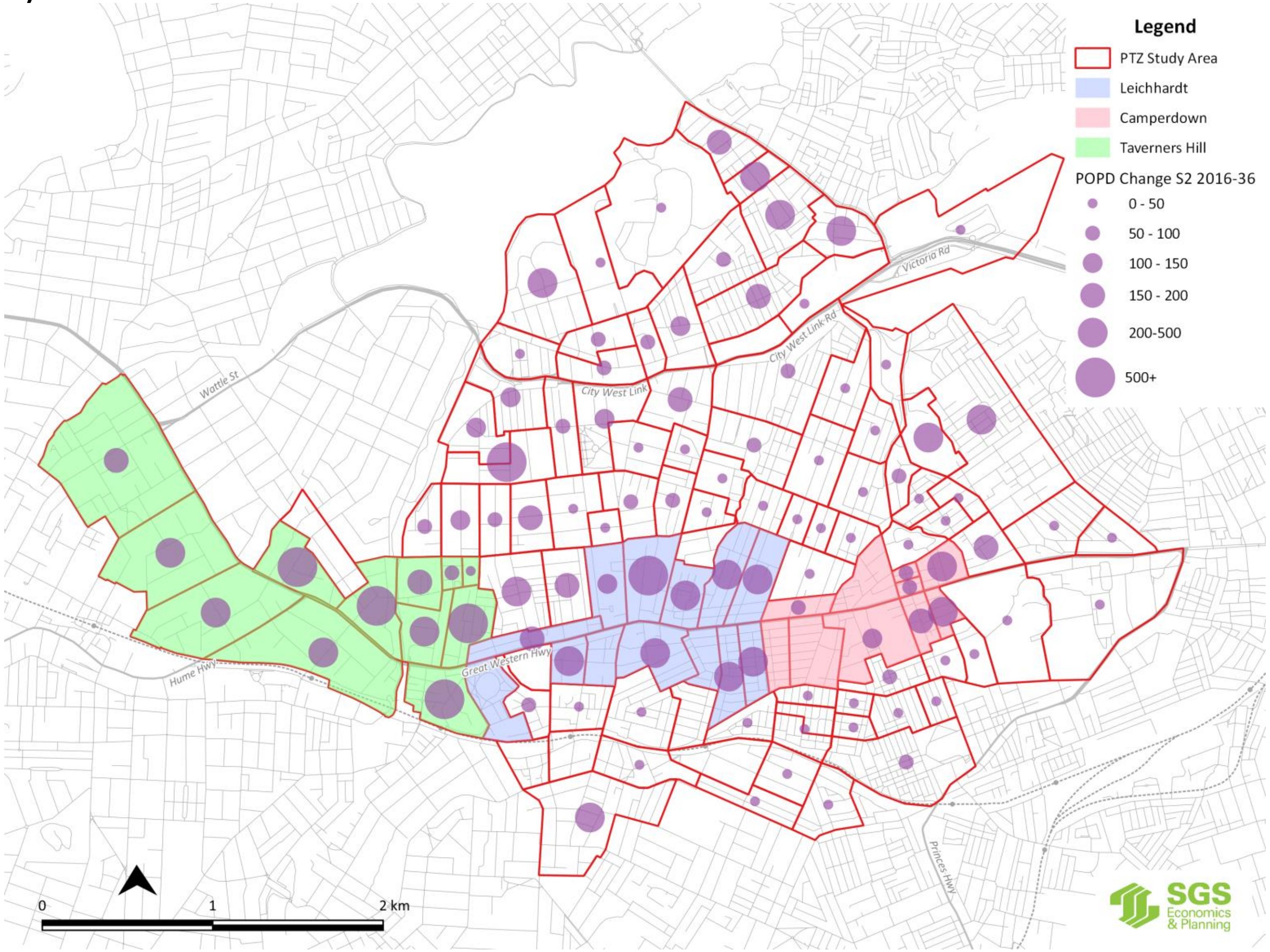
2016 to 2026 - Scenario 2 (With PRCUTS)



SGS Economics & Planning

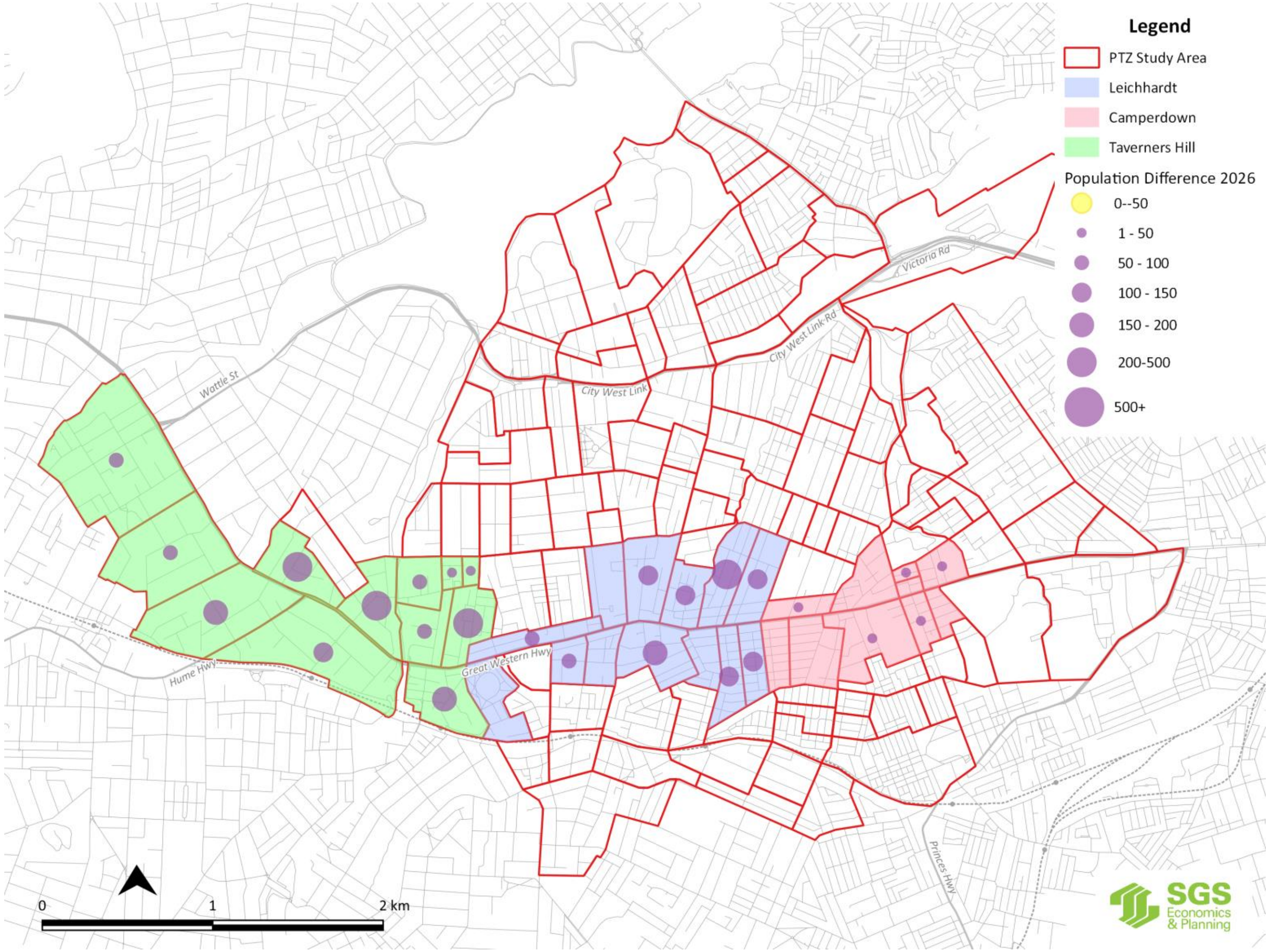
Population Change

2016 to 2036 - Scenario 2 (With PRCUTS)



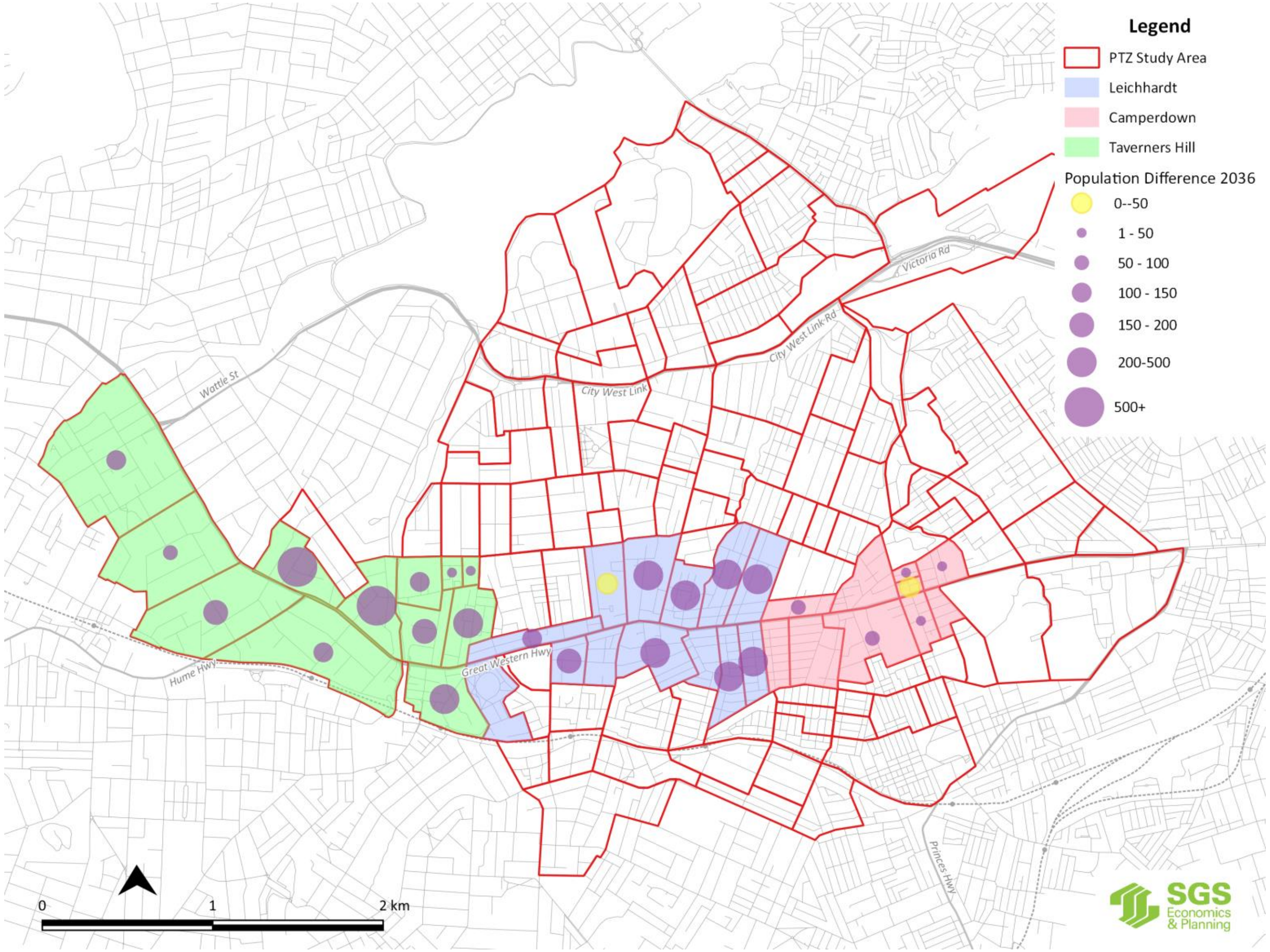
Scenario Population Difference

2026 - Scenario 2 (With PRCUTS) – Scenario 1



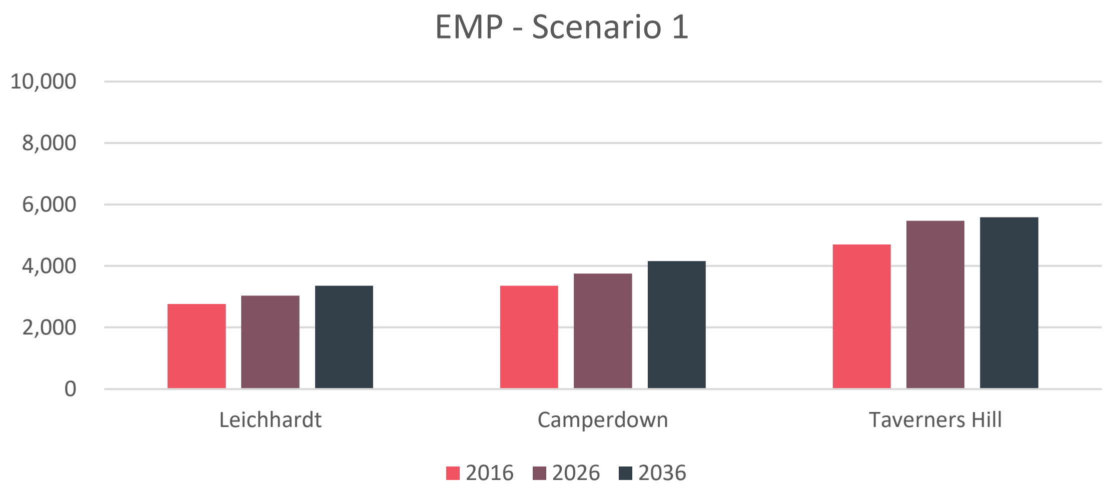
Scenario Population Difference

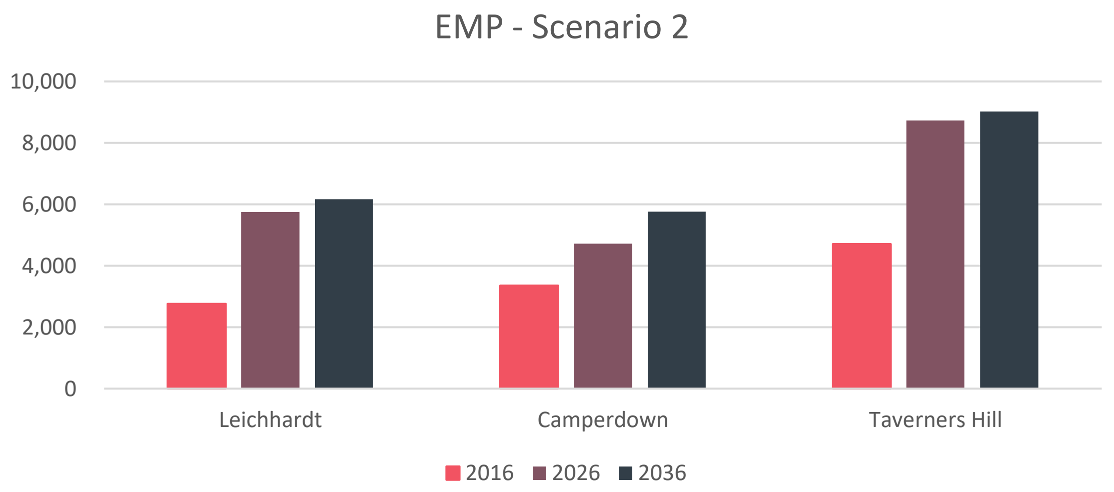
2036 - Scenario 2 (With PRCUTS) – Scenario 1



Employment overview

EMP	2016	2026	2036	2016-26	2016-36
Scenario 1: Reference Case (without PRCUTS)					
Leichhardt	2,766	3,033	3,363	267	597
Camperdown	3,354	3,752	4,162	398	808
Taverners Hill	4,705	5,471	5,590	765	884
Remainder	12,294	14,978	19,804	2,685	7,510
Total (Entire Study Area)	**23,119**	**27,234**	**32,918**	**4,115**	**9,799**
Total (Traffic Model Area)	19,755	23,268	29,299	3,512	9,543
Scenario 2: Full development (with PRCUTS)					
Leichhardt	2,766	5,748	6,172	2,983	3,406
Camperdown	3,354	4,716	5,767	1,362	2,413
Taverners Hill	4,705	8,732	9,025	4,026	4,319
Remainder	12,294	15,131	19,965	2,838	7,672
Total (Entire Study Area)	**23,119**	**34,327**	**40,929**	**11,208**	**17,811**
Total (Traffic Model Area)	19,755	30,361	37,310	10,606	17,555



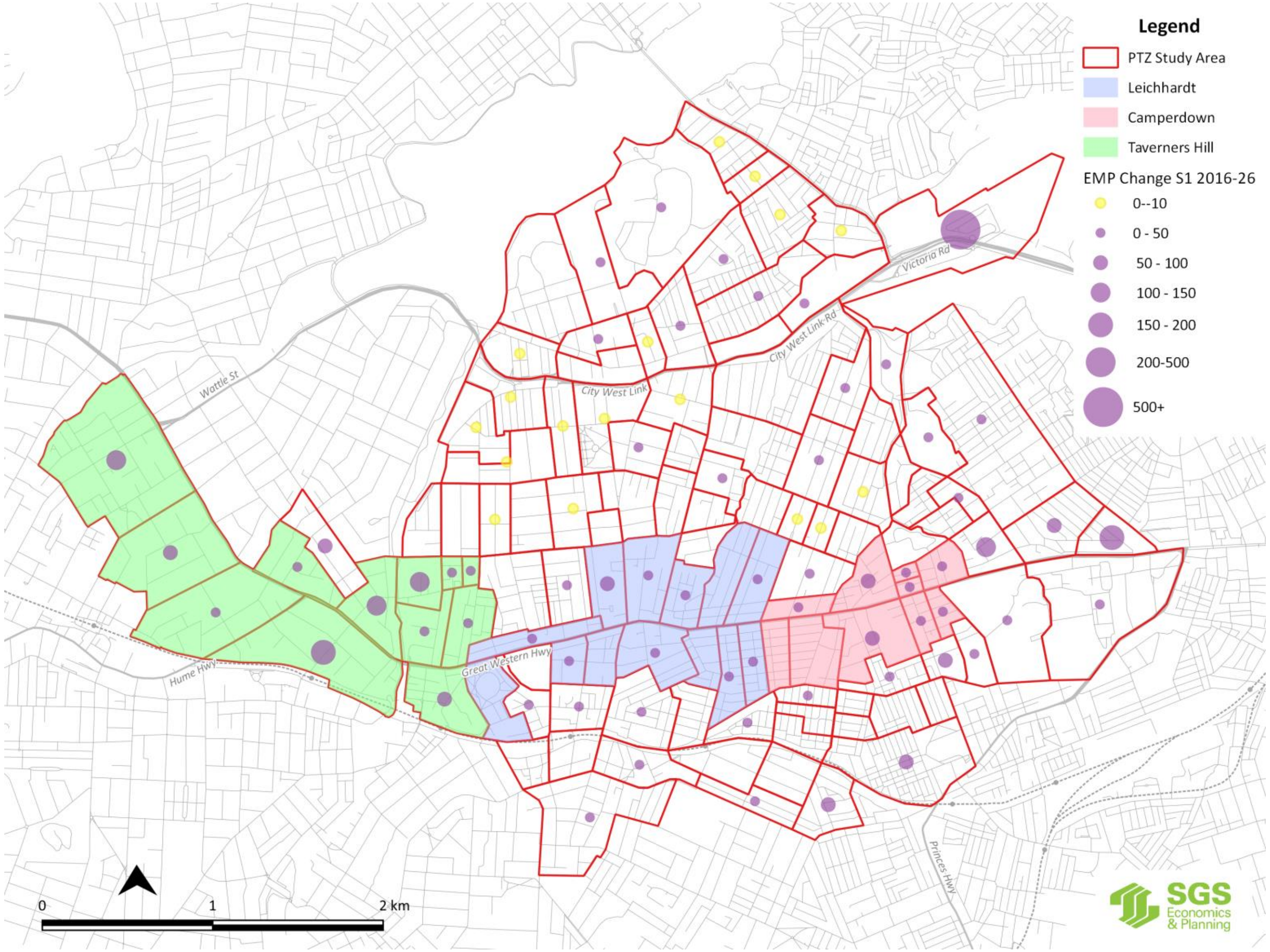


Employment overview

	Retail			Office			Commercial			Other (inc. Hospital)		
EMP	**2016**	**2036**	**2016-36**	**2016**	**2036**	**2016-36**	**2016**	**2036**	**2016-36**	**2016**	**2036**	**2016-36**
Scenario 1: Reference Case (without PRCUTS)												
Leichhardt	1,351	1,569	218	2	3	1	337	444	107	759	880	121
Camperdown	803	997	194	1,068	1,384	316	461	573	112	951	1,105	154
Taverners Hill	1,080	1,236	156	1,420	1,891	471	476	701	225	270	343	73
Remainder	3,546	4,228	682	1,843	3,351	1,509	1,697	5,119	3,422	2,633	3,092	458
Total (Entire Study Area)	**6,780**	**8,030**	**1,249**	**4,333**	**6,629**	**2,296**	**2,970**	**6,836**	**3,866**	**4,614**	**5,420**	**806**
Total (Traffic Model Area)	6,049	6,582	533	3,741	5,055	1,314	2,783	6,594	3,811	4,271	4,953	682
Scenario 2: Full development (with PRCUTS)												
Leichhardt	1,351	2,932	1,580	2	4	2	337	824	487	759	1,675	916
Camperdown	803	1,700	898	1,068	1,384	316	461	699	239	951	1,878	926
Taverners Hill	1,080	1,520	441	1,420	4,294	2,874	476	1,366	890	270	425	155
Remainder	3,546	4,331	784	1,843	3,351	1,509	1,697	5,148	3,451	2,633	3,121	488
Total (Entire Study Area)	**6,780**	**10,483**	**3,703**	**4,333**	**9,033**	**4,701**	**2,970**	**8,038**	**5,067**	**4,614**	**7,099**	**2,486**
Total (Traffic Model Area)	6,049	9,590	3,541	3,741	8,252	4,511	2,783	7,795	5,013	4,271	6,632	2,361

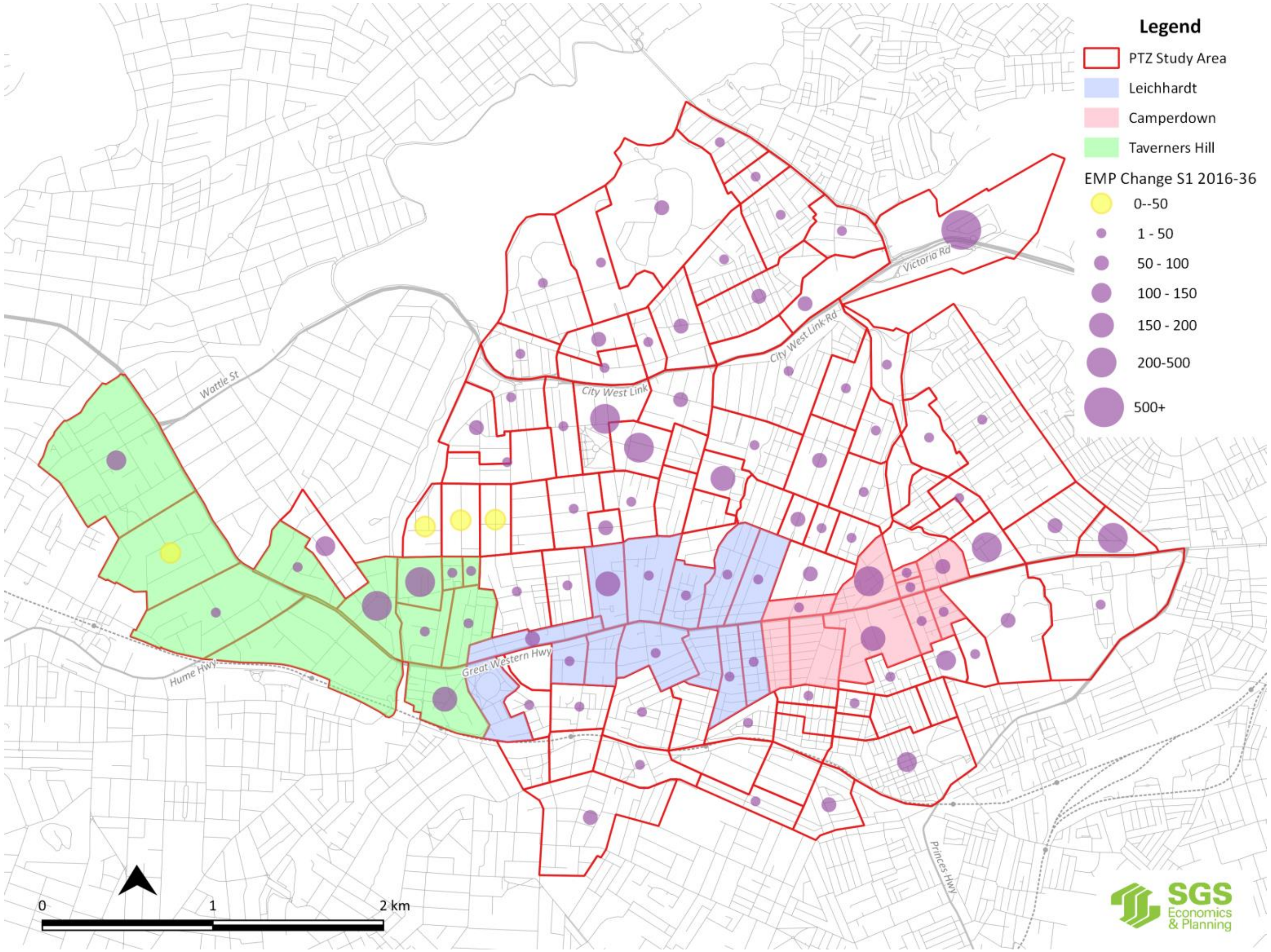
Employment Change

- 2016 to 2026 - Scenario 1



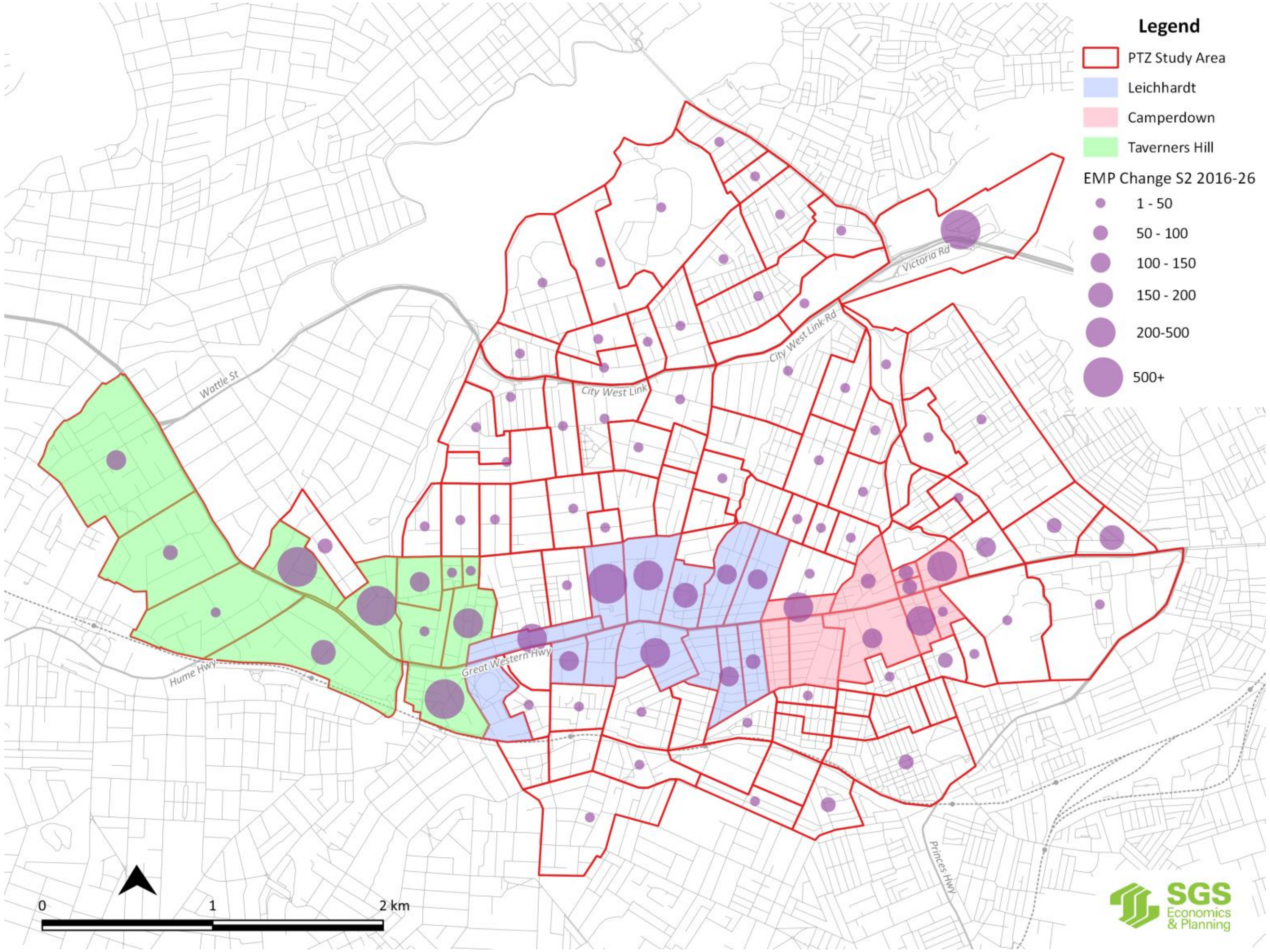
Employment Change

- 2016 to 2036 - Scenario 1



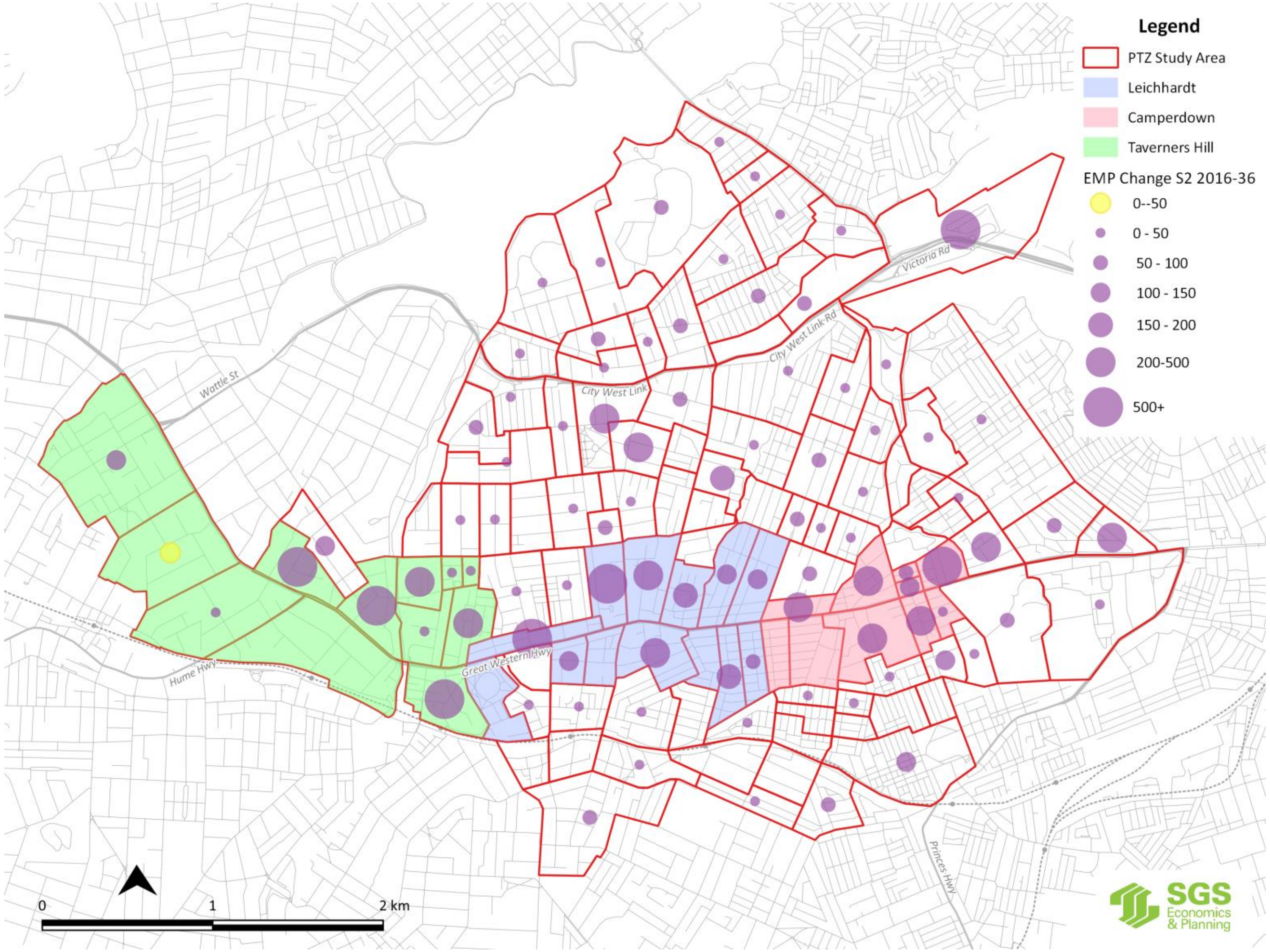
Employment – Change

- 2016 to 2026 - Scenario 2



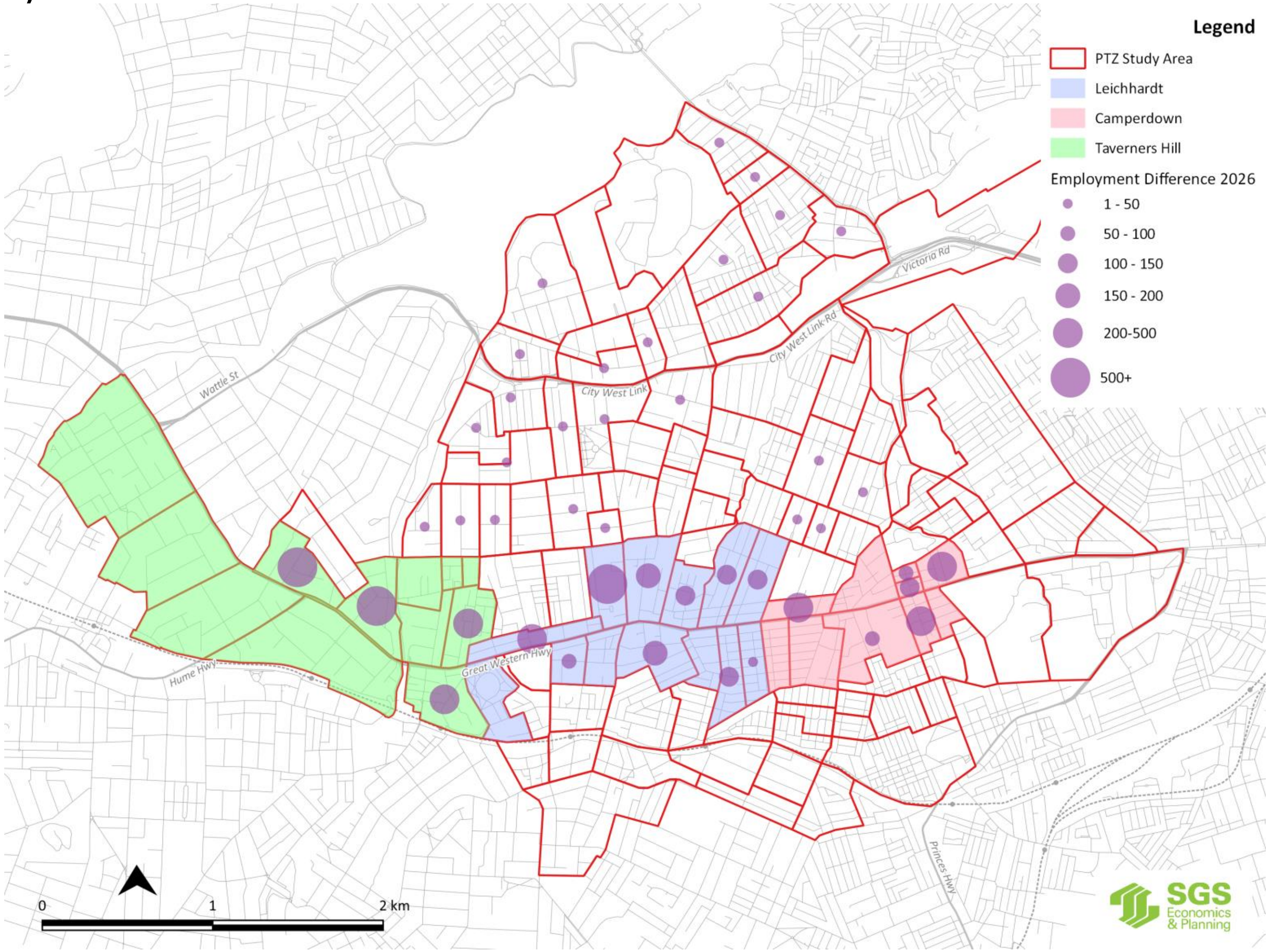
Employment Change

- 2016 to 2036 - Scenario 2



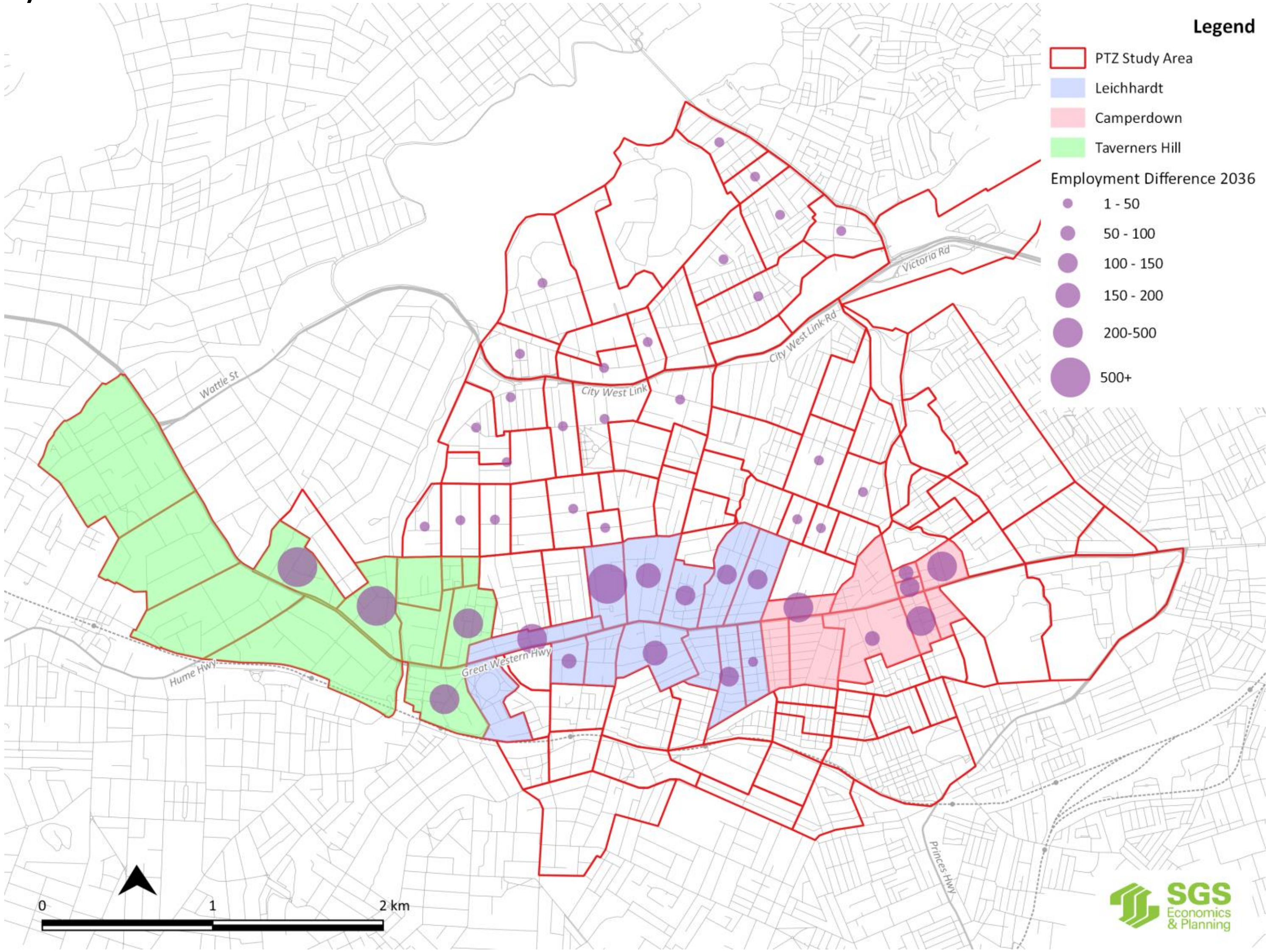
Employment Change

2016 to 2026 - Scenario 2 (With PRCUTS) – Scenario 1



Employment Change

2016 to 2036 - Scenario 2 (With PRCUTS) – Scenario 1



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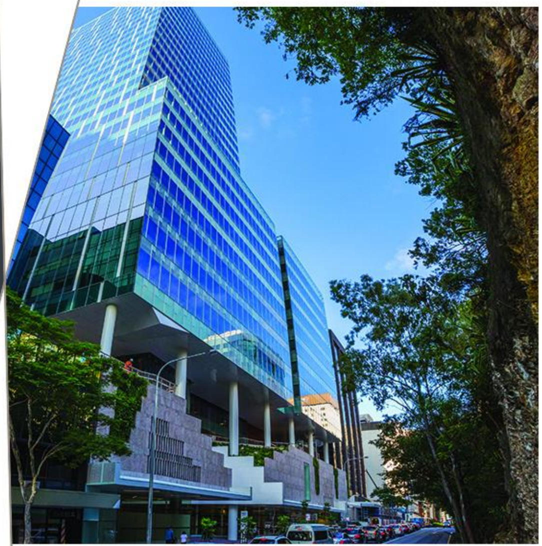
Future Modelling Report



Inner West Sydney Suburbs including Parramatta Road Corridor Urban Transformation Strategy

80018116

Prepared for Department of Planning, Industry and Environment in collaboration with Inner West Council

10 March 2022

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3	18/02/2022	Final	Stephen Payne Siavash Shahsavaripour	Ivo Pais
4	10/03/2022	Final Rev2	Ivo Pais Siavash Shahsavaripour	Ivo Pais

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Glossary

Abbreviation	Description
Aimsun	Traffic modelling software used for the hybrid mesoscopic/microscopic traffic model
CBD	Central Business District
DPIE	Department of Planning, Industry and Environment
DUE	Dynamic user equilibrium
HV	Heavy vehicle
IWC	Inner West Council
LCV	Light commercial vehicle
LOS	Level of service
LV	Light vehicle
M4	M4 Motorway
M5	M5 Motorway
M8	M8 Motorway
NSW	New South Wales
OD	Origin-destination pair
PPM	Parking Precinct Module
PRCUTS	Parramatta Road Corridor Urban Transformation Study
PTPM	Public Transport Project Model
PwC	Pricewaterhouse Coopers
SGS	SGS Economics & Planning
SRC	Stochastic route choice
STFM	Sydney Traffic Forecasting Model
VHT	Vehicle hours travelled
VKT	Vehicle kilometres travelled
WCX	WestConnex

1 Introduction

1.1 Project background

Cardno was engaged by Department of Planning, Industry and Environment (DPIE) in close collaboration with Inner West Council (IWC) to investigate the traffic network along the Parramatta Road corridor within the IWC local government area. The study involves the development of a hybrid (microscopic/mesoscopic) traffic simulation model using Aimsun. The purpose of the study is to better inform future traffic and safety works, and ensure that future development in the corridor can be sustained with existing and proposed infrastructure upgrades.

Figure 1-1 shows the regional context of the study area. The study area is located in the Inner West suburbs of Sydney, approximately five kilometres south-west of the CBD. Parramatta Road is a key arterial road corridor connecting the Sydney CBD to the metropolitan centre of Parramatta, as well as other major destinations in the Inner West. The boundary of the Parramatta Road corridor traffic model, the software platform and the model inputs have been endorsed by IWC, DPIE and Transport for NSW.

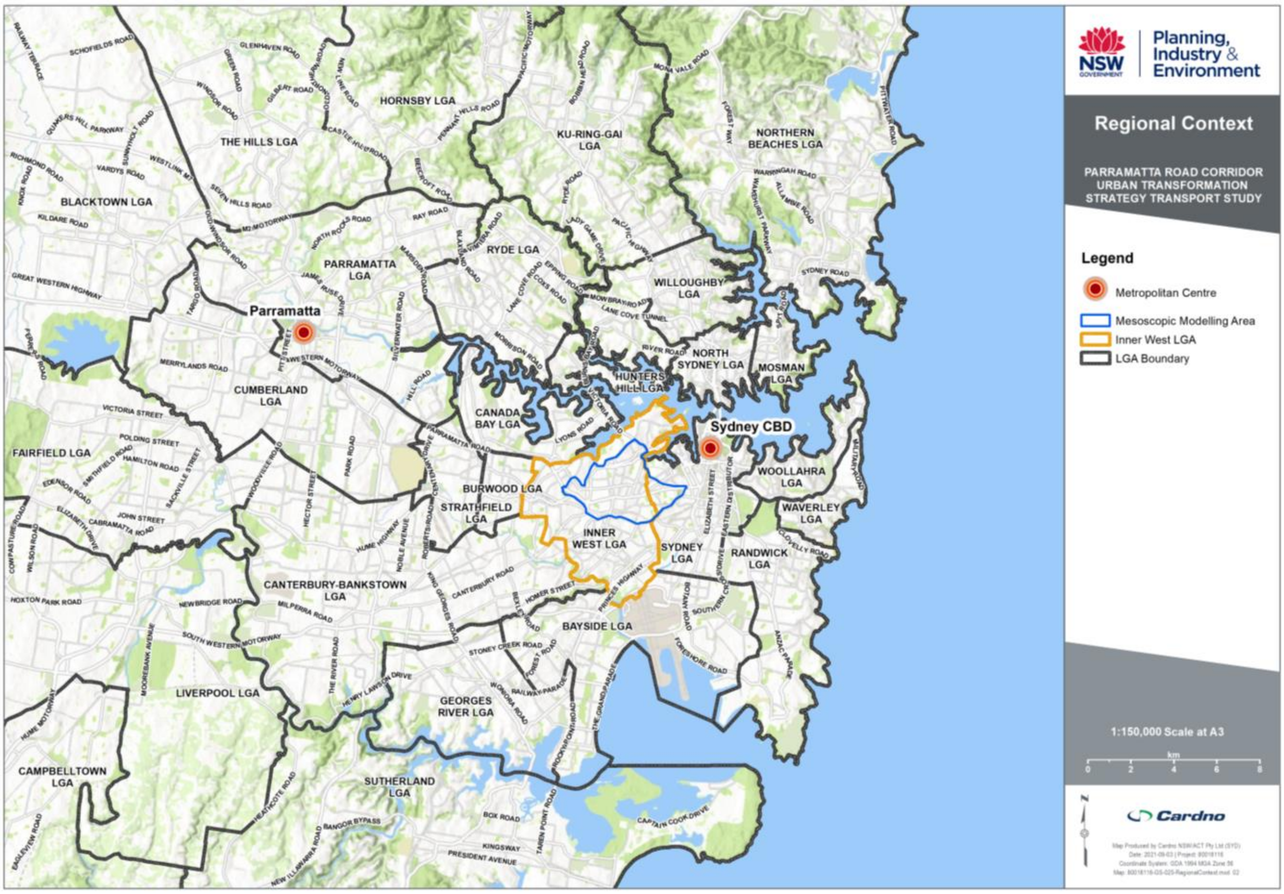


Figure 1-1 Regional context

1.2 Project objectives

The traffic modelling objectives of the Parramatta Road Corridor Urban Transformation Study (PRCUTS) are:

> Evaluate the impacts of future infrastructure upgrades and trip reassignment in the PRCUTS study area and other corridors within the inner western suburbs

> Assess the maximum network capacity and recommend public transport shift

> Analyse the impact of projected employment and population growth on the transport network

> Test and refine relevant items in the PRCUTS Infrastructure List.

1.3 Scope of works

The scope of works for the traffic modelling component of the study is:

> Review existing relevant works, previous traffic studies and development patterns along the Parramatta Road corridor
> Conduct traffic surveys and undertake analysis of the historical trends and existing traffic conditions
> Use existing strategic models to estimate current and future demands
> Develop, calibrate and validate a Base Model to capture existing conditions on a typical weekday to establish a reliable and robust platform for future-year testing, in accordance with the following guidelines:
  - *Traffic Modelling Guidelines* (Roads and Maritime Services, 2013)
  - *Technical Direction TTD 2018/002: Traffic signals in microsimulation modelling* (Roads and Maritime Services, 2018)
  - *Technical Direction TTD 2017/001: Operational modelling reporting structure* (Roads and Maritime Services, 2017)
> Develop scenarios to assess the future operation of Parramatta Road.

1.3.1 Previous reporting

Model Scoping Report (Cardno, 18 April 2018)

This document introduced the project and outlined the methodology for the traffic modelling, including:

> Defining the study area
> Outlining the survey data, strategic traffic demand sources and signal data
> Modelling methodology and assumptions
> Inception Meeting outcomes.

The modelling methodology was endorsed by all parties.

Base Model Development Report (Cardno, 29 October 2020)

This documented the development, calibration and validation of the Aimsun Base Model in accordance with the relevant guidelines including:

> *Traffic Modelling Guidelines* (Roads and Maritime Services, 2017)
> *Operational Modelling Reporting Structure* (Roads and Maritime Services, 2017)
> *Traffic Signals in Microsimulation Modelling* (Roads and Maritime Services, 2018).

The report included:

> Description and summary of the traffic data inputs including classified intersection counts
> Analysis of existing conditions and congestion hotspot locations
> Explanation of the study methodology and assumptions
> Statistical analysis of the stability of the Base Model
> Summary of the Base Model calibration and validation results
> Discussion of limitations and conclusions.

The *Base Model Development Report* (Cardno, October 2020) is attached to this report as **Appendix A**.

The Base Model was reviewed by Arup on behalf of DPIE and Transport for NSW and the findings are summarised in *Base Model Peer Review* (Arup, March 2020) which is attached to this report as **Appendix B**. The model and report were refined based on Arup's comments and resubmitted to Arup for independent review. The model was subsequently endorsed as fit for purpose by Arup.

For the future modelling stage, PwC were commissioned by DPIE to apply the PTPM growth to the STFM using a methodology designed in consultation with DPIE. The corresponding traffic growth was subsequently applied to the operational model in Aimsun.

1.3.2 This report

This report documents the Future Model development process, including modelling assumptions and demand estimation, and includes an operational performance assessment of the Base Model and Future Models. It is intended to be read in conjunction with previous reporting for the study.

1.4 Study area

The study area encompasses the precincts of Taverners Hill, Leichhardt and Camperdown which are all within the IWC local government area (except part of Camperdown precinct which is in the City of Sydney). **Figure 1-2** shows these precincts along Parramatta Road. The study is reviewing the traffic generation from the suburbs of inner west Sydney and includes the uplift proposed in these suburbs as well as that proposed by PRCUTS.

The study area includes the key links discussed below.

> Parramatta Road (Great Western Highway) between Haberfield and Ultimo including key intersections with Liverpool Road (Hume Highway), Pyrmont Bridge Road and City Road (Princes Highway). Parramatta Road is a major east-west route connecting the Sydney CBD to the Inner West, Strathfield, Lidcombe and Parramatta. At the western extent of the study area, Parramatta Road connects to the M4 East, twin tunnels between Haberfield and Homebush. On the calibration date (17 October 2018), the M4 East was under construction. It was subsequently opened on 13 July 2019.

> City-West Link Road between the Anzac Bridge in Rozelle and Dobroyd Point. This road forms part of the Western Distributor, a key link connecting North Sydney (via the Harbour Bridge) to Western Sydney. To the west of the study area, City-West Link Road connects to Parramatta Road and the M4 East.

> Victoria Road between City-West Link Road and Parramatta River. Victoria Road is a major north-south arterial road that connects the Western Distributor to Balmain, Rozelle, Drummoyne, Lane Cove and Ryde.

> Stanmore Road runs east-west along the southern edge of the study area. Stanmore Road connects to Enmore Road and King Street (Princes Highway) to the east of the study area and links Inner West suburbs Newtown, Petersham, Lewisham and Dulwich Hill to Old Canterbury Road.

The study area includes key trip generators (origins) and trip attractors (destinations) within the Inner West including three railway stations, seven light rail stops, commercial centres Leichhardt, Rozelle and Camperdown, the University of Sydney, Princes Alfred Hospital, numerous schools, parks, sports fields and light industries. Residential areas are generally low to medium density across the study area, with some high-density apartment complexes in Glebe, Lewisham and around the University of Sydney.

Figure 1-2 shows the study area.

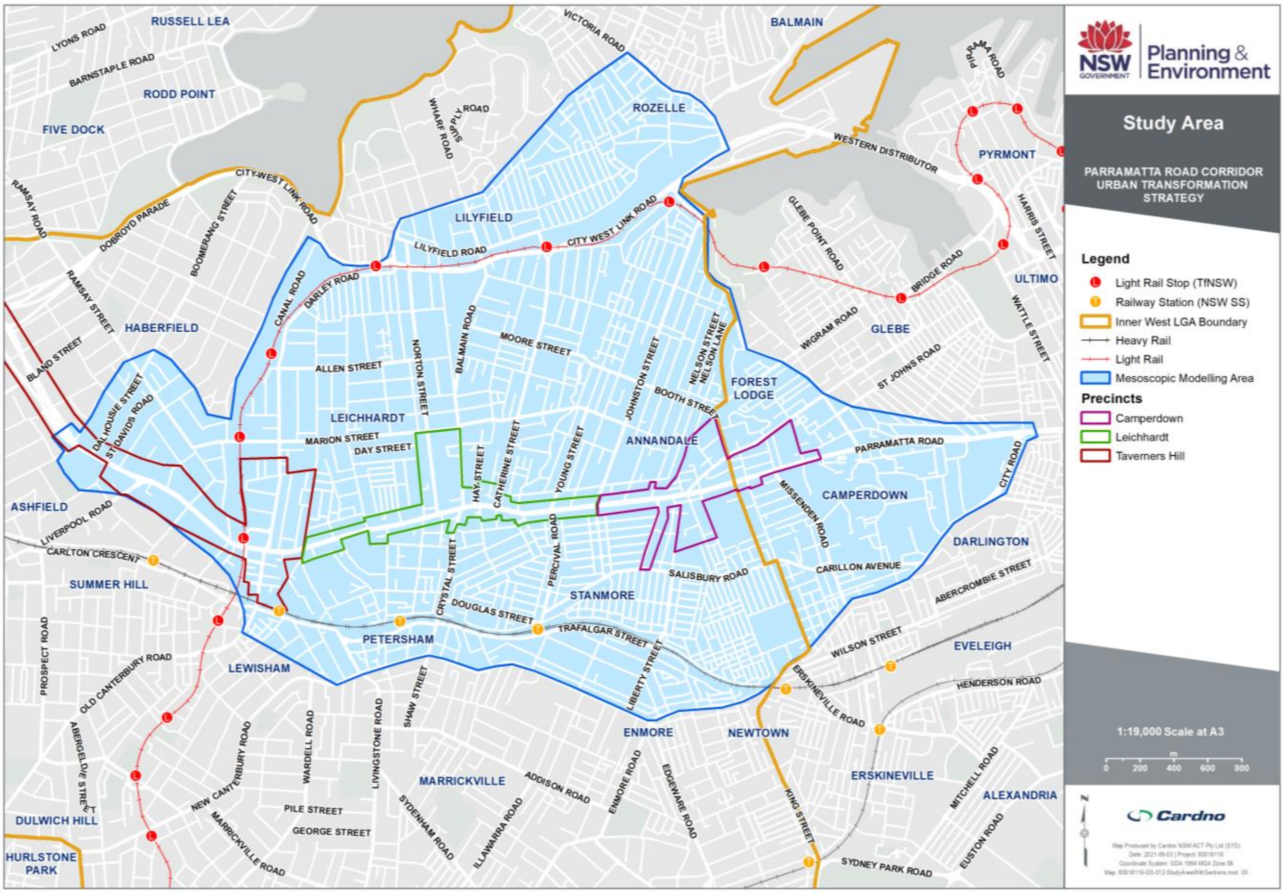


Figure 1-2 Study area

1.5 Stakeholders

The key stakeholders for this project are:

> Department of Planning, Industry and Environment (DPIE)[1]

> Inner West Council (IWC)

> Transport for NSW[2].

1.6 Report outline

This report follows the *Operational Modelling Reporting Structure* (Roads and Maritime Services, 2017). The structure of this report is outlined below:

> **Section 1 – Introduction**: Summarises the project objectives and reporting structure

> **Section 2 – Options testing**: Outlines the future years and scenarios assessed in the study

> **Section 3 – Assumptions**: Discusses the assumptions underlying the future models

> **Section 4 – Future demand development**: Outlines the methodology used to develop the future-year demands

> **Section 5** – **Base Model operational results**: Summarises the network and intersection performance results for the Base Model

> **Section 6** – **Do Minimum operational results**: Summarises the network and intersection performance results for the Do Minimum scenario

> **Section 7** – **With Upgrades operational results**: Summarises the network and intersection performance results for the With Upgrades scenario.

> **Section 8** – **Conclusions**.

[1] Formerly Department of Planning and Environment until 1 July 2018.
[2] Roads and Maritime Services existed as a separate agency until it was dissolved and functions transferred to Transport for NSW on 1 December 2018.

2 Options testing

This section outlines the infrastructure changes included in the future models, the scenarios assessed and the assessment years and time periods modelled.

2.1 Future infrastructure

DPIE provided a schedule of 10 infrastructure improvements in the area for consideration in the modelling. Cardno assessed each upgrade and determined that five upgrades would be included in the models. The remaining upgrades did not alter the road network (eg Sydney Metro West) or were outside the study area. The list of upgrades is included in **Appendix C**.

The future modelling included two infrastructure scenarios:

> **Do Minimum**: Includes all upgrades implemented between 2018 (the Base Model calibration year) and 2021, as well as the WestConnex Rozelle Interchange

> **With Upgrades**: Includes all upgrades from the Future Base, as well as localised intersection upgrades along Parramatta Road and at key intersections in the study area. More detailed investigations and consultation would need be carried out prior to any designs being prepared. The quantum of lost car parking spaces depends on road design requirements which would be determined during concept or detailed design stages.

The infrastructure upgrades included in each scenario are described in the following sections.

2.1.1 Do Minimum

Based on consultation with IWC, DPIE and Transport for NSW, five future upgrades were considered in the Do Minimum scenario. Four of these have already been implemented (as of July 2021) since the Base Model.

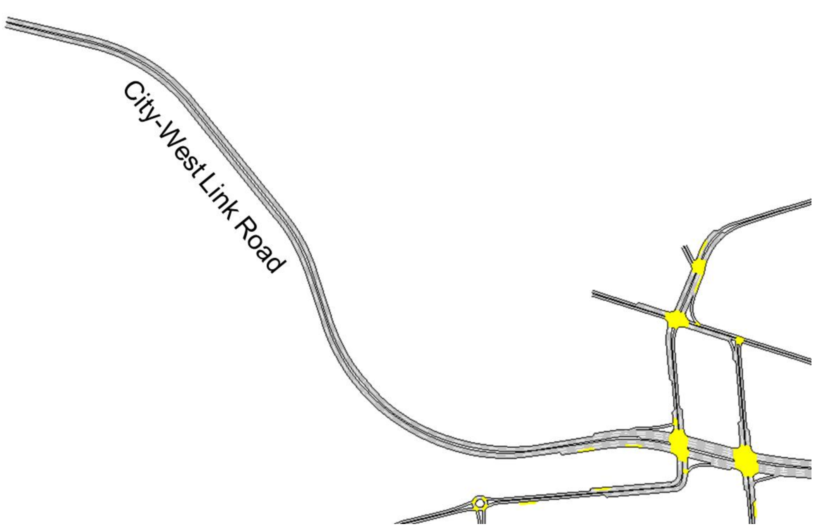
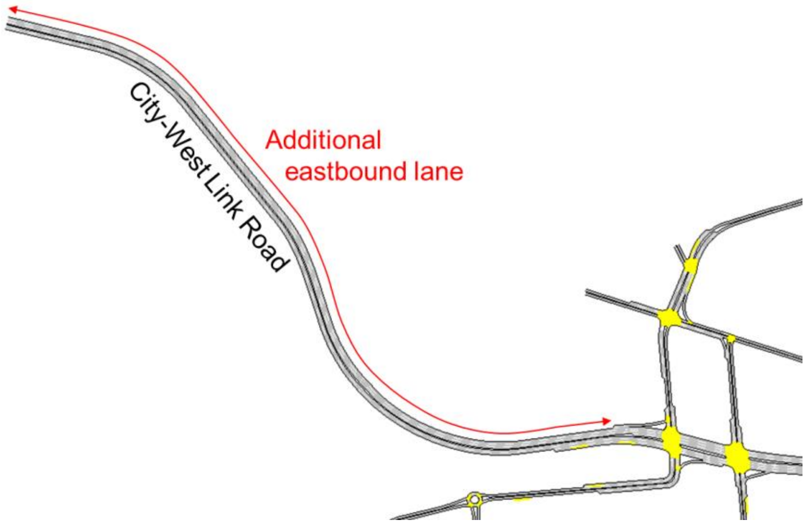
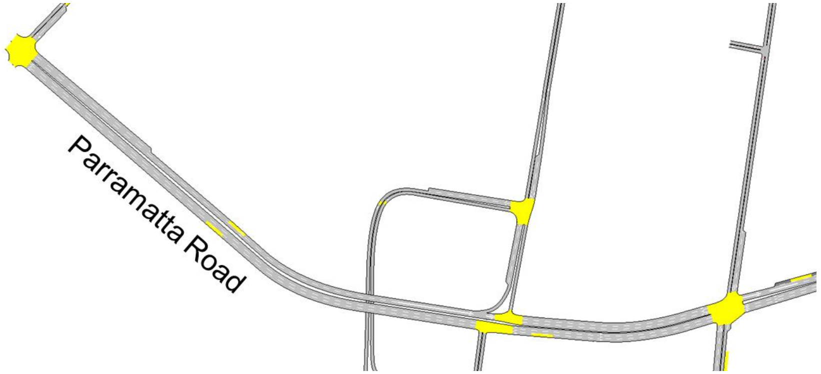
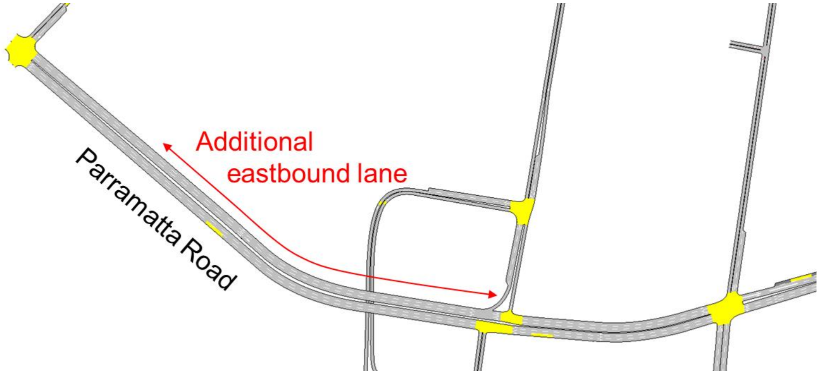
Table 2-1 describes the upgrades that were included in the Do Minimum scenario.

Table 2-1 List of upgrades

#	Upgrade location	Description of upgrade	Year implemented
1	City-West Link Road	Addition of third eastbound lane between Waratah Street and James Street	Late 2018
2	Parramatta Road / West Street	Extension of right turn bay and third lane on Parramatta Road eastbound from Tebbutt Street to 7/Eleven Haberfield	2018
3	Missenden Road	Reduction of speed limit from 50 to 40 kilometres per hour	2018
4	Parramatta Road / Crystal Street	Extension of right turn bay on Parramatta Road eastbound from Norton Street to west of Railway Street	2020
5	WestConnex Rozelle Interchange	Underground interchange between M4 Motorway, M8 Motorway, Victoria Road, City-West Link Road and Western Harbour Tunnel	Expected to open in 2023

Table 2-2 shows the layout for each upgrade outlined above.

Table 2-2 Do Minimum infrastructure layouts

Upgrade	Base layout	Future layout
1		
2		

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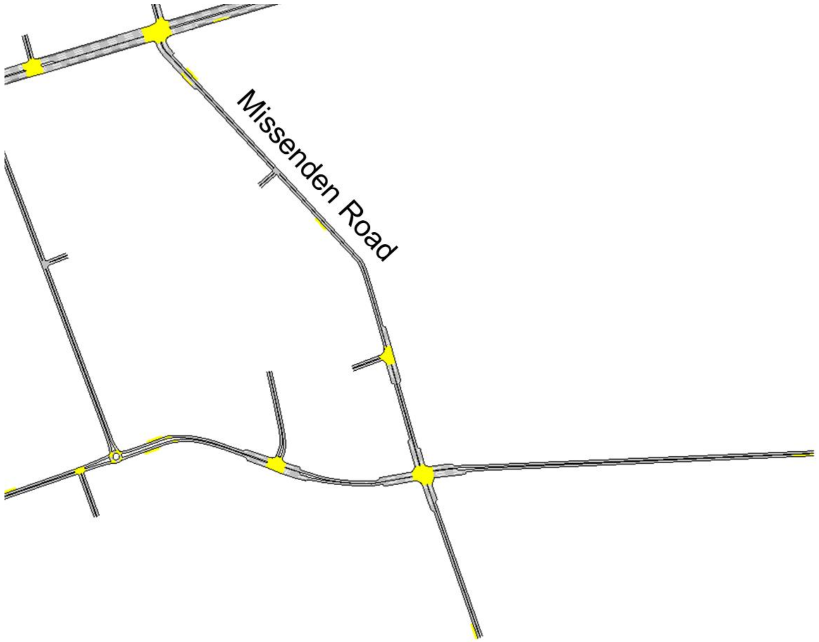
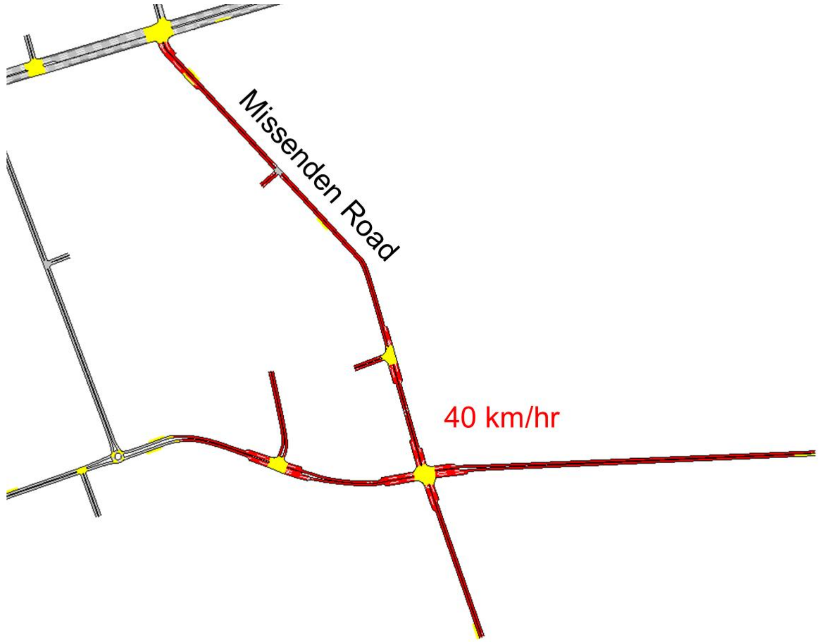
<tr><td>3</td><td>
</td><td>
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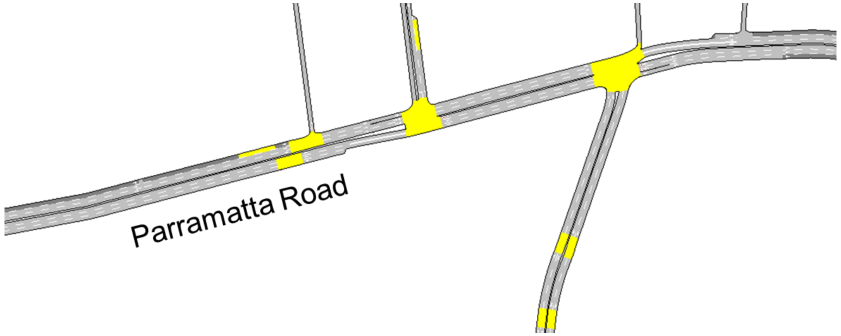
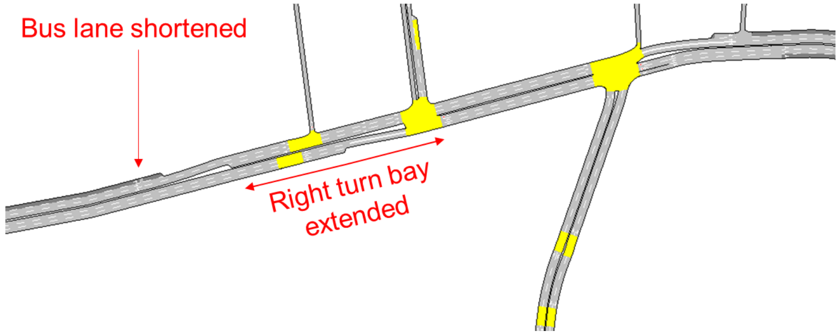
<tr><td>4</td><td>
</td><td>
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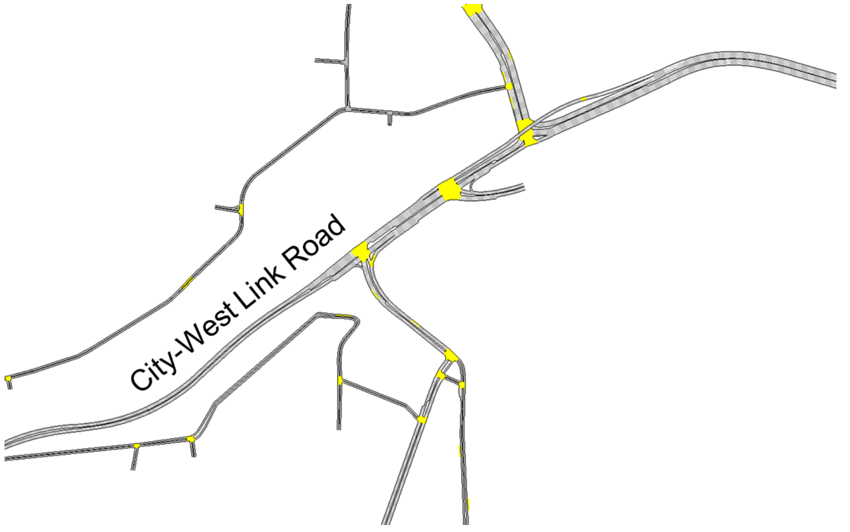
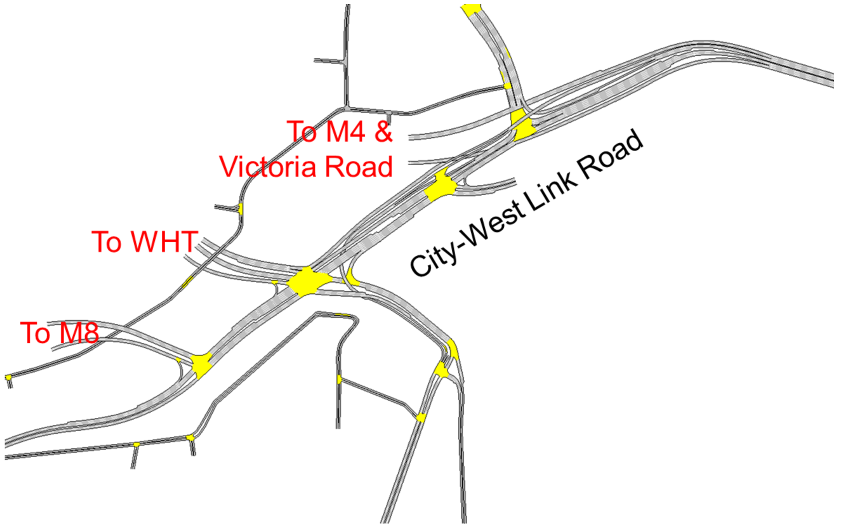
5		

2.1.2 With Upgrades

The With Upgrades scenario included localised upgrades proposed along Parramatta Road and at key locations across the study area. These suggestions were put forward by Cardno based on model results and observations and aim to improve traffic network performance. These upgrades have not been endorsed by Council, DPIE, Transport for NSW or any other stakeholders. Further traffic modelling is suggested during the Concept and Detailed Design stages to assess the viability of these upgrades in more detail as well as potential impact to other modes and place function.

The purpose of the upgrades was to alleviate queueing and congestion, and reduce the network average delay time. To avoid proposing unrealistic upgrades, the suggested improvements were chosen so that, if possible, they would:

- Fit within the existing road corridor
- Not require significant changes to bus stops or bus lanes
- Not require changes to approved heavy vehicle routes
- Retain the existing road hierarchy
- Require limited signal plan changes (such as introducing a right turn phase or split phase)
- Minimise the loss of on-street parking
- Not require tidal flow or contraflow lanes (excluding existing configuration on Victoria Road)
- Retain signalised pedestrian crossings at all current locations including midblock crossings, and no changes to pedestrian green times or late starts at intersections.

Consideration of vehicle swept paths has not been included.

Table 2-3 describes the upgrades that were included in the With Upgrades models.

Table 2-3 List of upgrades

#	Upgrade location	Description of upgrade
6	Parramatta Road / West Street	Flood Street – removal of parking/kerbside lane in northbound direction to provide space for dedicated right turn lane in southbound direction
7	Parramatta Road / Crystal Street	Crystal Street – altered lane configuration to provide dedicated right turn lane and combined left/through/right lane
8	Parramatta Road / Catherine Street	Catherine Street (north) – removal of parking/kerbside lane in northbound direction to provide space for additional right turn lane in southbound direction Catherine Street (north) – altered lane configuration to provide dual right turn lanes and combined left/through lane
9	Johnston Street	Shorten right turn lane on Johnston Street (northbound) at Booth Street to provide space to remove the southbound merge on Johnston Street and allow two continuous through lanes
10	Parramatta Road / Johnston Street	Johnston Street (north) – removal of parking/kerbside lane in northbound direction to provide space for additional right turn lane in southbound direction Johnston Street (north) – altered lane configuration to provide dedicated right turn lane, combined through/right and dual left turn lanes Johnston Street (south) – removal of parking/kerbside lane in southbound direction to provide space for dedicated right turn lane in northbound direction
11	Parramatta Road / Bridge Road	Parramatta Road (west) – extend right turn bay using available space Bridge Road – altered lane configuration to provide dual right turn lanes and dedicated left turn lane
12	Parramatta Road / Ross Street	Ross Street – removal of parking/kerbside lane in northbound direction to provide space for dedicated left turn lane in southbound direction
13	Salisbury Road	Salisbury Road – removal of westbound kerbside lane between Kingston Road and Cardigan Street Salisbury Road – provide right turn bays at Cardigan Street and Kingston Road Salisbury Road – extend left turn lane leading to Kingston Road
14	Liberty Street / Trafalgar Street	Liberty Street (north) – ban right turn into Trafalgar Street
15	Stanmore Road	Stanmore Road – remove parking between Liberty Street and Wemyss Street to provide two continuous westbound lanes
16	Railway Terrace / West Street	Railway Terrace (west) – provide left turn bay
17	Pyrmont Bridge Road / Mallett Street / Booth Street	Booth Street - removal of parking/kerbside lane in northbound direction to provide space for additional right turn lane in southbound direction Booth Street – altered lane configuration to provide dedicated right turn lane, through lane and combined left/through lane Mallett Street – remove timed parking on Mallett Street southbound Mallett Street – Altered lane configuration to provide dedicated right turn lane and combined left/through lane

Table 2-4 shows the layout for each upgrade outlined above.

Table 2-4 With Upgrades infrastructure layouts

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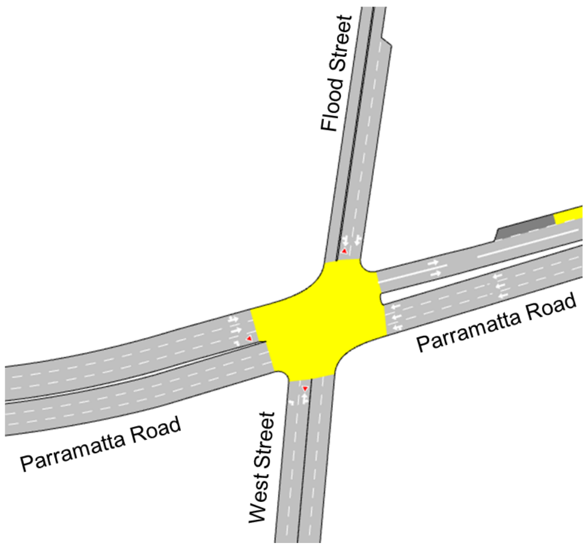
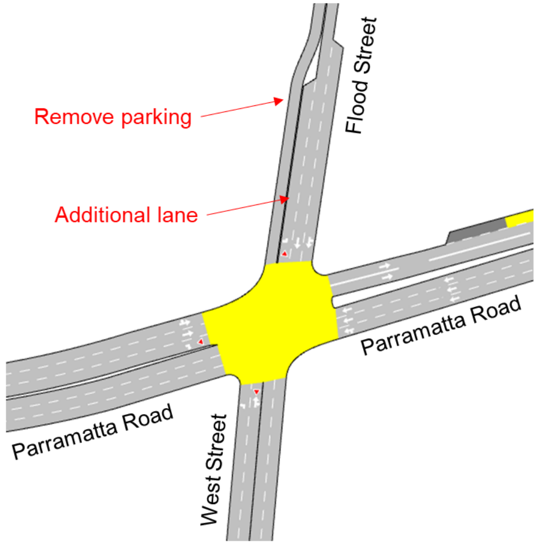
<tr><td>6</td><td>
</td><td>
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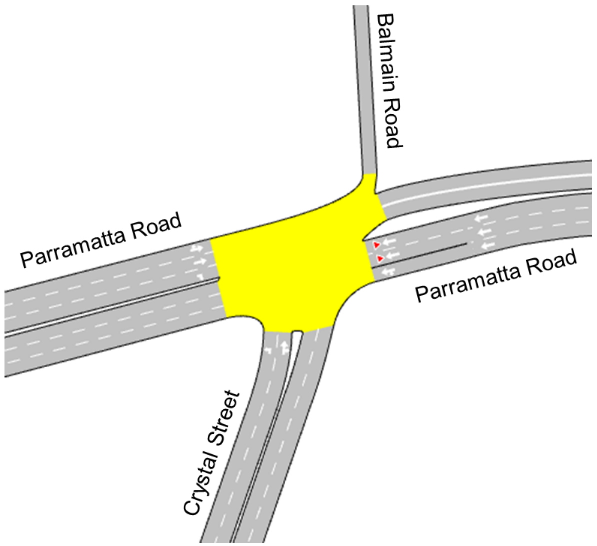
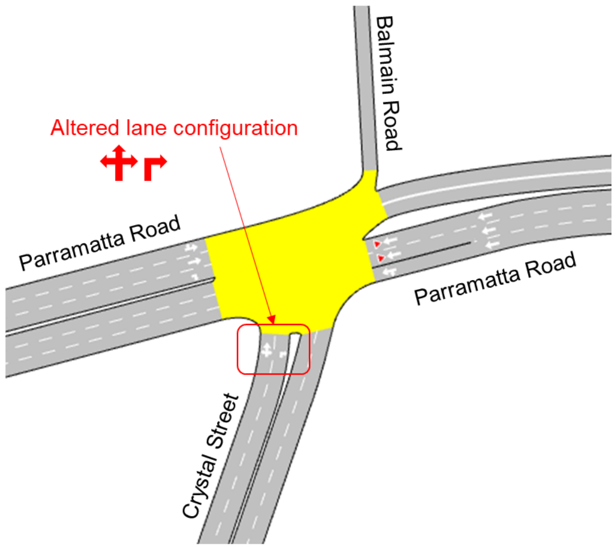
<tr><td>7</td><td>
</td><td>
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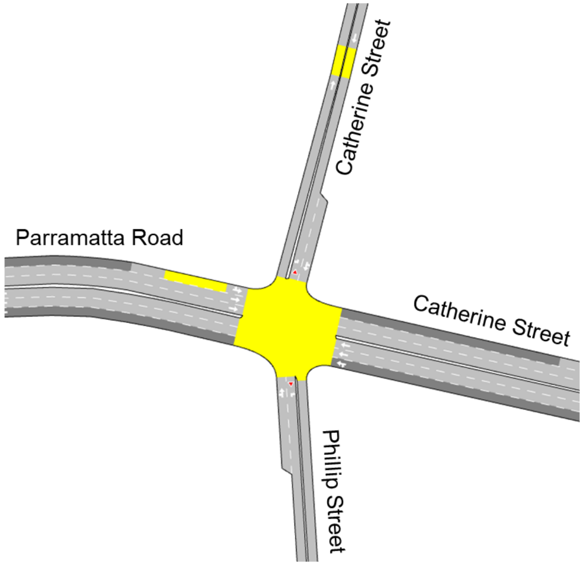
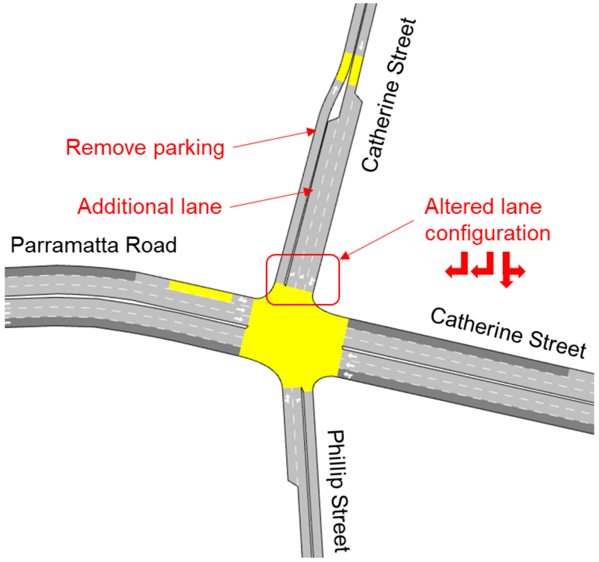
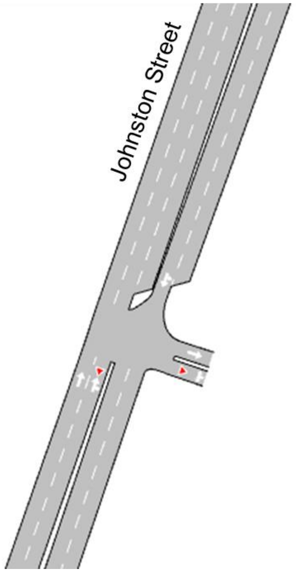
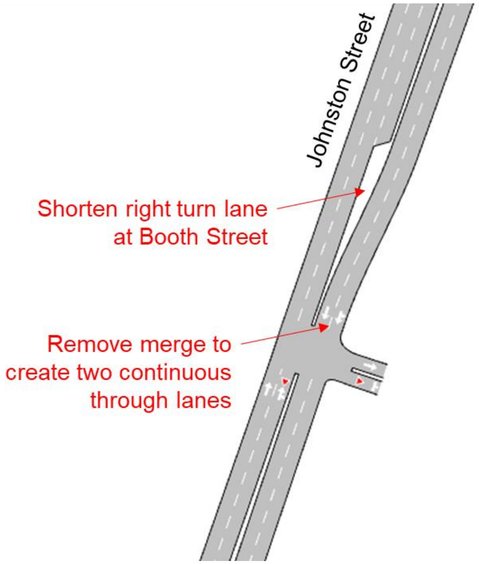
8		
9		

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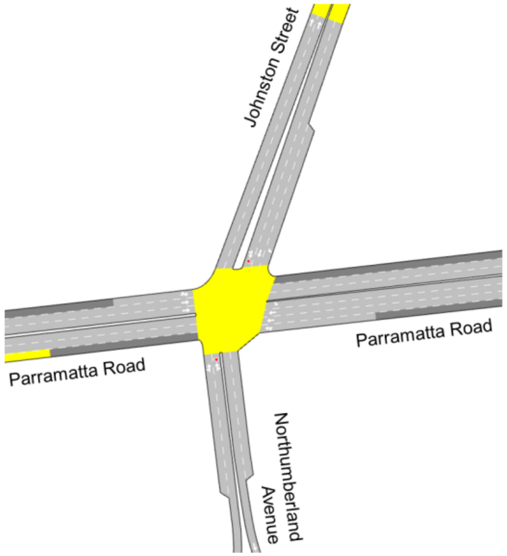
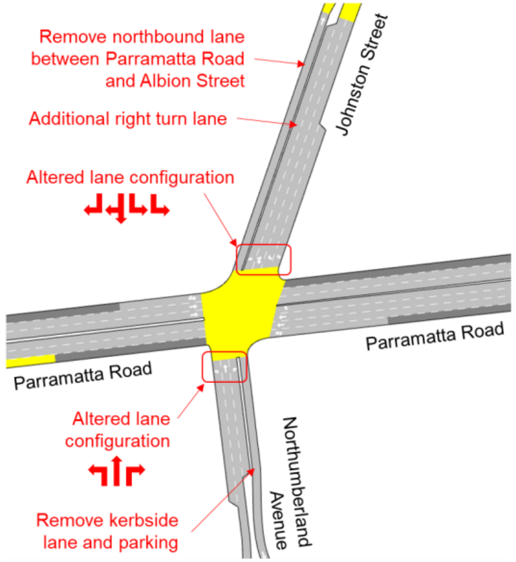
<tr><td>10</td><td>
</td><td>
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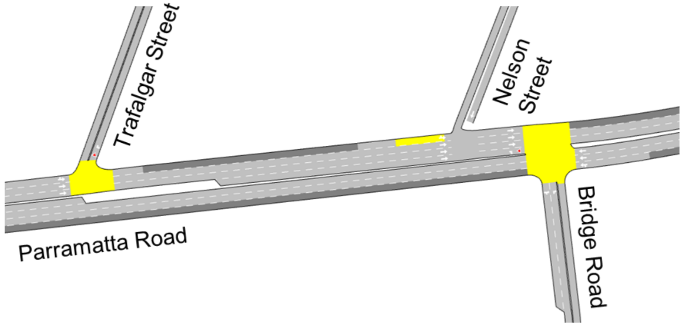
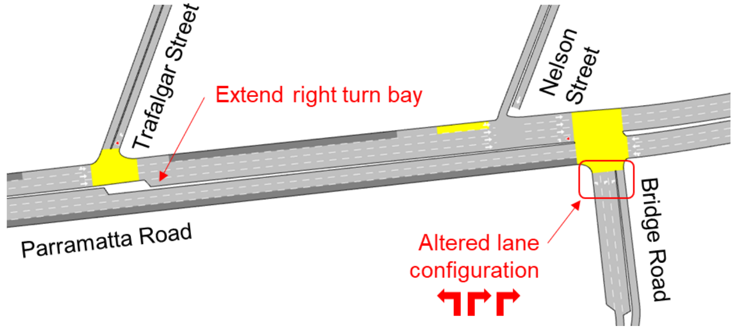
<tr><td>11</td><td>
</td><td>
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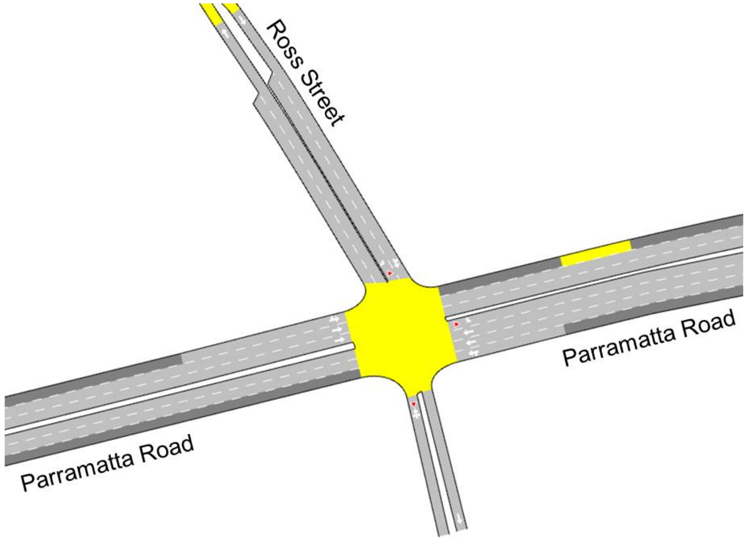
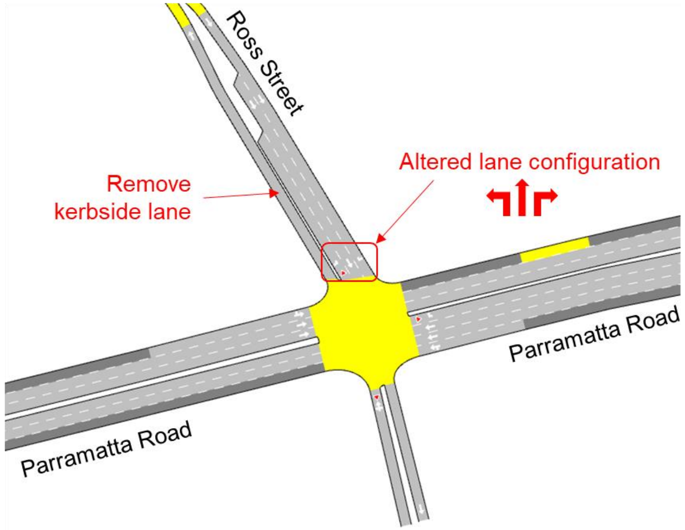
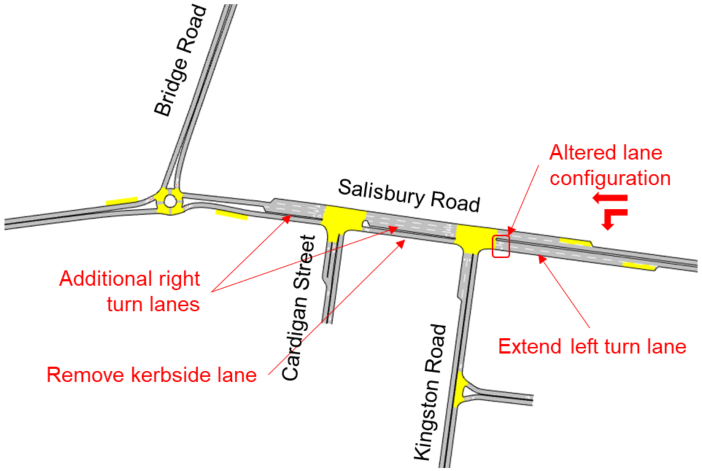
12		
13		

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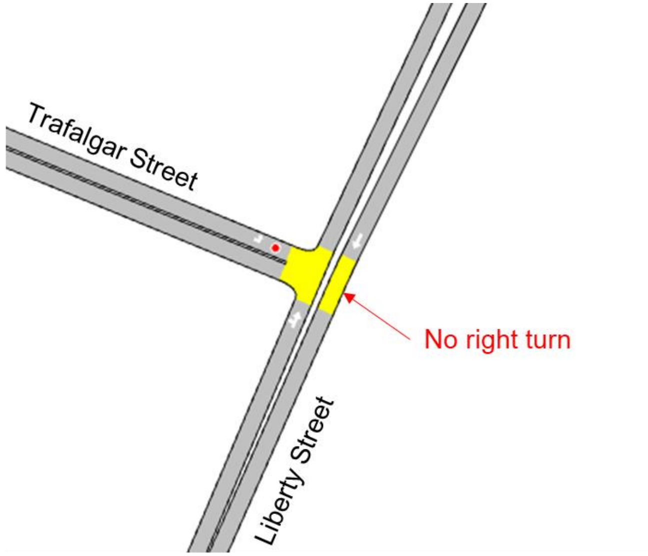
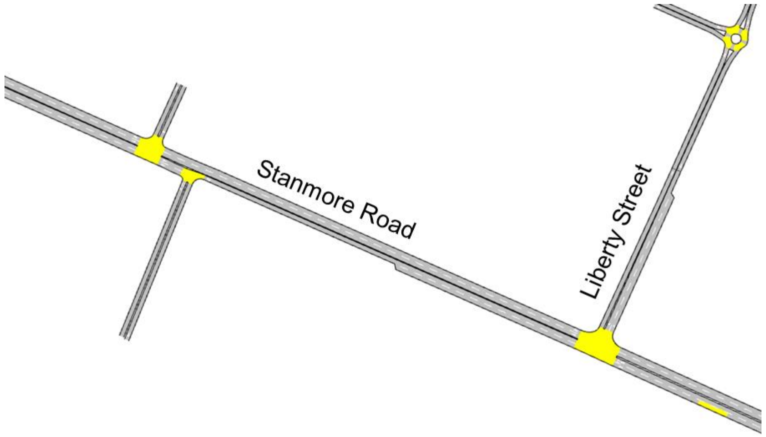
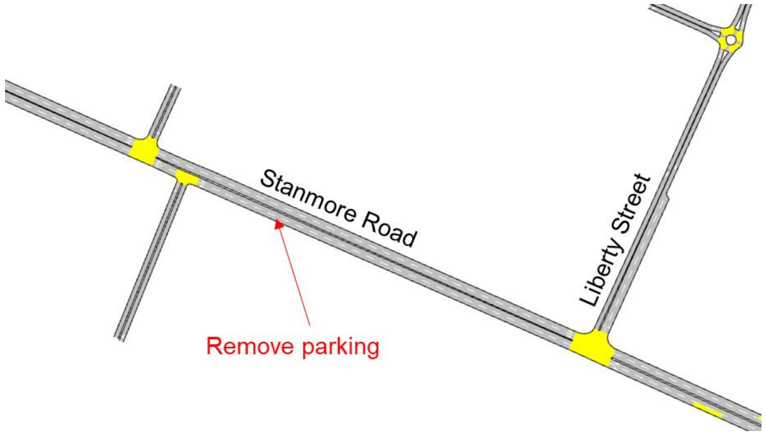
14		
15		

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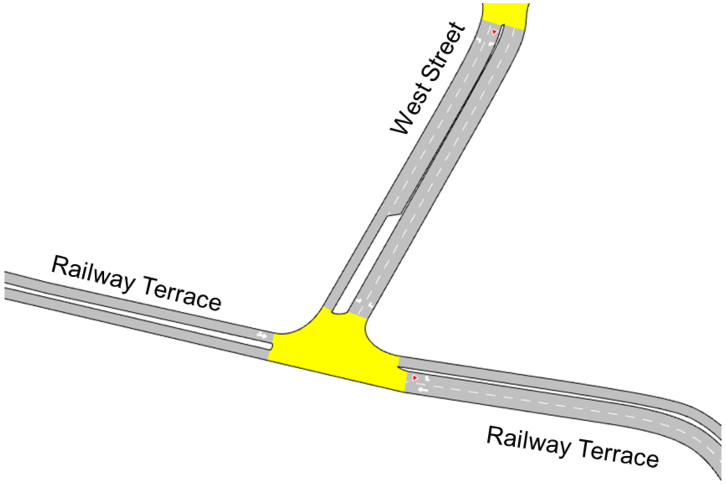

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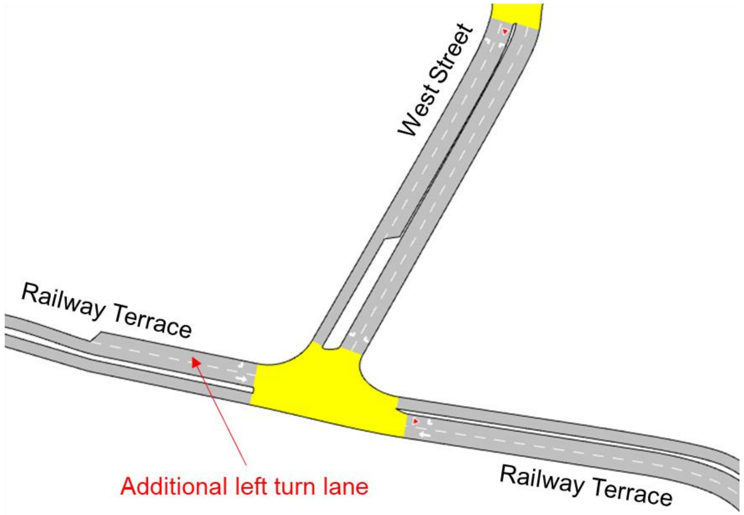

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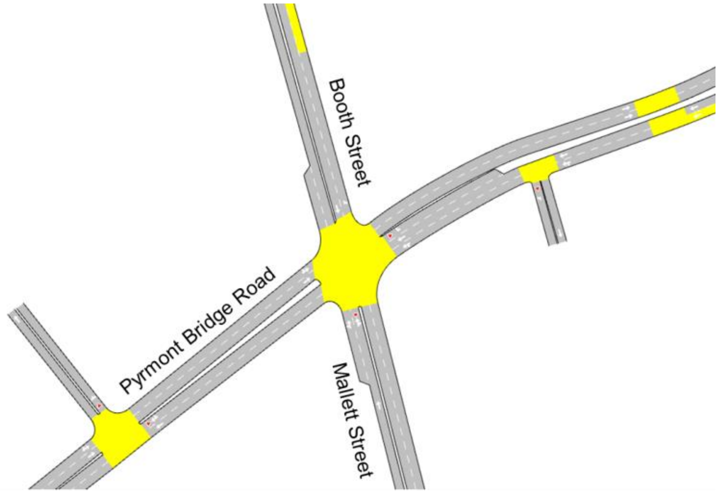

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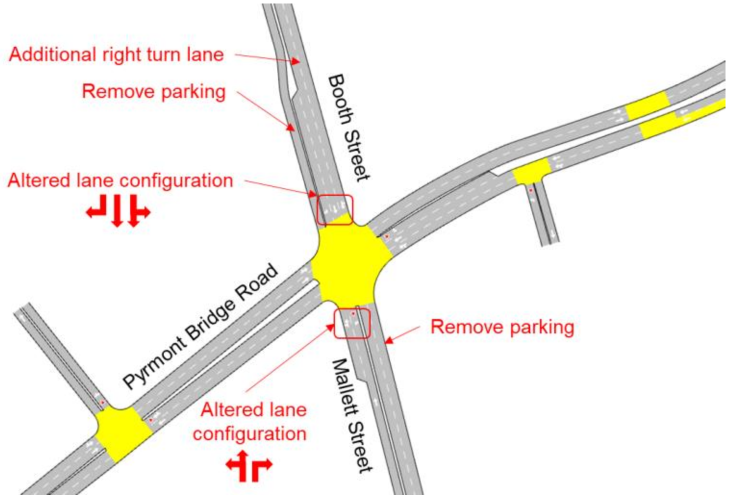

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2.2 Assessment scenarios

Cardno assessed the following scenarios:

> Base Model
> Network Capacity Model
> Do Minimum
> With Upgrades.

Each of these scenarios is described below.

2.2.1 Base Model

The Base Model was previously developed, calibrated and validated for the study area. This was documented in *Base Model Development Report* (Cardno, 2020), attached to this report as **Appendix A**. The Base Model network and intersection performance results are contained within this report.

A Future Base ("Do Nothing") scenario was not assessed for future years given that some of the infrastructure upgrades have already been implemented, are under construction or are committed.

2.2.2 Network Capacity Model

The Network Capacity Model was used to determine the maximum capacity of the network in 2036 by applying incremental proportions of the traffic growth from the PTPM. The purpose of the Network Capacity Model was to determine the necessary penalty for private vehicle mode to ensure adequate capacity within the network up to 2036. This scenario was only used in the future demand development procedure and does not represent an actual projected future year scenario, so no results other than VKT for comparison to the PTPM scenarios have been included in this report.

The Network Capacity Model included the Do Minimum infrastructure.

2.2.3 Do Minimum

The Do Minimum scenario uses traffic growth from the STFM to predict the future network state and identify network deficiencies in 2026 and 2036 assuming a private vehicle mode penalty to shift some users to other modes. The Do Minimum scenario includes all upgrades implemented since the Base Model calibration date (2018), and the WestConnex Rozelle Interchange.

2.2.4 With Upgrades

The With Upgrades scenario included localised upgrades along Parramatta Road and at key locations across the study area. The purpose of the upgrades was to alleviate queueing and congestion, and reduce the network average delay time. The With Upgrades scenario includes the Do Minimum infrastructure upgrades and the additional upgrades listed in **Table 2-3**.

2.3 Assessment years and time periods

Table 2-5 summarises the scenarios and years assessed. Each scenario was assessed for two peaks consistent with the Base Model:

> 7:15AM – 9:15AM
> 4:30PM – 6:30PM.

Table 2-5 Scenarios assessed

Scenario	2018		2026		2036	
	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
Do Nothing (Base)	✓	✓	-	-	-	-
Network Capacity Model	-	-	-	-	✓	✓
Do Minimum	-	-	✓	✓	✓	✓
With Upgrades	-	-	✓	✓	✓	✓

3 Assumptions

This section outlines the assumptions underlying the Future Models and the metrics for assessing network and intersection performance.

3.1 Future Model assumptions

This section outlines the assumptions adopted in the development of the Future Models:

> All bus routes and timetables were assumed to remain the same as in the Base Model.

> The peak hours were assumed to remain consistent with the Base Model for each peak.

> The traffic profile for each future peak was assumed to remain consistent with the Base Models.

> Adjustments were made to some signal phase times to balance flows caused by future growth and traffic reassignment. Cycle times were assumed to remain consistent with the Base Model.

> Pedestrian phases at signalised intersections were assumed to remain consistent with the Base Model as no future pedestrian modelling was available.

> Assessment of intersections that were not calibrated in the Base Model is not recommended.

> Assessment of travel time on routes that were not calibrated in the Base Model is not recommended.

> The model only considers road vehicles (cars, trucks and buses), so does not include any improvements to public transport, walking or cycling infrastructure.

3.2 Performance metrics

This section outlines the performance metrics used for assessing the Base and Future Models.

3.2.1 Network performance metrics

Model operation is quantified based on a number of statistical outputs. **Table 3-1** provides a summary of the network performance statistics reported for this study.

Table 3-1 Network performance metrics

Metric	Unit	Description
Total traffic demand	veh	> The total number of trips that enter the network during the modelled hour
Total vehicles arrived	veh	> The total number of vehicles that arrive at their destination during the modelled peak hour > The total vehicles arrived includes vehicles generated during the warm-up period that arrive during the simulated period, so may be higher than the total traffic demand
Vehicle kilometres travelled (VKT)	km	> The distance travelled by all vehicles in the network > Useful for identifying savings in road user and external costs
Vehicle hours travelled (VHT)	hrs	> The total travel time of all vehicles across the network > Useful for identifying network efficiency and performance, possible congestion issues and future travel time savings
Total number of stops	stops	> The number of times a vehicle stops, summed across all vehicles in the network
Average vehicle kilometres travelled	km	> Average number of kilometres travelled by vehicles all vehicles in the network
Average time travelled in network	sec	> Average time spent in the network across all vehicles
Average number of stops	stops	> Average number of stops per vehicle
Average speed	km/hr	> Average speed for all vehicles in the network > Equivalent to VKT divided by VHT
Average delay	sec	> Average delay time for all vehicles in the network > Delay time is the difference between the experienced travel time on a route, and the travel time on that route under free-flow conditions > Useful for assessing the impacts of each scenario on road users
Unreleased demand	veh	> The number of vehicles that were unable to enter the modelled network during the modelled period > Unreleased demand is caused by queueing that extends to the edge of the modelled network
Deleted vehicles	veh	> The microscopic/mesoscopic network checker removes vehicles that are stationary in the model for too long > This is designed to prevent unrealistic gridlocks, such as at roundabouts, where vehicles in the real world are capable of manoeuvring to avoid each other

DPIE requested Cardno to provide key network performance statistics per person. **Table 3-2** shows the assumed vehicle occupancies for each vehicle type. The following network statistics were provided by person in the study area:

- Total persons arrived
- Total person-kilometres travelled
- Total person-travel time
- Average speed
- Average delay.

Table 3-2 Assumed vehicle occupancies

	Vehicle type		
	Light vehicles	Heavy vehicles	Buses
Assumed occupancy (persons)	1.11	1.00	30.00

3.2.2 Travel time

Travel time data was used to validate the Base Model. It provides an indication of congestion hotspots along a particular route within a network and can be used to compare the future network performance. Travel times along five key routes were compared between scenarios. Average speed along each route is also provided. Cardno has adopted a colour code based on the speed ratio along the length of the route. Speed ratio is simulated speed divided by the posted speed limit. **Table 3-3** shows the colour code used throughout this report.

Table 3-3 Speed ratio colour code

Speed ratio					
0.00 – 0.30	0.30 – 0.40	0.40 – 0.50	0.50 – 0.67	0.67 – 0.80	> 0.80

Cardno also extracted travel times on Parramatta Road between the PRCUTS precincts.

3.2.3 Intersection performance metrics

The following performance metrics were used in the analysis of intersections:

- **Delay time**: Average delay experienced by all vehicles at the intersection
- **Level of service** (LOS): An intersection performance measure that is based on delay per vehicle
- **Queue length**[3]: Maximum queue length by approach.

Table 3-4 shows the level of service categories for intersections in NSW from *Guide to Traffic Generating Developments* (Roads and Traffic Authority, 2002).

For signalised intersections, level of service is based on the weighted average delay of all approaches. For unsignalised intersections (priority intersections and roundabouts), level of service is based on the maximum delay of all approaches.

Intersections operating at LOS C or better are considered satisfactory. LOS D indicates that the intersection is approaching capacity and an accident study may be required. LOS E indicates that the intersection is at capacity, and this level of service is generally unsuitable for unsignalised intersections. LOS F indicates that the intersection is failing and requires additional capacity.

[3] Intersections in the PRCUTS precincts only.

Table 3-4 Level of service criteria for intersections

Level of service	Description	Delay
A	Good operation	Less than 14 seconds
B	Good operation, with acceptable delays and spare capacity	15 – 28 seconds
C	Satisfactory operation	29 – 42 seconds
D	Near capacity	43 – 56 seconds
E	At capacity	57 – 70 seconds
F	Capacity exceeded	More than 70 seconds

Source: *Guide to Traffic Generating Developments (Roads and Traffic Authority, 2002)*

The average delay on each approach is measured from the preceding intersection. Consequently, if the queue from one intersection spills back to the preceding intersection, this delay is captured at the second intersection and not the first. Where intersections are closely spaced, this may result in the intersection that is causing the delay appearing to perform better than other intersections nearby.

3.2.4 Network plots

DPIE requested the following network plots:

> **Traffic density**: Simulated vehicles per lane per kilometre over the modelled period
> **Speed ratio**: Simulated average speed over the modelled period for each section divided by the posted speed limit for that section
> **Heavy vehicle proportions** on each link.

4 Future demand development

This section provides an overview of the process used for deriving the future traffic demand. The methodology is outlined below. The numbered steps were completed by Cardno.

The Public Transport Project Model (PTPM) was run by TfNSW with the latest land-use and travel demand assumptions from STM. The specifics of these assumptions were documented in *Strategic Transport Modelling Interface Methodology* (VIAE Consulting, October 2020). This report is provided in **Appendix D**. The PTPM was run with the Precinct Parking Module (PPM) which applies additional travel costs to the private vehicle mode to reduce its utility and reflect capacity constraints not otherwise accounted for. The PTPM matrices with PPM penalties were provided to Cardno to complete Steps 1 to 3.

Steps 1 to 3 are based on the methodology outlined in *Strategic Transport Modelling Interface Methodology* (VIAE Consulting, October 2020).

1. Estimation of future growth using the PTPM 2018 and 2036 demand matrices (refer to **Section 4.1**).
2. Incremental application of the future growth to the Base Model demand to determine the point at which the network capacity is reached (refer to **Section 4.2**).
3. Comparison of the network-wide vehicle kilometres travelled (VKT) between the Network Capacity Model (Step 2) and the future demand scenarios from PTPM using the PPM penalties (refer to **Section 4.3**).

SGS Economics & Planning (SGS) were commissioned by DPIE to review and update the land-use projections within the study area. The updated land-use was supplied to Transport for NSW to run the STM, PTPM and PPM. PwC were commissioned by DPIE to apply the PTPM growth to the STFM using a modified methodology designed to account for negative growth in the PTPM. The methodology for this assessment was outlined in *PRCUTS Transport Model Update Recommendations Action Plan, updated based on comments from TfNSW* (PwC, June 2021). This report has been provided in **Appendix E**. The STFM matrices from the PwC update were provided to Cardno to complete Step 4.

4. Estimation of the future traffic demand using the outputs from the STFM (refer to **Section 4.4**).

This methodology has been endorsed by Transport for NSW and DPIE for use in this project. The assumptions and limitations of the methodology are explained in **Appendix D** and have been acknowledged by both agencies.

The following sections describe the methodology, assumptions and results of each stage.

4.1 PTPM growth estimation

This section outlines the methodology used to extract the future growth from the PTPM and summarises the results. The PTPM only includes the AM Peak.

The PTPM demands for the 2018 base-year scenario and 2036 high-growth scenario were extracted. The PTPM cordon provided included 119 centroids, consisting of:

- 65 external gates representing origins/destinations outside the study area
- 15 additional gates representing the approaches to the future WestConnex (WCX) Rozelle Interchange (not present in the 2018 base-year scenario cordon)
- 27 internal zones representing origins/destinations inside the study area
- Three zones representing train stations
- Seven zones representing light rail stops
- Two zones representing other destinations (Glebe Island Container Terminal and Glebe Point Ferry).

Appendix F shows the PTPM cordon and zoning for 2018 and 2036.

Only the entrance and exit points to the WestConnex Rozelle Interchange on City-West Link Road were included in the model. Consequently, any trips between the following centroids do not enter the modelled road network at any point:

- New M4 Motorway
- M8 Motorway
- Western Harbour Tunnel
- Victoria Road.

The demands between these centroids were removed from the matrix. Note that the demands between the centroids listed above and all other centroids in the study area remain in the matrix as these vehicles will enter the modelled network.

The PTPM includes four road-user vehicle types:

- Cars
- Light commercial vehicles (LCV)
- Rigid heavy vehicles
- Articulated heavy vehicles.

The Aimsun model only differentiates between light vehicles and heavy vehicles. The PTPM matrix was aggregated to produce two separate matrices representing light and heavy vehicles.

Growth across the study area was determined separately for each OD pair in the strategic model. The growth was calculated based on a subtraction of the 2018 PTPM matrix from the 2036 PTPM matrix. Zones that only exist in the 2036 PTPM matrix (i.e. those representing the WestConnex Rozelle Interchange) were assigned zero demand in 2018.

The strategic model growth was disaggregated to match the zoning structure already established in the Aimsun model. As was the case with the Base Model, the vehicle demand for train stations and light rail stops in the study area was low. These were not included as separate centroids in the Base Model, with the demand for these locations incorporated into the surrounding zone/s. The growth at these locations was similarly incorporated into the surrounding zones in the Aimsun model.

4.2 Incremental growth application

The traffic demand was incrementally applied to the Base Model to determine the network capacity. The following methodology was used:

1. Add a fixed proportion of the PTPM growth to the Base Model demand.
2. Apply this demand to the Aimsun model.
3. Run the model and extract the model input count (the number of vehicles that are able to enter the model during the simulation period).
4. Graph the proportion of growth applied versus the model input count for each scenario to determine the maximum network capacity.

The network capacity was assumed to occur at the proportion of the PTPM growth applied where the number of vehicles able to enter the model during the simulation period is at a maximum.

Figure 4-1 shows the demand applied and number of vehicles arrived in the network by the end of the simulation period for the proportions of the PTPM demand applied. The application of 40 per cent, to the nearest five percent, of the PTPM growth to the Base Network resulted in a peak in the number of vehicles able to enter the model during the simulation period.

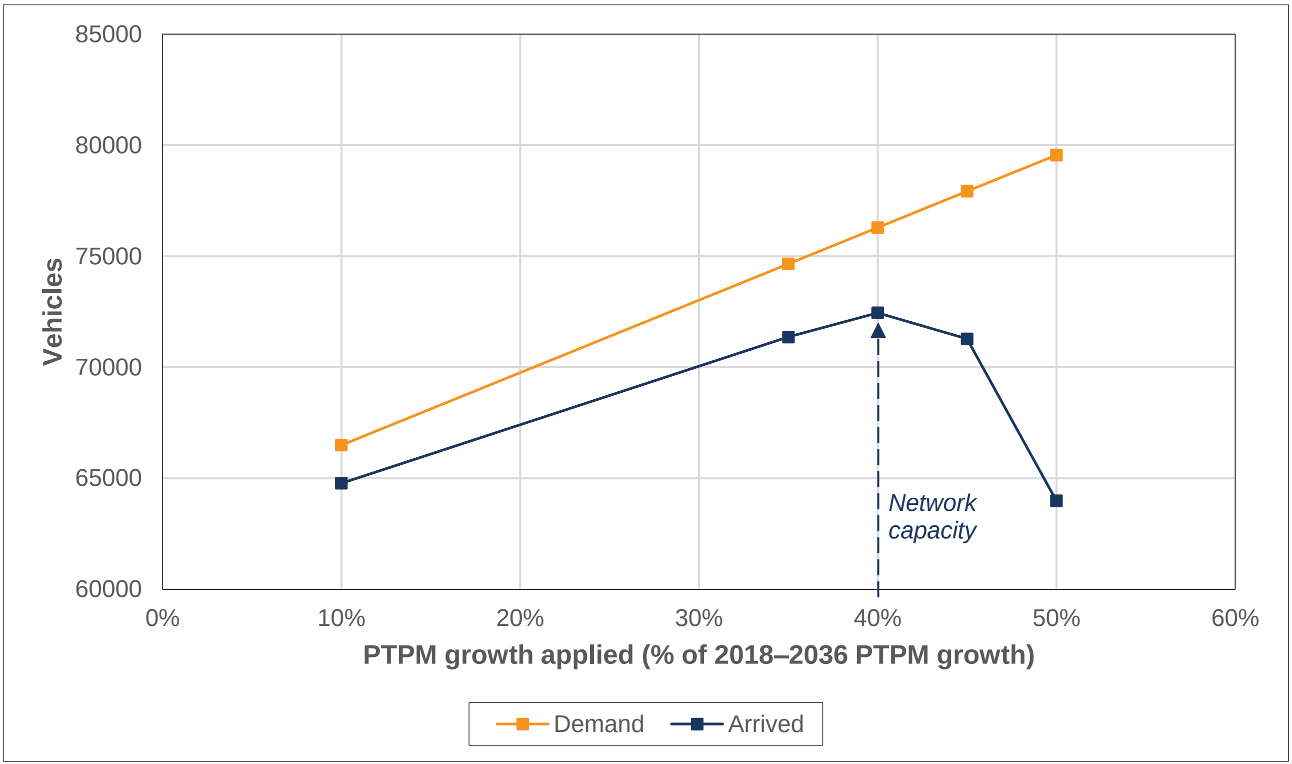


Figure 4-1 Incremental growth application results

4.3 Comparison of network capacity VKT to PPM penalty scenarios

The following procedure was used to determine the PTPM scenario with PPM penalty that most closely corresponds to the Network Capacity Model:

1. Calculate the change in vehicle kilometres travelled (VKT) between the Aimsun Network Capacity Model and Base Model as a percentage of the Base Model VKT
2. For each PPM penalty scenario, determine the change in VKT between the PTPM future scenario and PTPM base scenario as a percentage of the base VKT
3. Compare the Aimsun VKT change to the PTPM VKT change and identify which PPM penalty scenario has a VKT closest to that of the Aimsun model.

Figure 4-2 shows the change in VKT from the PTPM base scenario (2018) with each PPM penalty scenario applied. PPM0 resulted in an increase in VKT of 10.1 per cent while PPM60 resulted in a decrease of 11.0 per cent. The Network Capacity Model (2036 40% Growth) exhibited a decrease in VKT of 3.9 per cent compared to the Aimsun base scenario (2018). A decrease of 3.9 per cent corresponds to between PPM30 and PPM45 in the PTPM.

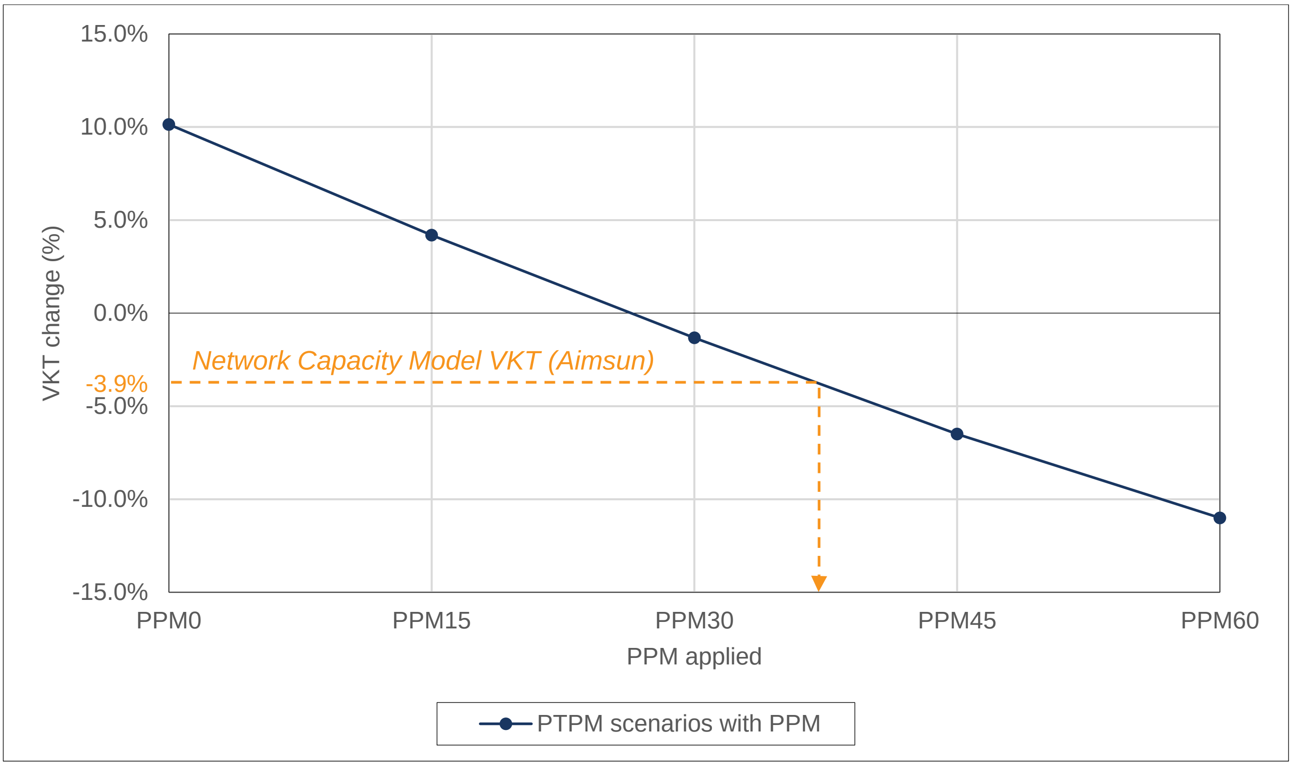


Figure 4-2 Comparison of Aimsun and PTPM VKT changes between scenarios

Cardno was advised by Transport for NSW and DPIE that to maintain consistency with other precincts along the corridor, PPM15 would be applied to all subsequent modelling.

4.4 STFM demand estimation

SGS Economics & Planning (SGS) were commissioned by DPIE to review and update the land-use within the study area. The updated land-use was supplied to Transport for NSW to run the STM, PTPM and PPM. PwC were commissioned by DPIE to apply the PTPM growth to the STFM using a modified methodology designed to account for negative growth in the PTPM. The methodology for this assessment was outlined in *PRCUTS Transport Model Update Recommendations Action Plan, updated based on comments from TfNSW* (PwC, June 2021). The STFM matrices from the PwC update for the study area were provided to Cardno.

The STFM was run with two scenarios:

> No Development

> With Development.

Cardno was instructed by DPIE to use the With Development scenario in the Aimsun model. All future references to the STFM demand in this report refer to the With Development scenario demand.

This section outlines the methodology for developing the future traffic demands using the STFM matrices. The steps are briefly outlined below:

1. Growth in the STFM for each origin-destination (OD) pair was calculated by subtraction of the base year matrix (2018) from the future year matrix (2026 or 2036)
2. The STFM growth was disaggregated to match the Aimsun zoning structure.
3. The growth was applied to the base matrices.
4. The future matrices were profiled using the same profile as the base matrices.

The following sections summarise the STFM and Aimsun demands.

4.4.1 STFM demand summary

This section provides a summary of the STFM demand

4.4.1.1 WestConnex demands

The STFM demands include trips that only use the WestConnex tunnels and do not interact with the surface network at all. **Figure 4-3** shows the number of trips in each year and peak that only use the WestConnex network within the study area. Only the entry and exit portals to WestConnex are part of the model, so vehicles that do not use the surface network at all are not included in the Aimsun models. This demand was removed from the STFM demands prior to calculating the STFM growth in the study area.

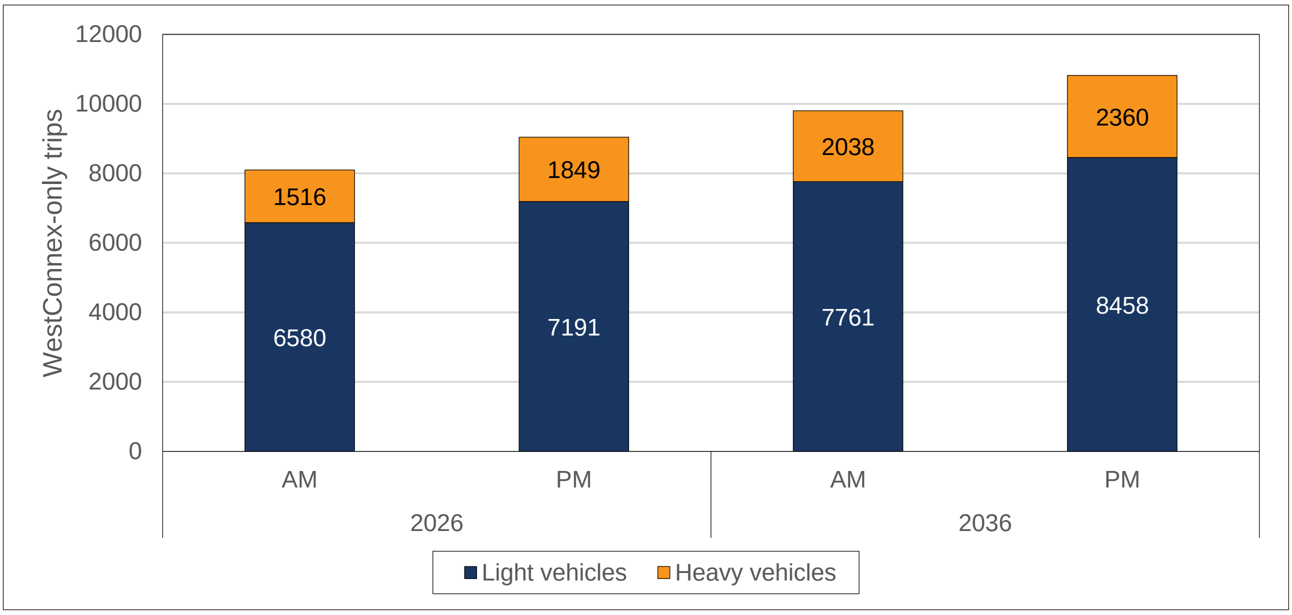


Figure 4-3 STFM WestConnex-only trips

4.4.1.2 STFM trip distribution

Trips were classified based on their origin and destination:

> **External-external** (through trips): Trips with both origin and destination outside the study area, but that transit through the study area

> **Internal-external**: Trips with an origin inside the study area but destination outside the study area

> **External-internal**: Trips with an origin outside the study area but destination inside the study area

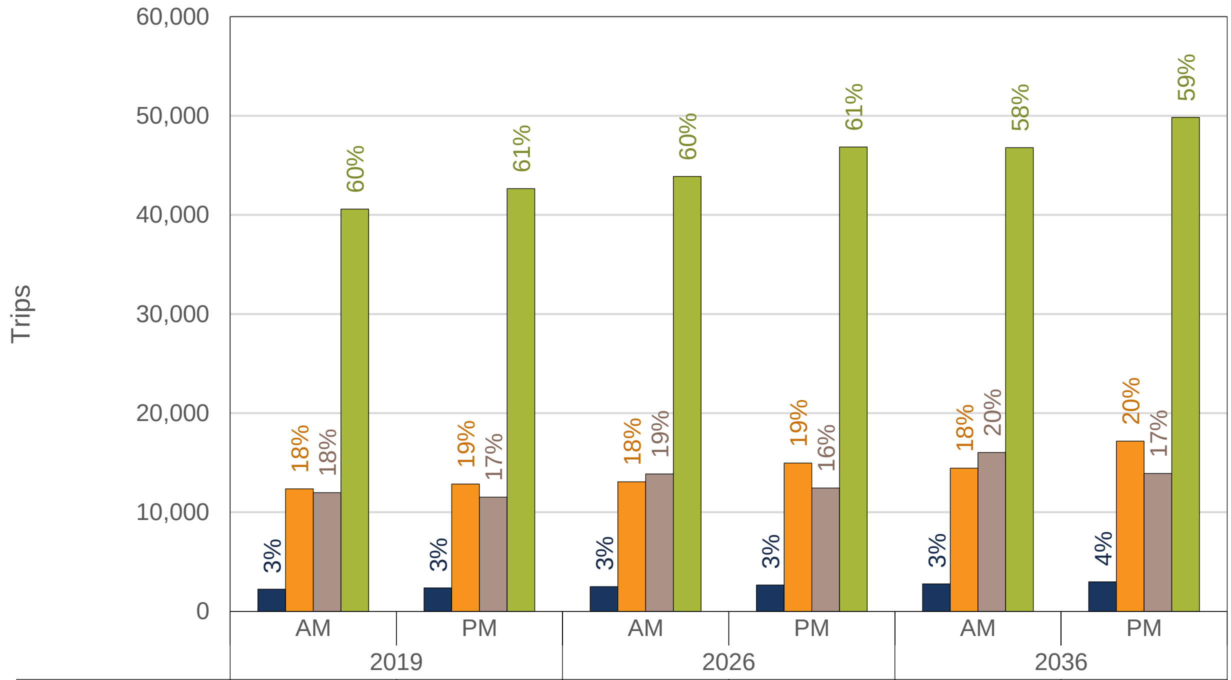
> **Internal-internal**: Trips with both origin and destination inside the study area.

Figure 4-4 shows the distribution of trips in the study area. The main observations are listed below.

> Trips entirely within the study area only represent a small proportion of the total demand in each peak.

> Trips with either an origin or destination in the study area, but not both, make up between 35 and 38 per cent of the total demand in each peak. Trips from the study area to external destinations are typically higher in the AM Peak, while trips from external destinations to the study area are higher in the PM Peak.

> Through trips (external-external) make up about 60 per cent of the total demand in each year.



	2019 AM	2019 PM	2026 AM	2026 PM	2036 AM	2036 PM
Internal-internal	2236	2361	2495	2665	2775	2974
Internal-external	12364	12849	13079	14963	14447	17167
External-internal	11970	11526	13860	12443	16020	13918
External-external	40586	42657	43879	46847	46788	49836

Internal-internal Internal-external External-internal External-external

Figure 4-4 STFM trip distribution

4.4.1.3 STFM demand summary

Figure 4-5 shows the STFM demand in each future year. These values exclude the WestConnex-only trips identified in **Section 4.4.1.1**.

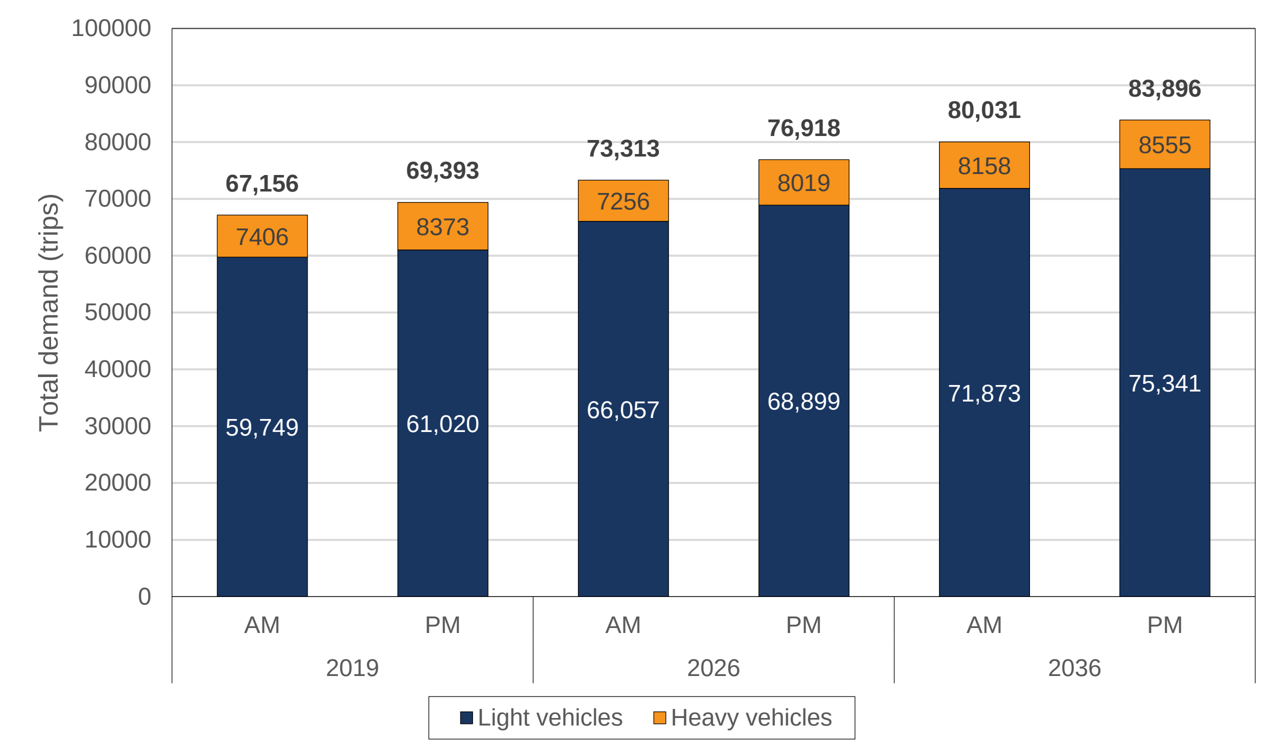


Figure 4-5 STFM demand in each future year

Table 4-1 provides a summary of the STFM demand and growth between 2019 and the two future years for each vehicle type. The main findings are discussed below.

> Between 2019 and 2026, the overall traffic demand increases by 11 per cent in the AM Peak and 13 per cent in the PM Peak. This corresponds to an additional 6308 and 7879 trips respectively.

> There is a decrease in the total heavy vehicle demand between 2019 and 2026 of two per cent in the AM Peak and four per cent in the PM Peak. The reduction is cause by diverting through traffic truck trips to WestConnex.

> Both light and heavy vehicle volumes increase between 2026 and 2036. The total traffic increase from 2019 is 19 per cent in the AM Peak and 21 per cent in the PM Peak.

Table 4-1 STFM growth summary

Year	AM Peak			PM Peak		
	Light vehicles	Heavy vehicles	All vehicles	Light vehicles	Heavy vehicles	All vehicles
2019	59,749	7406	67,156	61,020	8373	69,393
2026	66,057	7256	73,313	68,899	8019	76,918
2019 – 2026 growth	6308 (+11%)	-150 (-2%)	6157 (+9%)	7879 (+13%)	-354 (-4%)	7525 (11%)
2036	71,873	8158	80,031	75,341	8555	83,896
2019 – 2036 growth	12124 (+20%)	752 (+10%)	12876 (+19%)	14321 (+23%)	182 (+2%)	14503 (+21%)

4.4.2 Aimsun traffic demand

The STFM growth was disaggregated to match the Aimsun zoning structure.

Figure 4-5 shows the STFM demand in each future year. The values indicated exclude the WestConnex-only trips identified in **Section 4.4.1.1**.

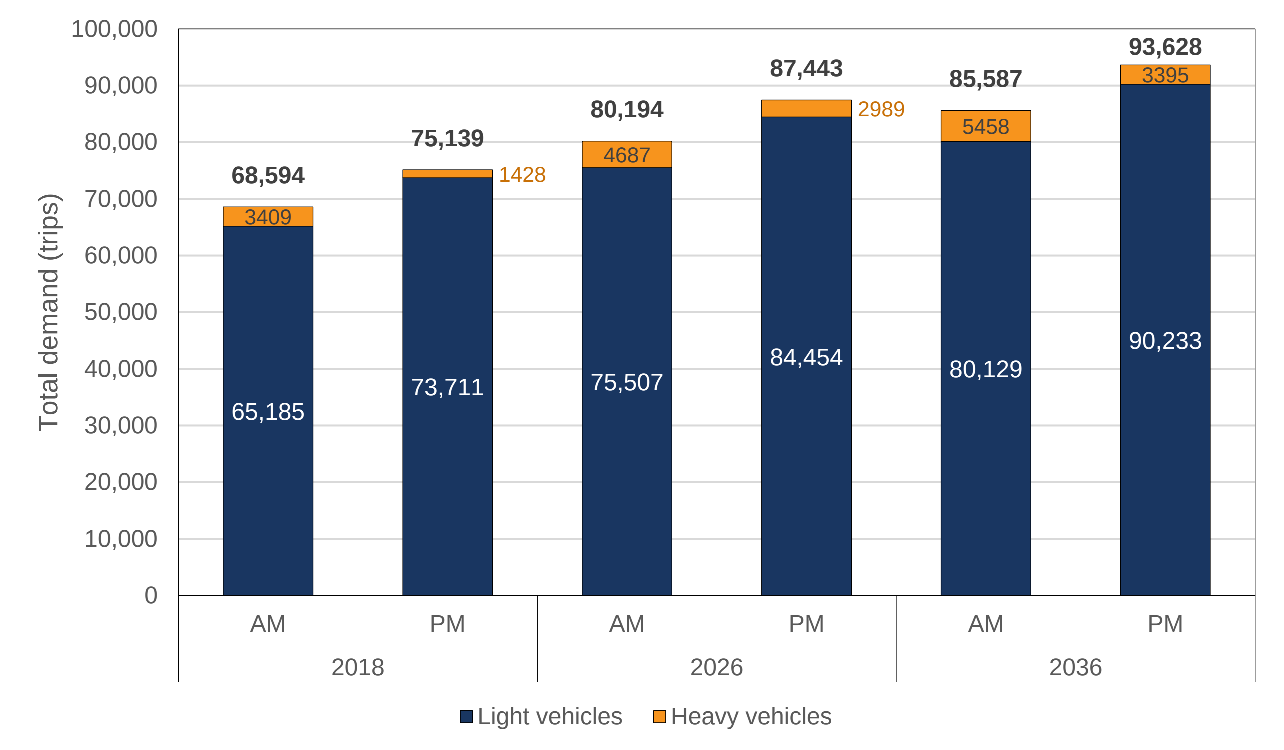


Table 4-3 summarises the future demand for the Aimsun model. The key observations are highlighted below.

> The STFM heavy vehicle demand for the base year is much higher than the Aimsun model demand. The Aimsun demand was validated using traffic surveys for more than 80 intersections across the study area.

> Application of the heavy vehicle growth from STFM (including negative growth) results in a number of ODs with negative heavy vehicle trips in the Aimsun matrix. **Table 4-2** shows that the STFM growth results in about 10 to 14 per cent of ODs having a negative heavy vehicle volume. These ODs were set to zero trips in the Aimsun matrix, which is a conservative assumption as it increases the number of vehicles in the model.

Table 4-2 ODs with negative trips in the Aimsun traffic demand

Year	Number of ODs with negative HV trips		Total number of negative HV trips	
	AM Peak	PM Peak	AM Peak	PM Peak
2026	3085 (13%)	3347 (14%)	1498 (30%)	2015 (64%)
2036	2432 (10%)	2640 (11%)	1366 (21%)	1901 (46%)

> The Aimsun growth is higher than the STFM growth because:

- The Aimsun growth includes an additional year of growth (2018-2019) as the Aimsun base year is 2018 while the STFM base year is 2019.
- ODs where the demand became negative when the STFM growth was applied were set to nil which introduces more trips into the matrix.

Table 4-3 Aimsun traffic demand

Year	AM Peak			PM Peak		
	Light vehicles	Heavy vehicles	All vehicles	Light vehicles	Heavy vehicles	All vehicles
2019	65,185	3409	68,594	73,711	1428	75139
2026	75,507	4687	80194	84,454	2989	87443
2019 – 2026 growth	10,322 (+16%)	1278 (+37%)	11,600 (17%)	10,743 (15%)	1,561 (109%)	12,304 (16%)
2036	80,129	5458	85587	90,233	3395	93628
2019 – 2036 growth	14,944 (23%)	2,049 (60%)	16,993 (25%)	16,522 (22%)	1,967 (138%)	18,489 (25%)

5 Base Model operational results

This section outlines the Base Model operational results. The development, calibration and validation of the Base Models was previously outlined in *Base Model Development Report* (Cardno, 28 October 2020). The results in this section establish the base reference case for comparative assessment with future scenarios.

5.1 Data inputs

The Base Models were developed using the following inputs:

> Cordon matrices from the STFM
> Intersection counts
> Travel time data from TomTom
> Traffic signal data, including historical phase times, cycle times and offsets
> Public transport operations from the GTFS feed.

5.2 Model specifications and assumptions

The traffic model was developed to replicate the road network conditions observed at the time of development. The settings and parameters of note from the Base Model are:

> Aimsun version 8.4.3[4] was used to develop the Base Models
> The vehicle experiment results were calculated from stochastic route choice (SRC) using vehicle paths derived from dynamic user equilibrium (DUE) assignment
> Signals were coded as fixed using historical timings from SCATS data in 15-minute intervals (microsimulation area) or one-hour intervals (mesoscopic simulation area)
> The peak periods were identified using traffic counts across all surveyed intersections:
  - AM Peak: 7:15AM – 9:15AM
  - PM Peak: 4:30PM – 6:30PM.
> The Base Model was developed in accordance with *Traffic Modelling Guidelines* (Roads and Maritime Services, 2013). The calibration and validation results showed that the Base Model provides an acceptable representation of existing conditions, including:
  - High network-wide calibration with over 89 per cent of turns having a GEH less than five in the AM Peak and over 90 per cent in the PM Peak
  - High statistical correlation between modelled and observed turning volumes
  - Modelled travel time on key routes fits well with the observed data.

The *Base Model Development Report* (Cardno, October 2020) is attached to this report as **Appendix A**.

The Base Model was reviewed by Arup on behalf of DPIE and Transport for NSW and the findings summarised in *Base Model Peer Review* (Arup, March 2020) which is attached to this report as **Appendix B**. The model and report were refined based on Arup’s comments and resubmitted to Arup for independent review. The model was subsequently endorsed as fit for purpose by Arup.

[4] 2020-06-03 (b46ec77181 x64 Python 2)

5.3 Existing network performance

5.3.1 Network performance summary

Table 5-1 summarises the Base Model network performance results for all peaks. Traffic demand is highest in the PM Peak, and this corresponds to a higher VKT and VHT. However, network performance is generally worse in the AM Peak with a lower mean speed and increased average delay. Unreleased demand is very low in both peaks.

Table 5-1 Network performance results – Base Model

Network performance metric	Unit	2018 Base Model results	
		AM Peak	PM Peak
All vehicles			
Total traffic demand	veh	68,595	75,142
Total vehicles arrived	veh	68,933	74,849
Total kilometres travelled (VKT)	km	168,922	188,415
Vehicle hours travelled (VHT)	hr	6718	6988
Average per vehicle			
Average kilometres travelled	km	2.5	2.5
Average time travelled in network	s	147	138
Average speed	km/hr	27.6	29.0
Average delay	s	78	71
Unreleased demand			
Unreleased demand (% of total demand)	veh (%)	4 (0.0%)	3 (0.0%)

5.3.2 Person statistics

Table 5-2 shows key network statistics per person based on the assumed vehicle occupancies outlined in **Section 3.2.1**.

Table 5-2 Network statistics by person – Base Model

Network performance metric	Unit	2018 Base Model results			
		AM Peak		PM Peak	
		LV	HV	LV	HV
Network statistics by vehicle type					
Total vehicles arrived	veh	65,210	3361	73,284	1486
Total kilometres travelled (VKT)	km	158,156	9785	183,672	4531
Vehicle hours travelled (VHT)	hr	6254	401	6800	176
Average speed	km/hr	27.7	27.0	29.0	28.6
Average delay	s	78	78	71	69
Network statistics by person					
Total persons arrived	person	72,698	3361	81,699	1486
Total person-kilometres travelled	km	176,316	9785	204,762	4531
Total person-hours travelled	hr	6973	401	7581	176
Average speed per person	km/hr	27.7	27.0	29.0	28.6
Average delay per person	s	87	78	79	69

5.4 Existing travel times

This section provides an overview of the travel times on key routes and through the PRCUTS precincts in the 2018 Base Model.

5.4.1 Travel times on key routes

Travel times on key routes were validated in the development of the Base Model. **Table 5-3** lists the modelled 2018 travel times on each route. The average speed along each route is also included. The colour code shown was presented in **Section 3.2.2** and excludes any temporary speed reductions such as school zones.

Note that the travel times shown in this table are for vehicles that traverse the full length of the route only.

Table 5-3 Travel times on key routes – Base Model

Route	Dir.	Travel time (s)		Average speed (km/hr)	
		AM Peak	PM Peak	AM Peak	PM Peak
Balmain Road	NB	332	250	15.5	20.6
	SB	188	169	18.3	20.4
Crystal Street	NB	176	195	17.6	15.9
	SB	273	224	11.4	13.9
Johnston Street	NB	312	284	20.2	22.2
	SB	254	302	24.7	20.8
Marion Street	EB	320	219	17.5	25.6
	WB	209	205	26.8	27.3
Parramatta Road	EB	1165	881	19.1	25.2
	WB	820	927	27.0	23.9

5.4.2 Travel times through precincts

Table 5-4 shows the modelled travel time through each precinct in each direction. Overleaf, **Figure 5-1** and **Figure 5-2** show travel times through each precinct along Parramatta Road for the eastbound and westbound directions respectively.

Table 5-4 Precinct travel times – Base Model

Direction	Travel time through precinct (s)		
	Taverners Hill	Leichhardt	Camperdown
AM Peak			
Eastbound	407	390	223
Westbound	197	284	115
PM Peak			
Eastbound	278	332	126
Westbound	215	292	179

Note that the travel times shown in these graphs are the cumulative sum of the travel times of each section along the route, so include vehicles that only traverse part of the route.

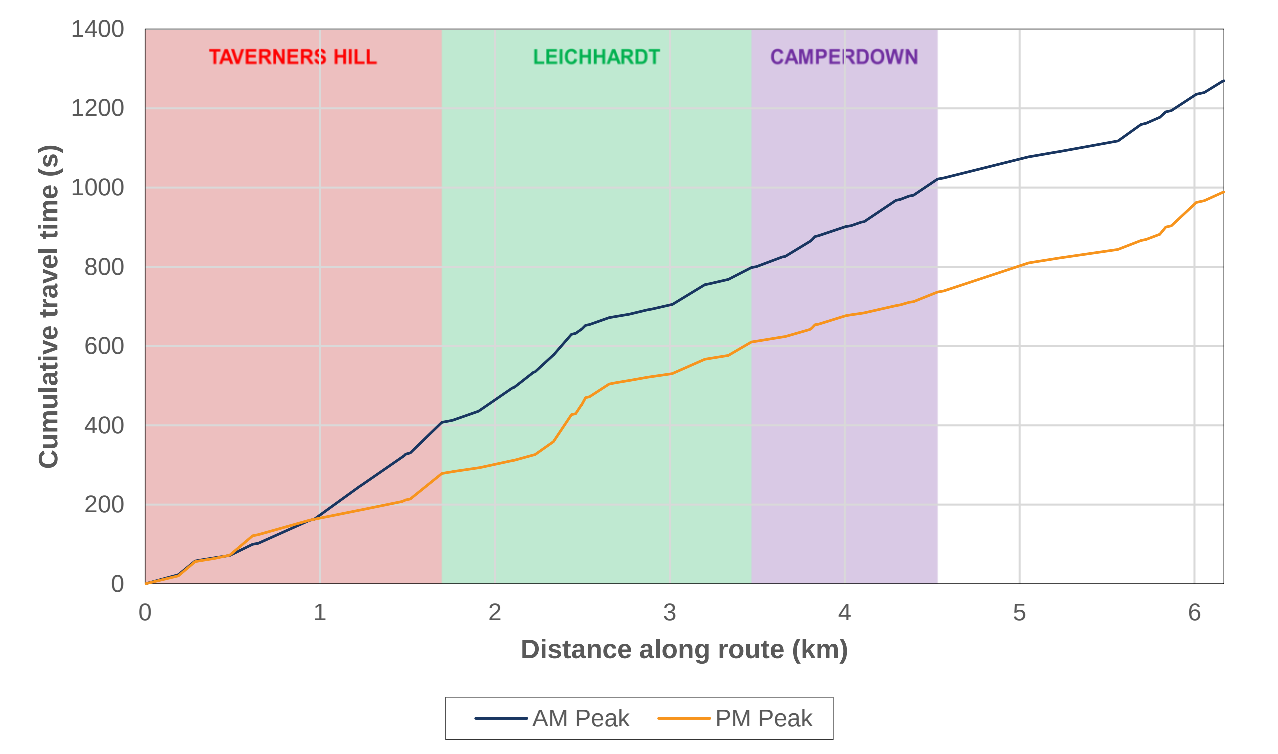


Figure 5-1 Travel times between precincts (eastbound) –Base Model

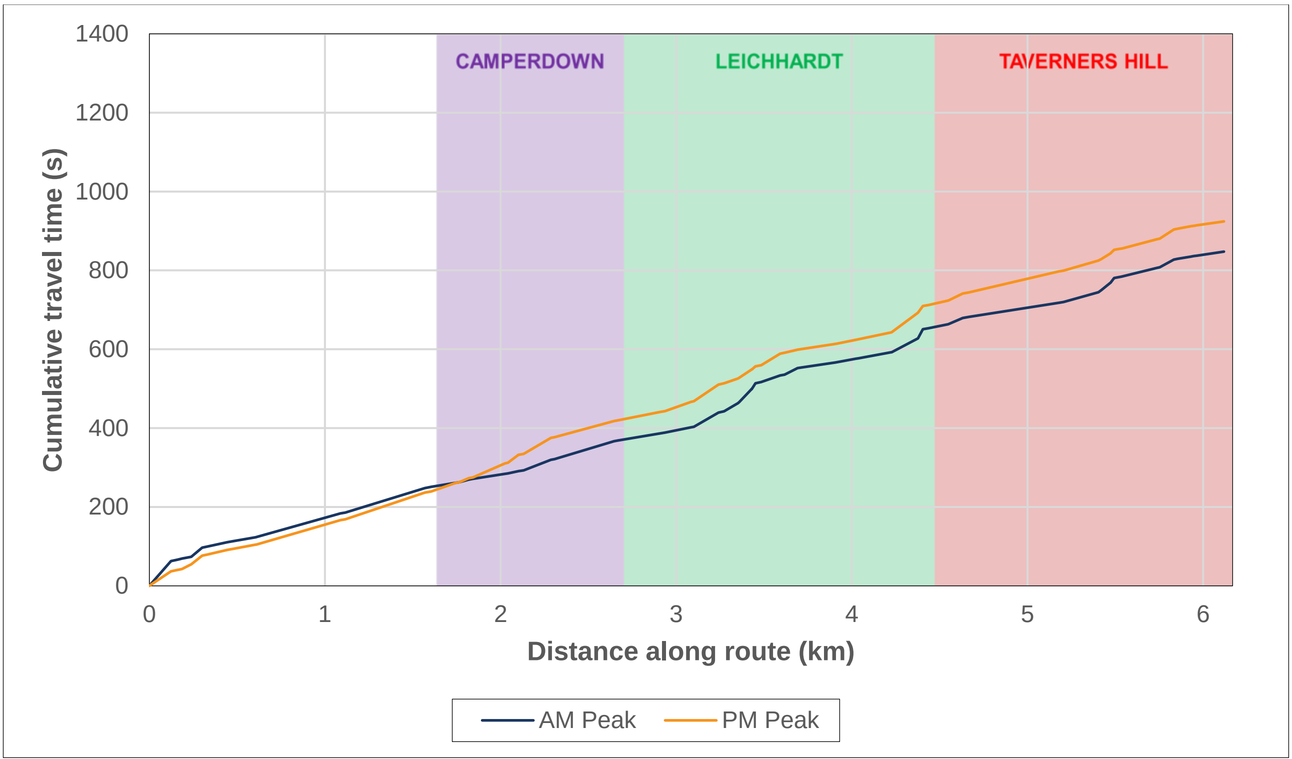


Figure 5-2 Travel times between precincts (westbound) –Base Model

5.5 Existing intersection performance

This section provides an overview of intersection performance in the study area. The results shown are for intersections in the PRCUTS precincts only. Detailed performance results for all intersections assessed are provided in **Appendix H**.

5.5.1 Intersection operation

Table 5-5 and **Table 5-6** show the intersection performance results for the AM and PM peaks respectively. These intersections were among those calibrated using survey data as documented in *Base Model Development Report* (Cardno, 2020). It is not recommended to assess the performance of intersections that were not calibrated.

The following sections provide a brief summary of the turns, movements and intersections that are at or over capacity in each peak. In general, most intersections along the corridor show acceptable performance for through traffic on Parramatta Road, however there is in most cases insufficient capacity on the side roads and some right turns from Parramatta Road.

Intersection performance at signalised intersections is based on the weighted average delay. Given that the through traffic movements on Parramatta Road are considerably higher than other movements at these intersections, overall intersection performance may be acceptable while there remain significant delays on the side road approaches.

AM Peak

- At Marion Street / Leichhardt Street / Balmain Road, the average delay on Balmain Road in both directions exceeds 70 seconds which corresponds to LOS F. The worst approach is Balmain Road (S). All movements on these approaches are LOS F across both hours.
- While the overall performance of Pyrmont Bridge Road / Booth Street / Mallett Street is LOS D, delays on Booth Street correspond to LOS E or F in both hours, and the right turn from Pyrmont Bridge Road is also LOS E in both hours.
- Parramatta Road / Liverpool Road is LOS C overall, but performance of the right turns from Liverpool Road and Parramatta Road is LOS E with an average delay of more than 60 seconds in the second hour.
- While the Parramatta Road movements at Sloane Street all have average delays of less than 38 seconds, most movements from Sloane Street in both directions are LOS E in both hours.
- Parramatta Road / Old Canterbury Road / Tebbutt Street performs at LOS F due queue spillback from the West Street intersection.
- The left and right turns out of Norton Street at Parramatta Road perform at LOS F in the first hour of the AM Peak. Performance improves to LOS C on the left turn and LOS E on the right turn in the second hour.
- The right turn from Parramatta Road into West Street experiences delays of over 140 seconds in both hours. At this intersection, some movements on Flood Street also perform at LOS F.
- The through and right turn movements from Crystal Street at Parramatta Road experience delays exceeding 80 seconds in both hours, corresponding to LOS F. This intersection in particular is a bottleneck in the AM Peak with the average delay eastbound on Parramatta Road also exceeding 80 seconds by the second hour.
- At Parramatta Road / Catherine Street / Phillip Street, most movements on the side roads perform at LOS E or worse in both hours. The highest delay is on the right turn movements. By the second hour, the average delay on Catherine Street exceeds 200 seconds.
- On Percival Road approaching Parramatta Road, average delay exceeds 70 seconds for all movements by the second hour.
- Average delays on Johnston Street and Northumberland Avenue were at least 52 seconds for all movements, with some turns experiencing delays of up to 89 seconds. The right turn from Parramatta Road also experienced heavy delays of up to 107 seconds.
- The right turn from Bridge Road is LOS F in the first hour and LOS E in the second hour.
- Average delay on Pyrmont Bridge Road is equivalent to LOS E in both peaks.

> At Parramatta Road / Mallett Street, delays increase throughout the AM Peak, with all movements on the southern approach exceeding 70 seconds average delay by the second hour.

> The side road movements at Parramatta Road / Missenden Avenue / Lyons Road experience delays of up to 106 seconds. The worst-performing movements are on Lyons Road. The right turn from Parramatta Road also has an average delay of 85 seconds in the first hour and 110 seconds in the second hour.

PM Peak

> At Marion Street / Leichhardt Street / Balmain Road, average delay on Balmain Road in both directions corresponds to LOS F. Delays on the southern approach are highest and were up to 89 seconds.

> At Liverpool Road, the right turn from Parramatta Road is LOS F in both peaks with delays up to 159 seconds. The right turn from Liverpool Road is also LOS E in the first hour but improves to LOS D in the second.

> The northern approach to Parramatta Road / Sloane Street is over capacity in both hours with delays exceeding 62 seconds on all approaches. Most movements on the southern approach are also LOS E in both hours.

> At Parramatta Road / Norton Street, the right turn from Norton Street performs at LOS E in both peaks, but all other movements have average delays less than 56 seconds (LOS D or better).

> Overall intersection performance at Parramatta Road / Flood Street / West Street is LOS E in both hours of the PM Peak. Average delays on at least one movement on all approaches except West Street corresponds to LOS F in one or both hours. The worst performing movements are the through and right turn from Flood Street, all movements on Parramatta Road in the westbound direction and the right turn from Parramatta Road (W) into West Street.

> All movements on Crystal Street at Parramatta Road experience delays corresponding to LOS F in one or both hours. In particular, the through and right turn movements experience protracted delays of up to 153 seconds. The right turn from Parramatta Road into Crystal Street also has an average delay corresponding to LOS E in both hours.

> The left turn from Phillip Street onto Parramatta Road has an average delay corresponding to LOS F in both hours. This is caused by downstream queueing which prevents vehicles from turning into Parramatta Road.

> The through and right turn movements on Johnston Street have average delays of up to 107 seconds. The right turn from Parramatta Road into Johnston Street also experiences delays up to 82 seconds (LOS F).

> The right turn from Parramatta Road at Bridge Road is LOS E in the first hour and LOS F in the second hour. The right turn from Bridge Road is also LOS E in the second hour.

> Pyrmont Bridge Road experiences long delays in both hours that correspond to LOS F. The maximum delay is 116 seconds. In the second hour, queueing on Parramatta Road in the westbound direction also results in delays of up to 70 seconds.

> Mallett Street performs poorly in both directions. The average delay on the left and through movements is LOS E in most instances, and the right turns are LOS F with average delays of up to 185 seconds.

> The right turn out of Dalhousie Street has an average delay of up to 94 seconds and is LOS F in both hours.

> At Missenden Road, most movements on Missenden Road are LOS E in both peaks.

Table 5-5 Intersection performance results – Base Model (AM Peak)

Intersection		Type	7:15AM – 8:15AM			8:15AM – 9:15AM		
			Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS
19	Marion Street / Norton Street	S	1753	28.0	B	1718	27.5	B
20	Marion Street / Leichhardt Street / Balmain Road	S	1611	41.5	C	1545	41.1	C
30	Pyrmont Bridge Road / Booth Street / Mallett Street	S	1783	51.0	D	1690	39.0	C
39	Parramatta Road / Liverpool Road	S	4055	38.0	C	4048	35.6	C
42	Tebbutt Street / Lords Road	S	1449	12.4	A	1498	15.6	B
44	Tebbutt Street / Hathern Street	S	1425	19.7	B	1508	20.0	B
45	Parramatta Road / Sloane Street	S	3975	18.3	B	3893	27.4	B
47	Parramatta Road / Old Canterbury Road / Tebbutt Street	S	3727	73.5	F	3763	80.7	F
50	Parramatta Road / Norton Street	S	3285	24.6	B	3321	14.7	B
51	Parramatta Road / Flood Street / West Street	S	3648	56.4	D	3672	56.4	D
52	Parramatta Road / Crystal Street / Balmain Road	S	3813	33.1	C	3731	42.7	D
53	Parramatta Road / Catherine Street / Phillip Street	S	3305	14.9	B	3292	38.4	C
67	Parramatta Road / Young Street / Percival Road	S	3433	26.6	B	3448	32.0	C
68	Parramatta Road /Northumberland Avenue / Johnston Street	S	4059	29.1	C	4050	32.9	C
69	Parramatta Road / Bridge Road	S	3964	38.2	C	3931	44.0	D
70	Parramatta Road /Pyrmont Bridge Road / Denison Street	S	3960	12.9	A	3980	12.5	A
71	Parramatta Road / Mallett Street	S	3850	33.2	C	3933	39.3	C
81	Parramatta Road / Dalhousie Street	S	3114	34.3	C	3169	37.0	C
83	Parramatta Road / Missenden Avenue / Lyons Road	S	3455	39.7	C	3676	49.0	D

Table 5-6 Intersection performance results – Base Model (PM Peak)

Intersection		Type	4:30PM – 5:30PM			5:30PM – 6:30PM		
			Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS
19	Marion Street / Norton Street	S	1575	24.5	B	1596	28.3	B
20	Marion Street / Leichhardt Street / Balmain Road	S	1456	40.5	C	1441	41.7	C
30	Pyrmont Bridge Road / Booth Street / Mallett Street	S	1689	23.8	B	1864	25.2	B
39	Parramatta Road / Liverpool Road	S	4584	33.5	C	4671	43.1	D
42	Tebbutt Street / Lords Road	S	1656	16.0	B	1657	16.1	B
44	Tebbutt Street / Hathern Street	S	1774	25.4	B	1763	30.3	C
45	Parramatta Road / Sloane Street	S	4484	22.3	B	4589	28.3	B
47	Parramatta Road / Old Canterbury Road / Tebbutt Street	S	4065	17.7	B	4217	17.1	B
50	Parramatta Road / Norton Street	S	3595	32.0	C	3808	30.7	C
51	Parramatta Road / Flood Street / West Street	S	4048	59.1	E	4339	59.4	E
52	Parramatta Road / Crystal Street / Balmain Road	S	3971	38.4	C	4167	32.2	C
53	Parramatta Road / Catherine Street / Phillip Street	S	3407	24.3	B	3542	27.5	B
67	Parramatta Road / Young Street / Percival Road	S	3468	16.7	B	3603	17.1	B
68	Parramatta Road /Northumberland Avenue / Johnston Street	S	4287	28.3	B	4470	33.8	C
69	Parramatta Road / Bridge Road	S	3876	26.2	B	4037	31.9	C
70	Parramatta Road /Pyrmont Bridge Road / Denison Street	S	3818	32.8	C	3991	49.7	D
71	Parramatta Road / Mallett Street	S	3494	19.1	B	3594	19.3	B
81	Parramatta Road / Dalhousie Street	S	3551	35.4	C	3707	37.2	C
83	Parramatta Road / Missenden Avenue / Lyons Road	S	3431	46.0	D	3564	37.0	C

Figure 5-3 and **Figure 5-4** show the intersection performance results on a map of the study area.

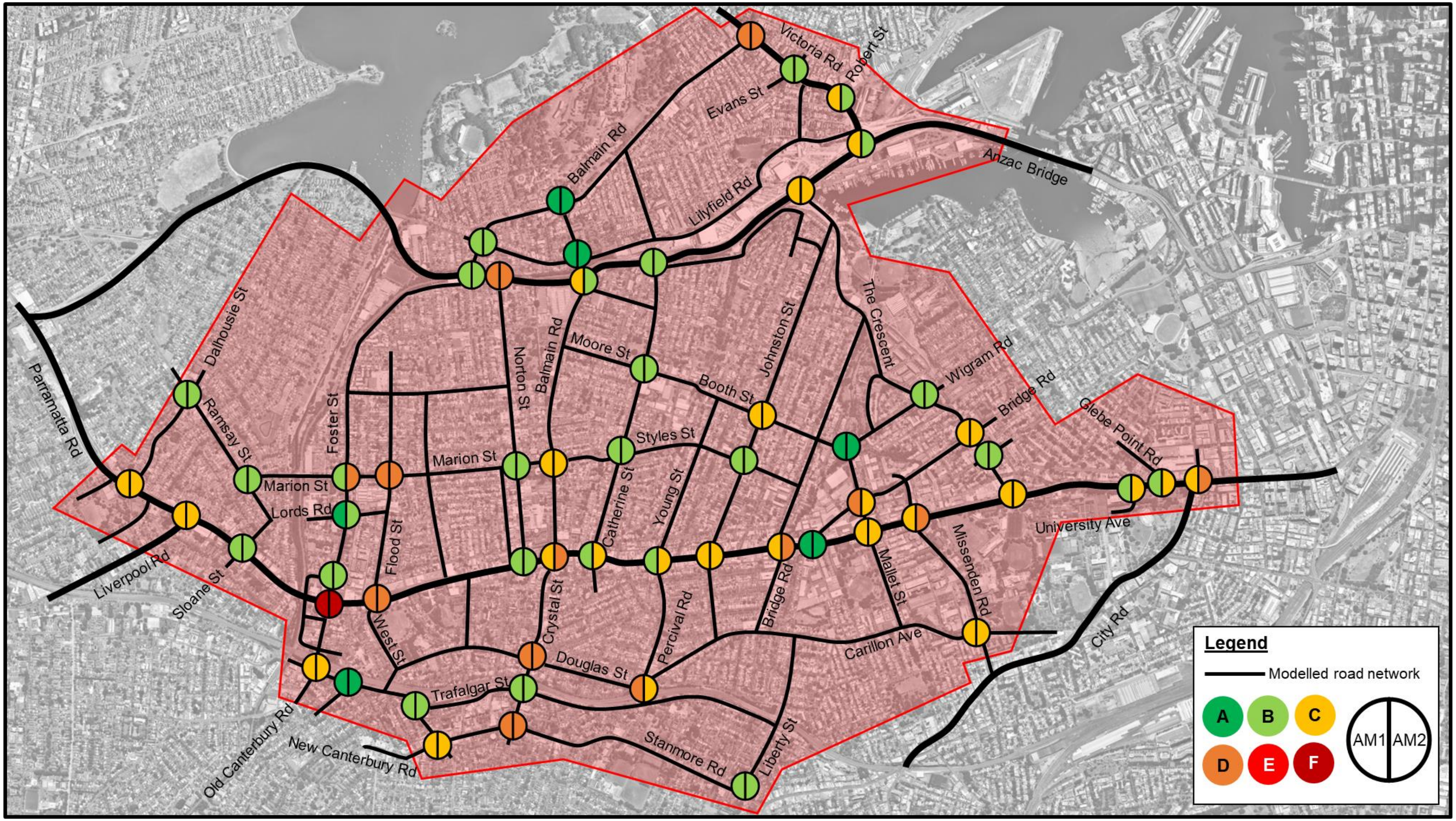


Figure 5-3 Intersection level of service – Base Model (AM Peak)

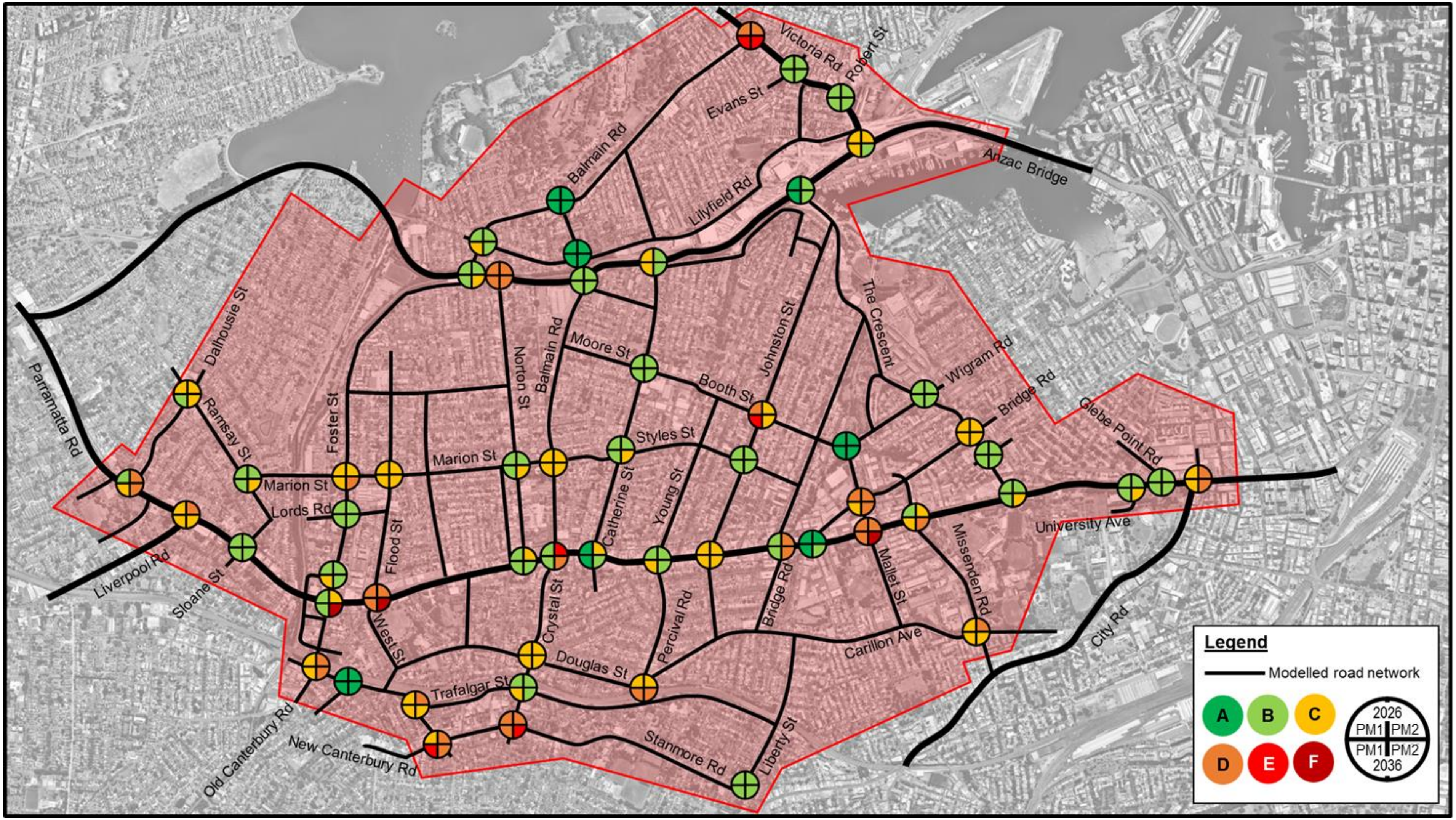


Figure 5-4 Intersection level of service – 2018 Base Model (PM Peak)

5.5.2 Queue lengths at major intersections

Table 5-7 shows the maximum queue length at major intersections along Parramatta Road in the PRCUTS precincts. On side roads, only queueing within the microsimulation area is included.

Table 5-7 Maximum queue length at major intersections in the PRCUTS precincts – Base Model

Intersection	Approach		Maximum queue length (m)	
			AM Peak	PM Peak
Parramatta Road / Dalhousie Street	N	Dalhousie Street	87	114
	E	Parramatta Road	91	86
	W	Parramatta Road	301	294
Parramatta Highway / Hume Highway	E	Parramatta Road	32	32
	S	Hume Highway	28	29
	W	Parramatta Road	116	136
Parramatta Road / Sloane Street	N	Sloane Street	45	50
	E	Parramatta Road	291	328
	S	Sloane Street	298	300
	W	Parramatta Road	306	147
Parramatta Road / Flood Street / West Street	N	Flood Street	134	231
	E	Parramatta Road	476	487
	S	West Street	66	68
	W	Parramatta Road	193	184
Parramatta Road / Norton Street	N	Norton Street	72	71
	E	Parramatta Road	117	121
	W	Parramatta Road	35	37
Parramatta Road / Crystal Street / Balmain Road	E	Parramatta Road	36	37
	S	Crystal Street	160	162
	W	Parramatta Road	115	116
Parramatta Road / Catherine Street	N	Catherine Street	176	68
	E	Parramatta Road	223	223
	S	Catherine Street	98	105
	W	Parramatta Road	51	48
Parramatta Road / Young Street / Percival Road	N	Young Street	104	100
	E	Parramatta Road	66	58
	S	Percival Road	82	65
	W	Parramatta Road	244	41
Parramatta Road / Johnston Street / Northumberland Avenue	N	Johnston Street	56	54
	E	Parramatta Road	83	81
	S	Northumberland Avenue	45	44
	W	Parramatta Road	146	140
Parramatta Road / Bridge Road	E	Parramatta Road	45	45
	S	Bridge Road	87	88
	W	Parramatta Road	34	26

Intersection	Approach		Maximum queue length (m)	
			AM Peak	PM Peak
Parramatta Road / Pyrmont Bridge Road / Denison Street	N	Pyrmont Bridge Road	73	164
	E	Parramatta Road	194	268
	W	Parramatta Road	40	39
Parramatta Road / Mallett Street	N	Mallett Street	72	71
	E	Parramatta Road	36	39
	S	Mallett Street	238	140
	W	Parramatta Road	265	37
Parramatta Road / Lyons Road / Missenden Road	N	Lyons Road	97	78
	E	Parramatta Road	198	353
	S	Missenden Road	62	103

5.6 Existing network plots

5.6.1 Traffic density

Figure 5-5 and **Figure 5-6** show the simulated traffic density for the AM and PM peaks respectively. In both peaks, traffic density is highest along Parramatta Road, with significant queueing approaching the Parramatta Road / West Street / Flood Street intersection in the AM Peak. Other areas with high traffic density include Crystal Street and the approaches to Victoria Road.

5.6.2 Speed ratio

Figure 5-7 and **Figure 5-8** show the simulated speed ratio for the AM and PM peaks respectively. Speed ratio is the average section speed as a proportion of the posted speed limit. The simulated speed ratio is low along Parramatta Road, particularly eastbound in the AM Peak and westbound in the PM Peak. Speed ratio is low on most approaches to signalised intersections along Parramatta Road, Victoria Road and City-West Link Road. Simulated speeds on Crystal Street and Stanmore Road, and their approaches, were low in both peaks also.

5.6.3 Heavy vehicle proportions

Figure 5-9 and **Figure 5-10** show the proportion of the total traffic volume on each link that is heavy vehicles. The proportion of heavy vehicles is significantly higher in the AM Peak than in the PM Peak on most roads. In the AM Peak, the heavy vehicle proportion on Parramatta Road westbound and City-West Link Road westbound is more than eight per cent. There is also high heavy vehicle traffic on Norton Street, Livingstone Road and Glebe Point Road.

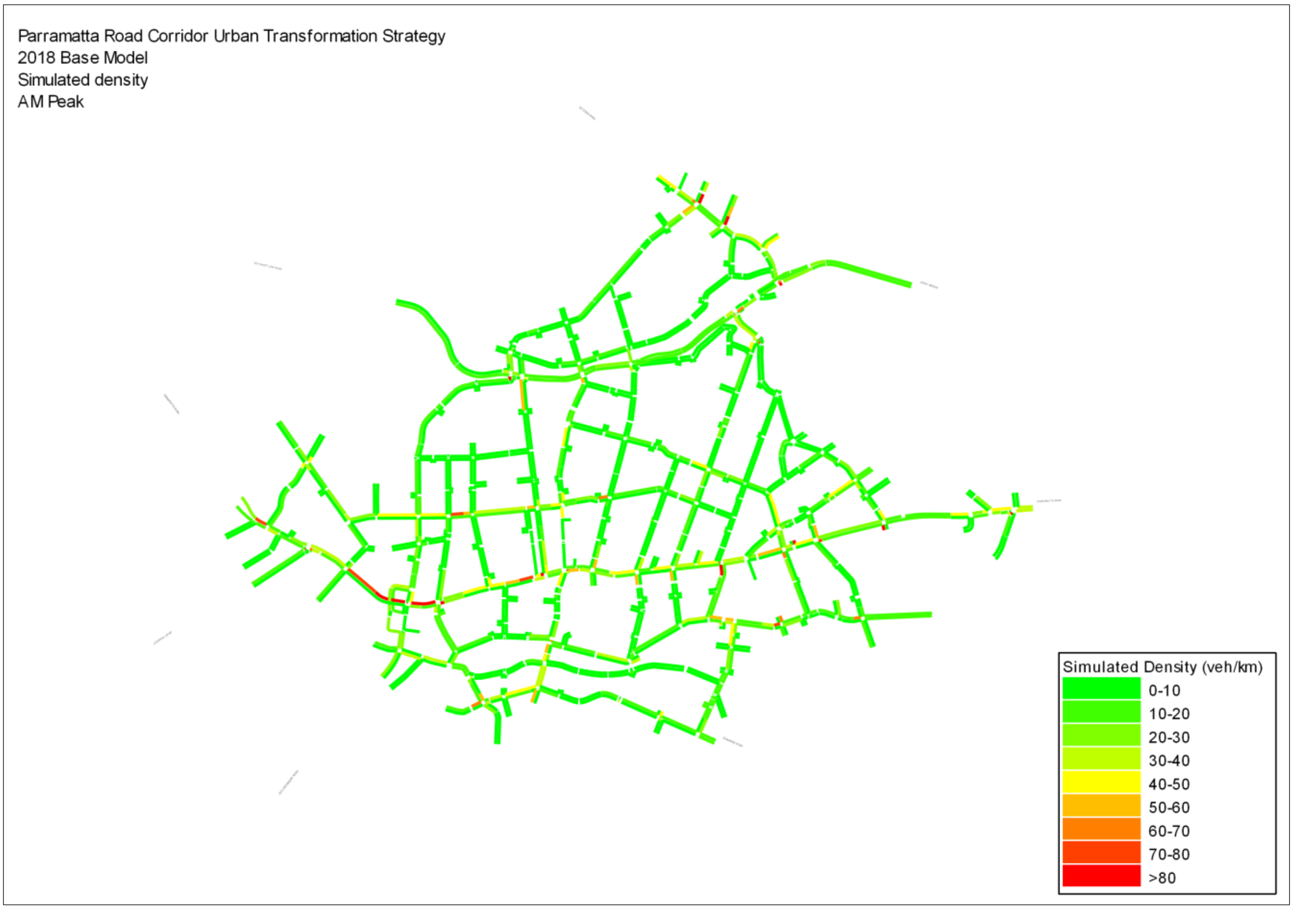


Figure 5-5 Simulated density – Base Model (AM Peak)

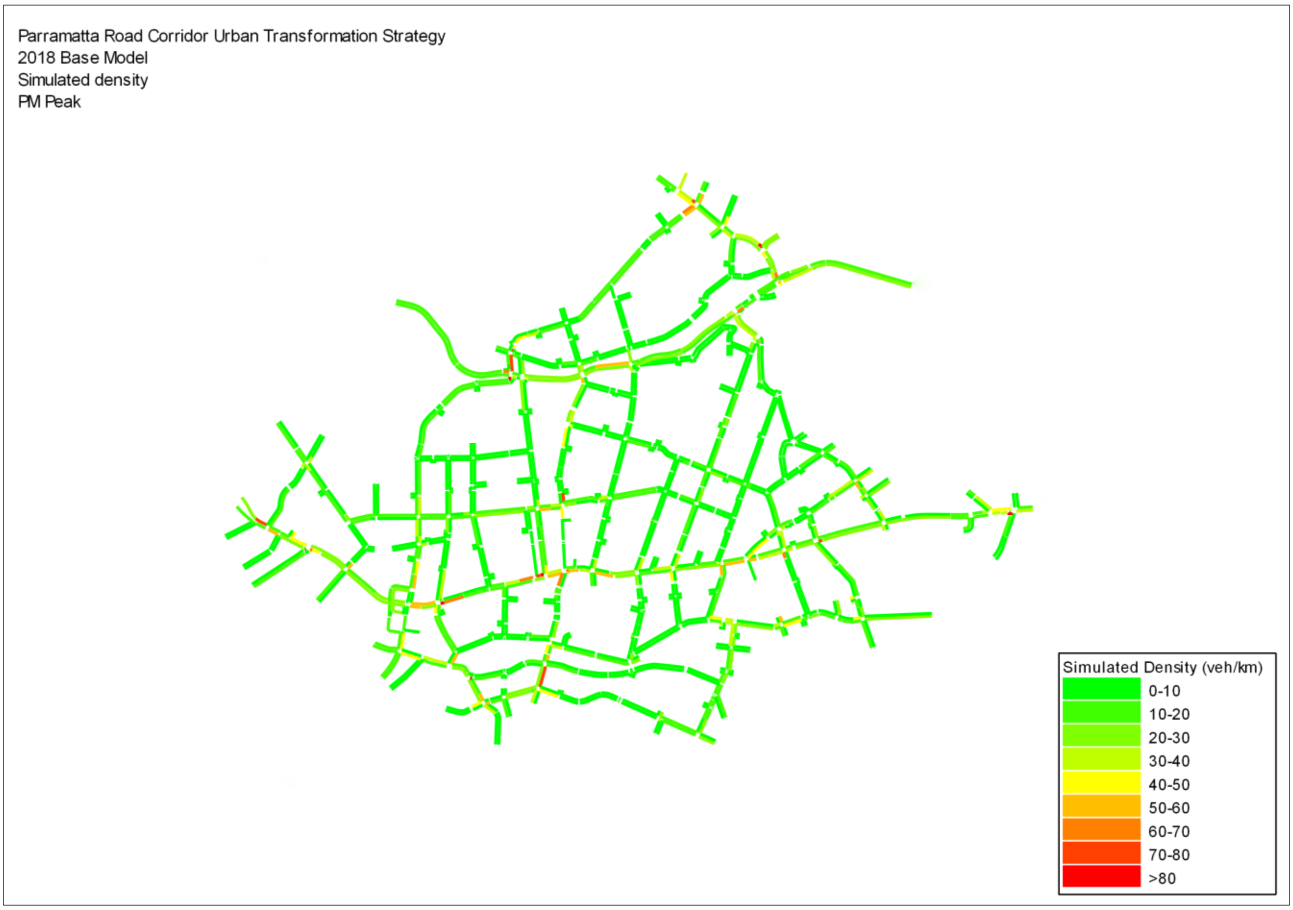


Figure 5-6 Simulated density – Base Model (PM Peak)

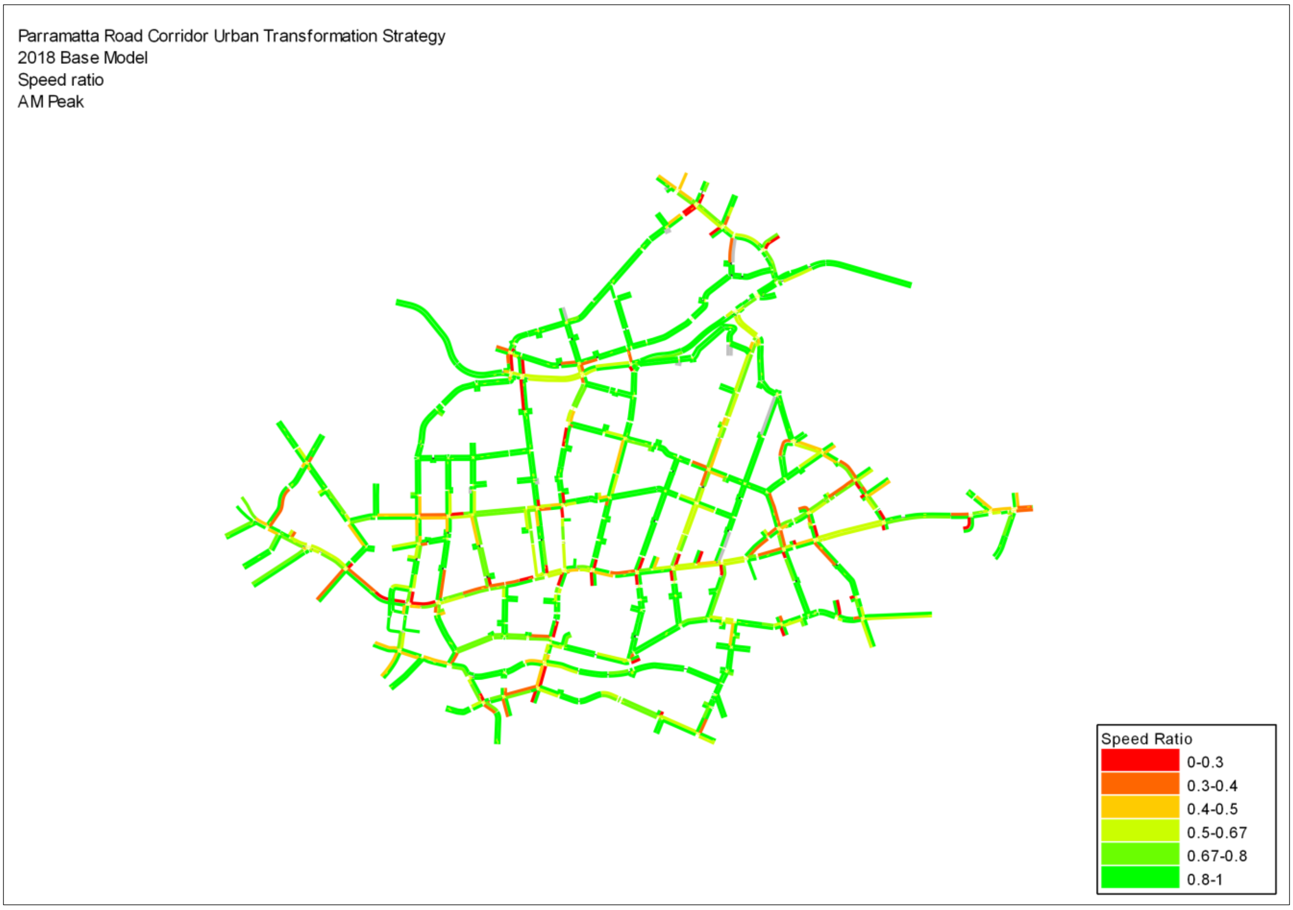


Figure 5-7 Speed ratio – Base Model (AM Peak)

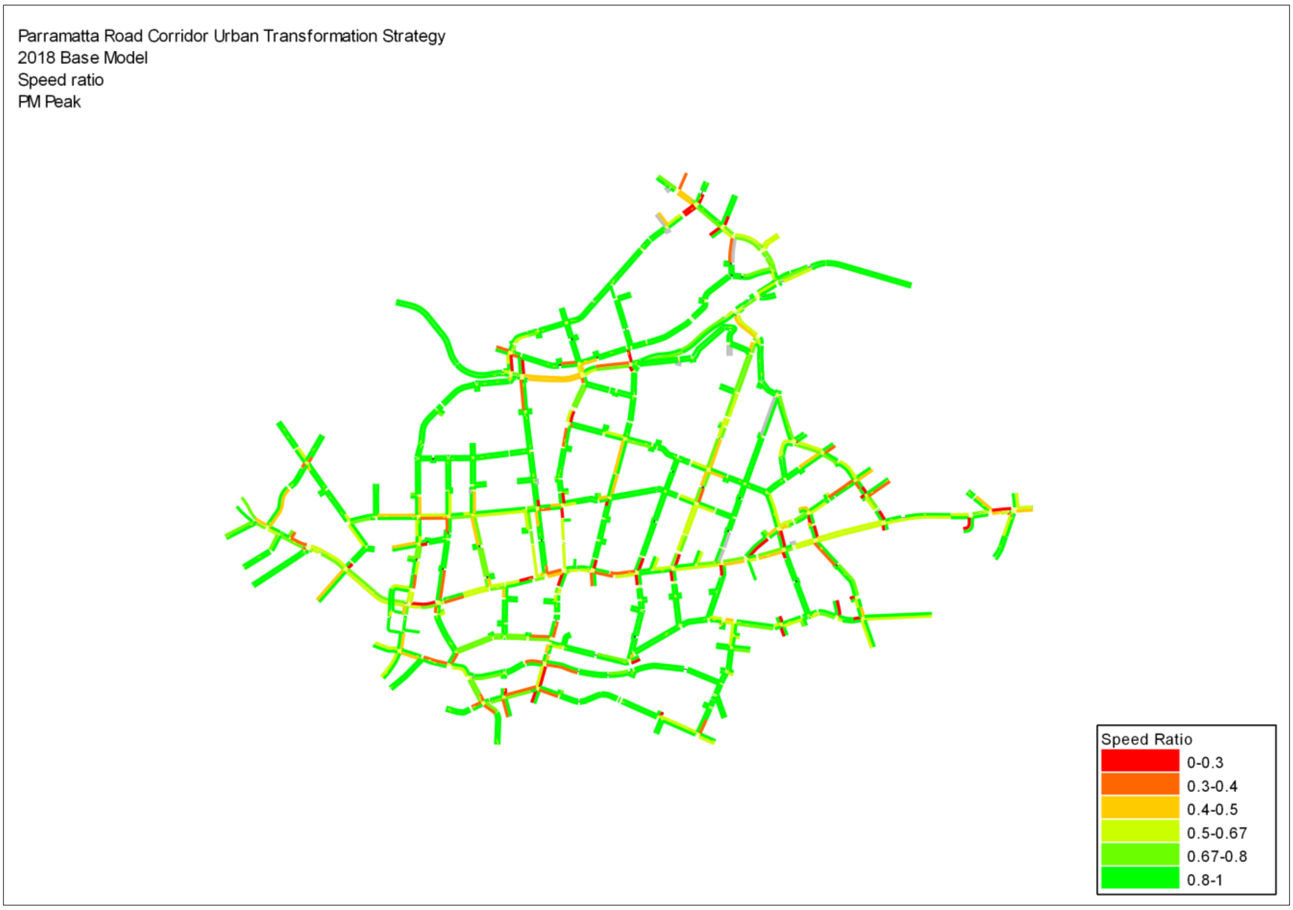


Figure 5-8 Speed ratio – Base Model (PM Peak)

Figure 5-9 Heavy vehicle proportions – Base Model (AM Peak)

Figure 5-10 Heavy vehicle proportions – Base Model (PM Peak)

6 Do Minimum operational results

The Do Minimum model was used to identify network deficiencies in the future network performance. It included the following infrastructure upgrades:

> City-West Link road additional eastbound lane between Waratah Street and James Street
> Parramatta Road / West Street right turn lane extension
> Missenden Road speed limit reduction
> Parramatta Road / Crystal Street right turn lane extension
> WestConnex Rozelle Interchange including Iron Cove Tunnel from Victoria Road to Anzac Bridge.

The above upgrades were outlined in greater detail in **Section 2.1**. These models identify deficiencies in the future road network absent any upgrades beyond those already implemented or under construction.

6.1 Do Minimum network performance

6.1.1 Network performance summary

Table 6-1 shows the network performance results for the Do Minimum scenario. The key findings are summarised below.

> Between 2018 and 2026, the total traffic demand increases by 11,598 trips in the AM Peak and 12,301 trips in the PM Peak. There are an additional 5394 trips in the AM Peak and 6185 trips in the PM Peak in 2036 compared to 2026.

> In 2026, the total distance travelled by all vehicles in the simulation (VKT) increases by 13.3 per cent in the AM Peak and by 7.8 per cent in the PM Peak. In 2036, these increases are 13.5 per cent and 8.3 per cent. These are less than the proportional increase in demand in each peak which results in a lower average kilometres travelled per vehicle.

  This reduction is primarily caused by the WestConnex tunnels. VKT is only measured while vehicles are on the modelled road network, which excludes the tunnels. Vehicles that use the tunnels for part of their journey have a lower distance travelled in the network, which increases the proportion of shorter trips within the study area.

> Vehicle hours travelled (VHT) generally increases more than the increase in demand, which indicates greater congestion in the network.

> In the AM Peak, average speed increases by 2.4 kilometres per hour between 2018 and 2026. The increase is 1.1 kilometres per hour up to 2036. In the PM Peak, the increase is 2.0 and 0.2 kilometres per hour. Network improvements including WestConnex, upgrades to Parramatta Road eastbound and upgrades to City-West Link Road eastbound have improved travel times on these roads. Some key congestion hotspots from 2018 such as Victoria Road and Parramatta Road have lower traffic volumes due to WestConnex.

  Average speed is also higher because vehicles using the WestConnex tunnels no longer have to traverse the surface network. The tunnels, such as the Iron Cove Tunnel, bypass some of the most congested parts of the network, which improves the overall vehicle average speed.

> Average delay time increases in all years and peaks, with the greatest increase in the PM Peak in both years.

> In 2026, the total of unreleased and deleted vehicles is 706 vehicles in the AM Peak and 740 vehicles in the PM Peak. These represent 0.9 per cent of the total demand. In 2036, the number of vehicles unreleased and deleted is 2110 in the AM Peak and 2738 in the PM Peak. Unreleased demand is discussed in the next section.

6.1.2 Person statistics

Table 6-2 shows key network statistics per person for the Do Minimum scenario based on the assumed vehicle occupancies outlined in **Section 3.2.1**.

Table 6-1 Network performance results – Do Minimum

Network performance metric	Unit	2026				2036			
		Do Minimum results		Compared to Base		Do Minimum results		Compared to Base	
		AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
All vehicles									
Total traffic demand	veh	80,193	87,443	+11,598 (+16.9%)	+12,301 (+16.4%)	85,587	93,628	+16,992 (+22.6%)	+18,486 (+24.6%)
Total vehicles arrived	veh	78,904	85,173	+9971 (+14.5%)	+10,324 (+13.8%)	80,962	86,585	+12,029 (+16.1%)	+11,736 (+15.7%)
Total kilometres travelled (VKT)	km	191,466	203,096	+22,544 (+13.3%)	+14,681 (+7.8%)	194,433	204,051	+25,511 (+13.5%)	+15,636 (+8.3%)
Vehicle hours travelled (VHT)	hr	7671	8589	+953 (+14.2%)	+1601 (+22.9%)	8542	9898	1824 (+26.1%)	+2910 (+41.6%)
Average per vehicle									
Average kilometres travelled	km	2.4	2.4	-0.0 (-1.0%)	-0.1 (-5.3%)	2.4	2.4	-0.0 (-1.9%)	-0.2 (-6.4%)
Average time travelled in network	s	146	153	-1 (-0.4%)	+15 (+10.9%)	158	181	+11 (+8.3%)	+43 (+31.5%)
Average speed	km/hr	30.0	31.0	+2.4 (+8.6%)	+2.0 (+7.0%)	28.7	29.2	+1.1 (+3.6%)	+0.2 (+0.8%)
Average delay	s	79	87	+1 (+1.1%)	+16 (+23.0%)	91	115	+13 (+18.4%)	+45 (+63.6%)
Unreleased demand									
Unreleased demand (% of total demand)	veh (%)	73 (0.1%)	417 (0.5%)	+69	+414	916 (1.1%)	1839 (2.0%)	+912	+1836
Deleted vehicles (% of total demand)	veh (%)	633 (0.8%)	323 (0.4%)	+633	+323	1194 (1.4%)	899 (1.0%)	+1194	+899
Total unreleased and deleted (% of total demand)	veh (%)	706 (0.9%)	740 (0.8%)	+702	+737	2110 (2.5%)	2738 (2.9%)	+2106	+2735

Table 6-2 Network statistics by person – Do Minimum

Network performance metric	Unit	2026				2036			
		AM Peak		PM Peak		AM Peak		PM Peak	
		LV	HV	LV	HV	LV	HV	LV	HV
Network statistics by vehicle type									
Total vehicles arrived	veh	73,916	4517	82,113	2890	75,395	5094	83,200	3219
Total kilometres travelled (VKT)	km	178,438	11,681	195,520	7111	179,825	13,255	195,592	8015
Vehicle hours travelled (VHT)	hr	7108	478	8262	298	7861	593	9492	376
Average speed	km/hr	30.0	31.4	30.8	38.6	28.6	30.2	29.0	36.3
Average delay	s	79	74	88	62	92	83	117	79
Network statistics by person									
Total persons arrived	person	82,403	4517	91,541	2890	84,052	5094	92,753	3219
Total person-kilometres travelled	km	198,927	11,681	217,970	7111	200,473	13,255	218,050	8015
Total person-hours travelled	hr	7924	478	9210	298	8763	593	10,582	376
Average speed per person	km/hr	30.0	31.4	30.8	38.6	28.6	30.2	29.0	36.3
Average delay per person	s	88	74	98	62	102	83	130	79

6.1.3 Unreleased demand

Unreleased demand refers to vehicles that are unable to enter the study are by the end of the simulation period. This is caused by queueing on their arrival link that extends back to the edge of the study area. High unreleased demand is an indication of significant network congestion.

The following sections outline the total unreleased demand and locations of unreleased demand in the AM and PM peaks for the Do Minimum scenario.

AM Peak

The unreleased demand in the AM Peak is 73 vehicles in 2026 and 916 vehicles in 2036. **Figure 6-1** and **Figure 6-3** show the locations of unreleased demand in 2026 and 2036 respectively. The main locations with unreleased demand are discussed below.

> Unreleased demand on Shaw Street is caused by the nearby Crystal Street / Shaw Street / Stanmore Road / New Canterbury Road intersection. This totals 31 vehicles in 2026 and 143 vehicles in 2036.

> While there is no unreleased demand on Old Canterbury Road in 2026, in 2036, 180 vehicles are unreleased due to queueing from the Old Canterbury Road / Railway Terrace intersection.

> Queueing on West Street causes unreleased demand on Station Street up to 269 vehicles in 2036.

> Unreleased demand on Darling Street and Robert Street is caused by queueing on Victoria Road.

PM Peak

The unreleased demand in the PM Peak is 417 vehicles in 2026 and 1839 vehicles in 2036. **Figure 6-2** and **Figure 6-4** show the locations of unreleased demand in 2026 and 2036 respectively. The main locations with unreleased demand are discussed below.

> Unreleased demand on Bridge Road is 210 vehicles in 2026 and 297 vehicles in 2036. This is cause by queueing from the Bridge Road / Ross Street intersection.

> Queueing on Old Canterbury Road approaching Railway Terrace causes 76 vehicles to be unreleased in 2026 and 212 vehicles in 2036.

> Queueing on West Street causes unreleased demand on Station Street up to 162 vehicles in 2036.

Glebe Point Road experiences queueing in 2036 that results in 137 vehicles being unreleased.

Figure 6-1 Unreleased demand – 2026 Do Minimum (AM Peak)

Figure 6-2 Unreleased demand – 2026 Do Minimum (PM Peak)

Figure 6-3 Unreleased demand – 2036 Do Minimum (AM Peak)

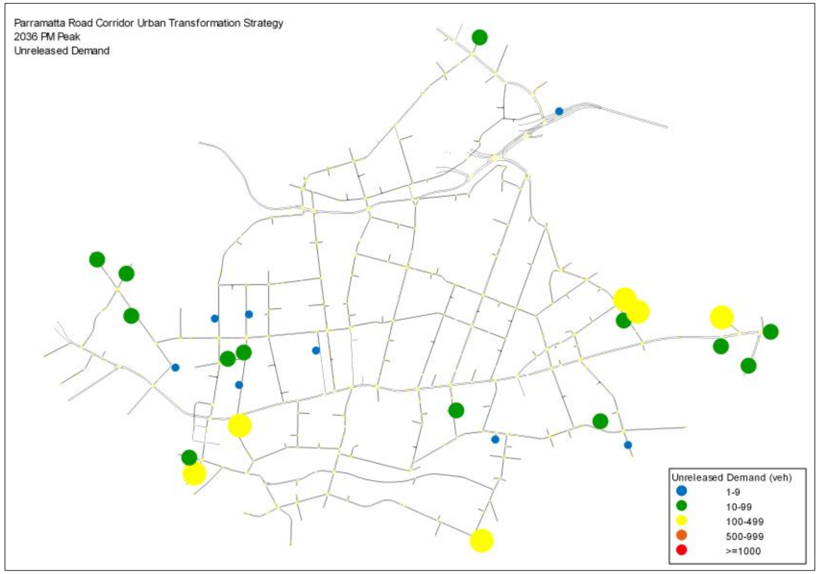


Figure 6-4 Unreleased demand – 2036 Do Minimum (PM Peak)

6.2 Do Minimum travel times

This section provides an overview of travel times on key routes and through the PRCUTS precincts in the 2026 and 2036 Do Minimum scenarios.

6.2.1 Travel times on key routes

Table 6-3 lists the modelled travel times on each route in the 2026 and 2036 Do Minimum scenarios. The key findings are discussed below.

> Travel times on Balmain Road in both directions decreased. Traffic volumes on Balmain Road significantly decreased with WestConnex. In 2018, the northbound volume was 354 vehicles, and in the southbound direction the volume was 160 vehicles. In 2026, these are reduced to 218 and 122 vehicles respectively.

> Travel times on Crystal Street increase in both directions, however the greatest increase is approaching Parramatta Road. In the AM Peak, travel times in that direction increased by 23 seconds in 2026 and by 24 seconds in 2036.

> Travel times generally increased on Johnston Street. In the PM Peak, the southbound travel time increased by 125 seconds in 2026 and 91 seconds in 2036. The traffic volume was lower in 2036 due to congestion elsewhere in the network, unreleased vehicles and deleted vehicles which resulted in an apparent improvement in performance.

> In 2026, travel times on Marion Street in the eastbound direction decreased in the AM Peak. Due to a combination of WestConnex and improvements in the eastbound direction along Parramatta Road, Marion Street becomes a less attractive rat-run, resulting in improved performance. However, travel times in the westbound direction increased by 56 seconds. In 2036, travel times in both peaks increased, with the greatest increase being in the PM Peak (up to 202 seconds).

> The number of vehicles using Parramatta road decreases due to WestConnex. Furthermore, network improvements such as an additional eastbound travel lane between Sloane Street and West Street, extended right turn bays at West Street and Crystal Street, and signal optimisation improve eastbound travel times. In the 2026 AM Peak, the resulting decrease represents a travel time saving of 261 seconds in the eastbound direction. In the 2026 PM Peak, the decrease is 32 seconds. However, the higher traffic volume by 2036 means that the eastbound travel time is 70 seconds longer in the AM Peak and 30 seconds longer in the PM Peak than the 2018 values.

Travel times in the westbound direction increase by 165 seconds in the 2026 AM Peak and 217 seconds in the 2026 PM Peak. This is caused by additional congestion at key intersections including at West Street and Crystal Street. The increases are 302 and 223 seconds respectively in 2036.

Note that the travel times shown in this table are for vehicles that traverse the full length of the route only.

Table 6-3 Travel times on key routes – Do Minimum

Route	Dir.	Do Minimum results				Compared to 2018 Base			
		Travel times (s)		Average speed (km/hr)		Travel times (s)		Average speed (km/hr)	
		AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
2026									
Balmain Road	NB	288	254	17.9	20.3	-44	+4	+2.4	-0.3
	SB	169	140	20.4	24.5	-19	-29	+2.1	+4.2
Crystal Street	NB	199	186	15.5	16.7	+23	-9	-2.1	+0.8
	SB	238	249	13.0	12.4	-35	+25	+1.7	-1.4
Johnston Street	NB	288	282	21.9	22.3	-24	-2	+1.7	+0.1
	SB	264	427	23.8	14.7	+10	+125	-0.9	-6.1
Marion Street	EB	243	214	23.0	26.2	-77	-5	+5.5	+0.6
	WB	261	202	21.5	27.8	+52	-3	-5.3	+0.5
Parramatta Road	EB	904	849	24.6	26.2	-261	-32	+5.5	+1.0
	WB	985	1144	22.5	19.4	+165	+217	-4.5	-4.5
2036									
Balmain Road	NB	324	390	15.9	13.2	-8	+140	+0.4	-7.4
	SB	186	149	18.6	23.1	-2	-20	+0.2	+2.7
Crystal Street	NB	200	203	15.5	15.3	+24	+8	-2.1	-0.6
	SB	253	477	12.3	6.5	-20	+253	+0.9	-7.3
Johnston Street	NB	297	289	21.2	21.8	-15	+5	+1.0	-0.4
	SB	278	393	22.6	16.0	+24	+91	-2.1	-4.8
Marion Street	EB	335	421	16.7	13.3	+15	+202	-0.8	-12.3
	WB	279	313	20.1	17.9	+70	+108	-6.7	-9.4
Parramatta Road	EB	1235	911	18.0	24.4	+70	+30	-1.1	-0.8
	WB	1122	1150	19.7	19.3	+302	+223	-7.3	-4.6

6.2.2 Travel times through precincts

Table 6-4 shows the modelled travel time through each precinct in each direction. Overleaf, **Figure 6-5** and **Figure 6-6** show travel times through each precinct along Parramatta Road for the eastbound and westbound directions respectively.

AM Peak

> Eastbound travel time through Taverners Hill is reduced from the Base Model in both 2026 and 2036. The reduction is caused by an additional lane provided between Sloane Street and West Street.

> Eastbound travel time through Leichhardt is also lower in 2026 than in 2018 due to upgrades around Crystal Street, however by 2036 the travel time through Leichhardt is higher than in the Base Model.

> In the westbound direction, travel time increased from 2018 to 2026 and 2036 in Taverners Hill and Leichhardt, and remained about the same through Camperdown.

PM Peak

> Intersection upgrades improve the eastbound travel time through Leichhardt in the PM Peak.

> Eastbound travel time through Taverners Hill is about the same in 2026 as in 2018, but increases by over 90 seconds in 2036.

> Eastbound travel times through Camperdown increase by 20 seconds from 2018 to 2026 and by an additional 27 seconds from 2026 to 2036.

> In the westbound direction, travel times through Taverners Hill remain about the same, while those through Leichhardt and Camperdown increase in both future years. The increase through Leichhardt is 39 seconds in 2026 and 57 seconds in 2036, while in Camperdown, this amounts to 30 additional seconds in 2026 and 50 seconds in 2036.

Table 6-4 Precinct travel times – Do Minimum

Direction	Travel time through precinct (s)					
	2026			2036		
	Taverners Hill	Leichhardt	Camperdown	Taverners Hill	Leichhardt	Camperdown
AM Peak						
Eastbound	307	259	188	291	446	231
Westbound	227	359	110	244	430	113
PM Peak						
Eastbound	276	313	146	363	312	173
Westbound	203	331	209	218	349	229

Note that the travel times shown in these graphs are the cumulative sum of the travel times of each section along the route, so include vehicles that only traverse part of the route.

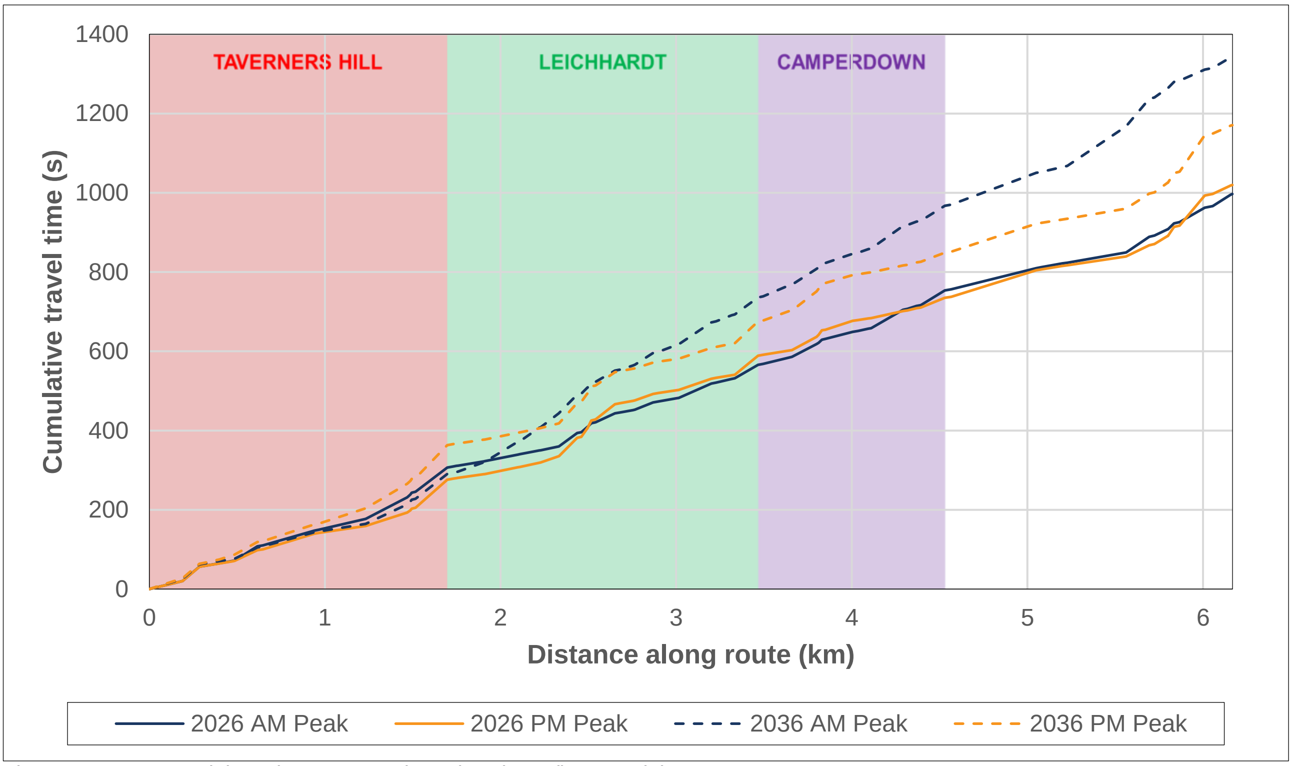


Figure 6-5 Travel times between precincts (eastbound) – Do Minimum

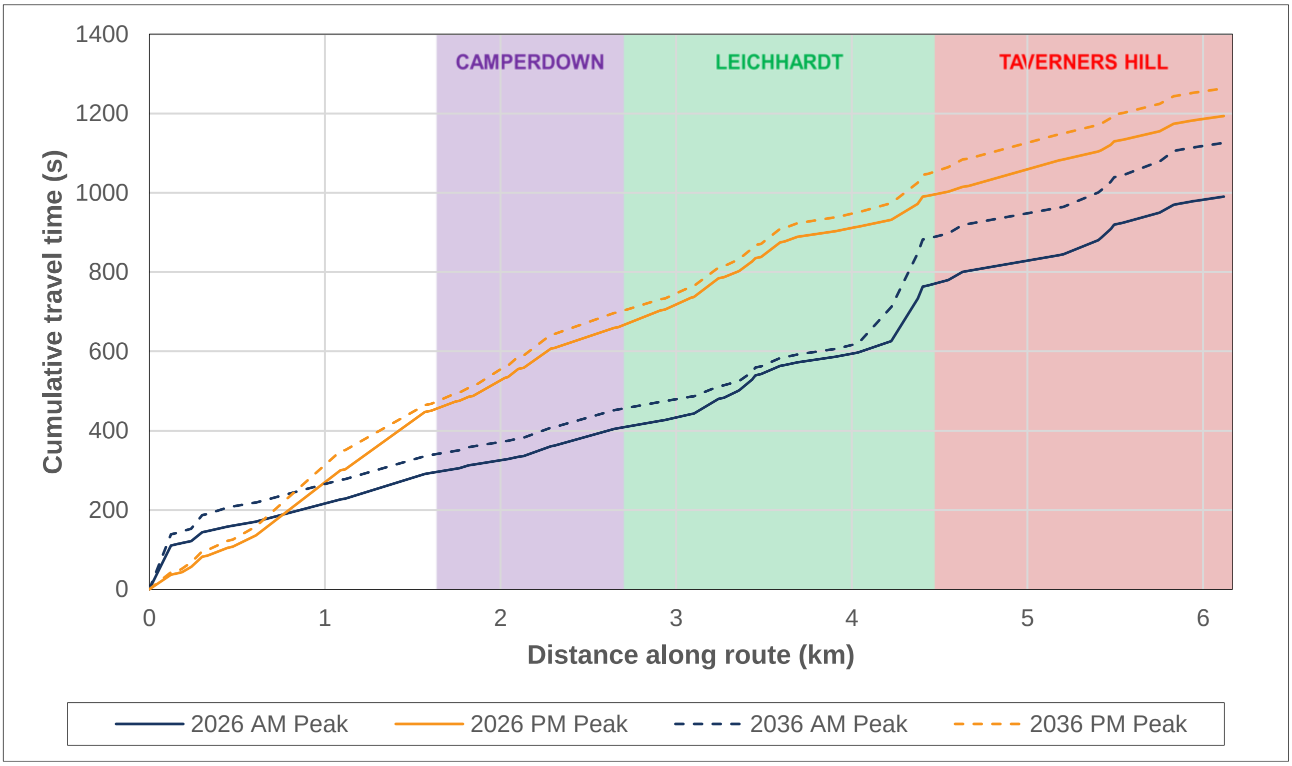


Figure 6-6 Travel times between precincts (westbound) – Do Minimum

6.3 Do Minimum intersection performance

This section provides an overview of intersection performance in the study area in the Do Minimum scenario. The results shown are for intersections in the PRCUTS precincts. Detailed performance results for all intersections assessed are provided in **Appendix H**.

6.3.1 Intersection operation

Table 6-5 and **Table 6-6** show the intersection performance results for the AM and PM peaks respectively. These intersections were among those calibrated using survey data as documented in *Base Model Development Report* (Cardno, 2020). It is not recommended to assess the performance of intersections that were not calibrated.

The following sections provide a brief summary of the key turns, movements and intersections that are at or over capacity in each peak. In general, the performance of side roads already noted as over capacity in the Base Model deteriorated, with most approaches to Parramatta Road performing at LOS E or F by 2036. Some other side roads that were not over capacity in 2018 are over capacity by 2026 or 2036. Some right turns from Parramatta Road also exhibited protracted delays in 2026 and/or 2036.

Intersection performance at signalised intersections is based on the weighted average delay. Given that the through traffic movements on Parramatta Road are considerably higher than other movements at these intersections, overall intersection performance may be acceptable while still recording significant delays on the side road approaches.

The performance of some movements or intersections may appear to improve as the proportion of the demand that arrives at the intersection by the end of the simulation period is reduced by the high levels of congestion in the model in this year.

AM Peak

> While the Marion Street and Leichhardt Street approaches to Marion Street / Leichhardt Street / Balmain Road continue to perform acceptably (LOS C or better), all movements on Balmain Road have average delays exceeding 72 seconds (LOS F). Overall intersection remains LOS C in 2026 and LOS C/D[5] in 2036.

> In 2026, both movements from Booth Street at Pyrmont Bridge Road / Booth Street / Mallett Street have delays of over 67 seconds. In 2036, average delays on this approach exceed 74 seconds, corresponding to LOS F. The right turn from Pyrmont Bridge Road continues to perform at LOS E up to 2036.

> Liverpool Road experiences average delays of up to 249 seconds by 2036, and delays increase over the simulation period as queues build up on Parramatta Road. Overall intersection performance deteriorates from LOS C in 2018 to LOS F in the second hour in 2036.

> Parramatta Road / Norton Street continues to perform at LOS B up to 2036. The right turn movement out of Norton Street is LOS E in both hours. Additionally, the right turn from Parramatta Road performs at LOS F in the first hour in 2036, up from LOS D in 2018.

> The performance of Parramatta Road / Flood Street / West Street deteriorates from LOS D in 2018 to LOS F by 2026. Almost all movements at this intersection perform at LOS F with delays exceeding 100 seconds on Parramatta Road (E), West Street and the right turns from Parramatta Road (W) and Flood Street.

> The through and right turn movements out of Crystal Street remain LOS F, but the maximum delay increases from 91 seconds to 149 second by 2026.

> Queueing on Young Street and Percival Road increase throughout the peak period, with delays on these side roads exceeding 100 seconds in the second hour by 2036. Overall intersection performance deteriorates from LOS B/C to LOS C/D by 2036.

> All movements on Northumberland Drive perform at LOS F by 2026, and on Johnston Street by 2036. Overall performance in the second hour is worse as queues build up over the simulation period. Level of service goes from LOS C in 2018 to LOS E by 2036.

[5] LOS C in the first hour and LOS D in the second hour.

> All movements on Bridge Road continue to fail in 2026 and 2036. By 2036, the eastbound Parramatta Road movement at this location is also LOS F.
> Queueing on Missenden Road and Lyons Road build up over the simulation period such that these approaches perform at LOS F by the second hour of the AM Peak by 2026. The right turn from Parramatta Road remains LOS F in both future years.

PM Peak

> As was the case in the Base Model, Balmain Road (S) at Marion Street / Leichhardt Street / Balmain Road is over capacity with delays corresponding to LOS F in both hours. However, due to WestConnex, the volume on Balmain Road (N) is reduced, and LOS improves from LOS F in 2018 to LOS D in 2036.
> While all movements at Pyrmont Bridge Road / Booth Street / Mallett Street were acceptable in 2018, performance in the second hour particularly deteriorates by 2036 with all movements on Booth Street and Mallett street experiencing average delays corresponding to LOS E or F.
> Delay on the right turn from Liverpool Road increases from LOS E/D in 2018 to LOS F/F in 2026. By 2036, the left turn is also over capacity at LOS E/F. Overall intersection performance is LOS E in 2036.
> Tebbutt Street / Lords Road and Tebbutt street / Hathern Street perform at LOS E in the second hour in 2036. This is caused by queue spillback from Parramatta Road along Tebbutt Street.
> All southbound movements on Sloane Street remain over capacity in both future years with LOS E or F recorded. Overall intersection performance is LOS D in the second hour by 2036.
> Norton Street is severely over capacity by 2036 with average delays of over 200 seconds observed. The right turn from Parramatta Road also experiences delays corresponding to LOS E. Overall intersection performance is LOS E in 2026 and 2036.
> Parramatta Road / Flood Street / West Street performed at LOS E in 2018. By 2026, all movements except those on Parramatta Road (W) perform at LOS E or worse and the overall intersection delay is 73 seconds. By 2036, overall intersection delay is 104 seconds.
> Parramatta Road / Crystal Street performs similarly to the Base Model, with the main delays being all movements on Crystal Street. Average delay increases from 38 seconds in 2018 to 47 seconds in 2036.
> All movements on Catherine Street are LOS F in both hours. Additionally, Parramatta Road westbound is LOS F in the second hour with delays exceeding 75 seconds.
> At Parramatta Road / Northumberland Avenue / Johnston Street, the side road movements remain over capacity up to 2036. Traffic volume on the right turn from Parramatta Road is reduced with WestConnex, and performance of this movement improves from LOS F in 2018 to LOS E by 2036.
> All movements on Bridge Road at Parramatta Road are LOS F by 2036. Additionally, the right turn from Parramatta Road at this location is also LOS F, with delays of up to 287 seconds experienced.
> Pyrmont Bridge Road performs at LOS F in both hours. By the second hour, queueing on Parramatta Road in the westbound direction at this location also results in LOS F for these movements. Overall intersection performance remains LOS D up to 2036.
> All movements except the left and through movements on Parramatta Road (W) at Parramatta Road / Missenden Road / Lyons Road are LOS E or F in 2026 and 2036. Overall intersection performance corresponds to LOS F also.

Table 6-5 Intersection performance results – Do Minimum (AM Peak)

Intersection		Type	2026						2036					
			7:15AM – 8:15AM			8:15AM – 9:15AM			7:15AM – 8:15AM			8:15AM – 9:15AM		
			Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS
19	Marion Street / Norton Street	S	1879	28.6	C	1650	23.4	B	1956	29.5	C	1908	54.0	D
20	Marion Street / Leichhardt Street / Balmain Road	S	1628	33.1	C	1423	32.3	C	1670	36.0	C	1626	47.3	D
30	Pyrmont Bridge Road / Booth Street / Mallett Street	S	2149	53.2	D	2132	68.5	E	2126	54.3	D	2068	63.4	E
39	Parramatta Road / Liverpool Road	S	4279	48.0	D	4388	64.9	E	4341	42.2	C	4328	94.5	F
42	Tebbutt Street / Lords Road	S	2000	27.3	B	1827	18.0	B	1970	19.6	B	1996	20.1	B
44	Tebbutt Street / Hathern Street	S	1936	23.6	B	1780	27.7	B	1780	24.4	B	1893	24.7	B
45	Parramatta Road / Sloane Street	S	4495	20.6	B	4446	18.0	B	4589	22.4	B	4546	20.8	B
47	Parramatta Road / Old Canterbury Road / Tebbutt Street	S	4076	50.4	D	4450	33.9	C	4145	43.7	D	4156	27.9	B
50	Parramatta Road / Norton Street	S	3463	21.9	B	3624	18.0	B	3488	22.8	B	3374	22.3	B
51	Parramatta Road / Flood Street / West Street	S	4278	76.6	F	4730	89.3	F	4459	66.9	E	4324	144.3	F
52	Parramatta Road / Crystal Street / Balmain Road	S	4018	48.2	D	4245	33.8	C	4072	38.5	C	4012	38.4	C
53	Parramatta Road / Catherine Street / Phillip Street	S	3480	37.6	C	3751	45.3	D	3483	24.8	B	3554	35.5	C
67	Parramatta Road / Young Street / Percival Road	S	3571	25.3	B	3717	23.9	B	3557	34.7	C	3587	49.0	D
68	Parramatta Road /Northumberland Avenue / Johnston Street	S	4275	36.6	C	4332	35.7	C	4094	40.0	C	4171	58.0	E
69	Parramatta Road / Bridge Road	S	4060	38.5	C	4223	43.5	D	4012	53.1	D	4176	61.0	E
70	Parramatta Road /Pyrmont Bridge Road / Denison Street	S	4117	10.4	A	4245	9.2	A	4048	15.1	B	4249	11.1	A
71	Parramatta Road / Mallett Street	S	4225	54.9	D	4164	50.2	D	4120	53.7	D	4229	39.6	C
81	Parramatta Road / Dalhousie Street	S	3322	38.9	C	3350	32.5	C	3402	47.5	D	3274	47.8	D
83	Parramatta Road / Missenden Avenue / Lyons Road	S	3859	41.4	C	3900	55.6	D	3895	44.8	D	3874	46.7	D

Table 6-6 Intersection performance results – Do Minimum (PM Peak)

Intersection		Type	2026						2036					
			4:30PM – 5:30PM			5:30PM – 6:30PM			4:30PM – 5:30PM			5:30PM – 6:30PM		
			Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS
19	Marion Street / Norton Street	S	1650	22.7	B	1701	30.5	C	1736	103.8	F	1654	40.6	C
20	Marion Street / Leichhardt Street / Balmain Road	S	1245	29.8	C	1361	33.5	C	1290	37.9	C	1523	47.0	D
30	Pyrmont Bridge Road / Booth Street / Mallett Street	S	1921	41.4	C	1771	44.8	D	1996	31.4	C	1738	65.8	E
39	Parramatta Road / Liverpool Road	S	4637	29.0	C	4928	31.2	C	4821	44.0	D	4642	59.6	E
42	Tebbutt Street / Lords Road	S	1880	22.6	B	1894	19.8	B	1987	25.0	B	1744	70.3	E
44	Tebbutt Street / Hathern Street	S	2008	24.5	B	2091	25.1	B	2029	25.2	B	1982	67.2	E
45	Parramatta Road / Sloane Street	S	4654	33.0	C	4999	39.9	C	4854	30.1	C	4712	50.1	D
47	Parramatta Road / Old Canterbury Road / Tebbutt Street	S	3958	22.8	B	4239	13.4	A	4149	16.6	B	3802	76.3	F
50	Parramatta Road / Norton Street	S	3399	32.6	C	3561	56.9	E	3564	61.1	E	3613	51.1	D
51	Parramatta Road / Flood Street / West Street	S	4278	73.2	F	4529	64.9	E	4347	81.5	F	4041	106.4	F
52	Parramatta Road / Crystal Street / Balmain Road	S	3771	30.9	C	3957	53.0	D	3988	43.6	D	3691	46.8	D
53	Parramatta Road / Catherine Street / Phillip Street	S	3199	36.9	C	3318	78.1	F	3427	39.7	C	3177	57.0	E
67	Parramatta Road / Young Street / Percival Road	S	3041	14.5	A	3303	39.7	C	3289	17.7	B	3075	35.1	C
68	Parramatta Road /Northumberland Avenue / Johnston Street	S	3877	42.3	C	4255	82.9	F	4203	44.7	D	4096	78.7	F
69	Parramatta Road / Bridge Road	S	3533	50.9	D	3740	47.4	D	3741	47.6	D	3413	84.3	F
70	Parramatta Road /Pyrmont Bridge Road / Denison Street	S	3502	35.4	C	3817	43.2	D	3708	49.2	D	3477	44.4	D
71	Parramatta Road / Mallett Street	S	3682	32.3	C	4067	32.3	C	3823	36.3	C	3743	36.6	C
81	Parramatta Road / Dalhousie Street	S	3735	44.9	D	3957	101.5	F	3772	84.4	F	3807	86.8	F
83	Parramatta Road / Missenden Avenue / Lyons Road	S	3492	71.2	F	3875	114.9	F	3754	63.3	E	3731	109.5	F

Figure 6-7 and **Figure 6-8** show the intersection performance results on a map of the study area.

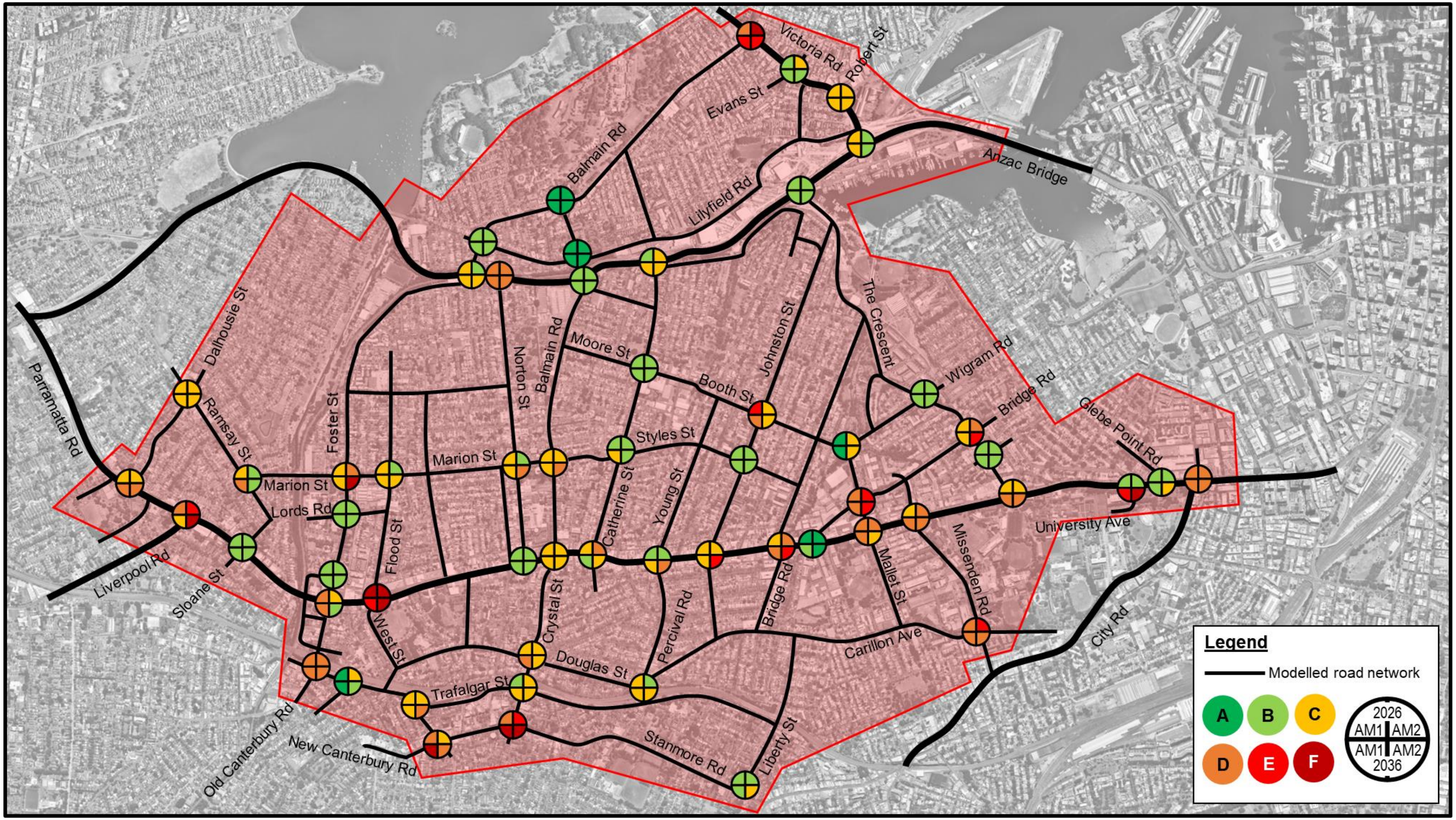


Figure 6-7 Intersection level of service – Do Minimum (AM Peak)

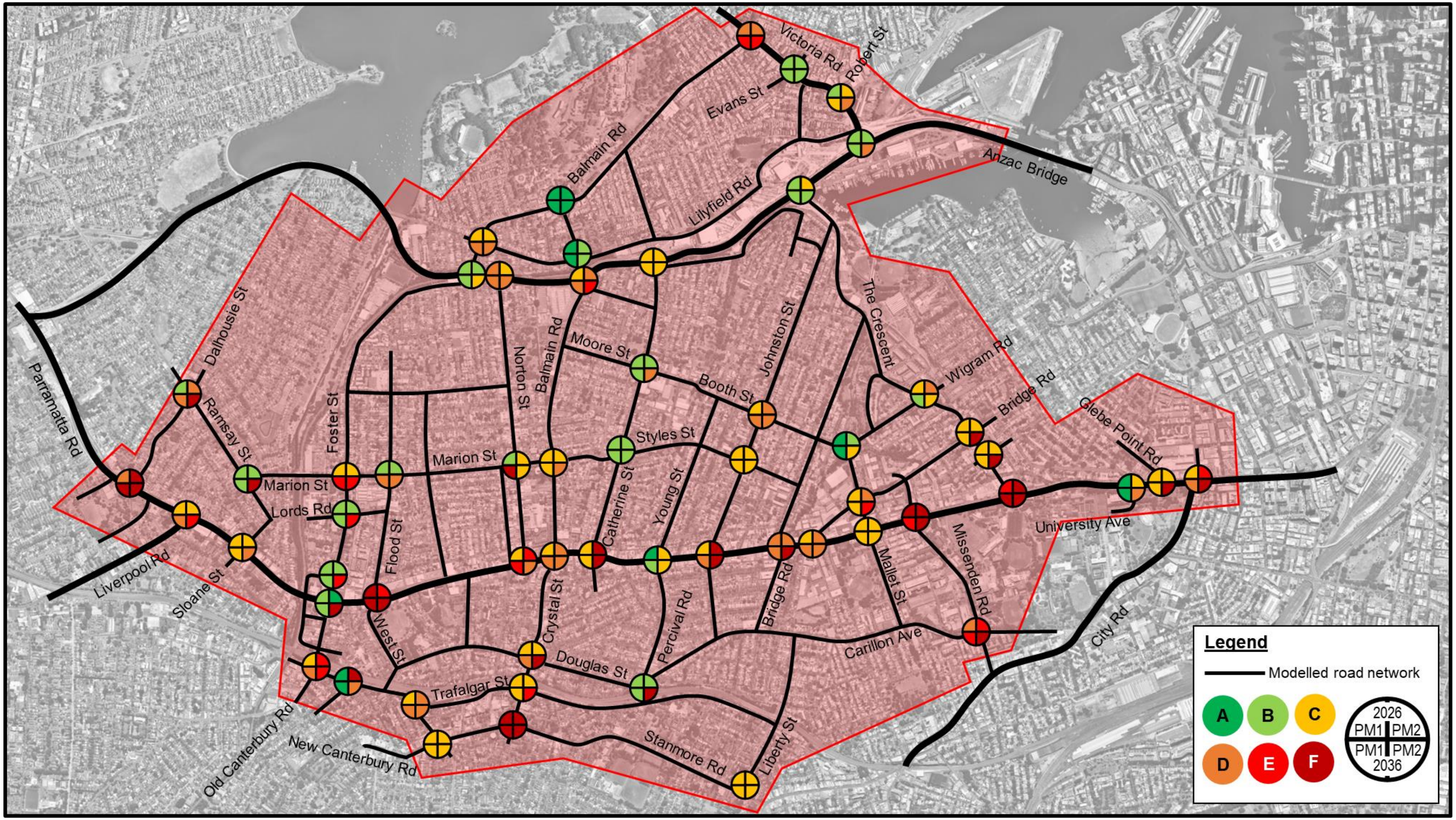


Figure 6-8 Intersection level of service – Do Minimum (PM Peak)

6.3.2 Queue lengths at major intersections

Table 6-7 shows the maximum queue length at major intersections along Parramatta Road in the PRCUTS precincts. On side roads, only queueing within the microsimulation area is included.

Table 6-7 Maximum queue length at major intersections in the PRCUTS precincts – Do Minimum

Intersection	Approach		Maximum queue length (m)			
			2026		2036	
			AM Peak	PM Peak	AM Peak	PM Peak
Parramatta Road / Dalhousie Street	N	Dalhousie Street	157	325	209	331
	E	Parramatta Road	91	88	93	90
	W	Parramatta Road	301	295	300	297
Parramatta Highway / Hume Highway	E	Parramatta Road	31	32	32	33
	S	Hume Highway	29	28	27	28
	W	Parramatta Road	139	136	99	136
Parramatta Road / Sloane Street	N	Sloane Street	44	54	49	60
	E	Parramatta Road	299	376	329	319
	S	Sloane Street	299	299	299	297
	W	Parramatta Road	302	144	302	174
Parramatta Road / Flood Street / West Street	N	Flood Street	231	239	205	240
	E	Parramatta Road	473	480	492	494
	S	West Street	74	69	73	74
	W	Parramatta Road	194	190	194	192
Parramatta Road / Norton Street	N	Norton Street	72	71	73	70
	E	Parramatta Road	119	118	113	114
	W	Parramatta Road	65	62	65	65
Parramatta Road / Crystal Street / Balmain Road	E	Parramatta Road	37	37	34	36
	S	Crystal Street	168	161	170	161
	W	Parramatta Road	116	125	121	123
Parramatta Road / Catherine Street	N	Catherine Street	185	186	176	183
	E	Parramatta Road	223	225	189	225
	S	Catherine Street	100	103	103	101
	W	Parramatta Road	52	50	52	43
Parramatta Road / Young Street / Percival Road	N	Young Street	105	105	107	113
	E	Parramatta Road	66	67	60	61
	S	Percival Road	84	62	91	73
	W	Parramatta Road	244	40	244	41
Parramatta Road / Johnston Street / Northumberland Avenue	N	Johnston Street	56	57	56	55
	E	Parramatta Road	82	82	93	84
	S	Northumberland Avenue	44	42	45	44
	W	Parramatta Road	200	251	243	251
Parramatta Road / Bridge Road	E	Parramatta Road	44	44	41	44
	S	Bridge Road	91	90	95	94
	W	Parramatta Road	34	31	33	34

Intersection	Approach		Maximum queue length (m)			
			2026		2036	
			AM Peak	PM Peak	AM Peak	PM Peak
Parramatta Road / Pyrmont Bridge Road / Denison Street	N	Pyrmont Bridge Road	73	157	81	187
	E	Parramatta Road	200	270	199	265
	W	Parramatta Road	37	40	40	35
Parramatta Road / Mallett Street	N	Mallett Street	81	80	80	81
	E	Parramatta Road	34	42	33	41
	S	Mallett Street	241	233	242	233
	W	Parramatta Road	264	33	262	39
Parramatta Road / Lyons Road / Missenden Road	N	Lyons Road	95	96	96	99
	E	Parramatta Road	181	489	211	494
	S	Missenden Road	226	224	187	229

6.4 Do Minimum network plots

6.4.1 Traffic density

Figure 6-9 to **Figure 6-12** show the simulated traffic density for the Do Minimum scenario. Traffic density is generally highest along Parramatta Road, and at major side road approaches to the corridor including Crystal Street, Catherine Street, Johnston Street and Mallett Street. In 2036, traffic density is also high on roads below the corridor such as Stanmore Road and Salisbury Road.

6.4.2 Speed ratio

Figure 6-13 to **Figure 6-16** show the simulated speed ratio for the Do Minimum scenario. Speed ratio is the average section speed as a proportion of the posted speed limit. The simulated speed ratio is low along Parramatta Road, particularly eastbound in the AM Peak and westbound in the PM Peak. Speed ratio is low on most approaches to signalised intersections along Parramatta Road, Victoria Road and City-West Link Road. In 2036, the speed ratio is reduced on parallel routes to Parramatta Road including Marion Street and Salisbury Road as vehicles reroute to avoid congestion along the main corridor.

6.4.3 Heavy vehicle proportions

Figure 6-17 to **Figure 6-20** show the proportion of the total traffic volume on each link that is heavy vehicles for the Do Minimum scenario. The proportion of heavy vehicles is significantly higher in the AM Peak than in the PM Peak on most roads.

In the AM Peak, the heavy vehicle percentage is highest on WestConnex, Victoria Road and Anzac Bridge. The heavy vehicle proportion on Parramatta is also between eight and 10 per cent. The main north-south routes used by heavy vehicles are Johnston Street, Balmain Road and Norton Street.

In the PM Peak, heavy vehicle proportions remain highest on WestConnex. The heavy vehicle proportion on Parramatta Road is between four and eight per cent at most locations. The main north-south route used by heavy vehicles is Balmain Road.

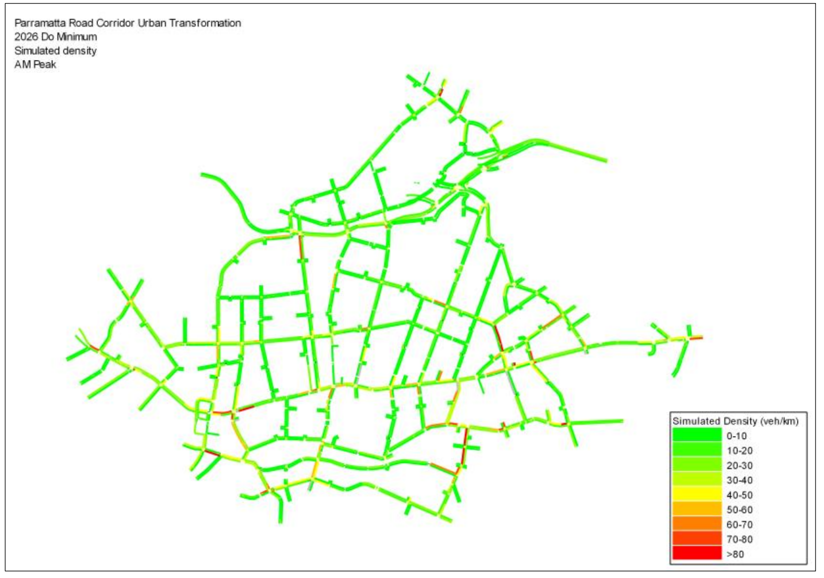


Figure 6-9 Simulated density – 2026 Do Minimum (AM Peak)

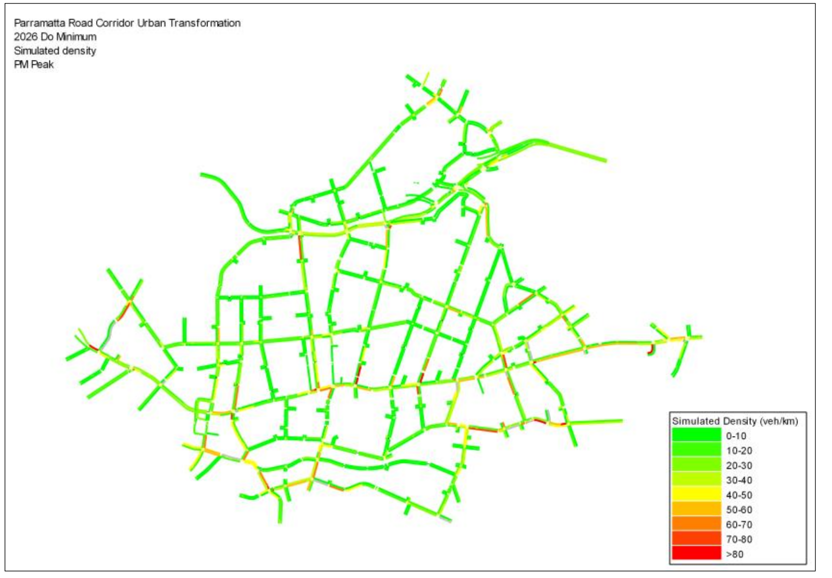


Figure 6-10 Simulated density – 2026 Do Minimum (PM Peak)

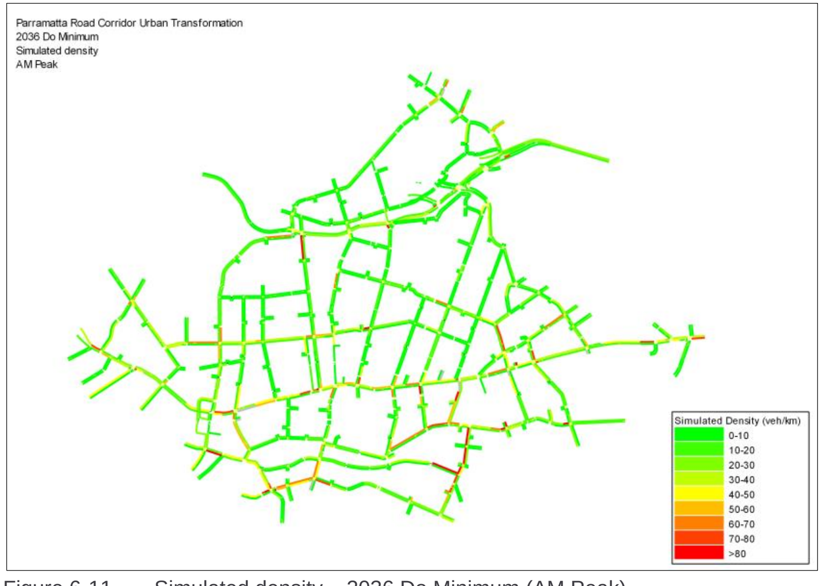


Figure 6-11 Simulated density – 2036 Do Minimum (AM Peak)

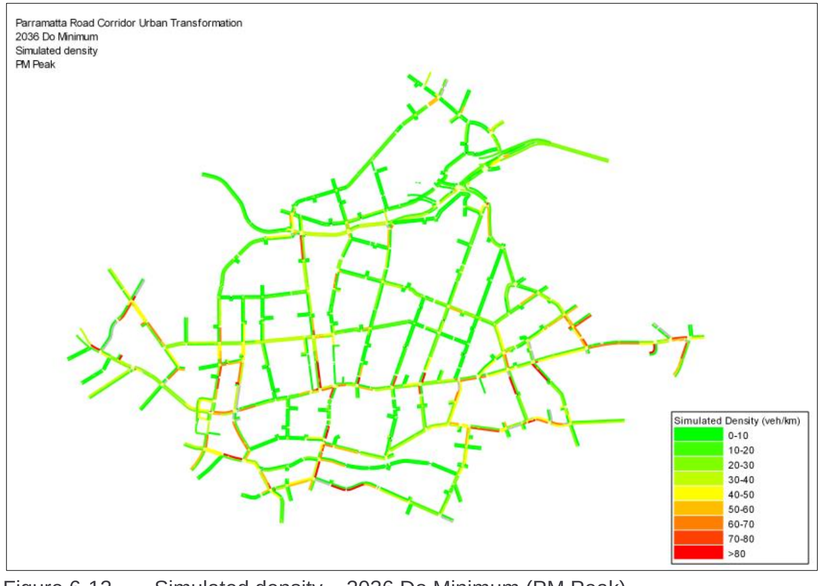


Figure 6-12 Simulated density – 2036 Do Minimum (PM Peak)

Figure 6-13 Speed ratio – 2026 Do Minimum (AM Peak)

Figure 6-14 Speed ratio – 2026 Do Minimum (PM Peak)

Figure 6-15 Speed ratio – 2036 Do Minimum (AM Peak)

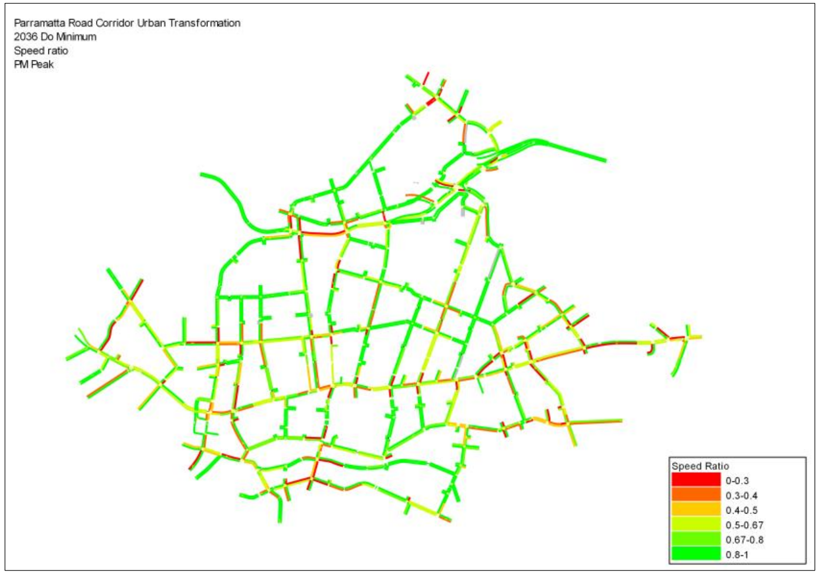


Figure 6-16 Speed ratio – 2036 Do Minimum (PM Peak)

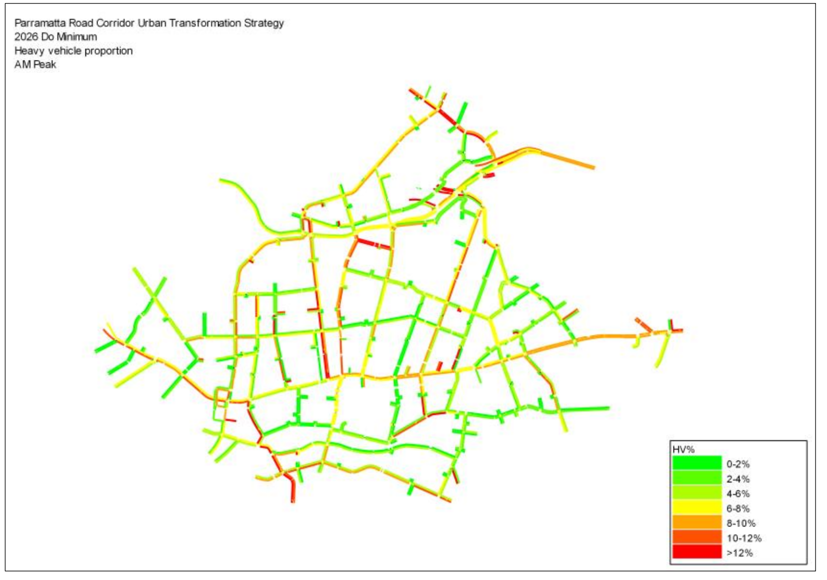


Figure 6-17 Heavy vehicle proportions – 2026 Do Minimum (AM Peak)

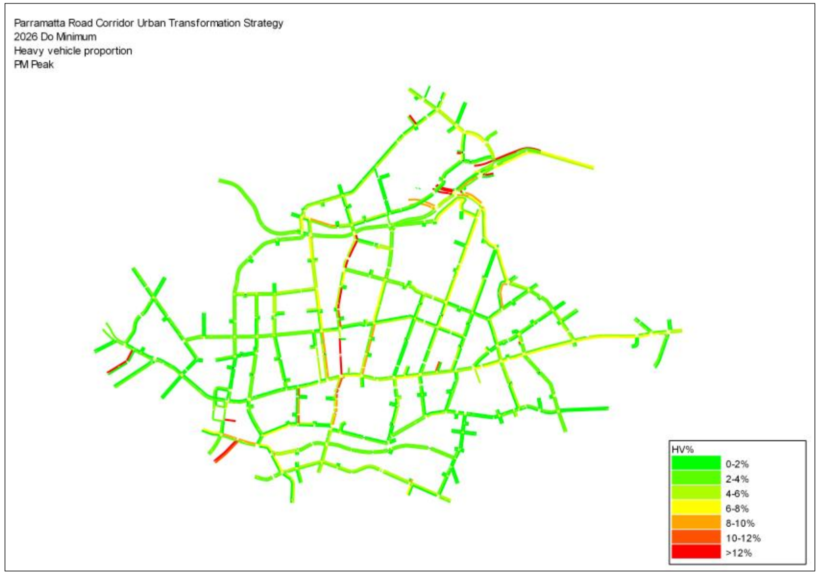


Figure 6-18 Heavy vehicle proportions – 2026 Do Minimum (PM Peak)

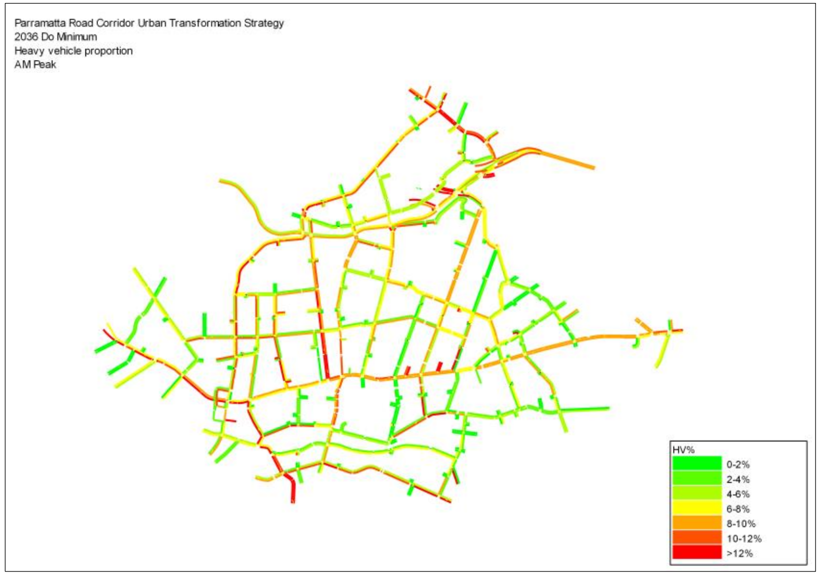


Figure 6-19 Heavy vehicle proportions – 2036 Do Minimum (AM Peak)

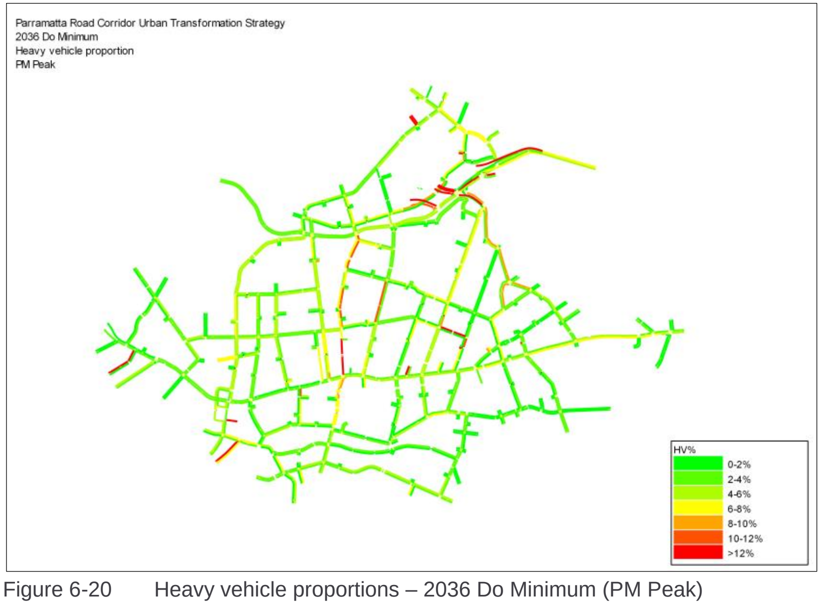


Figure 6-20 Heavy vehicle proportions – 2036 Do Minimum (PM Peak)

7 With Upgrades operational results

The With Upgrades model was used to optimise network performance by introducing localised infrastructure upgrades across the study area. The upgrades included were discussed in **Section 2.1.2**. As discussed in that section, the localised upgrades were Cardno's suggestions for how the traffic performance of the network could be improved, and are not endorsed by Council, DPIE, Transport for NSW or any other stakeholders. Further traffic modelling is suggested during the Concept and Detailed Design stages to assess the viability of these upgrades.

7.1 With Upgrades network performance

7.1.1 Network performance summary

Table 7-1 shows the network performance results for the With Upgrades scenario. The key findings are summarised below.

> The total traffic demand remains the same as the Do Minimum scenario.

> The number of vehicles arrived increases in all peaks. The increase is greatest in the PM Peak in each future year. In 2036, an additional 2554 vehicles arrive at their destination by the end of the simulation period. This is a result of reduced congestion throughout the network, fewer unreleased vehicles and fewer deleted vehicles.

> In 2026, the total distance travelled by all vehicles in the simulation (VKT) increase by 0.8 per cent in the AM Peak and 1.8 per cent in the PM Peak. In 2036, these increases are 1.8 per cent and 3.8 per cent respectively. This is also a result of reduced congestion throughout the network as more vehicles are able to complete their trips (ie travel further) in the simulation period.

> Vehicle hours travelled (VHT) reduces in both peaks. In 2026, the reduction is up to 4.6 per cent and in 2036 the reduction is up to 3.5 per cent. This is a result of lower congestion in the model which increases average speeds and decreases delay time.

> Average speed increases by 0.6 kilometres per hour in the 2026 AM Peak and by 0.3 kilometres per hour in the 2026 PM Peak. In 2036, these values are 0.4 and 0.3 respectively.

> Average delay decreases by five to 10 seconds in 2026 and by up to 18 seconds in 2036.

> The total of deleted and unreleased demand is reduced by 829 vehicles in the AM Peak and 993 vehicles in the PM Peak. Unreleased demand is discussed in the next section.

7.1.2 Person statistics

Table 7-2 shows key network statistics per person for the With Upgrades scenario based on the assumed vehicle occupancies outlined in **Section 3.2.1**.

Table 7-1 Network performance results – With Upgrades

Network performance metric	Unit	2026				2036			
		With Upgrades results		Compared to Base		With Upgrades results		Compared to Base	
		AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
All vehicles									
Total traffic demand	veh	80,193	87,443	0 (+0.0%)	0 (+0.0%)	85,587	93,628	0 (0.0%)	0 (0.0%)
Total vehicles arrived	veh	79,425	86,386	+521 (+0.7%)	+1213 (+1.4%)	82,289	89,139	+1050 (+1.3%)	+2554 (+3.1%)
Total kilometres travelled (VKT)	km	193,032	206,804	+1566 (+0.8%)	+3708 (+1.8%)	200,098	211,719	+4049 (+2.1%)	+7668 (+3.8%)
Vehicle hours travelled (VHT)	hr	7320	8251	-351 (-4.6%)	-338 (-3.9%)	8302	9597	-163 (-1.9%)	-301 (-3.5%)
Average per vehicle									
Average kilometres travelled	km	2.4	2.4	+0.0 (+0.2%)	+0.0 (+0.4%)	2.4	2.4	0 (+0.8%)	0 (+0.8%)
Average time travelled in network	s	141	143	-5 (-3.4%)	-10 (-6.4%)	153	164	-4 (-2.4%)	-18 (-10.6%)
Average speed	km/hr	30.6	31.3	+0.6 (+2.1%)	+0.3 (+0.9%)	29.2	29.6	+0.4 (+1.2%)	+0.3 (+1.2%)
Average delay	s	74	77	-5 (-6.3%)	-10 (-11.3%)	86	97	-4 (-4.3%)	-18 (-20.9%)
Unreleased demand									
Unreleased demand (% of total demand)	veh (%)	31 (0.0%)	107 (0.1%)	-42	-310	715 (0.8%)	472 (0.5%)	-40	-1367
Deleted vehicles (% of total demand)	veh (%)	147 (0.2%)	232 (0.3%)	-486	-91	343 (0.4%)	1273 (1.4%)	-789	374
Total unreleased and deleted (% of total demand)	veh (%)	178 (0.2%)	339 (0.4%)	-528	-401	1058 (1.2%)	1745 (1.9%)	-829	-993

Table 7-2 Network statistics by person – With Upgrades

Network performance metric	Unit	2026				2036			
		AM Peak		PM Peak		AM Peak		PM Peak	
		LV	HV	LV	HV	LV	HV	LV	HV
Network statistics by vehicle type									
Total vehicles arrived	veh	74,407	4547	83,272	2941	76,621	5196	85,652	3315
Total kilometres travelled (VKT)	km	179,861	11,824	199,010	7316	184,947	13,802	202,828	8414
Vehicle hours travelled (VHT)	hr	6779	459	7935	287	7619	597	9187	381
Average speed	km/hr	30.6	31.9	31.1	38.8	29.2	30.3	29.3	36.1
Average delay	s	74	69	78	55	86	81	98	72
Average per vehicle									
Total persons arrived	person	82,951	4547	92,833	2941	85,419	5196	95,487	3315
Total person-kilometres travelled	km	200,513	11,824	221,860	7316	206,183	13,802	226,117	8414
Total person-hours travelled	hr	7557	459	8846	287	8494	597	10,241	381
Average speed per person	km/hr	30.6	31.9	31.1	38.8	29.2	30.3	29.3	36.1
Average delay per person	s	83	69	87	55	96	81	110	72

7.1.3 Unreleased demand

Unreleased demand refers to vehicles that are unable to enter the study are by the end of the simulation period. This is caused by queueing on their arrival link that extends back to the edge of the study area. High unreleased demand is an indication of significant network congestion.

The following sections outline the total unreleased demand and locations of unreleased demand in the AM and PM peaks for the With Upgrades scenario.

AM Peak

- Unreleased demand in 2026 is 31 vehicles which represents a reduction of 42 vehicles compared to the Do Minimum. In 2036, the unreleased demand is 715 vehicles which is a reduction of 472 vehicles compared to the Do Minimum.
- In 2026, there was significant unreleased demand on Darling Street approaching Victoria Road, as well as on Western Avenue near Parramatta Road. Unreleased demand as these locations have been removed/reduced by localised intersection upgrades.
- Localised intersection upgrades in 2036 resulted in a reduction of unreleased demand on Shaw Street and Station Street. Unreleased demand on Old Canterbury Road and Parramatta Road was also significantly reduced.

PM Peak

- Unreleased demand in 2026 is 107 vehicles which represents a reduction of 310 vehicles compared to the Do Minimum. In 2036, the unreleased demand is 472 vehicles which is a reduction of 1367 vehicles compared to the Do Minimum.
- Localised intersection improvements around Ross Street remove significant unreleased demand on Bridge Road, St Johns Road and Western Avenue in 2026.
- In 2036, reduced congestion along Parramatta Road and its approaches leads to the removal/reduction of unreleased demand on Dalhousie Street, Tebbutt Street, Station Street, along Salisbury Road, around Bridge Rod and St Johns Road and Glebe Point Road. Some unreleased demand remains on Old Canterbury Road, Parramatta Road and Victoria Road.

Figure 7-1 Unreleased demand – 2026 With Upgrades (AM Peak)

Figure 7-2 Unreleased demand – 2026 With Upgrades (PM Peak)

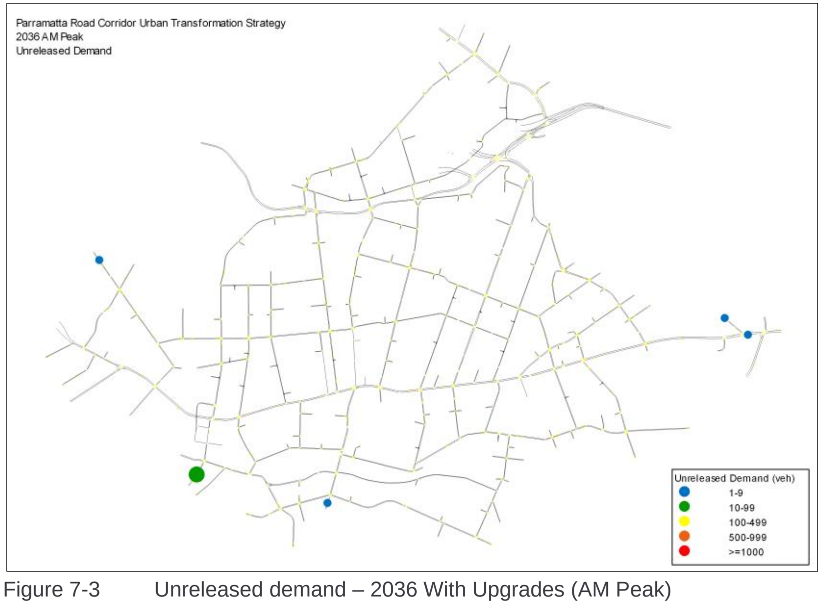


Figure 7-3 Unreleased demand – 2036 With Upgrades (AM Peak)

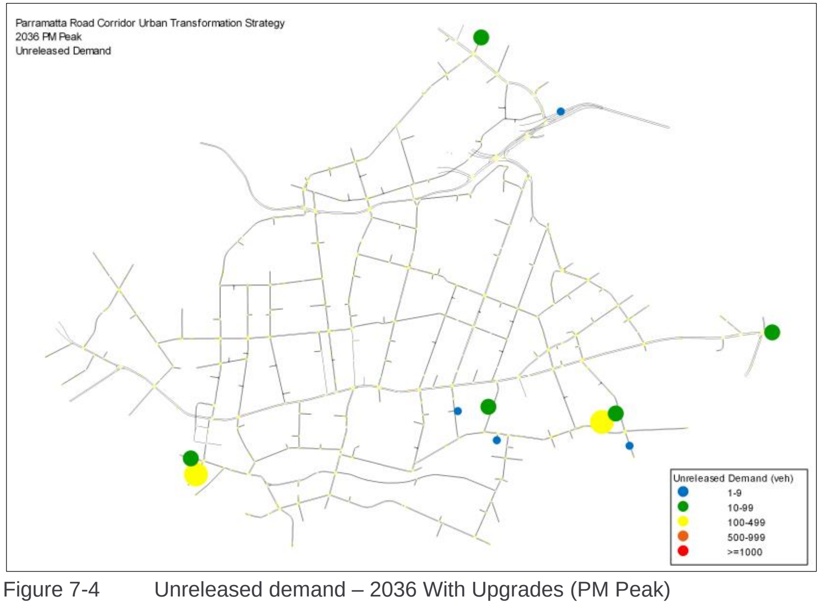


Figure 7-4 Unreleased demand – 2036 With Upgrades (PM Peak)

7.2 With Upgrades travel times

This section provides an overview of travel times on key routes and through the PRCUTS precincts in the 2026 and 2036 Do Minimum scenarios.

7.2.1 Travel times on key routes

Table 7-3 lists the modelled travel times on each route in the 2026 and 2036 Do Minimum scenarios. In general, the intersection upgrades improve the performance of Parramatta Road and reduce queueing on side road approaches. This reduces travel time on most routes compared to the Do Minimum scenario.

> The With Upgrades scenario provides improvements to travel times along Balmain Road in both peaks and future years. In 2026, travel times in the northbound direction are up to 15 seconds shorter than in the Do Minimum scenario, while those in the southbound direction are up to 16 seconds shorter. In 2036, the travel time savings are more extreme. In the 2036 PM Peak, travel times in the northbound direction are more than two minutes faster, while those in the southbound direction are 28 seconds shorter in the 2036 AM Peak.

> Travel times on Crystal Street generally improve in 2026, however travel times were longer in 2036 than in the Do Minimum scenario. This is one of the most congested areas of the model in both scenarios.

> Intersection improvements at Johnston Street reduce the southbound travel time by 109 seconds in 2026 and by 26 seconds in 2036. There are also improvements to travel times in the northbound direction in the AM Peak in both years.

> Travel times along Marion Street remain similar in 2026, but significantly improve in 2036, particularly in the PM Peak. Intersection improvements along Parramatta Road make Marion Street a less attractive rat-run which improves its performance. It is also less affected by queue spillback from Parramatta Road in the second hour of the peak.

> Travel times along Parramatta Road improve in both peaks and future years. Intersection improvements significantly reduced travel times in the westbound direction on Parramatta Road. In the 2026 AM Peak, travel times are reduced by 236 seconds, corresponding to an increase in average speed of 7.1 kilometres per hour. In the 2026 PM Peak, the reduction is 176 seconds. In 2036, 341 seconds are saved in the AM Peak in the westbound direction, corresponding to an average speed increase of 8.6 kilometres per hour compared to the Do Minimum scenario.

Note that the travel times shown in this table are for vehicles that traverse the full length of the route only.

Table 7-3 Travel times on key routes – With Upgrades

Route	Dir.	Do Minimum results				Compared to 2018 Base			
		Travel times (s)		Average speed (km/hr)		Travel times (s)		Average speed (km/hr)	
		AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
2026									
Balmain Road	NB	281	239	18.4	21.6	-7	-15	0.4	1.3
	SB	153	131	22.6	26.3	-16	-9	2.2	1.7
Crystal Street	NB	195	268	15.9	11.6	-4	82	0.3	-5.1
	SB	235	225	13.2	13.8	-3	-24	0.2	1.3
Johnston Street	NB	268	287	23.5	22.0	-19	4	1.6	-0.3
	SB	273	317	23.0	19.8	9	-109	-0.8	5.1
Marion Street	EB	245	219	22.8	25.6	2	5	-0.2	-0.7
	WB	284	199	19.7	28.1	23	-3	-1.8	0.4
Parramatta Road	EB	836	798	26.6	27.9	-67	-51	2.0	1.7
	WB	748	968	29.6	22.9	-236	-176	7.1	3.5
2036									
Balmain Road	NB	280	263	18.4	19.6	-44	-126	2.5	6.4
	SB	158	138	21.9	24.9	-28	-11	3.3	1.8
Crystal Street	NB	283	470	10.9	6.6	84	267	-4.6	-8.7
	SB	257	499	12.1	6.2	4	22	-0.2	-0.3
Johnston Street	NB	272	281	23.2	22.4	-26	-8	2.0	0.6
	SB	264	367	23.8	17.1	-14	-26	1.2	1.1
Marion Street	EB	311	252	18.0	22.2	-24	-169	1.3	8.9
	WB	286	222	19.6	25.3	7	-92	-0.5	7.4
Parramatta Road	EB	1058	837	21.0	26.5	-176	-74	3.0	2.2
	WB	781	1136	28.3	19.5	-341	-14	8.6	0.2

7.2.2 Travel times through precincts

Table 7-4 shows the modelled travel time through each precinct in each direction. Overleaf, **Figure 7-5** and **Figure 7-6** show travel times through each precinct along Parramatta Road for the eastbound and westbound directions respectively.

AM Peak

> Eastbound travel time through Taverners Hill is reduced from the Do Minimum scenario in both 2026 and 2036. In 2026, the reduction is 50 seconds and 27 seconds in 2036.

> Eastbound travel time through Leichhardt is also reduced, with the most significant reductions occurring in the AM Peak. In 2026, the reduction is 34 seconds and in 2036 it is 43 seconds.

> The most significant reduction in the precinct travel time is through Leichhardt in the westbound direction. In the Do Minimum scenario, the travel time in 2026 was 359 seconds and in 2036 it was 430 seconds. With upgrades, these are reduced to 217 seconds and 242 seconds, a saving of over three minutes by 2036.

PM Peak

> Travel times through Taverners Hill are reduced in the eastbound direction by up to 51 seconds. Travel times are slightly increased in the westbound direction which is caused by intersection and signal optimisation to reduce queueing on side roads.

> Travel times also slightly increase in the westbound direction through Leichhardt in both future years.

> Through Camperdown, travel times decreased in both future years, with the greatest decrease occurring in the westbound direction in 2026.

Table 7-4 Precinct travel times – With Upgrades

Direction	Travel time through precinct (s)					
	2026			2036		
	Taverners Hill	Leichhardt	Camperdown	Taverners Hill	Leichhardt	Camperdown
AM Peak						
Eastbound	257	293	157	264	489	190
Westbound	244	217	99	261	242	104
PM Peak						
Eastbound	261	304	150	312	332	147
Westbound	224	342	177	227	420	233

Note that the travel times shown in these graphs are the cumulative sum of the travel times of each section along the route, so include vehicles that only traverse part of the route.

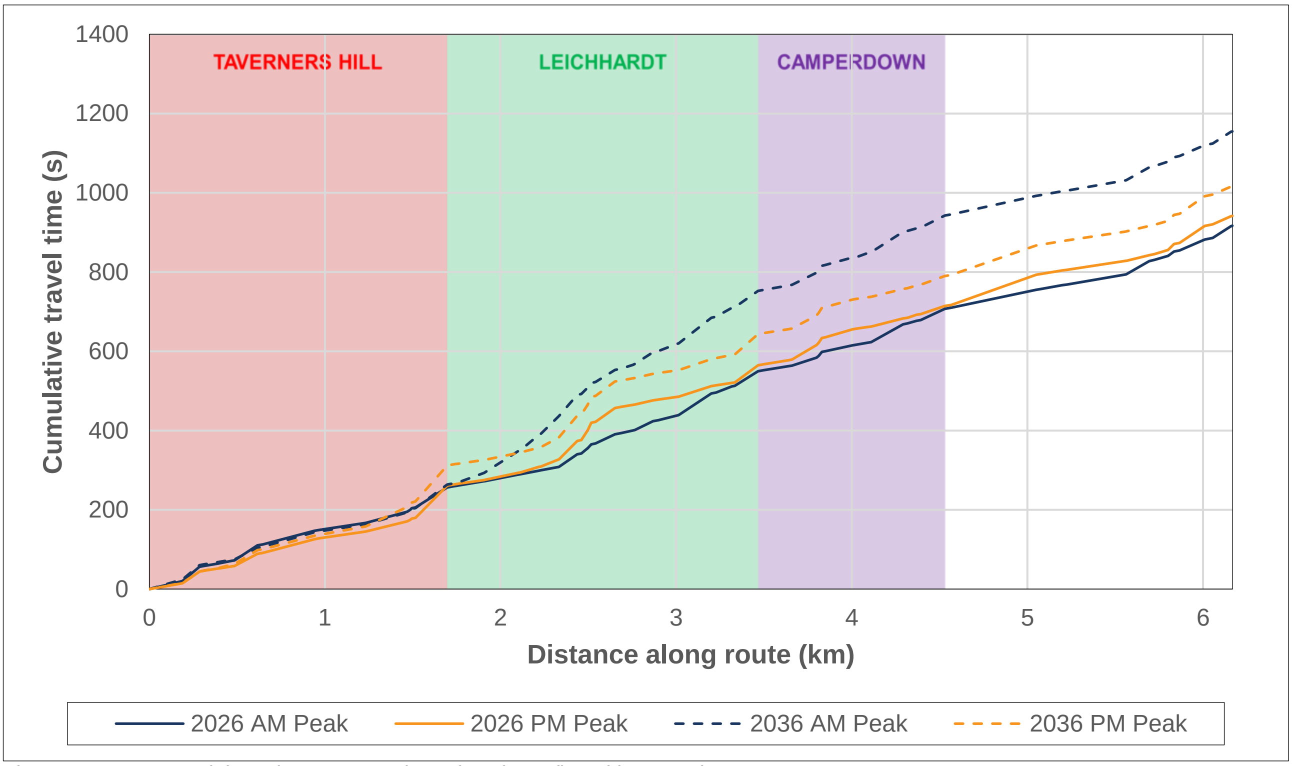


Figure 7-5 Travel times between precincts (eastbound) –With Upgrades

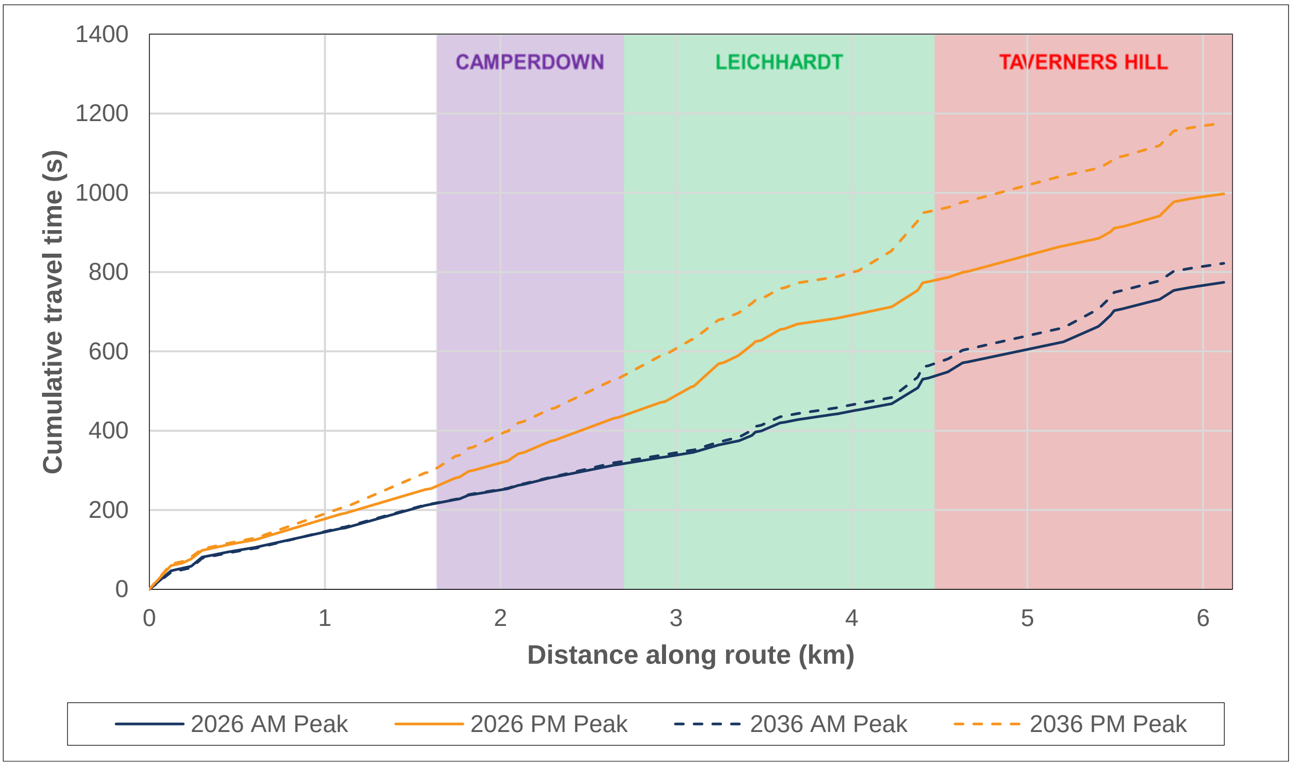


Figure 7-6 Travel times between precincts (westbound) – With Upgrades

7.3 With Upgrades intersection performance

This section provides an overview of intersection performance in the study area in the With Upgrades scenario. The results shown are for intersections in the PRCUTS precincts. Detailed performance results for all intersections assessed are provided in **Appendix H**.

7.3.1 Intersection operation

Table 7-5 and **Table 7-6** show the intersection performance results for the AM and PM peaks respectively.

The following sections provide a brief summary of the turns, movements and intersections where there is a notable improvement in performance between the Do Minimum scenario and corresponding With Upgrades scenario. In general, the modelled upgrades provide additional capacity for the side road approaches to Parramatta Road. This reduces the average delay on these approaches. In some cases, the green time for side roads could be reduced due to additional turn lanes (ie higher capacity), which provides benefits for traffic on Parramatta Road.

AM Peak

Table 7-5 shows the intersection performance for key intersections in the study area. **Figure 7-7** shows the performance of these intersections on a map of the study area.

> Upgrades at Booth Street improve the overall intersection performance from LOS D/E in the 2036 Do Minimum scenario to LOS C/C in the 2036 With Upgrades scenario. All movements on Booth Street have acceptable delays (LOS C or better), in comparison to the Do Minimum scenario where they were LOS F.

> While Parramatta Road / Flood Street / West Street remains over capacity in 2036, with upgrades, the average delay is reduced from 144 seconds (LOS F) to 62 seconds (LOS E) in the second hour of the AM Peak. Average delay is also reduced on the West Street and Flood Street approaches, although these remain LOS F.

> At Percival Road and Young Street, average delays on the side roads are reduced by intersection upgrades, but overall intersection performance remains LOS D.

> The overall performance of Parramatta Road / Northumberland Avenue / Johnston Street is improved, with the average delay in the second hour decreased from 58 seconds (LOS E) to 46 seconds (LOS D).

> Performance of Parramatta Road / Bridge Road improves as the average delay decreases from 61 seconds (LOS E) to 33 seconds (LOS C).

> Performance of Parramatta Road / Missenden Road / Lyons Road is improved from LOS D to LOS C in 2036.All movements on Missenden Road except the right turn experience average delays less than 52 seconds (corresponding to LOS D), while in the Do Minimum scenario, these movements were all LOS E or F.

PM Peak

Table 7-6 shows the intersection performance for key intersections in the study area. **Figure 7-8** shows the performance of these intersections on a map of the study area.

> Intersection improvements at Pyrmont Bridge Road / Booth Street / Mallett Street improve the overall intersection performance. In 2036, overall delay in the second hour is reduced from 66 seconds (LOS E) to 50 seconds (LOS D), and delays on Booth street and Mallett Street are reduced with upgrades.

> Queue spillback on Parramatta Road affecting Tebbutt Street is greatly reduced with the upgrades, which improves the performance of Tebbutt Street / Lords Road and Tebbutt Street / Hathern Road. Both intersections perform acceptably in 2036 with upgrades.

> Although the performance of Parramatta Road / Flood Street / West Street remains LOS F in 2036, upgrades to the side road approaches reduce their average delays. Flood street in the PM Peak experiences up to 845 seconds delay in 2036 Do Minimum, but with upgrades, this is reduced to 295.

> Maximum delay on Young Street decreases from 141 seconds to 92 seconds with upgrades.

> While remaining over capacity, overall delay at Parramatta Road / Northumberland Avenue / Johnston Street is reduced from 79 seconds (LOS F) to 62 seconds (LOS E) in the second hour.

> The performance of Parramatta Road / Bridge Road improves from LOS D/F to LOS C/D in 2036.

> Parramatta Road / Missenden Road / Lyons Road remains over capacity, however the average delay is decreased from 110 seconds to 85 seconds. Improvements on Lyons Road and Missenden Road reduce the average delays associated with these approaches, but they remain LOS F.

Table 7-5 Intersection performance results – With Upgrades (AM Peak)

Intersection		Type	2026						2036					
			7:15AM – 8:15AM			8:15AM – 9:15AM			7:15AM – 8:15AM			8:15AM – 9:15AM		
			Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS
19	Marion Street / Norton Street	S	1705	35.6	C	2008	39.8	C	1705	35.6	C	2008	39.8	C
20	Marion Street / Leichhardt Street / Balmain Road	S	1364	30.5	C	1604	51.8	D	1364	30.5	C	1604	51.8	D
30	Pyrmont Bridge Road / Booth Street / Mallett Street	S	1845	39.4	C	1964	50.4	D	1845	39.4	C	1964	50.4	D
39	Parramatta Road / Liverpool Road	S	4640	39.4	C	4933	48.0	D	4640	39.4	C	4933	48.0	D
42	Tebbutt Street / Lords Road	S	1979	23.4	B	2028	22.2	B	1979	23.4	B	2028	22.2	B
44	Tebbutt Street / Hathern Street	S	1960	18.7	B	2159	33.6	C	1960	18.7	B	2159	33.6	C
45	Parramatta Road / Sloane Street	S	4682	26.5	B	5039	39.5	C	4682	26.5	B	5039	39.5	C
47	Parramatta Road / Old Canterbury Road / Tebbutt Street	S	4038	13.9	A	4290	41.7	C	4038	13.9	A	4290	41.7	C
50	Parramatta Road / Norton Street	S	3384	53.2	D	3533	32.3	C	3384	53.2	D	3533	32.3	C
51	Parramatta Road / Flood Street / West Street	S	4357	74.6	F	4438	153.0	F	4357	74.6	F	4438	153.0	F
52	Parramatta Road / Crystal Street / Balmain Road	S	4006	54.0	D	3847	71.5	F	4006	54.0	D	3847	71.5	F
53	Parramatta Road / Catherine Street / Phillip Street	S	3614	52.7	D	3516	40.8	C	3614	52.7	D	3516	40.8	C
67	Parramatta Road / Young Street / Percival Road	S	3488	40.8	C	3362	27.6	B	3488	40.8	C	3362	27.6	B
68	Parramatta Road /Northumberland Avenue / Johnston Street	S	4116	62.3	E	4155	62.4	E	4116	62.3	E	4155	62.4	E
69	Parramatta Road / Bridge Road	S	4028	38.7	C	4027	51.0	D	4028	38.7	C	4027	51.0	D
70	Parramatta Road /Pyrmont Bridge Road / Denison Street	S	4087	40.2	C	4152	44.8	D	4087	40.2	C	4152	44.8	D
71	Parramatta Road / Mallett Street	S	3769	36.1	C	3747	30.8	C	3769	36.1	C	3747	30.8	C
81	Parramatta Road / Dalhousie Street	S	3788	67.2	E	4007	87.0	F	3788	67.2	E	4007	87.0	F
83	Parramatta Road / Missenden Avenue / Lyons Road	S	3812	44.0	D	3794	85.4	F	3812	44.0	D	3794	85.4	F

Table 7-6 Intersection performance results – With Upgrades (PM Peak)

Intersection		Type	2026						2036					
			4:30PM – 5:30PM			5:30PM – 6:30PM			4:30PM – 5:30PM			5:30PM – 6:30PM		
			Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS	Vol. (veh)	Delay (s)	LOS
19	Marion Street / Norton Street	S	1714	23.0	B	1791	29.3	C	1705	35.6	C	2008	39.8	C
20	Marion Street / Leichhardt Street / Balmain Road	S	1322	28.7	C	1399	33.9	C	1364	30.5	C	1604	51.8	D
30	Pyrmont Bridge Road / Booth Street / Mallett Street	S	1878	44.2	D	1987	47.6	D	1845	39.4	C	1964	50.4	D
39	Parramatta Road / Liverpool Road	S	4572	29.2	C	4969	33.4	C	4640	39.4	C	4933	48.0	D
42	Tebbutt Street / Lords Road	S	1819	20.7	B	1796	17.9	B	1979	23.4	B	2028	22.2	B
44	Tebbutt Street / Hathern Street	S	1852	17.9	B	1959	18.5	B	1960	18.7	B	2159	33.6	C
45	Parramatta Road / Sloane Street	S	4654	28.3	B	5080	31.6	C	4682	26.5	B	5039	39.5	C
47	Parramatta Road / Old Canterbury Road / Tebbutt Street	S	4042	17.9	B	4345	11.2	A	4038	13.9	A	4290	41.7	C
50	Parramatta Road / Norton Street	S	3360	30.3	C	3489	33.8	C	3384	53.2	D	3533	32.3	C
51	Parramatta Road / Flood Street / West Street	S	4472	83.1	F	4753	71.0	F	4357	74.6	F	4438	153.0	F
52	Parramatta Road / Crystal Street / Balmain Road	S	3805	44.9	D	3918	51.2	D	4006	54.0	D	3847	71.5	F
53	Parramatta Road / Catherine Street / Phillip Street	S	3472	53.2	D	3501	57.3	E	3614	52.7	D	3516	40.8	C
67	Parramatta Road / Young Street / Percival Road	S	3338	13.4	A	3338	30.3	C	3488	40.8	C	3362	27.6	B
68	Parramatta Road /Northumberland Avenue / Johnston Street	S	3963	35.5	C	4188	51.6	D	4116	62.3	E	4155	62.4	E
69	Parramatta Road / Bridge Road	S	4093	37.9	C	4228	35.1	C	4028	38.7	C	4027	51.0	D
70	Parramatta Road /Pyrmont Bridge Road / Denison Street	S	4080	25.0	B	4317	34.9	C	4087	40.2	C	4152	44.8	D
71	Parramatta Road / Mallett Street	S	3737	27.6	B	3942	28.9	C	3769	36.1	C	3747	30.8	C
81	Parramatta Road / Dalhousie Street	S	3708	45.9	D	4036	61.3	E	3788	67.2	E	4007	87.0	F
83	Parramatta Road / Missenden Avenue / Lyons Road	S	3603	36.7	C	3899	41.3	C	3812	44.0	D	3794	85.4	F

Figure 7-7 and **Figure 7-8** show the intersection performance results on a map of the study area.

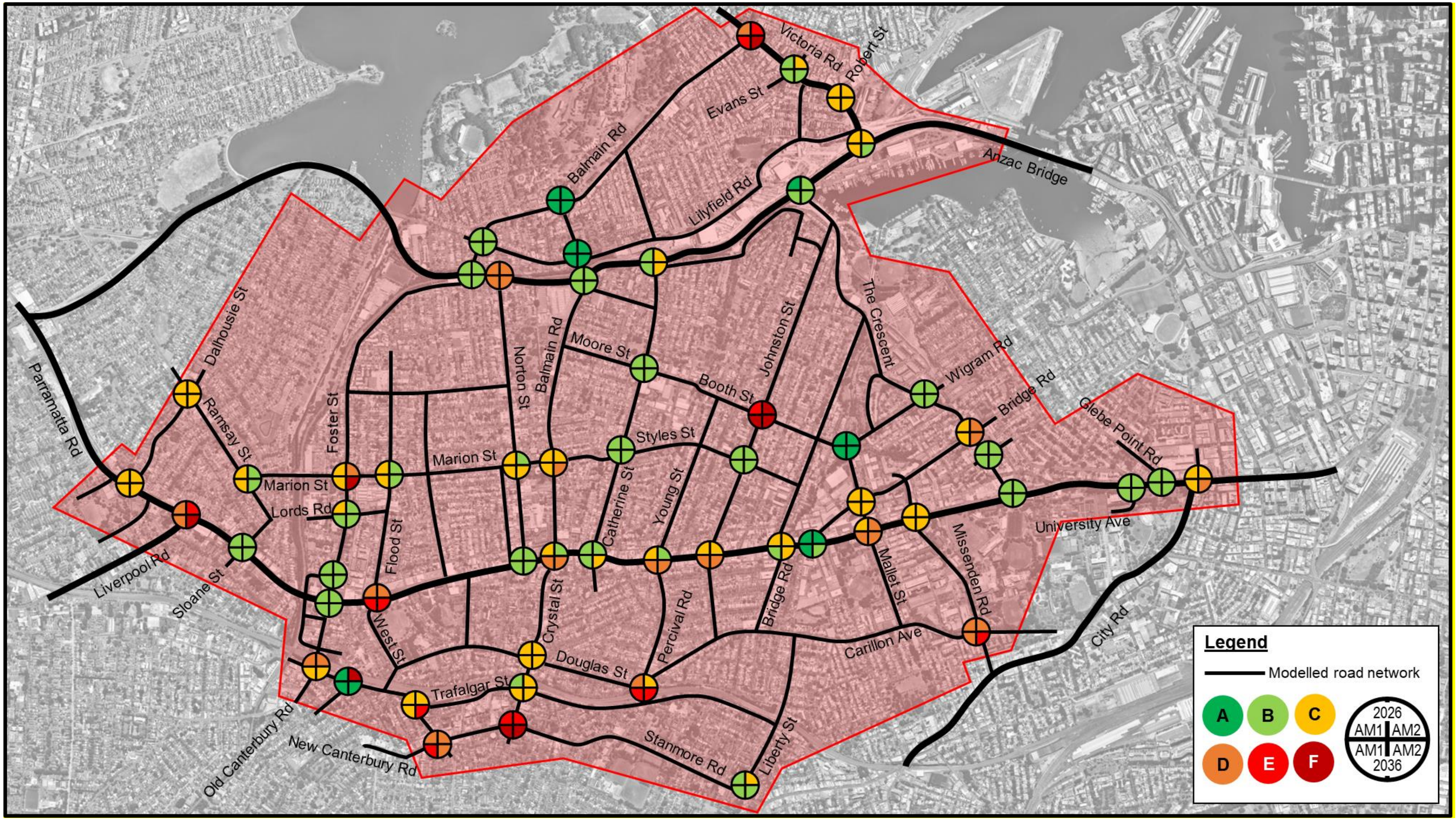


Figure 7-7 Intersection level of service – With Upgrades (AM Peak)

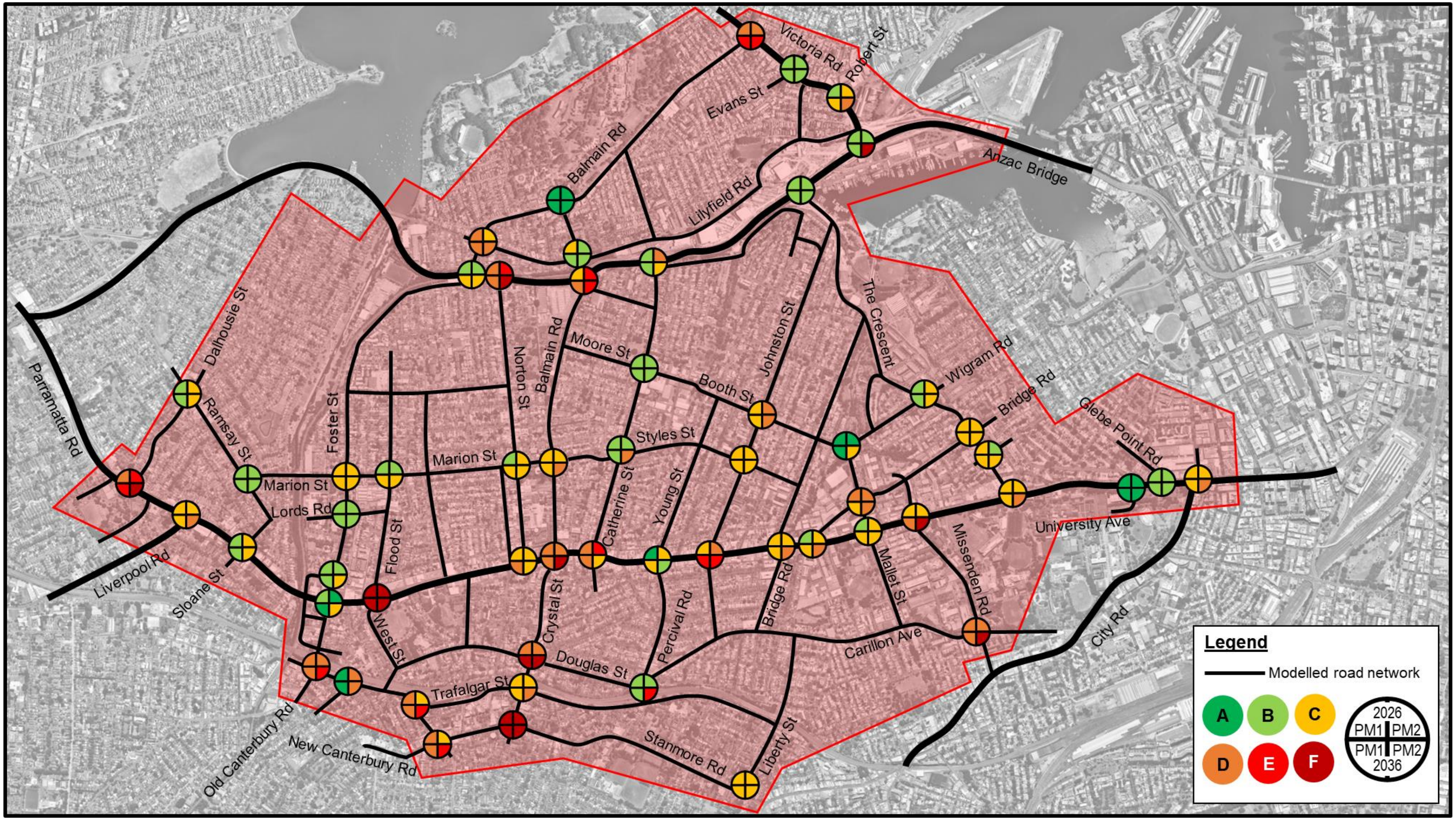


Figure 7-8 Intersection level of service – With Upgrades (PM Peak)

7.3.2 Queue lengths at major intersections

Table 7-7 shows the maximum queue length at major intersections along Parramatta Road in the PRCUTS precincts. On side roads, only queueing within the microsimulation area is included.

Table 7-7 Maximum queue length at major intersections in the PRCUTS precincts – With Upgrades

Intersection	Approach		Maximum queue length (m)			
			2026		2036	
			AM Peak	PM Peak	AM Peak	PM Peak
Parramatta Road / Dalhousie Street	N	Dalhousie Street	129	322	169	329
	E	Parramatta Road	94	91	95	93
	W	Parramatta Road	301	291	301	295
Parramatta Highway / Hume Highway	E	Parramatta Road	31	29	31	32
	S	Hume Highway	30	24	30	28
	W	Parramatta Road	140	133	110	137
Parramatta Road / Sloane Street	N	Sloane Street	41	50	51	54
	E	Parramatta Road	345	379	312	334
	S	Sloane Street	299	299	299	297
	W	Parramatta Road	304	153	306	143
Parramatta Road / Flood Street / West Street	N	Flood Street	232	238	221	240
	E	Parramatta Road	491	484	481	496
	S	West Street	70	70	69	66
	W	Parramatta Road	193	193	189	193
Parramatta Road / Norton Street	N	Norton Street	74	72	75	76
	E	Parramatta Road	111	113	116	113
	W	Parramatta Road	69	62	67	65
Parramatta Road / Crystal Street / Balmain Road	E	Parramatta Road	36	35	36	35
	S	Crystal Street	169	168	171	172
	W	Parramatta Road	115	122	119	116
Parramatta Road / Catherine Street	N	Catherine Street	148	186	127	149
	E	Parramatta Road	42	226	45	225
	S	Catherine Street	100	104	103	105
	W	Parramatta Road	52	52	52	48
Parramatta Road / Young Street / Percival Road	N	Young Street	104	88	105	105
	E	Parramatta Road	57	68	57	68
	S	Percival Road	82	49	83	83
	W	Parramatta Road	243	34	244	41
Parramatta Road / Johnston Street / Northumberland Avenue	N	Johnston Street	50	56	56	56
	E	Parramatta Road	87	83	93	91
	S	Northumberland Avenue	45	37	43	43
	W	Parramatta Road	78	245	59	256
Parramatta Road / Bridge Road	E	Parramatta Road	80	84	79	85
	S	Bridge Road	95	89	97	89
	W	Parramatta Road	34	33	34	33

Intersection	Approach		Maximum queue length (m)			
			2026		2036	
			AM Peak	PM Peak	AM Peak	PM Peak
Parramatta Road / Pyrmont Bridge Road / Denison Street	N	Pyrmont Bridge Road	111	192	116	205
	E	Parramatta Road	201	263	202	266
	W	Parramatta Road	39	33	39	38
Parramatta Road / Mallett Street	N	Mallett Street	129	84	131	112
	E	Parramatta Road	41	41	39	41
	S	Mallett Street	242	243	243	239
	W	Parramatta Road	259	42	269	43
Parramatta Road / Lyons Road / Missenden Road	N	Lyons Road	96	96	98	93
	E	Parramatta Road	168	210	164	488
	S	Missenden Road	88	132	67	226

7.4 With Upgrades network plots

7.4.1 Traffic density

Figure 7-9 to **Figure 7-12** show the simulated traffic density for With Upgrades scenario. The density results are similar across the network to the Do Minimum scenario, however the impact of localised upgrades can be seen in reduced densities on side roads to Parramatta Road, on Booth Street, along Salisbury Road and on Liberty Street.

7.4.2 Speed ratio

Figure 7-13 to **Figure 7-16** show the simulated speed ratio for the With Upgrades scenario. Speed ratio is the average section speed as a proportion of the posted speed limit. The With Upgrades scenario shows improvements to the speed ratio, particularly on side roads with intersection upgrades including Liverpool Road, Booth Street and Missenden Road.

7.4.3 Heavy vehicle proportions

Figure 7-17 to **Figure 7-20** show the proportion of the total traffic volume on each link that is heavy vehicles. The proportion of heavy vehicles is significantly higher in the AM Peak than in the PM Peak on most roads. There is no significant change to the heavy vehicle distribution with upgrades.

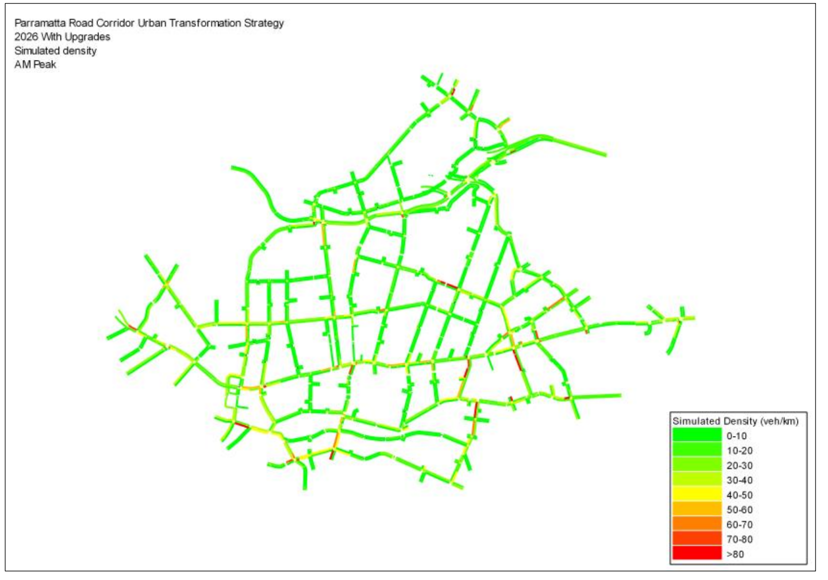


Figure 7-9 Simulated density – 2026 With Upgrades (AM Peak)

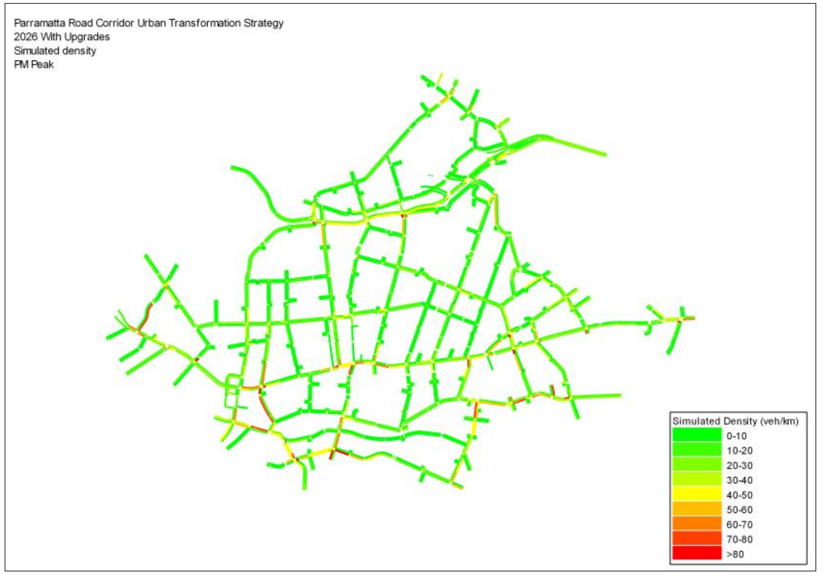


Figure 7-10 Simulated density – 2026 With Upgrades (PM Peak)

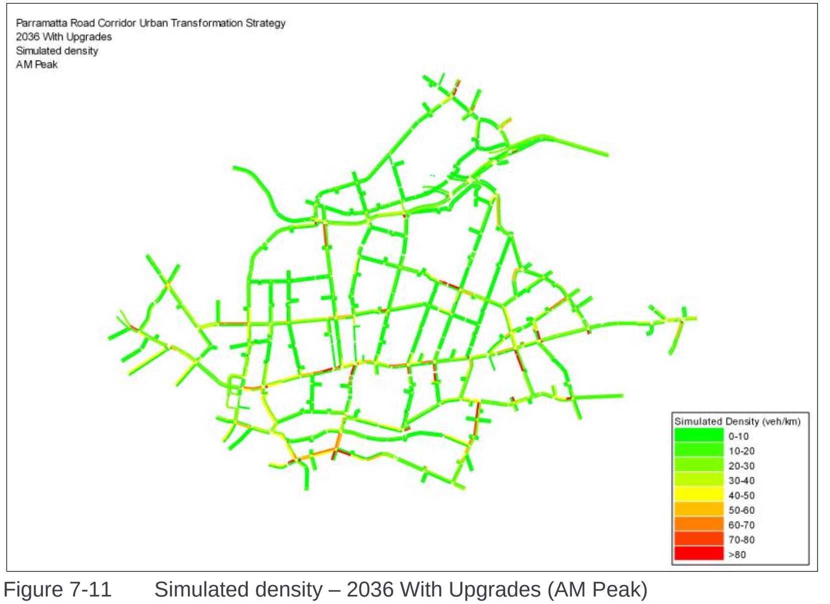


Figure 7-11 Simulated density – 2036 With Upgrades (AM Peak)

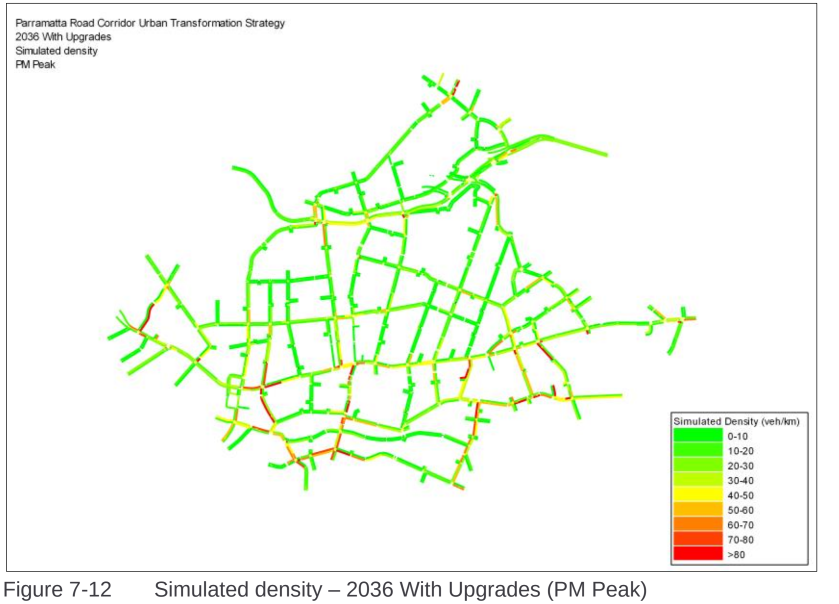


Figure 7-12 Simulated density – 2036 With Upgrades (PM Peak)

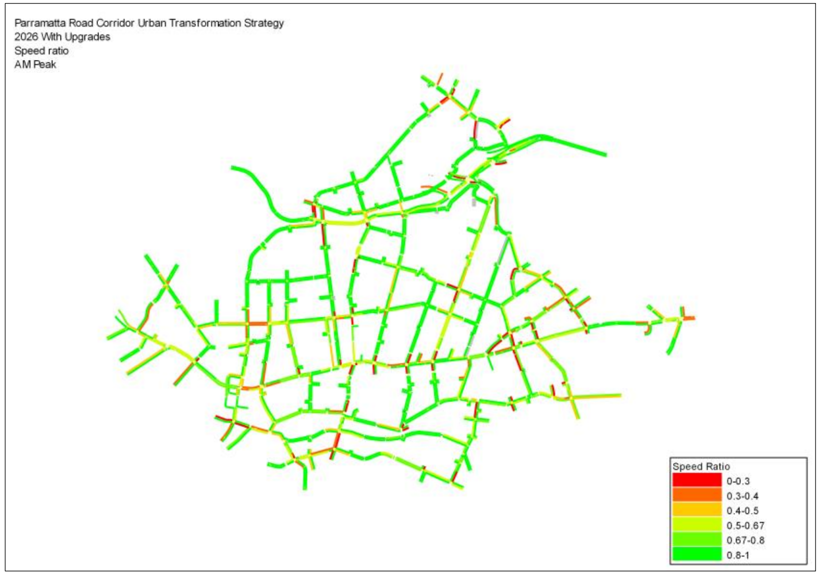


Figure 7-13 Speed ratio – 2026 With Upgrades (AM Peak)

Figure 7-14 Speed ratio – 2026 With Upgrades (PM Peak)

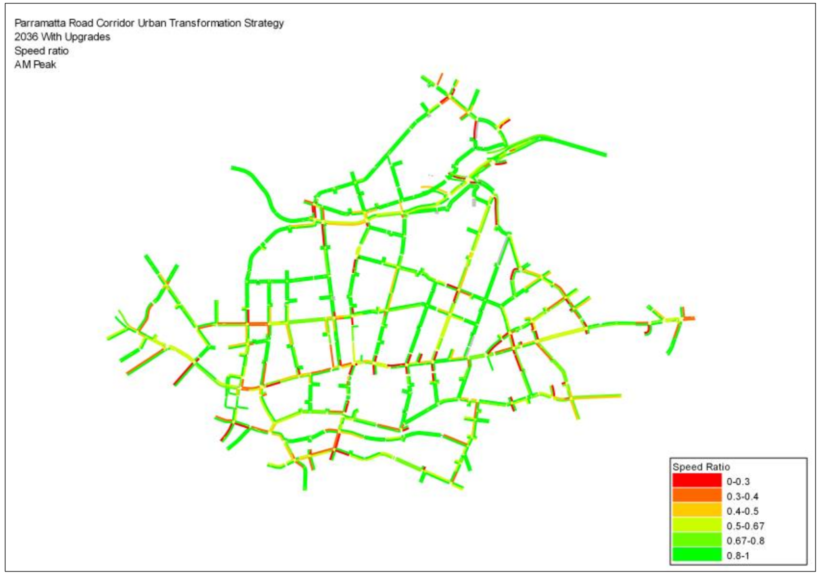


Figure 7-15 Speed ratio – 2036 With Upgrades (AM Peak)

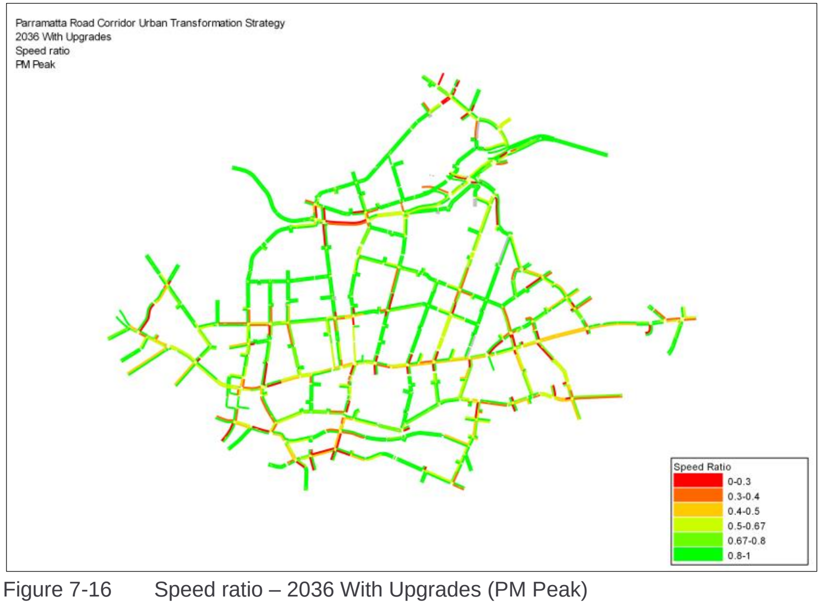


Figure 7-16 Speed ratio – 2036 With Upgrades (PM Peak)

Figure 7-17 Heavy vehicle proportions – 2026 With Upgrades (AM Peak)

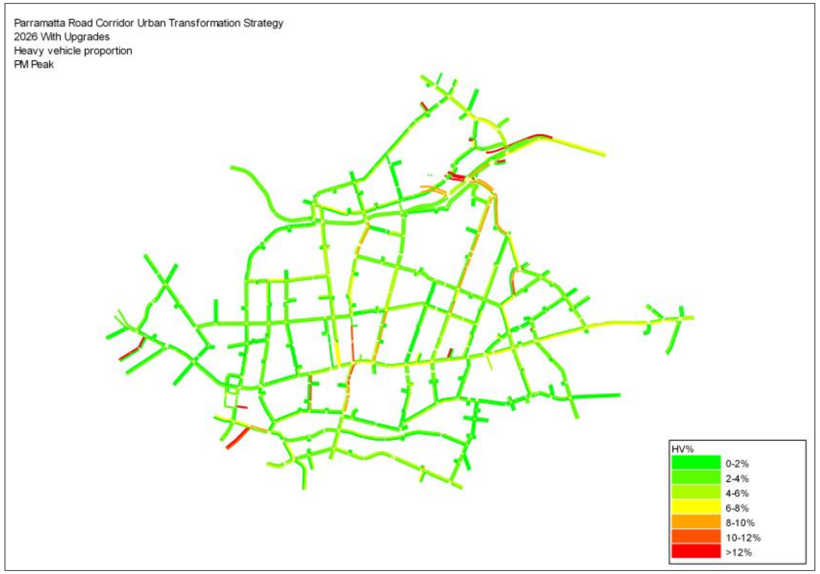


Figure 7-18 Heavy vehicle proportions – 2026 With Upgrades (PM Peak)

Figure 7-19 Heavy vehicle proportions – 2036 With Upgrades (AM Peak)

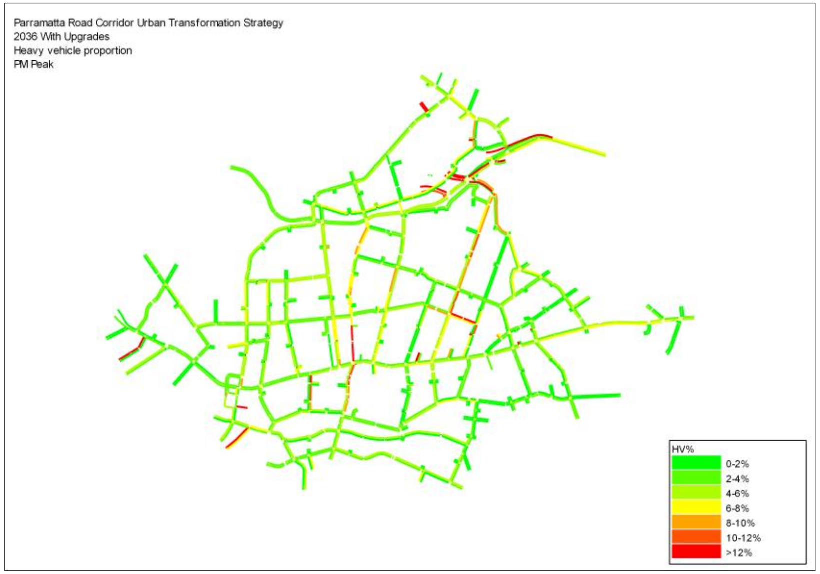


Figure 7-20 Heavy vehicle proportions – 2036 With Upgrades (PM Peak)

8 Conclusion

This report documents the development and results of the hybrid mesoscopic / microscopic model of the Parramatta Road corridor through Taverners Hill, Leichhardt and Camperdown, and the surrounding road network. The purpose of the study was to assess the impact of traffic demands on the operation of the corridor after the opening of the WestConnex interchange. The model will be used to develop strategies to cater for that demand. The following scenarios were modelled in detail:

> Base / Do Nothing
> Do Minimum.

Two peaks were modelled to capture typical weekday operation:

> 7:15AM – 9:15AM
> 4:30PM – 6:30PM.

A summary of the main findings is presented below.

> The traffic demand increased by 11,598 trips in the AM Peak and 12,301 trips in the PM Peak between 2018 and 2026. The increase between 2026 and 2036 was 5394 and 6185 trips respectively.
> The key findings of the Do Minimum scenario are:
  - The total distance travelled by all vehicles in the simulation increases in both future years, but by proportionally less than the demand increase which results in a lower average kilometres travelled per vehicle
  - Vehicle hours travelled also increases in both future years, but network improvements including WestConnex result in an increase in average speed between 2018 and 2026
  - Average delay increases in each future year, with the greatest increase in the PM Peak in both years
  - Up to three per cent of the total demand is either unreleased or deleted due to congestion across the network
  - Travel times on most routes increase, although there is a short-term decrease in travel times on Parramatta Road due to upgrades at West Street and Crystal Street
  - Many side road approaches to Parramatta Road are over capacity by 2026 and/or 2036 which results in long queues and significant approach delays.
> The localised upgrades were Cardno's suggestions for how the traffic performance of the network could be improved, and are not endorsed by Council, DPIE, Transport for NSW or any other stakeholders. Further traffic modelling is suggested during the Concept and Detailed Design stages to assess the viability of these upgrades.
> The key findings of the With Upgrades scenario are:
  - The upgrades resulted in an increased number of vehicles arrived within the simulation period, fewer unreleased vehicles and fewer deleted vehicles across all peaks
  - Vehicle kilometres travelled increased as more vehicles were able to complete their trips
  - Vehicle hours travelled decreased in all peaks as a result of less congestion within the study area
  - Average speed across the network increased with the upgrades and average delay time decreased by up to 18 seconds in 2036
  - Less than 0.4 per cent of the total demand was unreleased or deleted in 2026, and less than two per cent in 2036
  - The upgrades provided travel time improvements to key routes across the study area including Parramatta Road in both directions
  - Intersection performance was improved at most key locations, particularly for side road movements, by providing additional capacity such as dedicated turning lanes and/or dual turning lanes.

APPENDIX

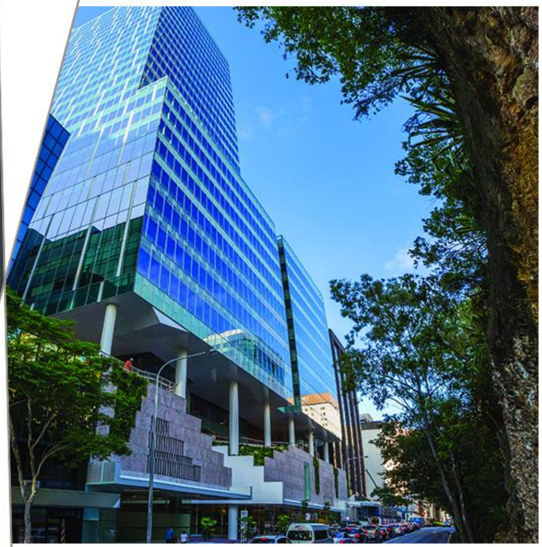
A

BASE MODEL DEVELOPMENT REPORT

Base Model Development Report

Parramatta Road Corridor Urban Transformation Strategy

80018116



Prepared for

Department of Planning, Industry and Environment

28 October 2020

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Document History

Version	Effective Date	Description of Revision	Prepared by	Reviewed by
1	12/04/2019	Draft	Kevin Wu Stephen Payne	Ghaith Farfour
2	29/10/2020	Response to comments	Stephen Payne	Siavash Shahsavaripour

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1 Introduction

1.1 Project background

Cardno was engaged by Department of Planning, Industry and Environment (DPIE) to investigate the traffic network along the Parramatta Road corridor within the Inner West Council (IWC) local government area. The study involves the development of a hybrid (microscopic/mesoscopic) traffic simulation model using Aimsun, and the analysis of key sites on Parramatta Road using SIDRA Intersection. The purpose of the study is to better inform future minor traffic and safety works.

Figure 1-1 shows the regional context of the study area. The study area is located in the Inner West suburbs of Sydney approximately five kilometres south west of the CBD. The Parramatta Road is a key arterial road corridor connecting the Sydney CBD to the metropolitan centre of Parramatta, as well as other major destinations in inner western Sydney.

The boundary of the Parramatta Road corridor traffic model, the software platform and the locations and types of traffic surveys for input into the model development have been previously endorsed Inner West Council (IWC), Department of Planning, Industry and Environment (DPIE) and Transport for NSW (TfNSW) and used as the basis for developing the base mode.

This report documents the development, calibration and validation of the hybrid Aimsun model. A separate report was previously submitted detailing the SIDRA Intersection analysis (*SIDRA Base Model Development Report*, Cardno, April 2019).

1.2 Project objectives

The objectives of the Parramatta Road Corridor Urban Transformation Study (PRCUTS) are to:

- Evaluate the impacts of future infrastructure upgrades and trip reassignment in the study area on Parramatta Road and other major corridors
- Investigate future developments and land use changes in the study area
- Asses the maximum network capacity and recommended public transport mode shift
- Investigate optimal configuration of intersection improvements at key locations.

1.3 Scope of works

The traffic modelling scope of work for this traffic study is as follows:

- Review existing relevant works, previous traffic studies and development patterns in the Parramatta Road study area
- Conduct traffic surveys and undertake analysis of the historical trends and existing traffic conditions within the study area
- Use existing strategic models to estimate current and future demands across the study area
- Develop, calibrate and validate a Base Model to capture existing conditions on a typical weekday in the study area to establish a reliable and robust platform for future year testing, in accordance with the following guidelines:
  - *Traffic Modelling Guidelines* (Roads and Maritime Services, 2017)
  - *Technical Direction TTD 2018/002: Traffic signals in microsimulation modelling* (Roads and Maritime Services, 2018)
  - *Technical Direction TTD 2017/001: Operational modelling reporting structure* (Roads and Maritime Services, 2018).

Develop future year scenarios to assess the operation of Parramatta Road and the surrounding network in the future

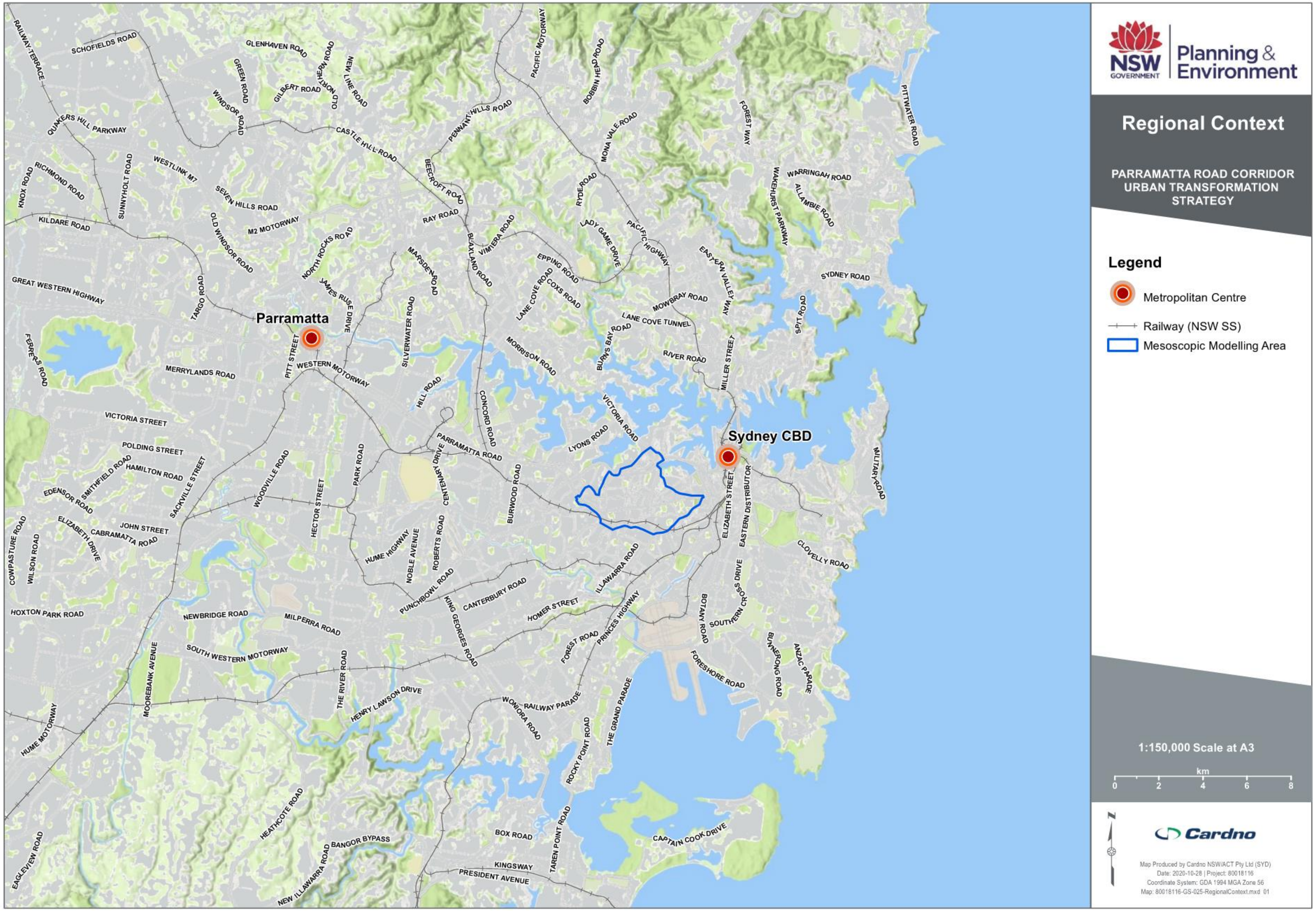


Figure 1-1 Regional context

1.4 Stakeholders

The key stakeholders for this project are:

> Department of Planning, Industry and Environment (DPIE)[1]

> Inner West Council (IWC)

> Transport for NSW (TfNSW)[2].

1.5 Report outline

This report documents the Base Model development process, including discussion of the modelling assumptions, stability, calibration and validation process, limitations and conclusions. It follows the *Operational Modelling Reporting Structure* (Roads and Maritime Services, 2017) and is intended to be read in isolation from previous reporting.

The structure of this report is outlined below:

> **Section 1 – Introduction**

> **Section 2 – Existing conditions**: discussion of the study area, explanation of the data inputs used in the study including classified intersection counts, travel time data and signal timings, and existing congestion locations

> **Section 3 – Model assumptions**: explanation of the study methodology and discussion of the assumptions underlying the development of the Base Model

> **Section 4 – Model stability**: statistical analysis of the stability of the Base Model

> **Section 5 – Model calibration and validation**: summary of the Base Model calibration and validation results

> **Section 6 – Limitations**: discussion of the limitations of the Base Model that could affect future modelling, and suggestions for accounting for these limitations in future year model outputs

> **Section 7 – Conclusions**.

[1] Formerly Department of Planning and Environment until 1 July 2019
[2] Roads and Maritime Services existed as a separate agency until it was dissolved and functions transferred to Transport for NSW on 1 December 2019

2 Existing conditions

2.1 Study area

The study area encompasses the precincts of Taverners Hill, Leichhardt and Camperdown which are all within the IWC local government area. **Figure 2-1** shows these precincts along Parramatta Road.

The study area includes the following key links:

> Parramatta Road (Great Western Highway) between Haberfield and Ultimo including key intersections with Liverpool Road (Hume Highway), Pyrmont Bridge Road and City Road (Princes Highway). Parramatta Road is a major east-west route connecting the Sydney CBD to the Inner West, Strathfield, Lidcombe and Parramatta. At the western extent of the study area, Parramatta Road connects to the M4 East, twin tunnels between Haberfield and Homebush. On the calibration date (17 October 2018), the M4 East was under construction. It was subsequently opened on 13 July 2019

> City-West Link Road between the Anzac Bridge in Rozelle and Dobroyd Point. This road forms part of the Western Distributor, a key link connecting North Sydney (via the Harbour Bridge) to Western Sydney. To the west of the study area, City-West Link Road connects to Parramatta Road and the M4 East

> Victoria Road between City-West Link Road and Parramatta River. Victoria Road is a major north-south arterial road that connects the Western Distributor to Balmain, Rozelle, Drummoyne, Lane Cove and Ryde

> Stanmore Road runs east-west along the southern edge of the study area. Stanmore Road connects to Enmore Road and King Street (Princes Highway) to the east of the study area and links Inner West suburbs Newtown, Petersham, Lewisham and Dulwich Hill to Old Canterbury Road.

The study area includes key trip generators (origins) and trip attractors (destinations) within the Inner West including three railway stations, seven light rail stops, commercial centres Leichhardt, Rozelle and Camperdown, the University of Sydney, Princes Alfred Hospital, numerous schools, parks, sports fields and light industries. Residential areas are generally low to medium density across the study area, with some high-density apartment complexes in Glebe, Lewisham and around the University of Sydney.

Figure 2-2 shows the study area.

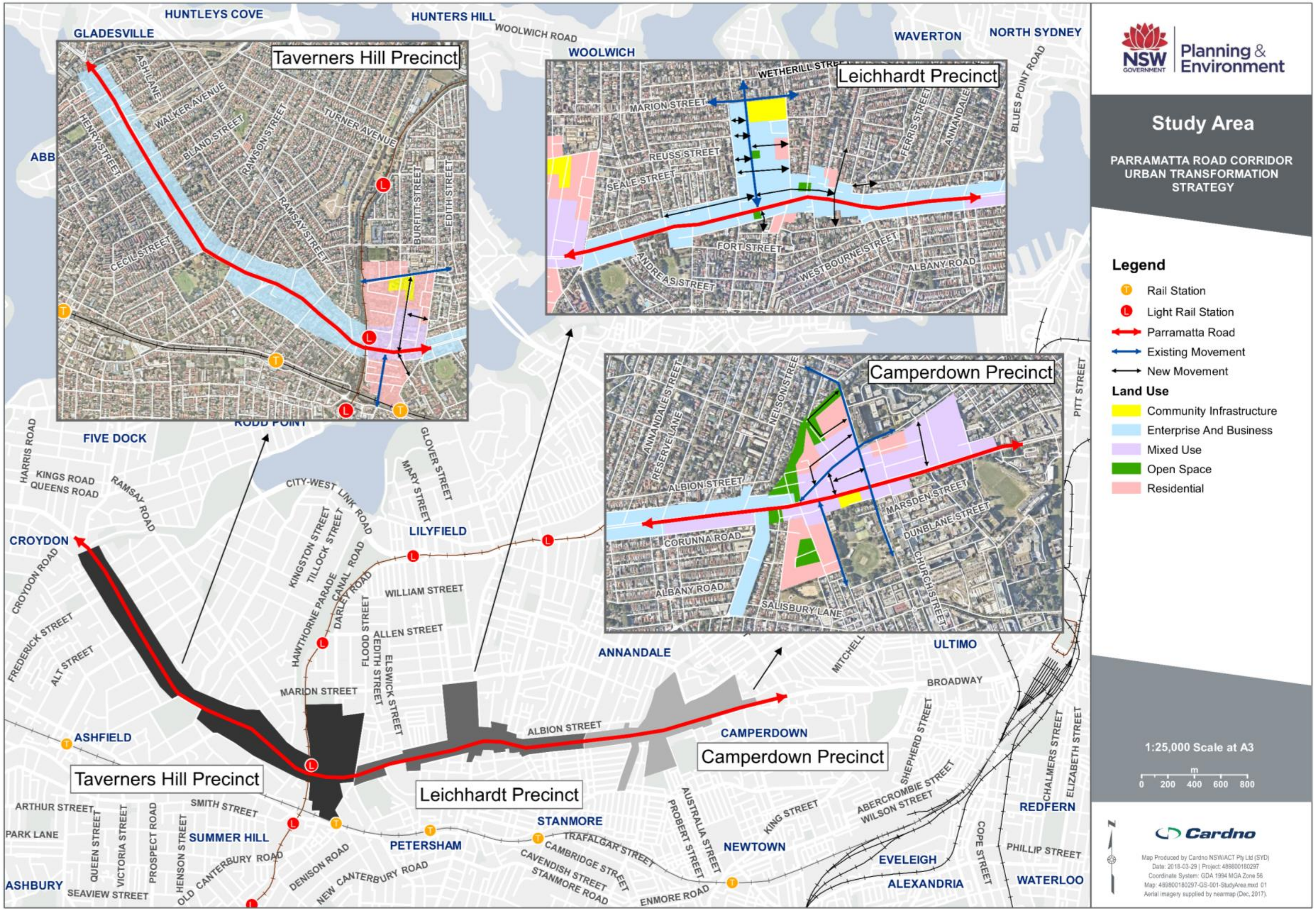


Figure 2-1 IWC precincts along Parramatta Road

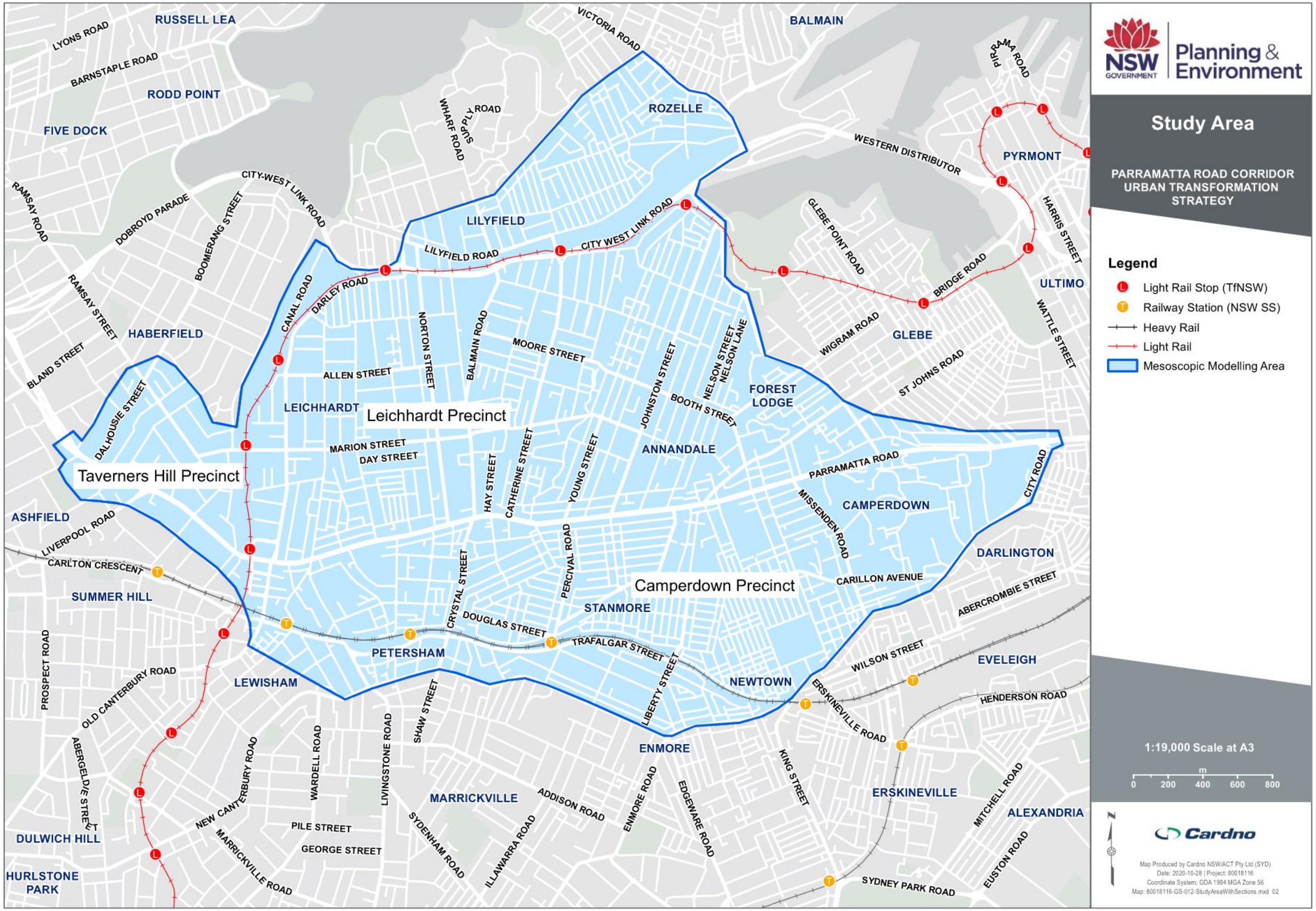


Figure 2-2 Study area

2.2 Data inputs

Traffic models rely on a range of survey inputs to capture existing conditions including vehicle routing, driver behaviour and congestion hotspots. The more data that is used in the development of a model, the better the model can replicate existing conditions to provide a more reliable and robust basis for future year assessments.

The data set for the microsimulation model was compiled from the following sources:

> Cordon matrices from the Sydney Transport Forecast Model (STFM) provided by TfNSW
> Classified intersection counts undertaken at 88 locations in 2018
> Travel time data from TomTom
> Average speed data from TomTom
> Traffic signal data obtained from TfNSW.

The data collected for each of the above categories is outlined in the following sections.

2.2.1 Cordon matrices

TfNSW provided traffic matrices from the STFM for 2016.The cordon matrices consisted of 96 centroids made up of:

> 51 internal travel zones wholly or partially within the study area
> 31 external gates
> Three railway station centroids
> Nine light rail stop centroids
> One ferry wharf centroid
> One container terminal centroid.

The locations and STFM zoning structure is discussed in **Section 3.6**.

2.2.2 Classified intersection counts

Classified intersection counts record vehicle movements for all approaches to an intersection. The number of vehicles making each turn are used in the development of the Base Model to ensure that the modelled volumes are reflective of those in reality.

Classified intersection counts were undertaken for 88 intersections on Wednesday 17 October 2018. The counts were classified into the following classes:

> Light vehicles (cars)
> Heavy vehicles (trucks)
> Pedestrians.

The classified intersection counts were undertaken for the following four-hour periods in each peak:

> 6:00AM – 10:00AM
> 3:00PM – 7:00PM.

Table 2-1 lists the survey locations for classified intersection counts. Following the table, **Figure 2-3** shows these locations on a map of the study area.

Table 2-1 Classified intersection count survey locations

Survey ID	Intersection	Type[3]
1	Victoria Road / Darling Street	S
2	Victoria Road / Evans Street	S
3	Victoria Road / Robert Street	S
4	Balmain Road / Cecily Street / Park Drive	S
5	Balmain Road / Lilyfield Road	S
6	The Crescent / Victoria Road	S
7	Balmain Road / Perry Street / Wharf Road	S
8	City-West Link Road / The Crescent	S
9	City-West Link Road / Norton Street	S
10	City-West Link Road / Brenan Street / Balmain Road	S
11	City-West Link Road / Brenan Street / Catherine Street	S
12	Catherine Street / Piper Street	P
13	Catherine Street / Moore Street	S
14	Styles Street / Catherine Street	S
15	Balmain Road / Moore Street	S
16	Grove Street and O'Neill Lane	P
17	Salisbury Road / Carillon Avenue / Church Street	S
18	Norton Street / Allen Street	S
19	Marion Street / Norton Street	S
20	Marion Street / Leichhardt Street / Balmain Road	S
21	Young Street / Collins Street	R
22	Johnston Street / Collins Street	S
23	Johnston Street / Booth Street	S
24	Lilyfield Road / Lamb Street	P
25	Johnston Street / Rose Street	P
26	The Crescent / Nelson Street	R
27	Booth Street / Wigram Road	R
28	Minogue Crescent / Wigram Road	S
29	Ross Street / Bridge Road	S
30	Pyrmont Bridge Road / Booth Street / Mallett Street	S
31	Allen Street / Elswick Street	R
32	Allen Street / Flood Street	R
33	Allen Street / Foster Street / Darley Road	R

Survey ID	Intersection	Type[3]
34	Marion Street / Foster Street	S
35	Marion Street / Flood Street	S
36	Marion Street / Ramsay Street	S
39	Parramatta Road / Liverpool Road (Hume Highway)	S
41	City-West Link Road / James Street	S
42	Tebbutt Street / Lords Road	S
43	Lilyfield Road / James Street	S
44	Tebbutt Street / Hathern Street	S
45	Parramatta Road / Sloane Street	P
46	Cook Street / Old Canterbury Road	P
47	Parramatta Road / Old Canterbury Road / Tebbutt Street	P
48	Old Canterbury Road / Barker Street	P
49	Old Canterbury Road / Railway Terrace / Longport Street	S
50	Parramatta Road / Norton Street	S
51	Parramatta Road / Flood Street / West Street	S
52	Parramatta Road / Crystal Street / Balmain Road	S
53	Parramatta Road / Catherine Street / Phillip Street	S
54	Parramatta Road / Elswick Street	P
55	Crystal Street / Fort Street / Robert Street	P
56	Crystal Street / Douglas Street / Brighton Street	S
57	Crystal Street / Trafalgar Street	S
58	New Canterbury Road / Stanmore Road / Crystal Street / Shaw Street	S
59	Gordon Street / Trafalgar Street	S
60	New Canterbury Road / Gordon Street / Livingstone Road	S
61	Stanmore Road / Wemyss Street / Merchant Street	S
62	Ramsay Road / Dalhousie Street	S
64	Stanmore Road / Merton Street	P
65	Stanmore Road / Liberty Street	S
66	Ross Street / St Johns Road	S

[3] S = signalised, R = roundabout, P = priority

Survey ID	Intersection	Type[3]
67	Parramatta Road / Young Street / Percival Road	S
68	Parramatta Road /Northumberland Avenue / Johnston Street	S
69	Parramatta Road / Bridge Road	S
70	Parramatta Road /Pyrmont Bridge Road / Denison Street	S
71	Parramatta Road / Mallett Street	S
72	Parramatta Road / Ross Street / Western Avenue	S
73	Great Western Highway / Glebe Point Road	S
74	Broadway / City Road (Princes Highway) / Bay Street	S
75	University Avenue / Parramatta Road / Derwent Street / Arundel Street	S
76	Gordon Street / Lilyfield Road / Burt Street	P

Survey ID	Intersection	Type[3]
77	Salisbury Road / Northumberland Ave	R
78	Liberty Street / Trafalgar Street	P
79	Douglas Street / Percival Road	S
80	Railway Terrace / Victoria Street	P
81	Parramatta Road / Dalhousie Street	S
82	Carillon Avenue / Missenden Road	S
83	Parramatta Road / Missenden Avenue / Lyons Road	S
84	Parramatta Road / Rofe Street	S
85	Dot Lane / Balmain Road	P
86	Parramatta Road / Renwick Street / Railway Street	P
87	Crystal Street / Queen Street	S
88	Parramatta Road / Petersham Street	P

Figure 2-3 Classified intersection count locations

2.2.3 Travel time routes

TomTom captures 3.5 million kilometres of floating car data (FCD) every day in Australia. The data is collected from a combination of TomTom devices (fleet and consumer), third party auto original-equipment manufacturers (OEMs) and mobile devices. FCD provides a new method for measuring speeds, travel times and road performance. Probe devices in vehicles, which may be cellular phones or Global Positioning System (GPS) devices, provide average travel time data in large sample sizes per route segment. This method of data collection is advantageous to the traditional floating car method and less susceptible to being skewed by anomalous data points.

Travel time and speed data for vehicles travelled along six key routes in the study area was extracted from TomTom. The data was aggregated over a four-week period including the survey date (Wednesday 17 October 2018) for Tuesdays, Wednesdays and Thursdays only. The data was separately aggregated for each hour of each peak.

Table 2-2 lists the travel time routes. Each route is bi-directional. **Figure 2-4** shows the locations of these routes in the study area.

Table 2-2 Travel time routes

Route #	Description
1	Parramatta Road between Princes Highway (City Road) and Orpington Street
2	Crystal Street between Trafalgar Street and Parramatta Road
3	Balmain Road between Parramatta Road and City-West Link Road[4]
4	Brighton Street between West Street and Crystal Street, then Douglas Street between Crystal Street and Salisbury Road, then Salisbury Road between Douglas Street and Australia Street
5	Marion Street between Ramsay Street and Balmain Road
6	Johnston Street between Parramatta Road and The Crescent

2.2.4 Average speed data

Average speed data was extracted from TomTom for all major roads in the study area for the AM Peak and PM Peak to identify congestion locations and compare to the modelled outputs (refer to **Section 5.3.3**).

[4] In the southbound direction, Route 3 ends at Marion Street at Balmain Road is one-way in the opposite direction between Parramatta Road and Marion Street.

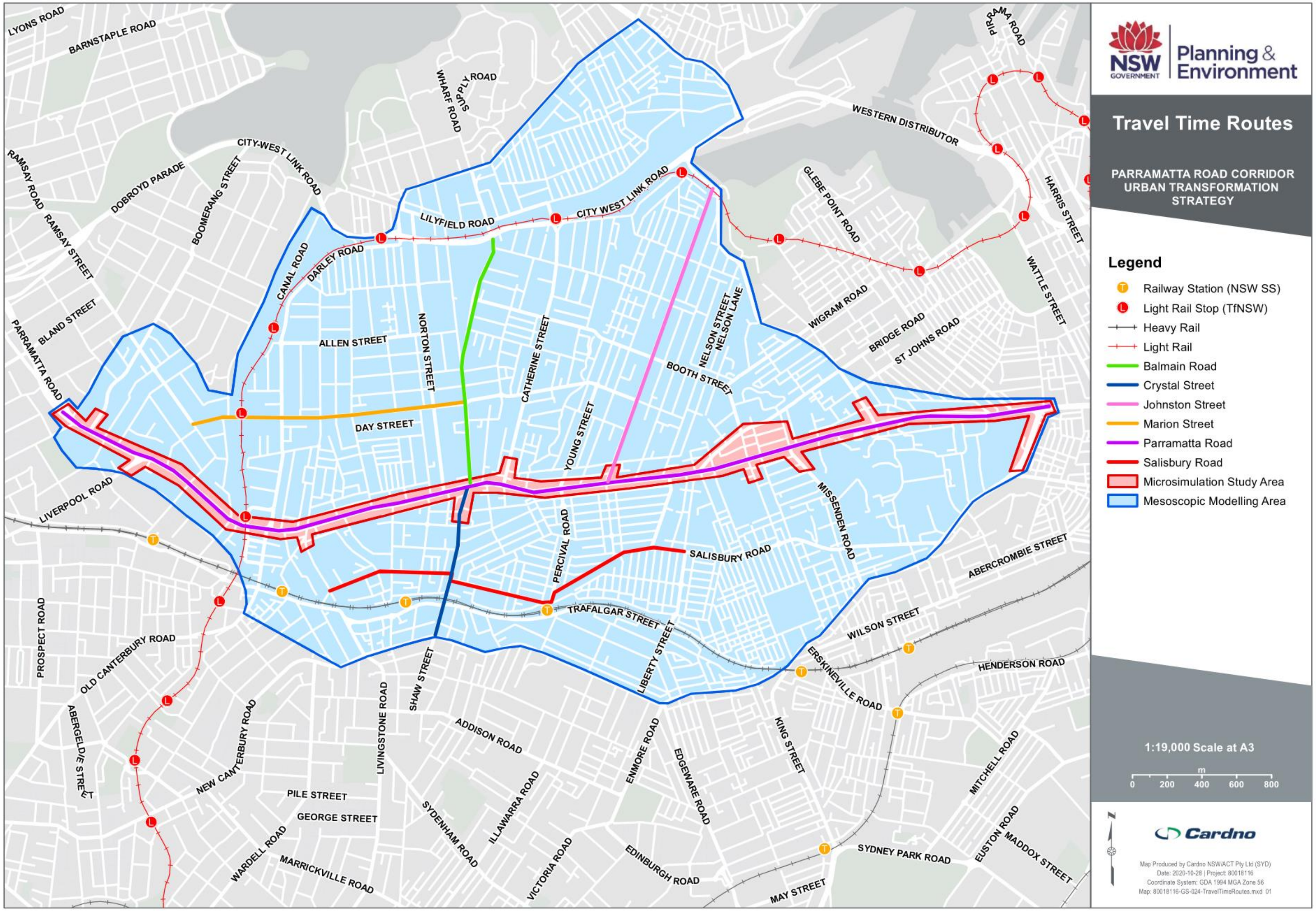


Figure 2-4 Travel time routes

2.2.5 SCATS traffic signal data

The following SCATS traffic signal information was obtained from TfNSW for the signalised intersections within the study area:

> SCATS history file

> TCS graphic plots

> SCATS Region LX files

> TCS plans.

Table 2-3 shows the TCS number for all signalised intersections in the study area and the subsystems to which they belong.

Table 2-3 TCS number and subsystem for signalised intersections

TCS	SS	Intersection
2	ROZ 24	Parramatta Road / Pyrmont Bridge Road / Denison Street
4	ROZ 25	Pyrmont Bridge Road / Booth Street
13	NEW 11	Salisbury Road / Australia Street
16	LEW 27	Parramatta Road / Flood Street
17	LEW 43	Old Canterbury Road / Longport Street / Railway Terrace
18	LEW 22	Parramatta Road / Sloane Street
19	LEW 22	Salisbury Road / Cardigan Street
21	LEW 50	Parramatta Road / Bridge Road
33	LEW 30	Parramatta Road / Percival Road / Young Street
62	LEW 50	Ross Street / Bridge Road
63	ROZ 36	Marion Street / Foster Street
70	LEW 22	Parramatta Road / Liverpool Road
87	ROZ 8	Balmain Road / Lilyfield Road
91	ROZ 37	Norton Street / Marion Street
92	LEW 92	Parramatta Road / Johnston Street / Northumberland Avenue
93	LEW 28	Parramatta Road / Balmain Road / Crystal Street
97	LEW 44	Railway Terrace / Cardigan Street
100	LEW 7	Crystal Street / New Canterbury Road / Shaw Street / Stanmore Road
101	LEW 10	Crystal Street / Trafalgar Street
102	LEW 13	New Canterbury Road / Gordon Street / Livingstone Road
132	LEW 32	Parramatta Road / Missenden Road
140	LEW 49	Parramatta Road / Dalhousie Street
143	LEW 45	Parramatta Road / Norton Street

TCS	SS	Intersection
176	LEW 0	Percival Road / Douglas Street
179	ROZ 27	Catherine Street / Styles Street
215	ROZ 13	Johnston Street / Booth Street
327	LEW 57	Dalhousie Street / Ramsay Street
373	LEW 28	Parramatta Road / Catherine Street / Philip Street
384	LEW 32	Parramatta Road / Mallett Street
385	LEW 32	Parramatta Road / Layton Street
411	ULT 4	Parramatta Road / Broadway / Derwent Street / University Avenue
412	ULT 4	Broadway / Glebe Point Road
413	ULT 4	Broadway / Princes Highway
414	ULT 25	Broadway / Mountain Street
434	LEW 33	Parramatta Road / Ross Street / Western Avenue
438	LEW 16	Crystal Street / Douglas Street
546	ROZ 8	City West Link Road / Brenan Street / Balmain Road
651	ROZ 2	Victoria Road / The Crescent
652	ROZ 6	Victoria Road / Roberts Street
653	ROZ 35	Victoria Road / Gordon Street
654	ROZ 35	Victoria Road / Evans Street
655	-	Victoria Road / Darling Street
656	ROZ 1	Victoria Road / Wellington Street
661	NEW 5	City Road / Princes Highway / Carillon Avenue
664	NEW 1	King Street / Missenden Road
667	NEW 2	King Street / Mary Street / Erskineville Road
721	FIDO1 0	Catherine Street / Moore Street
747	LEW 13	New Canterbury Road / Audley Street

TCS	SS	Intersection
821	LEW 14	New Canterbury Road / Wardell Road
861	ROZ 36	Marion Street / Flood Street
862	ROZ 11	City West Link Road / Brenan Street / Catherine Street
884	NEW 23	Stanmore Road / Liberty Street
902	LEW 52	New Canterbury Road / Constitution Road / Beach Road
1081	ROZ 92	Lilyfield Road / Mary Street / James Street
1143	ROZ 25	Pyrmont Bridge Road / Alexandria Drive / Lyons Road
1208	ROZ 12	City West Link Road / The Crescent
1209	ROZ 26	Wigram Road / Minogue Crescent
1406	ROZ 36	Foster Street / Tebutt Street / Lords Road
1407	ROZ 13	Collins Street / Johnston Street
1502	ROZ 33	City West Link Road / Norton Street
1527	ROZ 34	City West Link Road / James Street / Darley Street
1540	ROZ 32	The Crescent / Johnston Street
1585	NEW 23	Stanmore Road / Merchant Street / Wemyss Street
1864	ROZ 27	Balmain Road / Marion Street
1865	LEW 45	Pedestrian crossing: Parramatta Road near Railway Street

TCS	SS	Intersection
1873	FIDO2 29	Balmain Road / Perry Street / Wharf Road
1879	ROZ 24	Ross Street / St Johns Road
1881	LEW 21	Railway Terrace / Trafalgar Street / Gordon Street
1913	NEW 0	Pedestrian crossing: Trafalgar Street outside Stanmore Station
1939	FIDO1 0	Balmain Road / Cecily Street / Park Drive
2004	NEW 23	Pedestrian crossing: Stanmore Road outside Newington College
2020	ROZ 13	Pedestrian crossing: Johnston Street outside Annandale North Public School
2087	ROZ 25	Pedestrian crossing: Pyrmont Bridge Road near Layton Street
2124	LEW 27	Pedestrian crossing: Parramatta Road opposite Tebbutt Street
2405	NEW 11	Salisbury Road / Kingston Road
2673	ROZ 53	Balmain Road / Moore Street
2753	ROZ 36	Marion Street / Elswick Street
3495	NEW 48	Missenden Road / Carillon Avenue
3547	ROZ 38	Marion Street / Ramsay Street
4207	ROZ 1	Darling Street / Waterloo Road / Belmore Street
4221	ROZ 53	Balmain Road / Alfred Street
4441	ROZ 45	Minogue Crescent / The Crescent / Scotsman Street
4559	ROZ 15	Tebbutt Street / Hathern Street

2.3 Congestion locations

Cardno extracted speed data from TomTom for five Wednesdays in October 2018 to assist with identifying congestion hotspots across the study area. **Figure 2-5** and **Figure 2-6** show the median speed data graphically across the study area. Only roads with a sufficient sample size are shown. Note the following limitations of the TomTom output:

> The median speed on local roads is the average of both directions
> On major roads such as Parramatta Road, the median speed is reported in each direction but in the output one direction is often obscured by the other
> Anomalous speed data appears to have been recorded on Trafalgar Street and Railway Terrace. Both these roads have speed limits of 50 kilometres per hour, however the median speed data recorded speeds of up to 90 kilometres per hour. This is likely due to the close proximity of this road to the railway line. As TomTom data is also captured from mobile phones, it is likely that some of the data collected for this road is actually sourced from mobile phones on the train line. These roads will not be considered in the hotspot validation.

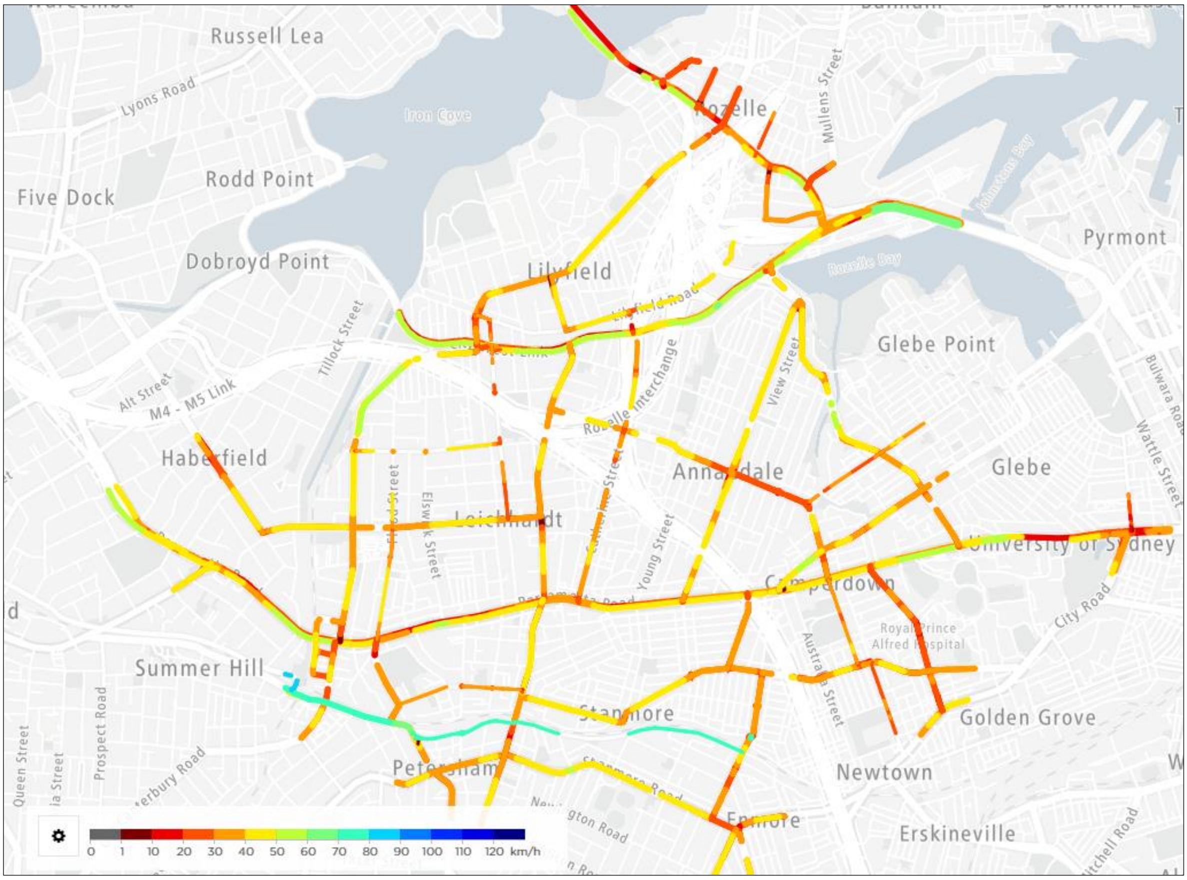


Figure 2-5 TomTom median speed (AM Peak)

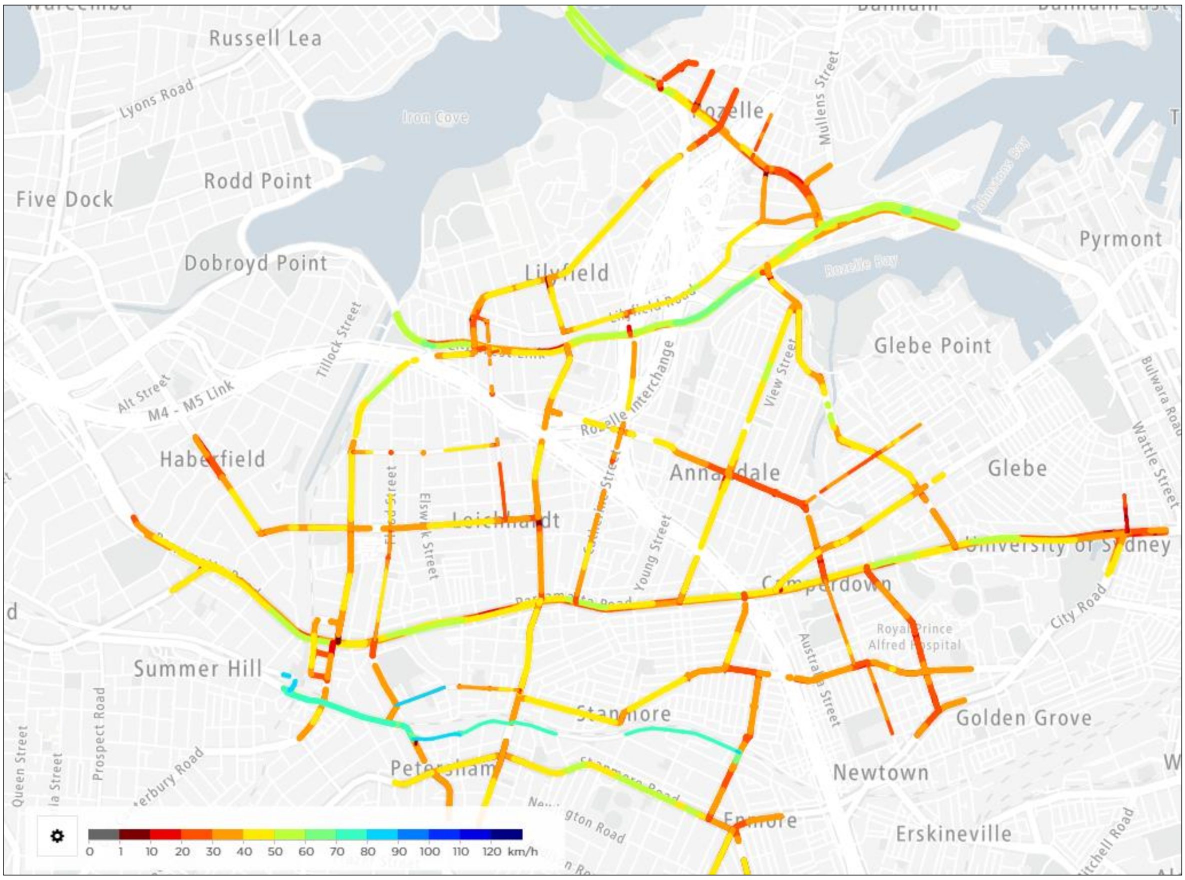


Figure 2-6 TomTom median speed (PM Peak)

In the AM Peak, the following key congestion locations were observed from the site visit and TomTom data:

> Parramatta Road eastbound generally exhibited very low average speeds, in particular at the following locations:
  - Between Liverpool Road and West Street the average speed on Parramatta Road was observed to be less than 25 kilometres per hour. Some segments, in particular around the merge from three lanes to two lanes, had an average speed of less than 10 kilometres per hour over the two-hour AM Peak
  - Approaching Balmain Road, the average speed on Parramatta Road is approximately 15 kilometres per hour across the AM Peak with queues regularly extending back to West Street
  - Between Balmain Road and Johnston Street, the average speed is less than 20 kilometres per hour
  - East of Pyrmont Bridge Road, traffic was generally observed to be less congested on Parramatta Road with the average speed approximately 30 kilometres per hour
  - Congestion was observed approaching City Road and Broadway on Parramatta Road with the average speed across the AM Peak being approximately 25 kilometres per hour.

> Long queues and slow-moving traffic were observed in both directions on Crystal Street in the AM Peak

> Long queueing was observed approaching Parramatta Road on Missenden Road

> Long queues and slow-moving traffic were observed on Booth Street approaching the Wigram Road roundabout. This was mainly caused by queue propagation from the Pyrmont Bridge Road / Bridge Road / Mallett Street / Booth Street intersection

> Average speeds on City-West Link Road in the eastbound direction were generally less than 40 kilometres per hour west of Balmain Road. Traffic was more free-flowing between Balmain Road and Victoria Road where more lanes are provided with an average speed approaching 60 kilometres per hour. However, the average speed over the Anzac Bridge was approximately 35 kilometres per hour

> Congestion and slow-moving traffic was observed on Victoria Road in the southbound direction. The average speed between Terry Street and City-West Link Road was approximately 25 kilometres per hour. Significant queueing was also observed on all side roads leading to Victoria Road from Rozelle (to the north)

> In the non-peak direction (westbound), traffic was generally more free-flowing with the average speed on Parramatta Road approximately 40 kilometres per hour and on City-West Link Road approximately 55 kilometres per hour.

In the PM Peak, the following key congestion locations were observed from the site visit and TomTom data:

> Parramatta Road westbound generally exhibited low average speeds, in particular at the following locations:
  - West of Johnston Street, traffic was generally slow-moving with average speeds varying between 30 and 40 kilometres per hour with the highest average speeds observed in longer sections and away from traffic signals
  - Average speed on the section of Parramatta Road approaching Catherine Street was approximately 25 kilometres per hour in the PM Peak
  - Congestion and queueing were also observed on Booth Street where the average speed in the PM Peak was less than 30 kilometres per hour approaching Wigram Road
  - Long queueing was also observed on Perry Street approaching City-West Link Road
  - Victoria Road was slow-moving in the northbound direction with the average speed between City-West Link Road and Darling Street being about 25 kilometres per hour
  - Average speed on the Anzac Bridge in the westbound direction was 30 kilometres per hour
  - Significant queueing and slow-moving traffic was observed on Carillon Avenue and Liberty Street, and on Missenden Road and Mallett Street approaching Parramatta Road
  - In the non-peak direction (eastbound), traffic was generally more free-flowing with the average speed on Parramatta Road approximately 30-40 kilometres per hour and on City-West Link Road approximately 60 kilometres per hour.

3 Model assumptions

This section outlines the assumptions behind the Base Model development.

3.1 Modelling platform

The PRCUTS model was developed using Aimsun version 8.4.3[5]. Aimsun was considered an appropriate tool for this study as it seamlessly integrates microscopic and mesoscopic simulation into the one model (hybrid simulation). It is capable of modelling baseline conditions and incorporating future infrastructure changes, and quantifying the performance of the traffic network.

Mesoscopic models bridge the gap between strategic planning models (macroscopic models) and detailed operational models (microscopic models). Mesoscopic modelling utilises the dynamic traffic simulation framework similar to microscopic models but at a lower level of detail. The level of detail in mesoscopic models is sufficient to determine the performance of the road network under proposed future land use scenarios and provide guidance on the need for further road infrastructure requirements. Additionally, mesoscopic simulation allows for true dynamic equilibrium assignment where vehicles can select their optimum/preferred travel routes based on their perceived cost. This provides a confidence that the modelled pattern of traffic represents a realistic response to the delays and capacity constraints that would be experience by users on a daily basis.

The microscopic simulation (microsimulation) section of the hybrid model provides a higher level of detail beneficial to this study. Microsimulation allows for detailed interaction between vehicles and/or pedestrians at intersections to be modelled and visualised which results in accurate queueing behaviour only achievable with this type of modelling. Microsimulation also more accurately replicates travel times due to detailed friction, acceleration and deceleration factors and it provides a visualisation of the simulation to verify driver behaviour.

3.2 Modelled network

3.2.1 BSORT / PRRP model

Following discussions with DPIE, IWC and TfNSW, Cardno obtained the previously-developed Burwood to Sydney On-street Rapid Transit Model (BSORT) which was used as the basis for the model development. This included the Parramatta Road Reconfiguration Program (PRRP) models (September 2018), however these were not considered fit for the purpose of this project following an internal review as the calibration and validation targets from *Traffic Modelling Guidelines* (Roads and Maritime Services, 2013) were not met. The PRRP model was only used to import the network geometry to develop the hybrid model.

3.2.2 PRCUTS model network

The PRCUTS model extent covers an area of approximately 15 square kilometres including the Taverners Hill, Leichhardt and Camperdown precincts in the IWC local area. Geometry and coding from the PRRP model were checked against aerial photography from *Nearmap*[6]. Network infrastructure and road geometry for the Base Model was based on that which existed on the calibration date (17 October 2018).

Figure 3-1 shows the modelled road network including the extent of the microsimulation area.

[5] 2020-06-03 (b46ec77181 x64 Python 2)
[6] Aerial photography from Tuesday 23 October 2018

Figure 3-1 Modelled road network

3.3 Time period

The traffic peak periods were determined from the classified intersection counts. The busiest two-hour period in each peak was identified as the period during which the greatest number of turn movements were recorded across all intersections. The model provides an indication of the performance of the network during the worst two-hour period in each peak.

The peak periods were identified as:

> 7:15AM – 9:15AM

> 4:30PM – 6:30PM.

Figure 3-2 and **Figure 3-3** show the traffic profiles for the AM Peak and PM Peak respectively.

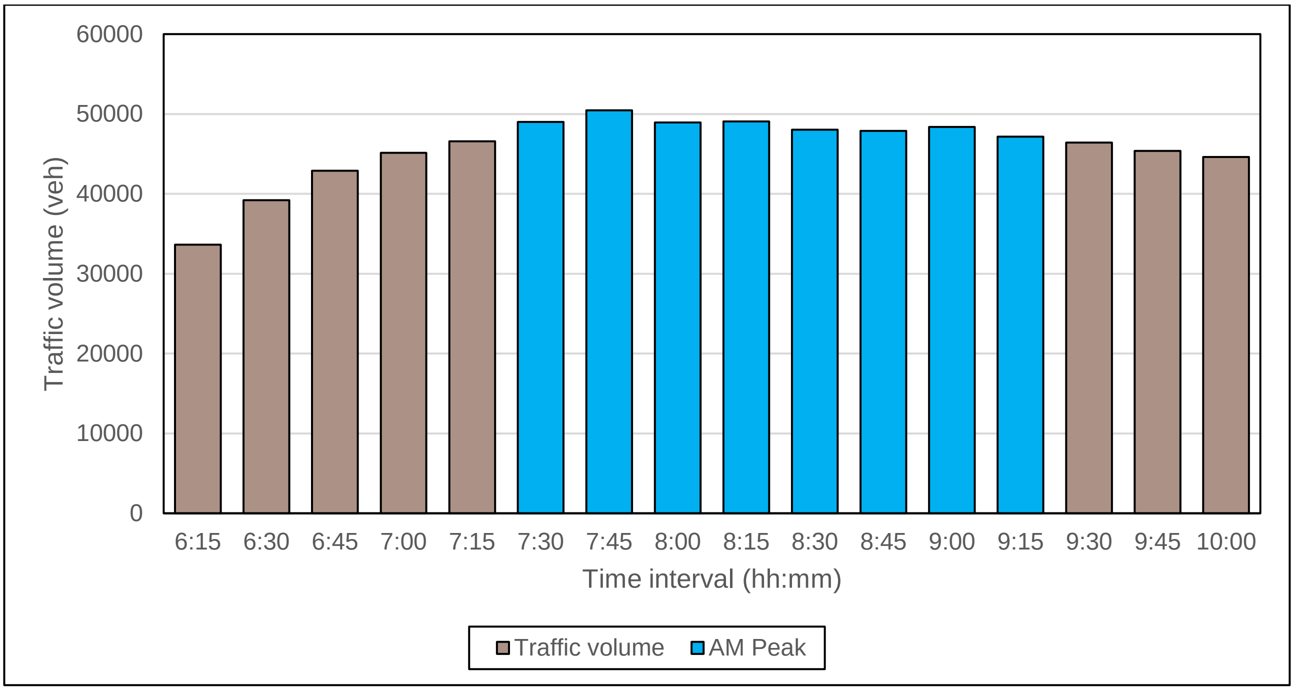


Figure 3-2 Traffic profile (AM Peak)

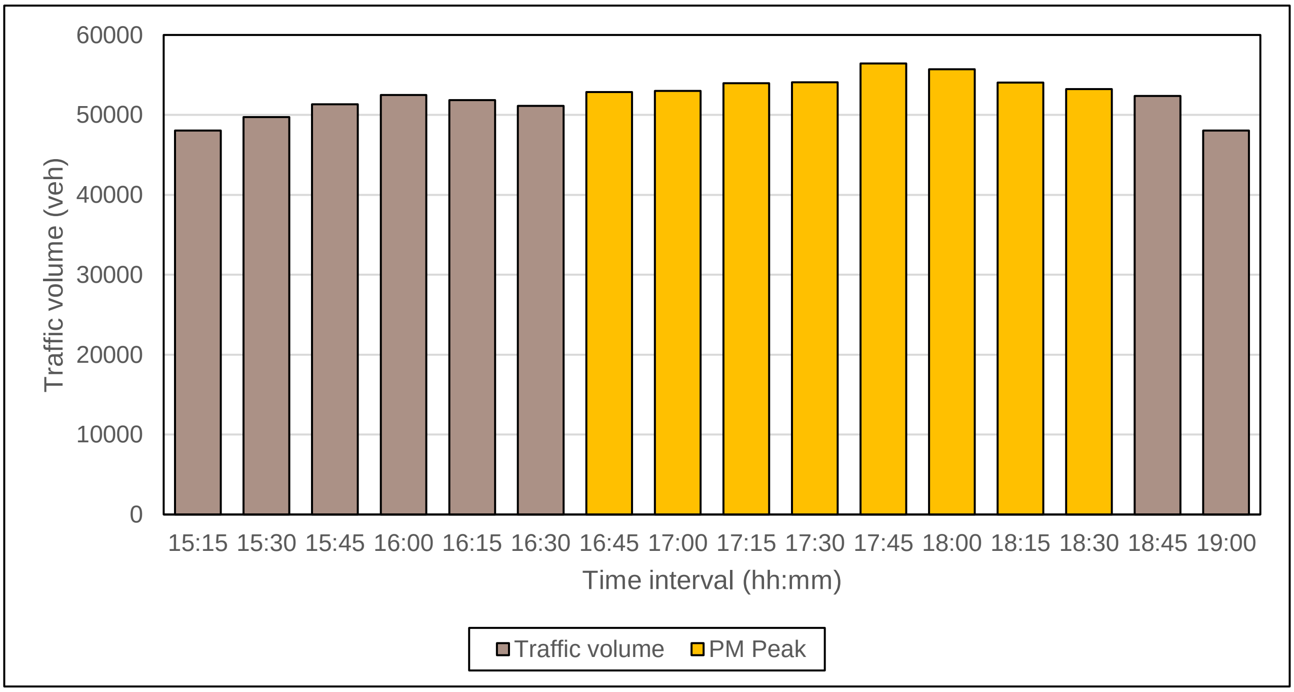


Figure 3-3 Traffic profile (PM Peak)

3.4 Assignment type

This section outlines the assignment types used in the model. **Section 3.12** provides greater detail of the demand estimation and assignment process.

3.4.1 Static assignment

Static assignment uses deterministic algorithms to assign traffic volumes to links in the network. Individual vehicles are not modelled and the performance of each section is determined by the link performance function. Typically link performance functions are based on the number of vehicles assigned to a section and the section capacity, although other attributes may also be considered.

The aim of static assignment is to minimise the total generalised cost (usually a function of travel time) across the network. The total travel time for the network is calculated by the product of the volume on each link multiplied by the travel time on that link (given by the link performance function), summed for all links in the network. At equilibrium, all paths that are used between a given origin and destination will have the same generalised cost.

3.4.2 Dynamic user equilibrium

To assess options that impact vehicle route choice, dynamic user equilibrium (DUE) assignment was used. Dynamic assignment is based on an iterative simulation process where drivers choose their routes through the network based on the travel cost they experienced in the previous iteration. The simulation continues until a stable model environment is reached where travel times and volumes do not change significantly between iterations.

The principle of this assignment is that users will try to minimise their individual travel times by travelling on a route which they perceive to be the shortest path given the traffic conditions. To achieve a dynamic equilibrium state, the travel times of each OD pair for vehicles departing at the same time must be equal across all used routes, and less than that of a single user on any of the unused routes (Ran and Boyce's dynamic version of Wardrop's equilibrium).

3.4.3 Stochastic route choice assignment

The stochastic route choice (SRC) assignment is based on discrete route choice models or on a user-defined assignment, Discrete route choice models are based on discrete choice theory and emulate the decisions of users selecting paths from those that area available. This model uses the probability of choosing alternative paths from the available paths as a function of their disutility, typically travel time or travel cost.

3.5 Vehicle types

The following vehicle types were used in the models:

> Light vehicles (cars)
> Heavy vehicles (trucks)
> Buses.

Cardno adopted the definition of light vehicle from Austroads (1994). A light vehicle is any vehicle with only two axles that does not have dual tyres on the rear axle, and is up to 5.5 metres in length. This can include cars, SUVs, small vans and motorcycles. The default Aimsun maximum car length was increased from 4.5 metres to 5.5 metres to align with the Austroads classification.

A heavy vehicle is any vehicle with more than two axles, or with dual tyres on the rear axle. This includes rigid vehicles, trucks and heavy articulated vehicles but excludes buses. Buses were included as a separate vehicle type. The demand for buses was adopted using fixed routes and timetables (refer to **Section 3.11**).

Aimsun defaults were generally adopted for all parameters. Cardno notes that the PRRP model inherited for this project contained substantial adjustment to many of the vehicle parameters. In some cases, these were restored to Aimsun defaults as the adjusted values were found to be unrealistic. **Figure 3-4** presents the values for key vehicle attributes adopted in the models.

Figure 3-4 Key vehicle attributes

Attribute	Vehicle type	Mean	Deviation	Minimum	Maximum
Length	Car	4.50 m	1.00 m	3.50 m	5.50 m
	Truck	12.00 m	4.00 m	8.00 m	16.00 m
	Bus	13.00 m	1.00 m	12.00 m	14.50 m
Speed acceptance	Car	1.00	0.10	0.90	1.10
	Truck	0.90	0.10	0.80	1.00
	Bus	0.90	0.10	0.80	1.00
Clearance	Car	1.00 m	0.50 m	0.50 m	1.50 m
	Truck	2.00 m	0.50 m	1.50 m	2.50 m
	Bus	2.00 m	0.50 m	1.50 m	2.50 m

3.6 Traffic zones/input

Traffic demands were informed by the STFM. The demand development procedure is discussed in **Section 3.12**. The STFM cordon included 96 centroids made up of:

> 51 internal travel zones wholly or partially within the study area
> 31 external gates
> Three railway station centroids
> Nine light rail stop centroids
> One ferry wharf centroid
> One container terminal centroid.

Figure 3-5 shows the location and numbering of the STFM centroids within the study area.

Zones for railway stations, light rail stops, ferry wharves and the container terminal were aggregated into the surrounding zone as their demands were low (refer to **Section 3.11**). The 51 internal travel zones were disaggregated into 114 zones in the Aimsun model. Proportions were based on land use assumptions and traffic survey counts (where available). **Figure 3-6** shows the Aimsun zone numbering system indicating how the STFM centroids were disaggregated and incorporated into the hybrid model.

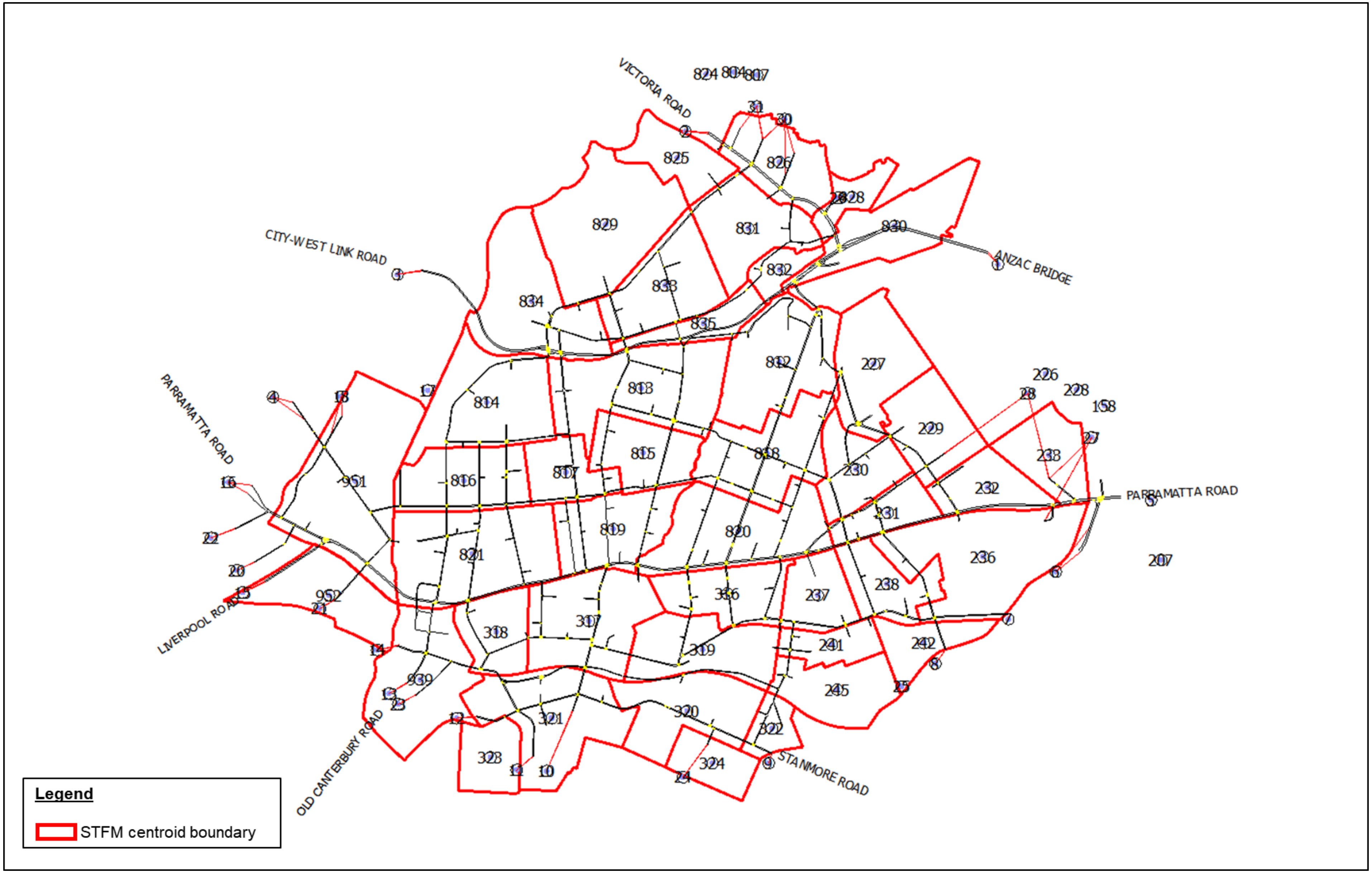


Figure 3-5 STFM centroid numbering and zone boundaries

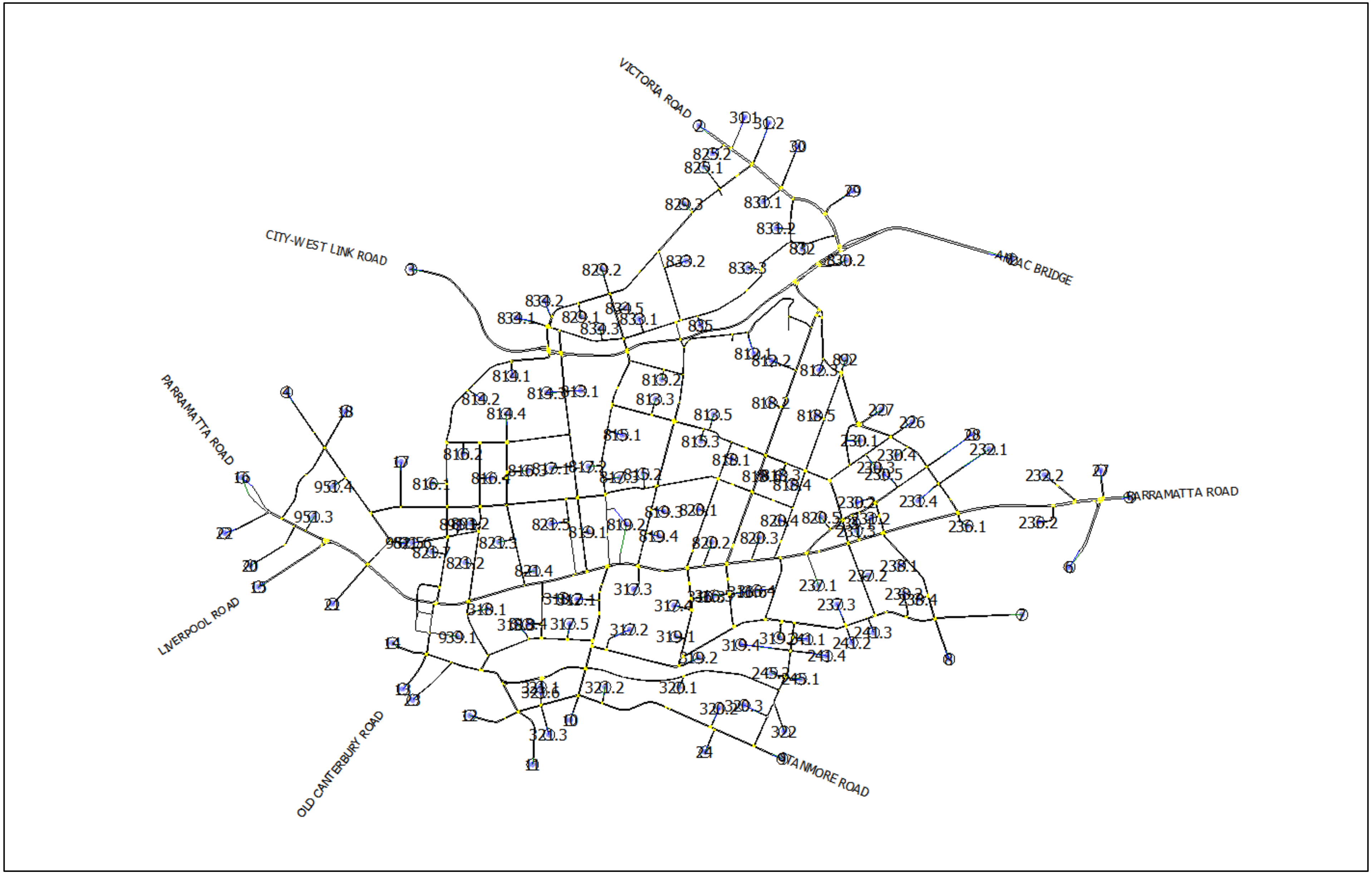


Figure 3-6 Aimsun centroid disaggregation and numbering

3.7 Road types

3.7.1 Modelled road types

Road types were inherited from the previous PRRP model, however upon review Cardno found inconsistencies in the capacities and speed limits of some sections from that model. Section capacities and road types were updated to provide consistency across the PRCUTS model and create more realistic vehicle assignment. **Table 2-3** shows the road types and section capacities adopted in the model.

Table 3-1 Road types and section capacities

Description	Road type	Capacity (PCU/ln/hr)
Local	Sydney 01. LOCAL	700
Sub-arterial	Sydney 02. Sub-ART (non-commercial)	800
Arterial (undivided)	Sydney 04. ART (Undivided)	900
Arterial (divided)	Sydney 05. ART (Divided)	1100
State highway (undivided)	Sydney 06. SH(UD)	1200
State highway (divided)	Sydney 07. SH(D)	1200
Expressway ramp	Sydney 08. EXP RAMP	900
Expressway	Sydney 09. EXP	1800
Expressway bridge	Sydney 14. HARBOUR BRIDGES	1500

The capacities of individual sections were adjusted during the calibration stage based on observed conditions. Examples of factors that influenced the capacity adjustments included:

- On street parking, clearways or lane closures (such as bus lanes)
- Speed humps and other traffic calming
- Driveways and access points, particular yin commercial/residential areas.

Figure 3-7 shows the modelled road types used in the model.

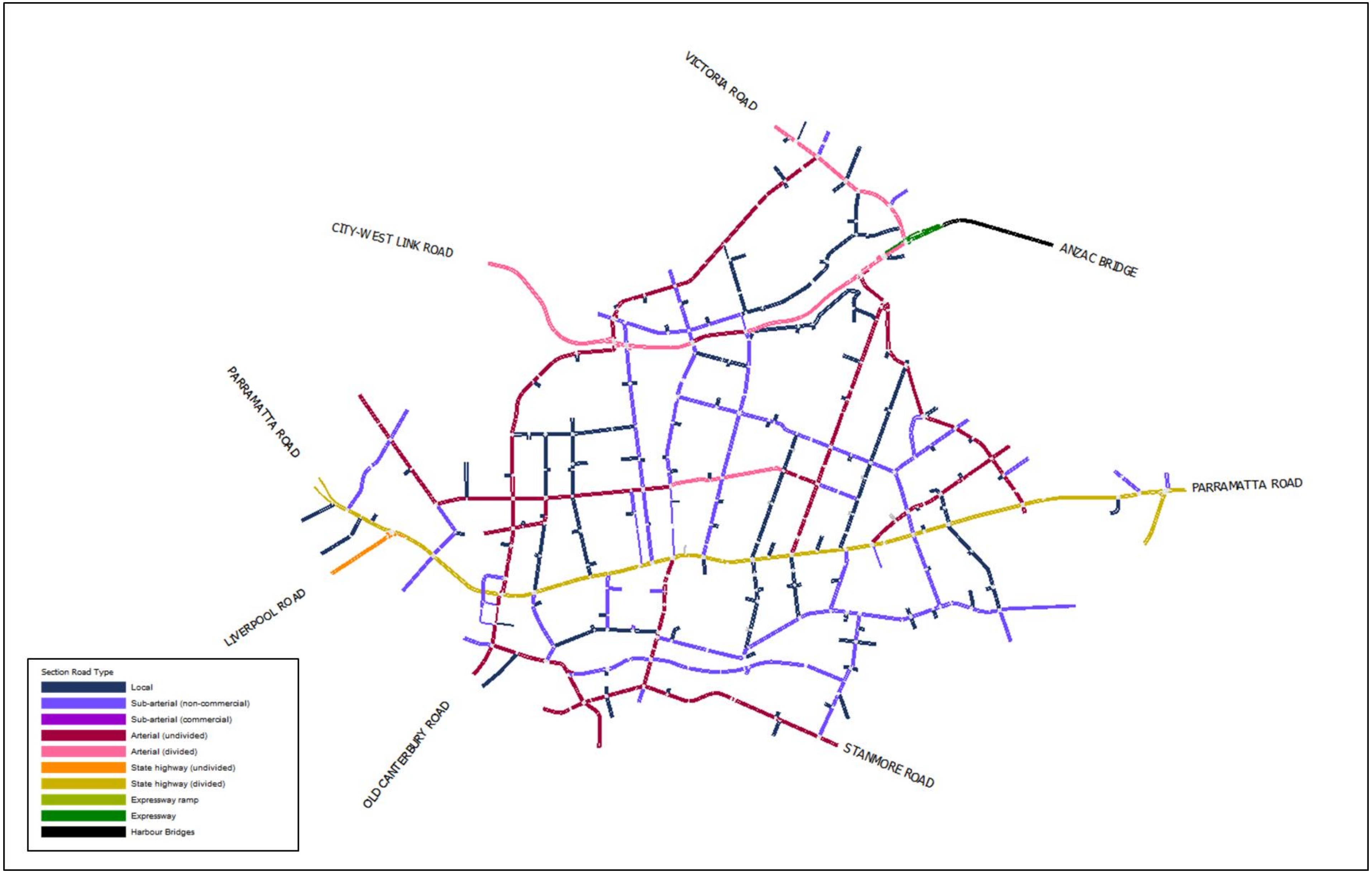


Figure 3-7 Modelled road types

3.7.2 Lane cooperation

Lane cooperation was maintained as default (50 per cent) for all sections except the following locations:

> Parramatta Road (EB) approaching Tebbutt Street. Queues were observed to often spill back from the right turn into West Street and obstruct one of the through lanes on Parramatta Road. The cooperation was increased to 80 per cent so that vehicles were more likely to merge out of the partially-obstructed through lane into the kerbside lane. This was necessary to match observed queueing and travel times on this section

> City-West Link Road and Victoria Road approaching Robert Street. The right turn bay from Victoria Road into Robert Street is only accessible from the right lane of Victoria Road. Due to the high demand for this turn, queues in the model were observed to build up disproportionately in the right lane, whereas observed data suggested an even queueing pattern across all lanes. The cooperation was increased to 60-70 per cent to increase the number of vehicles using other lanes to turn right from City-West Link Road and then merging on the section of Victoria Road between City-West Link Road and Robert Street.

3.7.3 Acceleration factor

Acceleration factors were applied locally on side roads at some signalised intersections. The queue discharge rate at each location was able to be determined using the historical SCATS phase times and turn volumes from classified intersection counts. In some locations it was observed that default Aimsun queue dissipation resulted in a much lower intersection throughput than was recorded from the survey volumes. In such locations, the acceleration factor of the section was increased to account for the observed rate of queue dissipation.

Acceleration factors were used at the extremities of Parramatta Road to increase delay associated with congestion outside the modelled area. Acceleration factors were also used on Parramatta Road around Balmain Road / Catherine Street. Due to curves in the road, queues often extended further than the visibility of the traffic lights. Acceleration factors were used to account for the impacts of reduced visibility, parking manoeuvres, queue jumps at Crystal Street and Norton Street, and buses merging in and out of bus lanes.

3.8 Elevation and slope profile

Slopes have an impact on traffic behaviour, queue dispersion and travel times. A slope model was developed to factor the acceleration of each vehicle class within the model proportionally to the slope of the road at any given point. Higher penalties are imposed on heavier vehicles such as those belonging to the truck and bus classes.

Slope data was obtained from a five-metre resolution digital terrain model available from Department of Finance, Services and Innovation Spatial Services. The slope was calculated using the Slope Tool in ArcGIS (v10.6) from the digital terrain model. The slope was queried at the start and end points of the sections in the Aimsun model based on whether the point fell in a particular grid square of the slope map. The start and end altitude points were set for each section of the Aimsun model.

3.9 Speed profiles

All roads were coded with speed limit as it was posted in October 2018. **Figure 3-8** shows the posted speed limits in the model. Speed profiles for each vehicle type are given in **Section 3.5**.

3.9.1 Local roads

Local roads do not always have a speed limit posted. The speed limit on all local roads is 50 kilometres per hour unless otherwise indicated. Some local roads in Leichhardt, Annandale, Rozelle and Glebe have posted speed limits of 40 kilometres per hour.

3.9.2 School zones

School zones surround all schools in NSW. When in operation, the speed limit on signposted roads is reduced to 40 kilometres per hour. Generally, this is during 8:00AM – 9:30AM and 2:30PM – 4:00PM. **Figure 3-9** shows the locations of school zones within the study area.

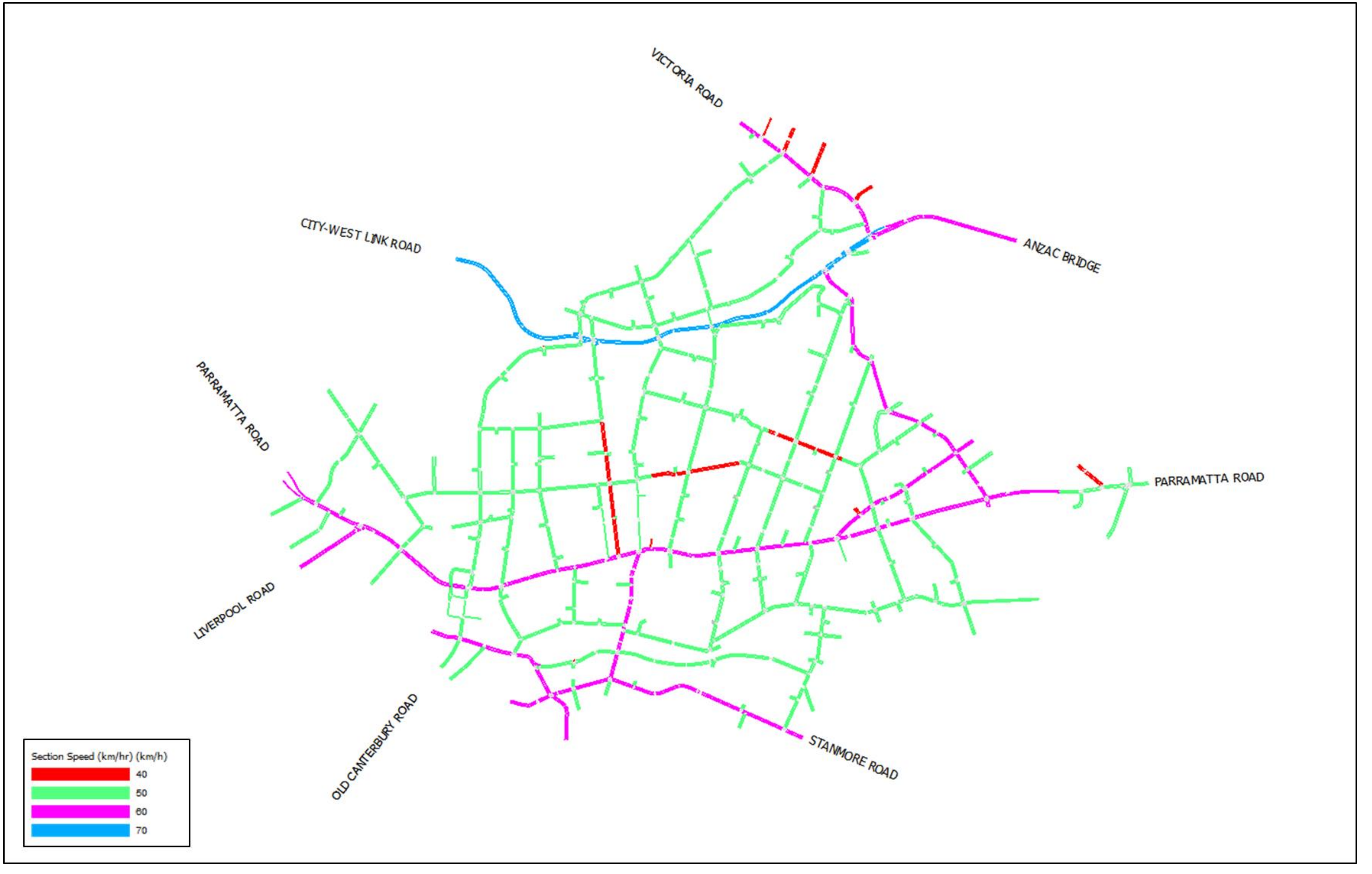


Figure 3-8 Posted speed limits

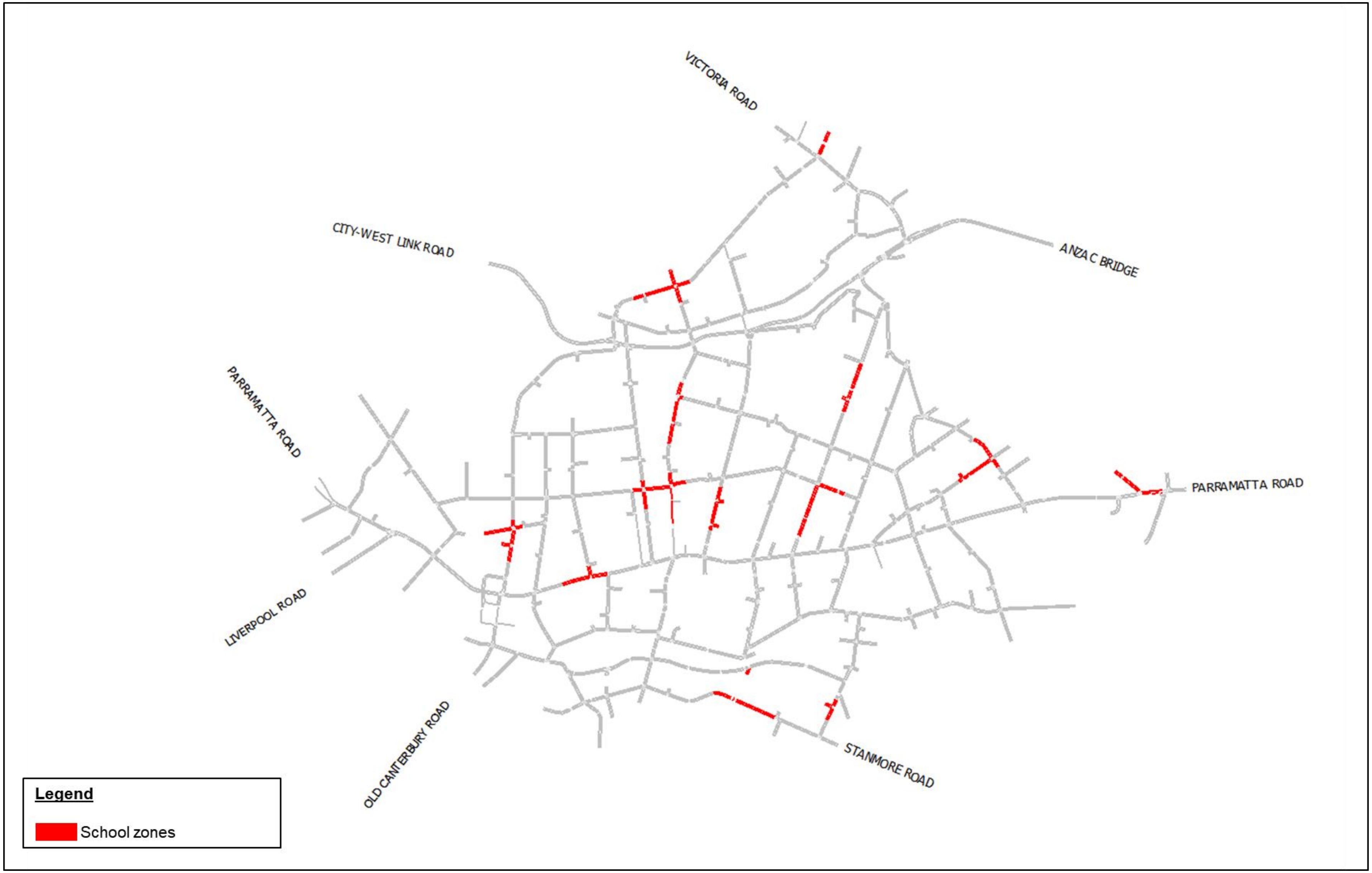


Figure 3-9 School zones

3.9.3 Local speed reductions

Aimsun supports detailed section speeds where the maximum speed on part of a section may be reduced, such as due to a speed hump, traffic calming, parking or other delays. However, as detailed speeds are not supported in mesoscopic simulations due to software limitations, to capture these delays, Cardno applied a reduction to the maximum desired speed on some key links in the mesoscopic portion of the model during the validation stage. **Table 3-2** lists the links on which a localised maximum desired speed reduction was applied. Generally, this reduction was only applied to sections where travel time data was available, so that the realism of the speed reduction could be verified.

Table 3-2 Local speed reductions

Road	Location	Posted speed limit (km/hr)	Maximum desired speed (km/hr)	Justification
Balmain Road	Parramatta Road – Marion Street	50	30	Balmain Road is a narrow one-way road with parking on both sides and traffic calming. The posted speed limit on the parallel Norton Street is 40 kilometres per hour. The maximum desired speed on Balmain Road was reduced to 30 kilometres per hour to capture the impacts of parking and traffic calming, and to reduce the attractiveness of Balmain Road as an alternative to Norton Street.
Brighton Street	West Street – Crystal Street	50	40	Brighton Street is a narrow local road with parking on both sides and a posted speed limit of 50 kilometres per hour. It has four wombat humps and two roundabouts along a stretch of approximately 500 metres. The maximum desired speed on Brighton Street was reduced to 40 kilometres per hour to capture delays associated with parking and traffic calming.
Elswick Street	Parramatta Road – Marion Street	50	40	Elswick Street is a narrow local road with a posted speed limit of 50 kilometres per hour. It has a wombat hump at either end and parking on both sides. Parking on one or both sides of the road is angle parking. No angle parking lines are marked and the angle of vehicles relative to the kerb was observed to vary from site visit observations and *Google Streetview*, which impacts the parking space length. Longer vehicles were observed to occasionally partially obstruct the traffic lanes so that through traffic would have to cross the centre line. Elswick Street was observed to be less utilised than the parallel Norton Street and Foster Street. The maximum desired speed on Elswick Street was reduced to 40 kilometres per hour to capture delays associated with parking and traffic calming, and to reduce the attractiveness of Elswick Street as an alternative to Norton Street or Foster Street.
Johnston Street	Parramatta Road – The Crescent	50	40	Johnston Street is a mostly-two-lane local road with a posted speed limit of 50 kilometres per hour. Parking on one or both sides of the road is angle parking. As noted for Elswick Street above, parked vehicles were often observed to partially obstruct through traffic lanes and it was observed that vehicles tended to use the centre lane in preference to the outside lane, likely due to parked cars. The maximum desired speed on Johnston Street was reduced to 40 kilometres per hour to capture delays associated with parking.

3.10 Traffic signals

Due to the complexity of the network, all signalised intersections were modelled as fixed-time based on intersection diagnostic monitor (IDM) data provided by TfNSW for the modelled date (17 October 2018). Average phase and cycle times for each intersection were calculated from the SCATS data and coded using:

> Fixed-time signals in 15-minute intervals inside the microsimulation area

> Fixed-time signals in 1-hour intervals outside the microsimulation area (mesoscopic simulation area).

Signal coordination offsets were extracted from the SCATS LX files. The signal offsets coordinate adjacent intersections to more realistically model the traffic flow. The signal offsets were calculated based on the average phase times in each 15-minute interval.

Intersections 721, 1873 and 1939 had no SCATS historical data for the survey date. Phase times were estimated based on modelled flows and SCATS phasing to achieve satisfactory calibration and validation results.

Figure 3-10 shows the locations of signalised intersections and pedestrian crossings in the study area.

Figure 3-11 shows the relationships between intersections and subsystems. These relationships were used to code the signal offsets to accurately model coordination between adjacent signalised intersections.

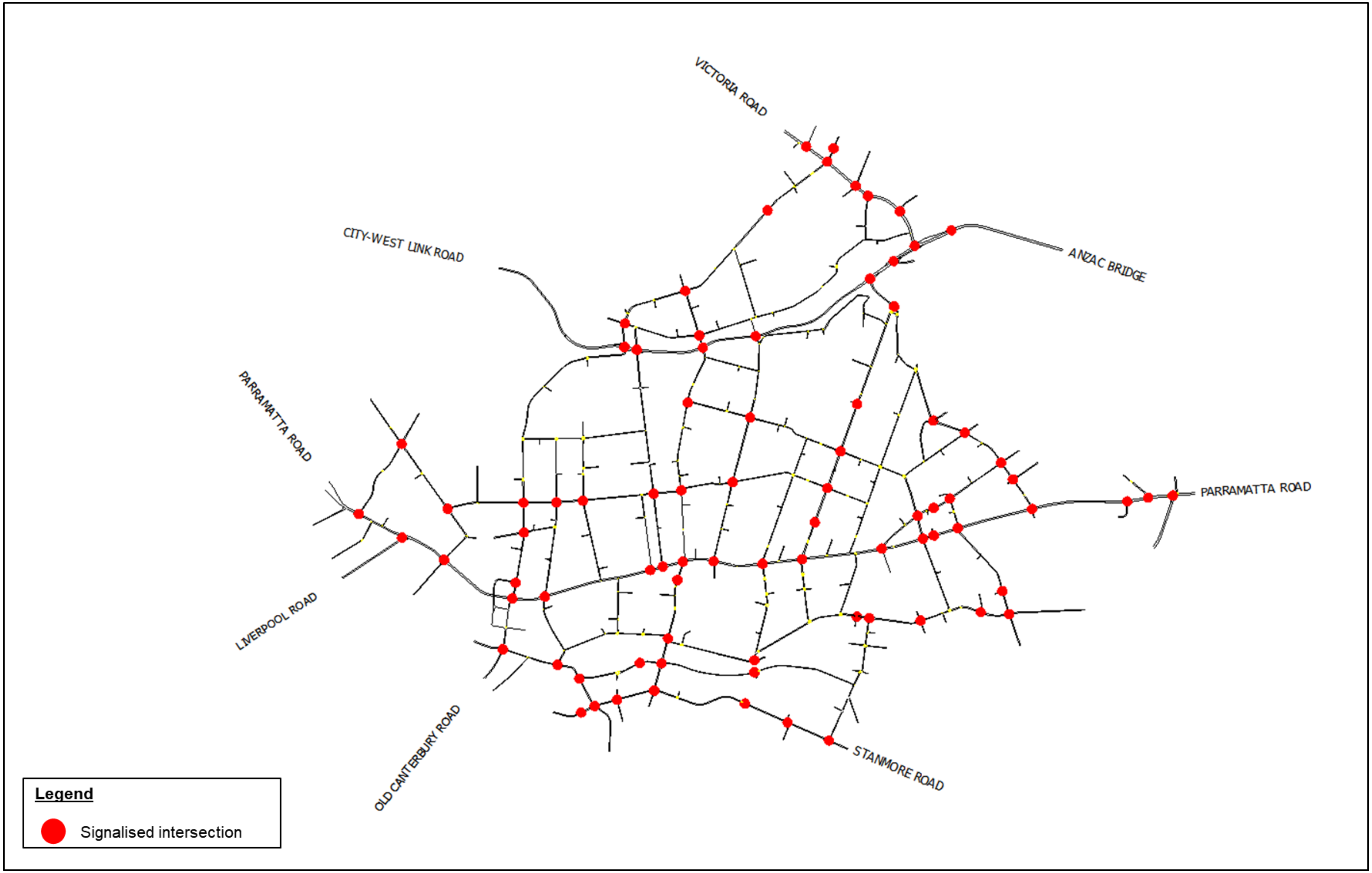


Figure 3-10 Signalised intersection locations

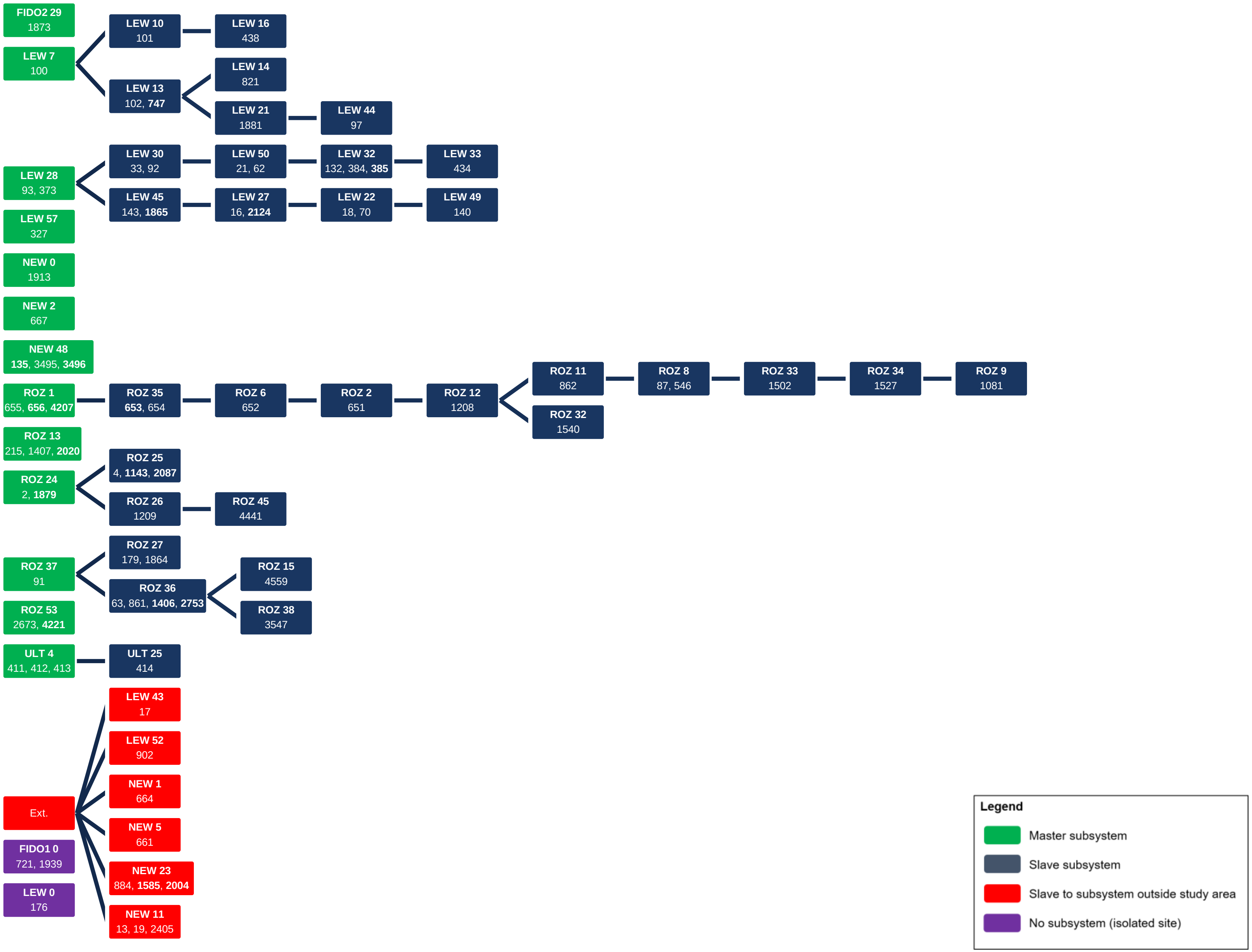


Figure 3-11 SCATS subsystem hierarchy

3.11 Public transport services

3.11.1 Train services

The Main Western Railway Line runs through the study area with stations at Stanmore, Petersham and Lewisham within the model boundary. The Main Western Railway Line is a six-track mainline that services the western, south-western and north-western areas of Sydney. The line has six tracks but only local trains stop at stations within the study area. Stanmore, Petersham and Lewisham are serviced by the Sydney Trains T2 Inner West Line which operates from the City Circle to Parramatta, Homebush and Leppington. Trains stop approximately every 15 minutes during off-peak periods and on weekends, with additional trains during peak hours.

All road-rail crossings in the study area are grade-separated, so there is no interaction between the trains and road vehicles.

Station barrier counts provide an indication of the number of trips made to and from a station by train on a typical weekday. **Table 3-3** shows the average number of station entries and exits during the modelled peak hours and across the entire day, calculated based on Opal data available from 21-25 November 2017.

Table 3-3 Station barrier counts (November 2017)

Station	AM Peak (7:15AM – 9:15AM)			PM Peak (4:30PM – 6:30PM)			Daily average		
	In	Out	Total	In	Out	Total	In	Out	Total
Stanmore Station	1770	315	2085	389	1216	1605	3834	3339	7173
Petersham Station	1183	528	1712	387	856	1244	3292	3152	6444
Lewisham Station	1164	278	1442	308	719	1027	2446	2090	4536

Table 3-4 indicates trip demand for the railway stations within the STM. The strategic model includes the railway stations are centroids separate from the surrounding zones.

Table 3-4 Vehicle trips to train stations from STM data (2016)

Station	Total trips (7:15AM – 9:15AM)		Total trips (4:30PM – 6:30PM)	
	To	From	To	From
Stanmore Station	74	2	5	65
Petersham Station	69	2	4	72
Lewisham Station	85	2	4	82

None of the three stations have commuter car park facilities and there is limited on-street parking in close proximity. The minimal number of trips in the STM demand suggests that the majority of train users take public transport (such as bus or light rail) or walk to the station. Consequently, due to their low demand, the railway stations were not included as separate centroids within the model and their trips were incorporated into the surrounding zone.

3.11.2 Bus services

The study area is in Region 6 of the Sydney bus network. Local bus services are primarily operated by Transit Systems. Some bus routes only operate at certain times such as peak hours or late at night. The bus routes that are wholly or partially within the study area are listed below:

- L23 Kingsgrove to City Martin Place (Limited Stops)
- L28 Canterbury to City Martin Place (Limited Stops)
- L37 Haberfield to City Town Hall (Limited Stops)
- L38 Abbotsford to City Martin Place (Limited Stops)
- L39 Mortlake to City Martin Place (Limited Stops)
- M10 Maroubra Junction to Leichhardt via City
- M30 Sydenham to Taronga Zoo
- M50 Coogee to Drummoyne
- M52` Parramatta to City Circular Quay
- N50 Liverpool to City Town Hall (NightRide)
- N60 Fairfield to City Town Hall (NightRide)
- N61 Carlingford to City Town Hall (NightRide)
- N80 Hornsby to City Town Hall via Strathfield (NightRide)
- N81 Parramatta to City Town Hall via Sydney Olympic Park (NightRide)
- X00 City to Ryde (Express Service)
- X04 City Domain to Chiswick (Express Service)
- X06 City Domain to East Ryde (Express Service)
- X15 City Town Hall to Eastwood (Express Service)
- X18 City Town Hall to Denistone East (Express Service)
- 412 Campsie to City Martin Place via Earlwood
- 413 Campsie to City Martin Place
- 422 Kogarah to City via Newtown
- 423 Kingsgrove to City Martin Place
- 426 Dulwich Hill to City Martin Place
- 428 Canterbury to City Martin Place
- 431 Glebe Point to City Martin Place
- 433 Balmain Gladstone Park to Central Pitt Street
- 436 Rodd Point and Chiswick to Central Pitt Street
- 438 Abbotsford to Martin Place
- 439 Mortlake to City Martin Place
- 440 Bondi Junction to Rozelle
- 441 City Art Gallery to Birchgrove via QVB (Loop Service)
- 442 City QVB to Balmain East Wharf (Loop Service)
- 445 Campsie to Balmain via Leichhardt Marketplace
- 447 Lilyfield to Leichhardt Marketplace (Loop Service)
- 461 Burwood to City Domain
- 470 Lilyfield to City Martin Place
- 480 Strathfield to Central Pitt Street via Homebush Road
- 483 Strathfield to Central Pitt Street via South Strathfield
- 500 Ryde to City Circular Quay
- 501 West Ryde to Central Pitt Street via Pyrmont and Ultimo
- 502 Five Dock to City Town Hall
- 504 Chiswick to City Domain
- 505 Woolwich to City Town Hall
- 506 Macquarie University to City Domain via East Ryde
- 507 Macquarie University to City Circular Quay via Putney
- 508 Drummoyne to City Town Hall
- 510 Ryde to City Town Hall
- 515 Eastwood to City Circular Quay
- 518 Macquarie University to City Circular Quay
- 520 Parramatta to City Circular Quay via West Ryde.

The major roads supporting the bus network within the model are Parramatta Road, Victoria Road, Norton Street, Marion Street and Balmain Road.

Bus routes and timetables were imported into the model using GTFS data. The purpose of the GTFS bus timetable feed is to publish in advance the schedule and route information of bus services operated under the Sydney Metropolitan and Outer Sydney Olympic Park Major Events Bus Contracts. GTFS data is typically used for TfNSW Transport Info, real-time transport apps and online map services such as Google Maps and Apple Maps. GTFS data is provided in the following nine data files:

> agency.txt – defines one or more transit agencies (operators) that provide the data in this feed
> calendar.txt – defines dates for service IDs using a weekly schedule; provides the start and end dates as well as the days of the week when the service is available
> calendar_dates.txt – defines exceptions for the service IDs defined in the calendar.txt file
> routes.txt – defines transit routes
> shapes.txt – defines rules for drawing lines on a map to represent a transit agency's routes
> stop_times.txt – provides the times that a vehicle arrives at or departs from individual stops for each trip including dwell times
> stops.txt – provides individual locations where vehicles pick up or drop off passengers
> trips.txt – provides the trips for each route (a trip is a sequence of two or more stops that occurs at a specific time)
> notes.txt – this file is an extension of the GTFS file set standard; it contains a list of notes references from trips.txt and stop_times.txt.

To utilise this data, Aimsun includes a GTFS importing function. GTFS data from November 2018 was sourced from the NSW Government Open Data Portal and used for the base model development for the AM and PM peak periods. Cardno undertook sanity-checks of the public transport routes to ensure that the import process did not produce incomplete routing. In cases where public transport lines were not properly imported or where links were not present in the model, manual adjustments were made to the routes.

3.11.3 Light rail

The L1 Dulwich Hill Line runs through the study area. The following seven light rail stops are present within the model boundary:

> Rozelle Bay
> Lilyfield
> Leichhardt North
> Hawthorne
> Marion
> Taverners Hill
> Lewisham West.

The line operates between Central and Dulwich Hill Station. Although services do not run from the L1 Line onto the L2 Randwick and L3 Juniors Kingsford lines[7], a new maintenance facility has been constructed at Lilyfield within the study area for the maintenance of vehicles used on these routes.

All road-light rail crossings in the study area are grade separated so there is no interaction between the light rail vehicles and road vehicles. Pedestrian crossings are present at most light rail stops and between some stops.

There are no carparks provided at any of the stops within the study area and limited on-street parking is available in close proximity. The minimal number of trips in the STM demand suggests that the majority of light rail users take public transport or walk to the stop. Consequently, due to the low demand, the light rail stops were not included as separate centroids within the model and their trips were incorporated into the surrounding zone.

[7] Under construction during the modelled periods (October 2018) but subsequently opened in 2019 and 2020 respectively.

3.12 Demand assumptions and adjustment

3.12.1 Demand estimation procedure overview

The methodology to develop the Base Model demand is outlined below:

1. The prior matrix for each scenario was extracted from the STFM
2. The prior matrix was disaggregated based on estimated vehicle splits based on observed land uses and classified intersection counts
3. The prior matrix was imported into Aimsun and run through a static assignment experiment. This experiment loads the demand into the network and allows for identification of areas where the trips are under- or over-estimated by the strategic model
4. The prior matrix was manually adjusted based on observed counts. Generally, the strategic model was observed to underestimate the trips generated by residential areas. Trips were generally adjusted proportionally to all centroids, except in instances where an exact number of trips could be derived (such as between two centroids with only one turn in between)
5. The static model was calibrated to eliminate unrealistic route choice. As the static model does not fully consider delays associated with intersections, traffic calming, parking, local streets or congestion, user-defined costs were introduced in some locations to simulate these delays and improve the static assignment
6. The Aimsun Static OD Adjustment tool was used to refine the matrix using the observed counts for each scenario. The matrix elasticity and trip distribution elasticity were constrained to ensure that the final matrix did not significantly deviate from the strategic demand. A one-hour warm-up was included to ensure that a realistic number of vehicles were pre-loaded in the network at the beginning of the first modelled interval
7. Some minor manual adjustments were made to the matrix to account for areas where the Static OD Adjustment process was found to have unrealistically increased or decreased the demand significantly
8. The profiled matrix was used in dynamic experiments
9. The final traffic demand and assignment from the stochastic route choice experiment were used in the calibration and validation process to ensure that the models accurately represent existing conditions.

The demand estimation procedure is iterative and involves continual refinement of the model parameters and demand matrix. **Figure 3-12** provides a diagrammatic representation of the demand estimation, calibration and validation process.

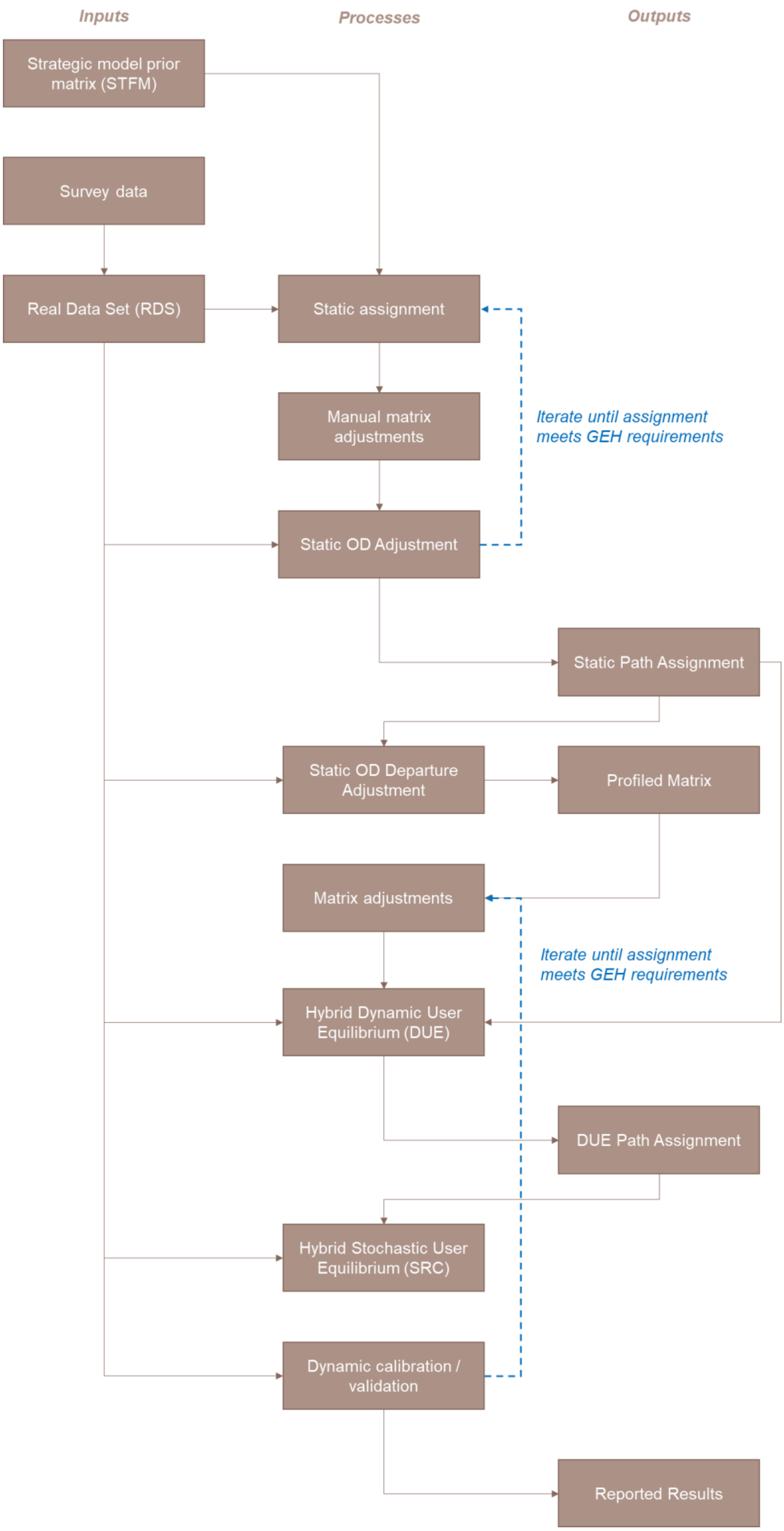


Figure 3-12 Multi-level modelling framework process

3.12.2 Demand adjustment

The following adjustments were made to the STFM demand:

- The initial STFM matrix was disaggregated and adjusted to account for unrealistic demands such as trips with the same origin and destination and trips between adjacent gates where there is a more direct route outside the modelled area
- The AM STFM matrix was also found to be substantially lower than suggested by traffic survey volumes so was scaled up by 27.8 per cent
- This matrix was run through the Aimsun Static OD Adjustment process which adjusts the demand to match survey counts at intersections. The process was restricted using the matrix and trip length elasticity constraints in Aimsun
- The adjusted demand was profiled using the Aimsun Static OD Departure Adjustment to match the surveyed traffic profile. Some manual adjustments were also made to the profiled demand to account for unrealistic inflation or deflation of demand during the Static OD Adjustment process.

Figure 3-13 provides a comparison of the total number of trips for each of the above steps in the demand estimation procedure.

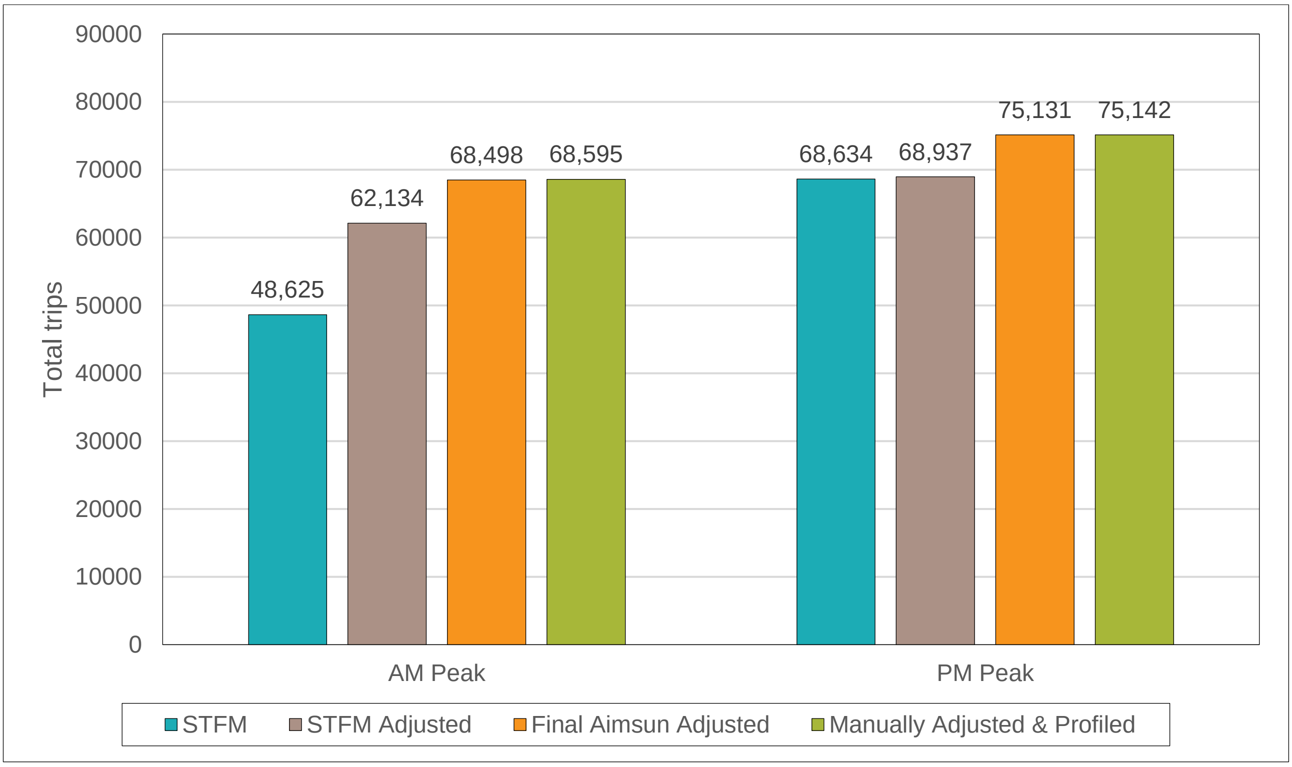


Figure 3-13 Total trips

3.12.3 OD adjustment and trip length distribution

Figure 3-14 and **Figure 3-15** show the trip length distribution outputs for all vehicles following the final Static OD Adjustment experiment for the AM Peak and PM Peaks respectively. There are no significant changes to the shape of the profile following the final adjustment.

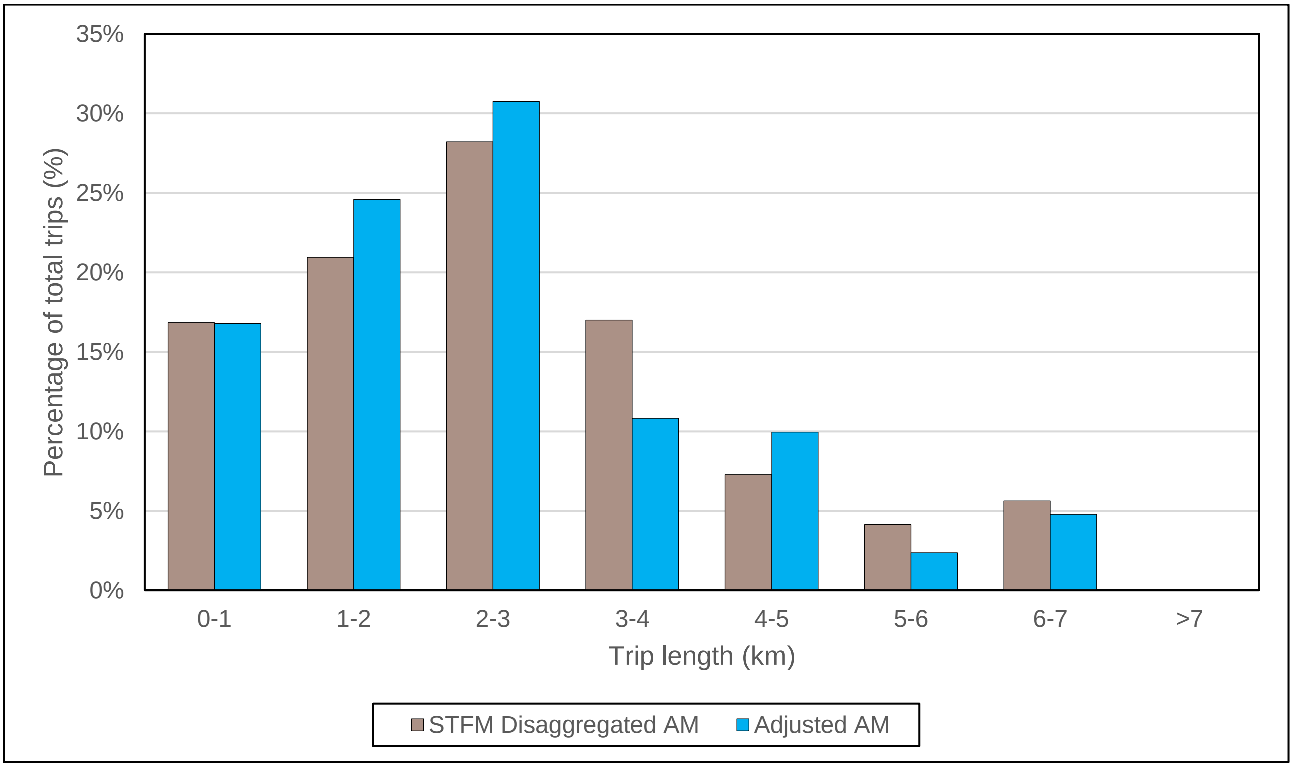


Figure 3-14 AM Peak trip length distribution

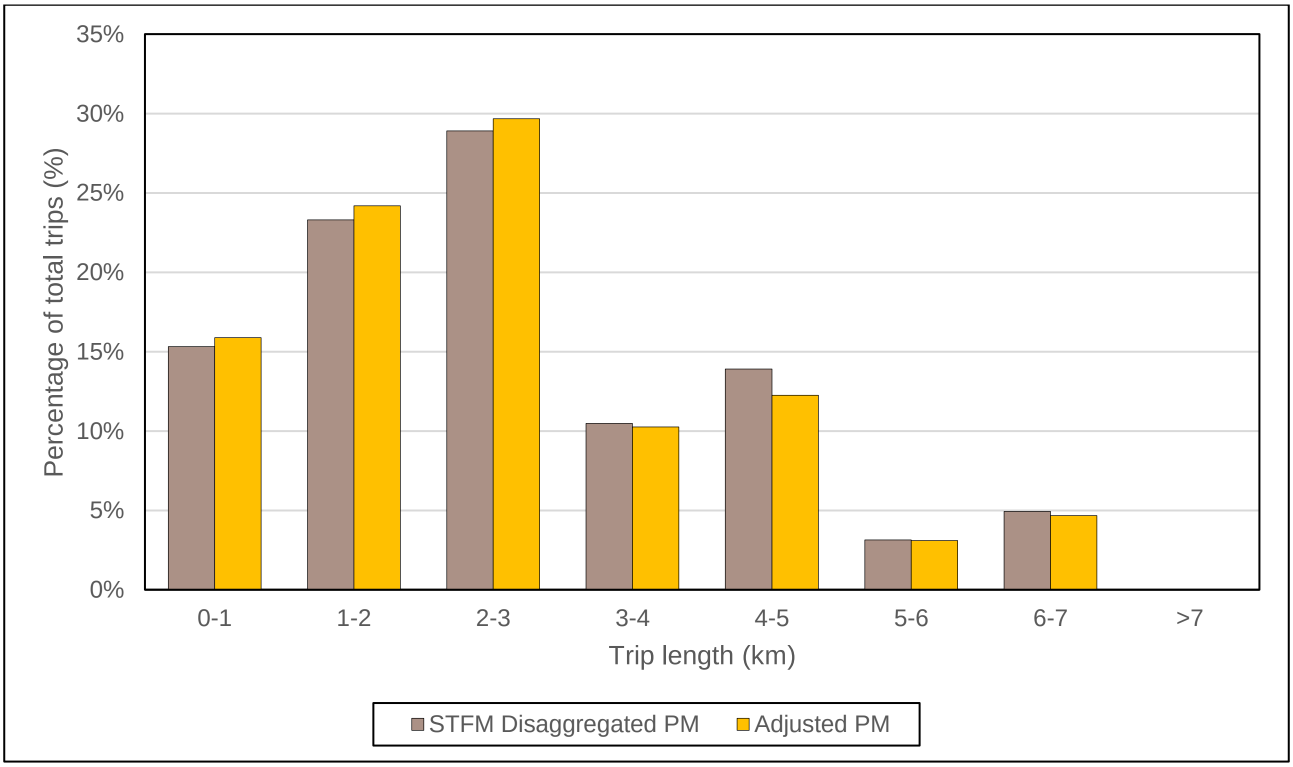


Figure 3-15 PM Peak trip length distribution

3.12.4 Departure adjustment

The two-hourly traffic demand was profiled using the Aimsun Static OD Departure Adjustment based on the profile of the RDS (refer to **Section 2.2.2**). This process was used to generate a profiled demand in 15-minute intervals.

Figure 3-16 and **Figure 3-17** show a comparison between the profile of the RDS and the profiled demand for the AM Peak and PM Peak respectively. All values are within 0.4 per cent of the total demand and there are no significant changes to the shape of the profile.

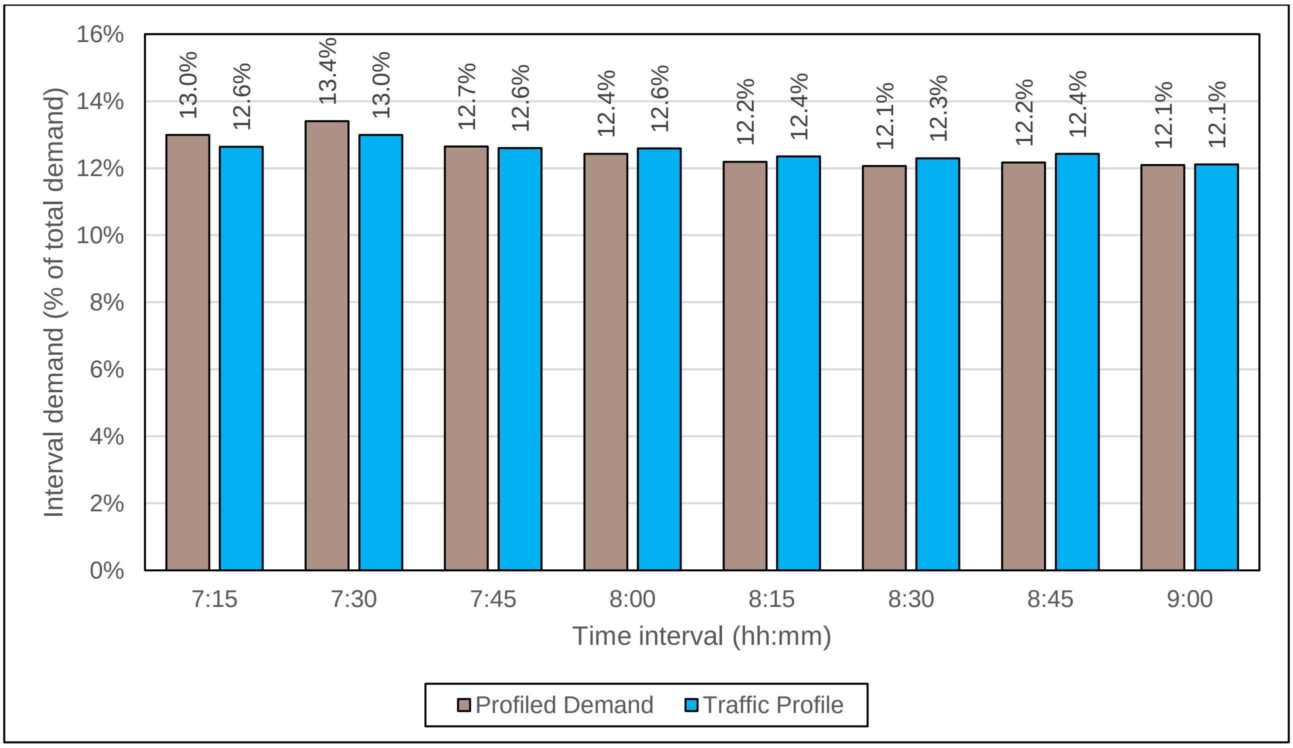


Figure 3-16 Profiled demand comparison (AM Peak)

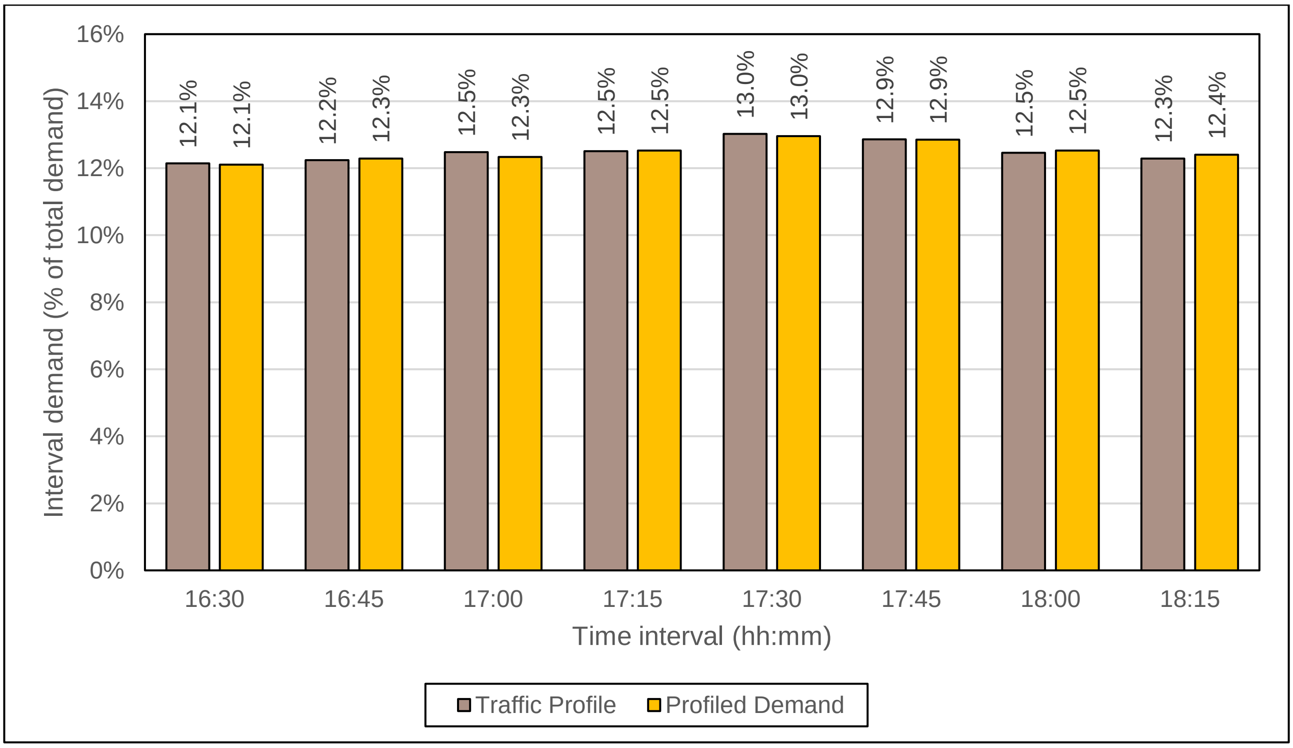


Figure 3-17 Profiled demand comparison (PM Peak)

3.12.5 Traffic demand composition

The traffic demands differentiated between light and heavy vehicles (refer to **Section 3.5**). **Table 3-5** summarises the traffic composition of the demand for each peak. Note that buses are part of the heavy vehicle class but are not included in the demand as they follow fixed routes and run to a fixed timetable.

Table 3-5 Profile demand traffic composition

Peak	Light vehicles		Heavy vehicles		All vehicles
	Demand (veh)	% of total demand	Demand (veh)	% of total demand	Total demand (veh)
AM Peak	65,185	95.0%	3409	5.0%	68,595
PM Peak	73,713	98.1%	1428	1.9%	75142

3.13 Pedestrians and cyclists

Consideration for pedestrian movements in the model was mainly at the intersection level due to the lack of information on mid-block pedestrian paths and walking destinations.

Cyclist volumes were not considered in the model.

3.14 Behaviour parameters

Aimsun defaults were generally adopted for all parameters. Cardno notes that the PRRP model inherited for this project contained substantial adjustment to many of the vehicle behavioural parameters. In some cases, these were restored to Aimsun defaults as the adjusted values were found to be unrealistic. **Figure 3-18** lists the key behavioural parameters that were adjusted based on observations during the calibration and validation process. Note that higher reaction times were utilised in the mesoscopic simulation area. In mesoscopic simulation, vehicles are assumed to accelerate and decelerate instantaneously. Increasing the reaction time factor in mesoscopic simulations is accepted best-practice to account for vehicle acceleration and deceleration time.

Figure 3-18 Key behavioural parameters

Vehicle type	Reaction time	Reaction time at stop	Reaction time for front vehicle at traffic lights	Probability
Microsimulation area				
Car	0.9	1.1	1.3	1
Truck	0.8	1.2	1.5	1
Bus	0.8	1.2	1.5	1
Mesoscopic simulation area				
Car	1.3	-	1.7	1
Truck	1.3	-	1.7	1
Bus	1.3	-	1.7	1

3.15 End constraints at model boundary

To correctly represent queue spillback into the model area as a means of reflecting broader network congestion in the microsimulation model area, dummy signals were included on Parramatta Road in the eastbound direction (east of City Road). The green time on the dummy signals was adjusted to ensure a good match with travel time data and generate variable queue on the edge of the model.

Note that although the signals are located at the Broadway / Mountain Street intersection, they are not intended to represent queue spillback from this intersection but rather queues propagating back along Broadway in the eastbound travel direction caused by congestion on Broadway and George Street that was observed during the site visit and from *Google Traffic* data.

3.16 Calibration criteria

The Base Model was calibrated in accordance with the criteria outlined in *Traffic Modelling Guidelines* (Roads and Maritime Series, 2013) to ensure that the existing traffic conditions are replicated to a statistically high level of accuracy.

The recommended method of calibration is the modified Chi-Square empirical formula developed by Geoffrey E. Harves in the 1970s, known as the GEH-statistic. The GEH-statistic measures the degree of divergence of the modelled value from the observed value while accounting for the relative scale of each movement, that is, movements with higher volumes are more important to match than those with lower volumes.

The GEH-statistic is given by **Equation 1**:

$$GEH = \sqrt{\frac{(V_o - V_m)^2}{0.5(V_o + V_m)}} \qquad \text{Equation 1}$$

where:

V_o = the observed traffic flow
V_m = the modelled traffic flow.

The GEH-statistic is used for individual flows and the R-squared (R^2) statistical measure is used for correlation of the entire data set.

A GEH less than five is considered a good match between the modelled and observed traffic flows while a GEH value of greater than 10 requires further explanation. *Traffic Modelling Guidelines* (Roads and Maritime Services, 2013) recommends the following criteria for model calibration:

- 85 per cent of turn and link flow comparisons to have a GEH less than five
- 100 per cent of turn and link flow comparisons to have a GEH less than 10
- The R-square (R^2) statistic to be greater than 0.95 for a flow plot of observed versus modelled turn volumes (where R^2 = 1.0 indicates a perfect correlation).

Due to the size of the model and time constraints during the calibration stage, a reduced GEH criteria was agreed with DPIE for the mesoscopic area. The relaxed criteria was 80 per cent of turns to have a GEH less than five and 95 per cent of turns to have a GEH less than 10.

3.17 Validation criteria

Validation ensures that factors that influence traffic (other than traffic volumes) such as road capacity, driver behaviour and responsiveness are adequately captured in the model. The Base Model was validated in accordance with the criteria outlined in *Traffic Modelling Guidelines* (Roads and Maritime Services, 2013) to ensure accurate replication of driver behaviour and road conditions. Two validation criteria were used for the Base Model:

- Travel time validation
- Signal validation
- Congestion hotspot validation.

These are outlined below.

3.17.1 Travel time validation

The validation of travel time on key routes confirms that the model is accurately replicating observed congestion and driver behaviour. *Traffic Modelling Guidelines* (Roads and Maritime Services, 2013) recommends the following criteria for travel time validation:

> Average modelled journey time to be within 15 per cent or one minute (whichever is greater) of the average observed journey time for the full length of the route

> Average modelled time for each section to be within 15 per cent of the observed journey time for that section.

The travel time routes are shown in **Section 2.2.3**.

3.17.2 Signal validation

Traffic Modelling Guidelines (Roads and Maritime Services, 2013) recommends the following criteria for signal timing validation:

> Average modelled cycle time for each one-hour period to be within 10 per cent of the observed average cycle time for the same one-hour period

> Total of green time over each one-hour period to be within 10 per cent of the observed equivalent for each phase

> Call frequency of demand-dependent phases (including pedestrian call phases) to be compared with observed data to ensure phase activation occurs to a similar level over each hour period.

3.17.3 Congestion hotspot validation

Modelled average speed by section was plotted for each peak and compared to the average speed data extracted from TomTom (refer to **Section 2.3**). This provided an additional layer of verification that the average speeds in the model were reflective of those in reality.

4 Model stability

The stochasticity of a microsimulation model can cause instability. This can undermine the reliability of the model to forecast future traffic conditions. It is important that the Base Model is stable and has an appropriate degree of accuracy for future options assessment. To determine the stability of a model, a total of five seed values and the default time-step value in Aimsun are initially used to iteratively determine the number of runs, as recommended by *Traffic Modelling Guidelines* (Roads and Maritime Services, 2013).

Vehicle hours travelled (VHT) was the statistic chosen to determine the model stability. The VHT results are a single-figure summary that provide an indication of whole-network performance by identifying whether the model has unrealistic gridlocks and/or excessive delays. VHT is calculated by summing the individual travel time for each vehicle across the whole network. In Aimsun, VHT is only calculated using vehicles which complete a trip from their origin to their destination; any vehicles remaining in the network at the conclusion of the simulation period are excluded from the VHT.

4.1 Seeds run

To analyse the model stability, each peak period model was assessed using the five seed values recommended in *Traffic Modelling Guidelines* (Roads and Maritime Services, 2013). The different seeds introduce slight variations to the number of vehicles in the network for regular intervals throughout the simulation. The seed values used were:

> 560

> 28

> 7771

> 86524

> 2849.

4.2 Stability assessment

Figure 4-1 and **Figure 4-2** show the variation in VHT per 15-minute interval for the AM Peak and PM Peak respectively. The results show that the model performs similarly across the five seeds run.

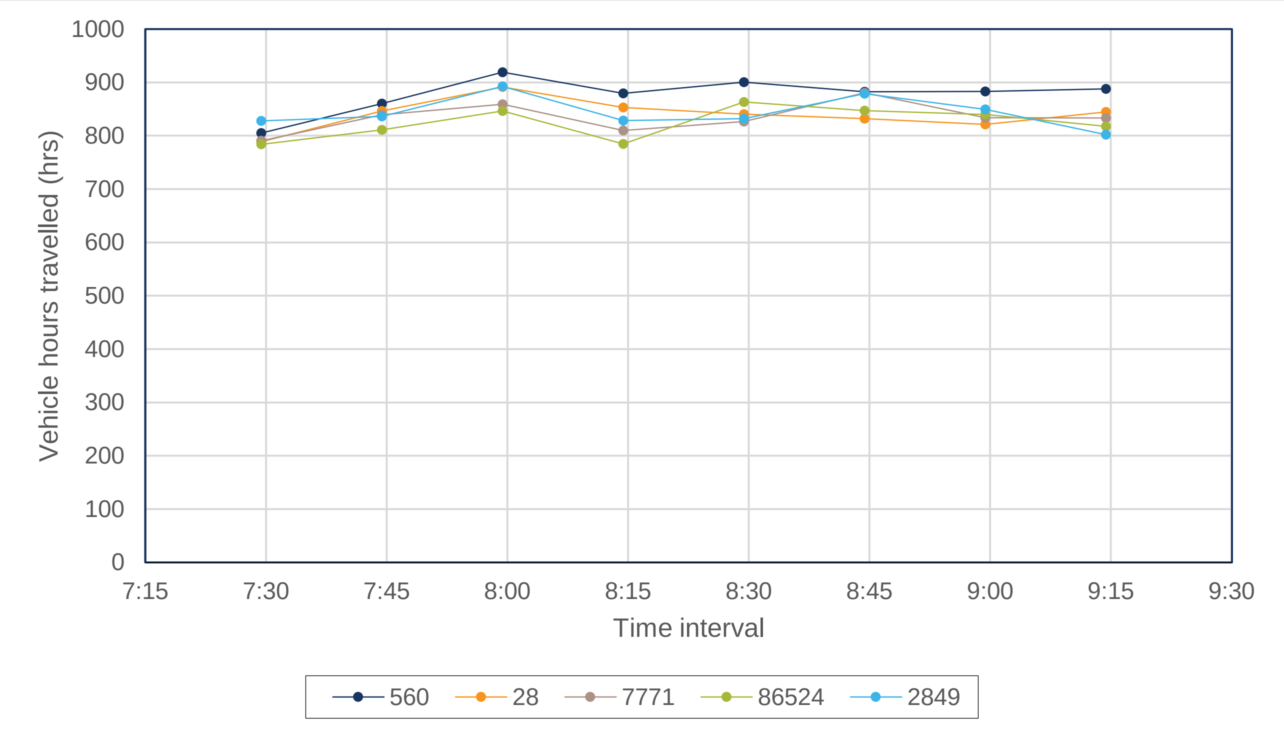


Figure 4-1 Vehicle hours travelled (VHT) across all seeds (AM Peak)

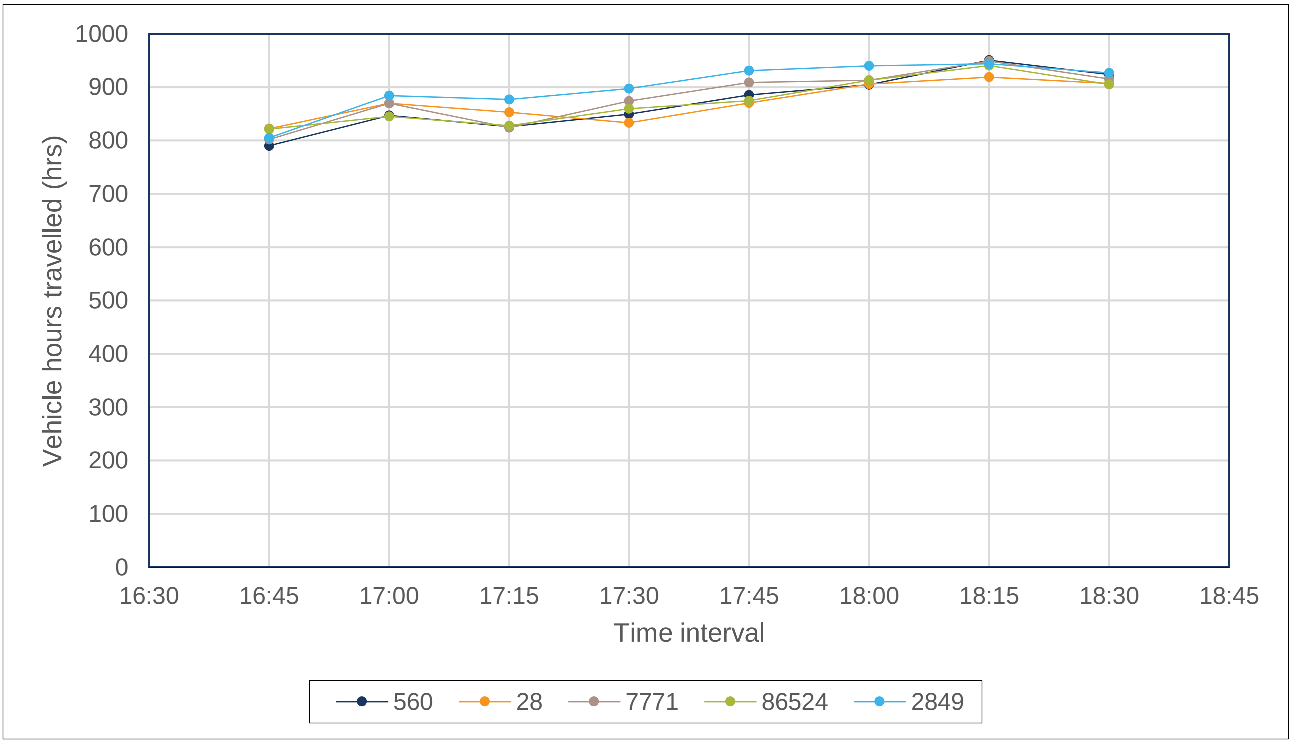


Figure 4-2 Vehicle hours travelled (VHT) across all seeds (PM Peak)

The number of seed runs required to determine the stability of the model is calculated iteratively using **Equation 2**:

$$N = \left(\frac{t\sigma}{\Delta}\right)^2$$ Equation 2

where:

N = number of runs required
t = two-tailed inverse of Student's t-distribution
σ = standard deviation
Δ = acceptable error (produce of precision and sample mean).

The t-value required for a confidence interval of 95 per cent given five initial seeds is 2.776. The number of runs required for each peak period are shown in **Table 4-1**.

Table 4-1 Number of simulation runs required

Parameter	AM peak	PM peak
t	2.776	2.776
σ	160.3	97.4
x̄	6750	7041
Δ	337.51	352.04
N	1.74	0.59

The number of simulation runs required (N) is less than the initial five seeds used in both peaks, therefore it is sufficient to retain the initial five seeds for a confidence interval of 95 per cent. **Table 4-2** shows the VHT bounds and the median seed for each peak.

Table 4-2 Median seed values

Peak	All seeds			Median seed	
	VHT lower bound	Mean VHT	VHT upper bound	VHT	Seed value
AM Peak	6594	6750	7012	6718	28
PM Peak	6976	7041	7205	6988	86524

The results reported in the remainder of this report for calibration and validation are based on the median seed values for each peak shown in **Table 4-2**.

5 Model calibration and validation

5.1 Convergence

As outlined in Section 3.4.2, DUE is an iterative procedure that involves shifting users to the shortest path given the travel times on each path in the previous iteration. The relative gap (RGap) is a measure of the difference between the modelled travel times and the travel times if all vehicles were using the shortest path. It provides an indication of whether the DUE assignment has converged to the optimal solution. Due to the size of the model and required run time for DUE convergence, a stopping RGap of 1.0 per cent was adopted.

Figure 5-1 and **Figure 5-2** show the DUE convergence for the AM Peak and PM Peak respectively. Both peaks converge within four iterations.

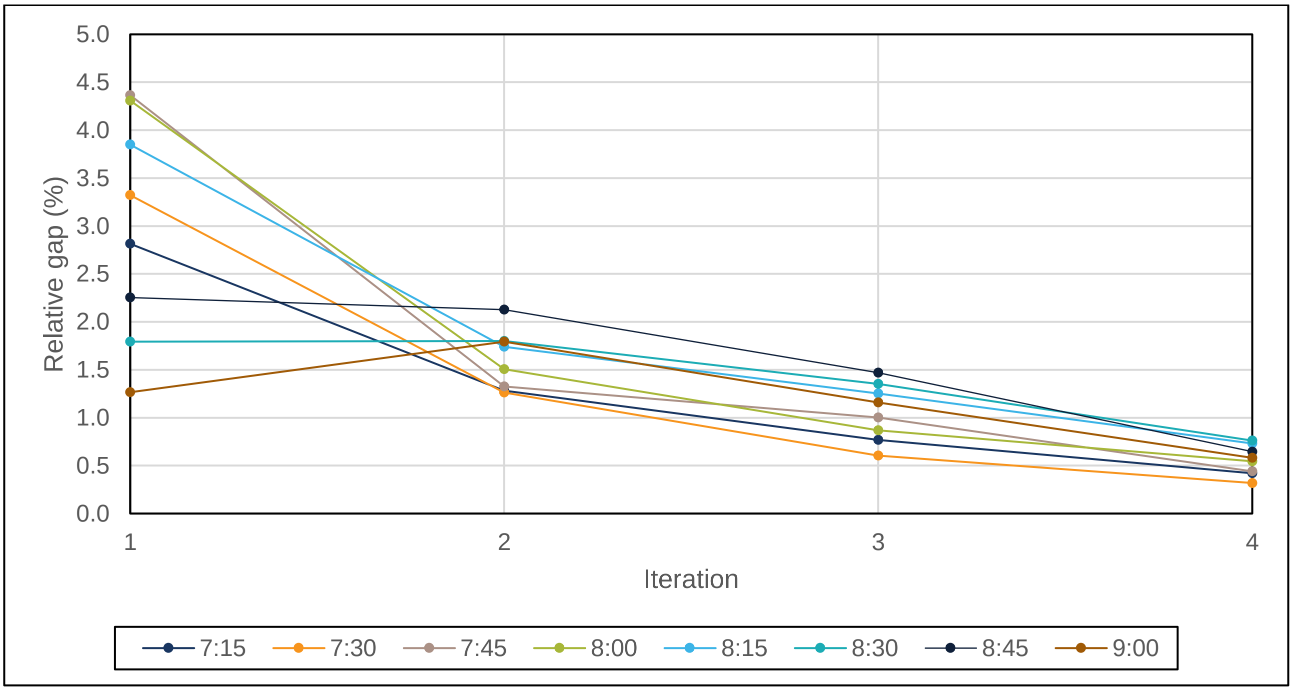


Figure 5-1 AM Peak DUE convergence

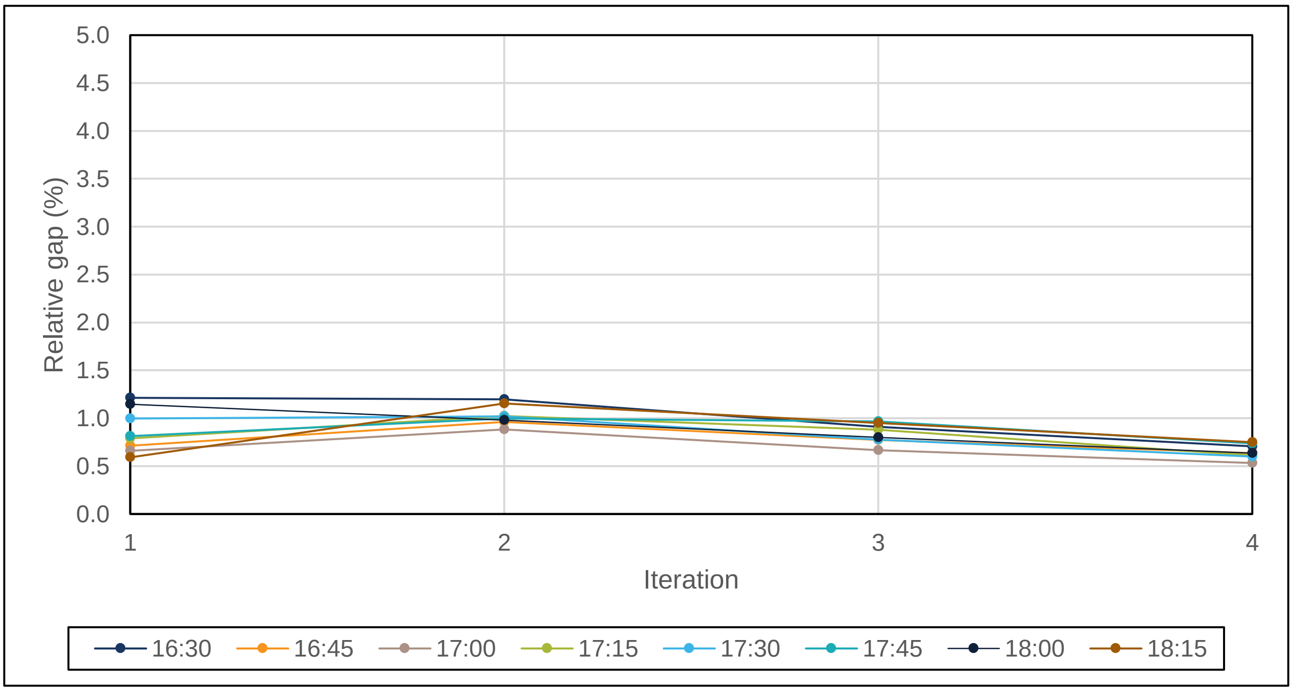


Figure 5-2 PM Peak DUE convergence

5.2 Calibration results

This section outlines the calibration results. **Table 5-1** provides a summary of the GEH criteria and for turning counts and the number of compliant counts for each hour of each peak.

Table 5-1 Summary of GEH statistics for each modelled hour

Model area	Criteria	AM Peak		PM Peak	
		7:15AM – 8:15AM	8:15AM – 9:15AM	4:30PM – 5:30PM	5:30PM – 6:30PM
Light vehicles					
Micro	Turns with GEH < 5	133 / 142 93.7%	131 / 142 92.3%	129 / 142 90.8%	127 / 142 89.4%
	Turns with GEH < 10	142 / 142 100.0%	142 / 142 100.0%	142 / 142 100.0%	142 / 142 100.0%
	Calibration achieved?	✓	✓	✓	✓
Meso	Turns with GEH < 5	412 / 462 89.2%	410 / 462 88.7%	424 / 462 91.8%	417 / 462 90.3%
	Turns with GEH < 10	459 / 462 99.4%	461 / 462 99.8%	456 / 462 98.7%	458 / 462 99.1%
	Calibration achieved?	✓	✓	✓	✓
All	Turns with GEH < 5	545 / 604 90.2%	541 / 604 89.6%	553 / 604 91.6%	544 / 604 90.1%
	Turns with GEH < 10	601 / 604 99.5%	603 / 604 99.8%	598 / 604 99.0%	600 / 604 99.3%
	Calibration achieved?	✓	✓	✓	✓
Heavy vehicles					
Micro	Turns with GEH < 5	142 / 142 100.0%	140 / 142 98.6%	140 / 142 98.6%	140 / 142 98.6%
	Turns with GEH < 10	142 / 142 100.0%	142 / 142 100.0%	142 / 142 100.0%	142 / 142 100.0%
	Calibration achieved?	✓	✓	✓	✓
Meso	Turns with GEH < 5	458 / 462 99.1%	452 / 462 97.8%	457 / 462 98.9%	450 / 462 97.4%
	Turns with GEH < 10	462 / 462 100.0%	462 / 462 100.0%	462 / 462 100.0%	462 / 462 100.0%
	Calibration achieved?	✓	✓	✓	✓
All	Turns with GEH < 5	600 / 604 99.3%	592 / 604 98.0%	597 / 604 98.8%	590 / 604 97.7%
	Turns with GEH < 10	604 / 604 100.0%	604 / 604 100.0%	604 / 604 100.0%	604 / 604 100.0%
	Calibration achieved?	✓	✓	✓	✓

Across the four modelled hours, a total 11 different turns have a GEH greater than 10. **Table 5-2** lists the locations of these turns and the modelled hours for which the GEH exceeds 10. All such turns are in the mesoscopic area of the model so only indirectly impact the calibration of the Parramatta Road corridor. Nevertheless, a short explanation of each turn and the reason/s that the GEH exceeds 10 in the given modelled hours is provided in the table.

In most cases the GEH did not significantly exceed 10. The average GEH of turns with a GEH above 10 was 11.25 and the maximum value across all modelled hours was 13.83. Furthermore, the total number of turns with GEH exceeding 10 was not more than six in any modelled hour, which represents less than one per cent of the total number of comparisons. Due to the low number of turns with GEH exceeding 10 and their location outside the Parramatta Road corridor (the key focus of the model), the impact of this on the calibration of the model is considered to be negligible. Most of the turns with GEH greater than 10 were concentrated in two areas for the following reasons:

- Near Lilyfield Road and City-West Link Road due to a large number of local roads that were not modelled and scarcity of survey data in this area to understand OD patterns and vehicle routing behaviour
- Moore Street / Booth Street caused by limited survey data along Moore Street and Booth Street and a lack of local roads that may be used as shortcuts.

Table 5-2 Turns with GEH greater than 10

Turn ID	Description	GEH	Model area	Modelled hours with GEH > 10	Notes
3NR	Right turn from Catherine Street to City-West Link Road	10.70	Meso	4:30PM – 5:30PM	Underrepresented in the model with 58 vehicles (surveyed volume was 173 vehicles). This is likely caused by the high density of local roads in this area of the model that have not been modelled and the scarcity of survey data in this area to identify routes to a high degree of accuracy. The GEH for this turn is also not substantially above 10.
5ER	Right turn from Moore Street to Catherine Street	13.83 13.40	Meso	4:30PM – 5:30PM 5:30PM – 6:30PM	Underrepresented in the model due to a lack of vehicles on Moore Street and Booth Street. Only limited survey data was available on Moore Street and Booth Street so vehicle routing and OD patterns could not be modelled to a high level of accuracy.
7SR	Right turn from Balmain Road to Moore Street	12.74	Meso	8:15AM – 9:15AM	
15NL	Left turn from Johnston Street to Collins Street	11.93	Meso	7:15AM – 8:15AM	Overrepresented in the model. This is likely due to an overestimation of the demand for destinations in this area as this route does not provide a shortcut to any other key destinations in the model.
16WR	Right turn from Booth Street to Johnston Street	10.04	Meso	7:15AM – 8:15AM	Overrepresented in the model due to uncertainty surrounding vehicle routing and OD patterns on Booth Street / Moore Street due to scarcity of survey data in this vicinity. The GEH for this turn is also not substantially above 10.
16SL	Left turn from Johnston Street to Booth Street	11.30 12.09	Meso	4:30PM – 5:30PM 5:30PM – 6:30PM	Underrepresented in the model due to uncertainty surrounding vehicle routing and OD patterns on Booth Street / Moore Street due to scarcity of survey data in this vicinity.

Turn ID	Description	GEH	Model area	Modelled hours with GEH > 10	Notes
33NT	Through movement from James Street to Darley Road	10.79	Meso	5:30PM – 6:30PM	Overrepresented in the model. It was observed that vehicles tended to use Darley Street rather than Catherine Street or Norton Street as major north-to-south connectors. Subsequently traffic volumes on Darley Road were higher than observed while those on Catherine Street and Norton Street were lower. This is likely caused by the high density of local roads in the area that have not been modelled and the scarcity of survey data to accurately identify routes and OD patterns. The GEH for this turn is also not substantially above 10.
35EL	Left turn from Lilyfield Road to James Street	10.03	Meso	4:30PM – 5:30PM	Underrepresented in the model due to uncertainty surrounding traffic volumes on Lilyfield Road (see above). The GEH for this turn is also not substantially above 10.
41NL	Left turn from Tebbutt Street to Railway Terrace	10.10 10.20	Meso	4:30PM – 5:30PM 5:30PM – 6:30PM	Underrepresented in the model due to the zoning system. The GEH for this turn is also not substantially above 10.
42ET	Through movement on Lilyfield Road at Balmain Road	10.09	Meso	4:30PM – 5:30PM	Underrepresented in the model due to uncertainty surrounding traffic volumes on Lilyfield Road (see above). The GEH for this turn is also not substantially above 10.
56NL	Left turn from Dalhousie Street to Ramsay Street	10.28	Meso	7:15AM – 8:15AM	Overrepresented in the model with more vehicles tending to turn left onto Ramsay Street rather than going through then turning left at Parramatta Road. The GEH for this turn is also not substantially above 10.

Figure 5-3 and **Figure 5-4** show the results of a regression analysis of the results for the AM Peak. **Figure 5-5** and **Figure 5-6** show the results of a regression analysis of the results for the PM Peak.

Table 5-3 provides a summary of the regression analysis results. For each modelled hour, the results indicate a strong correlation between the modelled and observed flows. The coefficient of determination (R^2) exceeds the required value of 0.95 for all hours.

Table 5-3 Regression analysis summary

Modelled hour	Slope	Coefficient of determination (R^2)	Calibration achieved?
7:15AM – 8:15AM	1.0155	0.9922	✓
8:15AM – 9:15AM	0.9708	0.9894	✓
4:30PM – 5:30PM	0.9965	0.9946	✓
5:30PM – 6:30PM	0.9849	0.9940	✓

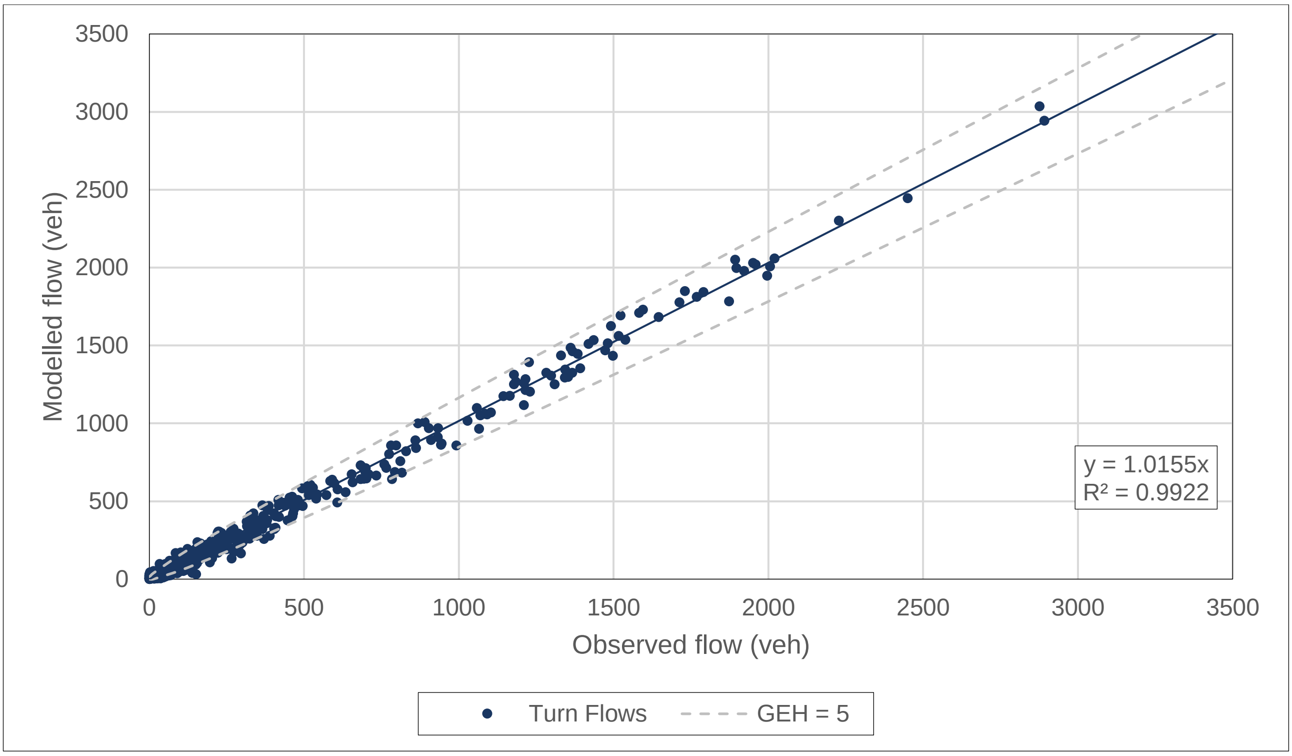


Figure 5-3 AM Peak (7:15AM – 8:15AM) regression plot

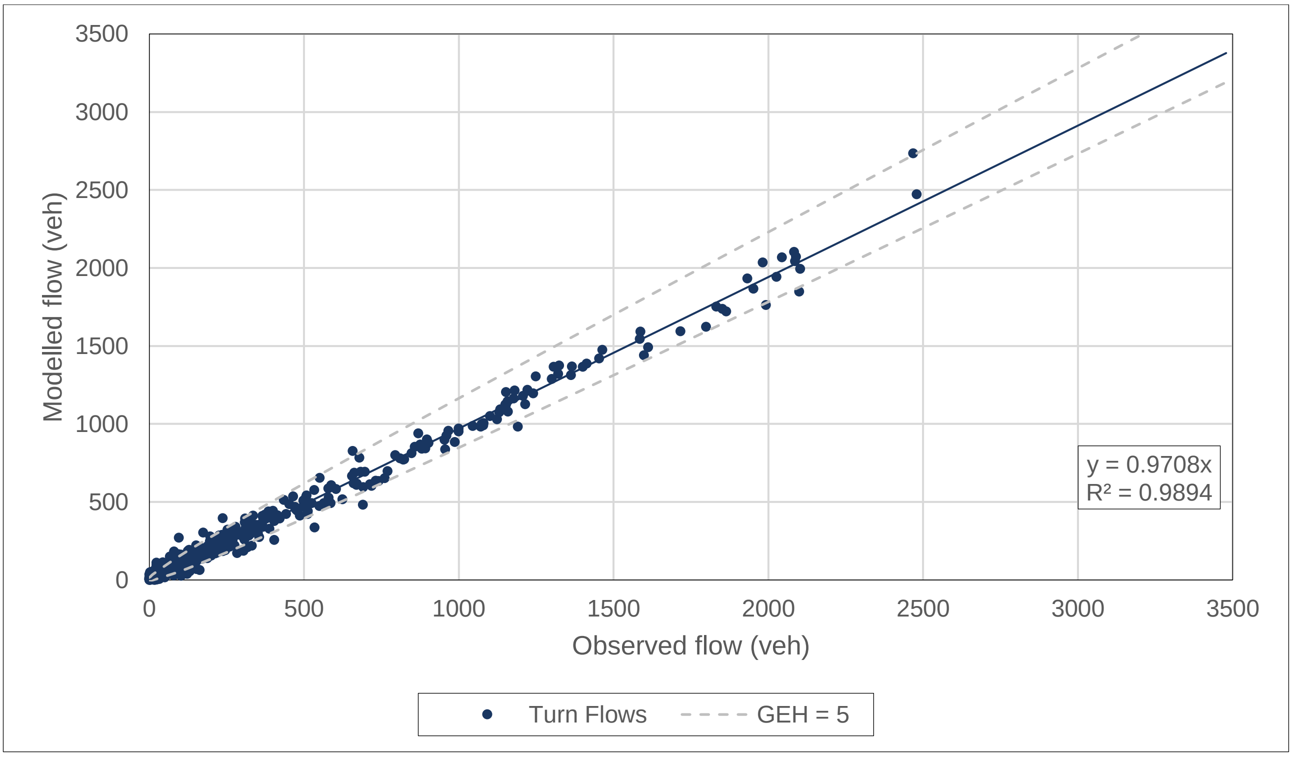


Figure 5-4 AM Peak (8:15AM – 9:15AM) regression plot

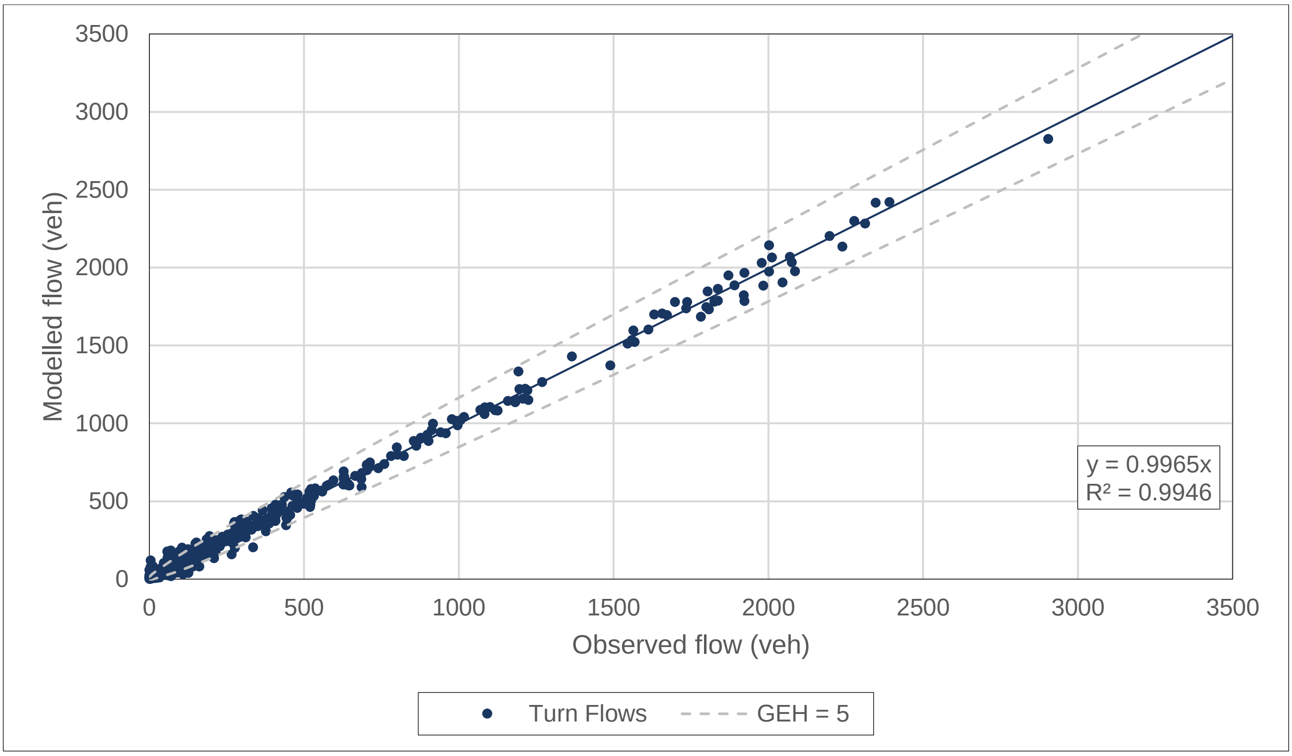


Figure 5-5 PM Peak (4:30PM – 5:30PM) regression plot

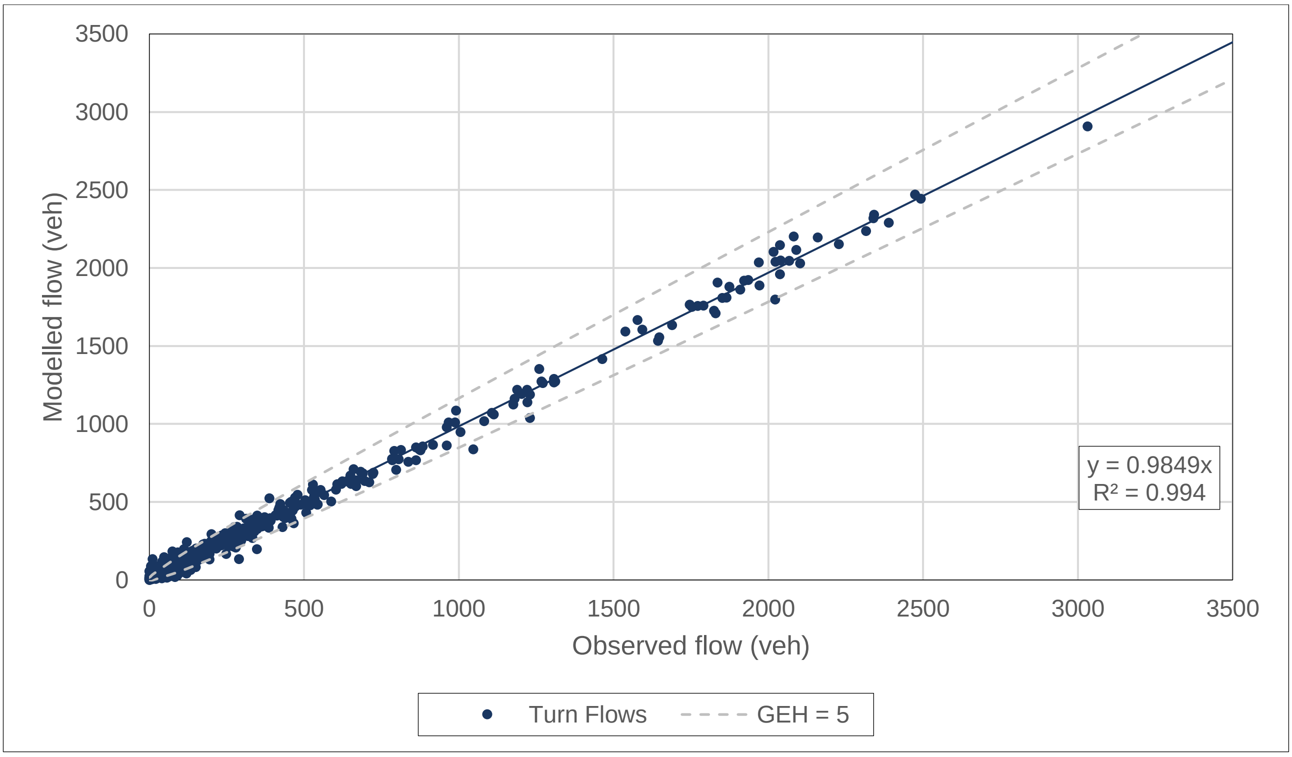


Figure 5-6 PM Peak (5:30PM – 6:30PM) regression plot

5.3 Validation results

5.3.1 Travel time validation

This section outlines the travel time validation results. Six bi-directional routes were used for travel time validation as discussed in **Section 2.2.3**. **Table 5-4** shows the travel time validation results for each route for each modelled hour. All routes are within 60 seconds or 15 per cent of the observed value as required by *Traffic Modelling Guidelines* (Roads and Maritime Services, 2013).

Table 5-4 Travel time validation results by route

Modelled hour	Modelled (s)	Observed (s)	Difference (s)	Difference (%)	Validation
Parramatta Road (eastbound)					
7:15AM – 8:15AM	1113	1261	-148	-11.7%	✓
8:15AM – 9:15AM	1249	1385	-136	-9.8%	✓
4:30PM – 5:30PM	887	970	-83	-8.5%	✓
5:30PM – 6:30PM	950	1086	-136	-12.5%	✓
Parramatta Road (westbound)					
7:15AM – 8:15AM	836	866	-30	-3.5%	✓
8:15AM – 9:15AM	833	967	-134	-13.9%	✓
4:30PM – 5:30PM	916	908	+8	+0.9%	✓
5:30PM – 6:30PM	933	1006	-72	-7.2%	✓
Crystal Street (northbound)					
7:15AM – 8:15AM	173	147	+26	+17.5%	✓
8:15AM – 9:15AM	185	152	+33	+21.9%	✓
4:30PM – 5:30PM	216	209	+7	+3.3%	✓
5:30PM – 6:30PM	179	218	-39	-17.8%	✓
Crystal Street (southbound)					
7:15AM – 8:15AM	257	304	-47	-15.5%	✓
8:15AM – 9:15AM	293	339	-46	-13.7%	✓
4:30PM – 5:30PM	207	264	-56	-21.4%	✓
5:30PM – 6:30PM	233	289	-56	-19.4%	✓
Balmain Road (northbound)					
7:15AM – 8:15AM	337	363	-25	-6.9%	✓
8:15AM – 9:15AM	314	344	-30	-8.9%	✓
4:30PM – 5:30PM	301	321	-20	-6.3%	✓
5:30PM – 6:30PM	283	303	-20	-6.7%	✓
Balmain Road (southbound)					
7:15AM – 8:15AM	173	218	-45	-20.8%	✓
8:15AM – 9:15AM	179	221	-42	-18.8%	✓
4:30PM – 5:30PM	178	174	+4	+2.4%	✓
5:30PM – 6:30PM	154	176	-22	-12.4%	✓

Modelled hour	Modelled (s)	Observed (s)	Difference (s)	Difference (%)	Validation
Brighton Street – Douglas Street – Salisbury Road (eastbound)					
7:15AM – 8:15AM	458	457	+1	+0.3%	✓
8:15AM – 9:15AM	444	497	-53	-10.6%	✓
4:30PM – 5:30PM	371	371	0	0.0%	✓
5:30PM – 6:30PM	368	381	-13	-3.4%	✓
Salisbury Road – Douglas Street – Brighton Street (westbound)					
7:15AM – 8:15AM	311	277	+35	+12.5%	✓
8:15AM – 9:15AM	300	278	+23	+8.2%	✓
4:30PM – 5:30PM	321	280	+41	+14.5%	✓
5:30PM – 6:30PM	312	295	+17	+5.8%	✓
Marion Street (eastbound)					
7:15AM – 8:15AM	310	308	+2	+0.6%	✓
8:15AM – 9:15AM	317	333	-16	-4.7%	✓
4:30PM – 5:30PM	223	278	-55	-19.8%	✓
5:30PM – 6:30PM	212	181	+31	+17.0%	✓
Marion Street (westbound)					
7:15AM – 8:15AM	211	199	24	12.5%	✓
8:15AM – 9:15AM	218	213	+5	+2.3%	✓
4:30PM – 5:30PM	206	203	+3	+1.7%	✓
5:30PM – 6:30PM	220	207	+13	+6.1%	✓
Johnston Street (northbound)					
7:15AM – 8:15AM	321	297	+26	+8.7%	✓
8:15AM – 9:15AM	276	299	-23	-7.7%	✓
4:30PM – 5:30PM	261	290	-29	-9.9%	✓
5:30PM – 6:30PM	286	290	-3	-1.2%	✓
Johnston Street (southbound)					
7:15AM – 8:15AM	246	270	-24	-8.9%	✓
8:15AM – 9:15AM	256	303	-47	-15.5%	✓
4:30PM – 5:30PM	313	312	+1	+0.2%	✓
5:30PM – 6:30PM	275	319	-44	-13.8%	✓

Table 5-5 compares the observed and modelled travel time for each segment of each route for each modelled hour. Following the table, **Figure 5-7** to **Figure 5-18** provide a comparison between the modelled and observed travel time for each segment of each route. The results show an acceptable replication of the travel time along each route. Consequently, the Base Models are considered to accurately replicate traffic and congestion patterns along key routes in the study area.

Table 5-5 Modelled versus observed travel time by segment

Segment	AM Peak						PM Peak					
	7:15AM – 8:15AM			8:15AM – 9:15AM			4:30PM – 5:30PM			5:30PM – 6:30PM		
	Modelled (s)	Observed (s)	Difference (s)	Modelled (s)	Observed (s)	Difference (s)	Modelled (s)	Observed (s)	Difference (s)	Modelled (s)	Observed (s)	Difference (s)
Parramatta Road (eastbound)												
1	365	410	-46	400	410	-10	251	239	12	277	299	-22
2	267	264	3	250	286	-36	199	196	3	242	225	17
3	200	238	-38	242	241	1	143	190	-48	165	189	-24
4	283	349	-67	357	448	-91	295	345	-50	266	373	-108
Parramatta Road (westbound)												
1	298	323	-26	294	365	-71	371	370	1	319	388	-69
2	203	202	1	223	248	-26	186	196	-10	237	234	3
3	125	128	-3	129	155	-26	160	149	11	143	142	1
4	210	212	-2	187	199	-12	200	193	7	234	241	-7
Crystal Street (northbound)												
1	71	54	17	88	57	31	70	44	26	60	44	16
2	102	94	8	97	94	2	145	165	-19	119	173	-54
Crystal Street (southbound)												
1	144	174	-29	169	212	-43	100	158	-58	94	167	-73
2	112	130	-18	124	128	-3	107	106	2	139	122	17
Balmain Road (northbound)												
1	123	126	-2	149	164	-15	108	127	-19	114	129	-15
2	91	95	-5	81	92	-11	100	92	9	61	79	-18
3	123	141	-18	84	89	-5	93	102	-9	108	96	12
Balmain Road (southbound)												
1	54	81	-27	55	69	-13	66	78	-12	65	74	-9
2	119	137	-18	124	152	-28	112	96	16	90	103	-13

Segment	AM Peak						PM Peak					
	7:15AM – 8:15AM			8:15AM – 9:15AM			4:30PM – 5:30PM			5:30PM – 6:30PM		
	Modelled (s)	Observed (s)	Difference (s)	Modelled (s)	Observed (s)	Difference (s)	Modelled (s)	Observed (s)	Difference (s)	Modelled (s)	Observed (s)	Difference (s)
Brighton Street – Douglas Street – Salisbury Road (westbound)												
1	218	146	72	196	147	49	176	149	27	168	137	30
2	72	82	-11	63	82	-19	55	67	-12	56	73	-17
3	116	163	-46	137	185	-48	103	111	-9	107	124	-17
4	52	66	-14	47	82	-35	38	45	-7	37	47	-10
Salisbury Road – Douglas Street – Brighton Street (eastbound)												
1	31	31	-1	30	33	-2	40	33	7	42	36	6
2	113	103	10	109	100	8	99	98	1	103	106	-3
3	101	61	41	96	62	34	113	65	48	95	69	26
4	33	38	-5	33	39	-6	33	38	-5	33	38	-5
5	33	43	-10	33	44	-11	35	46	-11	39	46	-7
Marion Street (eastbound)												
1	149	167	-18	141	169	-28	112	120	-8	98	92	6
2	160	141	19	177	164	13	111	158	-47	114	90	25
Marion Street (westbound)												
1	121	96	26	121	114	8	114	116	-2	132	113	19
2	90	92	-2	96	99	-3	92	87	5	88	95	-6
Johnston Street (northbound)												
1	71	83	-12	68	88	-21	69	85	-16	73	78	-5
2	47	44	4	49	55	-5	34	54	-19	59	49	10
3	203	169	34	159	156	3	158	151	7	154	163	-8
Johnston Street (southbound)												
1	128	142	-14	134	165	-31	139	152	-13	141	143	-1
2	30	33	-3	28	34	-6	60	32	28	36	33	3
3	88	95	-7	95	105	-10	114	128	-14	98	143	-45

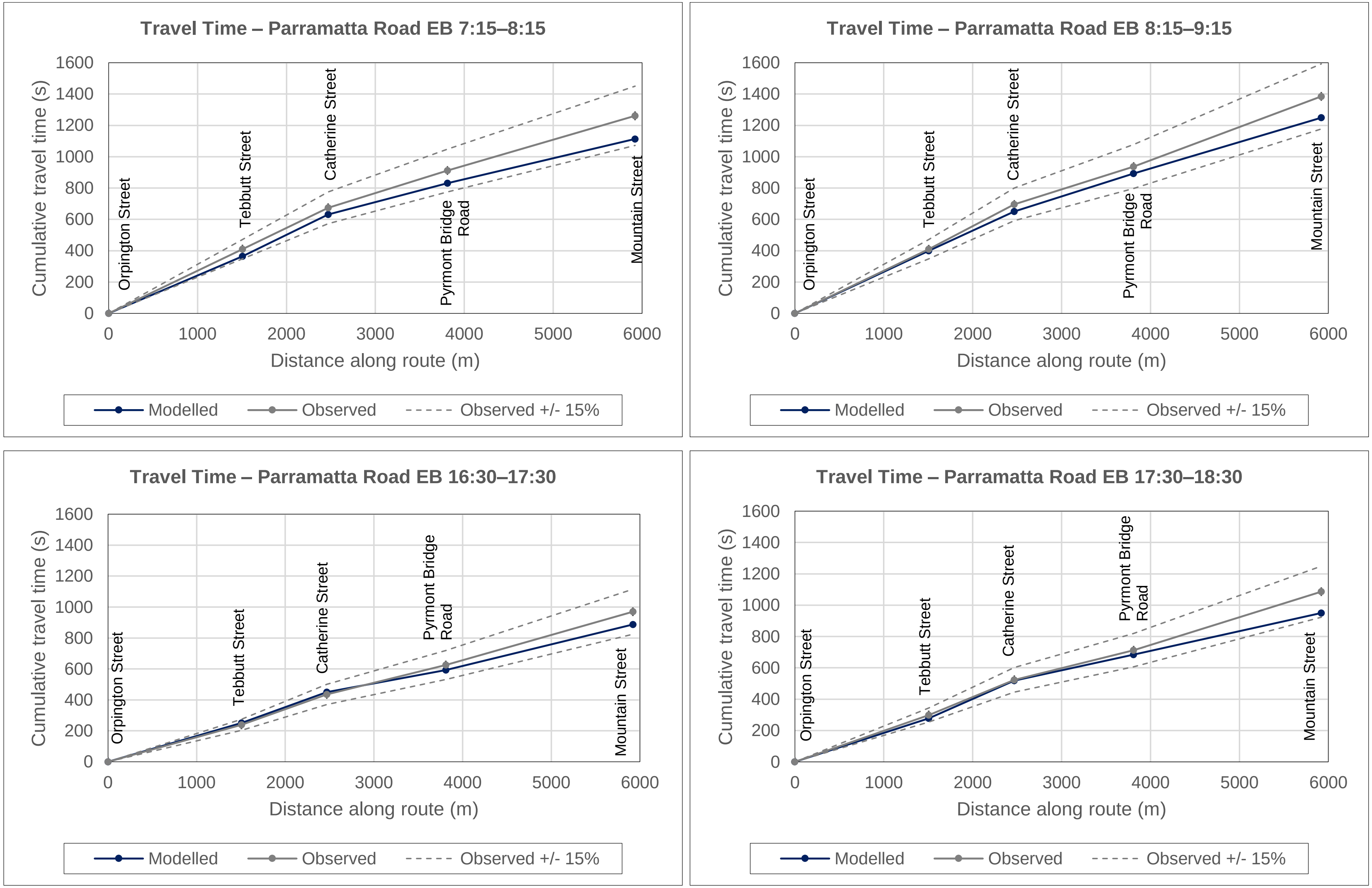


Figure 5-7 Travel times on Parramatta Road (eastbound)

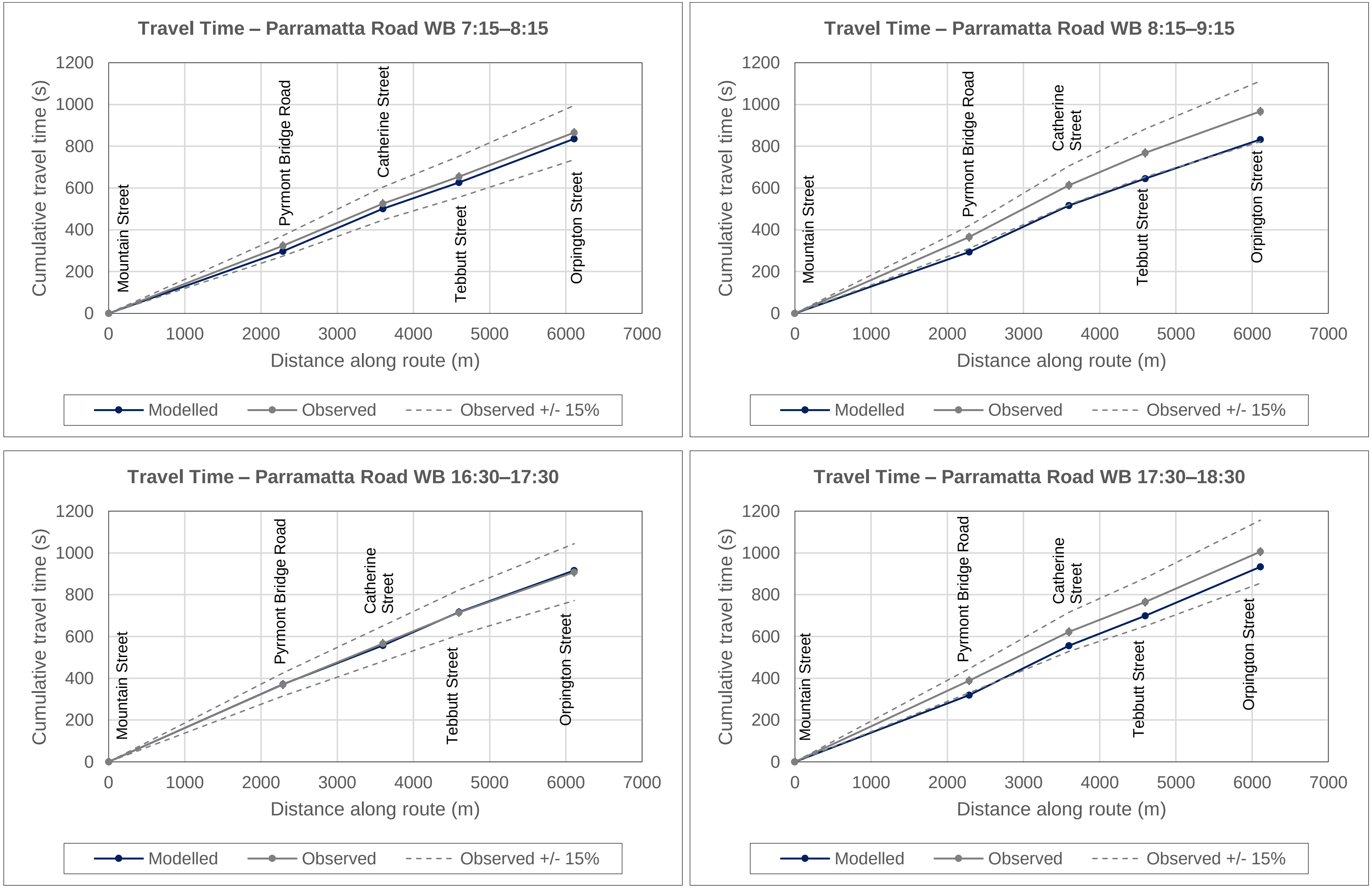


Figure 5-8 Travel times on Parramatta Road (westbound)

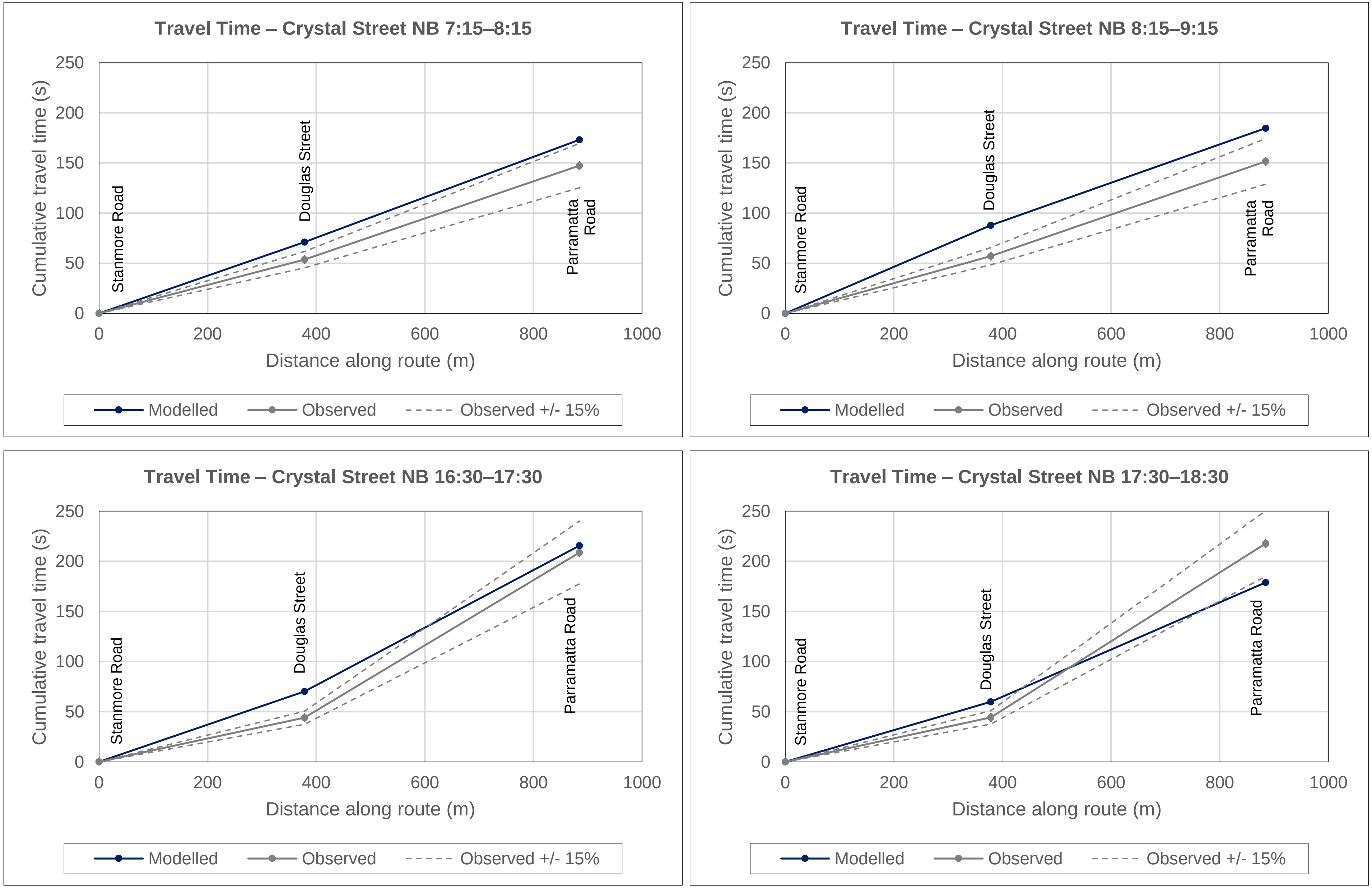


Figure 5-9 Travel times on Crystal Street (northbound)

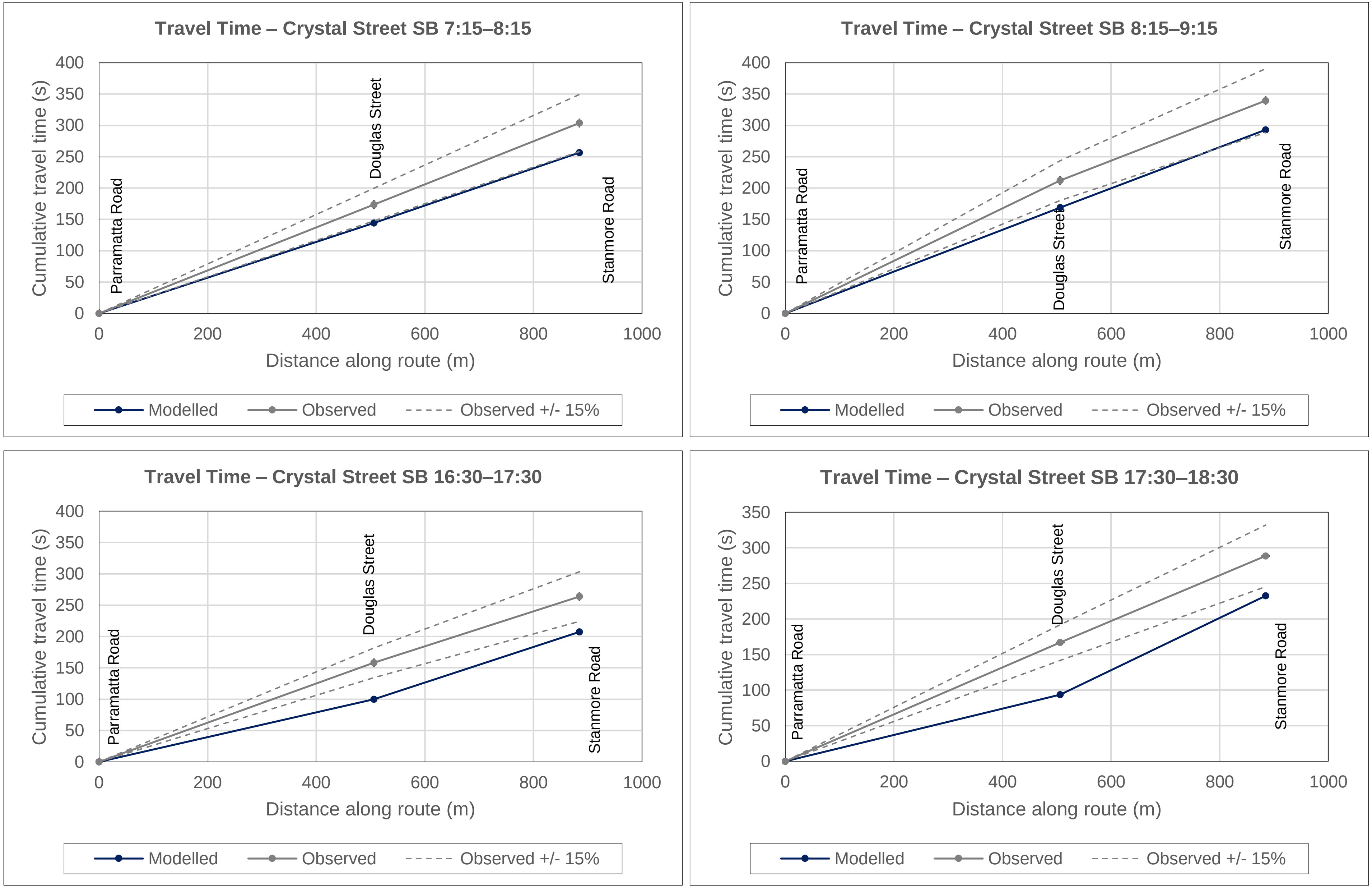


Figure 5-10 Travel times on Crystal Street (southbound)

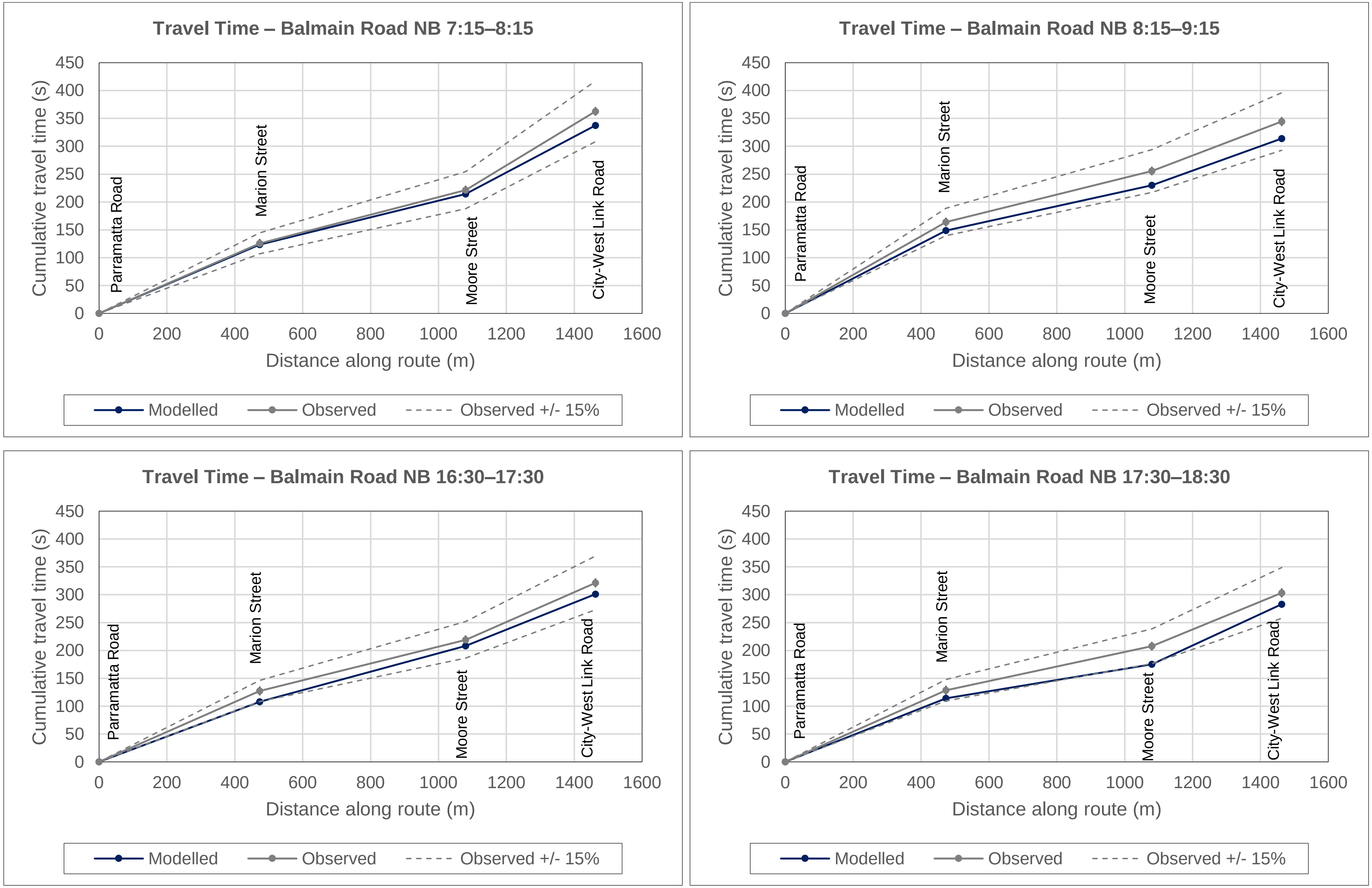


Figure 5-11 Travel times on Balmain Road (northbound)

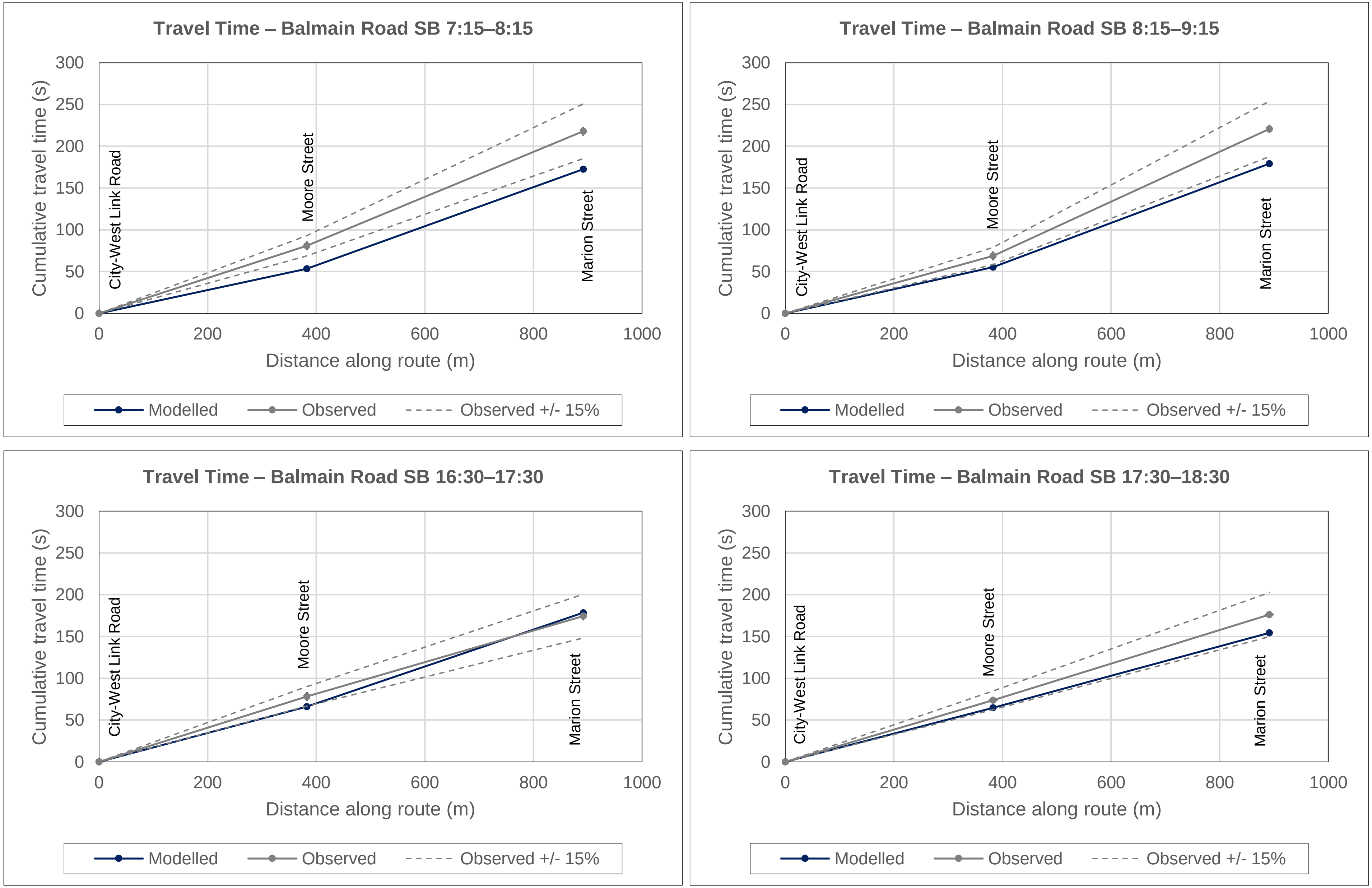


Figure 5-12 Travel times on Balmain Road (southbound)

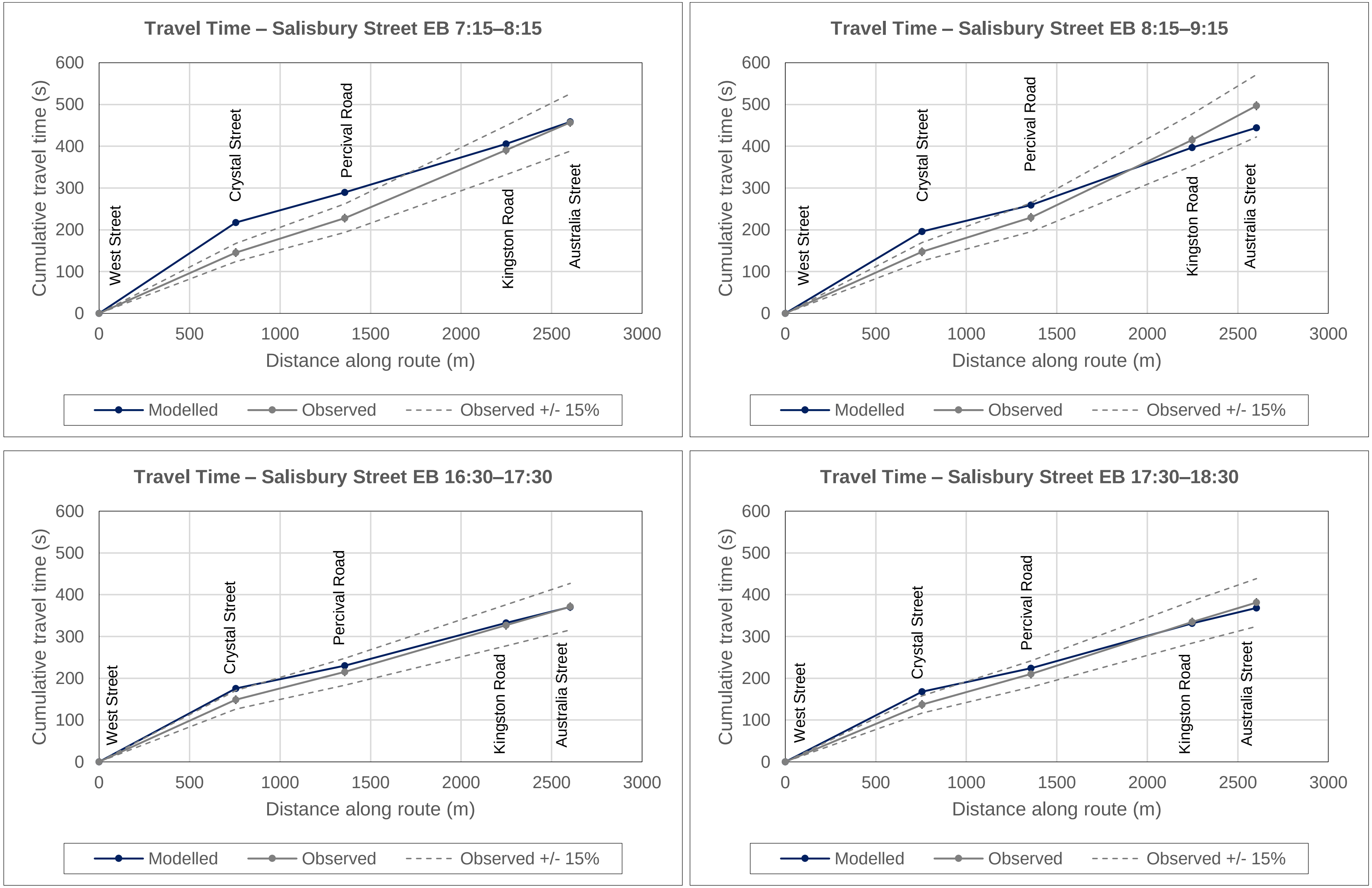


Figure 5-13 Travel times on Salisbury Street (eastbound)

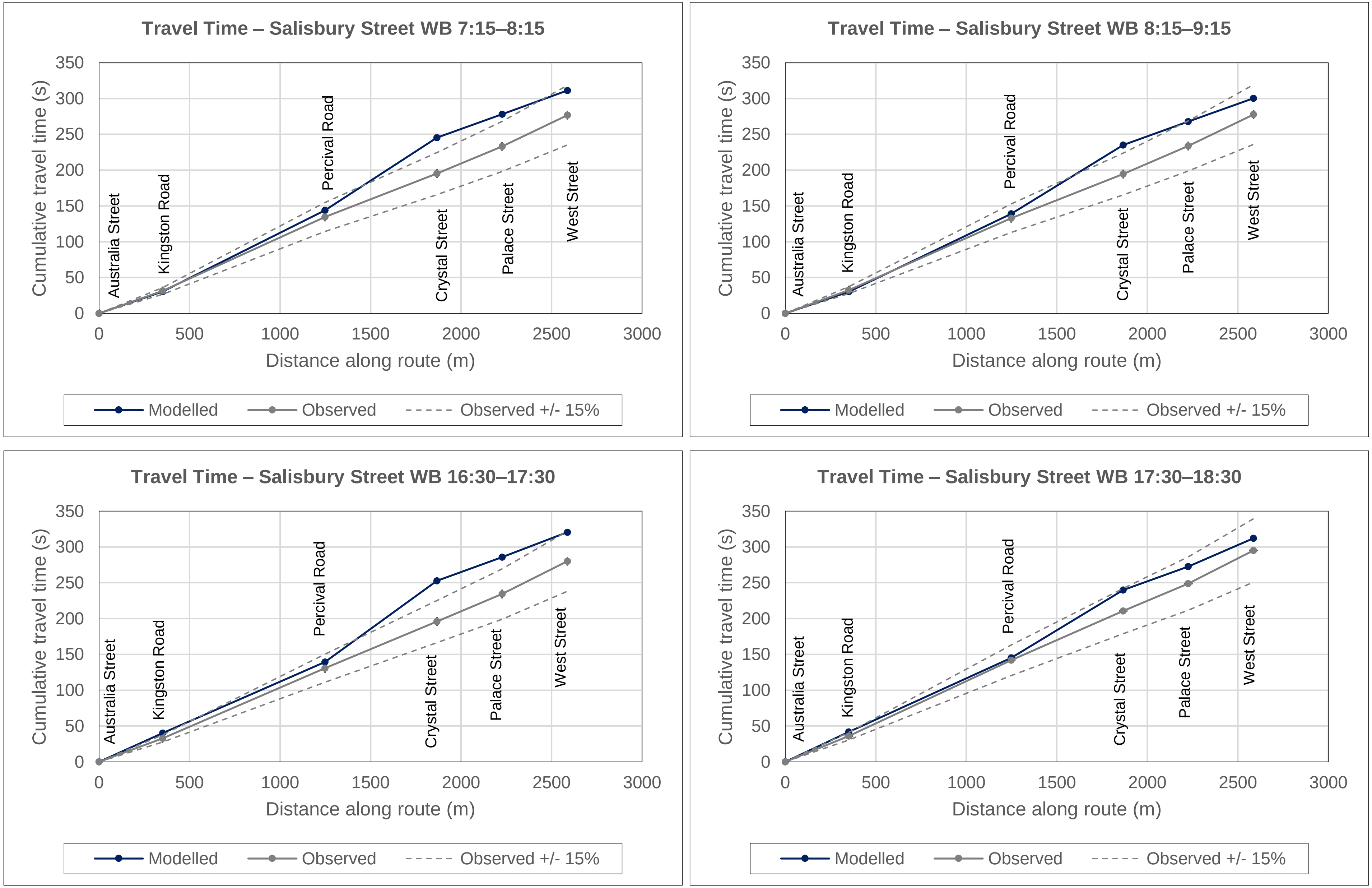


Figure 5-14 Travel times on Salisbury Street (westbound)

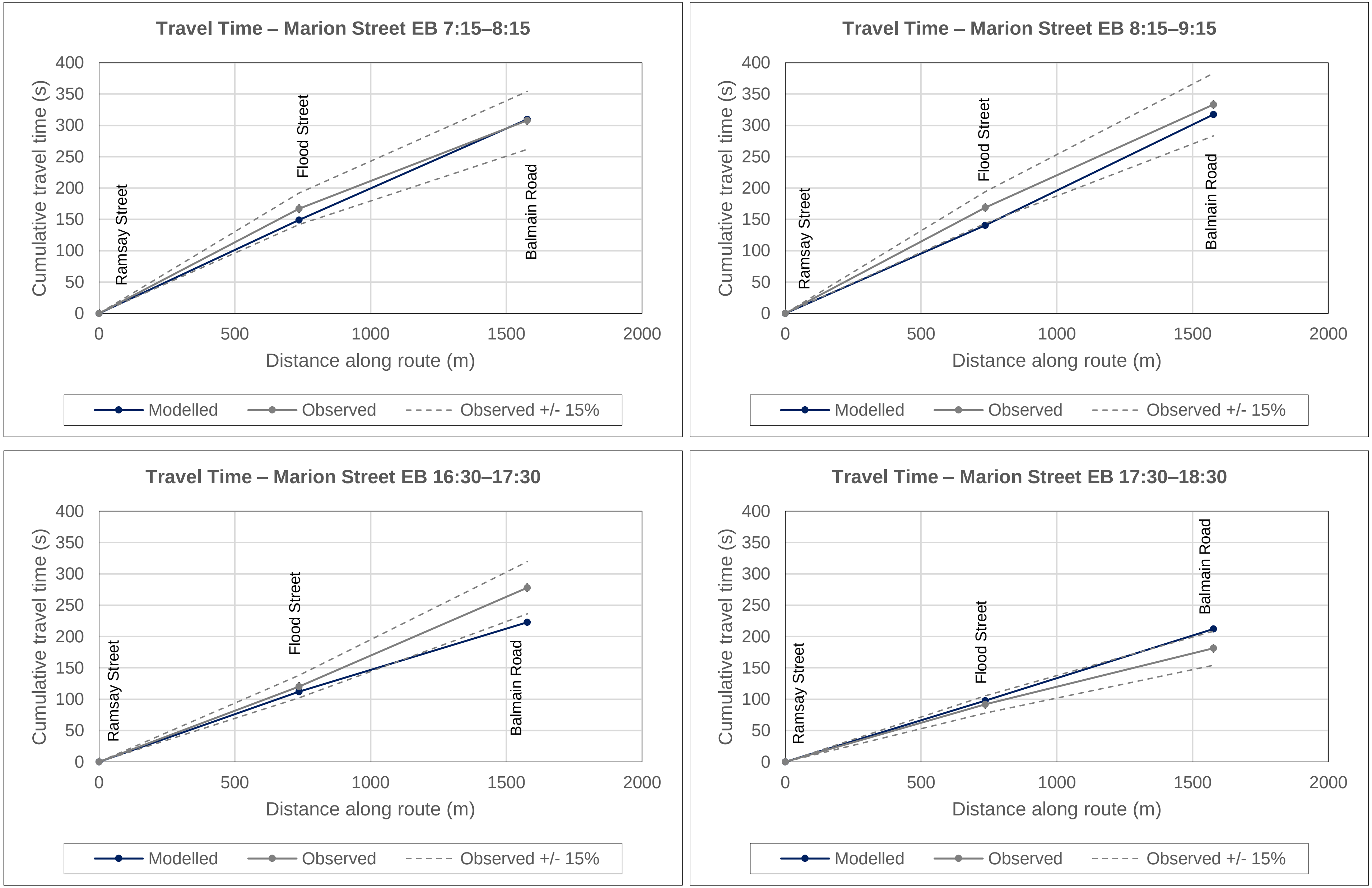


Figure 5-15 Travel times on Marion Street (eastbound)

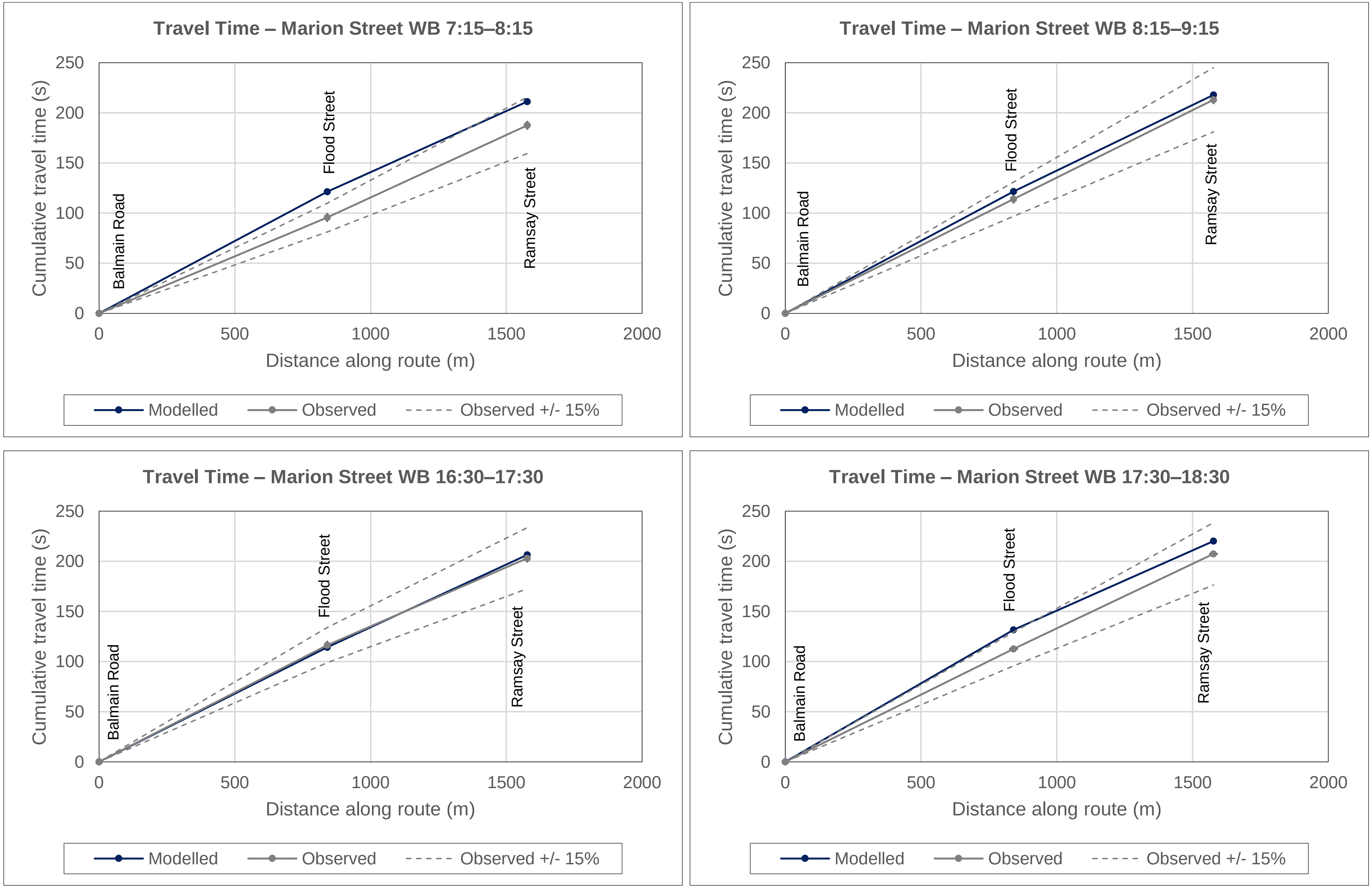


Figure 5-16 Travel times on Marion Street (westbound)

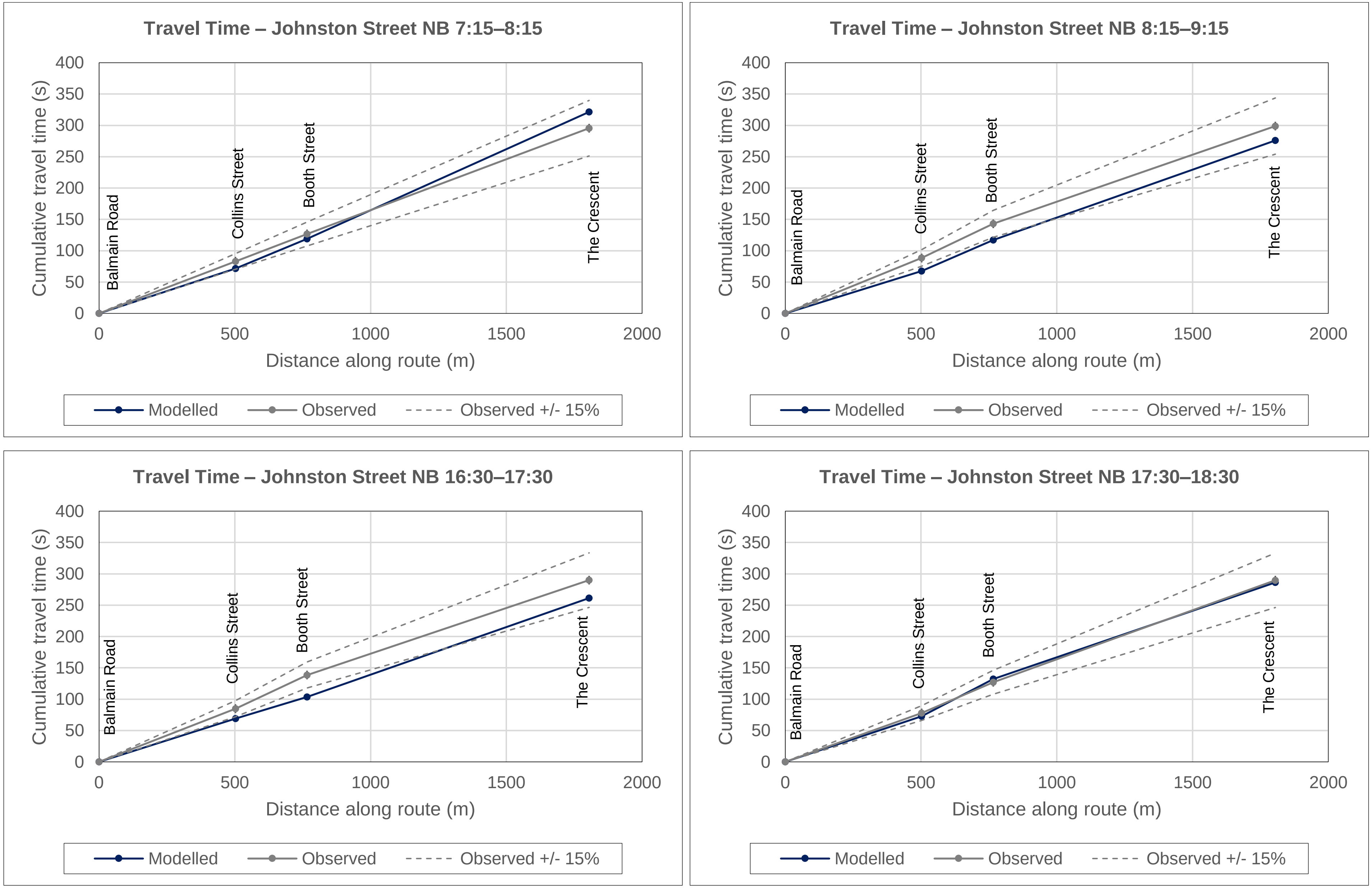


Figure 5-17 Travel times on Johnston Street (northbound)

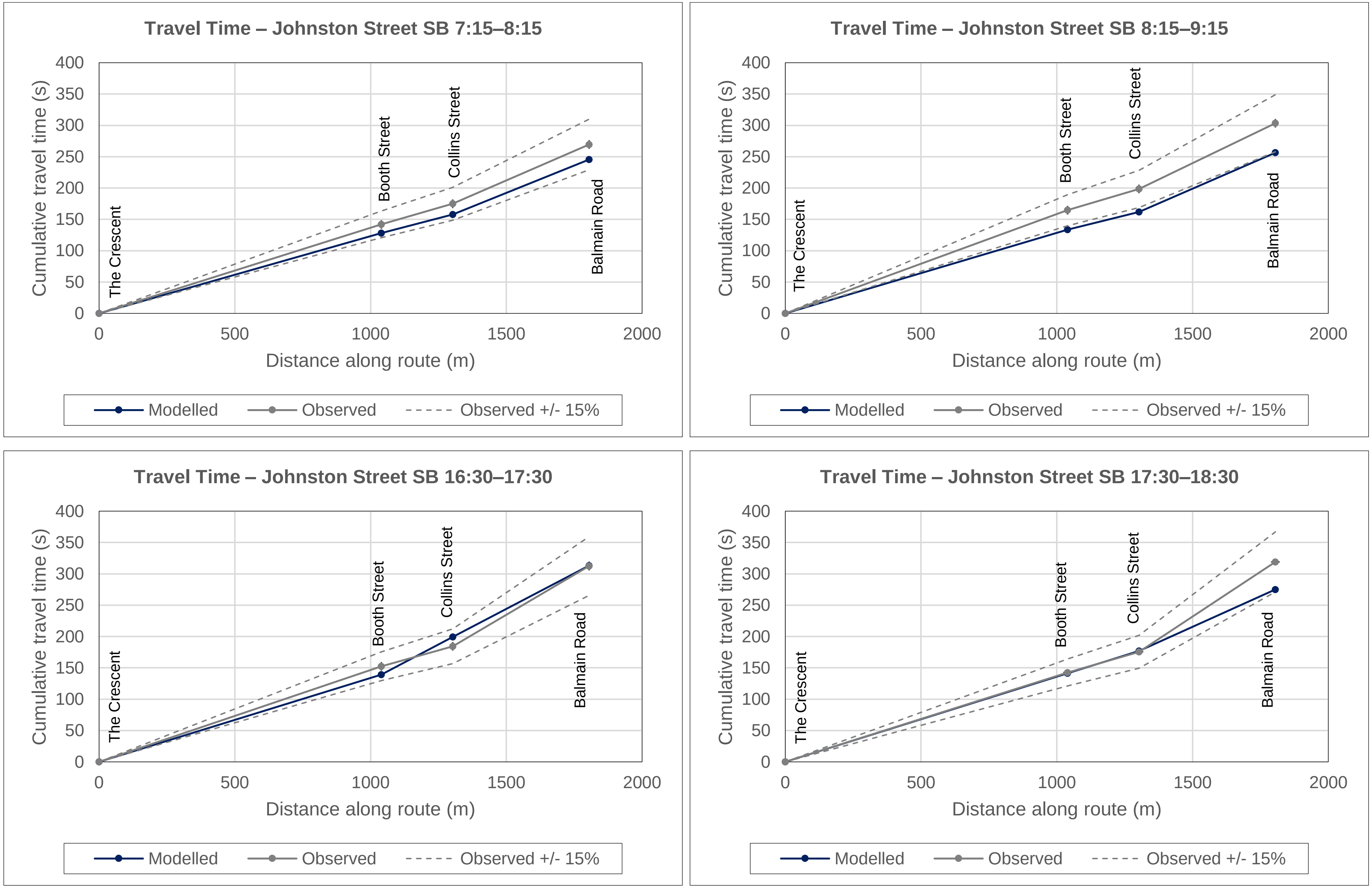


Figure 5-18 Travel times on Johnston Street (southbound)

Table 5-6 shows segments where the modelled travel time was significantly outside the recommended 15 per cent tolerance and provides an explanation for each instance.

Table 5-6 Segments with travel times exceeding 15 per cent of the observed value

Route	Segment	Applicable modelled hours	Notes
Crystal Street (southbound)	1	5:30PM – 6:30PM	Travel time is underrepresented on Crystal Street in the southbound direction in the second hour of the PM Peak. This is attributable to frictional effects of parking and driveways that are not considered in the model. On-street parking is permitted on Crystal Street after 6:00PM.
Salisbury Road (westbound)	2	7:15AM – 8:15AM 8:15AM – 9:15AM 4:30PM – 5:30PM	Travel times were generally overestimated on this segment of Salisbury Road in the westbound direction. In the model this is likely caused by queueing on Crystal Street in the southbound direction that was necessary to meet observed travel times in both the AM and PM peaks.

5.3.2 Travel time variability

Figure 5-19, **Figure 5-20**, **Figure 5-21** and **Figure 5-22** show a comparison between the modelled and observed travel times on each route. The bars show the 10th and 90th percentile for both the modelled (calculated based on the standard deviation assuming a normal distribution of travel times) and observed (extracted from TomTom travel time data).

Traffic Modelling Guidelines (Roads and Maritime Services, 2013) recommends the use of the 5th/95th percentile for this comparison. Cardno has used the 10th/90th percentile due to a small number of significant outliers in the TomTom data that are likely caused by parking manoeuvres, stopped vehicles and pedestrians.

The graphs indicate that all modelled travel times fit within the 10th and 90th percentile of the observed data for all routes. For all routes the modelled percentiles were within the observed percentiles. This is because the TomTom data captures vehicles circulating for on-street parking, parking manoeuvres and vehicles that are stopped for short periods of time.

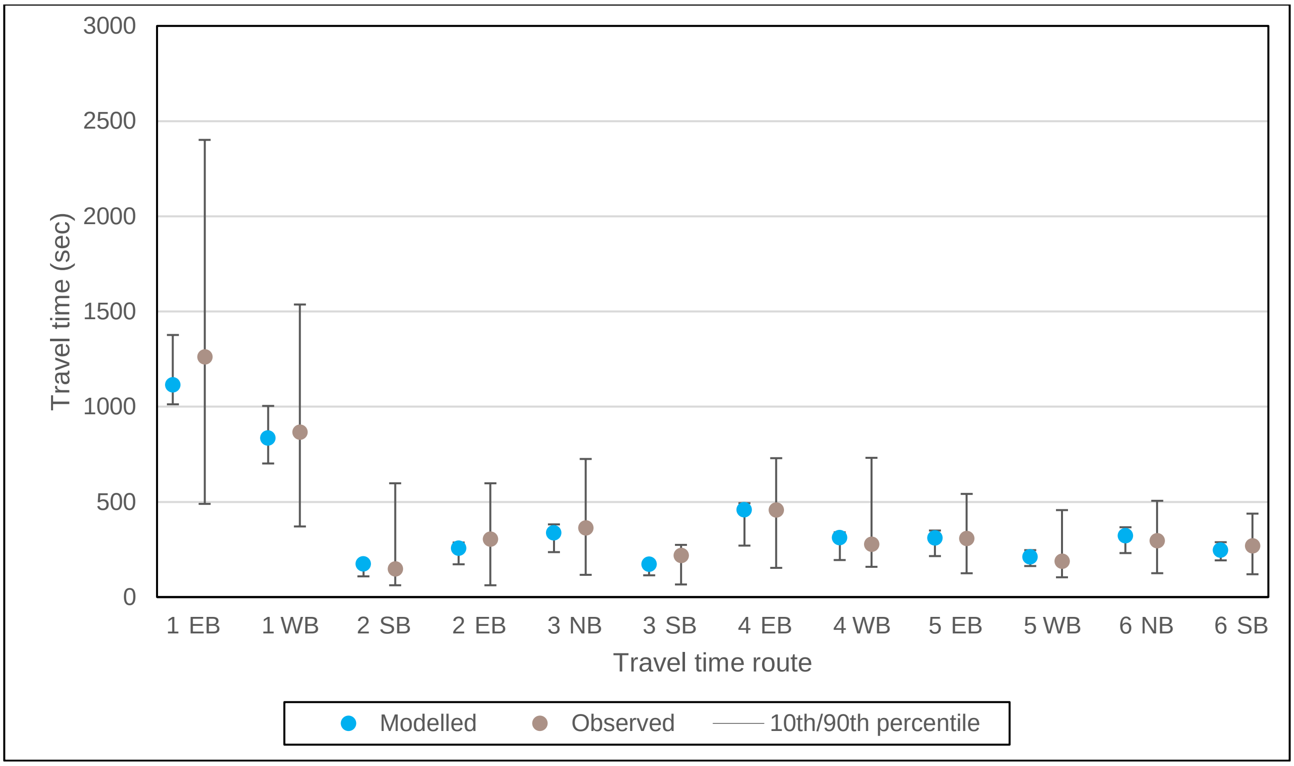


Figure 5-19 Travel time variability (7:15AM – 8:15AM)

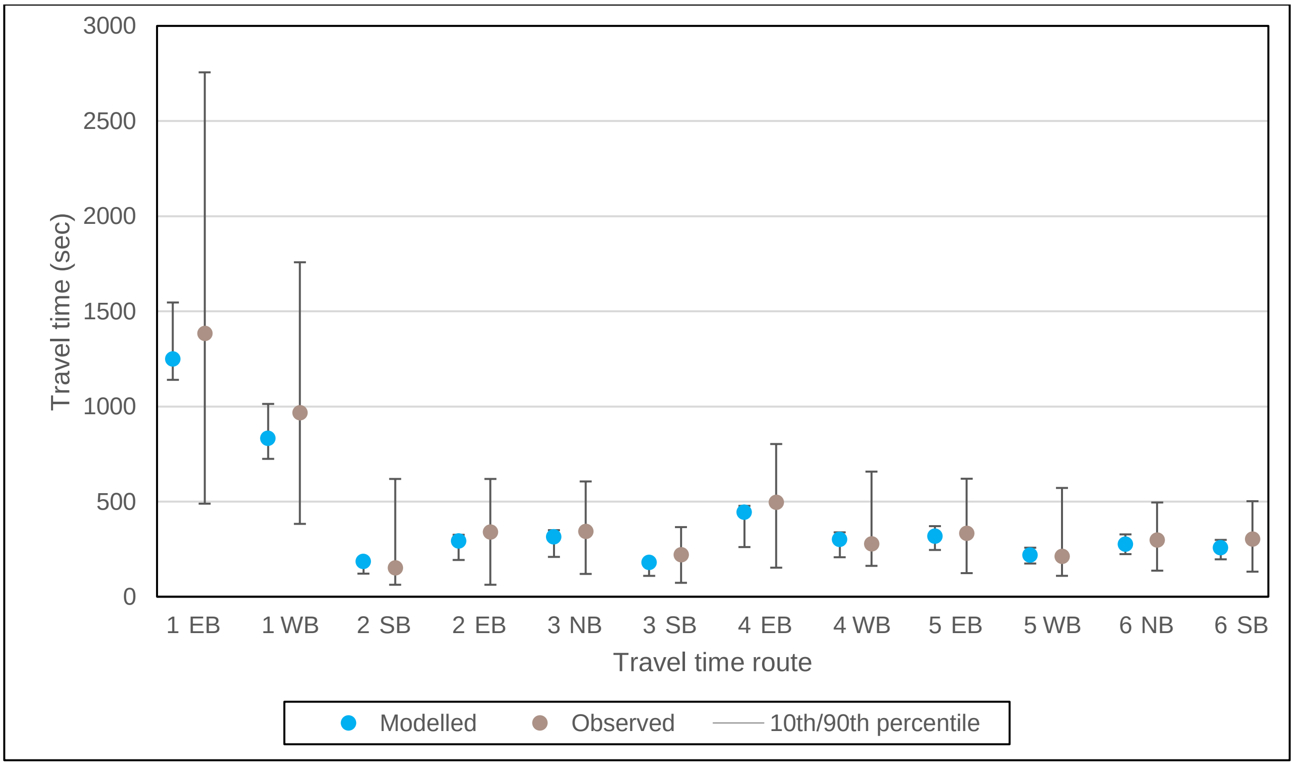


Figure 5-20 Travel time variability (8:15AM – 9:15AM)

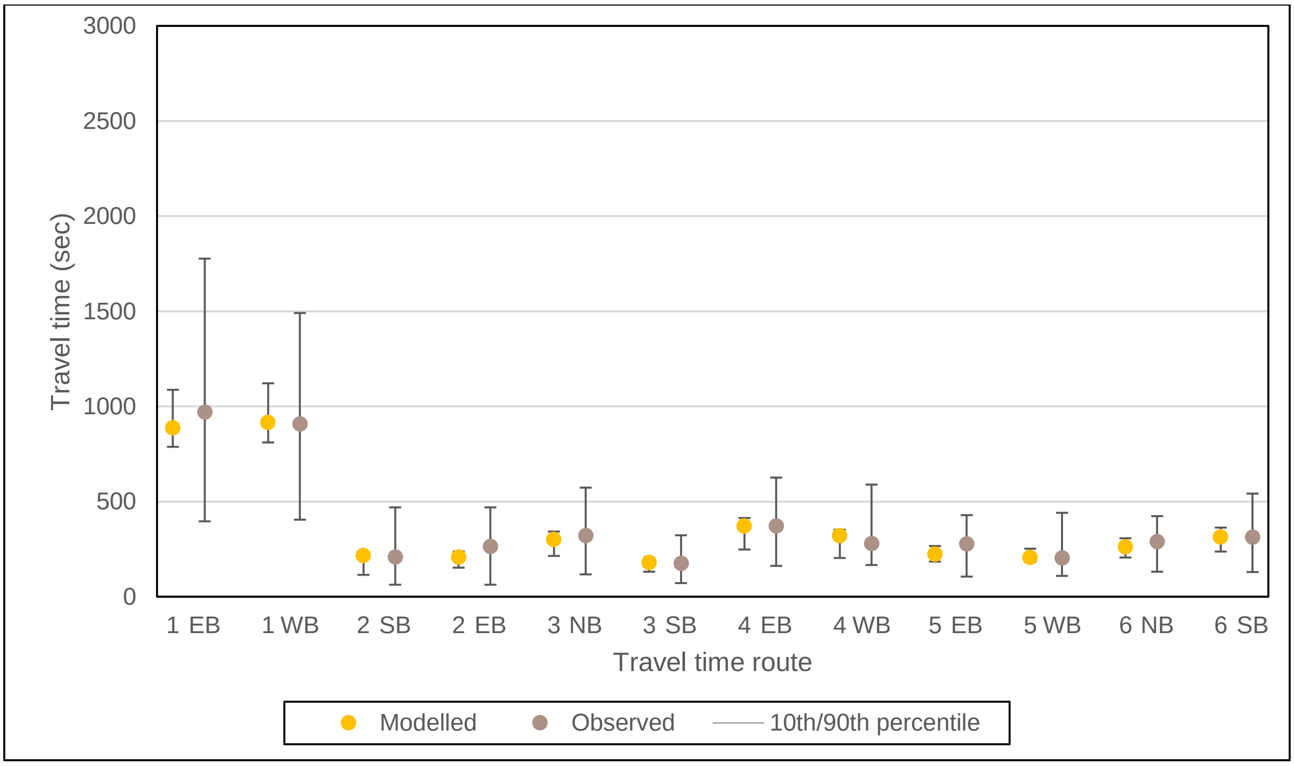


Figure 5-21 Travel time variability (4:30PM – 5:30PM)

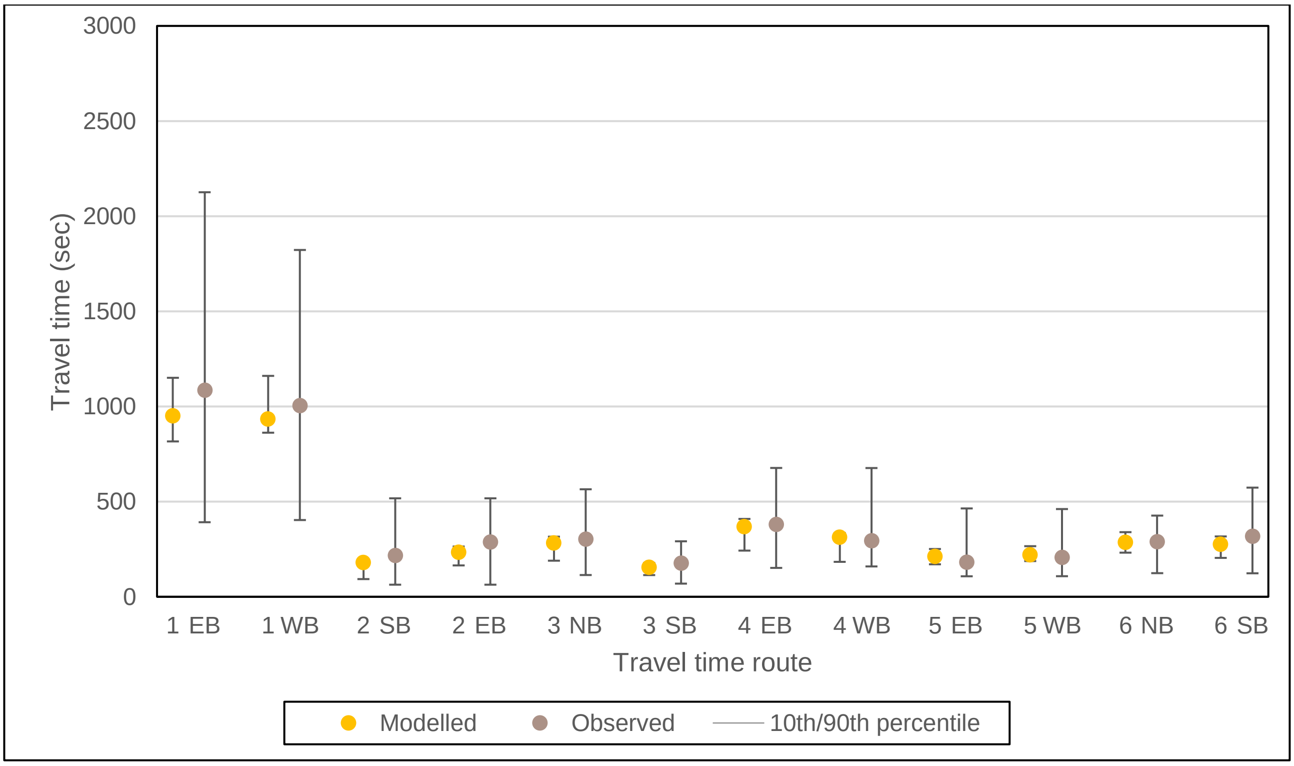


Figure 5-22 Travel time variability (5:30PM – 6:30PM)

5.3.3 Signal timing validation

Cycle times were coded in the model based on historical cycle times from SCATS data. Phase times were based on historical phase times scaled proportionally to account for reduced call frequency of some phases. All signals were coded as fixed so all phases were called in each cycle. Offsets were calculated based on the signal LX files and were applied to the model to ensure realistic coordination between adjacent intersections.

5.3.4 Congestion hotspot validation

Figure 5-23 and **Figure 5-24** show a comparison between the observed and modelled average speed on key links. The model generally shows an adequate replication of observed speeds on key routes.

In the AM Peak:

> There is good correlation between the modelled and observed speeds on Parramatta Road in the eastbound (peak) direction. The most congested sections in the model are approaching West Street and Catherine Street. The model also replicates slow-moving vehicles at the Parramatta Road / City Road intersection on the eastern extent of the study area

> In the opposite direction, the model generally replicates observed average speeds along Parramatta Road with the modelled speed typically between 40 and 50 kilometres per hour which is consistent with the data from TomTom

> Slow-moving vehicles on Victoria Road and on the approaches to Victoria Road from the north (Rozelle) are well-replicated in the model with both modelled and observed average speeds being about 20-30 kilometres per hour

> The model also mostly replicates congestion on City-West Link Road approaching the Anzac Bridge and there is good correlation between average speeds on James Street approaching City-West Link Road

> Most congestion is well-replicated on north-south routes between Parramatta Road and City-West Link Road including on Johnston Street, Catherine Street and Balmain Road

> Slow-moving vehicles on Booth Street approaching Wigram Street and Pyrmont Bridge Road are also replicated in the model

> The model appears to over-estimate the number of slow-moving vehicles on Crystal Street with apparently more queueing approaching Stanmore Road than was observed. However, as the TomTom data is the aggregate of vehicles in both directions, and this route was validated using directional travel time data, it is considered to be an accurate representation of average speeds on Crystal Street

In the PM Peak:

> There is good correlation between the modelled and observed speeds on Parramatta Road in the westbound (peak) direction. The model replicates slow-moving vehicles around City Road as well as congestion on Parramatta Road approaching Johnston Street and Catherine Street

> In the opposite direction, there is good correlation between the modelled and observed speeds with congestion replicated in key locations including approaching West Street, Catherine Street and City Road

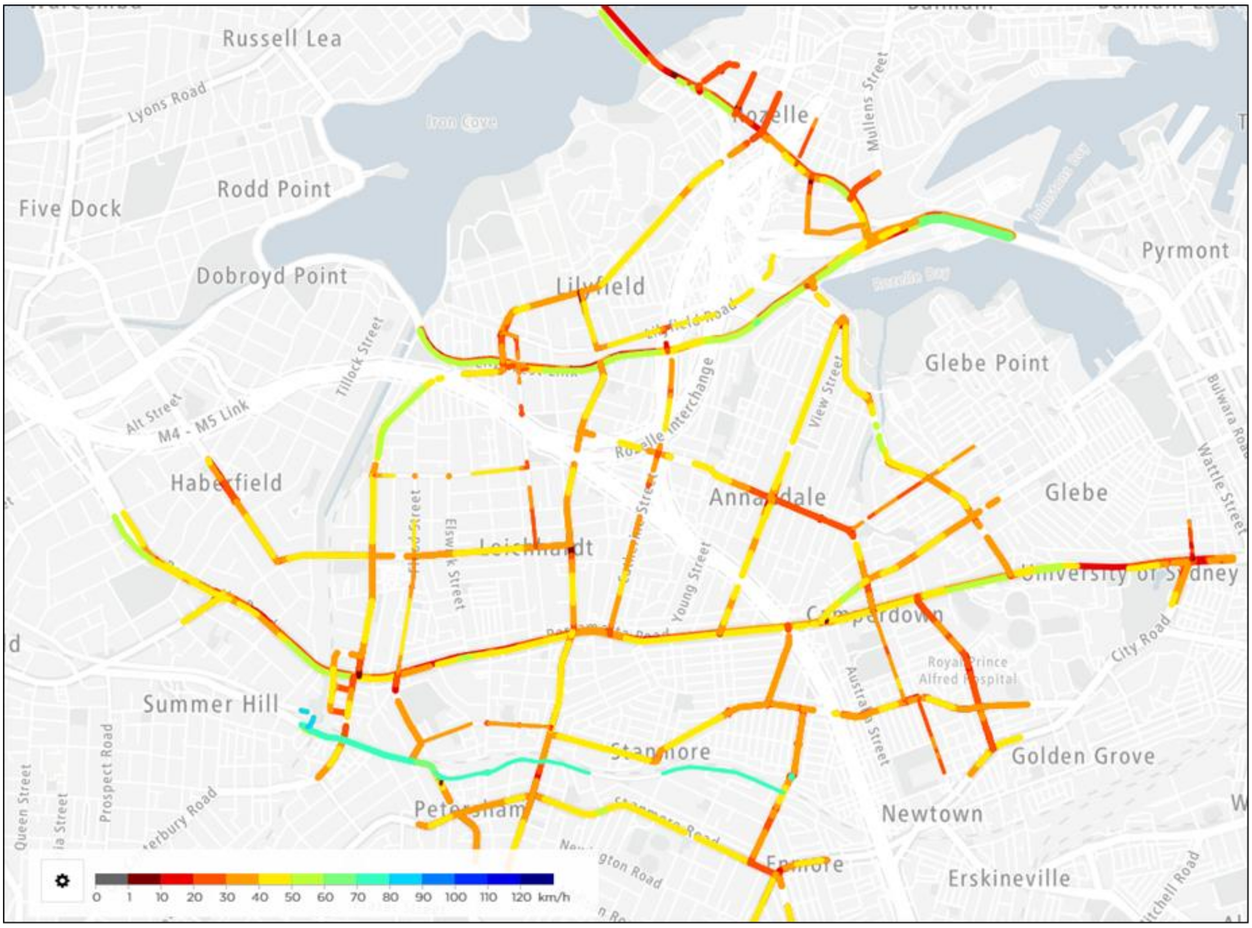
> Queueing on Victoria Road and on the approaches to Victoria Road from the north (Rozelle) is captured in the model with observed and modelled speeds being between 20 and 40 kilometres per hour

> The model also mostly replicates congestion on City-West Link Road with queueing approaching Victoria Road in the westbound direction and approaching James Street, but mostly free-flowing traffic between these intersections

> Congestion is mostly well-replicated on north-south routes between Parramatta Road and City-West Link Road including on Johnston Street, Catherine Street and Balmain Road

> Slow-moving vehicles on Booth Street approaching Wigram Street and Pyrmont Bridge Road are also replicated in the model.

As noted in **Section 2.3**, for minor roads the TomTom data is the aggregate of both directions, so in some locations the average speed may appear higher in the observed plot than the modelled outputs. Notwithstanding, the model appears to replicate the observed average speeds on key links including Parramatta Road, City-West Link Road and Victoria Road.



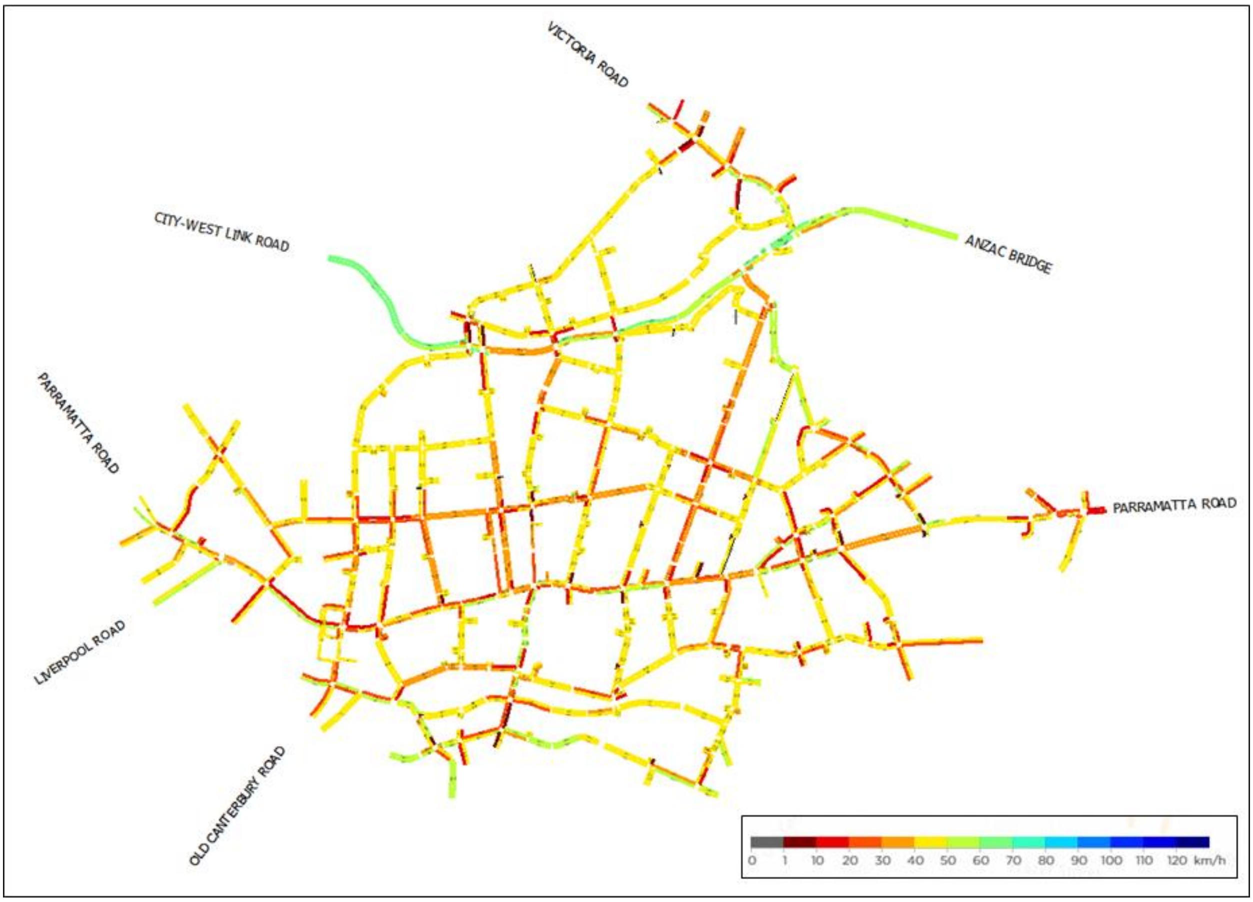


Figure 5-23 Observed (top) and modelled (bottom) average speed plots (AM Peak)

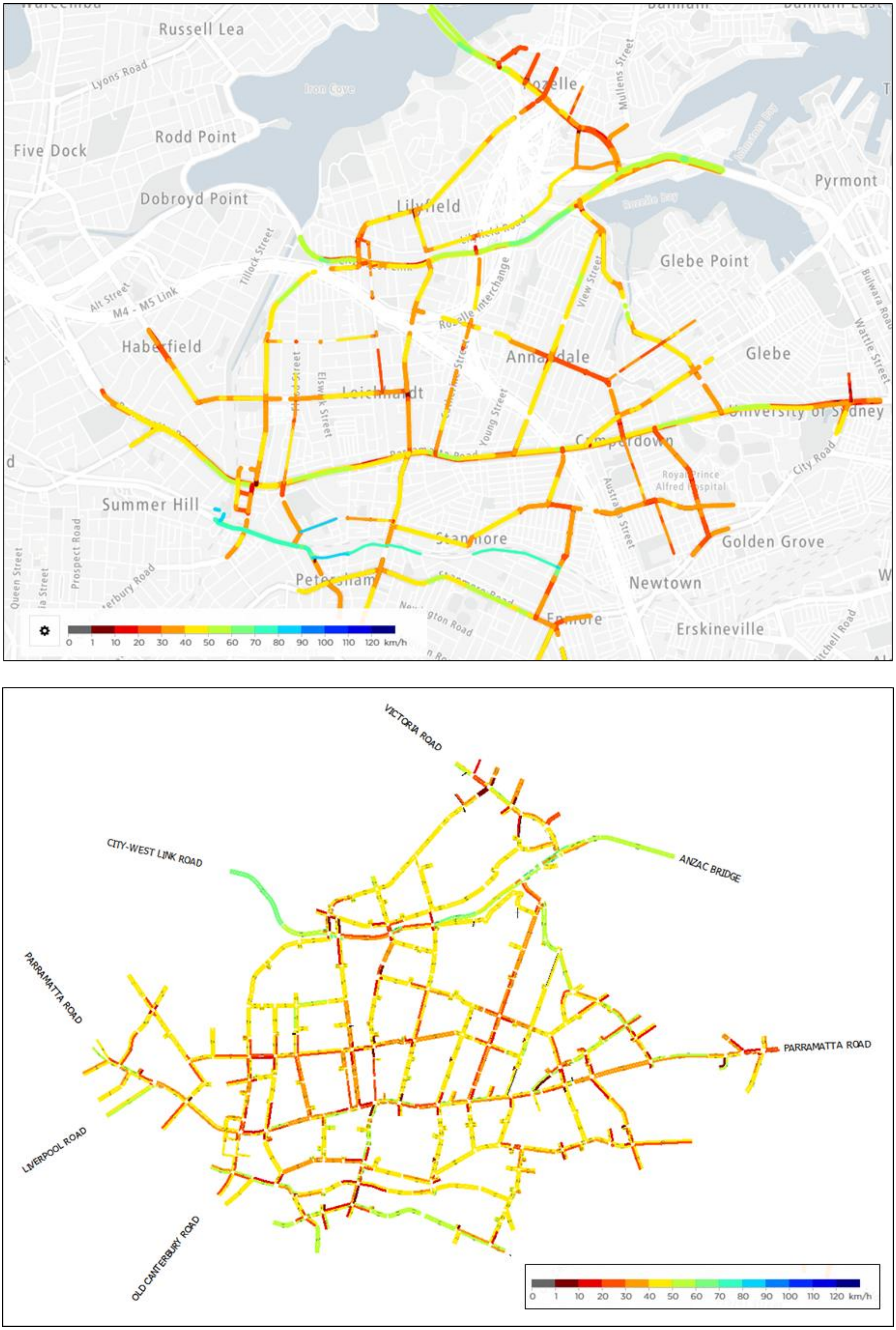


Figure 5-24 Observed (top) and modelled (bottom) average speed plots (PM Peak)

6 Model limitations

The Base Model has been developed in accordance with *Traffic Modelling Guidelines* (Roads and Maritime Services, 2013). Notwithstanding, the main assumptions and limitations of the modelling are outlined below:

> Fixed signal timings were used in the Base Models due to the size and complexity of the network. Control plans were coded in 15-minute intervals in the microsimulation area and one-hour intervals in the mesoscopic simulation area

> Signal timings were adjusted to meet minimum green time requirements and include pedestrian walk times at major intersections

> Empty running buses were not included in the model as the GTFS data used to code public transport does not include these vehicles

> The modelled road network does not include all the roads and intersections within the study area. The internal road network reduction was assumed to minimise path allocation and route choice to roads that could not be verified using survey counts

> The model should not be used to assess intersections that were not calibrated to the survey data

> Consideration for pedestrians was limited to an intersection level. Pedestrian walk times were included at signalised intersections

> Cyclist volumes and infrastructure were not considered in the model

> The impact of congestion on Broadway in the eastbound direction outside the study area (represented by dummy signals in the Base Model) should be considered in future options

> The models do not consider the impact of on-street parking.

7 Conclusions

This report documents the development of the hybrid microscopic-mesoscopic model for the Parramatta Road Corridor Urban Transformation Study (PRCUTS) project.

The existing traffic conditions were analysed from traffic data collected in October 2018, SCATS historical timings and TomTom travel time data. Strategic demands were extracted from the Sydney Traffic Forecasting Model (STFM) and used as the starting point for demand estimation for the Base Models. These were adjusted manually and using the matrix adjustment procedures available in Aimsun to match the observed traffic counts.

The Base Models were calibrated to represent two peaks:

> Wednesday 17 October 2018, 7:15AM – 9:15AM

> Wednesday 17 October 2018, 4:30PM – 6:30PM.

The Base Models were developed in accordance with the relevant traffic modelling guidelines for NSW. A statistical analysis of stability indicated that the models are stable with less than five seeds required to ensure a confident statistical result. The calibration and validation results indicate that the Base Models have:

> Acceptable calibration of the microsimulation area with greater than 89 per cent of turns having a GEH less than five in the AM Peak and greater than 90 per cent in the PM Peak

> Twelve turns had a GEH greater than 10 across the four modelled hours, representing less than one per cent of the total number of count locations for each peak. All turns with GEH greater than 10 were outside the microsimulation area

> High statistical correlation between modelled and observed turning volumes with $R^2 > 0.98$ across all modelled hours

> Modelled travel time on key routes fits well with the observed data.

The Base Models are considered fit-for-purpose for assessing existing and future network performance. They are considered to provide a realistic replication of existing traffic conditions across the study area and provide a robust foundation on which to base the future-year assessment.

These models are designed to assist DPIE, TfNSW, IWC and other relevant stakeholders in understanding the current operation of the Parramatta Road corridor, and future planning to support land use changes along the corridor in the future.

APPENDIX

A

GEH SUMMARY

Turn Name	Aimsun ID	Area	AM Peak															
			715-815								815-915							
			LV				HV				LV				HV			
			Modelled	Observed	Difference	GEH	Modelled	Observed	Difference	GEH	Modelled	Observed	Difference	GEH	Modelled	Observed	Difference	GEH
30ST	61436	Meso	101	61	40	4.44	1	0	1	1.41	102	63	39	4.29	0	3	-3	2.45
30ER	61437	Meso	254	246	8	0.51	17	12	5	1.31	203	212	-9	0.62	14	18	-4	1.00
30NT	61438	Meso	61	64	-3	0.38	1	0	1	1.41	68	87	-19	2.16	0	0	0	0.00
30EL	61439	Meso	29	29	0	0.00	1	1	0	0.00	24	38	-14	2.51	0	0	0	0.00
30NL	61440	Meso	867	854	13	0.44	43	38	5	0.79	838	843	-5	0.17	64	34	30	4.29
30SR	61441	Meso	190	190	0	0.00	2	4	-2	1.15	216	176	40	2.86	4	1	3	1.90
29WT	61459	Meso	907	876	31	1.04	25	34	-9	1.66	862	821	41	1.41	30	21	9	1.78
29NL	61460	Meso	13	12	1	0.28	0	0	0	0.00	15	9	6	1.73	0	1	-1	1.41
29SR	61461	Meso	226	181	45	3.15	4	12	-8	2.83	166	191	-25	1.87	8	6	2	0.76
29WL	61462	Meso	39	45	-6	0.93	0	0	0	0.00	29	24	5	0.97	1	0	1	1.41
29ER	61463	Meso	10	9	1	0.32	1	1	0	0.00	9	1	8	3.58	0	0	0	0.00
29ST	61464	Meso	75	95	-20	2.17	2	0	2	2.00	100	88	12	1.24	15	2	13	4.46
29WR	61465	Meso	84	42	42	5.29	0	0	0	0.00	65	55	10	1.29	6	0	6	3.46
29EL	61466	Meso	143	91	52	4.81	7	1	6	3.00	146	163	-17	1.37	3	1	2	1.41
29NT	61467	Meso	96	90	6	0.62	5	0	5	3.16	72	138	-66	6.44	2	3	-1	0.63
31WR	69795	Micro	248	184	64	4.35	8	13	-5	1.54	254	247	7	0.44	16	21	-5	1.16
31SR	69796	Micro	741	644	97	3.69	52	42	10	1.46	618	448	170	7.36	72	34	38	5.22
31WT	69797	Micro	1215	1296	-81	2.29	115	138	-23	2.04	1341	1351	-10	0.27	123	123	0	0.00
76ET	69812	Micro	1133	1130	3	0.09	82	82	0	0.00	1053	979	74	2.32	77	96	-19	2.04
76NR	69813	Micro	110	113	-3	0.28	13	11	2	0.58	105	112	-7	0.67	8	5	3	1.18
76WT	69814	Micro	1418	1388	30	0.80	120	148	-28	2.42	1449	1457	-8	0.21	138	134	4	0.34
76NL	69815	Micro	62	116	-54	5.72	3	1	2	1.41	122	153	-31	2.64	1	7	-6	3.00
76WL	69816	Micro	81	62	19	2.25	11	5	6	2.12	94	59	35	4.00	22	3	19	5.37
76ER	69817	Micro	265	265	0	0.00	11	12	-1	0.29	254	290	-36	2.18	9	6	3	1.10
56WT	70256	Meso	464	441	23	1.08	32	28	4	0.73	501	318	183	9.04	33	18	15	2.97
56NL	70257	Meso	265	122	143	10.28	1	10	-9	3.84	169	147	22	1.75	0	5	-5	3.16
56SR	70258	Meso	75	112	-37	3.83	10	2	8	3.27	79	108	-29	3.00	26	3	23	6.04
56ET	70259	Meso	237	260	-23	1.46	14	9	5	1.47	204	234	-30	2.03	12	17	-5	1.31
56NR	70260	Meso	24	27	-3	0.59	0	1	-1	1.41	20	28	-8	1.63	0	0	0	0.00
56SL	70261	Meso	72	42	30	3.97	0	2	-2	2.00	68	48	20	2.63	0	1	-1	1.41
56ER	70262	Meso	25	19	6	1.28	0	3	-3	2.45	21	29	-8	1.60	0	5	-5	3.16
56WL	70263	Meso	14	12	2	0.55	0	1	-1	1.41	20	19	1	0.23	0	0	0	0.00
56ST	70264	Meso	199	178	21	1.53	11	8	3	0.97	199	193	6	0.43	6	3	3	1.41
56EL	70265	Meso	94	69	25	2.77	5	1	4	2.31	83	73	10	1.13	2	0	2	2.00
56WR	70266	Meso	0	15	-15	5.48	3	1	2	1.41	0	16	-16	5.66	1	2	-1	0.82
56NT	70267	Meso	77	160	-83	7.62	8	7	1	0.37	148	151	-3	0.25	6	6	0	0.00
28NL	71068	Meso	11	12	-1	0.29	1	1	0	0.00	7	17	-10	2.89	0	0	0	0.00
28SR	71069	Meso	110	89	21	2.11	1	5	-4	2.31	88	104	-16	1.63	2	1	1	0.82
28WT	71070	Meso	910	945	-35	1.15	23	23	0	0.00	845	821	24	0.83	35	20	15	2.86
28ST	71071	Meso	370	457	-87	4.28	16	11	5	1.36	452	434	18	0.86	22	18	4	0.89
28WL	71072	Meso	276	207	69	4.44	13	5	8	2.67	288	250	38	2.32	19	8	11	2.99
28EL	71073	Meso	56	60	-4	0.53	0	8	-8	4.00	63	59	4	0.51	0	5	-5	3.16
28NT	71074	Meso	204	283	-79	5.06	16	12	4	1.07	165	291	-126	8.34	9	12	-3	0.93
28WR	71075	Meso	225	272	-47	2.98	10	9	1	0.32	247	266	-19	1.19	14	7	7	2.16
28ET	71076	Meso	245	261	-16	1.01	14	10	4	1.15	203	244	-41	2.74	11	16	-5	1.36
28NR	71077	Meso	40	40	0	0.00	1	2	-1	0.82	42	42	0	0.00	4	3	1	0.53
28SL	71078	Meso	81	62	19	2.25	3	1	2	1.41	94	74	20	2.18	0	2	-2	2.00
39WT	71093	Micro	1654	1666	-12	0.29	136	176	-40	3.20	1781	1727	54	1.29	171	140	31	2.49
39NL	71094	Micro	169	176	-7	0.53	0	10	-10	4.47	192	202	-10	0.71	1	7	-6	3.00
39ET	71095	Micro	1318	1420	-102	2.76	101	88	13	1.34	1260	1197	63	1.80	102	116	-14	1.34
39EL	71097	Micro	209	202	7	0.49	8	10	-2	0.67	210	208	2	0.14	5	4	1	0.47
41ET	71099	Meso	464	492	-28	1.28	16	15	1	0.25	503	464	39	1.77	22	29	-7	1.39
41SL	71100	Meso	47	66	-19	2.53	0	1	-1	1.41	55	47	8	1.12	3	2	1	0.63
41WT	71101	Meso	342	383	-41	2.15	26	21	5	1.03	366	391	-25	1.29	21	23	-2	0.43
41NL	71102	Meso	81	71	10	1.15	33	18	15	2.97	136	60	76	7.68	27	4	23	5.84
41EL	71104	Meso	26	26	0	0.00	1	2	-1	0.82	21	23	-2	0.43	0	3	-3	2.45
41NT	71105	Meso	567	606	-39	1.61	17	22	-5	1.13	497	525	-28	1.24	11	16	-5	1.36
41WL	71106	Meso	58	58	0	0.00	4	2	2	1.15	68	69	-1	0.12	4	4	0	0.00
41ST	71108	Meso	884	948	-64	2.11	19	20	-1	0.23	943	932	11	0.36	23	24	-1	0.21
1NT	73126	Meso	227	209	18	1.22	14	17	-3	0.76	214	263	-49	3.17	16	19	-3	0.72
1EL	73127	Meso	48	59	-11	1.50	9	5	4	1.51	51	67	-16	2.08	13	6	7	2.27
1SL	73128	Meso	250	180	70	4.77	10	15	-5	1.41	232	192	40	2.75	11	11	0	0.00
1ET	73129	Meso	1155	1135	20	0.59	75	67	8	0.95	909	859	50	1.68	90	92	-2	0.21
1ST	73130	Meso	214	234	-20	1.34	7	20	-13	3.54	190	261	-71	4.73	7	17	-10	2.89
1ER	73132	Meso	125	101	24	2.26	18	13	5	1.27	120	129	-9	0.81	8	9	-1	0.34
1NL	73134	Meso	210	156	54	3.99	11	13	-2	0.58	182	148	34	2.65	14	12	2	0.55
23EL	73152	Meso	646	695	-49	1.89	37	34	3	0.50	636	745	-109	4.15	43	39	4	0.62
23NT	73153	Meso	2756	2800	-44	0.83	136	142	-6	0.51	2356	2345	11	0.23	123	127	-4	0.36
23SR	73154	Meso	571	541	30	1.27	37	35	2	0.33	517	617	-100	4.20	33	38	-5	0.84
23NL	73155	Meso	20	44	-24	4.24	0	3	-3	2.45	18	40	-22	4.09	0	1	-1	1.41
23ST	73156	Meso	1249	1212	37	1.05	93	81	12	1.29	1045	1015	30	0.93	105	108	-3	0.29
3NL	73175	Meso	193	198	-5	0.36	11	9	2	0.63	187	202	-15	1.08	3	7	-4	1.79
3WT	73176	Meso	1482	1580	-98	2.50	100	129	-29	2.71	1024	1004	20	0.63	110	89	21	2.11
3NR	73177	Meso	99	86	13	1.35	0	0	0	0.00	110	93	17	1.69	4	7	-3	1.28
3ET	73178	Meso	1264	1238	26	0.74	128	114	14	1.27	1191	1155	36	1.05	109	133	-24	2.18
3SL	73179	Meso	128	176	-48	3.89	26	11	15	3.49	81	150	-69	6.42	22	11	11	2.71
3NT	73180	Meso	256	194	62	4.13	26	17	9	1.94	256	275	-19	1.17	24	23	1	0.21
42ET	73195	Meso	57	54	3	0.40	1	2	-1	0.82	46	49	-3	0.44	1	2	-1	0.82
42SL	73196	Meso	39	34	5	0.83	2	2	0	0.00	40	54	-14	2.04	1	0	1	1.41
42WL	73197	Meso	3	18	-15	4.63	0	0	0	0.00	13	16	-3	0.79	0	0	0	0.00
42ER	73198	Meso	1	14	-13	4.75	3	0	3	2.45	3	7	-4	1.79	4	0	4	2.83
42ST	73199	Meso	329	295	34	1.92	11	8	3	0.97	271	327	-56	3.24	7	13	-6	1.90
42WT	73200	Meso	218	209	9	0.62	9	2	7	2.98	228	250	-22	1.42	4	11	-7	2.56
42NL	73201	Meso	65	50	15	1.98	6	1	5	2.67	59	66	-7	0.89	1	1	0	0.00
42SR	73202	Meso	383	298	85	4.61	25	30	-5	0.95	334	367	-33	1.76	34	16	18	3.60
42WR	73203	Meso	9	35	-26	5.54	0	0	0	0.00	10	39	-29	5.86	5	0	5	3.16
42NT	73204	Meso	183	217	-34	2.40	11	5	6	2.12	158	195	-37	2.79	2	7	-5	2.36
42EL	73205	Meso	6	23	-17	4.46	4	0	4	2.83	10	38	-28	5.72	4	1	3	1.90
63EL	73214	Meso	185	192	-7	0.51	13	5	8	2.67	186	171	15	1.12	2	7	-5	2.36
63WR	73215	Meso	72	51	21	2.68	3	2	1	0.63	57	63	-6	0.77	1	2	-1	0.82
63SR	73216	Meso	246	252	-6	0.38	7	9	-2	0.71	206	253	-47	3.10	4	12	-8	2.83
63WT	73217	Meso	318	381	-63	3.37	8	26	-18	4.37	342	386	-44	2.31	23	23	0	0.00
63SL	73218	Meso	49	46	3	0.44	4	0	4	2.83	55	87	-32	3.80	5	0	5	3.16
63ET	73219	Meso	200	217	-17	1.18	14	23	-9	2.09	248	238	10	0.64	21	19	2	0.45
35SR	73221	Meso	75	82	-7	0.79	9	2	7	2.98	84	99	-15	1.57	3	0	3	2.45
35EL	73223	Meso	3	31	-28	6.79	0	1	-1	1.41	6	23	-17	4.46	1	0	1	1.41
35NT	73224	Meso	138	139	-1	0.08	11	12	-1	0.29	179	153	26	2.02	18	6	12	3.46
35ER	73225	Meso	71	98	-27	2.94	6	16	-10	3.02	83	113	-30	3.03	4	15	-11	3.57
35ST	73226	Meso	258	274	-16	0.98	10	12	-2	0.60	306	307	-1	0.06	21	9	12	3.10
11ET	73238	Meso	282	211	71	4.52	11	8	3	0.97	257	253	4	0.25	7	11	-4	1.33
11SL	73239	Meso	23	39	-16	2.87	7	7	0	0.00	34	65	-31	4.41	4	12	-8	2.83
11NR	73240	Meso	42	32	10	1.64	1	3	-2	1.41	37	51	-14	2.11	1	1	0	0.00
11WT	73241	Meso	849	822	27	0.93	13	19	-6	1.50	807	760	47	1.68	16	13	3	0.79
11SR	73242	Meso	7	33	-26	5.81	1	0	1	1.41	5	24	-19	4.99	6	1	5	2.67
11NL	73243	Meso	105	52	53	5.98	1	0	1	1.41	148	69	79	7.58	4	0	4	2.83
11WR	73244	Meso	145	166	-21	1.68	0	19	-19	6.16	152	164	-12	0.95	5	14	-9	2.92
11EL	73245	Meso	92	123	-31	2.99	0	3	-3	2.45	94	163	-69	6.09	0	1	-1	1.41
11NT	73246	Meso	162	181	-19	1.45	18	21	-3	0.68	165	185	-20	1.51	17	20	-3	0.70
11WL	73247	Meso	71	62	9	1.10	5	7	-2	0.82	57	69	-12	1.51	3	3	0	0.00

11ER	73248	Meso	0	36	-36	8.49	3	0	3	2.45	3	40	-37	7.98	1	1	0	0.00
11ST	73249	Meso	83	97	-14	1.48	10	20	-10	2.58	86	84	2	0.22	8	23	-15	3.81
13ET	73258	Meso	224	206	18	1.23	7	3	4	1.79	205	227	-22	1.50	6	6	0	0.00
13SL	73259	Meso	20	43	-23	4.10	1	1	0	0.00	18	67	-49	7.52	1	1	0	0.00
13NR	73260	Meso	138	157	-19	1.56	5	5	0	0.00	127	187	-60	4.79	1	5	-4	2.31
13WT	73261	Meso	702	665	37	1.42	7	6	1	0.39	721	627	94	3.62	20	6	14	3.88
13SR	73262	Meso	42	24	18	3.13	0	0	0	0.00	43	39	4	0.62	0	0	0	0.00
13NL	73263	Meso	30	18	12	2.45	0	0	0	0.00	30	42	-12	2.00	0	0	0	0.00
13WL	73264	Meso	256	250	6	0.38	8	15	-7	2.06	242	210	32	2.13	6	6	0	0.00
13ER	73265	Meso	23	21	2	0.43	1	1	0	0.00	23	22	1	0.21	0	0	0	0.00
13ST	73266	Meso	207	184	23	1.64	0	5	-5	3.16	176	199	-23	1.68	0	2	-2	2.00
7NL	73268	Meso	49	77	-28	3.53	1	13	-12	4.54	49	67	-18	2.36	1	3	-2	1.41
7SR	73269	Meso	122	182	-60	4.87	1	11	-10	4.08	93	263	-170	12.74	2	7	-5	2.36
7ER	73270	Meso	111	102	9	0.87	9	11	-2	0.63	126	148	-22	1.88	12	13	-1	0.28
7ST	73271	Meso	383	432	-49	2.43	0	9	-9	4.24	334	348	-14	0.76	3	7	-4	1.79
7EL	73272	Meso	115	79	36	3.66	1	6	-5	2.67	108	150	-42	3.70	1	5	-4	2.31
7NT	73273	Meso	100	111	-11	1.07	0	3	-3	2.45	84	122	-38	3.74	0	4	-4	2.83
5SL	73275	Meso	40	25	15	2.63	3	3	0	0.00	56	37	19	2.79	1	4	-3	1.90
5NR	73276	Meso	0	23	-23	6.78	0	2	-2	2.00	0	34	-34	8.25	0	1	-1	1.41
5ET	73277	Meso	166	143	23	1.85	4	14	-10	3.33	181	236	-55	3.81	15	11	4	1.11
5NT	73279	Meso	104	107	-3	0.29	10	2	8	3.27	118	113	5	0.47	4	10	-6	2.27
5EL	73280	Meso	47	25	22	3.67	0	1	-1	1.41	33	37	-4	0.68	2	2	0	0.00
5WL	73281	Meso	49	30	19	3.02	4	4	0	0.00	55	45	10	1.41	5	1	4	2.31
5ST	73282	Meso	65	87	-22	2.52	6	4	2	0.89	66	87	-21	2.40	8	3	5	2.13
5ER	73283	Meso	100	89	11	1.13	10	8	2	0.67	65	75	-10	1.20	13	8	5	1.54
5WT	73284	Meso	280	245	35	2.16	4	21	-17	4.81	256	290	-34	2.06	12	10	2	0.60
5SR	73285	Meso	33	87	-54	6.97	5	3	2	1.00	50	79	-29	3.61	3	1	2	1.41
16NT	73288	Meso	226	265	-39	2.49	10	10	0	0.00	222	247	-25	1.63	6	7	-1	0.39
16EL	73289	Meso	86	77	9	1.00	1	2	-1	0.82	77	75	2	0.23	0	2	-2	2.00
16WR	73290	Meso	130	38	92	10.04	9	1	8	3.58	105	48	57	6.52	9	2	7	2.98
16ST	73291	Meso	536	507	29	1.27	3	9	-6	2.45	483	403	80	3.80	3	9	-6	2.45
16ER	73292	Meso	91	69	22	2.46	0	2	-2	2.00	64	87	-23	2.65	3	1	2	1.41
16WL	73293	Meso	76	69	7	0.82	1	3	-2	1.41	63	97	-34	3.80	1	2	-1	0.82
16SR	73294	Meso	285	192	93	6.02	1	3	-2	1.41	308	207	101	6.29	10	4	6	2.27
16NL	73295	Meso	49	67	-18	2.36	6	11	-5	1.71	60	57	3	0.39	2	8	-6	2.68
16WT	73296	Meso	366	331	35	1.87	7	24	-17	4.32	397	394	3	0.15	17	20	-3	0.70
16SL	73297	Meso	1	40	-39	8.61	1	3	-2	1.41	1	47	-46	9.39	1	2	-1	0.82
16NR	73298	Meso	63	51	12	1.59	4	2	2	1.15	89	88	1	0.11	5	7	-2	0.82
16ET	73299	Meso	235	216	19	1.27	10	12	-2	0.60	229	306	-77	4.71	24	15	9	2.04
15WL	73301	Meso	369	255	114	6.45	1	2	-1	0.82	394	253	141	7.84	10	4	6	2.27
15ST	73302	Meso	454	469	-15	0.70	4	14	-10	3.33	410	388	22	1.10	4	10	-6	2.27
15NR	73303	Meso	68	71	-3	0.36	2	2	0	0.00	64	72	-8	0.97	1	0	1	1.41
15SL	73304	Meso	82	55	27	3.26	7	2	5	2.36	83	73	10	1.13	1	4	-3	1.90
15NT	73305	Meso	225	285	-60	3.76	8	11	-3	0.97	230	279	-49	3.07	6	10	-4	1.41
15WR	73306	Meso	186	221	-35	2.45	1	0	1	1.41	185	216	-31	2.19	4	4	0	0.00
6NR	73315	Meso	42	26	16	2.74	0	1	-1	1.41	24	36	-12	2.19	2	2	0	0.00
6SL	73316	Meso	66	48	18	2.38	0	0	0	0.00	61	81	-20	2.37	1	0	1	1.41
6ET	73317	Meso	145	116	29	2.54	7	6	1	0.39	140	164	-24	1.95	4	2	2	1.15
6WL	73318	Meso	82	42	40	5.08	5	3	2	1.00	109	39	70	8.14	9	1	8	3.58
6ST	73319	Meso	54	73	-19	2.38	8	2	6	2.68	63	92	-29	3.29	3	2	1	0.63
6ER	73320	Meso	2	2	0	0.00	0	0	0	0.00	0	5	-5	3.16	0	0	0	0.00
6WR	73321	Meso	26	4	22	5.68	1	0	1	1.41	18	5	13	3.83	0	0	0	0.00
6NT	73322	Meso	97	134	-37	3.44	9	8	1	0.34	109	112	-3	0.29	4	6	-2	0.89
6EL	73323	Meso	11	8	3	0.97	2	0	2	2.00	14	10	4	1.15	1	1	0	0.00
6WT	73324	Meso	689	712	-23	0.87	2	4	-2	1.15	685	689	-4	0.15	11	5	6	2.12
6NL	73325	Meso	15	3	12	4.00	1	0	1	1.41	17	8	9	2.55	0	0	0	0.00
6SR	73326	Meso	15	11	4	1.11	0	1	-1	1.41	23	10	13	3.20	2	0	2	2.00
18ST	73344	Meso	650	661	-11	0.43	4	11	-7	2.56	572	575	-3	0.13	6	12	-6	2.00
18WL	73345	Meso	62	48	14	1.89	4	1	3	1.90	52	64	-12	1.58	1	5	-4	2.31
18NT	73346	Meso	324	355	-31	1.68	19	24	-5	1.08	341	334	7	0.38	16	21	-5	1.16
18WR	73347	Meso	2	12	-10	3.78	0	2	-2	2.00	4	23	-19	5.17	0	0	0	0.00
18NR	73348	Meso	37	38	-1	0.16	0	2	-2	2.00	47	35	12	1.87	0	2	-2	2.00
18SL	73349	Meso	53	33	20	3.05	0	3	-3	2.45	35	93	-58	7.25	0	1	-1	1.41
75SL	73351	Meso	71	78	-7	0.81	0	0	0	0.00	67	56	11	1.40	0	1	-1	1.41
75ET	73352	Meso	422	452	-30	1.44	17	19	-2	0.47	456	415	41	1.96	21	29	-8	1.60
75EL	73354	Meso	7	12	-5	1.62	0	2	-2	2.00	10	16	-6	1.66	3	2	1	0.63
75WT	73355	Meso	425	445	-20	0.96	60	42	18	2.52	502	443	59	2.71	47	30	17	2.74
75SR	73356	Meso	16	5	11	3.39	0	0	0	0.00	11	6	5	1.71	3	0	3	2.45
22ET	73381	Meso	408	380	28	1.41	11	19	-8	2.07	396	393	3	0.15	15	13	2	0.53
22SL	73382	Meso	141	91	50	4.64	3	7	-4	1.79	98	122	-24	2.29	2	6	-4	2.00
22WT	73383	Meso	810	795	15	0.53	20	24	-4	0.85	831	791	40	1.40	16	22	-6	1.38
22NL	73384	Meso	68	69	-1	0.12	2	3	-1	0.63	73	73	0	0.00	0	1	-1	1.41
22NT	73385	Meso	331	356	-25	1.35	5	10	-5	1.83	387	431	-44	2.18	12	11	1	0.29
22WL	73386	Meso	36	32	4	0.69	3	4	-1	0.53	31	44	-13	2.12	4	2	2	1.15
22ER	73387	Meso	43	29	14	2.33	0	0	0	0.00	27	46	-19	3.14	1	4	-3	1.90
22ST	73388	Meso	139	115	24	2.13	4	3	1	0.53	137	171	-34	2.74	4	5	-1	0.47
67NR	73421	Micro	73	44	29	3.79	0	5	-5	3.16	61	68	-7	0.87	0	5	-5	3.16
67ET	73422	Micro	992	957	35	1.12	93	103	-10	1.01	987	949	38	1.22	114	101	13	1.25
67WL	73423	Micro	33	39	-6	1.00	0	1	-1	1.41	28	39	-11	1.90	0	2	-2	2.00
67ER	73424	Micro	194	160	34	2.56	31	19	12	2.40	206	234	-28	1.89	21	31	-10	1.96
67WT	73425	Micro	1855	1783	72	1.69	141	163	-22	1.78	1892	1909	-17	0.39	152	158	-6	0.48
67NL	73426	Micro	273	239	34	2.13	39	35	4	0.66	304	316	-12	0.68	39	37	2	0.32
66WT	73434	Micro	1740	1619	121	2.95	133	163	-30	2.47	1844	1639	205	4.91	148	122	26	2.24
66NL	73435	Micro	129	88	41	3.94	7	5	2	0.82	113	104	9	0.86	10	6	4	1.41
66ET	73436	Micro	862	783	79	2.75	82	86	-4	0.44	862	836	26	0.89	98	88	10	1.04
66NR	73437	Micro	110	161	-51	4.38	0	4	-4	2.83	147	152	-5	0.41	4	3	1	0.53
66ER	73438	Micro	106	113	-7	0.67	5	5	0	0.00	85	131	-46	4.43	6	8	-2	0.76
66WL	73439	Micro	196	238	-42	2.85	4	4	0	0.00	237	387	-150	8.49	0	8	-8	4.00
78NL	73441	Meso	60	53	7	0.93	0	0	0	0.00	56	93	-37	4.29	5	2	3	1.60
78SR	73442	Meso	61	58	3	0.39	6	7	-1	0.39	87	76	11	1.22	1	8	-7	3.30
78WT	73443	Meso	1795	1815	-20	0.47	127	163	-36	2.99	1945	1919	26	0.59	141	124	17	1.48
78ST	73444	Meso	95	113	-18	1.77	5	3	2	1.00	98	100	-2	0.20	7	4	3	1.28
78WL	73445	Meso	29	14	15	3.23	2	0	2	2.00	27	13	14	3.13	4	1	3	1.90
78EL	73446	Meso	111	127	-16	1.47	0	10	-10	4.47	142	120	22	1.92	2	11	-9	3.53
78NT	73447	Meso	187	192	-5	0.36	6	4	2	0.89	176	164	12	0.92	5	8	-3	1.18
78WR	73448	Meso	150	184	-34	2.63	2	12	-10	3.78	144	214	-70	5.23	7	8	-1	0.37
78ET	73449	Meso	859	776	83	2.90	83	86	-3	0.33	888	800	88	3.03	99	83	16	1.68
78NR	73450	Meso	13	5	8	2.67	4	0	4	2.83	12	10	2	0.60	4	1	3	1.90
78SL	73451	Meso	84	113	-29	2.92	4	9	-5	1.96	81	86	-5	0.55	0	4	-4	2.83
24WL	73460	Meso	63	55	8	1.04	11	2	9	3.53	67	60	7	0.88	7	5	2	0.82
24ER	73461	Meso	128	130	-2	0.18	7	11	-4	1.33	124	147	-23	1.98	22	12	10	2.43
24ST	73462	Meso	187	104	83	6.88	9	2	7	2.98	124	121	3	0.27	8	2	6	2.68
24ET	73463	Meso	234	227	7	0.46	13	9	4	1.21	216	225	-9	0.61	10	15	-5	1.41
24SL	73464	Meso	23	16	7	1.59	2	2	0	0.00	13	14	-1	0.27	0	0	0	0.00
24NL	73465	Meso	289	229	60	3.73	21	27	-6	1.22	300	204	96	6.05	31	16	15	3.09
24WT	73466	Meso	444	508	-64	2.93	17	20	-3	0.70	438	468	-30	1.41	14	18	-4	1.00
24SR	73467	Meso	90	99	-9	0.93	0	0	0	0.00	116	74	42	4.31	1	1	0	0.00
24NT	73468	Meso	378	274	104	5.76	11	3	8	3.02	337	264	73	4.21	18	11	7	1.84
24EL	73469	Meso	29	59	-30	4.52	0	0	0	0.00	38	56	-18	2.63	3	2	1	0.63
64WL	73471	Micro	483	572	-89	3.88	29	23	6	1.18	480	503	-23	1.04	26	25	1	0.20
64NL	73472	Micro	0	17	-17	5.83	0	1	-1	1.41	4	18	-14	4.22	0	1	-1	1.41
64WT	73473	Micro	1871	1843	28	0.65	134	163	-29	2.38	1948	1944	4	0.09	141	128	13	1.12
64NR	73474	Micro	224	226	-2	0.13	11	11	0	0.00	226	233	-7	0.46	5	15	-10	3.16

64ET	73475	Micro	998	961	37	1.18	93	96	-3	0.31	978	906	72	2.35	96	92	4	0.41
61NL	73477	Micro	241	205	36	2.41	7	3	4	1.79	225	206	19	1.29	6	7	-1	0.39
61WT	73478	Micro	1740	1804	-64	1.52	157	191	-34	2.58	1790	1783	7	0.17	142	150	-8	0.66
61SR	73479	Micro	60	34	26	3.79	1	0	1	1.41	60	78	-18	2.17	0	1	-1	1.41
61ER	73480	Micro	121	113	8	0.74	7	12	-5	1.62	113	129	-16	1.45	3	3	0	0.00
61WL	73481	Micro	63	36	27	3.84	2	4	-2	1.15	57	31	26	3.92	2	4	-2	1.15
61ST	73482	Micro	341	337	4	0.22	2	4	-2	1.15	328	297	31	1.75	1	3	-2	1.41
61ET	73483	Micro	988	963	25	0.80	82	87	-5	0.54	987	891	96	3.13	92	99	-7	0.72
61SL	73484	Micro	12	21	-9	2.22	0	0	0	0.00	10	14	-4	1.15	0	1	-1	1.41
61EL	73485	Micro	12	18	-6	1.55	0	0	0	0.00	20	27	-7	1.44	0	0	0	0.00
61NT	73486	Micro	224	298	-74	4.58	2	6	-4	2.00	236	256	-20	1.28	3	7	-4	1.79
46WL	73488	Micro	51	40	11	1.63	8	1	7	3.30	63	90	-27	3.09	5	5	0	0.00
46NR	73489	Micro	105	102	3	0.29	1	1	0	0.00	95	101	-6	0.61	4	5	-1	0.47
46ET	73490	Micro	1095	1166	-71	2.11	89	100	-11	1.13	1085	1055	30	0.92	92	107	-15	1.50
46NL	73491	Micro	35	27	8	1.44	1	1	0	0.00	25	19	6	1.28	0	3	-3	2.45
46WT	73492	Micro	1586	1664	-78	1.93	144	184	-40	3.12	1708	1592	116	2.86	143	145	-2	0.17
45WL	73494	Micro	6	30	-24	5.66	0	2	-2	2.00	5	50	-45	8.58	0	1	-1	1.41
45ST	73495	Micro	206	165	41	3.01	1	5	-4	2.31	187	189	-2	0.15	0	4	-4	2.83
45WT	73496	Micro	1515	1516	-1	0.03	131	165	-34	2.79	1663	1481	182	4.59	136	141	-5	0.42
45SR	73497	Micro	145	171	-26	2.07	23	14	9	2.09	156	161	-5	0.40	11	15	-4	1.11
45SL	73499	Micro	166	177	-11	0.84	12	20	-8	2.00	172	160	12	0.93	9	18	-9	2.45
45WR	73501	Micro	208	289	-81	5.14	14	15	-1	0.26	215	213	2	0.14	7	20	-13	3.54
47ET	73503	Micro	1130	1024	106	3.23	80	92	-12	1.29	1103	888	215	6.81	87	94	-7	0.74
47WT	73504	Micro	1328	1404	-76	2.06	108	130	-22	2.02	1474	1423	51	1.34	110	121	-11	1.02
44SL	73506	Micro	321	256	65	3.83	27	21	6	1.22	294	176	118	7.70	23	33	-10	1.89
44ET	73507	Micro	1100	1232	-132	3.87	78	80	-2	0.23	1097	1130	-33	0.99	83	85	-2	0.22
44NR	73508	Micro	106	50	56	6.34	4	1	3	1.90	80	42	38	4.87	1	1	0	0.00
44WR	73509	Micro	442	393	49	2.40	22	28	-6	1.20	426	511	-85	3.93	39	24	15	2.67
44EL	73510	Micro	3	17	-14	4.43	3	2	1	0.63	11	23	-12	2.91	0	3	-3	2.45
44NT	73511	Micro	147	151	-4	0.33	8	1	7	3.30	130	130	0	0.00	14	3	11	3.77
44WT	73512	Micro	1258	1350	-92	2.55	103	133	-30	2.76	1487	1311	176	4.71	111	128	-17	1.56
44NL	73513	Micro	21	23	-2	0.43	0	1	-1	1.41	15	24	-9	2.04	0	0	0	0.00
44WL	73514	Micro	65	54	11	1.43	8	2	6	2.68	74	78	-4	0.46	17	3	14	4.43
44ST	73515	Micro	229	181	48	3.35	4	6	-2	0.89	205	181	24	1.73	13	3	10	3.54
34ST	73517	Meso	503	588	-85	3.64	17	16	1	0.25	581	563	18	0.75	22	19	3	0.66
34NT	73518	Meso	343	454	-111	5.56	22	18	4	0.89	318	394	-76	4.03	17	18	-1	0.24
52NT	73533	Meso	332	345	-13	0.71	77	57	20	2.44	367	385	-18	0.93	75	38	37	4.92
43ER	73536	Micro	188	189	-1	0.07	24	27	-3	0.59	195	191	4	0.29	13	35	-22	4.49
43WL	73537	Micro	4	16	-12	3.79	0	3	-3	2.45	36	51	-15	2.27	0	2	-2	2.00
43NL	73538	Micro	238	271	-33	2.07	25	31	-6	1.13	296	252	44	2.66	26	32	-6	1.11
43NR	73540	Micro	51	85	-34	4.12	1	11	-10	4.08	64	90	-26	2.96	4	6	-2	0.89
43ET	73541	Micro	1099	1166	-67	1.99	79	84	-5	0.55	1052	1008	44	1.37	87	84	3	0.32
50ST	73543	Meso	1320	1279	41	1.14	46	44	2	0.30	1338	1328	10	0.27	27	40	-13	2.25
50WL	73544	Meso	183	192	-9	0.66	9	16	-7	1.98	206	158	48	3.56	7	12	-5	1.62
50NT	73546	Meso	437	504	-67	3.09	16	18	-2	0.49	426	479	-53	2.49	8	33	-25	5.52
50EL	73547	Meso	11	11	0	0.00	0	0	0	0.00	15	9	6	1.73	0	0	0	0.00
50NR	73548	Meso	84	82	2	0.22	6	11	-5	1.71	86	70	16	1.81	9	9	0	0.00
50SL	73549	Meso	25	4	21	5.51	2	1	1	0.82	24	22	2	0.42	5	1	4	2.31
50ET	73550	Meso	143	129	14	1.20	1	2	-1	0.82	161	140	21	1.71	3	3	0	0.00
50NL	73551	Meso	36	77	-41	5.45	1	3	-2	1.41	56	71	-15	1.88	3	2	1	0.63
50WT	73553	Meso	178	187	-9	0.67	6	2	4	2.00	203	190	13	0.93	15	4	11	3.57
49EL	73555	Meso	159	217	-58	4.23	2	4	-2	1.15	194	209	-15	1.06	8	8	0	0.00
49NTR	73556	Meso	396	479	-83	3.97	21	28	-7	1.41	373	403	-30	1.52	12	36	-24	4.90
49SR	73557	Meso	678	630	48	1.88	15	14	1	0.26	718	625	93	3.59	13	10	3	0.88
49NL	73558	Meso	143	120	23	2.01	0	4	-4	2.83	130	180	-50	4.02	1	3	-2	1.41
49STL	73559	Meso	822	846	-24	0.83	38	44	-6	0.94	846	894	-48	1.63	23	46	-23	3.92
49ETR	73560	Meso	91	85	6	0.64	4	2	2	1.15	82	106	-24	2.48	0	3	-3	2.45
73NR	73648	Meso	149	173	-24	1.89	3	4	-1	0.53	169	179	-10	0.76	10	10	0	0.00
73ET	73649	Meso	84	80	4	0.44	0	1	-1	1.41	103	94	9	0.91	0	1	-1	1.41
73WL	73650	Meso	795	669	126	4.66	21	14	7	1.67	744	640	104	3.95	16	12	4	1.07
73ER	73651	Meso	138	121	17	1.49	0	1	-1	1.41	109	147	-38	3.36	4	3	1	0.53
73WT	73652	Meso	102	100	2	0.20	0	0	0	0.00	120	127	-7	0.63	0	0	0	0.00
73NL	73653	Meso	56	62	-6	0.78	3	0	3	2.45	47	43	4	0.60	1	1	0	0.00
58WT	73665	Meso	833	945	-112	3.76	35	53	-18	2.71	807	806	1	0.04	51	48	3	0.43
58NL	73666	Meso	299	297	2	0.12	25	13	12	2.75	304	303	1	0.06	15	16	-1	0.25
58ET	73667	Meso	452	537	-85	3.82	41	44	-3	0.46	474	398	76	3.64	38	43	-5	0.79
58NR	73668	Meso	128	103	25	2.33	6	3	3	1.41	122	101	21	1.99	3	2	1	0.63
58ER	73669	Meso	354	308	46	2.53	11	13	-2	0.58	313	347	-34	1.87	10	10	0	0.00
58WL	73670	Meso	105	136	-31	2.82	4	1	3	1.90	78	178	-100	8.84	2	4	-2	1.15
55EL	73684	Meso	41	40	1	0.16	2	0	2	2.00	45	56	-11	1.55	2	0	2	2.00
55ET	73686	Meso	546	592	-46	1.93	45	45	0	0.00	547	444	103	4.63	38	47	-9	1.38
55SL	73687	Meso	114	133	-19	1.71	0	1	-1	1.41	113	136	-23	2.06	3	2	1	0.63
51ST	73689	Meso	475	463	12	0.55	9	9	0	0.00	470	460	10	0.46	1	7	-6	3.00
51WL	73690	Meso	663	623	40	1.58	20	18	2	0.46	667	672	-5	0.19	16	22	-6	1.38
51ER	73691	Meso	210	187	23	1.63	20	17	3	0.70	224	189	35	2.44	14	14	0	0.00
51NT	73692	Meso	249	216	33	2.16	2	3	-1	0.63	217	233	-16	1.07	2	5	-3	1.60
51EL	73693	Meso	34	3	31	7.21	2	0	2	2.00	27	8	19	4.54	1	0	1	1.41
51NR	73694	Meso	99	120	-21	2.01	7	7	0	0.00	101	121	-20	1.90	4	11	-7	2.56
51SL	73695	Meso	2	0	2	2.00	0	0	0	0.00	2	0	2	2.00	0	0	0	0.00
51ET	73696	Meso	354	338	16	0.86	25	19	6	1.28	361	296	65	3.59	27	32	-5	0.92
51NL	73697	Meso	102	125	-23	2.16	6	8	-2	0.76	122	100	22	2.09	2	18	-16	5.06
51WT	73699	Meso	767	812	-45	1.60	30	44	-14	2.30	742	771	-29	1.05	52	29	23	3.61
54SL	73701	Meso	17	25	-8	1.75	4	3	1	0.53	16	17	-1	0.25	3	8	-5	2.13
54ET	73702	Meso	302	295	7	0.41	25	18	7	1.51	291	303	-12	0.70	19	27	-8	1.67
54NT	73703	Meso	244	288	-44	2.70	72	51	21	2.68	277	312	-35	2.04	76	31	45	6.15
54EL	73704	Meso	18	13	5	1.27	2	1	1	0.82	12	24	-12	2.83	1	4	-3	1.90
54WL	73705	Meso	34	39	-5	0.83	2	0	2	2.00	46	45	1	0.15	0	4	-4	2.83
54ST	73706	Meso	373	388	-15	0.77	31	33	-2	0.35	313	310	3	0.17	33	33	0	0.00
54ER	73707	Meso	152	158	-6	0.48	6	9	-3	1.10	172	123	49	4.03	15	17	-2	0.50
54WT	73708	Meso	1299	1292	7	0.19	45	52	-7	1.01	1263	1324	-61	1.70	61	50	11	1.48
54NL	73709	Meso	111	64	47	5.02	6	8	-2	0.76	97	78	19	2.03	6	9	-3	1.10
32WT	79337	Meso	514	549	-35	1.52	15	36	-21	4.16	506	545	-39	1.70	27	31	-4	0.74
32ET	79339	Meso	394	448	-54	2.63	24	24	0	0.00	447	437	10	0.48	23	30	-7	1.36
12NL	79573	Meso	296	163	133	8.78	0	0	0	0.00	284	171	113	7.49	0	1	-1	1.41
12EL	79575	Meso	10	8	2	0.67	0	0	0	0.00	8	15	-7	2.06	0	1	-1	1.41
12NT	79576	Meso	124	99	25	2.37	0	3	-3	2.45	108	125	-17	1.58	0	1	-1	1.41
12ST	79577	Meso	110	105	5	0.48	3	0	3	2.45	115	133	-18	1.62	0	3	-3	2.45
84ST	80097	Meso	181	149	32	2.49	7	16	-9	2.65	196	184	12	0.87	10	19	-9	2.36
84WL	80098	Meso	0	17	-17	5.83	0	0	0	0.00	0	35	-35	8.37	0	0	0	0.00
84ER	80099	Meso	18	14	4	1.00	1	2	-1	0.82	30	25	5	0.95	0	2	-2	2.00
84NT	80100	Meso	87	86	1	0.11	12	10	2	0.60	97	134	-37	3.44	10	13	-3	0.88
84WR	80101	Meso	105	87	18	1.84	4	1	3	1.90	107	98	9	0.89	1	4	-3	1.90
84SL	80103	Meso	43	23	20	3.48	13	17	-4	1.03	44	64	-20	2.72	8	3	5	2.13
84ET	80104	Meso	1358	1398	-40	1.08	123	115	8	0.73	1288	1245	43	1.21	112	120	-8	0.74
84NL	80105	Meso	5	12	-7	2.40	4	0	4	2.83	3	3	0	0.00	0	0	0	0.00
84SR	80106	Meso	140	158	-18	1.47	5	4	1	0.47	104	99	5	0.50	6	3	3	1.41
84WT	80107	Meso	1422	1434	-12	0.32	94	127	-33	3.14	1007	941	66	2.11	116	89	27	2.67
59ER	80121	Meso	101	62	39	4.32	2	3	-1	0.63	81	104	-23	2.39	0	6	-6	3.46
59ST	80122	Meso	161	134	27	2.22	5	6	-1	0.43	118	180	-62	5.08	6	4	2	0.89
59NL	80123	Meso	104	98	6	0.60	10	21	-11	2.79	111	152	-41	3.58	16	18	-2	0.49
59SR	80124	Meso	115	57	58	6.25	2	0	2	2.00	134	122	12	1.06	1	0	1	1.41
59NT	80125	Meso	269	312	-43	2.52	3	11	-8	3.02	294	353	-59	3.28	14	15	-1	0.26
59EL	80126	Meso	20	48	-28	4.80	2	1	1	0.82	37	70	-33	4.51	0	2	-2	2.00

62WT	80256	Micro	1749	1873	-124	2.91	144	177	-33	2.60	1837	1897	-60	1.39	145	137	8	0.67
62SR	80257	Micro	614	551	63	2.61	20	6	14	3.88	570	595	-25	1.04	18	11	7	1.84
62ET	80258	Micro	1075	1076	-1	0.03	90	99	-9	0.93	1063	984	79	2.47	95	95	0	0.00
62SL	80259	Micro	56	49	7	0.97	0	5	-5	3.16	65	60	5	0.63	0	5	-5	3.16
62EL	80260	Micro	145	148	-3	0.25	13	4	9	3.09	145	189	-44	3.40	7	10	-3	1.03
62WR	80261	Micro	210	194	16	1.13	12	8	4	1.26	182	183	-1	0.07	5	13	-8	2.67
33NR	80647	Meso	77	113	-36	3.69	11	8	3	0.97	106	121	-15	1.41	17	7	10	2.89
33ET	80648	Meso	1157	1200	-43	1.25	126	123	3	0.27	1093	1069	24	0.73	114	110	4	0.38
33SL	80649	Meso	6	19	-13	3.68	7	0	7	3.74	4	8	-4	1.63	1	0	1	1.41
33ST	80651	Meso	168	186	-18	1.35	10	2	8	3.27	195	218	-23	1.60	8	4	4	1.63
33WT	80652	Meso	1202	1191	11	0.32	96	114	-18	1.76	767	788	-21	0.75	108	80	28	2.89
33NL	80653	Meso	8	3	5	2.13	0	0	0	0.00	11	10	1	0.31	0	0	0	0.00
33SR	80654	Meso	312	355	-43	2.35	3	13	-10	3.54	340	289	51	2.88	11	13	-2	0.58
33NT	80655	Meso	87	70	17	1.92	1	2	-1	0.82	92	87	5	0.53	4	2	2	1.15
2WL	80661	Meso	292	222	70	4.37	9	11	-2	0.63	276	273	3	0.18	23	10	13	3.20
2ER	80662	Meso	108	79	29	3.00	22	10	12	3.00	69	82	-13	1.50	10	11	-1	0.31
2ST	80663	Meso	351	309	42	2.31	7	19	-12	3.33	300	385	-85	4.59	9	9	0	0.00
2NR	80664	Meso	22	94	-72	9.45	11	2	9	3.53	20	91	-71	9.53	3	3	0	0.00
2ET	80665	Meso	1340	1355	-15	0.41	133	112	21	1.90	1289	1251	38	1.07	124	135	-11	0.97
2SL	80666	Meso	79	71	8	0.92	0	9	-9	4.24	92	65	27	3.05	2	4	-2	1.15
2NL	80667	Meso	57	29	28	4.27	3	0	3	2.45	41	34	7	1.14	7	1	6	3.00
2WT	80668	Meso	1276	1340	-64	1.77	91	122	-31	3.00	851	815	36	1.25	103	84	19	1.96
2SR	80669	Meso	149	226	-77	5.62	6	10	-4	1.41	152	157	-5	0.40	5	5	0	0.00
2NT	80670	Meso	116	139	-23	2.04	1	4	-3	1.90	116	141	-25	2.21	1	4	-3	1.90
2EL	80671	Meso	41	66	-25	3.42	0	2	-2	2.00	27	69	-42	6.06	0	1	-1	1.41
60WT	80701	Micro	1629	1631	-2	0.05	140	180	-40	3.16	1724	1571	153	3.77	140	150	-10	0.83
60NL	80702	Micro	32	38	-6	1.01	0	0	0	0.00	24	68	-44	6.49	0	0	0	0.00
60SR	80703	Micro	107	63	44	4.77	0	0	0	0.00	103	52	51	5.79	0	1	-1	1.41
60ET	80704	Micro	976	1002	-26	0.83	82	95	-13	1.38	988	902	86	2.80	92	102	-10	1.02
60NR	80705	Micro	91	59	32	3.70	1	2	-1	0.82	80	71	9	1.04	0	1	-1	1.41
60SL	80706	Micro	29	21	8	1.60	6	0	6	3.46	26	12	14	3.21	0	0	0	0.00
60WL	80707	Micro	6	13	-7	2.27	0	2	-2	2.00	2	20	-18	5.43	3	1	2	1.41
60ST	80708	Micro	144	149	-5	0.41	0	2	-2	2.00	126	130	-4	0.35	0	2	-2	2.00
60EL	80709	Micro	7	12	-5	1.62	0	0	0	0.00	8	17	-9	2.55	0	0	0	0.00
60NT	80710	Micro	196	177	19	1.39	0	0	0	0.00	168	136	32	2.60	3	0	3	2.45
74SR	80747	Meso	1076	1045	31	0.95	28	24	4	0.78	967	938	29	0.94	32	32	0	0.00
74WT	80748	Meso	1600	1640	-40	0.99	113	136	-23	2.06	1130	1106	24	0.72	110	90	20	2.00
74WR	80750	Meso	69	56	13	1.64	0	8	-8	4.00	86	81	5	0.55	2	3	-1	0.63
74ET	80751	Meso	1195	1145	50	1.46	114	104	10	0.96	1117	1088	29	0.87	105	130	-25	2.31
21EL	82727	Meso	11	12	-1	0.29	2	1	1	0.82	17	17	0	0.00	0	0	0	0.00
21WR	82728	Meso	0	5	-5	3.16	0	0	0	0.00	0	17	-17	5.83	0	0	0	0.00
21NT	82729	Meso	338	318	20	1.10	4	10	-6	2.27	409	383	26	1.31	12	10	2	0.60
21SL	82733	Meso	11	18	-7	1.84	1	0	1	1.41	6	33	-27	6.11	5	0	5	3.16
21ET	82734	Meso	132	82	50	4.83	0	0	0	0.00	93	129	-36	3.42	0	2	-2	2.00
21NR	82735	Meso	6	1	5	2.67	0	0	0	0.00	1	1	0	0.00	0	0	0	0.00
21ST	82736	Meso	162	134	28	2.30	6	6	0	0.00	143	164	-21	1.69	4	10	-6	2.27
21ER	82737	Meso	35	78	-43	5.72	0	13	-13	5.10	23	100	-77	9.82	0	11	-11	4.69
21WL	82738	Meso	22	7	15	3.94	0	0	0	0.00	21	1	20	6.03	1	0	1	1.41
69WT	82740	Micro	1881	1888	-7	0.16	139	170	-31	2.49	1949	1855	94	2.16	154	139	15	1.24
69ET	82742	Micro	977	883	94	3.08	88	80	8	0.87	963	875	88	2.90	108	108	0	0.00
65ST	82760	Micro	261	193	68	4.51	5	2	3	1.60	231	183	48	3.34	6	2	4	2.00
65WL	82761	Micro	39	30	9	1.53	6	2	4	2.00	23	32	-9	1.72	3	1	2	1.41
65NT	82762	Micro	215	201	14	0.97	7	2	5	2.36	237	185	52	3.58	8	6	2	0.76
65EL	82763	Micro	32	33	-1	0.18	1	0	1	1.41	40	53	-13	1.91	7	0	7	3.74
65NR	82764	Micro	61	31	30	4.42	1	0	1	1.41	31	22	9	1.75	1	3	-2	1.41
65SL	82765	Micro	19	33	-14	2.75	2	1	1	0.82	23	24	-1	0.21	2	1	1	0.82
65ET	82766	Micro	936	920	16	0.53	92	95	-3	0.31	949	891	58	1.91	96	96	0	0.00
65NL	82767	Micro	127	60	67	6.93	3	1	2	1.41	114	64	50	5.30	12	4	8	2.83
65SR	82768	Micro	72	49	23	2.96	2	3	-1	0.63	81	59	22	2.63	1	0	1	1.41
65WT	82769	Micro	1826	1867	-41	0.95	125	162	-37	3.09	1945	1974	-29	0.66	138	128	10	0.87
77ST	82771	Meso	167	199	-32	2.37	11	13	-2	0.58	181	180	1	0.07	7	13	-6	1.90
77ER	82772	Meso	60	68	-8	1.00	0	3	-3	2.45	60	73	-13	1.59	1	2	-1	0.82
77WL	82773	Meso	58	62	-4	0.52	3	5	-2	1.00	62	69	-7	0.86	2	6	-4	2.00
77NT	82774	Meso	153	153	0	0.00	6	19	-13	3.68	153	148	5	0.41	10	14	-4	1.15
77EL	82775	Meso	16	17	-1	0.25	0	2	-2	2.00	34	27	7	1.27	0	0	0	0.00
77WR	82776	Meso	13	48	-35	6.34	1	2	-1	0.82	14	51	-37	6.49	4	1	3	1.90
77NL	82777	Meso	83	124	-41	4.03	2	9	-7	2.98	78	143	-65	6.18	3	8	-5	2.13
77SR	82778	Meso	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	1	-1	1.41
77WT	82779	Meso	438	372	66	3.28	9	3	6	2.45	397	372	25	1.27	6	6	0	0.00
77NR	82780	Meso	33	46	-13	2.07	1	4	-3	1.90	47	66	-19	2.53	0	3	-3	2.45
77SL	82781	Meso	189	127	62	4.93	5	2	3	1.60	145	115	30	2.63	6	2	4	2.00
77ET	82782	Meso	213	215	-2	0.14	0	0	0	0.00	206	199	7	0.49	5	5	0	0.00
37ET	84210	Micro	1419	1593	-174	4.48	103	99	4	0.40	1351	1302	49	1.35	102	117	-15	1.43
37SL	84211	Micro	47	28	19	3.10	0	2	-2	2.00	38	46	-8	1.23	0	3	-3	2.45
37NR	84212	Micro	29	28	1	0.19	1	1	0	0.00	26	41	-15	2.59	0	1	-1	1.41
37WT	84213	Micro	1801	1845	-44	1.03	158	173	-15	1.17	1902	1693	209	4.93	198	156	42	3.16
37NL	84214	Micro	0	29	-29	7.62	0	2	-2	2.00	13	42	-29	5.53	0	2	-2	2.00
37EL	84215	Micro	9	28	-19	4.42	0	0	0	0.00	10	29	-19	4.30	4	0	4	2.83
37NT	84216	Micro	80	93	-13	1.40	1	0	1	1.41	84	79	5	0.55	0	0	0	0.00
37WL	84217	Micro	97	108	-11	1.09	5	3	2	1.00	107	106	1	0.10	2	2	0	0.00
37ST	84218	Micro	165	226	-61	4.36	1	2	-1	0.82	156	184	-28	2.15	0	3	-3	2.45
72WL	84220	Meso	150	141	9	0.75	6	1	5	2.67	176	184	-8	0.60	19	3	16	4.82
72ST	84221	Meso	750	700	50	1.86	15	13	2	0.53	645	810	-165	6.12	12	17	-5	1.31
72SL	84223	Meso	34	15	19	3.84	0	0	0	0.00	33	9	24	5.24	0	1	-1	1.41
72NT	84224	Meso	778	741	37	1.34	33	16	17	3.43	788	756	32	1.15	22	23	-1	0.21
36NT	88660	Meso	69	21	48	7.16	0	3	-3	2.45	78	30	48	6.53	0	2	-2	2.00
36WR	88661	Meso	102	165	-63	5.45	0	5	-5	3.16	124	181	-57	4.62	1	5	-4	2.31
36ST	88662	Meso	7	28	-21	5.02	0	4	-4	2.83	44	55	-11	1.56	0	3	-3	2.45
36WL	88663	Meso	754	788	-34	1.22	21	14	7	1.67	794	753	41	1.47	26	19	7	1.48
36SL	88664	Meso	66	51	15	1.96	19	18	1	0.23	108	52	56	6.26	22	3	19	5.37
36NR	88665	Meso	404	473	-69	3.30	29	16	13	2.74	355	402	-47	2.42	19	16	3	0.72
38WR	88667	Meso	467	521	-54	2.43	49	32	17	2.67	460	451	9	0.42	37	19	18	3.40
38NT	88668	Meso	209	204	5	0.35	8	9	-1	0.34	210	204	6	0.42	5	6	-1	0.43
40NT	88670	Meso	649	671	-22	0.86	50	40	10	1.49	631	585	46	1.87	38	23	15	2.72
40NL	88676	Meso	28	26	2	0.38	7	1	6	3.00	37	46	-9	1.40	4	0	4	2.83
68ET	92156	Micro	492	460	32	1.47	80	78	2	0.23	584	531	53	2.24	86	86	0	0.00
68WT	92158	Micro	1026	1025	1	0.03	118	148	-30	2.60	1122	1181	-59	1.74	126	124	2	0.18
68SR	92159	Micro	732	807	-75	2.70	49	49	0	0.00	603	562	41	1.70	57	57	0	0.00
68NL	92160	Micro	24	19	5	1.08	1	2	-1	0.82	28	24	4	0.78	1	4	-3	1.90
68WR	92161	Micro	930	783	147	5.02	62	74	-12	1.46	894	778	116	4.01	62	59	3	0.39
68EL	92162	Micro	342	343	-1	0.05	39	35	4	0.66	340	362	-22	1.17	35	30	5	0.88
68WL	92163	Micro	164	124	40	3.33	2	7	-5	2.36	174	159	15	1.16	2	6	-4	2.00
68ST	92164	Micro	180	165	15	1.14	7	3	4	1.79	180	161	19	1.46	8	7	1	0.37
81WT	104064	Micro	1372	1466	-94	2.50	119	157	-38	3.23	1497	1363	134	3.54	114	129	-15	1.36
81ET	104065	Micro	1136	1197	-61	1.79	79	86	-7	0.77	1124	1039	85	2.58	90	86	4	0.43
10WL	104081	Meso	146	149	-3	0.25	2	3	-1	0.63	138	127	11	0.96	7	5	2	0.82
10ST	104082	Meso	104	105	-1	0.10	15	25	-10	2.24	97	123	-26	2.48	13	22	-9	2.15
10NR	104083	Meso	79	49	30	3.75	14	5	9	2.92	65	49	16	2.12	16	0	16	5.66
10SL	104084	Meso	21	36	-15	2.81	0	1	-1	1.41	22	33	-11	2.10	1	1	0	0.00
10NT	104085	Meso	209	228	-19	1.29	18	23	-5	1.10	216	258	-42	2.73	17	28	-11	2.32
10WR	104086	Meso	92	116	-24	2.35	0	1	-1	1.41	127	126	1	0.09	8	1	7	3.30
48NT	117031	Meso	319	398	-79	4.17	17	23	-6	1.34	310	325	-15	0.84	9	32	-23	5.08
48ST	117032	Meso	479	501	-22	0.99	36	38	-2	0.33	478	469	9	0.41	20	40	-20	3.65

4SL	117169	Meso	73	38	35	4.70	0	1	-1	1.41	62	41	21	2.93	3	0	3	2.45
4NR	117170	Meso	0	12	-12	4.90	0	0	0	0.00	0	12	-12	4.90	0	1	-1	1.41
4WR	117171	Meso	26	24	2	0.40	2	0	2	2.00	28	6	22	5.34	4	0	4	2.83
4NT	117172	Meso	229	196	33	2.26	24	15	9	2.04	243	236	7	0.45	23	22	1	0.21
4WL	117173	Meso	35	14	21	4.24	1	0	1	1.41	21	6	15	4.08	1	1	0	0.00
4ST	117174	Meso	140	142	-2	0.17	20	11	9	2.29	125	140	-15	1.30	22	11	11	2.71
52EL	13089151	Meso	20	1	19	5.86	1	3	-2	1.41	13	3	10	3.54	8	4	4	1.63
52SR	13089152	Meso	0	2	-2	2.00	0	5	-5	3.16	0	0	0	0.00	0	4	-4	2.83
31EL	13089157	Micro	351	341	10	0.54	19	21	-2	0.45	343	318	25	1.38	24	22	2	0.42
31SL	13089166	Micro	79	61	18	2.15	11	8	3	0.97	88	90	-2	0.21	9	4	5	1.96
39SL	13089176	Micro	89	64	25	2.86	1	8	-7	3.30	102	74	28	2.98	3	5	-2	1.00
38WL	13089177	Meso	88	68	20	2.26	1	6	-5	2.67	102	67	35	3.81	3	5	-2	1.00
47WL	13089187	Micro	25	17	8	1.75	2	1	1	0.82	32	20	12	2.35	1	1	0	0.00
47NL	13089188	Micro	35	48	-13	2.02	3	2	1	0.63	39	40	-1	0.16	3	1	2	1.41
34WL	13089197	Meso	17	18	-1	0.24	3	1	2	1.41	24	15	9	2.04	1	2	-1	0.82
34WT	13089198	Meso	55	26	29	4.56	1	1	0	0.00	52	33	19	2.91	4	0	4	2.83
34WR	13089199	Meso	24	8	16	4.00	0	0	0	0.00	25	3	22	5.88	1	1	0	0.00
34ER	13089200	Meso	34	20	14	2.69	0	0	0	0.00	28	43	-15	2.52	0	1	-1	1.41
34ET	13089201	Meso	38	24	14	2.51	1	0	1	1.41	50	66	-16	2.10	0	2	-2	2.00
34EL	13089202	Meso	69	61	8	0.99	7	3	4	1.79	77	67	10	1.18	0	1	-1	1.41
34SR	13089203	Meso	242	222	20	1.31	5	4	1	0.47	237	270	-33	2.07	4	3	1	0.53
34SL	13089204	Meso	25	10	15	3.59	0	0	0	0.00	21	15	6	1.41	0	0	0	0.00
34NL	13089206	Meso	145	155	-10	0.82	4	12	-8	2.83	161	200	-39	2.90	6	7	-1	0.39
46SL	13089483	Micro	24	6	18	4.65	0	0	0	0.00	31	11	20	4.36	0	0	0	0.00
46ST	13089484	Micro	74	80	-6	0.68	0	0	0	0.00	60	100	-40	4.47	0	0	0	0.00
46SR	13089485	Micro	19	18	1	0.23	0	0	0	0.00	25	12	13	3.02	1	0	1	1.41
46EL	13089486	Micro	2	9	-7	2.98	0	0	0	0.00	1	12	-11	4.31	0	0	0	0.00
46NT	13089487	Micro	39	31	8	1.35	7	0	7	3.74	37	42	-5	0.80	0	1	-1	1.41
48WL	13089503	Meso	36	23	13	2.39	0	2	-2	2.00	35	32	3	0.52	0	1	-1	1.41
48WR	13089504	Meso	9	11	-2	0.63	1	5	-4	2.31	8	12	-4	1.26	0	4	-4	2.83
48NR	13089505	Meso	4	6	-2	0.89	0	0	0	0.00	4	11	-7	2.56	0	0	0	0.00
48SL	13089506	Meso	40	20	20	3.65	3	0	3	2.45	43	29	14	2.33	1	0	1	1.41
81NL	13089549	Micro	116	109	7	0.66	1	3	-2	1.41	128	147	-19	1.62	1	0	1	1.41
22WR	13089736	Meso	0	0	0	0.00	0	18	-18	6.00	0	0	0	0.00	0	17	-17	5.83
53ER	13089812	Meso	1386	1331	55	1.49	112	102	10	0.97	1186	1205	-19	0.55	135	116	19	1.70
53WL	13089814	Meso	578	466	112	4.90	29	25	4	0.77	545	463	82	3.65	19	28	-9	1.86
33EL	13089842	Meso	244	235	9	0.58	9	10	-1	0.32	241	243	-2	0.13	7	14	-7	2.16
35NL	13089853	Meso	99	95	4	0.41	8	11	-3	0.97	106	115	-9	0.86	7	13	-6	1.90
35WL	13089854	Meso	8	37	-29	6.11	0	1	-1	1.41	8	26	-18	4.37	0	0	0	0.00
35WT	13089855	Meso	95	67	28	3.11	2	0	2	2.00	94	68	26	2.89	3	6	-3	1.41
35WR	13089856	Meso	29	22	7	1.39	1	0	1	1.41	22	26	-4	0.82	2	2	0	0.00
35ET	13089857	Meso	56	36	20	2.95	0	4	-4	2.83	42	47	-5	0.75	1	4	-3	1.90
35NR	13089858	Meso	8	23	-15	3.81	0	0	0	0.00	13	15	-2	0.53	1	1	0	0.00
35SL	13089859	Meso	24	18	6	1.31	1	1	0	0.00	29	19	10	2.04	0	1	-1	1.41
23ER	13090099	Meso	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
59ET	13090152	Meso	10	19	-9	2.36	0	1	-1	1.41	9	12	-3	0.93	0	0	0	0.00
59WT	13090153	Meso	28	23	5	0.99	0	0	0	0.00	17	22	-5	1.13	0	1	-1	1.41
59WL	13090154	Meso	14	15	-1	0.26	0	1	-1	1.41	26	14	12	2.68	0	1	-1	1.41
59WR	13090155	Meso	2	9	-7	2.98	1	0	1	1.41	0	8	-8	4.00	2	1	1	0.82
59SL	13090156	Meso	79	56	23	2.80	0	0	0	0.00	102	26	76	9.50	1	0	1	1.41
59NR	13090157	Meso	16	2	14	4.67	0	0	0	0.00	17	0	17	5.83	0	0	0	0.00
68SL	13090179	Micro	689	609	80	3.14	44	54	-10	1.43	613	639	-26	1.04	49	47	2	0.29
66SL	13090338	Micro	10	26	-16	3.77	0	3	-3	2.45	13	30	-17	3.67	0	2	-2	2.00
66ST	13090339	Micro	50	32	18	2.81	0	1	-1	1.41	33	53	-20	3.05	0	1	-1	1.41
66SR	13090340	Micro	27	13	14	3.13	2	0	2	2.00	32	11	21	4.53	2	1	1	0.82
66EL	13090341	Micro	15	16	-1	0.25	0	2	-2	2.00	21	28	-7	1.41	5	0	5	3.16
66NT	13090342	Micro	54	65	-11	1.43	0	2	-2	2.00	67	90	-23	2.60	0	4	-4	2.83
69SL	13090343	Micro	15	1	14	4.95	0	2	-2	2.00	6	10	-4	1.41	0	0	0	0.00
69SR	13090345	Micro	6	13	-7	2.27	3	0	3	2.45	11	15	-4	1.11	0	2	-2	2.00
69EL	13090346	Micro	90	40	50	6.20	5	4	1	0.47	83	69	14	1.61	6	2	4	2.00
55NR	13119550	Meso	48	52	-4	0.57	0	4	-4	2.83	52	62	-10	1.32	0	2	-2	2.00
55WL	13119551	Meso	74	83	-9	1.02	0	0	0	0.00	80	77	3	0.34	0	2	-2	2.00
15NL	13119942	Meso	140	30	110	11.93	11	0	11	4.69	114	37	77	8.86	8	1	7	3.30
15EL	13119943	Meso	60	36	24	3.46	0	0	0	0.00	45	62	-17	2.32	0	0	0	0.00
63NR	13120448	Meso	0	1	-1	1.41	0	0	0	0.00	0	1	-1	1.41	0	4	-4	2.83
63NL	13120449	Meso	0	3	-3	2.45	0	0	0	0.00	0	6	-6	3.46	0	0	0	0.00
63ER	13120450	Meso	7	15	-8	2.41	0	0	0	0.00	16	17	-1	0.25	2	1	1	0.82
63WL	13120451	Meso	15	9	6	1.73	0	0	0	0.00	15	21	-6	1.41	0	0	0	0.00
63ST	13120452	Meso	22	28	-6	1.20	3	0	3	2.45	21	35	-14	2.65	2	1	1	0.82
63NT	13120458	Meso	0	10	-10	4.47	0	0	0	0.00	0	6	-6	3.46	0	0	0	0.00
64EL	13168443	Micro	32	19	13	2.57	2	2	0	0.00	25	30	-5	0.95	2	1	1	0.82
64NT	13168444	Micro	26	36	-10	1.80	2	2	0	0.00	22	37	-15	2.76	1	1	0	0.00
31ET	13405771	Micro	1146	1310	-164	4.68	81	82	-1	0.11	1075	1102	-27	0.82	77	102	-25	2.64
40NR	13405912	Meso	0	6	-6	3.46	0	0	0	0.00	0	8	-8	4.00	0	0	0	0.00
52ST	13405918	Meso	559	577	-18	0.76	39	38	1	0.16	531	477	54	2.41	48	50	-2	0.29
52ER	13405919	Meso	225	224	1	0.07	4	5	-1	0.47	265	215	50	3.23	10	7	3	1.03
55WT	13406071	Meso	854	956	-102	3.39	36	52	-16	2.41	843	852	-9	0.31	54	48	6	0.84
55NL	13406072	Meso	72	39	33	4.43	3	2	1	0.63	56	56	0	0.00	0	5	-5	3.16
71WT	13406099	Meso	771	627	144	5.45	13	13	0	0.00	702	603	99	3.88	11	11	0	0.00
71WL	13406100	Meso	121	87	34	3.33	3	2	1	0.63	111	111	0	0.00	6	2	4	2.00
71ETR	13406104	Meso	106	142	-36	3.23	5	3	2	1.00	95	129	-34	3.21	10	9	1	0.32
71NR	13406109	Meso	75	85	-10	1.12	0	1	-1	1.41	87	65	22	2.52	1	3	-2	1.41
71NL	13406110	Meso	229	246	-17	1.10	2	5	-3	1.60	254	237	17	1.08	10	7	3	1.03
72NR	13406231	Meso	66	54	12	1.55	1	2	-1	0.82	84	51	33	4.02	3	0	3	2.45
9ET	13406258	Meso	399	312	87	4.61	4	9	-5	1.96	351	345	6	0.32	11	12	-1	0.29
9WT	13406262	Meso	686	671	15	0.58	12	16	-4	1.07	697	587	110	4.34	21	15	6	1.41
22EL	13406293	Meso	57	41	16	2.29	8	4	4	1.63	40	69	-29	3.93	18	5	13	3.83
20WT	13406439	Meso	442	421	21	1.01	26	26	0	0.00	468	398	70	3.36	43	24	19	3.28
20WL	13406440	Meso	226	195	31	2.14	2	12	-10	3.78	225	278	-53	3.34	1	6	-5	2.67
20ETR	13406443	Meso	376	315	61	3.28	27	11	16	3.67	316	334	-18	1.00	37	17	20	3.85
20NL	13406448	Meso	198	132	66	5.14	5	1	4	2.31	134	131	3	0.26	5	2	3	1.60
20NR	13406449	Meso	86	96	-10	1.05	3	5	-2	1.00	70	150	-80	7.63	9	7	2	0.71
21NL	13406675	Meso	68	87	-19	2.16	1	18	-17	5.52	64	131	-67	6.79	2	18	-16	5.06
74EL	13406690	Meso	725	694	31	1.16	34	41	-7	1.14	737	658	79	2.99	33	39	-6	1.00
53ET	13406693	Meso	1253	1310	-57	1.59	131	135	-4	0.35	1179	1223	-44	1.27	127	142	-15	1.29
53NL.AM	13406696	Meso	2730	2898	-168	3.17	146	137	9	0.76	2324	2599	-275	5.54	144	135	9	0.76
53NR.AM	13406697	Meso	676	618	58	2.28	25	28	-3	0.58	666	569	97	3.90	25	26	-1	0.20
12ET	13406725	Meso	1257	1213	44	1.25	96	83	13	1.37	1044	1016	28	0.87	108	105	3	0.29
12NR	13406726	Meso	54	43	11	1.58	1	1	0	0.00	43	45	-2	0.30	1	3	-2	1.41
12SL	13406727	Meso	4	35	-31	7.02	4	0	4	2.83	8	24	-16	4.00	2	0	2	2.00
12WL	13406731	Meso	0	18	-18	6.00	0	1	-1	1.41	2	8	-6	2.68	0	0	0	0.00
12WT	13406732	Meso	2322	2310	12	0.25	128	134	-6	0.52	1909	1821	88	2.04	117	121	-4	0.37
33WL	13406803	Meso	192	193	-1	0.07	9	13	-4	1.21	221	224	-3	0.20	16	6	10	3.02
5NL	13406817	Meso	147	114	33	2.89	16	11	5	1.36	156	132	24	2.00	22	12	10	2.43
14STR	13406825	Meso	94	98	-4	0.41	0	4	-4	2.83	105	92	13	1.31	0	2	-2	2.00
14SL	13406826	Meso	35	45	-10	1.58	0	1	-1	1.41	36	33	3	0.51	1	0	1	1.41
14WTR	13406829	Meso	654	618	36	1.43	3	2	1	0.63	642	657	-15	0.59	13	9	4	1.21
14EL	13406831	Meso	32	27	5	0.92	1	1	0	0.00	34	24	10	1.86	0	0	0	0.00
14ETR	13406832	Meso	118	121	-3	0.27	8	3	5	2.13	113	133	-20	1.80	2	3	-1	0.63
29SL	13406949	Meso	27	43	-16	2.70	2	1	1	0.82	35	32	3	0.52	1	3	-2	1.41
29ET	13406950	Meso	232	229	3	0.20	12	17	-5	1.31	198	236	-38	2.58	10	21	-11	2.79
29NR	13406951	Meso	41	37	4	0.64	0	1	-1	1.41	37	24	13	2.35	1	0	1	1.41
27NT	13406968	Meso	279	281	-2	0.12	9	11	-2	0.63	275	294	-19	1.13	13	13	0	0.00

27NL	13406969	Meso	36	13	23	4.65	1	1	0	0.00	44	17	27	4.89	2	1	1	0.82
27EL	13406973	Meso	77	38	39	5.14	4	1	3	1.90	76	28	48	6.66	3	1	2	1.41
27ER	13406974	Meso	9	13	-4	1.21	4	1	3	1.90	20	16	4	0.94	9	0	9	4.24
27STR	13406976	Meso	522	528	-6	0.26	20	15	5	1.20	598	501	97	4.14	26	16	10	2.18
26STR	13406990	Meso	0	23	-23	6.78	0	0	0	0.00	8	29	-21	4.88	7	0	7	3.74
26SL	13406991	Meso	10	20	-10	2.58	3	1	2	1.41	22	18	4	0.89	6	0	6	3.46
26WTR	13406996	Meso	266	173	93	6.28	7	1	6	3.00	292	181	111	7.22	12	6	6	2.00
26ET	13407001	Meso	56	46	10	1.40	9	1	8	3.58	69	42	27	3.62	6	0	6	3.46
26EL	13407002	Meso	86	36	50	6.40	4	1	3	1.90	56	45	11	1.55	5	1	4	2.31
25STR	13407011	Meso	43	39	4	0.62	2	1	1	0.82	33	30	3	0.53	1	0	1	1.41
25SL	13407012	Meso	6	12	-6	2.00	1	0	1	1.41	6	11	-5	1.71	3	0	3	2.45
25WTR	13407017	Meso	214	227	-13	0.88	5	1	4	2.31	243	203	40	2.68	17	9	8	2.22
25ETR	13407022	Meso	66	55	11	1.41	10	3	7	2.75	58	60	-2	0.26	8	1	7	3.30
25EL	13407023	Meso	35	16	19	3.76	4	2	2	1.15	28	34	-6	1.08	9	0	9	4.24
14WL	13603367	Meso	61	49	12	1.62	0	0	0	0.00	87	47	40	4.89	0	0	0	0.00
14NTR	13603369	Meso	153	100	53	4.71	1	2	-1	0.82	125	126	-1	0.09	4	2	2	1.15
14NL	13603370	Meso	3	9	-6	2.45	0	0	0	0.00	5	20	-15	4.24	3	1	2	1.41
19SL	13603378	Meso	4	3	1	0.53	0	0	0	0.00	0	11	-11	4.69	0	0	0	0.00
19STR	13603393	Meso	304	243	61	3.69	20	15	5	1.20	286	283	3	0.18	19	16	3	0.72
19NT	13603399	Meso	453	387	66	3.22	9	16	-7	1.98	481	481	0	0.00	24	17	7	1.55
19NL	13603400	Meso	57	35	22	3.24	4	8	-4	1.63	48	51	-3	0.43	6	6	0	0.00
19ER	13603404	Meso	36	27	9	1.60	12	8	4	1.26	28	37	-9	1.58	2	5	-3	1.60
19EL	13603405	Meso	63	20	43	6.67	0	3	-3	2.45	62	35	27	3.88	0	5	-5	3.16
21WT	13603995	Meso	284	203	81	5.19	0	4	-4	2.83	283	288	-5	0.30	0	1	-1	1.41
32WL	13604612	Meso	46	10	36	6.80	0	0	0	0.00	45	31	14	2.27	0	1	-1	1.41
32ER	13604614	Meso	22	19	3	0.66	0	0	0	0.00	28	25	3	0.58	4	1	3	1.90
32NL	13604615	Meso	53	15	38	6.52	0	1	-1	1.41	50	17	33	5.70	0	0	0	0.00
32NR	13604617	Meso	0	2	-2	2.00	0	1	-1	1.41	0	9	-9	4.24	0	1	-1	1.41
41SR	13606020	Meso	0	0	0	0.00	0	4	-4	2.83	0	0	0	0.00	0	4	-4	2.83
1WT.AM	13608779	Meso	2111	2181	-70	1.51	117	119	-2	0.18	1729	1654	75	1.82	103	98	5	0.50
1WR.AM	13608780	Meso	146	189	-43	3.32	6	7	-1	0.39	196	151	45	3.42	4	5	-1	0.47
1WR.PM	13608783	Meso																
1WT.PM	13608784	Meso																
1WL.AM	13608787	Meso	21	27	-6	1.22	0	4	-4	2.83	26	28	-2	0.38	0	0	0	0.00
1WL.PM	13608788	Meso																
53NL.PM	13608794	Meso																
53NR.PM	13608795	Meso																
70ET	13610952	Meso	123	99	24	2.28	13	8	5	1.54	129	127	2	0.18	15	4	11	3.57
70ER	13610953	Meso	39	25	14	2.47	7	0	7	3.74	39	18	21	3.93	2	1	1	0.82
70NL	13610954	Meso	0	1	-1	1.41	0	0	0	0.00	0	3	-3	2.45	0	0	0	0.00
70NR	13610955	Meso	44	28	16	2.67	1	0	1	1.41	53	25	28	4.48	0	2	-2	2.00
70WT	13610956	Meso	64	80	-16	1.89	2	5	-3	1.60	44	111	-67	7.61	0	1	-1	1.41
70WL	13610957	Meso	241	188	53	3.62	8	3	5	2.13	202	218	-16	1.10	7	5	2	0.82
21SR	13611251	Meso	28	34	-6	1.08	0	0	0	0.00	19	55	-36	5.92	0	0	0	0.00
45ET	13611806	Micro	1120	1166	-46	1.36	90	92	-2	0.21	1066	1040	26	0.80	91	104	-13	1.32
45EL	13612038	Micro	116	115	1	0.09	2	9	-7	2.98	93	151	-58	5.25	2	12	-10	3.78
43WT	13612111	Micro	1476	1573	-97	2.48	119	156	-37	3.16	1599	1467	132	3.37	117	126	-9	0.82
61NR	13613542	Micro	0	0	0	0.00	0	2	-2	2.00	0	1	-1	1.41	0	0	0	0.00

Turn Name	Aimsun ID	Area	PM Peak															
			1630-1730								1730-1830							
			LV				HV				LV				HV			
			Modelled	Observed	Difference	GEH	Modelled	Observed	Difference	GEH	Modelled	Observed	Difference	GEH	Modelled	Observed	Difference	GEH
30ST	61436	Meso	95	73	22	2.40	0	1	-1	1.41	87	70	17	1.92	1	0	1	1.41
30ER	61437	Meso	403	395	8	0.40	8	18	-10	2.77	398	398	0	0.00	10	17	-7	1.91
30NT	61438	Meso	81	100	-19	2.00	0	0	0	0.00	79	82	-3	0.33	1	0	1	1.41
30EL	61439	Meso	100	64	36	3.98	3	1	2	1.41	99	68	31	3.39	0	0	0	0.00
30NL	61440	Meso	370	295	75	4.11	7	10	-3	1.03	343	355	-12	0.64	13	10	3	0.88
30SR	61441	Meso	150	155	-5	0.40	0	0	0	0.00	136	88	48	4.54	1	0	1	1.41
29WT	61459	Meso	439	380	59	2.92	4	13	-9	3.09	467	459	8	0.37	6	12	-6	2.00
29NL	61460	Meso	27	25	2	0.39	0	0	0	0.00	23	27	-4	0.80	0	0	0	0.00
29SR	61461	Meso	172	188	-16	1.19	0	8	-8	4.00	133	165	-32	2.62	0	4	-4	2.83
29WL	61462	Meso	12	17	-5	1.31	0	0	0	0.00	14	23	-9	2.09	0	0	0	0.00
29ER	61463	Meso	24	14	10	2.29	0	0	0	0.00	23	27	-4	0.80	0	0	0	0.00
29ST	61464	Meso	108	154	-46	4.02	0	0	0	0.00	128	152	-24	2.03	0	2	-2	2.00
29WR	61465	Meso	34	65	-31	4.41	0	0	0	0.00	40	52	-12	1.77	0	0	0	0.00
29EL	61466	Meso	239	237	2	0.13	0	1	-1	1.41	276	205	71	4.58	3	1	2	1.41
29NT	61467	Meso	125	191	-66	5.25	0	0	0	0.00	133	136	-3	0.26	0	0	0	0.00
31WR	69795	Micro	397	416	-19	0.94	0	3	-3	2.45	392	378	14	0.71	0	2	-2	2.00
31SR	69796	Micro	427	432	-5	0.24	4	9	-5	1.96	448	429	19	0.91	9	3	6	2.45
31WT	69797	Micro	1225	1221	4	0.11	44	43	1	0.15	1266	1258	8	0.23	41	29	12	2.03
76ET	69812	Micro	1429	1313	116	3.13	60	58	2	0.26	1485	1554	-69	1.77	53	37	16	2.39
76NR	69813	Micro	115	147	-32	2.80	4	8	-4	1.63	121	121	0	0.00	6	2	4	2.00
76WT	69814	Micro	1514	1487	27	0.70	45	46	-1	0.15	1554	1570	-16	0.40	39	33	6	1.00
76NL	69815	Micro	142	138	4	0.34	1	1	0	0.00	145	132	13	1.10	1	0	1	1.41
76WL	69816	Micro	72	58	14	1.74	0	4	-4	2.83	79	68	11	1.28	0	0	0	0.00
76ER	69817	Micro	195	261	-66	4.37	0	3	-3	2.45	225	216	9	0.61	0	4	-4	2.83
56WT	70256	Meso	302	270	32	1.89	7	8	-1	0.37	335	317	18	1.00	14	8	6	1.81
56NL	70257	Meso	106	65	41	4.43	0	2	-2	2.00	75	70	5	0.59	0	1	-1	1.41
56SR	70258	Meso	46	54	-8	1.13	0	0	0	0.00	36	54	-18	2.68	0	0	0	0.00
56ET	70259	Meso	332	391	-59	3.10	4	14	-10	3.33	343	372	-29	1.53	3	15	-12	4.00
56NR	70260	Meso	61	58	3	0.39	0	0	0	0.00	60	48	12	1.63	0	0	0	0.00
56SL	70261	Meso	108	86	22	2.23	0	1	-1	1.41	128	84	44	4.27	0	1	-1	1.41
56ER	70262	Meso	85	41	44	5.54	0	3	-3	2.45	84	31	53	6.99	0	3	-3	2.45
56WL	70263	Meso	55	62	-7	0.92	0	0	0	0.00	66	70	-4	0.49	0	0	0	0.00
56ST	70264	Meso	114	152	-38	3.30	0	3	-3	2.45	140	119	21	1.85	0	2	-2	2.00
56EL	70265	Meso	70	76	-6	0.70	4	3	1	0.53	55	72	-17	2.13	8	0	8	4.00
56WR	70266	Meso	22	25	-3	0.62	1	0	1	1.41	41	35	6	0.97	1	0	1	1.41
56NT	70267	Meso	165	179	-14	1.07	0	5	-5	3.16	165	175	-10	0.77	0	2	-2	2.00
28NL	71068	Meso	30	17	13	2.68	0	1	-1	1.41	27	18	9	1.90	0	0	0	0.00
28SR	71069	Meso	69	75	-6	0.71	0	3	-3	2.45	86	98	-12	1.25	0	1	-1	1.41
28WT	71070	Meso	387	372	15	0.77	4	9	-5	1.96	407	400	7	0.35	6	11	-5	1.71
28ST	71071	Meso	431	425	6	0.29	3	9	-6	2.45	434	424	10	0.48	7	3	4	1.79
28WL	71072	Meso	156	142	14	1.15	3	1	2	1.41	121	141	-20	1.75	8	0	8	4.00
28EL	71073	Meso	119	108	11	1.03	3	7	-4	1.79	128	119	9	0.81	3	7	-4	1.79
28NT	71074	Meso	456	543	-87	3.89	2	11	-9	3.53	474	536	-62	2.76	5	9	-4	1.51
28WR	71075	Meso	184	154	30	2.31	0	1	-1	1.41	155	123	32	2.71	0	0	0	0.00
28ET	71076	Meso	417	458	-41	1.96	11	20	-9	2.29	449	484	-35	1.62	9	17	-8	2.22
28NR	71077	Meso	80	75	5	0.57	0	1	-1	1.41	66	61	5	0.63	1	1	0	0.00
28SL	71078	Meso	169	202	-33	2.42	0	1	-1	1.41	176	187	-11	0.82	0	0	0	0.00
39WT	71093	Micro	1319	1385	-66	1.79	46	43	3	0.45	1415	1388	27	0.72	48	28	20	3.24
39NL	71094	Micro	116	137	-21	1.87	5	2	3	1.60	116	94	22	2.15	0	2	-2	2.00
39ET	71095	Micro	2161	2048	113	2.46	78	86	-8	0.88	2236	2173	63	1.34	80	63	17	2.01
39EL	71097	Micro	219	243	-24	1.58	11	4	7	2.56	224	282	-58	3.65	10	3	7	2.75
41ET	71099	Meso	670	661	9	0.35	17	20	-3	0.70	691	613	78	3.05	20	13	7	1.72
41SL	71100	Meso	83	82	1	0.11	2	1	1	0.82	94	108	-14	1.39	0	2	-2	2.00
41WT	71101	Meso	481	495	-14	0.63	3	0	3	2.45	459	466	-7	0.33	10	4	6	2.27
41NL	71102	Meso	0	51	-51	10.10	0	7	-7	3.74	0	52	-52	10.20	0	4	-4	2.83
41EL	71104	Meso	17	54	-37	6.21	8	4	4	1.63	24	64	-40	6.03	4	3	1	0.53
41NT	71105	Meso	1210	1131	79	2.31	15	17	-2	0.50	1206	1125	81	2.37	16	13	3	0.79
41WL	71106	Meso	78	77	1	0.11	3	1	2	1.41	63	62	1	0.13	0	0	0	0.00
41ST	71108	Meso	626	631	-5	0.20	2	14	-12	4.24	601	611	-10	0.41	6	2	4	2.00
1NT	73126	Meso	195	264	-69	4.55	0	11	-11	4.69	201	280	-79	5.09	0	13	-13	5.10
1EL	73127	Meso	64	53	11	1.44	0	6	-6	3.46	64	74	-10	1.20	6	5	1	0.43
1SL	73128	Meso	283	262	21	1.27	3	3	0	0.00	293	270	23	1.37	4	3	1	0.53
1ET	73129	Meso	2189	2223	-34	0.72	88	76	12	1.33	2301	2211	90	1.89	88	78	10	1.10
1ST	73130	Meso	247	233	14	0.90	0	9	-9	4.24	272	205	67	4.34	0	7	-7	3.74
1ER	73132	Meso	116	128	-12	1.09	0	5	-5	3.16	122	136	-14	1.23	0	6	-6	3.46
1NL	73134	Meso	125	80	45	4.44	0	7	-7	3.74	138	99	39	3.58	0	3	-3	2.45
23EL	73152	Meso	614	576	38	1.56	32	24	8	1.51	611	612	-1	0.04	26	20	6	1.25
23NT	73153	Meso	2120	2120	0	0.00	78	82	-4	0.45	2271	2251	20	0.42	68	66	2	0.24
23SR	73154	Meso	898	932	-34	1.12	14	24	-10	2.29	957	985	-28	0.90	10	24	-14	3.40
23NL	73155	Meso	28	48	-20	3.24	0	2	-2	2.00	48	45	3	0.44	0	0	0	0.00
23ST	73156	Meso	2259	2328	-69	1.44	88	88	0	0.00	2383	2372	11	0.23	91	97	-6	0.62
3NL	73175	Meso	62	97	-35	3.93	2	6	-4	2.00	59	103	-44	4.89	3	3	0	0.00
3WT	73176	Meso	2022	1895	127	2.87	64	80	-16	1.89	2027	2058	-31	0.69	63	57	6	0.77
3NR	73177	Meso	58	173	-115	10.70	0	3	-3	2.45	62	129	-67	6.86	0	7	-7	3.74
3ET	73178	Meso	1866	1715	151	3.57	57	69	-12	1.51	2012	2000	12	0.27	55	46	9	1.27
3SL	73179	Meso	139	160	-21	1.72	4	11	-7	2.56	147	172	-25	1.98	0	14	-14	5.29
3NT	73180	Meso	298	269	29	1.72	0	7	-7	3.74	316	277	39	2.26	3	3	0	0.00
42ET	73195	Meso	69	182	-113	10.09	0	1	-1	1.41	75	182	-107	9.44	0	0	0	0.00
42SL	73196	Meso	71	63	8	0.98	0	0	0	0.00	66	49	17	2.24	0	0	0	0.00
42WL	73197	Meso	33	14	19	3.92	0	0	0	0.00	34	28	6	1.08	0	0	0	0.00
42ER	73198	Meso	10	19	-9	2.36	0	0	0	0.00	6	15	-9	2.78	0	0	0	0.00
42ST	73199	Meso	301	307	-6	0.34	1	3	-2	1.41	305	308	-3	0.17	0	3	-3	2.45
42WT	73200	Meso	47	102	-55	6.37	0	1	-1	1.41	48	144	-96	9.80	0	1	-1	1.41
42NL	73201	Meso	63	25	38	5.73	2	0	2	2.00	63	22	41	6.29	2	0	2	2.00
42SR	73202	Meso	236	248	-12	0.77	5	11	-6	2.12	231	222	9	0.60	5	13	-8	2.67
42WR	73203	Meso	66	21	45	6.82	1	0	1	1.41	56	14	42	7.10	1	1	0	0.00
42NT	73204	Meso	276	322	-46	2.66	4	4	0	0.00	273	322	-49	2.84	2	7	-5	2.36
42EL	73205	Meso	76	58	18	2.20	0	0	0	0.00	61	47	14	1.91	1	0	1	1.41
63EL	73214	Meso	247	254	-7	0.44	6	3	3	1.41	234	269	-35	2.21	4	7	-3	1.28
63WR	73215	Meso	24	55	-31	4.93	0	1	-1	1.41	24	34	-10	1.86	0	1	-1	1.41
63SR	73216	Meso	242	245	-3	0.19	1	4	-3	1.90	232	278	-46	2.88	0	2	-2	2.00
63WT	73217	Meso	300	294	6	0.35	2	11	-9	3.53	325	322	3	0.17	3	14	-11	3.77
63SL	73218	Meso	48	49	-1	0.14	0	0	0	0.00	60	55	5	0.66	0	0	0	0.00
63ET	73219	Meso	442	332	110	5.59	0	13	-13	5.10	458	348	110	5.48	9	15	-6	1.73
35SR	73221	Meso	42	35	7	1.13	0	0	0	0.00	31	29	2	0.37	0	0	0	0.00
35EL	73223	Meso	12	80	-68	10.03	0	1	-1	1.41	19	53	-34	5.67	0	0	0	0.00
35NT	73224	Meso	335	200	135	8.25	0	3	-3	2.45	341	193	148	9.06	7	3	4	1.79
35ER	73225	Meso	134	123	11	0.97	1	9	-8	3.58	140	173	-33	2.64	0	14	-14	5.29
35ST	73226	Meso	277	251	26	1.60	1	3	-2	1.41	283	322	-39	2.24	3	2	1	0.63
11ET	73238	Meso	516	488	28	1.25	6	13	-7	2.27	515	472	43	1.94	4	6	-2	0.89
11SL	73239	Meso	102	142	-40	3.62	4	14	-10	3.33	96	140	-44	4.05	3	16	-13	4.22
11NR	73240	Meso	39	50	-11	1.65	0	2	-2	2.00	74	43	31	4.05	0	2	-2	2.00
11WT	73241	Meso	477	445	32	1.49	1	10	-9	3.84	457	486	-29	1.34	0	7	-7	3.74
11SR	73242	Meso	43	57	-14	1.98	0	0	0	0.00	62	54	8	1.05	0	1	-1	1.41
11NL	73243	Meso	73	38	35	4.70	0	1	-1	1.41	65	50	15	1.98	0	0	0	0.00
11WR	73244	Meso	119	121	-2	0.18	6	10	-4	1.41	135	128	7	0.61	2	6	-4	2.00
11EL	73245	Meso	145	186	-41	3.19	8	4	4	1.63	163	166	-3	0.23	6	1	5	2.67
11NT	73246	Meso	172	169	3	0.23	7	17	-10	2.89	173	202	-29	2.12	15	15	0	0.00
11WL	73247	Meso	77	74	3	0.35	0	1	-1	1.41	67	92	-25	2.80	0	5	-5	3.16

11ER	73248	Meso	48	36	12	1.85	0	0	0	0.00	52	46	6	0.86	0	0	0	0.00
11ST	73249	Meso	143	157	-14	1.14	3	15	-12	4.00	142	171	-29	2.32	3	20	-17	5.01
13ET	73258	Meso	350	366	-16	0.85	2	4	-2	1.15	381	334	47	2.49	5	0	5	3.16
13SL	73259	Meso	58	106	-48	5.30	0	3	-3	2.45	67	79	-12	1.40	1	1	0	0.00
13NR	73260	Meso	300	259	41	2.45	11	8	3	0.97	293	248	45	2.74	4	5	-1	0.47
13WT	73261	Meso	386	387	-1	0.05	0	4	-4	2.83	383	383	0	0.00	0	1	-1	1.41
13SR	73262	Meso	51	65	-14	1.84	0	0	0	0.00	71	53	18	2.29	0	0	0	0.00
13NL	73263	Meso	62	25	37	5.61	0	0	0	0.00	49	36	13	1.99	0	0	0	0.00
13WL	73264	Meso	205	192	13	0.92	1	6	-5	2.67	199	194	5	0.36	0	7	-7	3.74
13ER	73265	Meso	40	36	4	0.65	0	0	0	0.00	26	31	-5	0.94	0	0	0	0.00
13ST	73266	Meso	146	203	-57	4.31	3	2	1	0.63	173	208	-35	2.54	2	1	1	0.82
7NL	73268	Meso	48	44	4	0.59	0	2	-2	2.00	48	48	0	0.00	2	1	1	0.82
7SR	73269	Meso	106	119	-13	1.23	0	7	-7	3.74	83	122	-39	3.85	0	4	-4	2.83
7ER	73270	Meso	182	184	-2	0.15	0	2	-2	2.00	183	191	-8	0.59	3	3	0	0.00
7ST	73271	Meso	371	346	25	1.32	7	3	4	1.79	385	393	-8	0.41	6	3	3	1.41
7EL	73272	Meso	155	161	-6	0.48	0	9	-9	4.24	167	158	9	0.71	0	6	-6	3.46
7NT	73273	Meso	266	198	68	4.46	10	1	9	3.84	256	216	40	2.60	0	0	0	0.00
5SL	73275	Meso	9	23	-14	3.50	0	0	0	0.00	11	31	-20	4.36	0	2	-2	2.00
5NR	73276	Meso	10	32	-22	4.80	0	0	0	0.00	7	34	-27	5.96	0	0	0	0.00
5ET	73277	Meso	325	310	15	0.84	0	12	-12	4.90	330	295	35	1.98	3	8	-5	2.13
5NT	73279	Meso	92	160	-68	6.06	0	0	0	0.00	95	128	-33	3.13	0	0	0	0.00
5EL	73280	Meso	71	42	29	3.86	0	1	-1	1.41	61	64	-3	0.38	0	0	0	0.00
5WL	73281	Meso	8	27	-19	4.54	0	0	0	0.00	10	33	-23	4.96	0	1	-1	1.41
5ST	73282	Meso	113	95	18	1.77	0	2	-2	2.00	87	62	25	2.90	0	0	0	0.00
5ER	73283	Meso	4	107	-103	13.83	0	11	-11	4.69	11	119	-108	13.40	0	13	-13	5.10
5WT	73284	Meso	146	139	7	0.59	0	11	-11	4.69	125	150	-25	2.13	2	4	-2	1.15
5SR	73285	Meso	24	29	-5	0.97	0	1	-1	1.41	27	40	-13	2.25	0	2	-2	2.00
16NT	73288	Meso	479	467	12	0.55	1	5	-4	2.31	467	463	4	0.19	1	0	1	1.41
16EL	73289	Meso	67	96	-29	3.21	0	1	-1	1.41	57	84	-27	3.22	1	0	1	1.41
16WR	73290	Meso	26	19	7	1.48	2	0	2	2.00	28	23	5	0.99	0	0	0	0.00
16ST	73291	Meso	403	367	36	1.83	4	4	0	0.00	454	389	65	3.17	5	2	3	1.60
16ER	73292	Meso	101	87	14	1.44	1	0	1	1.41	108	102	6	0.59	0	0	0	0.00
16WL	73293	Meso	65	61	4	0.50	1	1	0	0.00	70	91	-21	2.34	2	1	1	0.82
16SR	73294	Meso	156	178	-22	1.70	0	1	-1	1.41	155	184	-29	2.23	0	0	0	0.00
16NL	73295	Meso	91	89	2	0.21	0	1	-1	1.41	125	118	7	0.64	1	0	1	1.41
16WT	73296	Meso	149	223	-74	5.43	3	11	-8	3.02	115	232	-117	8.88	6	9	-3	1.10
16SL	73297	Meso	4	75	-71	11.30	0	2	-2	2.00	5	87	-82	12.09	0	0	0	0.00
16NR	73298	Meso	109	119	-10	0.94	0	3	-3	2.45	112	142	-30	2.66	0	1	-1	1.41
16ET	73299	Meso	297	361	-64	3.53	0	21	-21	6.48	289	395	-106	5.73	3	20	-17	5.01
15WL	73301	Meso	180	150	30	2.34	0	1	-1	1.41	179	160	19	1.46	0	0	0	0.00
15ST	73302	Meso	404	470	-66	3.16	4	6	-2	0.89	449	492	-43	1.98	5	2	3	1.60
15NR	73303	Meso	75	128	-53	5.26	0	1	-1	1.41	62	124	-62	6.43	1	0	1	1.41
15SL	73304	Meso	212	170	42	3.04	2	3	-1	0.63	242	164	78	5.47	6	1	5	2.67
15NT	73305	Meso	428	438	-10	0.48	2	5	-3	1.60	421	443	-22	1.06	0	0	0	0.00
15WR	73306	Meso	90	112	-22	2.19	0	1	-1	1.41	110	112	-2	0.19	0	0	0	0.00
6NR	73315	Meso	34	43	-9	1.45	0	1	-1	1.41	32	35	-3	0.52	0	0	0	0.00
6SL	73316	Meso	87	84	3	0.32	0	0	0	0.00	85	90	-5	0.53	0	0	0	0.00
6ET	73317	Meso	281	312	-31	1.80	2	1	1	0.82	312	282	30	1.74	4	3	1	0.53
6WL	73318	Meso	72	56	16	2.00	0	0	0	0.00	55	47	8	1.12	0	0	0	0.00
6ST	73319	Meso	75	70	5	0.59	0	0	0	0.00	66	81	-15	1.75	0	1	-1	1.41
6ER	73320	Meso	2	14	-12	4.24	0	0	0	0.00	3	7	-4	1.79	0	0	0	0.00
6WR	73321	Meso	19	5	14	4.04	0	0	0	0.00	34	21	13	2.48	0	0	0	0.00
6NT	73322	Meso	128	134	-6	0.52	0	1	-1	1.41	125	142	-17	1.47	0	2	-2	2.00
6EL	73323	Meso	25	19	6	1.28	0	0	0	0.00	30	33	-3	0.53	0	1	-1	1.41
6WT	73324	Meso	407	373	34	1.72	1	1	0	0.00	423	484	-61	2.86	0	2	-2	2.00
6NL	73325	Meso	0	10	-10	4.47	0	0	0	0.00	0	9	-9	4.24	0	0	0	0.00
6SR	73326	Meso	3	8	-5	2.13	0	0	0	0.00	9	12	-3	0.93	0	0	0	0.00
18ST	73344	Meso	514	475	39	1.75	6	2	4	2.00	522	522	0	0.00	10	2	8	3.27
18WL	73345	Meso	37	29	8	1.39	0	1	-1	1.41	45	24	21	3.58	0	1	-1	1.41
18NT	73346	Meso	642	603	39	1.56	0	8	-8	4.00	667	635	32	1.25	3	2	1	0.63
18WR	73347	Meso	21	13	8	1.94	0	0	0	0.00	19	18	1	0.23	0	0	0	0.00
18NR	73348	Meso	113	100	13	1.26	0	0	0	0.00	126	112	14	1.28	0	0	0	0.00
18SL	73349	Meso	54	52	2	0.27	0	2	-2	2.00	71	90	-19	2.12	0	1	-1	1.41
75SL	73351	Meso	5	10	-5	1.83	0	0	0	0.00	9	15	-6	1.73	0	0	0	0.00
75ET	73352	Meso	688	702	-14	0.53	25	20	5	1.05	700	670	30	1.15	24	17	7	1.55
75EL	73354	Meso	74	57	17	2.10	0	1	-1	1.41	51	50	1	0.14	0	0	0	0.00
75WT	73355	Meso	476	534	-58	2.58	3	8	-5	2.13	461	517	-56	2.53	10	10	0	0.00
75SR	73356	Meso	2	3	-1	0.63	7	0	7	3.74	3	4	-1	0.53	4	0	4	2.83
22ET	73381	Meso	701	723	-22	0.82	2	11	-9	3.53	771	764	7	0.25	13	11	2	0.58
22SL	73382	Meso	211	237	-26	1.74	6	12	-6	2.00	250	275	-25	1.54	9	20	-11	2.89
22WT	73383	Meso	458	530	-72	3.24	4	6	-2	0.89	501	429	72	3.34	6	2	4	2.00
22NL	73384	Meso	58	58	0	0.00	1	1	0	0.00	65	52	13	1.70	1	0	1	1.41
22NT	73385	Meso	306	292	14	0.81	4	4	0	0.00	318	294	24	1.37	7	3	4	1.79
22WL	73386	Meso	83	64	19	2.22	1	0	1	1.41	86	67	19	2.17	0	0	0	0.00
22ER	73387	Meso	105	108	-3	0.29	1	1	0	0.00	108	119	-11	1.03	0	0	0	0.00
22ST	73388	Meso	349	388	-39	2.03	4	2	2	1.15	411	417	-6	0.29	1	1	0	0.00
67NR	73421	Micro	158	183	-25	1.91	0	3	-3	2.45	145	166	-21	1.68	0	3	-3	2.45
67ET	73422	Micro	1566	1589	-23	0.58	91	114	-23	2.27	1648	1658	-10	0.25	98	105	-7	0.69
67WL	73423	Micro	37	45	-8	1.25	6	2	4	2.00	34	45	-11	1.75	3	0	3	2.45
67ER	73424	Micro	207	227	-20	1.36	9	22	-13	3.30	213	236	-23	1.54	4	23	-19	5.17
67WT	73425	Micro	1140	1268	-128	3.69	53	63	-10	1.31	1191	1293	-102	2.89	69	58	11	1.38
67NL	73426	Micro	293	360	-67	3.71	0	16	-16	5.66	317	370	-53	2.86	2	14	-12	4.24
66WT	73434	Micro	943	934	9	0.29	53	53	0	0.00	1023	971	52	1.65	59	46	13	1.79
66NL	73435	Micro	154	79	75	6.95	6	2	4	2.00	124	111	13	1.20	11	1	10	4.08
66ET	73436	Micro	1486	1443	43	1.12	82	79	3	0.33	1554	1450	104	2.68	89	83	6	0.65
66NR	73437	Micro	106	199	-93	7.53	0	3	-3	2.45	112	196	-84	6.77	0	1	-1	1.41
66ER	73438	Micro	204	202	2	0.14	10	0	10	4.47	235	240	-5	0.32	12	0	12	4.90
66WL	73439	Micro	95	133	-38	3.56	0	1	-1	1.41	100	132	-32	2.97	0	0	0	0.00
78NL	73441	Meso	19	36	-17	3.24	9	0	9	4.24	19	41	-22	4.02	7	0	7	3.74
78SR	73442	Meso	62	73	-11	1.34	0	9	-9	4.24	44	68	-24	3.21	1	7	-6	3.00
78WT	73443	Meso	973	992	-19	0.61	44	47	-3	0.44	1054	1028	26	0.81	53	42	11	1.60
78ST	73444	Meso	175	183	-8	0.60	3	0	3	2.45	194	165	29	2.16	0	1	-1	1.41
78WL	73445	Meso	23	29	-6	1.18	3	0	3	2.45	25	19	6	1.28	0	0	0	0.00
78EL	73446	Meso	122	138	-16	1.40	0	10	-10	4.47	124	160	-36	3.02	0	11	-11	4.69
78NT	73447	Meso	127	107	20	1.85	0	0	0	0.00	136	130	6	0.52	1	0	1	1.41
78WR	73448	Meso	194	146	48	3.68	5	5	0	0.00	149	165	-16	1.28	19	0	19	6.16
78ET	73449	Meso	1482	1512	-30	0.78	82	84	-2	0.22	1557	1482	75	1.92	91	72	19	2.10
78NR	73450	Meso	0	14	-14	5.29	0	0	0	0.00	0	8	-8	4.00	0	1	-1	1.41
78SL	73451	Meso	207	130	77	5.93	2	3	-1	0.63	192	129	63	4.97	3	2	1	0.63
24WL	73460	Meso	60	67	-7	0.88	1	2	-1	0.82	82	74	8	0.91	2	2	0	0.00
24ER	73461	Meso	261	260	1	0.06	2	11	-9	3.53	285	291	-6	0.35	2	14	-12	4.24
24ST	73462	Meso	146	143	3	0.25	1	1	0	0.00	159	169	-10	0.78	0	0	0	0.00
24ET	73463	Meso	515	489	26	1.16	3	10	-7	2.75	575	497	78	3.37	13	6	7	2.27
24SL	73464	Meso	27	15	12	2.62	0	1	-1	1.41	40	31	9	1.51	0	0	0	0.00
24NL	73465	Meso	175	135	40	3.21	0	5	-5	3.16	195	161	34	2.55	0	5	-5	3.16
24WT	73466	Meso	275	274	1	0.06	2	2	0	0.00	268	253	15	0.93	5	1	4	2.31
24SR	73467	Meso	43	71	-28	3.71	0	0	0	0.00	63	62	1	0.13	0	0	0	0.00
24NT	73468	Meso	225	227	-2	0.13	7	0	7	3.74	220	222	-2	0.13	13	0	13	5.10
24EL	73469	Meso	114	91	23	2.27	3	1	2	1.41	124	114	10	0.92	1	1	0	0.00
64WL	73471	Micro	310	298	12	0.69	2	4	-2	1.15	329	340	-11	0.60	5	4	1	0.47
64NL	73472	Micro	1	18	-17	5.52	0	0	0	0.00	0	17	-17	5.83	0	0	0	0.00
64WT	73473	Micro	1085	1033	52	1.60	40	49	-9	1.35	1161	1163	-2	0.06	56	41	15	2.15
64NR	73474	Micro	493	475	18	0.82	2	11	-9	3.53	533	475	58	2.58	11	8	3	0.97

64ET	73475	Micro	1740	1692	48	1.16	85	88	-3	0.32	1757	1731	26	0.62	94	76	18	1.95
61NL	73477	Micro	118	75	43	4.38	3	2	1	0.63	145	107	38	3.39	0	0	0	0.00
61WT	73478	Micro	1171	1166	5	0.15	43	54	-11	1.58	1248	1228	20	0.57	63	44	19	2.60
61SR	73479	Micro	21	10	11	2.79	2	0	2	2.00	25	14	11	2.49	3	0	3	2.45
61ER	73480	Micro	247	255	-8	0.50	2	5	-3	1.60	252	285	-33	2.01	6	2	4	2.00
61WL	73481	Micro	60	44	16	2.22	1	1	0	0.00	59	38	21	3.02	0	1	-1	1.41
61ST	73482	Micro	319	343	-24	1.32	3	3	0	0.00	351	343	8	0.43	5	1	4	2.31
61ET	73483	Micro	1700	1580	120	2.96	82	103	-21	2.18	1731	1645	86	2.09	93	79	14	1.51
61SL	73484	Micro	70	17	53	8.04	0	1	-1	1.41	83	18	65	9.15	0	1	-1	1.41
61EL	73485	Micro	88	69	19	2.14	1	1	0	0.00	103	51	52	5.93	0	1	-1	1.41
61NT	73486	Micro	331	330	1	0.06	0	3	-3	2.45	336	344	-8	0.43	0	1	-1	1.41
46WL	73488	Micro	36	54	-18	2.68	0	1	-1	1.41	37	42	-5	0.80	0	0	0	0.00
46NR	73489	Micro	135	115	20	1.79	0	0	0	0.00	139	116	23	2.04	0	0	0	0.00
46ET	73490	Micro	1842	1863	-21	0.49	81	102	-21	2.20	1932	1954	-22	0.50	91	84	7	0.75
46NL	73491	Micro	22	22	0	0.00	1	0	1	1.41	23	24	-1	0.21	1	0	1	1.41
46WT	73492	Micro	1145	1100	45	1.34	40	50	-10	1.49	1211	1230	-19	0.54	56	42	14	2.00
45WL	73494	Micro	39	44	-5	0.78	0	3	-3	2.45	26	48	-22	3.62	0	1	-1	1.41
45ST	73495	Micro	135	150	-15	1.26	3	1	2	1.41	156	162	-6	0.48	2	0	2	2.00
45WT	73496	Micro	1088	1032	56	1.72	29	51	-22	3.48	1170	1176	-6	0.18	50	43	7	1.03
45SR	73497	Micro	123	97	26	2.48	11	1	10	4.08	103	104	-1	0.10	8	1	7	3.30
45SL	73499	Micro	265	224	41	2.62	2	9	-7	2.98	253	270	-17	1.05	7	10	-3	1.03
45WR	73501	Micro	216	207	9	0.62	12	2	10	3.78	254	240	14	0.89	5	2	3	1.60
47ET	73503	Micro	1973	1830	143	3.28	73	74	-1	0.12	1948	1727	221	5.16	74	70	4	0.47
47WT	73504	Micro	977	982	-5	0.16	28	37	-9	1.58	1017	812	205	6.78	30	25	5	0.95
44SL	73506	Micro	334	328	6	0.33	17	11	6	1.60	414	331	83	4.30	16	8	8	2.31
44ET	73507	Micro	1940	1981	-41	0.93	72	83	-11	1.25	1944	2054	-110	2.46	73	48	25	3.21
44NR	73508	Micro	111	62	49	5.27	0	0	0	0.00	103	73	30	3.20	1	1	0	0.00
44WR	73509	Micro	270	323	-53	3.08	19	14	5	1.23	323	304	19	1.07	16	6	10	3.02
44EL	73510	Micro	8	18	-10	2.77	0	6	-6	3.46	11	21	-10	2.50	0	5	-5	3.16
44NT	73511	Micro	264	267	-3	0.18	0	0	0	0.00	284	277	7	0.42	0	2	-2	2.00
44WT	73512	Micro	1041	1054	-13	0.40	28	32	-4	0.73	1081	1041	40	1.23	32	19	13	2.57
44NL	73513	Micro	9	20	-11	2.89	0	0	0	0.00	11	10	1	0.31	0	0	0	0.00
44WL	73514	Micro	92	90	2	0.21	1	1	0	0.00	136	86	50	4.75	3	1	2	1.41
44ST	73515	Micro	225	243	-18	1.18	0	2	-2	2.00	263	252	11	0.69	0	2	-2	2.00
34ST	73517	Meso	530	517	13	0.57	2	14	-12	4.24	528	533	-5	0.22	5	4	1	0.47
34NT	73518	Meso	698	684	14	0.53	5	14	-9	2.92	714	667	47	1.79	8	11	-3	0.97
52NT	73533	Meso	573	612	-39	1.60	22	20	2	0.44	624	601	23	0.93	28	14	14	3.06
43ER	73536	Micro	264	321	-57	3.33	9	32	-23	5.08	309	357	-48	2.63	12	34	-22	4.59
43WL	73537	Micro	75	55	20	2.48	4	0	4	2.83	78	61	17	2.04	1	2	-1	0.82
43NL	73538	Micro	274	245	29	1.80	18	24	-6	1.31	310	248	62	3.71	23	20	3	0.65
43NR	73540	Micro	101	134	-33	3.04	8	5	3	1.18	102	138	-36	3.29	3	7	-4	1.79
43ET	73541	Micro	1741	1653	88	2.14	67	78	-11	1.29	1783	1757	26	0.62	82	52	30	3.67
50ST	73543	Meso	948	923	25	0.82	10	12	-2	0.60	949	970	-21	0.68	12	8	4	1.26
50WL	73544	Meso	153	127	26	2.20	7	8	-1	0.37	123	139	-16	1.40	5	7	-2	0.82
50NT	73546	Meso	925	933	-8	0.26	16	8	8	2.31	953	859	94	3.12	8	2	6	2.68
50EL	73547	Meso	37	22	15	2.76	0	0	0	0.00	42	23	19	3.33	2	0	2	2.00
50NR	73548	Meso	221	219	2	0.13	2	10	-8	3.27	193	197	-4	0.29	2	12	-10	3.78
50SL	73549	Meso	41	32	9	1.49	0	0	0	0.00	38	38	0	0.00	1	0	1	1.41
50ET	73550	Meso	159	159	0	0.00	0	0	0	0.00	176	149	27	2.12	0	0	0	0.00
50NL	73551	Meso	21	37	-16	2.97	0	0	0	0.00	23	45	-22	3.77	0	1	-1	1.41
50WT	73553	Meso	99	152	-53	4.73	0	0	0	0.00	92	176	-84	7.26	0	0	0	0.00
49EL	73555	Meso	555	559	-4	0.17	2	7	-5	2.36	541	476	65	2.88	2	6	-4	2.00
49NTR	73556	Meso	612	642	-30	1.20	16	12	4	1.07	642	658	-16	0.63	8	10	-2	0.67
49SR	73557	Meso	296	309	-13	0.75	1	7	-6	3.00	305	326	-21	1.18	0	3	-3	2.45
49NL	73558	Meso	62	72	-10	1.22	0	0	0	0.00	77	83	-6	0.67	0	0	0	0.00
49STL	73559	Meso	806	775	31	1.10	16	15	1	0.25	775	815	-40	1.42	16	12	4	1.07
49ETR	73560	Meso	85	102	-17	1.76	0	0	0	0.00	86	126	-40	3.89	0	1	-1	1.41
73NR	73648	Meso	529	545	-16	0.69	2	6	-4	2.00	502	505	-3	0.13	2	5	-3	1.60
73ET	73649	Meso	64	71	-7	0.85	0	0	0	0.00	76	82	-6	0.68	0	0	0	0.00
73WL	73650	Meso	273	287	-14	0.84	1	6	-5	2.67	284	337	-53	3.01	0	3	-3	2.45
73ER	73651	Meso	112	118	-6	0.56	1	1	0	0.00	116	133	-17	1.52	0	2	-2	2.00
73WT	73652	Meso	69	76	-7	0.82	0	1	-1	1.41	91	84	7	0.75	0	0	0	0.00
73NL	73653	Meso	70	38	32	4.35	0	0	0	0.00	73	46	27	3.50	0	0	0	0.00
58WT	73665	Meso	514	556	-42	1.82	3	5	-2	1.00	526	603	-77	3.24	3	7	-4	1.79
58NL	73666	Meso	336	326	10	0.55	0	4	-4	2.83	320	333	-13	0.72	0	1	-1	1.41
58ET	73667	Meso	829	861	-32	1.10	25	25	0	0.00	809	738	71	2.55	28	19	9	1.86
58NR	73668	Meso	207	249	-42	2.78	0	1	-1	1.41	216	251	-35	2.29	0	3	-3	2.45
58ER	73669	Meso	358	357	1	0.05	7	8	-1	0.37	357	375	-18	0.94	9	4	5	1.96
58WL	73670	Meso	123	74	49	4.94	1	0	1	1.41	148	85	63	5.84	0	0	0	0.00
55EL	73684	Meso	151	119	32	2.75	0	0	0	0.00	138	118	20	1.77	0	2	-2	2.00
55ET	73686	Meso	891	973	-82	2.69	25	24	1	0.20	888	842	46	1.56	28	23	5	0.99
55SL	73687	Meso	37	56	-19	2.79	0	0	0	0.00	42	74	-32	4.20	3	1	2	1.41
51ST	73689	Meso	358	374	-16	0.84	4	2	2	1.15	371	398	-27	1.38	1	3	-2	1.41
51WL	73690	Meso	293	284	9	0.53	1	3	-2	1.41	280	300	-20	1.17	4	1	3	1.90
51ER	73691	Meso	342	346	-4	0.22	5	7	-2	0.82	334	324	10	0.55	8	5	3	1.18
51NT	73692	Meso	468	481	-13	0.60	10	1	9	3.84	470	469	1	0.05	1	0	1	1.41
51EL	73693	Meso	15	15	0	0.00	0	0	0	0.00	26	17	9	1.94	0	0	0	0.00
51NR	73694	Meso	349	358	-9	0.48	2	6	-4	2.00	379	354	25	1.31	3	0	3	2.45
51SL	73695	Meso	20	9	11	2.89	2	0	2	2.00	19	25	-6	1.28	0	0	0	0.00
51ET	73696	Meso	682	713	-31	1.17	20	18	2	0.46	676	614	62	2.44	20	20	0	0.00
51NL	73697	Meso	137	78	59	5.69	4	1	3	1.90	144	80	64	6.05	6	2	4	2.00
51WT	73699	Meso	508	514	-6	0.27	1	5	-4	2.31	535	509	26	1.14	0	6	-6	3.46
54SL	73701	Meso	98	92	6	0.62	2	10	-8	3.27	102	102	0	0.00	0	6	-6	3.46
54ET	73702	Meso	861	881	-20	0.68	16	25	-9	1.99	858	815	43	1.49	18	16	2	0.49
54NT	73703	Meso	452	507	-55	2.51	23	21	2	0.43	500	494	6	0.27	28	19	9	1.86
54EL	73704	Meso	45	36	9	1.41	0	0	0	0.00	61	44	17	2.35	0	1	-1	1.41
54WL	73705	Meso	31	28	3	0.55	6	0	6	3.46	41	25	16	2.79	1	1	0	0.00
54ST	73706	Meso	535	537	-2	0.09	24	24	0	0.00	603	601	2	0.08	18	14	4	1.00
54ER	73707	Meso	200	211	-11	0.77	8	5	3	1.18	191	178	13	0.96	7	10	-3	1.03
54WT	73708	Meso	663	650	13	0.51	2	12	-10	3.78	679	687	-8	0.31	4	7	-3	1.28
54NL	73709	Meso	148	107	41	3.63	0	3	-3	2.45	136	126	10	0.87	0	2	-2	2.00
32WT	79337	Meso	519	562	-43	1.85	3	15	-12	4.00	550	561	-11	0.47	3	16	-13	4.22
32ET	79339	Meso	680	571	109	4.36	6	18	-12	3.46	677	661	16	0.62	13	22	-9	2.15
12NL	79573	Meso	72	50	22	2.82	2	0	2	2.00	64	43	21	2.87	0	0	0	0.00
12EL	79575	Meso	25	34	-9	1.66	4	0	4	2.83	35	36	-1	0.17	6	0	6	3.46
12NT	79576	Meso	121	128	-7	0.63	0	0	0	0.00	139	141	-2	0.17	0	0	0	0.00
12ST	79577	Meso	110	104	6	0.58	0	2	-2	2.00	107	122	-15	1.40	0	0	0	0.00
84ST	80097	Meso	159	126	33	2.76	1	10	-9	3.84	148	174	-26	2.05	0	13	-13	5.10
84WL	80098	Meso	0	24	-24	6.93	0	0	0	0.00	0	24	-24	6.93	0	0	0	0.00
84ER	80099	Meso	22	21	1	0.22	0	0	0	0.00	36	37	-1	0.17	0	1	-1	1.41
84NT	80100	Meso	188	213	-25	1.77	1	12	-11	4.31	188	196	-8	0.58	3	11	-8	3.02
84WR	80101	Meso	121	115	6	0.55	0	7	-7	3.74	133	133	0	0.00	3	14	-11	3.77
84SL	80103	Meso	69	81	-12	1.39	4	1	3	1.90	78	69	9	1.05	1	2	-1	0.82
84ET	80104	Meso	1952	2084	-132	2.94	50	58	-8	1.09	2029	2159	-130	2.84	53	41	12	1.75
84NL	80105	Meso	16	10	6	1.66	2	0	2	2.00	20	26	-6	1.25	1	0	1	1.41
84SR	80106	Meso	46	76	-30	3.84	0	2	-2	2.00	30	87	-57	7.45	1	3	-2	1.41
84WT	80107	Meso	1837	1841	-4	0.09	54	44	10	1.43	1882	1878	4	0.09	53	43	10	1.44
59ER	80121	Meso	224	232	-8	0.53	0	10	-10	4.47	291	272	19	1.13	0	17	-17	5.83
59ST	80122	Meso	265	363	-98	5.53	10	3	7	2.75	302	391	-89	4.78	10	1	9	3.84
59NL	80123	Meso	70	59	11	1.37	0	4	-4	2.83	78	63	15	1.79	0	5	-5	3.16
59SR	80124	Meso	97	49	48	5.62	0	0	0	0.00	96	45	51	6.07	2	0	2	2.00
59NT	80125	Meso	265	274	-9	0.55	6	3	3	1.41	264	269	-5	0.31	11	2	9	3.53
59EL	80126	Meso	67	91	-24	2.70	0	0	0	0.00	49	96	-47	5.52	0	0	0	0.00

62WT	80256	Micro	1141	1085	56	1.68	41	50	-9	1.33	1210	1219	-9	0.26	61	43	18	2.50
62SR	80257	Micro	235	266	-31	1.96	1	4	-3	1.90	282	266	16	0.97	0	1	-1	1.41
62ET	80258	Micro	1916	1873	43	0.99	86	101	-15	1.55	1936	1877	59	1.35	101	82	19	1.99
62SL	80259	Micro	139	116	23	2.04	0	4	-4	2.83	139	132	7	0.60	0	1	-1	1.41
62EL	80260	Micro	354	366	-12	0.63	1	5	-4	2.31	348	412	-64	3.28	1	1	0	0.00
62WR	80261	Micro	160	196	-36	2.70	1	1	0	0.00	201	195	6	0.43	0	3	-3	2.45
33NR	80647	Meso	128	162	-34	2.82	0	2	-2	2.00	131	172	-41	3.33	4	2	2	1.15
33ET	80648	Meso	1578	1645	-67	1.67	53	52	1	0.14	1719	1720	-1	0.02	53	36	17	2.55
33SL	80649	Meso	24	30	-6	1.15	0	1	-1	1.41	32	24	8	1.51	4	1	3	1.90
33ST	80651	Meso	198	152	46	3.48	1	2	-1	0.82	187	208	-21	1.49	3	1	2	1.41
33WT	80652	Meso	1619	1647	-28	0.69	53	46	7	0.99	1707	1696	11	0.27	46	54	-8	1.13
33NL	80653	Meso	0	10	-10	4.47	0	0	0	0.00	2	15	-13	4.46	0	0	0	0.00
33SR	80654	Meso	328	310	18	1.01	2	6	-4	2.00	313	335	-22	1.22	9	3	6	2.45
33NT	80655	Meso	266	154	112	7.73	0	4	-4	2.83	287	131	156	10.79	3	2	1	0.63
2WL	80661	Meso	138	181	-43	3.40	4	1	3	1.90	154	162	-8	0.64	2	3	-1	0.63
2ER	80662	Meso	85	81	4	0.44	0	9	-9	4.24	88	95	-7	0.73	0	10	-10	4.47
2ST	80663	Meso	385	351	34	1.77	2	4	-2	1.15	360	340	20	1.07	3	2	1	0.63
2NR	80664	Meso	96	175	-79	6.79	0	1	-1	1.41	80	161	-81	7.38	1	6	-5	2.67
2ET	80665	Meso	1818	1879	-61	1.42	53	69	-16	2.05	1983	2092	-109	2.41	54	54	0	0.00
2SL	80666	Meso	139	110	29	2.60	0	4	-4	2.83	129	116	13	1.17	3	2	1	0.63
2NL	80667	Meso	125	38	87	9.64	1	1	0	0.00	119	39	80	9.00	1	2	-1	0.82
2WT	80668	Meso	1750	1701	49	1.18	50	44	6	0.88	1781	1861	-80	1.87	55	44	11	1.56
2SR	80669	Meso	114	150	-36	3.13	10	35	-25	5.27	156	184	-28	2.15	8	11	-3	0.97
2NT	80670	Meso	198	195	3	0.21	4	1	3	1.90	193	176	17	1.25	2	0	2	2.00
2EL	80671	Meso	153	76	77	7.20	8	3	5	2.13	147	114	33	2.89	1	1	0	0.00
60WT	80701	Micro	1166	1106	60	1.78	41	52	-11	1.61	1249	1224	25	0.71	58	42	16	2.26
60NL	80702	Micro	0	14	-14	5.29	0	1	-1	1.41	0	16	-16	5.66	0	0	0	0.00
60SR	80703	Micro	55	31	24	3.66	1	0	1	1.41	59	34	25	3.67	1	0	1	1.41
60ET	80704	Micro	1757	1687	70	1.69	80	100	-20	2.11	1817	1779	38	0.90	92	81	11	1.18
60NR	80705	Micro	71	73	-2	0.24	0	1	-1	1.41	87	65	22	2.52	0	0	0	0.00
60SL	80706	Micro	29	26	3	0.57	0	0	0	0.00	31	25	6	1.13	0	0	0	0.00
60WL	80707	Micro	20	19	1	0.23	0	0	0	0.00	19	19	0	0.00	0	0	0	0.00
60ST	80708	Micro	93	147	-54	4.93	0	1	-1	1.41	77	150	-73	6.85	0	1	-1	1.41
60EL	80709	Micro	87	41	46	5.75	3	0	3	2.45	78	27	51	7.04	3	1	2	1.41
60NT	80710	Micro	193	234	-41	2.81	0	2	-2	2.00	216	201	15	1.04	0	0	0	0.00
74SR	80747	Meso	792	833	-41	1.44	8	11	-3	0.97	853	755	98	3.46	9	11	-2	0.63
74WT	80748	Meso	1917	1799	118	2.74	67	84	-17	1.96	1906	1969	-63	1.43	63	65	-2	0.25
74WR	80750	Meso	183	140	43	3.38	1	6	-5	2.67	181	156	25	1.93	1	4	-3	1.90
74ET	80751	Meso	1647	1713	-66	1.61	51	64	-13	1.71	1821	1836	-15	0.35	53	42	11	1.60
21EL	82727	Meso	2	11	-9	3.53	0	0	0	0.00	5	16	-11	3.39	0	0	0	0.00
21WR	82728	Meso	58	24	34	5.31	0	0	0	0.00	46	21	25	4.32	0	0	0	0.00
21NT	82729	Meso	215	241	-26	1.72	6	2	4	2.00	238	296	-58	3.55	7	4	3	1.28
21SL	82733	Meso	41	57	-16	2.29	3	0	3	2.45	50	49	1	0.14	0	0	0	0.00
21ET	82734	Meso	135	100	35	3.23	0	1	-1	1.41	117	114	3	0.28	0	0	0	0.00
21NR	82735	Meso	0	9	-9	4.24	0	0	0	0.00	0	12	-12	4.90	0	0	0	0.00
21ST	82736	Meso	312	364	-52	2.83	3	3	0	0.00	343	393	-50	2.61	1	2	-1	0.82
21ER	82737	Meso	93	128	-35	3.33	0	10	-10	4.47	87	96	-9	0.94	2	14	-12	4.24
21WL	82738	Meso	12	12	0	0.00	0	0	0	0.00	12	11	1	0.29	0	0	0	0.00
69WT	82740	Micro	1136	1140	-4	0.12	60	79	-19	2.28	1159	986	173	5.28	71	52	19	2.42
69ET	82742	Micro	1647	1669	-22	0.54	91	109	-18	1.80	1732	1628	104	2.54	98	81	17	1.80
65ST	82760	Micro	189	182	7	0.51	1	1	0	0.00	210	220	-10	0.68	0	0	0	0.00
65WL	82761	Micro	32	29	3	0.54	0	1	-1	1.41	40	54	-14	2.04	0	0	0	0.00
65NT	82762	Micro	215	220	-5	0.34	0	1	-1	1.41	223	214	9	0.61	0	1	-1	1.41
65EL	82763	Micro	50	104	-54	6.15	1	1	0	0.00	42	114	-72	8.15	0	2	-2	2.00
65NR	82764	Micro	34	22	12	2.27	0	0	0	0.00	43	33	10	1.62	0	0	0	0.00
65SL	82765	Micro	64	50	14	1.85	0	2	-2	2.00	60	29	31	4.65	3	0	3	2.45
65ET	82766	Micro	1650	1649	1	0.02	84	88	-4	0.43	1696	1683	13	0.32	94	74	20	2.18
65NL	82767	Micro	83	50	33	4.05	10	0	10	4.47	78	40	38	4.95	14	0	14	5.29
65SR	82768	Micro	37	40	-3	0.48	0	0	0	0.00	31	21	10	1.96	0	0	0	0.00
65WT	82769	Micro	1059	1055	4	0.12	41	49	-8	1.19	1124	1120	4	0.12	56	41	15	2.15
77ST	82771	Meso	182	186	-4	0.29	4	3	1	0.53	208	204	4	0.28	2	5	-3	1.60
77ER	82772	Meso	106	81	25	2.59	0	7	-7	3.74	101	97	4	0.40	0	2	-2	2.00
77WL	82773	Meso	45	60	-15	2.07	0	4	-4	2.83	55	54	1	0.14	1	2	-1	0.82
77NT	82774	Meso	166	176	-10	0.76	5	9	-4	1.51	156	223	-67	4.87	18	5	13	3.83
77EL	82775	Meso	36	42	-6	0.96	0	0	0	0.00	39	39	0	0.00	0	1	-1	1.41
77WR	82776	Meso	40	63	-23	3.20	0	0	0	0.00	41	63	-22	3.05	0	1	-1	1.41
77NL	82777	Meso	162	162	0	0.00	0	4	-4	2.83	150	199	-49	3.71	1	2	-1	0.82
77SR	82778	Meso	2	2	0	0.00	0	0	0	0.00	1	0	1	1.41	0	0	0	0.00
77WT	82779	Meso	254	278	-24	1.47	0	8	-8	4.00	323	343	-20	1.10	0	2	-2	2.00
77NR	82780	Meso	56	77	-21	2.58	0	4	-4	2.83	65	95	-30	3.35	0	4	-4	2.83
77SL	82781	Meso	122	115	7	0.64	1	1	0	0.00	122	132	-10	0.89	0	3	-3	2.45
77ET	82782	Meso	462	462	0	0.00	0	6	-6	3.46	437	417	20	0.97	0	2	-2	2.00
37ET	84210	Micro	2233	2191	42	0.89	80	91	-11	1.19	2263	2275	-12	0.25	79	66	13	1.53
37SL	84211	Micro	48	24	24	4.00	0	2	-2	2.00	52	30	22	3.44	0	0	0	0.00
37NR	84212	Micro	70	67	3	0.36	3	0	3	2.45	73	127	-54	5.40	0	0	0	0.00
37WT	84213	Micro	1566	1558	8	0.20	46	44	2	0.30	1639	1598	41	1.02	50	35	15	2.30
37NL	84214	Micro	27	18	9	1.90	0	0	0	0.00	22	26	-4	0.82	0	0	0	0.00
37EL	84215	Micro	32	48	-16	2.53	0	0	0	0.00	24	39	-15	2.67	2	0	2	2.00
37NT	84216	Micro	157	178	-21	1.62	0	0	0	0.00	156	176	-20	1.55	1	0	1	1.41
37WL	84217	Micro	72	113	-41	4.26	0	1	-1	1.41	78	93	-15	1.62	1	0	1	1.41
37ST	84218	Micro	150	145	5	0.41	0	1	-1	1.41	144	170	-26	2.08	0	1	-1	1.41
72WL	84220	Meso	112	79	33	3.38	0	1	-1	1.41	117	82	35	3.51	0	0	0	0.00
72ST	84221	Meso	633	594	39	1.57	8	7	1	0.37	653	704	-51	1.96	7	6	1	0.39
72SL	84223	Meso	20	24	-4	0.85	0	0	0	0.00	38	10	28	5.72	2	0	2	2.00
72NT	84224	Meso	977	1020	-43	1.36	0	6	-6	3.46	988	1002	-14	0.44	0	7	-7	3.74
36NT	88660	Meso	35	28	7	1.25	1	0	1	1.41	38	18	20	3.78	0	2	-2	2.00
36WR	88661	Meso	79	108	-29	3.00	4	1	3	1.90	78	82	-4	0.45	0	0	0	0.00
36ST	88662	Meso	63	62	1	0.13	0	2	-2	2.00	78	57	21	2.56	2	3	-1	0.63
36WL	88663	Meso	578	588	-10	0.41	1	15	-14	4.95	549	560	-11	0.47	5	2	3	1.60
36SL	88664	Meso	188	163	25	1.89	0	6	-6	3.46	184	144	40	3.12	0	4	-4	2.83
36NR	88665	Meso	857	840	17	0.58	6	14	-8	2.53	861	826	35	1.21	11	11	0	0.00
38WR	88667	Meso	986	997	-11	0.35	4	19	-15	4.42	998	933	65	2.09	7	14	-7	2.16
38NT	88668	Meso	219	238	-19	1.26	11	4	7	2.56	222	275	-53	3.36	10	3	7	2.75
40NT	88670	Meso	1206	1186	20	0.58	15	25	-10	2.24	1213	1172	41	1.19	17	16	1	0.25
40NL	88676	Meso	3	14	-11	3.77	0	0	0	0.00	4	12	-8	2.83	0	0	0	0.00
68ET	92156	Micro	1073	1047	26	0.80	85	95	-10	1.05	1088	1019	69	2.13	88	105	-17	1.73
68WT	92158	Micro	741	723	18	0.67	40	67	-27	3.69	759	717	42	1.55	47	57	-10	1.39
68SR	92159	Micro	497	549	-52	2.27	39	33	6	1.00	538	523	15	0.65	27	20	7	1.44
68NL	92160	Micro	45	45	0	0.00	0	0	0	0.00	48	37	11	1.69	0	0	0	0.00
68WR	92161	Micro	618	671	-53	2.09	10	20	-10	2.58	654	585	69	2.77	14	16	-2	0.52
68EL	92162	Micro	597	619	-22	0.89	33	36	-3	0.51	588	598	-10	0.41	36	33	3	0.51
68WL	92163	Micro	93	165	-72	6.34	4	0	4	2.83	88	143	-55	5.12	8	1	7	3.30
68ST	92164	Micro	182	195	-13	0.95	0	3	-3	2.45	181	207	-26	1.87	0	1	-1	1.41
81WT	104064	Micro	1055	1029	26	0.81	28	29	-1	0.19	1172	1162	10	0.29	31	29	2	0.37
81ET	104065	Micro	1846	1740	106	2.50	75	82	-7	0.79	1886	1832	54	1.25	85	55	30	3.59
10WL	104081	Meso	66	77	-11	1.30	0	3	-3	2.45	81	88	-7	0.76	0	1	-1	1.41
10ST	104082	Meso	211	197	14	0.98	1	18	-17	5.52	198	225	-27	1.86	1	21	-20	6.03
10NR	104083	Meso	132	133	-1	0.09	2	4	-2	1.15	116	142	-26	2.29	0	1	-1	1.41
10SL	104084	Meso	54	59	-5	0.67	1	0	1	1.41	51	79	-28	3.47	2	0	2	2.00
10NT	104085	Meso	303	311	-8	0.46	5	21	-16	4.44	355	329	26	1.41	14	17	-3	0.76
10WR	104086	Meso	8	50	-42	7.80	0	0	0	0.00	4	55	-51	9.39	0	0	0	0.00
48NT	117031	Meso	435	427	8	0.39	14	7	7	2.16	494	486	8	0.36	7	3	4	1.79
48ST	117032	Meso	503	451	52	2.38	16	11	5	1.36	475	470	5	0.23	14	12	2	0.55

4SL	117169	Meso	15	37	-22	4.31	0	0	0	0.00	13	41	-28	5.39	0	1	-1	1.41
4NR	117170	Meso	7	18	-11	3.11	0	1	-1	1.41	2	36	-34	7.80	0	0	0	0.00
4WR	117171	Meso	22	14	8	1.89	0	0	0	0.00	27	11	16	3.67	0	0	0	0.00
4NT	117172	Meso	185	249	-64	4.34	0	5	-5	3.16	188	215	-27	1.90	3	3	0	0.00
4WL	117173	Meso	15	10	5	1.41	0	0	0	0.00	7	9	-2	0.71	0	0	0	0.00
4ST	117174	Meso	110	161	-51	4.38	0	11	-11	4.69	95	150	-55	4.97	0	15	-15	5.48
52EL	13089151	Meso	24	6	18	4.65	1	7	-6	3.00	24	7	17	4.32	0	4	-4	2.83
52SR	13089152	Meso	0	0	0	0.00	0	5	-5	3.16	0	0	0	0.00	0	3	-3	2.45
31EL	13089157	Micro	878	853	25	0.85	24	32	-8	1.51	857	837	20	0.69	26	18	8	1.71
31SL	13089166	Micro	154	160	-6	0.48	0	3	-3	2.45	168	144	24	1.92	1	0	1	1.41
39SL	13089176	Micro	106	42	64	7.44	2	3	-1	0.63	90	69	21	2.36	5	2	3	1.60
38WL	13089177	Meso	107	43	64	7.39	2	3	-1	0.63	90	64	26	2.96	5	2	3	1.60
47WL	13089187	Micro	75	30	45	6.21	0	0	0	0.00	70	44	26	3.44	1	1	0	0.00
47NL	13089188	Micro	109	30	79	9.48	0	0	0	0.00	90	27	63	8.24	0	0	0	0.00
34WL	13089197	Meso	15	20	-5	1.20	1	0	1	1.41	6	45	-39	7.72	0	0	0	0.00
34WT	13089198	Meso	51	28	23	3.66	0	0	0	0.00	43	37	6	0.95	0	1	-1	1.41
34WR	13089199	Meso	30	10	20	4.47	3	0	3	2.45	33	19	14	2.75	2	0	2	2.00
34ER	13089200	Meso	127	180	-53	4.28	0	0	0	0.00	164	133	31	2.54	2	0	2	2.00
34ET	13089201	Meso	41	39	2	0.32	0	0	0	0.00	41	35	6	0.97	0	0	0	0.00
34EL	13089202	Meso	149	228	-79	5.75	0	0	0	0.00	158	183	-25	1.91	0	4	-4	2.83
34SR	13089203	Meso	103	126	-23	2.15	0	1	-1	1.41	106	85	21	2.15	0	0	0	0.00
34SL	13089204	Meso	20	16	4	0.94	0	1	-1	1.41	20	11	9	2.29	2	0	2	2.00
34NL	13089206	Meso	59	134	-75	7.63	0	6	-6	3.46	43	108	-65	7.48	0	7	-7	3.74
46SL	13089483	Micro	10	20	-10	2.58	0	2	-2	2.00	12	14	-2	0.55	0	0	0	0.00
46ST	13089484	Micro	63	67	-4	0.50	0	0	0	0.00	60	59	1	0.13	0	1	-1	1.41
46SR	13089485	Micro	26	8	18	4.37	0	0	0	0.00	10	6	4	1.41	0	0	0	0.00
46EL	13089486	Micro	7	18	-11	3.11	0	0	0	0.00	7	8	-1	0.37	0	0	0	0.00
46NT	13089487	Micro	28	42	-14	2.37	0	0	0	0.00	39	57	-18	2.60	0	0	0	0.00
48WL	13089503	Meso	41	34	7	1.14	0	1	-1	1.41	29	35	-6	1.06	2	0	2	2.00
48WR	13089504	Meso	29	16	13	2.74	1	3	-2	1.41	39	30	9	1.53	0	4	-4	2.83
48NR	13089505	Meso	9	12	-3	0.93	3	0	3	2.45	9	11	-2	0.63	1	0	1	1.41
48SL	13089506	Meso	71	47	24	3.12	0	2	-2	2.00	76	67	9	1.06	0	0	0	0.00
81NL	13089549	Micro	74	80	-6	0.68	0	0	0	0.00	64	76	-12	1.43	0	2	-2	2.00
22WR	13089736	Meso	0	2	-2	2.00	0	3	-3	2.45	0	0	0	0.00	0	4	-4	2.83
53ER	13089812	Meso	2803	2728	75	1.43	101	96	5	0.50	2932	2804	128	2.39	99	102	-3	0.30
53WL	13089814	Meso	732	693	39	1.46	8	17	-9	2.55	791	687	104	3.83	6	18	-12	3.46
33EL	13089842	Meso	436	517	-81	3.71	1	8	-7	3.30	388	516	-128	6.02	0	7	-7	3.74
35NL	13089853	Meso	136	112	24	2.16	3	12	-9	3.29	134	118	16	1.43	3	11	-8	3.02
35WL	13089854	Meso	32	44	-12	1.95	0	0	0	0.00	40	41	-1	0.16	0	1	-1	1.41
35WT	13089855	Meso	71	53	18	2.29	0	0	0	0.00	72	82	-10	1.14	0	1	-1	1.41
35WR	13089856	Meso	60	46	14	1.92	0	1	-1	1.41	56	71	-15	1.88	0	1	-1	1.41
35ET	13089857	Meso	65	51	14	1.84	0	0	0	0.00	84	94	-10	1.06	0	0	0	0.00
35NR	13089858	Meso	19	25	-6	1.28	0	0	0	0.00	17	30	-13	2.68	0	2	-2	2.00
35SL	13089859	Meso	57	35	22	3.24	0	0	0	0.00	56	76	-20	2.46	0	0	0	0.00
23ER	13090099	Meso	21	42	-21	3.74	0	0	0	0.00	15	45	-30	5.48	0	0	0	0.00
59ET	13090152	Meso	13	10	3	0.88	0	0	0	0.00	13	13	0	0.00	0	0	0	0.00
59WT	13090153	Meso	29	29	0	0.00	0	0	0	0.00	27	36	-9	1.60	0	0	0	0.00
59WL	13090154	Meso	70	40	30	4.05	0	0	0	0.00	72	53	19	2.40	0	0	0	0.00
59WR	13090155	Meso	6	18	-12	3.46	0	0	0	0.00	9	14	-5	1.47	0	0	0	0.00
59SL	13090156	Meso	1	10	-9	3.84	0	0	0	0.00	2	7	-5	2.36	0	0	0	0.00
59NR	13090157	Meso	0	1	-1	1.41	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
68SL	13090179	Micro	696	722	-26	0.98	17	25	-8	1.75	772	748	24	0.87	13	19	-6	1.50
66SL	13090338	Micro	4	36	-32	7.16	0	0	0	0.00	8	35	-27	5.82	0	0	0	0.00
66ST	13090339	Micro	63	64	-1	0.13	0	1	-1	1.41	74	57	17	2.10	0	1	-1	1.41
66SR	13090340	Micro	17	14	3	0.76	0	0	0	0.00	21	26	-5	1.03	2	2	0	0.00
66EL	13090341	Micro	8	11	-3	0.97	1	1	0	0.00	9	16	-7	1.98	0	1	-1	1.41
66NT	13090342	Micro	76	67	9	1.06	0	1	-1	1.41	88	59	29	3.38	0	1	-1	1.41
69SL	13090343	Micro	55	26	29	4.56	0	0	0	0.00	47	26	21	3.48	0	1	-1	1.41
69SR	13090345	Micro	48	47	1	0.15	0	2	-2	2.00	54	39	15	2.20	0	0	0	0.00
69EL	13090346	Micro	77	59	18	2.18	0	5	-5	3.16	58	63	-5	0.64	0	4	-4	2.83
55NR	13119550	Meso	38	64	-26	3.64	0	0	0	0.00	46	37	9	1.40	0	0	0	0.00
55WL	13119551	Meso	14	18	-4	1.00	0	0	0	0.00	13	16	-3	0.79	2	0	2	2.00
15NL	13119942	Meso	37	38	-1	0.16	2	0	2	2.00	47	24	23	3.86	1	0	1	1.41
15EL	13119943	Meso	13	39	-26	5.10	3	0	3	2.45	21	55	-34	5.52	0	0	0	0.00
63NR	13120448	Meso	5	19	-14	4.04	0	0	0	0.00	1	10	-9	3.84	0	0	0	0.00
63NL	13120449	Meso	10	19	-9	2.36	0	0	0	0.00	17	11	6	1.60	0	0	0	0.00
63ER	13120450	Meso	17	10	7	1.91	0	0	0	0.00	21	5	16	4.44	0	0	0	0.00
63WL	13120451	Meso	8	8	0	0.00	0	1	-1	1.41	9	10	-1	0.32	0	0	0	0.00
63ST	13120452	Meso	5	20	-15	4.24	0	0	0	0.00	11	14	-3	0.85	0	0	0	0.00
63NT	13120458	Meso	23	39	-16	2.87	0	0	0	0.00	30	28	2	0.37	0	0	0	0.00
64EL	13168443	Micro	16	28	-12	2.56	0	0	0	0.00	27	26	1	0.19	0	0	0	0.00
64NT	13168444	Micro	48	50	-2	0.29	0	1	-1	1.41	58	45	13	1.81	0	0	0	0.00
31ET	13405771	Micro	1485	1447	38	0.99	60	63	-3	0.38	1525	1624	-99	2.49	52	42	10	1.46
40NR	13405912	Meso	0	8	-8	4.00	0	0	0	0.00	1	9	-8	3.58	0	0	0	0.00
52ST	13405918	Meso	764	774	-10	0.36	38	23	15	2.72	836	827	9	0.31	26	22	4	0.82
52ER	13405919	Meso	340	347	-7	0.38	2	0	2	2.00	320	282	38	2.19	2	1	1	0.82
55WT	13406071	Meso	622	602	20	0.81	5	5	0	0.00	645	643	2	0.08	4	9	-5	1.96
55NL	13406072	Meso	21	23	-2	0.43	0	0	0	0.00	27	25	2	0.39	0	0	0	0.00
71WT	13406099	Meso	245	266	-21	1.31	2	5	-3	1.60	263	300	-37	2.21	0	3	-3	2.45
71WL	13406100	Meso	60	65	-5	0.63	0	0	0	0.00	67	72	-5	0.60	0	0	0	0.00
71ETR	13406104	Meso	471	474	-3	0.14	6	7	-1	0.39	454	438	16	0.76	9	6	3	1.10
71NR	13406109	Meso	83	105	-22	2.27	0	1	-1	1.41	72	113	-41	4.26	0	0	0	0.00
71NL	13406110	Meso	239	237	2	0.13	0	2	-2	2.00	225	229	-4	0.27	0	0	0	0.00
72NR	13406231	Meso	133	125	8	0.70	0	0	0	0.00	129	84	45	4.36	0	0	0	0.00
9ET	13406258	Meso	684	636	48	1.87	1	5	-4	2.31	650	635	15	0.59	3	6	-3	1.41
9WT	13406262	Meso	382	382	0	0.00	0	6	-6	3.46	439	392	47	2.31	0	4	-4	2.83
22EL	13406293	Meso	33	37	-4	0.68	2	0	2	2.00	21	37	-16	2.97	4	0	4	2.83
20WT	13406439	Meso	264	290	-26	1.56	6	7	-1	0.39	267	333	-66	3.81	7	5	2	0.82
20WL	13406440	Meso	143	132	11	0.94	0	8	-8	4.00	116	135	-19	1.70	0	4	-4	2.83
20ETR	13406443	Meso	473	495	-22	1.00	4	16	-12	3.79	522	559	-37	1.59	4	17	-13	4.01
20NL	13406448	Meso	114	134	-20	1.80	1	0	1	1.41	115	130	-15	1.36	5	0	5	3.16
20NR	13406449	Meso	140	154	-14	1.15	3	7	-4	1.79	127	172	-45	3.68	0	7	-7	3.74
21NL	13406675	Meso	105	84	21	2.16	0	14	-14	5.29	114	132	-18	1.62	0	9	-9	4.24
74EL	13406690	Meso	892	912	-20	0.67	6	13	-7	2.27	984	1078	-94	2.93	7	6	1	0.39
53ET	13406693	Meso	1754	1789	-35	0.83	50	57	-7	0.96	1987	2008	-21	0.47	53	39	14	2.06
53NL.AM	13406696	Meso																
53NR.AM	13406697	Meso																
12ET	13406725	Meso	2305	2333	-28	0.58	86	87	-1	0.11	2406	2351	55	1.13	86	93	-7	0.74
12NR	13406726	Meso	50	67	-17	2.22	1	1	0	0.00	52	79	-27	3.34	4	0	4	2.83
12SL	13406727	Meso	21	27	-6	1.22	0	0	0	0.00	35	17	18	3.53	4	0	4	2.83
12WL	13406731	Meso	20	36	-16	3.02	0	0	0	0.00	23	29	-6	1.18	0	0	0	0.00
12WT	13406732	Meso	2003	1950	53	1.19	73	82	-9	1.02	2160	2092	68	1.47	68	59	9	1.13
33WL	13406803	Meso	182	163	19	1.45	0	1	-1	1.41	179	230	-51	3.57	0	1	-1	1.41
5NL	13406817	Meso	102	96	6	0.60	0	5	-5	3.16	115	97	18	1.75	3	3	0	0.00
14STR	13406825	Meso	68	74	-6	0.71	0	0	0	0.00	67	82	-15	1.74	0	0	0	0.00
14SL	13406826	Meso	38	54	-16	2.36	0	0	0	0.00	36	45	-9	1.41	0	0	0	0.00
14WTR	13406829	Meso	366	364	2	0.10	0	2	-2	2.00	386	364	22	1.14	0	0	0	0.00
14EL	13406831	Meso	34	28	6	1.08	0	1	-1	1.41	31	21	10	1.96	3	0	3	2.45
14ETR	13406832	Meso	253	264	-11	0.68	2	3	-1	0.63	272	240	32	2.00	4	0	4	2.83
29SL	13406949	Meso	96	112	-16	1.57	0	1	-1	1.41	124	100	24	2.27	0	1	-1	1.41
29ET	13406950	Meso	400	417	-17	0.84	13	28	-15	3.31	408	448	-40	1.93	12	16	-4	1.07
29NR	13406951	Meso	40	27	13	2.25	1	0	1	1.41	48	20	28	4.80	0	0	0	0.00
27NT	13406968	Meso	572	587	-15	0.62	1	11	-10	4.08	598	569	29	1.20	5	9	-4	1.51

27NL	13406969	Meso	51	31	20	3.12	0	0	0	0.00	37	31	6	1.03	1	0	1	1.41
27EL	13406973	Meso	68	32	36	5.09	0	3	-3	2.45	51	37	14	2.11	0	1	-1	1.41
27ER	13406974	Meso	31	12	19	4.10	1	0	1	1.41	28	16	12	2.56	0	0	0	0.00
27STR	13406976	Meso	495	476	19	0.86	5	7	-2	0.82	457	483	-26	1.20	10	3	7	2.75
26STR	13406990	Meso	12	53	-41	7.19	0	1	-1	1.41	19	68	-49	7.43	0	0	0	0.00
26SL	13406991	Meso	35	25	10	1.83	0	0	0	0.00	35	34	1	0.17	0	1	-1	1.41
26WTR	13406996	Meso	101	57	44	4.95	0	2	-2	2.00	79	65	14	1.65	0	0	0	0.00
26ET	13407001	Meso	76	58	18	2.20	1	4	-3	1.90	50	51	-1	0.14	2	2	0	0.00
26EL	13407002	Meso	110	75	35	3.64	1	0	1	1.41	134	63	71	7.15	0	0	0	0.00
25STR	13407011	Meso	18	36	-18	3.46	0	0	0	0.00	15	35	-20	4.00	0	0	0	0.00
25SL	13407012	Meso	15	16	-1	0.25	0	0	0	0.00	6	14	-8	2.53	0	1	-1	1.41
25WTR	13407017	Meso	62	107	-45	4.90	0	2	-2	2.00	40	93	-53	6.50	0	1	-1	1.41
25ETR	13407022	Meso	138	124	14	1.22	3	4	-1	0.53	120	109	11	1.03	2	1	1	0.82
25EL	13407023	Meso	48	34	14	2.19	0	1	-1	1.41	47	37	10	1.54	0	0	0	0.00
14WL	13603367	Meso	46	26	20	3.33	1	2	-1	0.82	44	30	14	2.30	0	0	0	0.00
14NTR	13603369	Meso	83	124	-41	4.03	0	1	-1	1.41	103	162	-59	5.13	0	0	0	0.00
14NL	13603370	Meso	8	18	-10	2.77	0	1	-1	1.41	17	14	3	0.76	0	0	0	0.00
19SL	13603378	Meso	15	24	-9	2.04	0	0	0	0.00	15	51	-36	6.27	0	0	0	0.00
19STR	13603393	Meso	390	443	-53	2.60	5	10	-5	1.83	426	392	34	1.68	6	12	-6	2.00
19NT	13603399	Meso	449	398	51	2.48	6	12	-6	2.00	498	484	14	0.63	9	6	3	1.10
19NL	13603400	Meso	33	49	-16	2.50	0	1	-1	1.41	27	83	-56	7.55	0	0	0	0.00
19ER	13603404	Meso	50	55	-5	0.69	0	0	0	0.00	64	63	1	0.13	0	0	0	0.00
19EL	13603405	Meso	29	30	-1	0.18	0	1	-1	1.41	28	45	-17	2.81	0	1	-1	1.41
21WT	13603995	Meso	117	98	19	1.83	0	0	0	0.00	116	113	3	0.28	0	0	0	0.00
32WL	13604612	Meso	31	15	16	3.34	0	1	-1	1.41	21	11	10	2.50	0	0	0	0.00
32ER	13604614	Meso	16	19	-3	0.72	0	0	0	0.00	16	17	-1	0.25	0	0	0	0.00
32NL	13604615	Meso	17	50	-33	5.70	0	0	0	0.00	15	16	-1	0.25	0	0	0	0.00
32NR	13604617	Meso	16	30	-14	2.92	0	1	-1	1.41	22	18	4	0.89	0	1	-1	1.41
41SR	13606020	Meso	0	0	0	0.00	0	2	-2	2.00	0	1	-1	1.41	0	2	-2	2.00
1WT.AM	13608779	Meso																
1WR.AM	13608780	Meso																
1WR.PM	13608783	Meso	439	388	51	2.51	6	0	6	3.46	428	443	-15	0.72	7	3	4	1.79
1WT.PM	13608784	Meso	1905	1958	-53	1.21	73	70	3	0.35	2035	1977	58	1.29	68	51	17	2.20
1WL.AM	13608787	Meso																
1WL.PM	13608788	Meso	80	76	4	0.45	0	0	0	0.00	93	78	15	1.62	0	1	-1	1.41
53NL.PM	13608794	Meso	1983	1985	-2	0.04	87	83	4	0.43	2076	2123	-47	1.03	83	71	12	1.37
53NR.PM	13608795	Meso	739	719	20	0.74	20	19	1	0.23	800	820	-20	0.70	13	12	1	0.28
70ET	13610952	Meso	363	435	-72	3.60	3	5	-2	1.00	415	443	-28	1.35	2	3	-1	0.63
70ER	13610953	Meso	23	31	-8	1.54	1	0	1	1.41	27	24	3	0.59	3	0	3	2.45
70NL	13610954	Meso	2	0	2	2.00	0	0	0	0.00	0	1	-1	1.41	0	0	0	0.00
70NR	13610955	Meso	54	35	19	2.85	0	1	-1	1.41	72	35	37	5.06	0	0	0	0.00
70WT	13610956	Meso	22	41	-19	3.39	0	3	-3	2.45	27	32	-5	0.92	0	1	-1	1.41
70WL	13610957	Meso	84	69	15	1.71	4	0	4	2.83	92	73	19	2.09	3	0	3	2.45
21SR	13611251	Meso	63	85	-22	2.56	0	0	0	0.00	92	92	0	0.00	0	0	0	0.00
45ET	13611806	Micro	1762	1763	-1	0.02	75	99	-24	2.57	1835	1839	-4	0.09	87	78	9	0.99
45EL	13612038	Micro	225	246	-21	1.37	5	6	-1	0.43	250	258	-8	0.50	3	1	2	1.41
43WT	13612111	Micro	1063	1073	-10	0.31	21	29	-8	1.60	1155	1190	-35	1.02	33	28	5	0.91
61NR	13613542	Micro	81	54	27	3.29	3	0	3	2.45	80	63	17	2.01	0	0	0	0.00

APPENDIX

B

BASE MODEL FLOW PLOTS

Parramatta Road Corridor Urban Transformation Strategy
2018 Base Model
Simulated Flow
AM Peak (7:15AM - 8:15AM)

Parramatta Road Corridor Urban Transformation Strategy
2018 Base Model
Simulated Flow
AM Peak (8:15AM - 9:15AM)

Simulated Flow
0 to 1000
1000 to 2000
2000 to 3000
3000 to 4000
4000 to 5000
5000 to inf

Parramatta Road Corridor Urban Transformation Strategy
2018 Base Model
Simulated Flow
PM Peak (4:30PM - 5:30PM)

Parramatta Road Corridor Urban Transformation Strategy
2018 Base Model
Simulated Flow
PM Peak (5:30PM - 6:30PM)

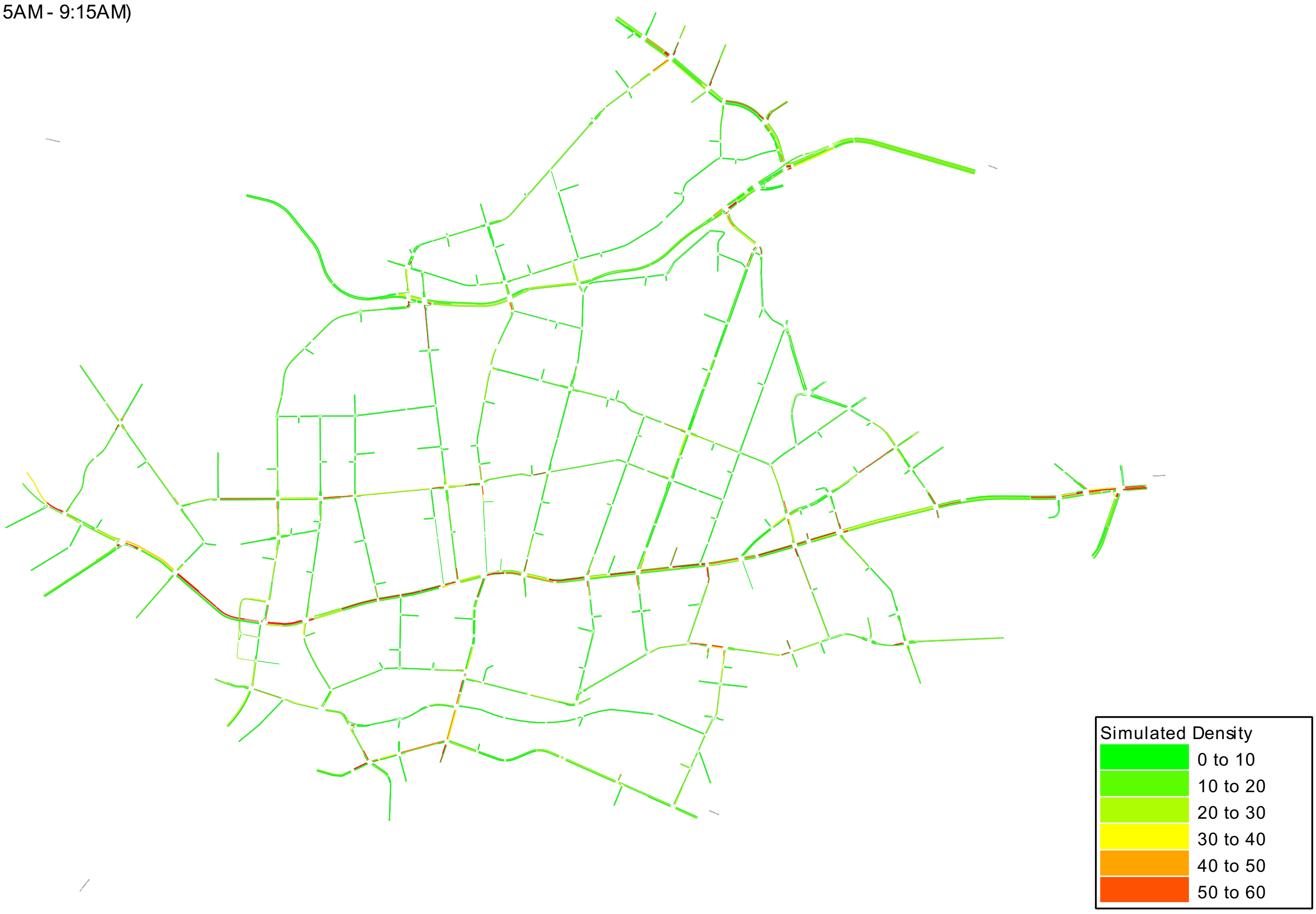
APPENDIX

C

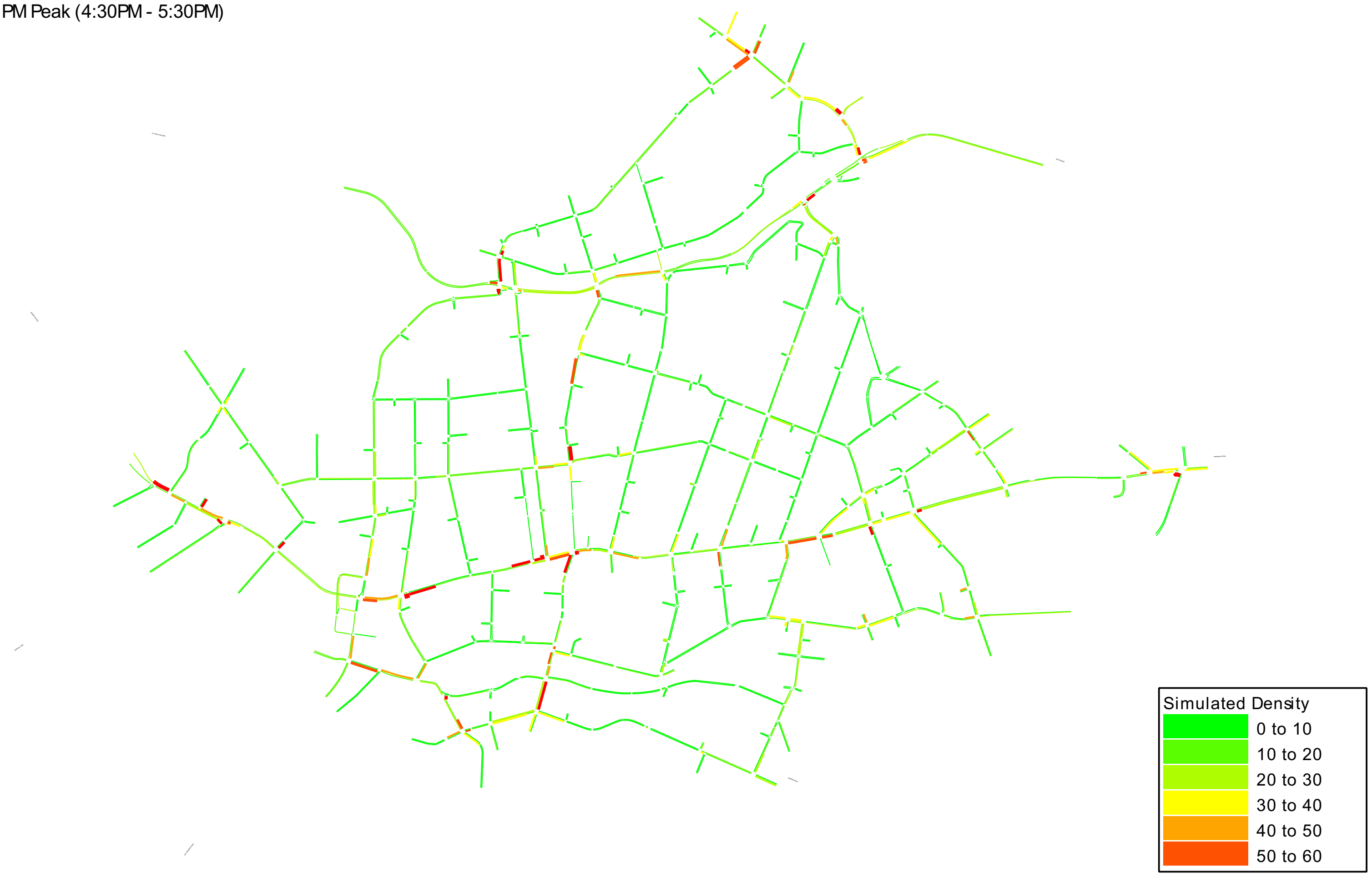
BASE MODEL DENSITY PLOTS

Parramatta Road Corridor Urban Transformation Strategy
2018 Base Model
Simulated Density
AM Peak (7:15AM - 8:15AM)

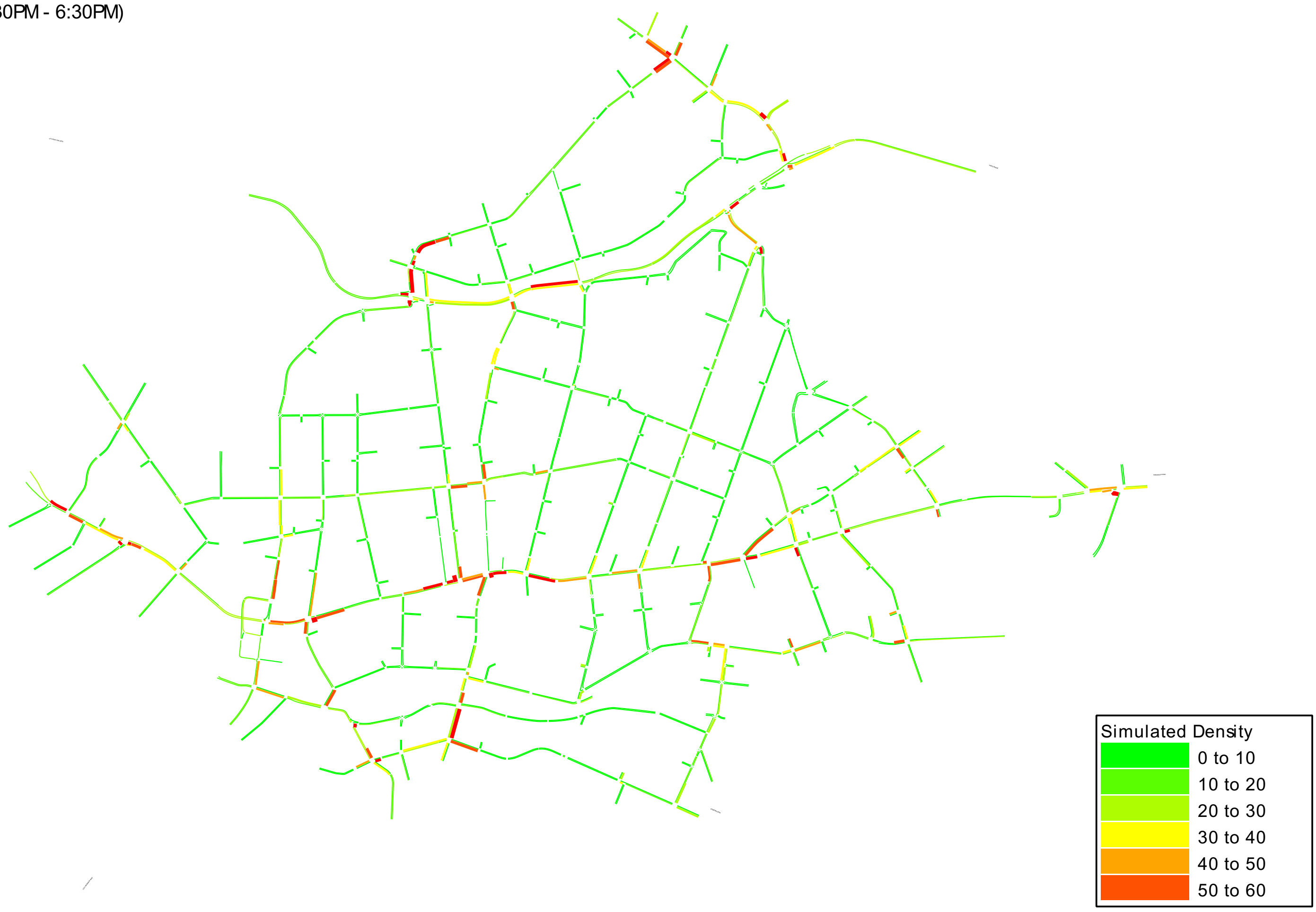
Parramatta Road Corridor Urban Transformation Strategy
2018 Base Model
Simulated Density
AM Peak (8:15AM - 9:15AM)



Parramatta Road Corridor Urban Transformation Strategy
2018 Base Model
Simulated Density
PM Peak (4:30PM - 5:30PM)



Parramatta Road Corridor Urban Transformation Strategy
2018 Base Model
Simulated Density
PM Peak (5:30PM - 6:30PM)



APPENDIX

B

BASE MODEL PEER REVIEW (ARUP, MARCH 2020)

File Note

ARUP

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Project title	Parramatta Road Urban Transformation Corridor	Job number	274030-00
cc	Navdeep Hanjra (DP&E) Kris Walsh (DP&E)	File reference	TN01
Prepared by	Hamid Safi	Date	18 March 2020
Subject	Base Model Peer Review		

1 Introduction

Arup has been engaged by the Department of Planning and Environment (DP&E) to undertake an independent model review of the Parramatta Road Corridor Urban Transformation Transport Study (PRCUTS), within the Inner West Council (IWC) local government area, Aimsun model. DP&E, through their consultants, have prepared an Aimsun model of the Parramatta Road Urban Transformation Corridor.

This technical note summarises the findings of this review, which has been undertaken to assess whether the model developed provides an accurate reflection of base year conditions and will ultimately provide a robust basis from which to forecast future year performance and identify appropriate road infrastructure requirements to support planned urban growth.

The Parramatta Road Urban Transformation Corridor model file that was reviewed was named:

- 20190412 - PRRP Base Model V1.0.ang

The model review process set out in this note is in accordance with key model development items defined in Roads and Maritime Service's (RMS) modelling guidelines. The structure of this note is outlined below:

- Model development
- Demand development
- Key modelling parameters and assumptions
- Intersections and signalisation
- Public transport inputs
- Active transport and pedestrians
- Assignment and convergence
- Calibration and validation

2 Model development

The Parramatta Road Corridor hybrid (microscopic and mesoscopic) model was developed using the Aimsun software package to address the following needs:

1. To evaluate the impacts of future infrastructure upgrades of the study area
2. To investigate future developments and land use changes in the study area for the horizon years
3. To assess the maximum road network capacity and recommended public transport mode shift
4. To investigate the optimal configuration of intersection improvements at key intersections.

The network coding of this model was mainly based on inputs from the Parramatta Road Reconfiguration Program (PRRP) model. The road network was further refined to reflect the latest network geometry properties of the study area. These refinements were mainly related to changes to sections' capacities and speed limits, geometry alignments, lane and parking restrictions and public transport routes. A slope model was applied in the network coding of the model to better replicate the performance of road traffic, mainly heavy vehicles. This model was based on inputs received from Department of Finance, Services and Innovation Spatial Services.

The Sydney Strategic Travel Model (STM) was considered as the reference point in this project for demand adjustment. A subarea cordon was established from the STM based on the extent of the modelled network. This was used to interrogate the STM to extract the 2016 travel demands.

For the purpose of this project, a classified intersection counts data collection was conducted at 83 important intersections within the study area. This data was mainly used for demand adjustment and model calibration. Moreover, in order to validate the performance of the model, the travel time data of eight major routes through the study area were collected and processed from the TomTom database for a four-week period. Three modes of vehicle (light vehicles, heavy vehicles and buses) were included in the development of this Aimsun model.

School zones within the study area were identified, and appropriate rules were defined in the model to restrict the maximum speed of related sections to 40 km/hr during school hours (8:00–9:30AM and 2:30pm–4:00PM).

Accordingly, a hybrid (microscopic and mesoscopic) model was developed for two two-hour weekday peak periods (7:15am–9:15am and 4:30pm–6:30pm). For each peak period, a "warm-up" period of 60 minutes was also included.

2.1 Review findings

The overall structure and model development requirements of the Parramatta Road Corridor model were reviewed, and main findings are summarised in Table 1.

Table 1: Main findings of the model development review

#	Item	Status	Finding
1	**Model Development**		
1.1	Aimsun Version	No issue	Aimsun Next 8.2.3 (R54491)
1.2	Methodology - Network coding	No issue	Generally acceptable
1.3	Methodology - Demand processing	No issue	Generally acceptable
1.4	Database definition and connection	Minor issue	Database of the model was not defined correctly. PM assignment results are not existing in the model.
1.5	Data collection	No issue	Acceptable coverage
1.6	Model dimensions / scale	No issue	Model determined to be correct scale based on spot checks
1.7	Layers	No issue	Checked
1.8	Background image file	No issue	Not available
1.9	Background coordinate system	No issue	No issues identified
1.10	Model Time Periods	No issue	Checked. Well supported
1.11	Pre-Peak Warm-Up	No issue	Included
1.12	Model Layout and Configuration	No issue	No issues identified
1.13	Vehicle Types	No issue	Checked. Well documented
1.14	Road and Lane Types	No issue	Reviewed. No issues identified

3 Demand development

The strategic-level demand data was adjusted based on actual turn movement data, introduced to the model as RDS files. The matrix adjustment tool within Aimsun (static OD adjustment) was used for this analysis. Matrix adjustment is a procedure for adjusting a prior OD matrix, using observed traffic data. The goal of the procedure is to reduce the least squares error between observed traffic data and traffic flows assigned by the model.

Key aspects of the demand development process for the PRCUTS base year model are summarised as follows:

- The starting point of demand calibration was a subarea model, which was defined on Sydney Strategic Travel Model (STM) – 2016 base case scenario
- The traversal demand matrices of the resulting cordon model, which included 96 centroids, was imported into Aimsun
- The collected turn movement data was processed and imported into the model for demand adjustment
- The strategic level demand matrices were adjusted using the Static OD adjustment tool based on the imported RDS files
- Resulting matrices were adjusted manually to improve calibration results, as required
- Adjusted demand matrices were profiled based on observed traffic data (RDS files) using the Static departure adjustment tool.
- 2-hour OD matrices for the AM peak (7:15-9:15AM) and PM peak (4:30-6:30PM) were generated based on traffic survey data;

- o A "warm-up" period of 60 minutes was included in the model to populate the road network;
- o Demands were split into 15-minute time slices and added to the model as an additional set of matrices

3.1 Review findings

The procedure of demand development for the Parramatta Road Corridor model was reviewed based on coded tools in the model and the provided report. Main findings are summarised below:

3.1.1 Zoning refinement

Considering the level of detail incorporated in a mesoscopic/microscopic model compared to a strategic model, it was expected that a refinement of the zoning system would have been required within the model to better replicate the behaviour of trip generators of the study area. No evidence was found in the report or the model in this regard.

3.1.2 Static OD adjustment – Sanity check

As a sanity check, Arup re-ran the existing model's "static OD adjustment" tool for AM peak period, using the provided strategic-level demand matrices and RDS files. This resulted in two relatively different matrices. Table 2 compares the total demand of cars and trucks in the existing and new matrices. It should also be noted that the resulting trip length distribution of the new run was slightly different compared to the existing run retrieved from the model.

Table 2: Comparison of existing and new OD adjustment results

	Existing matrices	New matrices	Diff	Diff (%)
Car - AM	63,217	65,944	2,727	4.3%
Truck - AM	2,870	2,572	- 298	-10.4%

3.1.3 PM peak-related assignments

Arup was unable to check the validity of PM assignment results in the model, as the received model did not include assignment/adjustment results for PM peak.

Due to an issue noticed in the defined public transport routes of the PM scenario, it was not possible to run the PM peak adjustment tools of the model. This issue is discussed further in Section 6.

3.1.4 Static departure adjustment

Inspection of the existing tools defined in the model showed that a warm-up period of 60 minutes was defined for the "static departure adjustment" tool in both the AM and PM periods. The "static departure adjustment" tool considers the simulated travel time of the network for profiling the demand for each origin-destination pair crossing an observation point. In other words, having realistic travel times form each origin to an observed point is crucial for an accurate demand profiling. Since this tool starts from an empty network, appropriate warm-up time is required to load the network sufficiently. This time for the PRCUTS model is around 60 minutes. In addition to the normal warm-up period, the "static departure adjustment" tool requires the network to work under a fully-loaded condition for some intervals to report realistic travel times for the crossing origin-destination pairs. Due to the extent of the model, 60 minutes is an insufficient warm-up duration for a “static OD departure adjustment, and it is recommended to increase this interval.

3.1.5 Dynamic OD adjustment

An overall view of the implemented demand adjustment procedure was provided in Figure 3-3 of the PRCUTS Base Model Development Report. This figure states that Aimsun’s “dynamic OD adjustment” tool was used for demand calibration, however no evidence of this was found in the model.

3.1.6 Findings summary

Review findings regarding the demand development are summarised in Table 3.

Table 3: Main findings of the demand development review

#	Item	Status	Finding
2	**Demand Development**		
2.1	Centroid Configuration	Minor issue	A zoning system refinement was expected considering the nature of the area
2.2	Centroid Configuration Name	No issue	No issues identified
2.3	Real Data Sets	No issue	Reviewed. No issues identified
2.4	Unavailable PM results	Moderate issue	No assignment results were existing in the database for PM period
2.5	Traffic Demands matrices	No issue	Reviewed. No issues identified
2.6	Origin - Destination Matrices	No issue	Reviewed. No issues identified
2.7	Origin - Destination Matrix Names	No issue	Reviewed. No issues identified
2.8	Traffic Demand Names	No issue	Reviewed. No issues identified
2.9	Static OD Adjustment	Major issue	Results of a re-run showed relatively different results
2.10	Static Departure Adjustment	Minor issue	Insufficient warm-up duration was considered in the model
2.11	Dynamic OD adjustment	Major issue	No evidence found in the model for this step
2.12	Path Assignment Names	No issue	Reviewed. No issues identified
2.13	Documentation of assumptions	No issue	Reviewed. No issues identified

4 Key modelling parameters and assumptions

As an operational traffic model, the Parramatta Road Corridor model consists of a significant number of parameters and assumptions. Based on extensive research and experience from other projects, Aimsun suggests default values for each of these parameters. Technically, any change to these default values needs to be recorded and justified. This section documents those important parameters that were changed from default values without appropriate justification.

4.1 Variation from software defaults

Based on observation of the model, a minimal intervention approach has been taken during the model development with most driver behaviour parameters were retained at the software default settings with the exceptions discussed below.

4.1.1 Reaction times

“Reaction Time at Stop” and “Reaction Time at Signals” were changed in the model without any justification:

- Reaction Time (mesoscopic) = 1.30 sec (default = 1.20 sec)
- Reaction Time at Traffic Light (mesoscopic) = 1.70 sec (default = 1.60 sec)

Additionally, “reaction time at stop” and “reaction time at signals” values used for turns in the Stochastic Route Choice (SRC) assignments are not consistent with similar factors for Dynamic User Equilibrium (DUE) assignments for both AM and PM periods.

4.1.2 Attractiveness weight

The “attractiveness weight” factor is an import parameter in dynamic route choice calculations, as it considers the importance of road hierarchy for users. This factor is useful for controlling rat-running on local streets, especially when the arterial network becomes congested. The Parramatta Road Corridor model has used an attractiveness factor of zero, which means the model does not differentiate between local and arterial roads in the route choice of users other than through travel speed and delays.

It is not apparent from the model results if rat-running is an issue in the base year model. However, this could become an issue in future year scenarios. Therefore, it is recommended that the modeller consider using the attractiveness weight factor in the dynamic assignment.

4.1.3 Give-way time

“Give-way time factor (mesoscopic)” for roundabout turns was increased from 1 to 2. Justification for this change was not included in reporting.

4.1.4 Queue discharge acceleration

The “queue discharge acceleration factor” was reduced from 1.0 to 0.5 for the “Paramatta Rd” and “City-West Link Rd” sections without justification.

4.1.5 Additional reaction time at stop and traffic light

“Additional reaction time at stop” and “additional reaction time at traffic light” are two local attributes which are sometimes used to calibrate the simulated traffic flow and right of way of intersections. The default value of these attributes is zero. Increasing this value for a turning movement means users will perform that movement with extra caution. It has been observed in the model that negative values were allocated for the “Additional reaction time at stop” and “Additional reaction time at traffic light” of the approaching section of the “City Rd” to “Parramatta Rd”, while negative values for “Additional reaction time at stop” and “Additional reaction time at traffic light” are not justifiable.

4.1.6 Lane changing cooperation

“Lane changing cooperation” values for the sections listed in Table 4 were changed from 50% without justification. The increase of “lane changing cooperation” attributes for a section means vehicles will support each other for easier lane changing. The modification of this attribute requires justification.

Table 4: Lane changing cooperation variations

Name	Section name	Lane-Changing Cooperation
N13701_N11731	WB approach of Parramatta Rd & Sloane St intersection	100
N10601_N12028	WB approach of Anzac Bridge & Victoria Rd intersection	70
N12026_N12025	SB approach of Victoria Rd & Anzac Bridge intersection	70
N12026_N12025	SB approach of Victoria Rd & Anzac Bridge intersection	70
N16236_N10601	WB approach of Parramatta Rd & Sloane St intersection	60
N12028_N12026	SB approach of Victoria Rd & Anzac Bridge intersection	60

4.1.7 Acceleration factor

As shown in Figure 1, varying acceleration factors have been applied to sections within the network. No logic was identified for this allocation of acceleration factors.

Figure 1: Acceleration factor visualisation of the road network

Increasing an acceleration factor means faster reaction of users, indirectly increasing the capacity of a section. Reduction of an acceleration factor has the inverse effect on capacity.

4.2 Review findings

Main findings regarding general modelling parameters and assumptions are summarised in Table 5.

Table 5: Review findings of general modelling parameters and assumptions

#	Item	Status	Finding
3.1	**Modelling parameters and assumptions - General**		
3.1.1	Arrival Type	No issue	Reviewed. No issues identified
3.1.2	Attractiveness weight	Minor issue	It is recommended to increase this weight (from zero) to be able to consider the impact of road hierarchy in the route choice decisions of vehicles. The value of zero means that there is no difference between local and arterial roads for route choice of users
3.1.3	Reaction Time at Stop	Major issue	Inconsistent values used for turns in SRC and DUE assignments for both AM and PM periods
3.1.4	Reaction Time at Signals	Major issue	Inconsistent values used for turns in SRC and DUE assignments for both AM and PM periods
3.1.5	Dynamic Cost Functions	No issue	Reviewed. No issues identified

Main findings regarding those modelling parameters and assumptions related to turns are summarised in Table 6.

Table 6: Review findings of modelling parameters and assumptions related to turns

#	Item	Status	Finding
3.2	**Modelling parameters and assumptions - Turns**		
3.2.1	Speeds	No issue	Reviewed. No issues identified
3.2.2	Yellow Box Speeds	No issue	Reviewed. No issues identified
3.2.3	Give Way Time Factor(s)	Minor issue	Give-way Time Factor (Meso) for roundabout turns increased to 2, while not reported

Main findings regarding modelling parameters and assumptions related to sections are summarised in Table 7.

Table 7: Review findings of modelling parameters and assumptions related to sections

#	Item	Status	Finding
3.3	Modelling parameters and assumptions - Sections		
3.3.1	Road Type	No issue	Reviewed. No issues identified
3.3.2	Speed	No issue	Reviewed. No issues identified
3.3.3	Additional reaction time at stop	Moderate issue	Negative values allocated to this attribute for the approaching section of the “City Rd” to “Parramatta Rd”, which is not justifiable
3.3.4	Additional reaction time at traffic light	Moderate issue	Negative values allocated to this attribute for the approaching section of the “City Rd” to “Parramatta Rd”, which is not justifiable
3.3.5	Capacity	No issue	Reviewed. No issues identified
3.3.6	Lane changing cooperation	Moderate issue	Lane changing cooperation of six sections increased from 50% without justification
3.3.7	Queue discharge acceleration factor	Moderate issue	This factor was reduced from 1.0 to 0.5 for Paramatta Rd” and “City-West Link Rd” sections, without justification
3.3.8	Acceleration factor	Major issue	No logic identified in the allocation of acceleration factor to road sections (See Figure 1)

5 Intersections and signalisation

There are of 50 intersections within the study area which are signal controlled. Key aspects of the modelled signal operations are summarised as follows:

- Traffic signal data was sourced from the same day as the surveys and provided in the form of intersection diagnostic monitor (IDM) data;
- Roads and Maritime SCATS system was engaged to extract the intersection diagnostic monitor data;
    - It is noted that the modelled signal operations are fixed-time based;
    - Conversion of in-situ actuated signals to fixed time signals, using the average behaviour of the actuated signals within each hour of the two-hour peaks;
- A standard inter-green time of 6 seconds was applied, incorporating 4 seconds of amber time and 2 seconds of all-red time; and
- The LX Data was interpreted to inform the co-ordination between signals by including signal offsets.

5.1 Review findings

Review findings regarding intersections and signalisation are summarised in Table 8.

Table 8: Review findings of intersections and signalisation

#	Item	Status	Finding
4	**Intersections and signalisation**		
4.1	Control Type	No issue	Reviewed. No issues identified
4.2	Yellow Time	No issue	Reviewed. No issues identified
4.3	Red Percentage	No issue	Reviewed. No issues identified
4.4	Phases	Moderate issue	Node 82756 does not have any movement allocated to third phase. Phasing of the "N4528 SITE 47 – Parramatta Rd & Old Canterbury Rd & Tebbutt St" intersection appears to be incorrect – only one phase of movement defined (minor movements don't have any phase) Phasing of External ID 17437 appears to be incorrect
4.5	Fixed time	No issue	All signalised intersections are modelled as fixed time based, due to the complexity of the network
4.6	Permitted Movements	Moderate issue	Time allocated for pedestrian crossings at signals appear to be too high (assumed 16 seconds in every 80 sec) - (External IDs: 13124, 13604337, 22438)
4.7	Sequences	Minor issue	Phasing of "N4528 SITE 86 - Parramatta Rd & Renwick St & Railway St" intersection appears to be incorrect – only one phase of movement defined (minor movements do not have any phase)

6 Public transport inputs

Key aspects of the public transport modelling are summarised as follows:

- Bus route and timetable information was derived and imported using the General Transit Specification Feed (GTFS);
- Bus dwell time at all stations are defined as below (based on GTFS inputs):
  - Mean = 30 seconds; and
  - Standard deviation = 10 seconds.
- Train services were not modelled since all road-rail junctions in the study area are grade-separated; and
- Light rail services were not modelled since all road-rail junctions in the study area are grade-separated.

6.1 Review findings

Review findings regarding the public transport inputs are summarised in Table 9.

Table 9: Review findings of the public transport inputs

#	Item	Status	Finding
5	**Public Transport Inputs**		
5.1	Public Transport Plans /Lines	Moderate issue	44 bus routes are not connected for the PM peak model. It is caused because of a new section added to the model, but not updated in the routes of these PT lines
5.2	Rail Routes and Stations	No issue	Not existing
5.3	Light Rail Routes and Stops	No issue	Not existing
5.4	Public Transport Stops	No issue	Reviewed. No issues identified

7 Active transport and pedestrians

Pedestrians have not been directly modelled and cyclist volumes and infrastructure were not considered in the PRCUTS Study base year model (PRCUTS Base Model Development Report, pg. 31). The review has concluded that at signalised intersections containing a pedestrian crossing, signal timings have included a phase which holds back left turns to mimic delays experienced by vehicles.

Existing traffic signal timings used for the base year modelling consider the probability of vehicular delay caused by pedestrian crossings. This results in pedestrian phase times which are lower than minimum requirements for pedestrian crossings. Analysis has been undertaken on the signal timing and .lx files received from Roads and Maritime to derive averaged pedestrian crossing timing of three seconds or more. It is noted that traffic signal timings assume that pedestrian crossings are always activated, thus considered a conservative assumption.

Active transport and pedestrian activities on mid-blocks and for walking destinations were not completely coded in the model due to the lack of information.

7.1 Review findings

Review findings regarding active transport and pedestrian inputs to the model are summarised in Table 10.

Table 10: Review findings of active transport and pedestrian inputs

#	Item	Status	Finding
6	**Active transport and pedestrians**		
6.1	Pedestrian crossings at intersections	Minor issue	Mostly coded correctly (with some minor issues, such as Node IDs N_13124, 13604337, N_22438, where inappropriate pedestrian phase durations were defined in the model)
6.2	Allocating required time (intersections)	No issue	A conservative approach was chosen for coding the signal times
6.3	Pedestrian crossings on mid-blocks	No issue	Not coded completely due to the lack of information on mid-block pedestrian paths and walking destinations
6.4	Allocating required movement and time	Minor issue	Mostly coded correctly (with some minor issues, such as N4528 SITE 47, N_17437 and N4528 SITE 86, where phases without any movement were observed)

8 Assignment and convergence

Three different levels of assignment were used to replicate the traffic assignment performance of the network. These assignments were performed in the order shown below and the output of each step was used as the input of the next step. These assignment steps were:

- Static (Frank & Wolfe) assignment at macro level,
- Dynamic User Equilibrium (DUE) assignment at hybrid level,
- Stochastic Route Choice (SRC) assignment at hybrid level

User route choice was first recorded in the path file generated by the static level traffic assignment. This routing was subsequently used as the starting point for the DUE traffic assignment. Static assignment convergence settings were targeted to achieve a 0.10% relative gap within 50 iterations in each peak period.

According to the implemented methodology, the next step was a DUE assignment. In this type of traffic assignment, it is assumed that all the users of a transportation network are familiar with the network and always seeking to minimize their travel time/cost from origins to their respective destinations. At the end of this type of assignment:

- The journey times of all used routes (for any pair of origin-destination) are equal, and less than those which would be experienced by a single vehicle on any unused route (user optimisation)
- The average journey time of the network is minimized (system optimisation)

The model achieves convergence when the relative gap in route costs between successive iterations reduces to below a user-defined threshold. Hybrid DUE convergence outputs show that the models were set to target a convergence of a 3.00% relative gap within 20 iterations in each peak period. In order to accelerate the convergence procedure and reduce the number of possible paths in each iteration, it was defined in the assignment settings to ignore paths containing less than 5% of the total demand for any origin-destination pair.

In the next step, the path file of the DUE assignment at hybrid level was used as the input for a series of SRC assignments. Since operational assignment models (microscopic and mesoscopic) dynamically simulate the traffic interaction and driver behaviour in a stochastic way, small changes on a network element can have significant cumulative impacts upon congestion and delays. To address the stochasticity impact of operational assignment models, the RMS Traffic Modelling Guidelines provides a list of random seed values to be used in SRC assignments to produce small levels of variability, reflecting behaviours exhibited in the real world. In accordance with this, each scenario was simulated using five different seed values to test model stability. The random seed that results in the median level of total vehicle hours travelled (VHT) should be used for model calibration and validation, as well as all future scenario analysis.

8.1 Review findings

Review findings regarding the employed assumptions for assignments and convergence criteria are summarised in the following sections.

8.1.1 Static assignment convergence

Static assignment does not achieve convergence for the AM period based on the 'Relative Gap' of 0.5 per cent (as specified in the tool). It achieved the relative gap of 0.91 after 50 iterations. Considering the importance of the static path file in this model, it is recommended to achieve the specified level of convergence by increasing the number of iterations.

- Convergence is a key modelling target, especially when the resulting path file is used as the main input for DUE and then SRC assignments at hybrid level. Since the calculation of additional path is disabled in the DUE assignment a high level of confidence in the resulting path file of the static assignment is desirable.

8.1.2 Dynamic User Equilibrium (DUE) convergence criteria

Dynamic User Equilibrium (DUE) convergence criteria is relatively loose:

- Relative Gap = 3.00% (default = 0.50%)
- Do Not Consider Paths with a Percentage Below = 5.00% (default = 1.00%)

8.1.3 Calculate additional path for hybrid DUE

The calculation of additional path for Hybrid DUE is disabled for both peak periods. It means that the DUE assignment will only use routes shortlisted in the static assignment results (maximum 3 routes for each origin-destination) and cannot add (or check) new routes.

Static assignment is a relatively inaccurate type of assignment, as it cannot directly consider the impact of signal controls or traffic congestion in route choice.

- As the AM period static assignment was not converged, disabling the calculation of additional paths for DUE could lead to significant shortcomings in the resultant assignment results.

To test the significance of this assumption, the AM and PM hybrid DUE models were re-run as part of the model review with the calculation of additional paths enabled. The resulting convergence graphs for these runs are compared to the original models in Figure 2.

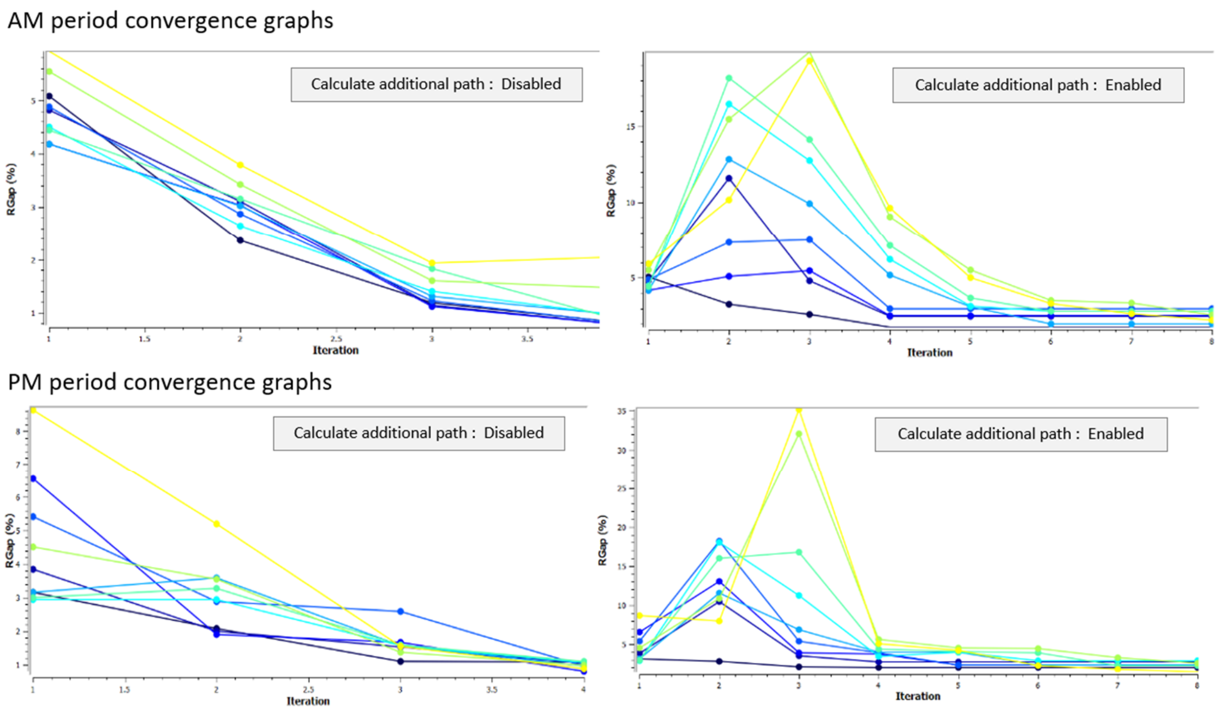


Figure 2: Convergence graphs of DUE hybrid assignments for AM and PM (with and without calculating additional path)

Figure 2 shows convergence graphs with and without calculating additional path have completely different behaviours, which indicates that the network is not under equilibrium condition when the possibility of calculating additional path is disabled.

As presented in Table 11, the comparison of modelling results with and without calculating additional path showed that performance through the model improved. In general, the use of static path file for DUE (without allowing adding new path) will cause more congestion on major roads and lead to:

- Higher delay times
- Lower speeds
- Higher total travel time

Table 11: Model results comparison (updated DUE parameters)

Peak period	Attribute	Unit	Additional Paths Enabled	Additional Paths Disabled	Diff	Diff (%)
AM Peak	Delay time	sec/km	75.75	86.38	10.63	14.0%
	Speed	km/h	27.07	25.89	- 1.18	-4.4%
	VHT	h	6,766	7,091	324.51	4.8%
	VKT	km	165,848	162,216	- 3,632.20	-2.2%
PM Peak	Delay time	sec/km	71.42	82.18	10.76	15.1%
	Speed	km/h	27.64	26.04	- 1.60	-5.8%
	VHT	h	7,089	7,835	746.84	10.5%
	VKT	km/h	183,901	181,934	- 1,966.67	-1.1%

8.1.4 SRC assignments - Seed numbers

The RMS Traffic Modelling Guidelines provides a list of random seed values to be used in SRC assignments and produce small levels of variability to reflect behaviours exhibited in the real world.

- One of the seed values which was supposed to be used in the model is 86524, while 86264 was used instead.

8.1.5 SRC assignments - Route choice variability

There are three different sets of SRC runs in the model for the AM peak period. Their difference is related to the share of users that can choose their route based on cost of each route.

- While three different shares (0%, 10% and 20%) were tested for the AM peak, only one value (0%) was tested for the PM peak
- It is not clear which share was used for the AM peak modelling results.

8.1.6 SRC assignments – Median or average

In figure 3-3 of the PRCUTS Base Model Development Report, it is stated that the median seed for each peak period was used for model calibration and reporting, but no evidence of this approach was found in the report.

8.1.7 Findings summary

Main findings of our review on the employed assumptions for assignments and convergence criteria are summarised Table 12.

Table 12: Review findings on the employed assumptions for assignments and convergence criteria

#	Item	Status	Finding
7	Assignment and convergence		
7.1	Assignment Type	No issue	Reviewed. No issues identified
7-2	Assignment convergence - Static	Major issue	Static assignment does not achieve convergence after 50 iterations for the AM period
7.3	Assignment convergence - Hybrid	Moderate issue	Dynamic User Equilibrium (DUE) convergence criteria is relatively loose: • Relative Gap = 3.00% (default = 0.50%) • Do Not Consider Paths with a Percentage Below = 5.00% (default = 1.00%)
7.4	Route Choice	Major issue	Calculation of additional path for Hybrid DUE was disabled
7.5	Path Files	Minor issue	Only a sub-path of static assignment was used as inputs for DUE assignment
7.6	Replication Seeds (SRC runs)	Minor issue	Five replications were developed, but no evidence found in the report for using the results of the median seed for reporting
7.7	Seed Values	Minor issue	Instead of the recommended value by RMS guidelines (86524), 86264 was used as the seed number
7.8	Route Choice Variability	Moderate issue	It is recommended to consider some level of variability in the route choice of SRC runs, but it is not considered for PM peak SRC runs

9 Calibration and validation

The PRCUTS model was developed as a Hybrid (microscopic/mesoscopic) model and it is stated in the base year model development report that the procedure of calibration and validation was according to the principles outlined in:

- Traffic Modelling Guideline (Roads and Maritime, 2013),
- Mesoscopic Network Representation – Protocols for Model Handling (TfNSW, 2016), and
- Mesoscopic Network Representation – Aimsun Network Coding Guidelines (TfNSW, 2016).

9.1 Model calibration

A comparison of assigned turning movement volumes against observed turning movement traffic count data was used to check the level of model calibration (PRCUTS Base Model Development Report, pg. 35). Table 11.1 of the RMS Traffic Modelling Guideline was referenced for checking the calibration of the PRCUTS model, for both the mesoscopic and microscopic sections of the model.

According to the criteria listed in Table 11.1 of the RMS guideline, the GEH value of at least 85% of turns should be less than 5 and justification is required for any turn with GEH greater than 10. However, revised criteria were agreed in a meeting with Department of Planning and Environment and Inner West Council on March 15th 2019, specifying that a GEH of less than 5 should be achieved for at least 75% of sites, and that a GEH of less than 10 should be achieved at 95% of sites (PRCUTS Base Model Development Report, pg. 35).

9.2 Model validation

Travel time data on eight major corridors of the study area was extracted and processed from the TomTom database for a four-week period. Table 11.5 of the RMS Traffic Modelling Guideline was referenced for checking the validity of the developed PRCUTS model. Accordingly, modelled and observed travel times along key routes should be within 15 per cent or one minute (whichever is greater) of the average observed travel time for the full length of the route for at least 95 per cent of observed travel time routes (PRCUTS Base Model Development Report, pg. 41).

9.3 Review findings

9.3.1 Core area calibration criteria

Although PRCUTS model was developed as a hybrid model, the calibration criteria for the “core area” (Table 11.2 of the RMS Traffic Modelling Guideline) was not checked for the microsimulation area of the model. The criteria used for checking microsimulation core area is based on comparison of flow differences rather than GEH.

Since the microsimulation area of the model is defined as the core area of the model, it is expected that the level of calibration of the model for this area be checked based on the criteria listed in Table 11.2 of the RMS guideline. However, only the “network wide” criteria from Table 11.1 of the RMS Traffic Modelling Guideline was used.

9.3.2 Adjusted criteria was not met

Based on the calibration results presented in the Table 4-3 of the PRCUTS base-year model development report, the developed model did not satisfy the adjusted criteria for one hour of the simulation period (5:30-6:30 PM). The statement provided in the report regarding this was that "this is attributed to the impacts of peak spreading for the PM peak hour and the dispersion of traffic from Parramatta Road to the surrounding road network due to congestions along the corridor." (PRCUTS Base Model Development Report, pg. 36). This is not considered to be an acceptable justification for the calibration results.

9.3.1 Reporting

According to Table 11.1 of the RMS Traffic Modelling Guideline, GEH =5 tolerance limits should be included in the plots of observed vs modelled hourly flows. These lines were not provided in the relevant figures in reporting (figures 4-1 to 4-8 of the PRCUTS base-year model development report).

According to Table 11.5 of the RMS Traffic Modelling Guideline, average and 95 per cent confidence intervals are to be plotted for observed and modelled travel times for each journey time route. These figures are missing in the report.

9.3.2 Validation criteria was not met

Sufficient information to justify the validation of travel times was not provided for this model. Based on RMS guidelines, the cumulative graph of travel time along each route should be created and observed and modelled results for each segment should be compared separately. These plots were not provided in reporting.

The processing of simulated travel time data for major routes of the study area showed that some key routes did not achieve the validation criteria:

- AM Peak period: The review of the modelled travel time outputs showed that the travel time criteria were not met for the WB direction of Route #4 (Booth Street and Moore Street between Paramatta Road and Catherine Street).
- PM Peak period: The validation criteria were not met for the EB direction of Route #5 (Collins Street and Marion Street between Johnston and Ramsay Streets) and the EB direction of Route #6 (Paramatta Road between Orrington Street and Princes Highway). It means that only 88% observed travel time routes met the criteria (which is less than 95%).

9.3.3 Stability check

As traffic simulation models are stochastic in nature, small changes in demand or supply can have significant cumulative impacts on modelling results. A sensitivity analysis must be undertaken to compare the relative performance of a model for a number of recommended seed values to evaluate the stability of modelling results. Section 11.7 of the RMS Modelling guidelines (RMS, 2013) provide guidance on model stability. No evidence of a stability check was found in the report.

9.3.4 Findings summary

The main findings of the review of calibration and validation results are summarised Table 13.

Table 13: Review findings on calibration and validation results

#	Item	Status	Finding
8	**Model Calibration and Validation**		
8.1	Model Calibration Check	Major issue	Calibration criteria for the "Core" area were not reported. Locations with GEH greater than 10 were not discussed.
8.2	Model Validation Check	Major issue	Sufficient information to justify the validation of travel times was not reported. It is noted that key routes did not achieve the validation criteria.
8.3	Model Stability Check	Major issue	Not provided
8.4	Reporting	Major issue	GEH =5 tolerance lines are missing in observed vs modelled hourly flow plots. Average and 95 percent confidence plots for observed and modelled travel times for each route is missing

10 Conclusion and recommendations

The review of the Parramatta Road Corridor Urban Transformation Transport Study base year model has shown that many aspects of the model should be updated to ensure it provides a robust basis from which to forecast future year performance and identify appropriate road infrastructure requirements to support planned urban growth.

We recommend the base model be revised primarily to address issues identified in the assignment process. The calibration results should also be revised and further information on validation checks are needed to ensure the model provides a suitable baseline representation of traffic movements on the network during both the AM and PM peak periods.

The main findings of the review are summarised in Table 14.

Table 14: Findings Summary

#	Item	Status	Finding
1	**Model Development**		
1.1	Aimsun Version	No issue	Aimsun Next 8.2.3 (R54491)
1.2	Methodology - Network coding	No issue	Generally acceptable
1.3	Methodology - Demand processing	No issue	Generally acceptable
1.4	Database definition and connection	Minor issue	Database of the model was not defined correctly. PM assignment results are not existing in the model.
1.5	Data collection	No issue	Acceptable coverage
1.6	Model dimensions / scale	No issue	Model determined to be correct scale based on spot checks
1.7	Layers	No issue	Checked
1.8	Background image file	No issue	Not available
1.9	Background coordinate system	No issue	No issues identified
1.10	Model Time Periods	No issue	Checked. Well supported
1.11	Pre-Peak Warm-Up	No issue	Included
1.12	Model Layout and Configuration	No issue	No issues identified
1.13	Vehicle Types	No issue	Checked. Well documented
1.14	Road and Lane Types	No issue	Reviewed. No issues identified
2	**Demand Development**		
2.1	Centroid Configuration	Minor issue	A zoning system refinement was expected considering the nature of the area
2.2	Centroid Configuration Name	No issue	No issues identified
2.3	Real Data Sets	No issue	Reviewed. No issues identified
2.4	Unavailable PM results	Moderate issue	No assignment results were existing in the database for PM period
2.5	Traffic Demands matrices	No issue	Reviewed. No issues identified
2.6	Origin - Destination Matrices	No issue	Reviewed. No issues identified
2.7	Origin - Destination Matrix Names	No issue	Reviewed. No issues identified
2.8	Traffic Demand Names	No issue	Reviewed. No issues identified
2.9	Static OD Adjustment	Major issue	Results of a re-run showed relatively different results
2.10	Static Departure Adjustment	Minor issue	Insufficient warm-up duration was considered in the model
2.11	Dynamic OD adjustment	Major issue	No evidence found in the model for this step
2.12	Path Assignment Names	No issue	Reviewed. No issues identified
2.13	Documentation of assumptions	No issue	Reviewed. No issues identified
3.1	**Modelling parameters and assumptions - General**		
3.1.1	Arrival Type	No issue	Reviewed. No issues identified
3.1.2	Attractiveness weight	Minor issue	It is recommended to increase this weight (from zero) to be able to consider the impact of road hierarchy in the route choice decisions of vehicles. The value of zero means that there is no difference between local and arterial roads for route choice of users
3.1.3	Reaction Time at Stop	Major issue	Inconsistent values used for turns in SRC and DUE assignments for both AM and PM periods
3.1.4	Reaction Time at Signals	Major issue	Inconsistent values used for turns in SRC and DUE assignments for both AM and PM periods

#	Item	Status	Finding
3.1.5	Dynamic Cost Functions	No issue	Reviewed. No issues identified
3.2	**Modelling parameters and assumptions - Turns**		
3.2.1	Speeds	No issue	Reviewed. No issues identified
3.2.2	Yellow Box Speeds	No issue	Reviewed. No issues identified
3.2.3	Give Way Time Factor(s)	Minor issue	Give-way Time Factor (Meso) for roundabout turns increased to 2, while not reported
3.3	**Modelling parameters and assumptions - Sections**		
3.3.1	Road Type	No issue	Reviewed. No issues identified
3.3.2	Speed	No issue	Reviewed. No issues identified
3.3.3	Additional reaction time at stop	Moderate issue	Negative values allocated to this attribute for the approaching section of the "City Rd" to "Parramatta Rd", which is not justifiable
3.3.4	Additional reaction time at traffic light	Moderate issue	Negative values allocated to this attribute for the approaching section of the "City Rd" to "Parramatta Rd", which is not justifiable
3.3.5	Capacity	No issue	Reviewed. No issues identified
3.3.6	Lane changing cooperation	Moderate issue	Lane changing cooperation of six sections increased from 50% without justification
3.3.7	Queue discharge acceleration factor	Moderate issue	This factor was reduced from 1.0 to 0.5 for Paramatta Rd" and "City-West Link Rd" sections, without justification
3.3.8	Acceleration factor	Major issue	No logic identified in the allocation of acceleration factor to road sections (See Figure 1)
4	**Intersections and signalisation**		
4.1	Control Type	No issue	Reviewed. No issues identified
4.2	Yellow Time	No issue	Reviewed. No issues identified
4.3	Red Percentage	No issue	Reviewed. No issues identified
4.4	Phases	Moderate issue	Node 82756 does not have any movement allocated to third phase. Phasing of the "N4528 SITE 47 – Parramatta Rd & Old Canterbury Rd & Tebbutt St" intersection appears to be incorrect – only one phase of movement defined (minor movements don't have any phase) Phasing of External ID 17437 appears to be incorrect
4.5	Fixed time	No issue	All signalised intersections are modelled as fixed time based, due to the complexity of the network
4.6	Permitted Movements	Moderate issue	Time allocated for pedestrian crossings at signals appear to be too high (assumed 16 seconds in every 80 sec) - (External IDs: 13124, 13604337, 22438)
4.7	Sequences	Minor issue	Phasing of "N4528 SITE 86 - Parramatta Rd & Renwick St & Railway St" intersection appears to be incorrect – only one phase of movement defined (minor movements do not have any phase)
5	**Public Transport Inputs**		
5.1	Public Transport Plans /Lines	Moderate issue	44 bus routes are not connected for the PM peak model. It is caused because of a new section added to the model, but not updated in the routes of these PT lines
5.2	Rail Routes and Stations	No issue	Not existing

#	Item	Status	Finding
5.3	Light Rail Routes and Stops	No issue	Not existing
5.4	Public Transport Stops	No issue	Reviewed. No issues identified
6	**Active transport and pedestrians**		
6.1	Pedestrian crossings at intersections	Minor issue	Mostly coded correctly (with some minor issues, such as Node IDs N_13124, 13604337, N_22438, where inappropriate pedestrian phase durations were defined in the model)
6.2	Allocating required time (intersections)	No issue	A conservative approach was chosen for coding the signal times
6.3	Pedestrian crossings on mid-blocks	No issue	Not coded completely due to the lack of information on mid-block pedestrian paths and walking destinations
6.4	Allocating required time (mid-blocks)	Minor issue	Mostly coded correctly (with some minor issues, such as N4528 SITE 47, N_17437 and N4528 SITE 86, where phases without any movement were observed)
7	**Assignment and convergence**		
7.1	Assignment Type	No issue	Reviewed. No issues identified
7-2	Assignment convergence - Static	Major issue	Static assignment does not achieve convergence after 50 iterations for the AM period
7.3	Assignment convergence - Hybrid	Moderate issue	Dynamic User Equilibrium (DUE) convergence criteria is relatively loose:
7.4	Route Choice	Major issue	• Relative Gap = 3.00% (default = 0.50%)
7.5	Path Files	Minor issue	• Do Not Consider Paths with a Percentage Below = 5.00% (default = 1.00%)
7.6	Replication Seeds (SRC runs)	Minor issue	Calculation of additional path for Hybrid DUE was disabled
7.7	Seed Values	Minor issue	Only a sub-path of static assignment was used as inputs for DUE assignment
7.8	Route Choice Variability	Moderate issue	Five replications were developed, but no evidence found in the report for using the results of the median seed for reporting
8	**Model Calibration and Validation**		
8.1	Model Calibration Check	Major issue	Calibration criteria for the “Core" area were not reported. Locations with GEH greater than 10 were not discussed.
8.2	Model Validation Check	Major issue	Sufficient information to justify the validation of travel times was not reported. It is noted that key routes did not achieve the validation criteria.
8.3	Model Stability Check	Major issue	Not provided
8.4	Reporting	Major issue	GEH =5 tolerance lines are missing in observed vs modelled hourly flow plots. Average and 95 percent confidence plots for observed and modelled travel times for each route is missing

DOCUMENT CHECKING (not mandatory for File Note)

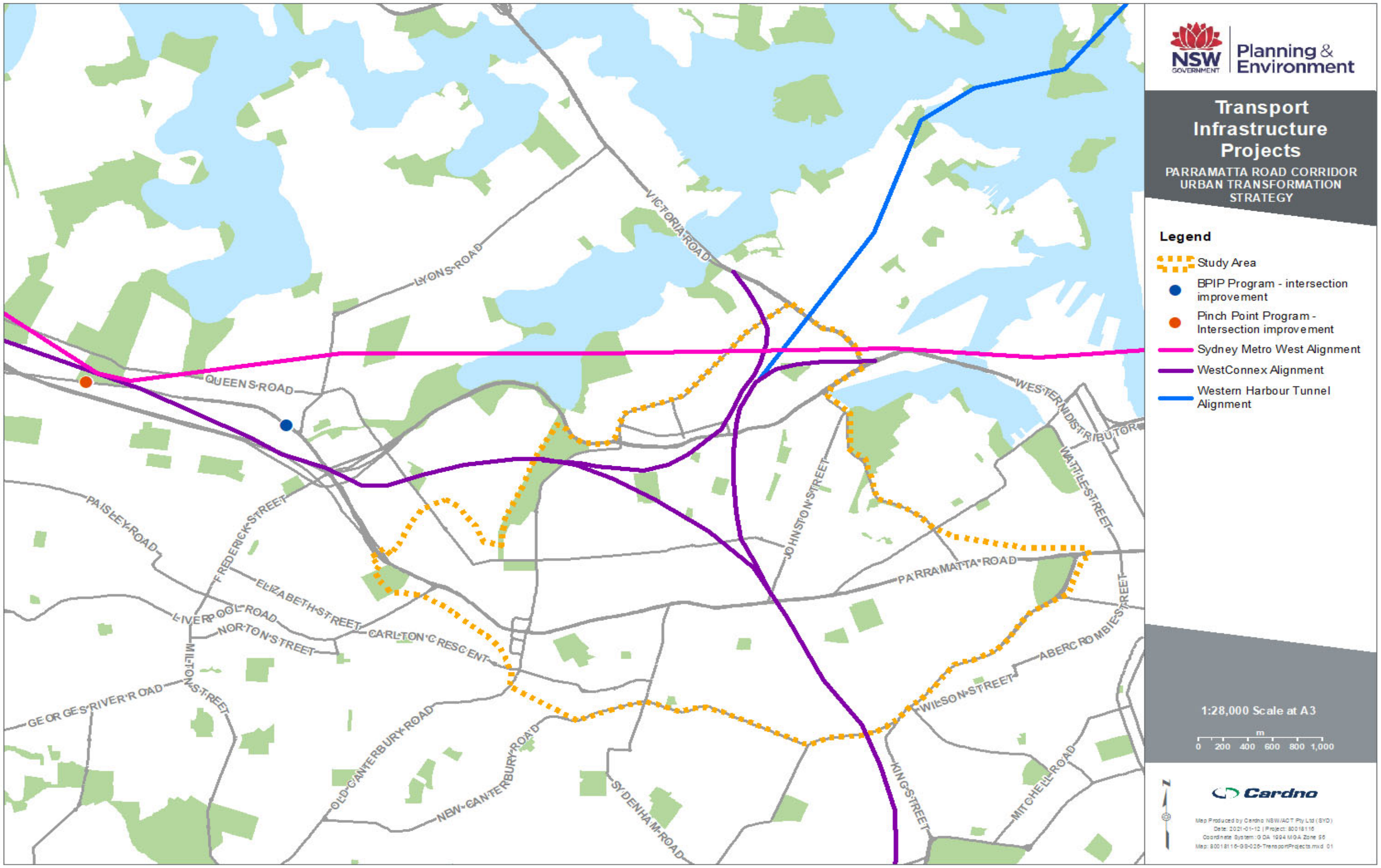
	Prepared by	Checked by	Approved by
Name	Hamid Safi	Roland Cathcart	Roland Cathcart
Signature			

APPENDIX

C

TRANSPORT PROJECTS FOR MODELLING

No	Project	Program	Status	Description	Source	Coded in model	New data received? I.e. dwg/ signal data.
1	Parramatta Road public transport improvements	Future Transport 56	Planning	Planning and considerations. Note, there is nothing to be incorporated into modelling at this stage.	https://future.transport.nsw.gov.au/delivering-future-transport-2056#greater-sydney https://www.infrastructureaustralia.gov.au/map/public-transport-capacity-parramatta-road-and-victoria-road-corridors	Nothing to be incorporated into the model	
2	Western Harbour Tunnel and Beaches Link		Planning	The Western Harbour Tunnel will connect to WestConnex at the Rozelle Interchange, cross under Sydney Harbour between the Birchgrove and Waverton areas and connect with the Warringah Freeway at North Sydney.	https://www.rms.nsw.gov.au/projects/index.html	✓	
3	WestConnex	WestConnex	In construction	The WestConnex M4 Tunnels opened to traffic in July 2019. WestConnex M4 (the New M4 Tunnels and the Widened M4), includes 5.5km tunnels and around 7.5km of surface roads. The WestConnex M4 links to the M4 at Parramatta in the west, and Wattle Street and Parramatta Road at Haberfield to the east. The WestConnex M4 will also connect to the M4-M5 Link Tunnels and Rozelle Interchange in 2023. The M4-M5 Link Tunnels project is the final and most critical component of WestConnex, featuring twin tunnels between the New M4 Tunnels at Haberfield and the M8 at St Peters. Each tunnel will be approximately 7.5km long and able to accommodate up to four lanes of traffic in each direction.	https://www.westconnex.com.au/explore-westconnex/interactive-map/	✓	
4	Intersection improvements at Parramatta Road and Shaftesbury Road, Concord	Pinch Point Program	In construction	Roads and Maritime Services is upgrading the intersection of Parramatta Road and Shaftesbury Road, Concord. The improvements will reduce congestion and improvement travel times on Parramatta Road, and increase the capacity for vehicles turning right into Shaftesbury Road.	https://www.rms.nsw.gov.au/projects/parramatta-rd-shaftesbury-rd-concord/index.html	Outside study area	
5	Arlington Street, Croydon Road and Parramatta Road intersection improvements (BPIP)	BPIP	Completed (Dec 2020)	In December 2020 work at the intersection of Parramatta Road, Arlington Street and Croydon Road, Five Dock and Croydon was completed.	https://www.rms.nsw.gov.au/projects/arlington-st-croydon-rd-parramatta-rd/index.html	Outside model area	
6	Sydney Metro West	Sydney Metro	Planning	The Sydney Metro West project will support a growing city and deliver world-class metro services to more communities. This new underground railway will connect Greater Parramatta and the Sydney CBD.	https://www.sydneymetro.info/west/project-overview	No road geometry changes	
7	City West Link, Dobroyd Parade and Wattle Street - Victoria Road, Rozelle to Parramatta Road, Ashfield	Sydney Clearways Strategy	Completed	New and extended clearways on City West Link, Dobroyd Parade and Wattle Street between Victoria Road, Rozelle and Parramatta Road, Ashfield.	https://www.rms.nsw.gov.au/projects/index.html	No road geometry changes	
8	City West Link improvement work		Completed	Roads and Maritime Services has completed the improvement of City West Link between Haberfield and Leichhardt in March 2019. An additional eastbound lane was opened to traffic in December 2018.	https://www.rms.nsw.gov.au/projects/city-west-link/index.html	✓	
9	Parramatta Road improvement work, Leichhardt		Completed	Improving traffic flow along Parramatta Road between Rofe Street and Cannon Street, Leichhardt to make your journey easier, faster and safer. (Lengthen right turn lane into Crystal Street).	https://www.rms.nsw.gov.au/projects/parramatta-road-improvement-work-leichhardt/index.html	✓	
10	Parramatta Road improvement work, Taverners Hill		Completed	Improving traffic flow and travel time reliability by adding a third lane on Parramatta Road	https://www.rms.nsw.gov.au/projects/parramatta-road-taverners-hill/index.html	✓	



NSW GOVERNMENT
Planning & Environment
Transport Infrastructure Projects
PARRAMATTA ROAD CORRIDOR URBAN TRANSFORMATION STRATEGY
Legend
Study Area
BPIP Program - intersection improvement
Pinch Point Program - Intersection improvement
Sydney Metro West Alignment
WestConnex Alignment
Western Harbour Tunnel Alignment
1:28,000 Scale at A3
m
0 200 400 600 800 1,000
Cardno
VICTORIA ROAD
LYONS ROAD
QUEENS ROAD
WESTERN DISTRIBUTOR
WATTLE STREET
JOHNSTON STREET
PARRAMATTA ROAD
PAISLEY ROAD
FREDERICK STREET
ELIZABETH STREET
LIVERPOOL ROAD
NORTON STREET
CARLTON CRESCENT
MILTON STREET
GEORGES RIVER ROAD
OLD CANTERBURY ROAD
NEW CANTERBURY ROAD
SYDENHAM ROAD
KING STREET
WILSON STREET
ABERCROMBIE STREET
MITCHELL ROAD

APPENDIX

D

STRATEGIC TRANSPORT MODELLING INTERFACE METHODOLOGY (VIAE CONSULTING, OCTOBER 2020)

Memorandum

VIAE
CONSULTING

Subject	**Strategic transport modelling interface methodology**		
Project	Parramatta Road Corridor Urban Transformation Strategy – Transport Modelling		
Project No	VC015	**File**	VC010M01_Scoping report review.docx
Prepared by	Iwan Smith	**Phone No**	0407 439 100
To	James Hall	**Copies to**	Malcolm Bradley

1. Introduction

This memorandum outlines the proposed methodology for interfacing strategic transport modelling associated with Parramatta Road Corridor Urban Transformation Strategy (PRCUTS) with simulation traffic modelling being undertaken for each precinct by Local Government.

This memorandum covers the following components of this interface:

- Land use assumptions
- Public Transport Project Model (PTPM) Precinct Parking Module (PPM)
- Identification of nominal road network capacity

2. Land use assumptions

Land use assumptions have been adopted for the following precincts within the PRCUTS study area base on forecast population and employment from Councils:

- Granville (Cumberland Council and City of Parramatta Council)
- Auburn (Cumberland Council and City of Parramatta Council)
- Homebush (Canada Bay Council, Strathfield Council and Burwood Council)
- Burwood (Canada Bay Council and Burwood Council)
- Kings Bay (Canada Bay Council and Inner West Council)
- Taverners Hill (Inner West Council)
- Leichhardt (Inner West Council)
- Camperdown (Inner West Council)

These land use assumptions have been combined with the standard land use scenario (TZP2016) to form the basis of the forecast land use that will be used to assess the transport impacts of the changes in land use proposed as part of the PRCUTS.

3. Public Transport Project Model

The Public Transport Project Model (PTPM) has been run with the land use and travel demand from STM as noted in Section 2. The purpose of the PTPM for the PRCUTS transport modelling is to refine the multi-modal assignment of travel demand, in particular to generate traffic demand forecasts that are more accurately matched to the capacity of the road network as it would exist in future forecast years. This will be achieved through use of the Precinct Parking Module, which applied additional travel costs to the private vehicle mode to reduce the utility of private vehicle travel and reflect capacity constraints that would otherwise not be accounted for.

It is noted that PTPM only models the morning peak period and that additional pivoting of PTPM demand is required to generate evening peak traffic volume forecasts.

The key challenge in applying the PPM for the purposes of forecasting future traffic demand is to select a defensible value for the additional cost penalty used to suppress private car demand. Ideally, the penalty value would be applied globally across the GMA and the selection of the penalty value would be based on a comparison of the resulting traffic volumes from PTPM against an appropriate estimate of network traffic capacity. Identifying the network capacity to select the appropriate penalty value is the primary focus of this document.

To date, PTPM has been run with the following values for PPM penalty (on a global basis)

- No penalty
- 15-minute penalty
- 30-minute penalty
- 45-minute penalty
- 60-minute penalty

4. Identification of network capacity

The primary challenge of interfacing PTPM forecast traffic demand with more detailed simulation modelling is identifying the practical capacity of the road network under future traffic conditions. Two key considerations must be resolved to be able to select an appropriate penalty for car travel in PPM:

- Identifying the point at which a traffic network is at or close to capacity
- Matching the forecast traffic capacity in the simulation model with a forecast demand and accompanying PPM penalty in PTPM.

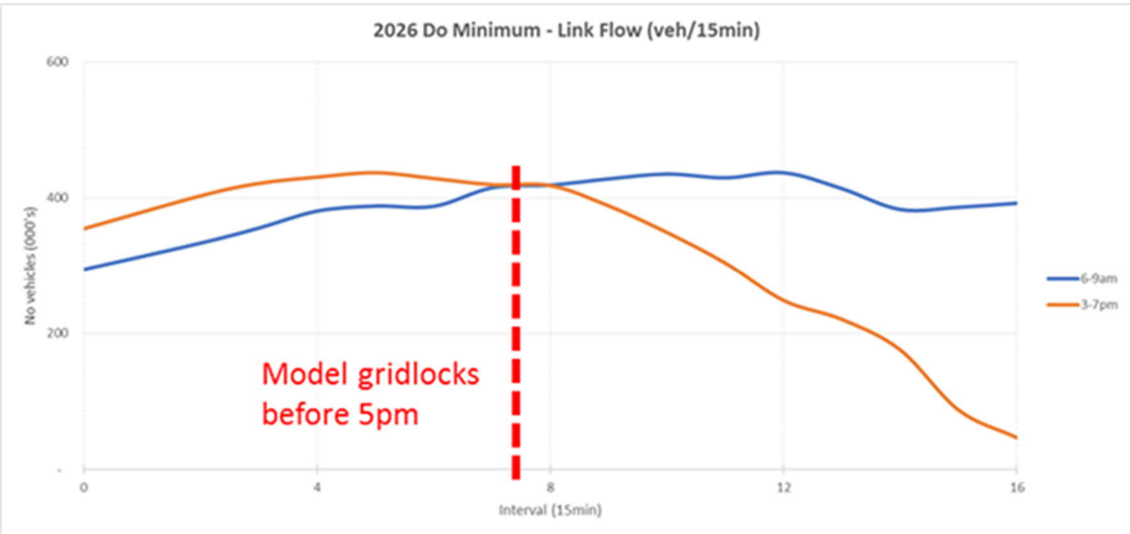
4.1. Identifying network traffic capacity

The practical capacity of the road network can be characterised as the point at which the delay experienced by vehicles making a trip during the peak period exceeds the utility that the vehicle gains by making the trip. This breakpoint is difficult to assess on a trip-by-trip basis within a model, however broader network-wide metrics can be used as a proxy to determine when the network capacity is exceeded:

1. Individual average trip speeds drop below a set level (say 10km/hr)
2. Unreleased vehicles exceed a given level (say more than 5% of total demand at aggregate level and more than 10% at the zone level))
3. Network throughput remains consistent across the modelled peak period.

For wide-area simulation models in urban environments, the primary model of failure when demand exceeds capacity is usually the result of network gridlock where vehicles become stuck in stationary queues and block throughput in the rest of the model.

This blocked state can be identified by plotting total vehicle throughput in the model over the modelled period, as shown in Figure 1.



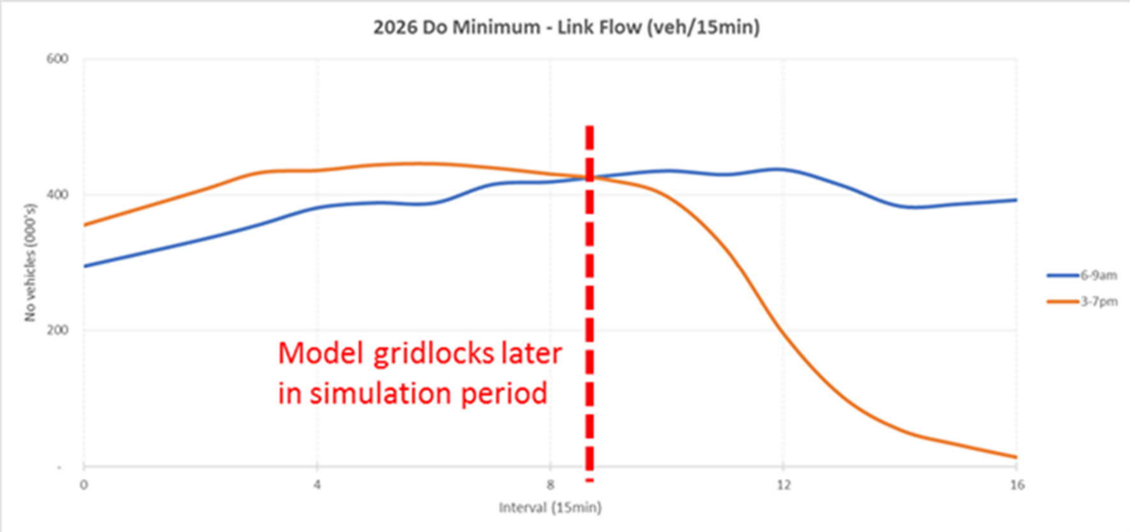


Figure 1 – Example of identification of network gridlock

Ideally, the network traffic capacity should correspond to the highest traffic demand that can be accommodated on the network during the peak period prior to the network reaching a "blocked" state, with throughput remaining relatively constant through the peak period as shown in Figure 2.

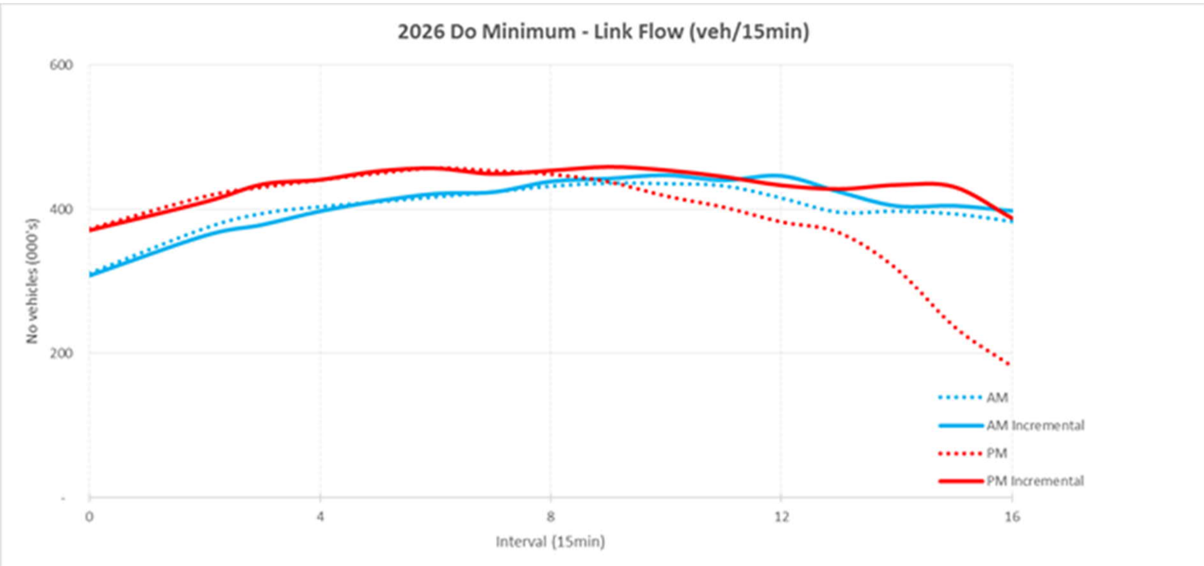


Figure 2 – Example of modelled throughput for a network at capacity

4.2. Matching network capacity between models

Once a practical peak period capacity has been identified, a metric is required to match the assigned traffic volume from PTPM with the identified network capacity from the simulation model. Metrics that would be candidates for this would be:

1. **Traffic volumes on specific links within the study area**: may be problematic due to differences in the detail of network and assignment between models
2. **Overall traffic demand or traffic growth within the study area**: may be problematic due to the differences in base travel demand and resolution of travel zones between models
3. **Cumulative VKT across the study area**: may be problematic to compare VKT directly, but equivalent proportional change in VKT may be a good metric.

To best account for the differences in model coverage, zonal resolution, base matrices and volume delay response, Option 3 (cumulative VKT) is considered the best candidate for matching equivalent demand scenarios between mesoscopic and strategic models.

5. Proposed strategic modelling interface

A summary of the proposed transport model interface is shown in Figure 3. This workflow describes the relationship of PTPM and mesoscopic model streams and process for selection and finalisation of treated demand is STFM as well as follow-up PTPM modelling to identify additional service requirements that may be required to support the modelled shift from private vehicle to other modes.

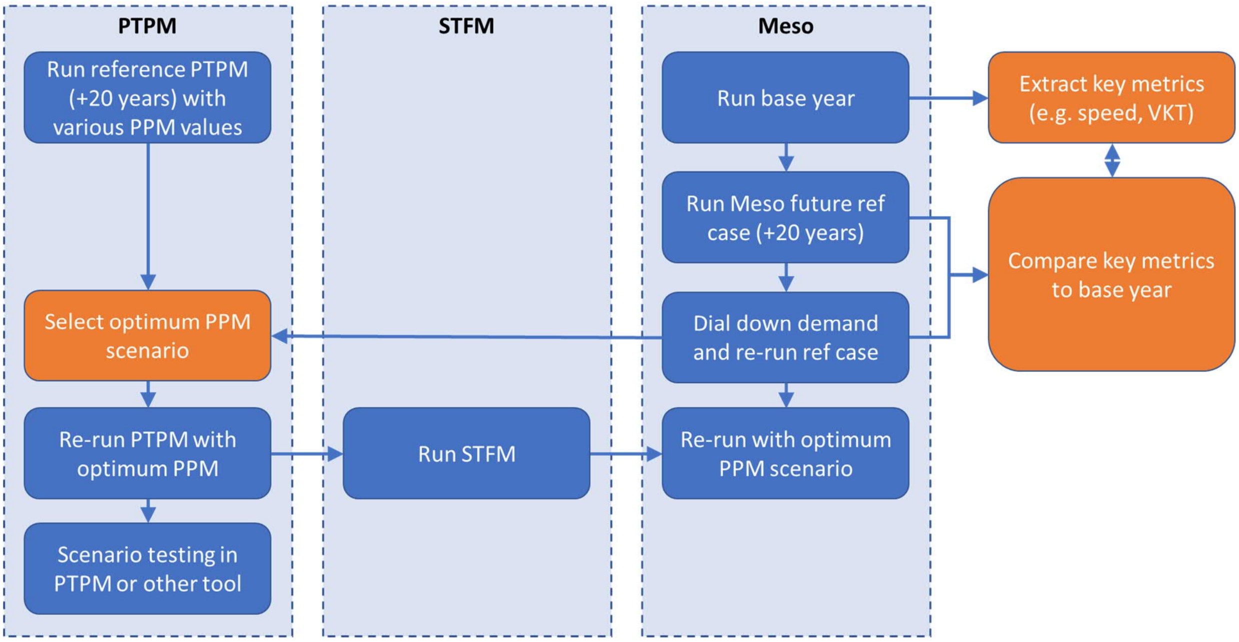


Figure 3 – Proposed strategic model interface

APPENDIX

E

PRCUTS TRANSPORT MODEL UPDATE
RECOMMENDATIONS ACTION PLAN (PWC, JUNE 2021)

Cardno®

Parramatta Road Corridor Urban Transformation Strategy Transport Model Update Action Plan Delivery Technical Note

To: Planning Delivery Unit, Department of Planning, Industry and Environment
From: PricewaterhouseCoopers
Date: 24 June 2021
Subject: **Parramatta Road Corridor Urban Transformation Strategy (PRCUTS) Transport Model Update Action Plan Delivery Technical Note**

PwC was commissioned by the Department of Planning, Industry and Environment ("DPIE") to undertake a review of the Parramatta Road Corridor Urban Transformation Strategy ("PRCUTS") Inner West AIMSUN hybrid model and the methodology applied to estimate forecast traffic growth, put forward recommendations and develop an Action Plan to deliver those.

This technical note provides a summary of the delivery of the Action Plan which covers the following activities:

1. Land use redistribution (undertaken by Transport for NSW ("TfNSW").
2. Sydney Strategic Travel Model ("STM"), Public Transport Project Model ("PTPM") and Parking Precinct Module ("PPM") runs (undertaken by TfNSW).
3. Provision of PTPM car demand matrices in Travel Zone 2016 ("TZ16") format for morning ("AM") peak period (undertaken by TfNSW).
4. Application of RAND method growth in Sydney Strategic Traffic Forecasting Model ("STFM") to be in line with PTPM growth for cars (undertaken by PwC).
5. Extract cordon matrices and produce volume plots from STFM models for each of the PRCUTS traffic study teams (undertaken by PwC).
6. Test the updated growth matrices for the 2026 AM and evening ("PM") peak period without development scenarios for the Inner West City Council study area in AIMSUN (undertaken by PwC).

1. Land use redistribution (undertaken by TfNSW)

Individual PRCUTS teams provided land use information for their respective PRCUTS study area:

1. Inner West (growth provided by SGS and applied by PwC).
2. Canada Bay, Burwood and Strathfield (provided by Bitzios).
3. Parramatta and Cumberland (provided by GTA).

The following land use scenarios were modelled:

1. 2026 without development.
2. 2026 with development.
3. 2036 without development.
4. 2036 with development.

Population and employment forecasts from each of the three study areas were collated to modelling scenarios and redistributed by TfNSW across the whole of Sydney Greater Metropolitan Area ("GMA"). Table 1 and Table 2 below provide population and employment totals respectively, together with annual linear growth summary by study area.

Table 1: Population by PRCUTS study area with and without development.

Study Area	Population					Linear annual growth			
	STM Base	Without Development		With Development		Without Development		With Development	
	2016	2026	2036	2026	2036	2026	2036	2026	2036
Parramatta, Cumberland	17,936	28,278	30,441	34,029	48,574	6%	3%	9%	9%
Canada Bay, Burwood and Strathfield	34,896	36,369	36,369	62,088	94,250	0%	0%	8%	9%
Inner West	91,207	99,398	101,725	103,050	108,144	1%	1%	1%	1%

Table 2: Employment by PRCUTS study area with and without development.

Study Area	Employment					Linear annual growth			
	STM Base	Without Development		With Development		Without Development		With Development	
	2016	2026	2036	2026	2036	2026	2036	2026	2036
Parramatta, Cumberland	15,661	21,142	28,844	20,911	31,311	3%	4%	3%	5%
Canada Bay, Burwood and Strathfield	23,307	23,588	23,588	27,274	34,032	0%	0%	2%	2%
Inner West	48,133	55,454	66,702	62,033	74,115	2%	2%	3%	3%

2. STM, PTPM and PPM runs (undertaken by TfNSW)

TfNSW ran the STM with the updated land use. The STM mechanised demand was fed into the PTPM with the PPM applied.

3. Provision of PTPM car demand matrices in TZ16 format for AM peak (undertaken by TfNSW)

TfNSW extracted the AM car matrices from PTPM. The AM PTPM matrices were then transposed by TfNSW to serve as PM car matrices.

Light commercial vehicles ("LCV") and heavy vehicles ("HV") were sourced from the STM.

4. Application of RAND method growth in STFM to be in line with PTPM growth for car (undertaken by PwC)

The STFM is an all-vehicle model. PwC has segmented the STFM assignment from one user class into the following three user classes:

1. Car.
2. LCV.
3. HV.

This segmentation allows for the application of growth inline with how it is applied in the STM. The RAND method was applied to car vehicles only. The LCV growth is based on the Light Commercial Vehicle Model ("LCVM") and HV growth is based on the Freight Movement Model ("FMM").

Table 3 provides a summary of car growth in PTPM and STFM in the Inner West Council PRCUTS study area.

Table 3: Comparison of PTPM and STFM trip growth in 2-hour AM peak (Inner West Council area zones).

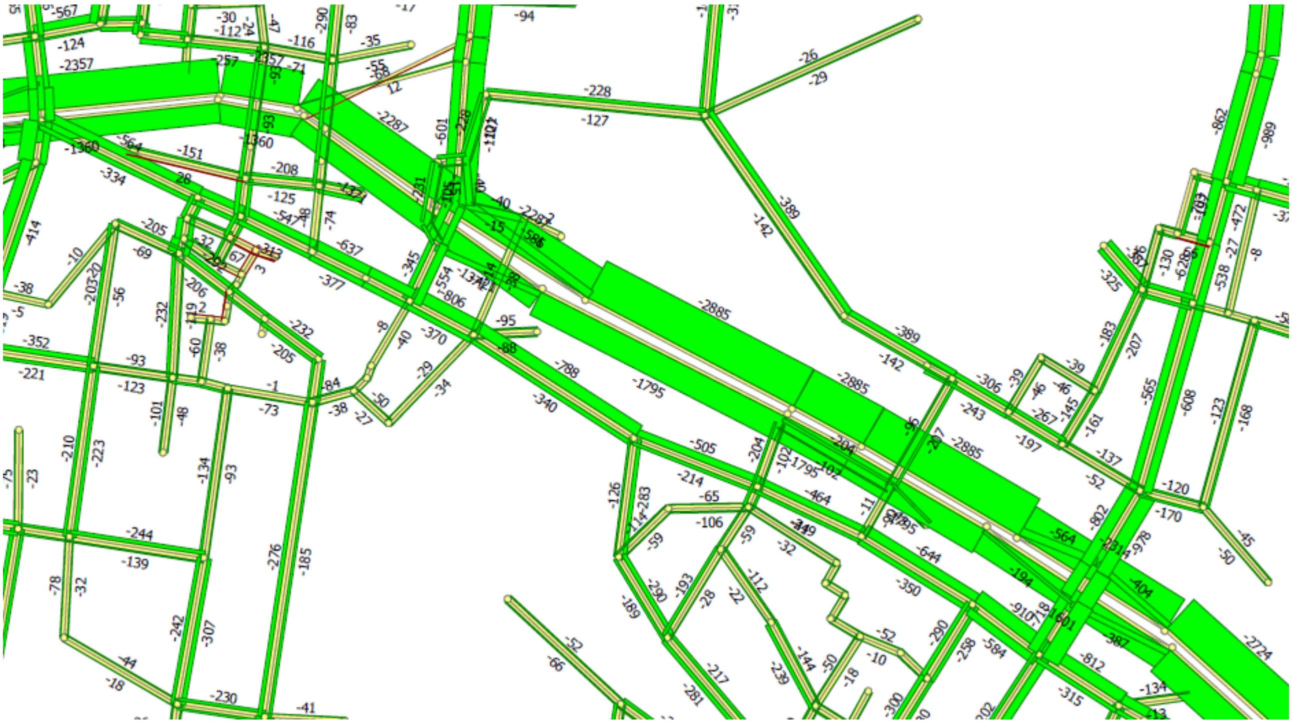
	Growth (Absolute)			Growth (%)		
From 2019 to 2026	**Population**	**Employment**	**Population + Employment**	**Population**	**Employment**	**Population + Employment**
Population and Employment forecasting (Internal Zones)						
PRCUTS Zones	3,855	5,414	9,269	15.60%	21.90%	20.70%
Other Zones	2,056	2,438	4,493	5.77%	6.84%	8.39%
Total	5,911	7,851	13,762	9.80%	13.01%	13.99%
From 2019 to 2026	**Origin**	**Destination**	**Origin + Destination**	**Origin**	**Destination**	**Origin + Destination**
PTPM AM 2-hour demand forecasting						
PRCUTS Zones	1,182	2,143	3,325	9.13%	25.28%	15.52%
Other Zones	424	169	593	5.45%	1.63%	3.26%
Total	1,606	2,312	3,918	7.75%	12.26%	9.89%
STFM AM 2-hour demand forecasting						
PRCUTS Zones	829	1,836	2,665	16.21%	30.78%	24.06%
Other Zones	-18	84	66	-0.25%	1.42%	0.50%
Total	811	1920	2731	6.60%	16.17%	11.30%

5. Extract cordon matrices and produce volume plots from STFM models for each of the PRCUTS traffic study teams (undertaken by PwC)

2-hour AM and PM peak STFM all-vehicle volume plots and cordon matrices by user class have been extracted by study area.

Figure 1 compares the original STFM 2026 AM Low scenario (based on previous land use and without negative growth application) with the updated STFM 2026 AM scenario without development. The comparison plot shows a reduction of up to 800 vehicles in a 2-hour peak on Parramatta Road.

Figure 1: 2-hour traffic volume difference between STFM 2026 AM Low scenario and the updated STFM 2026 AM scenario without development.



Note: *Green indicates a reduction and red indicates an increase in the updated STFM 2026 AM scenario without development.*

6. Test the updated growth matrices for the 2026 AM and PM without development scenario for the Inner West City Council study area in AIMSUN (undertaken by PwC).

PwC has applied the absolute STFM growth to the AIMSUN base matrix to test the performance of the model. Table 4 shows the growth within the PRCUTS Inner West City Council study for the AIMSUN model is up to 7% points higher than the STFM demand in the 2026 AM and PM peak Without Development scenario. Table 5 shows that the network statistics and unreleased vehicles in 2026 are within an acceptable range and additional treatment of demand growth in AIMSUN is therefore not required.

Table 4: Inner West Council study area traffic growth between 2018 and 2026 without development scenarios in AIMSUN and STFM.

2026-2018	Without Development	
	AM	PM
AIMSUN Growth (veh)	18,973	20,289
AIMSUN Growth (%)	28%	27%
STFM Growth (veh)	14,758	16,274
STFM Growth (%)	22%	20%

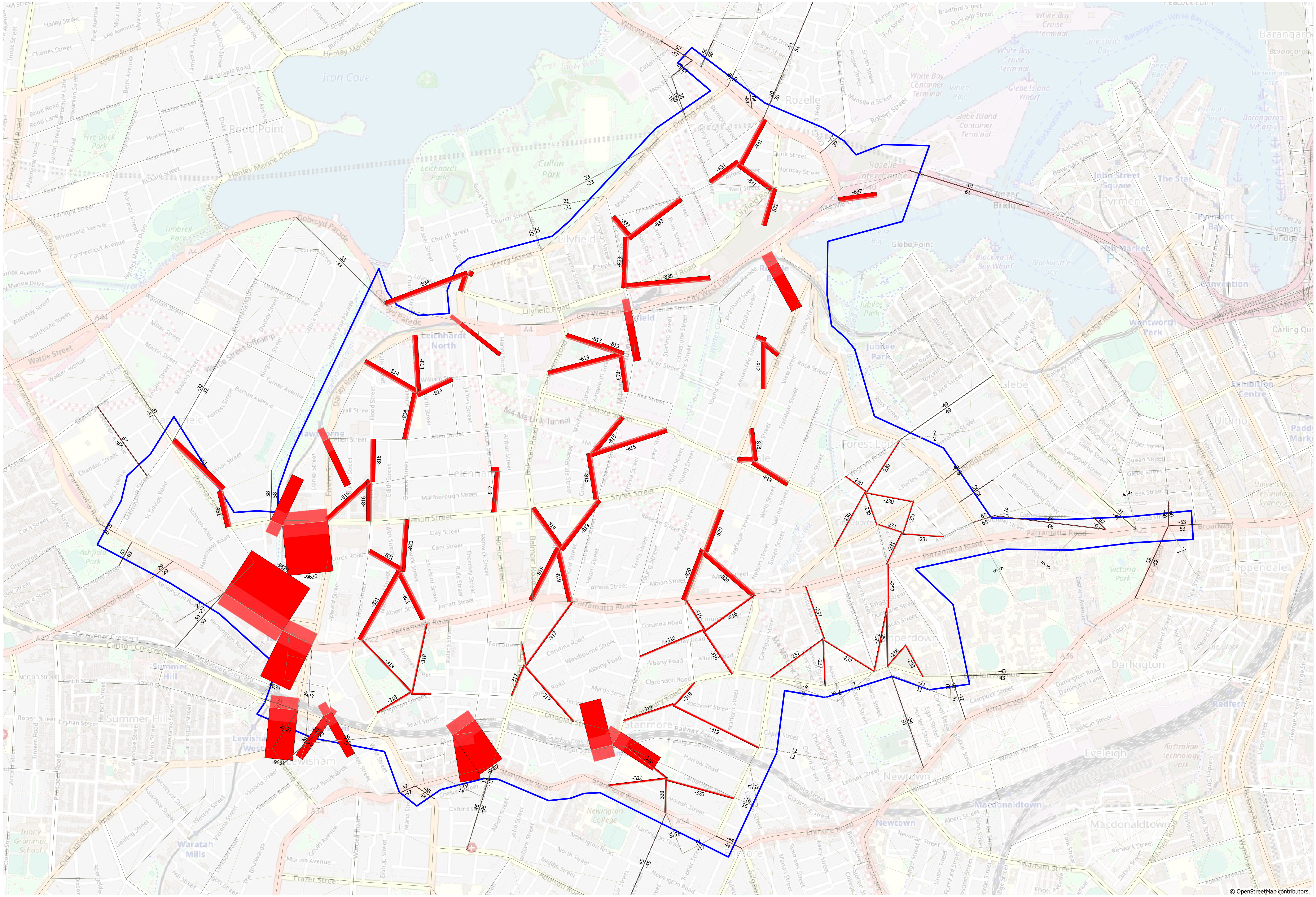
Table 5: Inner West Council AIMSUN network statistics for 2018 Base and 2026 without development AM and PM peak scenarios.

Network Statistics	2018 Base		2026 Without Development	
	AM	PM	AM	PM
Demand	68,594	75,141	87,567	95,430
Total Distance Travelled - All	168,922	188,415	195,206	207,381
Total Travel Time - All	6,718	6,988	8,532	9,392
Vehicles Waiting to Enter - All	4	3	14	1,854
Total Number of Stops - All	113,316	101,730	110,256	106,004
Average Speed (km/h)	25.1	27.0	22.9	22.1

APPENDIX

F

PTPM CORDONS



Iron Cove
Rodd Point
Callan Park
Rozelle
Rozelle Interchange
Lilyfield
Leichhardt North
Leichhardt
Annandale
Forest Lodge
Glebe
Glebe Point
Jubilee Park
Ultimo
Pyrmont
Camperdown
Darlington
Chippendale
Stanmore
Newtown
Eveleigh
Redfern
Macdonaldtown
Summer Hill
Lewisham West
Lewisham
Waratah Mills
Ashfield Park
Five Dock Park
Timbrell Park
Victoria Park
Anzac Bridge
Parramatta Road
Lilyfield Road
City West Link
M4-M8 Link Tunnel
Victoria Road
Broadway
Enmore Road
Stanmore Road
Darley Road
Norton Street
Balmain Road
Johnston Street
Booth Street
Marion Street
Dobroyd Parade
Henley Marine Drive
Lyons Road
Liverpool Road
Old Canterbury Road
Wattle Street
Glebe Island Container Terminal
White Bay Cruise Terminal
Jubilee Park
Wentworth Park
Fish Market
Australian Technology Park
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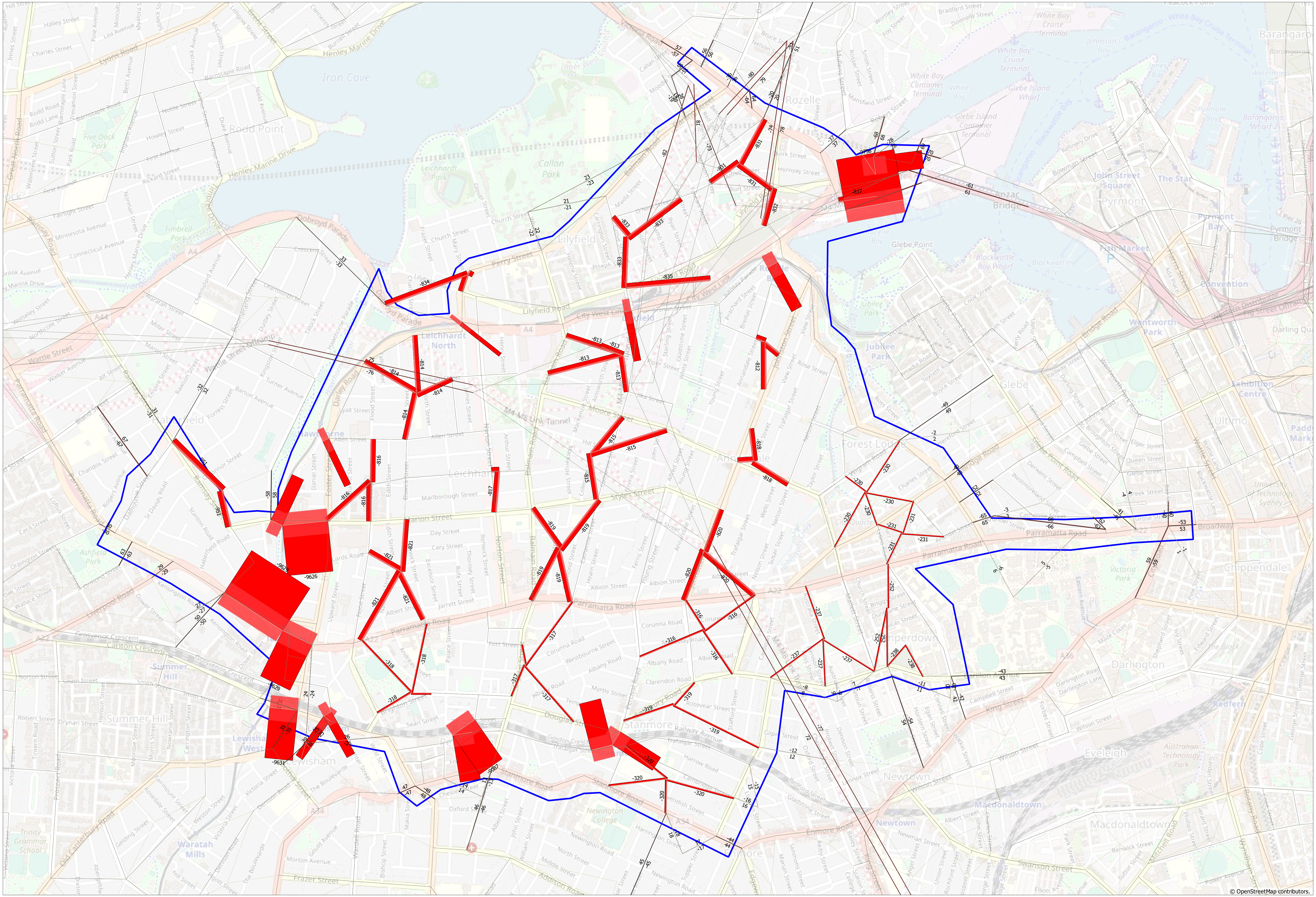

Iron Cove
Rodd Point
Callan Park
Rozelle
Lilyfield
Leichhardt North
Leichhardt
Annandale
Forest Lodge
Glebe
Glebe Point
Jubilee Park
Anzac Bridge
Pyrmont
John Street Square
The Star
Fish Market
Ultimo
Chippendale
Camperdown
Darlington
Redfern
Eveleigh
Newtown
Macdonaldtown
Stanmore
Petersham
Lewisham
Summer Hill
Ashfield
Haberfield
Five Dock
Barangaroo
Parramatta Road
City West Link
Victoria Road
Broadway
Victoria Park
Wentworth Park
Waratah Mills
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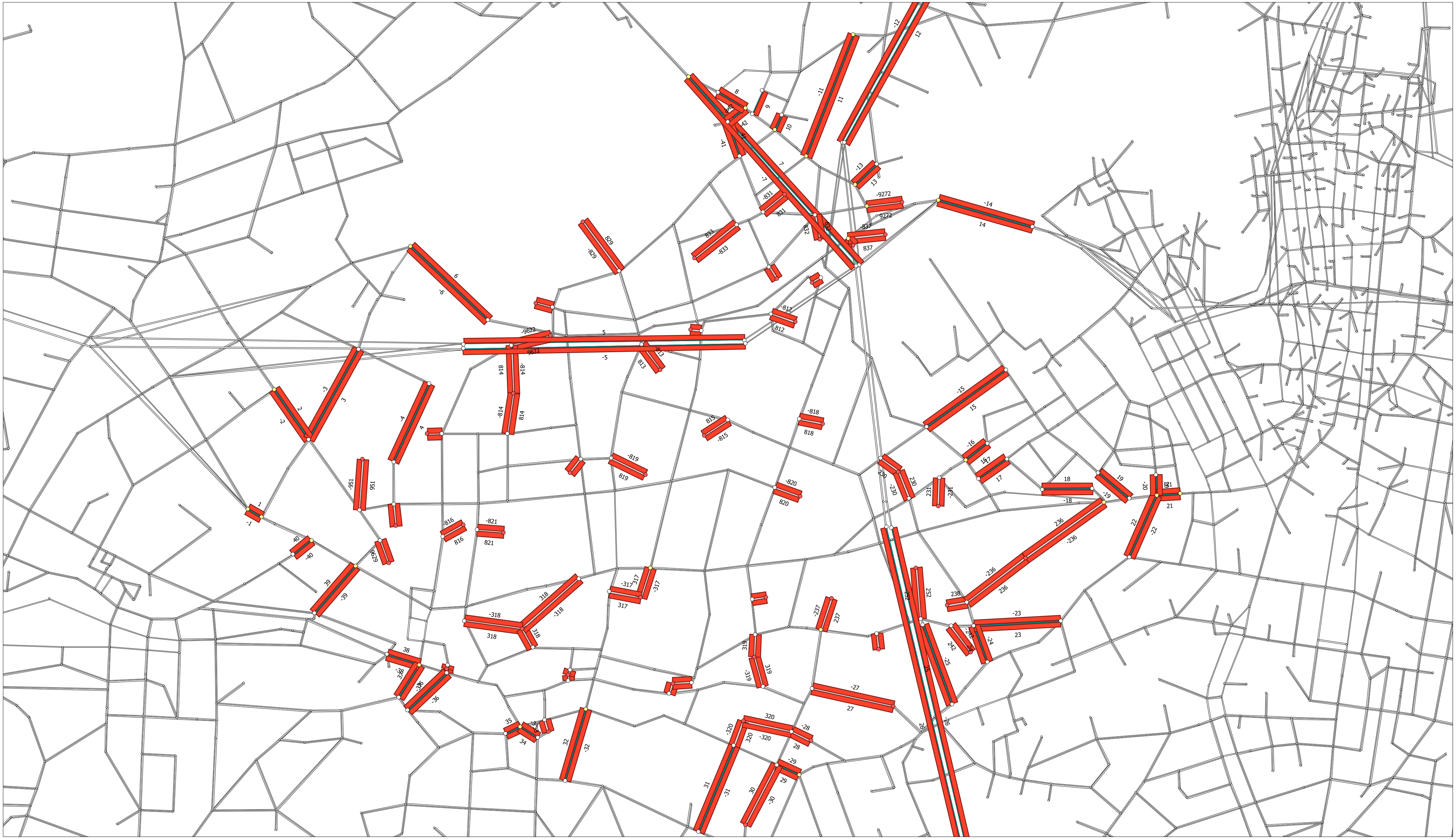
APPENDIX

G

STFM CORDONS

Cardno



APPENDIX

H

INTERSECTION PERFORMANCE

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
1	Victoria Rd / Darling St	S	N	Darling St	L	226	72.1	F	197	83.5	F
					T	243	89.9	F	234	104.0	F
			E	Victoria Rd	L	57	38.4	C	61	42.9	D
					T	1247	36.1	C	998	33.2	C
					R	144	32.1	C	128	25.9	B
			S	Darling St	L	248	84.2	F	251	85.0	F
					T	218	115.4	F	200	115.0	F
			W	Victoria Rd	L	21	54.2	D	26	47.2	D
					T	2228	51.9	D	1833	43.0	D
					R	154	89.9	F	197	50.4	D
			Total			**4786**	**55.7**	D	**1833**	**51.9**	D
2	Victoria Road / Evans Street	S	N	Evans St	L	300	94.6	F	283	81.4	F
					T	124	91.3	F	108	88.5	F
					R	56	105.0	F	40	86.2	F
			E	Victoria Rd	L	10	9.6	A	8	9.2	A
					T	1369	4.8	A	1154	3.0	A
			S	Evans St	L	8	77.4	F	10	42.3	C
					T	113	53.2	D	115	52.6	D
			W	Victoria Rd	L	0			2	6.4	A
					T	2517	10.2	A	2053	7.5	A
			Total			**4497**	**18.8**	B	**3773**	**16.3**	B
3	Victoria Road / Robert Street	S	N	Victoria Rd	L	20	45.6	D	18	15.9	B
					T	2972	33.2	C	2502	33.7	C
			E	Robert St	L	704	72.3	F	695	51.1	D
					R	0			0		
			S	Victoria Rd	T	1339	4.2	A	1146	3.4	A
					R	591	22.4	B	553	28.0	B
			Total			**5626**	**30.1**	C	**4914**	**28.4**	B
5	Balmain Road / Lilyfield Road	S	N	Balmain Rd	L	67	6.6	A	60	7.2	A
					T	145	5.2	A	134	5.5	A
			E	Lilyfield Rd	L	8	31.1	C	17	25.7	B
					T	3	14.7	B	2	16.1	B
					R	3	37.6	C	4	19.6	B
			S	Balmain Rd	L	42	9.1	A	42	7.7	A
					T	323	10.0	A	291	8.4	A
					R	417	14.0	A	371	11.2	A
			W	Lilyfield Rd	L	0			0		
					T	97	16.3	B	92	25.0	B
					R	1	36.1	C	6	37.9	C
			Total			**1106**	**11.5**	A	**1019**	**11.0**	A
6	The Crescent / Victoria Road	S	N	Victoria Rd	L	2888	5.9	A	2458	5.4	A
					R	697	29.0	C	708	24.6	B
			E		T	1386	73.2	F	1304	55.8	D
					R	1490	48.3	D	1329	42.5	D
			W	The Crescent	L	612	8.9	A	567	7.9	A
			Total			**7073**	**30.5**	C	**6366**	**25.9**	B

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
7	Balmain Road / Perry Street / Wharf Road	S	N	Wharf Rd	L	0			0		
					T	0			0		
					R	0			0		
			E	Balmain Rd	L	199	5.0	A	186	6.6	A
					T	215	4.9	A	273	6.1	A
					R	7	5.4	A	18	6.2	A
			S		L	20	2.4	A	15	3.7	A
					T	24	2.9	A	24	4.8	A
					R	238	4.0	A	219	5.6	A
			W	Perry St	L	15	4.6	A	15	12.0	A
					T	258	10.0	A	292	9.8	A
					R	3	8.8	A	3	9.3	A
			Total			**979**	**5.9**	**A**	**1045**	**7.2**	**A**
8	City-West Link Road / The Crescent	S	E	The Crescent	L	763	5.8	A	777	4.1	A
					T	1309	53.6	D	1223	49.2	D
			S		L	75	34.8	C	72	32.7	C
					R	1095	60.3	E	1020	64.1	E
			W	City-West Link Rd	T	1718	32.8	C	1241	24.8	B
					R	71	99.3	F	91	98.4	F
			Total			**5031**	**41.1**	**C**	**4424**	**38.6**	**C**
9	City-West Link Road / Norton Street	S	N		L	9	59.0	E	1	1.6	A
				Norton St	T	96	57.7	E	112	65.1	E
			E	City-West Link Rd	L	94	24.7	B	90	28.6	C
					T	1476	61.3	E	1409	55.7	D
					R	19	51.6	D	30	39.4	C
			S	Norton St	L	56	80.5	F	53	95.5	F
					T	186	105.2	F	206	112.6	F
					R	154	106.5	F	108	124.0	F
			W	City-West Link Rd	L	0			0		
					T	1519	8.3	A	1118	11.4	A
					R	107	59.4	E	107	64.0	E
			Total			**3716**	**42.8**	**D**	**3234**	**46.6**	**D**
10	City-West Link Road / Brenan Street / Balmain Road	S	N	Balmain Rd	L	69	45.0	D	47	39.0	C
					T	115	18.3	B	120	21.3	B
					R	31	21.5	B	31	48.7	D
			E	City-West Link Rd	L	41	7.0	A	26	13.7	A
					T	1474	8.0	A	1412	15.3	B
					R	127	22.6	B	91	22.5	B
			S	Balmain Rd	L	32	178.6	F	40	81.3	F
					T	336	183.2	F	314	71.4	F
					R	129	185.0	F	129	48.2	D
			W	City-West Link Rd	L	308	12.1	A	288	19.7	B
					T	1372	27.2	B	955	30.5	C
			Total			**4034**	**37.9**	**C**	**3453**	**28.0**	**B**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
11	City-West Link Road / Brenan Street / Catherine Street	S	N	Catherine St	L	194	45.7	D	190	47.6	D
					T	294	36.5	C	281	37.5	C
					R	99	43.5	D	110	46.6	D
			E	City-West Link Rd	T	1389	16.9	B	1304	17.0	B
			S	Catherine St	L	59	35.9	C	30	40.2	C
			W	City-West Link Rd	T	1591	26.6	B	1143	26.9	B
			Total			**3626**	**25.3**	B	**3058**	**25.8**	B
13	Catherine Street / Moore Street	S	N	Catherine St	L	177	4.3	A	181	3.1	A
					T	114	35.3	C	121	31.4	C
					R	0			0		
			E	Moore St	L	0			2	1.5	A
					T	148	12.1	A	172	13.4	A
					R	103	15.5	B	76	15.1	B
			S	Catherine St	L	43	30.7	C	54	31.2	C
					T	71	28.1	B	78	34.3	C
					R	39	32.8	C	54	33.2	C
			W	Moore St	L	2	27.7	B	1	44.2	D
					T	142	19.5	B	109	20.7	B
			Total			**839**	**18.6**	B	**848**	**19.2**	B
14	Styles Street / Catherine Street	S	N	Catherine St	L	16	18.3	B	17	18.7	B
					T	106	25.0	B	108	19.4	B
					R	42	21.0	B	31	16.9	B
			E	Styles St	L	13	12.0	A	14	6.7	A
					T	152	10.3	A	147	9.0	A
					R	5	20.9	B	0		
			S	Catherine St	L	66	20.9	B	60	22.1	B
					T	57	26.0	B	71	22.7	B
					R	5	20.8	B	3	30.6	C
			W	Styles St	L	91	21.2	B	113	24.5	B
					T	538	20.5	B	537	23.9	B
					R	20	22.4	B	18	26.4	B
			Total			**1111**	**19.8**	B	**1119**	**21.0**	B
19	Marion Street / Norton Street	S	N	Norton St	L	70	39.9	C	103	32.7	C
					T	179	41.8	C	190	32.5	C
					R	33	35.7	C	32	29.6	C
			E	Marion St	L	93	25.4	B	97	27.1	B
					T	295	16.2	B	267	23.0	B
					R	3	25.4	B	6	36.9	C
			S	Norton St	L	30	31.0	C	38	22.2	B
					T	95	34.5	C	87	32.4	C
					R	7	29.9	C	5	46.2	D
			W	Marion St	L	49	33.9	C	43	23.3	B
					T	745	26.3	B	690	26.4	B
					R	154	30.5	C	160	29.2	C
			Total			**1753**	**28.0**	B	**1718**	**27.5**	B

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
20	Marion Street / Leichhardt Street / Balmain Road	S	N	Balmain Rd	L	25	73.8	F	30	84.6	F
					R	135	97.1	F	124	72.3	F
			E	Leichhardt St	T	234	13.2	A	219	12.9	A
					R	23	19.7	B	23	23.2	B
			S	Balmain Rd	L	13	125.0	F	10	85.3	F
					T	198	111.7	F	173	115.0	F
					R	3	115.8	F	1	133.2	F
			W	Marion St	L	266	27.8	B	245	31.0	C
					T	714	23.7	B	720	28.1	B
			Total			**1611**	**41.5**	C	**1545**	**41.1**	C
22	Johnston Street / Collins Street	S	N	Johnston St	L	150	8.7	A	123	7.5	A
					T	244	16.2	B	237	13.6	A
					R	73	21.9	B	64	19.5	B
			E	Collins St	L	60	18.5	B	45	16.8	B
			S	Johnston St	L	92	31.6	C	86	37.9	C
					T	452	37.5	C	415	34.3	C
			W	Collins St	L	374	20.7	B	394	15.9	B
					R	185	20.9	B	182	16.3	B
			Total			**1630**	**24.2**	B	**1546**	**21.3**	B
23	Johnston Street / Booth Street	S	N	Johnston St	L	44	53.0	D	50	57.4	E
					T	214	56.0	D	199	59.3	E
					R	65	53.6	D	91	63.2	E
			E	Booth St	L	23	17.2	B	15	9.9	A
					T	245	22.3	B	261	26.7	B
					R	36	41.2	C	22	25.0	B
			S	Johnston St	L	1	50.2	D	3	39.1	C
					T	520	37.3	C	481	38.0	C
					R	284	21.9	B	310	26.7	B
			W	Booth St	L	74	36.6	C	61	30.3	C
					T	377	50.4	D	412	37.0	C
					R	137	56.3	D	108	41.3	C
			Total			**2020**	**39.7**	C	**2013**	**37.9**	C
27	Booth Street / Wigram Road	RB	N	Wigram Rd	L	62	2.2	A	40	2.2	A
					R	55	2.0	A	47	1.7	A
			E	Booth St	T	260	2.8	A	233	3.0	A
					R	128	2.8	A	94	2.4	A
			W		L	226	1.8	A	230	1.6	A
					T	482	2.0	A	510	1.8	A
			Total			**1213**	**2.8**	A	**1154**	**3.0**	A

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
28	Minogue Crescent / Wigram Road	S	N	Minogue Cres	L	66	15.5	B	69	13.3	A
					T	344	20.9	B	416	20.1	B
					R	6	13.9	A	2	17.0	B
			E		L	13	26.1	B	18	30.9	C
				Wigram Rd	T	132	22.0	B	92	22.3	B
					R	35	23.1	B	23	24.2	B
			S	Minogue Cres	L	2	17.6	B	6	33.0	C
					T	138	26.0	B	128	25.4	B
					R	29	10.5	A	20	24.7	B
			W	Wigram Rd	L	5	18.9	B	3	13.9	A
					T	223	25.1	B	215	26.0	B
					R	0			0		
			Total			**993**	**22.1**	B	**992**	**22.2**	B
29	Ross Street / Bridge Road	S	N	Ross St	L	49	29.3	C	54	27.3	B
					T	289	46.3	D	351	38.4	C
			E		L	65	14.1	A	55	17.8	B
				Bridge Rd	T	419	13.3	A	414	15.5	B
					R	43	14.1	A	28	30.6	C
			S	Ross St	L	151	56.5	D	106	49.4	D
					T	143	57.4	E	142	47.4	D
			W	Bridge Rd	L	30	43.2	D	33	52.0	D
					T	811	39.9	C	833	56.8	E
					R	18	20.9	B	8	30.9	C
			Total			**2018**	**36.0**	C	**2024**	**41.7**	C
30	Pyrmont Bridge Road / Booth Street / Mallett Street	S	N	Booth St	L	321	85.1	F	335	56.7	E
					T	386	68.1	E	357	45.0	D
			E	Pyrmont Bridge Rd	L	16	18.4	B	43	15.0	B
					T	234	22.5	B	207	12.7	A
					R	72	56.7	E	65	66.4	E
			S	Mallett St	L	22	26.3	B	9	36.3	C
					T	199	21.6	B	138	35.1	C
					R	96	33.6	C	115	45.2	D
			W	Pyrmont Bridge Rd	L	49	43.5	D	47	34.5	C
					T	388	44.9	D	374	30.1	C
			Total			**1783**	**51.0**	D	**1690**	**39.0**	C
34	Marion Street / Foster Street	S	N	Foster St	L	1	2.6	A	1	17.9	B
					T	111	31.1	C	91	24.3	B
					R	36	41.9	C	40	43.6	D
			E	Marion St	L	58	16.3	B	65	46.4	D
					T	267	21.1	B	223	36.2	C
			S	Foster St	L	83	26.1	B	92	32.5	C
					T	389	32.7	C	471	36.0	C
					R	111	36.6	C	88	36.9	C
			W	Marion St	L	282	26.3	B	305	48.9	D
					T	649	26.4	B	631	51.6	D
					R	94	26.7	B	101	59.1	E
			Total			**2081**	**27.7**	B	**2108**	**43.5**	D

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
35	Marion Street / Flood Street	S	N	Flood St	L	12	22.9	B	15	25.7	B
					T	96	26.5	B	73	19.5	B
					R	14	44.3	D	7	23.0	B
			E	Marion St	L	151	42.1	C	147	7.3	A
					T	249	27.6	B	218	15.6	B
					R	6	21.4	B	10	37.9	C
			S	Flood St	L	31	27.5	B	33	33.0	C
					T	75	29.4	C	110	13.0	A
					R	229	34.2	C	172	39.1	C
			W	Marion St	L	39	50.8	D	26	58.0	E
					T	951	66.5	E	891	69.6	E
					R	82	118.0	F	70	81.2	F
			Total			**1935**	**53.0**	D	**1772**	**48.1**	D
36	Marion Street / Ramsay Street	S	N	Ramsay St	L	797	19.5	B	766	17.3	B
					T	1	116.8	F	1	28.1	B
			E	Marion St	L	28	20.3	B	26	24.0	B
					R	279	14.6	B	224	11.9	A
			S	Ramsay St	T	103	29.0	C	100	29.9	C
					R	191	39.5	C	220	46.2	D
			Total			**1399**	**22.0**	B	**1337**	**22.2**	B
39	Parramatta Road / Liverpool Road (Hume Highway)	S	E	Parramatta Rd	L	375	2.5	A	367	2.7	A
					T	1232	59.8	E	1146	49.2	D
			S	Liverpool Rd	L	90	34.5	C	94	36.7	C
					R	793	51.9	D	693	62.5	E
			W	Parramatta Rd	T	1310	17.5	B	1477	15.9	B
					R	255	48.2	D	271	61.4	E
			Total			**4055**	**38.0**	C	**4048**	**35.6**	C
41	City-West Link Road / James Street	S	N	City-West Link Rd	L	7	50.5	D	11	97.0	F
					T	90	45.7	D	92	63.1	E
					R	89	46.9	D	122	78.8	F
			E	James St	L	255	0.8	A	249	0.8	A
					T	1277	3.8	A	1213	2.4	A
			S	City-West Link Rd	L	13	58.5	E	5	86.7	F
					T	177	55.8	D	205	57.4	E
					R	316	54.9	D	343	56.9	E
			W	James St	L	201	3.6	A	239	2.8	A
					T	1300	29.6	C	872	21.1	B
			Total			**3725**	**21.7**	B	**3351**	**21.0**	B

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
42	Tebbutt Street / Lords Road	S	N	Forster St	L	150	18.8	B	169	17.1	B
					T	366	10.9	A	327	13.0	A
			E	Lords Rd	L	39	23.4	B	33	24.8	B
					T	39	14.9	B	50	18.3	B
					R	20	11.7	A	21	31.2	C
			S	Tebbutt St	L	25	7.5	A	21	9.6	A
					T	489	8.0	A	550	12.5	A
					R	221	13.5	A	220	15.6	B
			W	Lords Rd	L	22	24.8	B	25	27.6	B
					T	53	23.7	B	56	33.0	C
					R	25	19.1	B	26	28.8	C
			Total			**1449**	**12.4**	A	**1498**	**15.6**	B
43	Lilyfield Road / James Street	S	N	Mary St	L	83	4.3	A	100	7.2	A
					T	148	35.9	C	193	56.3	D
					R	8	46.1	D	13	54.2	D
			E	Lilyfield Rd	L	1	3.1	A	3	2.9	A
					T	56	3.6	A	41	4.1	A
					R	1	20.8	B	0		
			S	James St	L	25	24.8	B	29	19.2	B
					T	263	25.7	B	328	20.9	B
					R	88	27.4	B	90	19.0	B
			W	Lilyfield Rd	L	9	19.8	B	10	29.2	C
					T	96	26.0	B	95	32.2	C
					R	30	26.6	B	24	23.7	B
			Total			**808**	**24.2**	B	**926**	**27.6**	B
44	Tebbutt Street / Hathern Street	S	N	Tebbutt St	T	67	9.1	A	65	16.3	B
					R	386	13.4	A	332	23.3	B
			S		L	85	4.9	A	128	5.1	A
					T	8	29.2	C	39	40.1	C
			W	Hathern St	L	776	24.1	B	817	19.2	B
					R	103	28.7	C	127	26.6	B
			Total			**1425**	**19.7**	B	**1508**	**20.0**	B
45	Parramatta Road / Sloane Street	S	N	Sloane St	L	0			12	59.4	E
					T	80	51.6	D	84	58.6	E
					R	30	80.5	F	27	61.8	E
			E	Parramatta Rd	L	9	5.8	A	14	11.7	A
					T	1540	4.5	A	1434	5.5	A
			S	Sloane St	L	47	65.6	E	38	57.1	E
					T	166	60.4	E	156	57.8	E
			W	Parramatta Rd	L	101	22.2	B	101	34.7	C
					T	2002	21.9	B	2027	37.8	C
			Total			**3975**	**18.3**	B	**3893**	**27.4**	B

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	Delay (s)	LOS	8:15AM - 9:15AM Volume (veh)	Delay (s)	LOS
47	Parramatta Road / Old Canterbury Road / Tebbutt Street	S	N	Tebbutt St	L	171	39.4	C	190	69.6	E
			E	Parramatta Rd	L	216	24.4	B	215	15.0	B
					T	1435	15.0	B	1340	10.7	A
			S	Old Canterbury Rd	L	91	15.8	B	107	12.4	A
			W	Parramatta Rd	T	1814	131.7	F	1911	142.1	F
			Total			**3727**	**73.5**	**F**	**3763**	**80.7**	**F**
49	Old Canterbury Road / Railway Terrace / Longport Street	S	N	Old Canterbury Rd	L	118	29.1	C	159	21.3	B
					T	585	24.8	B	506	20.8	B
			E	Railway Terrace	L	28	22.5	B	19	47.4	D
					T	412	21.7	B	456	38.1	C
			S	Old Canterbury Rd	L	47	29.4	C	58	26.1	B
					T	908	38.5	C	966	30.8	C
					R	0			0		
			W	Longport St	L	62	23.8	B	71	33.4	C
					T	368	24.4	B	388	32.5	C
			Total			**2528**	**29.4**	**C**	**2623**	**29.9**	**C**
50	Parramatta Road / Norton Street	S	N	Norton St	L	188	107.4	F	196	42.1	C
					R	57	189.2	F	68	59.0	E
			E	Parramatta Rd	T	1201	3.3	A	1125	3.3	A
					R	235	46.6	D	223	40.3	C
			W		L	4	0.7	A	35	8.3	A
					T	1600	21.7	B	1674	14.1	A
			Total			**3285**	**24.6**	**B**	**3321**	**14.7**	**B**
51	Parramatta Road / Flood Street / West Street	S	N	Flood St	L	4	54.8	D	1	94.9	F
					T	106	47.9	D	90	53.5	D
					R	13	101.0	F	9	53.2	D
			E	Parramatta Rd	L	7	64.5	E	11	94.3	F
					T	1154	52.6	D	1109	52.6	D
			S	West St	L	235	23.2	B	211	19.6	B
					T	184	42.4	C	160	42.2	C
					R	0			0		
			W	Parramatta Rd	L	74	38.8	C	92	40.0	C
					T	1401	37.5	C	1533	39.1	C
					R	470	147.5	F	456	148.5	F
			Total			**3648**	**56.4**	**D**	**3672**	**56.4**	**D**
52	Parramatta Road / Crystal Street / Balmain Road	S	E	Parramatta Rd	L	117	41.7	C	80	81.9	F
					T	1235	47.3	D	1150	88.8	F
			S	Crystal St	L	174	34.7	C	175	31.4	C
					T	203	86.3	F	185	90.9	F
					R	147	81.7	F	148	80.7	F
			W	Parramatta Rd	L	6	6.7	A	5	9.3	A
					T	1707	8.6	A	1774	5.8	A
					R	224	55.4	D	214	28.4	B
			Total			**3813**	**33.1**	**C**	**3731**	**42.7**	**D**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
53	Parramatta Road / Catherine Street / Phillip Street	S	N	Catherine St	L	12	60.0	E	1	314.3	F
					T	48	60.4	E	31	231.3	F
					R	79	71.4	F	43	298.6	F
			E	Parramatta Rd	L	2	24.2	B	0		
					T	1212	21.5	B	1176	76.7	F
			S	Phillip St	L	24	41.9	C	31	52.3	D
					T	75	44.7	D	60	56.6	E
					R	18	66.5	E	26	74.2	F
			W	Parramatta Rd	L	55	11.4	A	75	17.1	B
					T	1780	4.2	A	1849	4.2	A
			Total			**3305**	**14.9**	B	**3292**	**38.4**	C
56	Crystal Street / Douglas Street / Brighton Street	S	N	Crystal St	L	66	103.1	F	60	97.9	F
					T	263	109.7	F	244	115.5	F
			E	Douglas St	L	146	10.0	A	160	8.8	A
					T	33	44.1	D	33	46.3	D
					R	0			5	70.5	F
			S	Crystal St	L	356	22.1	B	365	30.2	C
					T	516	23.8	B	499	24.8	B
					R	703	32.2	C	729	33.1	C
			W	Brighton St	L	32	48.3	D	37	30.3	C
					T	74	96.4	F	72	83.6	F
					R	144	123.8	F	130	108.3	F
			Total			**2333**	**46.2**	D	**2334**	**45.4**	D
57	Crystal Street / Trafalgar Street	S	N	Crystal St	L	40	8.6	A	60	17.6	B
					T	462	10.5	A	432	13.4	A
					R	88	26.4	B	91	26.0	B
			E	Trafalger St	L	9	69.4	E	13	38.1	C
					T	46	35.2	C	69	28.4	B
			S	Crystal St	L	23	14.9	B	27	27.4	B
					T	1377	19.1	B	1363	28.0	B
			W	Trafalger St	L	196	35.9	C	217	25.1	B
					T	180	26.9	B	213	33.1	C
			Total			**2421**	**19.9**	B	**2485**	**25.4**	B
58	New Canterbury Road / Stanmore Road / Crystal Street / Shaw Street	S	N	Crystal St	L	106	84.8	F	124	96.6	F
					T	257	82.5	F	211	98.1	F
					R	110	90.5	F	105	102.6	F
			E	Stanmore Rd	L	36	25.9	B	28	35.4	C
					T	372	32.3	C	380	36.8	C
					R	228	51.1	D	238	52.3	D
			S	Shaw St	L	2	19.3	B	2	49.3	D
					T	484	49.1	D	471	73.5	F
			W	New Canterbury Rd	L	679	46.2	D	688	45.6	D
					T	798	38.1	C	790	36.4	C
			Total			**3072**	**48.9**	D	**3037**	**54.6**	D

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
59	Gordon Street / Trafalgar Street	S	N	Gordon St	T	411	12.5	A	437	11.7	A
			E	Trafalger St	L	21	1.6	A	21	1.2	A
					R	227	22.1	B	268	29.5	C
			S	Gordon St	T	222	24.3	B	229	23.2	B
					R	375	35.1	C	349	27.7	B
				Total		**1256**	**22.9**	B	**1304**	**21.5**	B
60	New Canterbury Road / Gordon Street / Livingstone Road	S	N	Gordon St	L	118	43.0	D	102	48.3	D
					T	318	51.3	D	353	54.5	D
			E	New Canterbury Rd	L	20	29.5	C	15	22.4	B
					T	331	13.3	A	307	16.0	B
					R	159	30.6	C	184	30.3	C
			S	Livingstone Rd	L	21	34.5	C	21	45.3	D
					T	404	34.6	C	346	34.7	C
			W	New Canterbury Rd	L	36	41.8	C	46	33.8	C
					T	1344	35.4	C	1325	32.4	C
			Total			**2751**	**34.6**	C	**2699**	**34.3**	C
62	Ramsay Road / Dalhousie Street	S	N	Dalhousie St	L	269	36.4	C	170	34.3	C
					T	85	33.9	C	154	32.2	C
					R	24	31.0	C	20	36.7	C
			E	Ramsay St	L	85	23.7	B	64	46.0	D
					T	255	24.7	B	220	15.0	B
					R	29	33.5	C	24	36.3	C
			S	Dalhousie St	L	72	39.0	C	66	36.8	C
					T	211	38.2	C	206	39.5	C
					R	87	28.8	C	99	33.8	C
			W	Ramsay St	L	14	10.7	A	20	26.0	B
					T	502	19.0	B	535	18.6	B
					R	3	4.6	A	1	2.2	A
			Total			**1636**	**28.0**	B	**1579**	**27.2**	B
65	Stanmore Road / Liberty Street	S	N	Liberty St	L	326	33.2	C	319	30.0	C
					R	134	44.6	D	125	53.6	D
			E	Stanmore Rd	T	493	7.4	A	509	6.9	A
					R	365	18.8	B	326	16.0	B
			W		L	109	7.9	A	76	10.7	A
					T	864	18.4	B	859	33.8	C
			Total			**2291**	**19.3**	B	**2214**	**24.8**	B

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
66	Ross Street / St Johns Road	S	N	Ross St	L	129	12.9	A	137	16.9	B
					T	274	12.1	A	302	16.1	B
					R	16	17.3	B	17	19.5	B
			E	St Johns Rd	L	20	39.6	C	38	42.5	C
					T	10	43.4	D	9	33.7	C
					R	108	41.7	C	83	48.1	D
			S	Ross St	L	77	15.6	B	104	12.7	A
					T	168	17.2	B	130	14.5	A
					R	117	16.8	B	137	9.4	A
			W	St Johns Rd	L	14	67.2	E	26	62.1	E
					T	28	53.2	D	17	45.3	D
					R	3	87.2	F	2	56.1	D
			Total			**964**	**20.5**	B	**1002**	**20.4**	B
67	Parramatta Road / Young Street / Percival Road	S	N	Young St	L	31	43.5	D	24	66.6	E
					T	195	46.5	D	169	49.9	D
					R	0			0		
			E	Parramatta Rd	L	7	16.5	B	8	10.8	A
					T	1087	3.0	A	1098	2.3	A
			S	Percival Rd	L	35	54.1	D	25	75.5	F
					T	144	54.8	D	126	70.9	F
					R	106	71.0	F	104	91.8	F
			W	Parramatta Rd	L	4	30.4	C	6	41.7	C
					T	1824	33.0	C	1888	40.8	C
			Total			**3433**	**26.6**	B	**3448**	**32.0**	C
68	Parramatta Road /Northumberland Avenue / Johnston Street	S	N	Johnston St	L	251	49.8	D	231	57.7	E
					T	234	57.5	E	234	65.4	E
					R	0			0		
			E	Parramatta Rd	L	12	6.4	A	21	8.0	A
					T	1100	19.2	B	1094	14.1	A
					R	128	95.7	F	118	107.3	F
			S	Northumberland Dr	L	12	50.9	D	9	67.3	E
					T	342	54.9	D	332	52.0	D
					R	69	89.3	F	58	62.9	E
			W	Parramatta Rd	L	57	25.8	B	55	34.6	C
					T	1854	17.1	B	1898	27.9	B
			Total			**4059**	**29.1**	C	**4050**	**32.9**	C
69	Parramatta Road / Bridge Road	S	E	Parramatta Rd	L	156	23.5	B	158	22.7	B
					T	1195	16.3	B	1173	16.8	B
			S	Bridge Rd	L	0			0		
					R	488	74.6	F	446	61.9	E
			W	Parramatta Rd	T	1914	41.2	C	1984	54.4	D
					R	211	62.6	E	170	83.3	F
			Total			**3964**	**38.2**	C	**3931**	**44.0**	D

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
70	Parramatta Road /Pyrmont Bridge Road / Denison Street	S	N	Pyrmont Bridge Rd	L	0			0		
					T	28	61.6	E	20	56.9	E
					R	215	60.6	E	201	45.8	D
			E	Parramatta Rd	L	34	15.9	B	30	24.4	B
					T	1121	3.0	A	1103	1.6	A
			W		L	508	9.8	A	511	10.1	A
					T	2054	13.4	A	2115	15.1	B
			Total			**3960**	**12.9**	A	**3980**	**12.5**	A
71	Parramatta Road / Mallett Street	S	N	Mallett St	L	130	38.6	C	122	50.7	D
					T	229	47.1	D	255	44.7	D
					R	63	56.3	D	33	71.8	F
			E	Parramatta Rd	L	31	15.1	B	36	9.0	A
					T	1055	4.8	A	1072	2.0	A
			S	Mallett St	L	18	42.9	D	24	70.0	E
					T	212	43.0	D	189	74.1	F
					R	65	48.3	D	80	149.8	F
			W	Parramatta Rd	L	49	25.3	B	14	34.0	C
					T	1998	44.4	D	2108	49.4	D
			Total			**3850**	**33.2**	C	**3933**	**39.3**	C
72	Parramatta Road / Ross Street / Western Avenue	S	N	Ross St	L	134	52.0	D	119	58.4	E
					T	54	61.8	E	68	64.9	E
					R	112	90.8	F	154	84.3	F
			E	Parramatta Rd	L	15	9.2	A	26	10.0	A
					T	974	7.4	A	979	11.8	A
					R	113	167.4	F	97	367.1	F
			S	Western Ave	L	10	227.4	F	13	105.9	F
					T	50	185.0	F	33	118.0	F
					R	29	159.5	F	33	128.4	F
			W	Parramatta Rd	L	192	33.4	C	248	40.9	C
					T	1930	18.2	B	2034	25.3	B
			Total			**3613**	**28.9**	C	**3804**	**37.6**	C
73	Great Western Highway / Glebe Point Road	S	N	Glebe Point Rd	L	312	31.0	C	343	35.2	C
					R	73	56.5	E	61	64.1	E
			E	Great Western Hwy	T	1085	5.7	A	1107	5.4	A
					R	224	85.1	F	227	89.5	F
			W		L	33	12.2	A	27	21.7	B
					T	2061	13.9	A	2084	33.6	C
			Total			**3788**	**18.0**	B	**3849**	**29.3**	C

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
74	Broadway / City Road (Princes Highway) / Bay Street	S	N	Bay St	L	24	15.3	B	29	21.2	B
			E	Broadway	L	381	16.0	B	375	12.6	A
					T	572	81.4	F	670	73.9	F
			S	City Rd	L	732	15.7	B	668	23.3	B
					T	187	43.9	D	187	53.4	D
					R	782	42.6	D	655	57.6	E
			W	Great Western Hwy	L	164	12.3	A	181	14.0	A
					T	1202	12.9	A	1284	17.4	B
					R	995	37.8	C	956	75.7	F
			Total			**5039**	**32.0**	**C**	**5005**	**43.0**	**D**
75	University Avenue / Parramatta Road / Derwent Street / Arundel Street	S	E	Parramatta Rd	L	95	2.1	A	89	2.0	A
					T	1098	1.9	A	1093	3.6	A
			S	University Ave	L	15	55.6	D	7	56.1	D
					R	9	78.5	F	12	194.8	F
			W	Parramatta Rd	T	2073	36.2	C	2147	48.7	D
			Total			**3290**	**24.0**	**B**	**3348**	**33.3**	**C**
79	Douglas Street / Percival Road	S	N	Percival Rd	L	54	30.5	C	41	28.3	B
					R	70	24.7	B	86	26.6	B
			E	Douglas St	T	78	42.6	D	109	26.9	B
					R	133	96.8	F	118	47.9	D
			W		L	654	34.7	C	644	24.2	B
					T	97	45.4	D	105	36.4	C
			Total			**1086**	**43.0**	**D**	**1103**	**28.5**	**C**
80	Railway Terrace / Victoria Street	P	E	Railway Terrace	L	7	1.4	A	13	1.5	A
					T	440	1.4	A	475	1.6	A
			S	Victoria St	L	71	2.8	A	67	2.7	A
					R	16	5.8	A	14	4.0	A
			W	Railway Terrace	T	489	1.5	A	546	1.6	A
			Total			**1023**	**5.8**	**A**	**1115**	**4.0**	**A**
81	Parramatta Road / Dalhousie Street	S	N	Dalhousie St	L	65	38.2	C	123	45.9	D
					R	125	69.6	E	106	66.5	E
			E	Parramatta Rd	T	1216	25.6	B	1122	12.5	A
					R	93	51.8	D	100	34.4	C
			W		L	94	39.3	C	113	50.2	D
					T	1521	36.8	C	1605	50.8	D
			Total			**3114**	**34.3**	**C**	**3169**	**37.0**	**C**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	Delay (s)	LOS	8:15AM - 9:15AM Volume (veh)	Delay (s)	LOS
82	Carillon Avenue / Missenden Road	S	N	Missenden Rd	L	83	12.8	A	83	18.6	B
					T	156	26.1	B	163	19.7	B
					R	34	33.5	C	45	31.2	C
			E	Carillon Ave	L	16	42.2	C	34	45.5	D
					T	217	47.7	D	212	42.7	D
					R	60	42.3	C	61	39.1	C
			S	Missenden Rd	L	194	15.2	B	153	21.0	B
					T	184	35.0	C	188	35.0	C
					R	0			0		
			W	Carillon Ave	L	66	48.8	D	58	54.4	D
					T	447	44.2	D	398	44.7	D
					R	16	34.1	C	21	40.5	C
			Total			**1473**	**35.8**	C	**1416**	**35.8**	C
83	Parramatta Road / Missenden Avenue / Lyons Road	S	N	Lyons Rd	L	28	73.4	F	38	103.1	F
					T	120	48.2	D	107	106.1	F
					R	6	61.2	E	9	105.2	F
			E	Parramatta Rd	L	115	18.8	B	147	34.1	C
					T	974	54.9	D	1007	58.9	E
			S	Missenden Rd	L	80	28.8	C	67	38.3	C
					T	58	39.8	C	55	64.7	E
					R	30	41.9	C	48	81.3	F
			W	Parramatta Rd	L	26	36.5	C	30	38.3	C
					T	1864	28.7	C	2018	35.7	C
					R	154	84.5	F	150	109.9	F
			Total			**3455**	**39.7**	C	**3676**	**49.0**	D

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
1	Victoria Rd / Darling St	S	N	Darling St	L	125	48.9	D	138	47.5	D
					T	195	66.7	E	201	62.8	E
			E	Victoria Rd	L	64	18.5	B	70	28.1	B
					T	2276	16.4	B	2389	13.7	A
					R	115	45.1	D	122	48.5	D
			S	Darling St	L	286	69.2	E	297	85.3	F
					T	248	108.5	F	271	107.6	F
			W	Victoria Rd	L	80	43.5	D	93	43.1	D
					T	1978	42.2	C	2103	47.1	D
					R	445	38.9	C	435	46.0	D
			Total			**5812**	**36.8**	**C**	**2389**	**38.8**	**C**
2	Victoria Road / Evans Street	S	N	Evans St	L	74	59.8	E	64	62.9	E
					T	121	61.5	E	139	60.7	E
					R	51	62.1	E	56	62.5	E
			E	Victoria Rd	L	29	10.1	A	41	15.3	B
					T	2383	11.4	A	2498	9.4	A
			S	Evans St	L	21	51.9	D	39	51.9	D
					T	110	51.8	D	107	60.5	E
			W	Victoria Rd	L	20	2.9	A	23	2.7	A
					T	2083	3.1	A	2235	3.4	A
			Total			**4892**	**11.4**	**A**	**5202**	**10.8**	**A**
3	Victoria Road / Robert Street	S	N	Victoria Rd	L	28	15.5	B	48	15.2	B
					T	2207	56.0	D	2346	54.3	D
			E	Robert St	L	646	27.9	B	637	28.5	C
					R	21	81.5	F	15	107.9	F
			S	Victoria Rd	T	2345	9.9	A	2457	8.8	A
					R	903	52.2	D	961	48.4	D
			Total			**6150**	**34.8**	**C**	**6464**	**33.4**	**C**
5	Balmain Road / Lilyfield Road	S	N	Balmain Rd	L	60	6.1	A	64	8.6	A
					T	230	7.5	A	220	6.4	A
			E	Lilyfield Rd	L	48	25.2	B	28	36.8	C
					T	48	29.2	C	58	27.0	B
					R	6	21.8	B	3	31.2	C
			S	Balmain Rd	L	71	12.1	A	66	10.7	A
					T	302	11.0	A	304	10.4	A
					R	242	14.7	B	235	12.4	A
			W	Lilyfield Rd	L	0			0		
					T	1	1.6	A	6	35.0	C
					R	0			0		
			Total			**1008**	**12.5**	**A**	**984**	**11.8**	**A**
6	The Crescent / Victoria Road	S	N	Victoria Rd	L	2076	4.5	A	2155	4.8	A
					R	758	76.5	F	813	75.4	F
			E		T	1804	25.3	B	2039	24.6	B
					R	2898	33.6	C	3019	33.2	C
			W	The Crescent	L	733	18.4	B	814	16.6	B
			Total			**8269**	**27.1**	**B**	**8840**	**26.7**	**B**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
7	Balmain Road / Perry Street / Wharf Road	S	N	Wharf Rd	L	10	1.7	A	17	1.7	A
					T	23	1.6	A	30	1.7	A
					R	5	1.8	A	1	1.9	A
			E	Balmain Rd	L	253	3.5	A	238	3.8	A
					T	442	4.0	A	467	4.2	A
					R	17	4.4	A	21	4.8	A
			S		L	15	2.7	A	16	2.0	A
					T	4	1.5	A	11	2.2	A
					R	204	3.1	A	203	3.2	A
			W	Perry St	L	8	2.7	A	9	2.8	A
					T	245	2.8	A	270	3.1	A
					R	0			0		
			Total			**1226**	**3.4**	**A**	**1283**	**3.6**	**A**
8	City-West Link Road / The Crescent	S	E	The Crescent	L	898	4.7	A	991	5.6	A
					T	1698	31.5	C	1872	28.2	B
			S		L	209	27.4	B	208	37.2	C
					R	792	67.5	E	881	78.0	F
			W	City-West Link Rd	T	1987	32.5	C	1965	43.1	D
					R	184	82.5	F	181	77.6	F
			Total			**5768**	**34.1**	**C**	**6098**	**38.3**	**C**
9	City-West Link Road / Norton Street	S	N		L	18	66.6	E	21	70.3	E
				Norton St	T	189	70.1	E	190	75.4	F
			E	City-West Link Rd	L	107	26.9	B	111	23.4	B
					T	2005	52.6	D	2082	48.3	D
					R	22	63.3	E	36	72.8	F
			S	Norton St	L	73	39.5	C	79	35.3	C
					T	160	58.0	E	148	61.1	E
					R	46	58.5	E	31	52.4	D
			W	City-West Link Rd	L	0			0		
					T	1891	4.2	A	1938	4.6	A
					R	121	48.6	D	136	50.5	D
			Total			**4632**	**33.0**	**C**	**4772**	**31.6**	**C**
10	City-West Link Road / Brenan Street / Balmain Road	S	N	Balmain Rd	L	126	44.8	D	120	38.5	C
					T	202	24.4	B	195	29.5	C
					R	96	31.5	C	81	24.6	B
			E	City-West Link Rd	L	162	16.2	B	148	28.6	C
					T	1863	16.7	B	2045	28.8	C
					R	85	23.5	B	88	32.4	C
			S	Balmain Rd	L	125	65.6	E	121	94.7	F
					T	361	64.2	E	346	85.8	F
					R	78	59.8	E	109	74.3	F
			W	City-West Link Rd	L	142	12.9	A	156	18.4	B
					T	1800	36.2	C	1834	52.8	D
			Total			**5040**	**30.2**	**C**	**5243**	**43.3**	**D**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
11	City-West Link Road / Brenan Street / Catherine Street	S	N	Catherine St	L	64	53.1	D	62	57.9	E
					T	297	48.6	D	319	50.7	D
					R	58	57.4	E	62	44.3	D
			E	City-West Link Rd	T	1916	14.5	A	2072	19.9	B
			S	Catherine St	L	0			0		
			W	City-West Link Rd	T	2087	30.4	C	2090	40.9	C
			Total			**4422**	**25.4**	B	**4605**	**32.4**	C
13	Catherine Street / Moore Street	S	N	Catherine St	L	102	1.7	A	118	1.6	A
					T	92	30.6	C	95	34.7	C
					R	10	39.8	C	7	56.8	E
			E	Moore St	L	0			0		
					T	296	9.8	A	303	11.4	A
					R	2	8.4	A	7	10.9	A
			S	Catherine St	L	9	35.9	C	11	27.5	B
					T	113	34.7	C	87	35.0	C
					R	24	31.2	C	27	33.2	C
			W	Moore St	L	2	23.3	B	2	26.6	B
					T	124	16.6	B	103	17.0	B
			Total			**774**	**17.3**	B	**760**	**17.7**	B
14	Styles Street / Catherine Street	S	N	Catherine St	L	0			0		
					T	128	23.0	B	125	28.7	C
					R	34	23.8	B	32	29.4	C
			E	Styles St	L	25	10.2	A	30	5.7	A
					T	283	10.5	A	313	9.8	A
					R	2	13.0	A	3	5.4	A
			S	Catherine St	L	55	26.5	B	44	27.0	B
					T	25	26.2	B	25	21.9	B
					R	1	39.2	C	2	26.0	B
			W	Styles St	L	71	14.4	A	53	17.7	B
					T	392	16.6	B	402	19.0	B
					R	19	17.5	B	34	21.1	B
			Total			**1035**	**16.4**	B	**1063**	**17.8**	B
19	Marion Street / Norton Street	S	N	Norton St	L	61	42.7	D	63	30.9	C
					T	154	38.3	C	161	34.3	C
					R	33	42.8	D	56	38.6	C
			E	Marion St	L	149	34.9	C	173	41.0	C
					T	523	26.9	B	519	34.4	C
					R	48	24.9	B	50	32.8	C
			S	Norton St	L	44	30.5	C	37	25.5	B
					T	74	33.2	C	81	31.9	C
					R	0			0		
			W	Marion St	L	30	8.7	A	15	18.7	B
					T	403	9.0	A	379	11.9	A
					R	56	10.1	A	62	11.1	A
			Total			**1575**	**24.5**	B	**1596**	**28.3**	B

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
20	Marion Street / Leichhardt Street / Balmain Road	S	N	Balmain Rd	L	33	70.8	F	21	59.4	E
					R	262	70.8	F	242	52.8	D
			E	Leichhardt St	T	352	19.4	B	383	22.3	B
					R	40	26.0	B	26	33.9	C
			S	Balmain Rd	L	35	72.4	F	41	89.4	F
					T	132	82.2	F	144	85.2	F
					R	9	76.5	F	1	60.5	E
			W	Marion St	L	206	27.0	B	200	33.4	C
					T	387	27.4	B	383	36.4	C
			Total			**1456**	**40.5**	C	**1441**	**41.7**	C
22	Johnston Street / Collins Street	S	N	Johnston St	L	13	22.1	B	4	26.6	B
					T	418	46.9	D	414	19.5	B
					R	71	34.3	C	59	30.8	C
			E	Collins St	L	16	22.8	B	21	20.5	B
			S	Johnston St	L	215	37.3	C	245	42.0	C
					T	409	34.9	C	454	37.6	C
			W	Collins St	L	180	18.8	B	179	23.1	B
					R	91	19.6	B	110	19.4	B
			Total			**1413**	**35.5**	C	**1486**	**29.7**	C
23	Johnston Street / Booth Street	S	N	Johnston St	L	82	69.9	E	107	81.6	F
					T	445	68.7	E	445	68.2	E
					R	92	50.8	D	90	59.9	E
			E	Booth St	L	65	18.3	B	59	19.5	B
					T	272	28.5	C	281	28.6	C
					R	73	33.5	C	90	34.1	C
			S	Johnston St	L	0			0		
					T	407	17.4	B	460	55.1	D
					R	154	25.1	B	155	9.9	A
			W	Booth St	L	57	15.3	B	65	17.4	B
					T	144	25.7	B	108	25.6	B
					R	26	35.4	C	28	40.3	C
			Total			**1817**	**37.9**	C	**1888**	**47.0**	D
27	Booth Street / Wigram Road	RB	N	Wigram Rd	L	51	1.9	A	48	1.9	A
					R	107	1.5	A	94	1.4	A
			E	Booth St	T	285	2.8	A	316	3.2	A
					R	169	2.8	A	180	3.3	A
			W	Booth St	L	143	1.5	A	116	1.5	A
					T	270	1.6	A	274	1.5	A
			Total			**1025**	**2.8**	A	**1028**	**3.3**	A

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
28	Minogue Crescent / Wigram Road	S	N	Minogue Cres	L	105	19.0	B	114	11.3	A
					T	219	20.5	B	245	13.6	A
					R	0			0		
			E	Wigram Rd	L	2	24.7	B	5	29.7	C
					T	135	24.0	B	117	22.4	B
					R	93	27.2	B	89	23.9	B
			S	Minogue Cres	L	42	6.1	A	48	7.4	A
					T	315	10.7	A	341	16.5	B
					R	62	10.7	A	92	11.8	A
			W	Wigram Rd	L	0			0		
					T	112	30.3	C	112	28.7	C
					R	44	29.0	C	32	22.9	B
			Total			**1129**	**18.8**	B	**1195**	**17.2**	B
29	Ross Street / Bridge Road	S	N	Ross St	L	59	20.6	B	66	23.8	B
					T	202	32.8	C	213	21.1	B
			E	Bridge Rd	L	35	21.7	B	25	24.5	B
					T	703	22.6	B	784	25.9	B
					R	106	27.3	B	108	28.0	B
			S	Ross St	L	217	44.9	D	259	46.6	D
					T	353	39.5	C	411	41.4	C
			W	Bridge Rd	L	83	35.2	C	86	27.6	B
					T	459	41.0	C	505	49.1	D
					R	0			0		
			Total			**2217**	**32.8**	C	**2457**	**35.1**	C
30	Pyrmont Bridge Road / Booth Street / Mallett Street	S	N	Booth St	L	174	24.2	B	196	21.7	B
					T	232	30.7	C	232	27.2	B
			E	Pyrmont Bridge Rd	L	108	12.1	A	117	17.6	B
					T	512	11.7	A	578	15.0	B
					R	138	41.5	C	158	43.1	D
			S	Mallett St	L	27	39.4	C	36	34.4	C
					T	146	30.6	C	155	30.8	C
					R	42	37.4	C	63	36.4	C
			W	Pyrmont Bridge Rd	L	49	34.6	C	65	37.7	C
					T	261	27.1	B	264	30.9	C
			Total			**1689**	**23.8**	B	**1864**	**25.2**	B
34	Marion Street / Foster Street	S	N	Foster St	L	24	27.0	B	19	26.7	B
					T	400	23.1	B	421	29.2	C
					R	80	28.9	C	61	36.2	C
			E	Marion St	L	122	50.4	D	130	40.4	C
					T	433	39.5	C	464	25.9	B
			S	Foster St	L	169	14.3	A	176	17.4	B
					T	433	20.1	B	442	25.1	B
					R	69	25.6	B	86	31.1	C
			W	Marion St	L	79	46.9	D	68	33.9	C
					T	293	43.8	D	316	28.4	B
					R	110	54.5	D	67	29.3	C
			Total			**2212**	**32.0**	C	**2250**	**27.7**	B

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	Delay (s)	LOS	8:15AM - 9:15AM Volume (veh)	Delay (s)	LOS
35	Marion Street / Flood Street	S	N	Flood St	L	0			1	18.0	B
					T	105	30.8	C	125	20.4	B
					R	11	34.3	C	18	27.8	B
			E	Marion St	L	239	10.6	A	279	14.3	A
					T	418	8.5	A	426	12.6	A
					R	24	9.7	A	23	5.2	A
			S	Flood St	L	95	41.4	C	121	40.5	C
					T	100	30.2	C	126	23.8	B
					R	163	47.2	D	130	38.8	C
			W	Marion St	L	12	19.3	B	14	24.9	B
					T	444	15.4	B	473	18.4	B
					R	34	25.2	B	40	32.2	C
			Total			**1645**	**19.8**	B	**1776**	**20.2**	B
36	Marion Street / Ramsay Street	S	N	Ramsay St	L	357	9.6	A	341	11.4	A
					T	70	47.6	D	69	41.3	C
			E	Marion St	L	103	10.6	A	99	10.6	A
					R	415	9.7	A	415	14.3	A
			S	Ramsay St	T	95	24.9	B	87	22.2	B
					R	150	30.3	C	138	21.8	B
			Total			**1190**	**15.8**	B	**1149**	**16.2**	B
39	Parramatta Road / Liverpool Road (Hume Highway)	S	E	Parramatta Rd	L	898	7.8	A	882	6.1	A
					T	1540	31.2	C	1570	61.6	E
			S	Liverpool Rd	L	154	24.2	B	171	26.2	B
					R	431	67.2	E	456	56.2	D
			W	Parramatta Rd	T	1228	10.4	A	1264	22.0	B
					R	333	159.2	F	328	126.2	F
			Total			**4584**	**33.5**	C	**4671**	**43.1**	D
41	City-West Link Road / James Street	S	N	City-West Link Rd	L	0			2	160.2	F
					T	265	87.9	F	290	117.7	F
					R	129	90.0	F	135	121.7	F
			E	James St	L	436	0.9	A	388	0.8	A
					T	1636	8.0	A	1772	6.9	A
			S	City-West Link Rd	L	24	62.0	E	36	49.6	D
					T	200	65.8	E	189	56.7	E
					R	330	57.1	E	322	51.9	D
			W	James St	L	182	4.2	A	179	6.1	A
					T	1672	29.9	C	1754	31.5	C
			Total			**4874**	**27.2**	B	**5067**	**29.4**	C

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	Delay (s)	LOS	8:15AM - 9:15AM Volume (veh)	Delay (s)	LOS
42	Tebbutt Street / Lords Road	S	N	Forster St	L	59	13.3	A	43	16.1	B
					T	703	17.5	B	721	16.7	B
			E	Lords Rd	L	23	27.7	B	20	30.0	C
					T	41	23.2	B	41	37.7	C
					R	118	25.7	B	145	27.8	B
			S	Tebbutt St	L	20	36.1	C	22	25.4	B
					T	490	6.9	A	477	6.6	A
					R	102	14.8	B	104	10.3	A
			W	Lords Rd	L	16	33.4	C	6	17.2	B
					T	51	27.7	B	43	33.7	C
					R	33	36.6	C	35	41.0	C
			Total			**1656**	**16.0**	B	**1657**	**16.1**	B
43	Lilyfield Road / James Street	S	N	Mary St	L	100	8.3	A	101	119.7	F
					T	317	96.5	F	342	259.4	F
					R	19	92.3	F	17	250.7	F
			E	Lilyfield Rd	L	0			0		
					T	32	48.6	D	48	30.1	C
					R	40	43.6	D	39	40.4	C
			S	James St	L	57	18.5	B	56	34.3	C
					T	278	21.1	B	286	23.5	B
					R	43	28.7	C	30	23.9	B
			W	Lilyfield Rd	L	32	48.5	D	40	41.6	C
					T	71	42.9	D	72	34.1	C
					R	60	42.9	D	56	37.1	C
			Total			**1049**	**49.4**	D	**1087**	**113.7**	F
44	Tebbutt Street / Hathern Street	S	N	Tebbutt St	T	36	26.9	B	38	50.3	D
					R	825	36.7	C	829	46.1	D
			S		L	188	11.1	A	184	9.0	A
					T	63	34.4	C	80	30.8	C
			W	Hathern St	L	579	12.7	A	554	12.6	A
					R	83	26.7	B	78	29.2	C
			Total			**1774**	**25.4**	B	**1763**	**30.3**	C
45	Parramatta Road / Sloane Street	S	N	Sloane St	L	27	75.4	F	22	70.6	F
					T	157	66.0	E	157	61.8	E
					R	73	95.3	F	73	64.7	E
			E	Parramatta Rd	L	32	18.6	B	26	27.9	B
					T	2313	20.5	B	2348	24.4	B
			S	Sloane St	L	48	63.2	E	52	56.5	E
					T	150	54.8	D	144	57.3	E
			W	Parramatta Rd	L	72	14.6	B	79	26.0	B
					T	1612	12.5	A	1688	25.1	B
			Total			**4484**	**22.3**	B	**4589**	**28.3**	B

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
47	Parramatta Road / Old Canterbury Road / Tebbutt Street	S	N	Tebbutt St	L	121	14.4	A	116	12.4	A
			E	Parramatta Rd	L	230	16.4	B	238	16.5	B
					T	2242	20.4	B	2304	15.9	B
			S	Old Canterbury Rd	L	107	11.9	A	97	12.6	A
			W	Parramatta Rd	T	1365	14.2	A	1462	19.9	B
			Total			**4065**	**17.7**	**B**	**4217**	**17.1**	**B**
49	Old Canterbury Road / Railway Terrace / Longport Street	S	N	Old Canterbury Rd	L	2	46.8	D	1	55.7	D
					T	1225	30.5	C	1220	31.9	C
			E	Railway Terrace	L	25	33.7	C	28	30.1	C
					T	683	35.3	C	701	26.9	B
			S	Old Canterbury Rd	L	85	31.6	C	94	30.8	C
					T	629	27.0	B	608	25.9	B
					R	0			0		
			W	Longport St	L	81	27.0	B	63	22.1	B
					T	484	25.7	B	469	26.8	B
			Total			**3214**	**30.1**	**C**	**3184**	**28.7**	**C**
50	Parramatta Road / Norton Street	S	N	Norton St	L	236	40.4	C	263	48.5	D
					R	101	65.9	E	99	68.1	E
			E	Parramatta Rd	T	1815	24.5	B	1849	20.8	B
					R	280	29.1	C	327	34.4	C
			W		L	79	34.3	C	79	12.4	A
					T	1084	40.3	C	1191	39.1	C
			Total			**3595**	**32.0**	**C**	**3808**	**30.7**	**C**
51	Parramatta Road / Flood Street / West Street	S	N	Flood St	L	3	56.5	E	6	31.8	C
					T	178	39.4	C	185	94.5	F
					R	77	49.6	D	93	162.4	F
			E	Parramatta Rd	L	8	66.0	E	12	68.7	E
					T	1812	73.1	F	1831	63.2	E
			S	West St	L	335	26.4	B	416	35.2	C
					T	184	35.3	C	206	45.2	D
					R	0			0		
			W	Parramatta Rd	L	93	30.8	C	139	30.4	C
					T	1069	36.6	C	1112	33.9	C
					R	289	131.3	F	339	125.3	F
			Total			**4048**	**59.1**	**E**	**4339**	**59.4**	**E**
52	Parramatta Road / Crystal Street / Balmain Road	S	E	Parramatta Rd	L	231	30.7	C	256	26.4	B
					T	1852	28.9	C	1907	25.5	B
			S	Crystal St	L	237	73.6	F	235	57.9	E
					T	134	146.1	F	150	102.4	F
					R	134	152.8	F	112	117.9	F
			W	Parramatta Rd	L	35	23.2	B	28	17.4	B
					T	1118	17.5	B	1225	17.2	B
					R	230	60.7	E	254	59.5	E
			Total			**3971**	**38.4**	**C**	**4167**	**32.2**	**C**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
53	Parramatta Road / Catherine Street / Phillip Street	S	N	Catherine St	L	7	64.4	E	9	46.4	D
					T	22	86.9	F	35	46.6	D
					R	99	63.0	E	105	55.9	D
			E	Parramatta Rd	L	7	22.3	B	7	36.3	C
					T	1949	33.6	C	1996	41.0	C
			S	Phillip St	L	10	75.6	F	12	76.3	F
					T	63	48.0	D	60	36.7	C
					R	26	52.7	D	10	46.3	D
			W	Parramatta Rd	L	36	6.5	A	37	4.9	A
					T	1188	2.7	A	1271	2.9	A
			Total			**3407**	**24.3**	B	**3542**	**27.5**	B
56	Crystal Street / Douglas Street / Brighton Street	S	N	Crystal St	L	39	67.9	E	38	61.0	E
					T	410	70.8	F	450	81.7	F
			E	Douglas St	L	546	18.0	B	533	18.4	B
					T	37	65.7	E	42	44.9	D
					R	12	94.8	F	6	93.1	F
			S	Crystal St	L	301	26.7	B	286	16.7	B
					T	520	28.8	C	505	13.6	A
					R	297	28.4	B	304	16.8	B
			W	Brighton St	L	24	31.9	C	26	24.3	B
					T	17	86.9	F	17	81.7	F
					R	188	105.6	F	184	110.9	F
			Total			**2391**	**41.3**	C	**2391**	**37.8**	C
57	Crystal Street / Trafalgar Street	S	N	Crystal St	L	21	21.7	B	22	18.4	B
					T	938	18.4	B	968	18.3	B
					R	223	18.9	B	195	20.3	B
			E	Trafalger St	L	18	54.5	D	20	65.5	E
					T	128	60.6	E	140	54.3	D
			S	Crystal St	L	41	11.9	A	39	13.1	A
					T	957	24.7	B	962	23.9	B
			W	Trafalger St	L	160	30.4	C	128	32.0	C
					T	99	44.4	D	92	50.6	D
			Total			**2585**	**24.8**	B	**2566**	**24.6**	B
58	New Canterbury Road / Stanmore Road / Crystal Street / Shaw Street	S	N	Crystal St	L	139	58.3	E	155	69.7	E
					T	476	61.4	E	472	71.6	F
					R	352	88.2	F	385	110.2	F
			E	Stanmore Rd	L	15	33.1	C	26	35.9	C
					T	622	29.2	C	618	45.9	D
					R	336	42.5	C	332	63.7	E
			S	Shaw St	L	22	52.6	D	19	52.4	D
					T	362	47.0	D	372	51.8	D
			W	New Canterbury Rd	L	294	52.5	D	284	58.7	E
					T	509	44.5	D	535	51.9	D
			Total			**3127**	**50.4**	D	**3198**	**63.2**	E

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	Delay (s)	LOS	8:15AM - 9:15AM Volume (veh)	Delay (s)	LOS
59	Gordon Street / Trafalgar Street	S	N	Gordon St	T	595	8.2	A	653	7.8	A
			E	Trafalger St	L	25	1.1	A	24	1.1	A
					R	342	70.6	F	322	75.0	F
			S	Gordon St	T	342	20.0	B	302	18.0	B
					R	462	36.6	C	559	38.9	C
				Total		**1766**	**29.9**	C	**1860**	**30.3**	C
60	New Canterbury Road / Gordon Street / Livingstone Road	S	N	Gordon St	L	148	38.7	C	136	37.4	C
					T	475	47.9	D	529	48.1	D
			E	New Canterbury Rd	L	45	20.7	B	61	23.0	B
					T	878	15.2	B	879	19.4	B
					R	208	26.4	B	198	27.3	B
			S	Livingstone Rd	L	100	39.2	C	102	34.7	C
					T	559	36.6	C	621	36.1	C
			W	New Canterbury Rd	L	37	32.7	C	42	27.1	B
					T	665	31.2	C	683	31.0	C
			Total			**3115**	**30.4**	C	**3251**	**31.6**	C
62	Ramsay Road / Dalhousie Street	S	N	Dalhousie St	L	106	30.2	C	75	20.3	B
					T	165	24.8	B	165	23.2	B
					R	61	26.4	B	60	26.1	B
			E	Ramsay St	L	69	19.2	B	64	18.8	B
					T	308	21.3	B	324	19.0	B
					R	87	20.9	B	82	22.5	B
			S	Dalhousie St	L	107	30.0	C	128	33.9	C
					T	115	28.9	C	142	33.9	C
					R	46	30.5	C	36	27.8	B
			W	Ramsay St	L	55	19.5	B	66	17.9	B
					T	309	17.8	B	349	14.0	A
					R	23	15.1	B	42	18.8	B
			Total			**1451**	**23.1**	B	**1533**	**21.6**	B
65	Stanmore Road / Liberty Street	S	N	Liberty St	L	336	28.2	B	320	34.5	C
					R	207	47.7	D	216	42.6	D
			E	Stanmore Rd	T	854	13.6	A	837	12.3	A
					R	365	15.5	B	366	19.4	B
			W		L	124	29.2	C	148	16.6	B
					T	515	33.6	C	530	9.7	A
			Total			**2401**	**24.0**	B	**2417**	**18.7**	B

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
66	Ross Street / St Johns Road	S	N	Ross St	L	70	17.8	B	78	14.3	A
					T	271	25.5	B	275	24.3	B
					R	0			0		
			E	St Johns Rd	L	67	42.6	D	49	37.7	C
					T	13	38.4	C	13	30.7	C
					R	224	45.7	D	291	41.3	C
			S	Ross St	L	1	2.8	A	2	6.5	A
					T	275	18.2	B	312	21.8	B
					R	97	26.2	B	96	27.9	B
			W	St Johns Rd	L	70	63.2	E	72	61.8	E
					T	29	60.6	E	27	38.5	C
					R	6	65.0	E	9	72.9	F
			Total			**1123**	**32.0**	C	**1224**	**30.8**	C
67	Parramatta Road / Young Street / Percival Road	S	N	Young St	L	0			0		
					T	122	51.1	D	135	47.7	D
					R	0			0		
			E	Parramatta Rd	L	89	10.7	A	81	16.1	B
					T	1851	5.2	A	1891	7.4	A
			S	Percival Rd	L	29	43.0	D	31	48.9	D
					T	93	49.6	D	77	45.9	D
					R	56	57.8	E	60	50.5	D
			W	Parramatta Rd	L	20	29.3	C	19	26.7	B
					T	1208	26.0	B	1309	24.0	B
			Total			**3468**	**16.7**	B	**3603**	**17.1**	B
68	Parramatta Road /Northumberland Avenue / Johnston Street	S	N	Johnston St	L	120	45.6	D	146	39.8	C
					T	333	75.7	F	332	68.1	E
					R	82	106.8	F	81	106.3	F
			E	Parramatta Rd	L	89	12.6	A	100	18.3	B
					T	1795	11.1	A	1812	16.9	B
					R	248	75.3	F	256	82.3	F
			S	Northumberland Dr	L	70	50.4	D	83	42.4	C
					T	321	50.4	D	356	44.8	D
					R	23	56.9	E	28	50.2	D
			W	Parramatta Rd	L	62	17.8	B	57	29.0	C
					T	1144	17.6	B	1219	31.1	C
			Total			**4287**	**28.3**	B	**4470**	**33.8**	C
69	Parramatta Road / Bridge Road	S	E	Parramatta Rd	L	355	35.3	C	348	39.7	C
					T	2013	30.0	C	2020	33.0	C
			S	Bridge Rd	L	6	71.5	F	5	44.0	D
					R	198	56.5	D	236	56.9	E
			W	Parramatta Rd	T	1143	6.6	A	1235	10.1	A
					R	161	59.4	E	193	114.8	F
			Total			**3876**	**26.2**	B	**4037**	**31.9**	C

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70	Parramatta Road /Pyrmont Bridge Road / Denison Street	S	N	Pyrmont Bridge Rd	L	0			0		
					T	43	92.8	F	59	113.6	F
					R	480	85.1	F	536	115.5	F
			E	Parramatta Rd	L	17	53.1	D	27	69.6	E
					T	1837	34.4	C	1823	60.6	E
			W		L	315	9.5	A	332	8.0	A
					T	1126	11.9	A	1214	12.1	A
			Total			**3818**	**32.8**	C	**3991**	**49.7**	D
71	Parramatta Road / Mallett Street	S	N	Mallett St	L	94	59.0	E	92	66.1	E
					T	215	58.1	E	222	69.1	E
					R	34	88.7	F	43	184.6	F
			E	Parramatta Rd	L	51	6.4	A	42	10.5	A
					T	1744	9.6	A	1773	9.2	A
			S	Mallett St	L	62	68.8	E	57	77.9	F
					T	135	65.0	E	129	77.6	F
					R	21	134.8	F	22	137.0	F
			W	Parramatta Rd	L	30	16.7	B	34	7.8	A
					T	1108	11.2	A	1180	4.7	A
			Total			**3494**	**19.1**	B	**3594**	**19.3**	B
72	Parramatta Road / Ross Street / Western Avenue	S	N	Ross St	L	160	37.0	C	135	39.8	C
					T	76	57.8	E	88	59.4	E
					R	106	48.8	D	112	61.8	E
			E	Parramatta Rd	L	9	40.7	C	9	27.2	B
					T	1576	40.0	C	1657	14.4	A
					R	214	79.0	F	247	82.0	F
			S	Western Ave	L	4	58.0	E	8	84.0	F
					T	63	47.6	D	74	65.5	E
					R	17	53.2	D	23	97.8	F
			W	Parramatta Rd	L	96	51.3	D	100	37.9	C
					T	998	52.6	D	1077	25.0	B
			Total			**3319**	**47.4**	D	**3530**	**28.4**	B
73	Great Western Highway / Glebe Point Road	S	N	Glebe Point Rd	L	293	24.6	B	319	23.1	B
					R	158	53.9	D	145	64.8	E
			E	Great Western Hwy	T	1657	22.6	B	1746	22.7	B
					R	216	54.6	D	217	37.0	C
			W		L	43	15.0	B	37	10.7	A
					T	1205	36.4	C	1242	12.1	A
			Total			**3572**	**30.6**	C	**3706**	**21.5**	B

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74	Broadway / City Road (Princes Highway) / Bay Street	S	N	Bay St	L	45	10.4	A	47	6.3	A
			E	Broadway	L	630	11.3	A	624	11.1	A
					T	1158	38.4	C	1176	34.9	C
			S	City Rd	L	713	34.7	C	785	45.3	D
					T	182	53.0	D	181	63.4	E
					R	536	50.6	D	565	55.4	D
			W	Great Western Hwy	L	97	22.2	B	96	25.5	B
					T	786	19.4	B	801	27.1	B
					R	629	78.6	F	663	86.8	F
			Total			**4776**	**37.8**	C	**4938**	**42.2**	C
75	University Avenue / Parramatta Road / Derwent Street / Arundel Street	S	E	Parramatta Rd	L	77	5.0	A	58	6.1	A
					T	1746	2.8	A	1844	4.1	A
			S	University Ave	L	55	60.4	E	47	75.7	F
					R	48	68.0	E	54	64.8	E
			W	Parramatta Rd	T	1208	6.9	A	1218	23.7	B
			Total			**3134**	**6.4**	A	**3221**	**13.6**	A
79	Douglas Street / Percival Road	S	N	Percival Rd	L	36	17.4	B	40	19.8	B
					R	320	21.5	B	321	20.7	B
			E	Douglas St	T	64	35.1	C	76	38.8	C
					R	113	41.2	C	116	43.4	D
			W		L	269	9.7	A	274	11.0	A
					T	70	36.4	C	89	37.5	C
			Total			**872**	**22.5**	B	**916**	**23.8**	B
80	Railway Terrace / Victoria Street	P	E	Railway Terrace	L	74	1.4	A	51	1.7	A
					T	714	1.6	A	723	1.7	A
			S	Victoria St	L	5	5.0	A	9	3.9	A
					R	9	4.7	A	7	4.8	A
			W	Railway Terrace	T	481	1.5	A	472	1.5	A
			Total			**1283**	**5.0**	A	**1262**	**4.8**	A
81	Parramatta Road / Dalhousie Street	S	N	Dalhousie St	L	143	41.9	C	145	53.1	D
					R	118	93.5	F	128	81.7	F
			E	Parramatta Rd	T	1478	21.7	B	1542	28.6	C
					R	181	53.6	D	220	70.2	E
			W		L	72	39.1	C	79	33.6	C
					T	1559	41.1	C	1593	36.1	C
			Total			**3551**	**35.4**	C	**3707**	**37.2**	C

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82	Carillon Avenue / Missenden Road	S	N	Missenden Rd	L	163	11.0	A	150	18.5	B
					T	170	27.2	B	174	25.9	B
					R	58	43.6	D	67	45.1	D
			E	Carillon Ave	L	36	46.7	D	39	39.8	C
					T	462	46.1	D	437	40.8	C
					R	106	42.0	C	101	37.7	C
			S	Missenden Rd	L	123	18.9	B	122	19.7	B
					T	188	30.8	C	212	33.9	C
					R	2	9.3	A	1	55.9	D
			W	Carillon Ave	L	45	47.6	D	56	59.5	E
					T	254	40.0	C	323	45.7	D
					R	40	52.1	D	41	57.4	E
			Total			**1647**	**35.8**	C	**1723**	**36.9**	C
83	Parramatta Road / Missenden Avenue / Lyons Road	S	N	Lyons Rd	L	24	42.9	D	25	57.5	E
					T	127	47.3	D	136	51.9	D
					R	0			0		
			E	Parramatta Rd	L	125	33.0	C	122	41.3	C
					T	1574	64.9	E	1645	43.6	D
			S	Missenden Rd	L	155	59.9	E	152	45.6	D
					T	133	65.3	E	153	63.7	E
					R	46	70.3	E	38	58.7	E
			W	Parramatta Rd	L	29	16.5	B	29	10.9	A
					T	1018	9.1	A	1098	12.4	A
					R	200	68.4	E	166	83.0	F
			Total			**3431**	**46.0**	D	**3564**	**37.0**	C

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
1	Victoria Rd / Darling St	S	N	Darling St	L	365	64.1	E	302	65.6	E
					T	173	84.4	F	196	88.3	F
			E	Victoria Rd	L	98	17.5	B	82	22.4	B
					T	120	16.3	B	128	17.4	B
					R	235	52.3	D	207	62.9	E
			S	Darling St	L	230	75.5	F	217	80.7	F
					T	194	114.1	F	197	122.3	F
			W	Victoria Rd	L	29	43.8	D	37	44.6	D
					T	385	26.9	B	287	24.0	B
					R	123	37.8	C	149	39.2	C
			Total			**1952**	**56.2**	D	**302**	**61.1**	E
2	Victoria Road / Evans Street	S	N	Evans St	L	313	55.4	D	300	53.2	D
					T	120	50.7	D	98	51.9	D
					R	27	48.3	D	46	58.2	E
			E	Victoria Rd	L	19	22.1	B	24	15.6	B
					T	401	9.2	A	345	13.0	A
			S	Evans St	L	26	55.8	D	22	40.4	C
					T	129	47.4	D	120	42.1	C
			W	Victoria Rd	L	4	1.6	A	0		
					T	811	14.7	B	618	13.9	A
			Total			**1850**	**26.1**	B	**1573**	**27.4**	B
3	Victoria Road / Robert Street	S	N	Victoria Rd	L	26	2.2	A	25	6.4	A
					T	1371	11.3	A	1193	11.9	A
			E	Robert St	L	798	54.0	D	781	50.7	D
					R	0			0		
			S	Victoria Rd	T	350	2.8	A	323	3.0	A
					R	628	34.3	C	535	55.9	D
			Total			**3173**	**25.6**	B	**2857**	**29.7**	C
5	Balmain Road / Lilyfield Road	S	N	Balmain Rd	L	72	3.0	A	52	6.0	A
					T	86	3.8	A	212	6.7	A
			E	Lilyfield Rd	L	9	28.9	C	54	28.4	B
					T	31	26.6	B	48	27.8	B
					R	6	22.8	B	20	22.0	B
			S	Balmain Rd	L	33	10.7	A	23	6.5	A
					T	227	6.7	A	250	4.8	A
					R	565	10.9	A	601	9.5	A
			W	Lilyfield Rd	L	45	34.2	C	5	34.1	C
					T	77	17.3	B	115	19.9	B
					R	2	29.4	C	7	23.7	B
			Total			**1153**	**11.1**	A	**1387**	**10.6**	A
6	The Crescent / Victoria Road	S	N	Victoria Rd	L	816	17.0	B	816	12.8	A
					R	1263	20.3	B	1114	14.0	A
			E		T	1470	62.2	E	1302	56.4	D
					R	401	44.1	D	348	44.0	D
			W	The Crescent	L	876	15.6	B	767	15.7	B
			Total			**4826**	**33.7**	C	**4347**	**29.1**	C

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM			8:15AM - 9:15AM		
						Volume (veh)	Delay (s)	LOS	Volume (veh)	Delay (s)	LOS
7	Balmain Road / Perry Street / Wharf Road	S	N	Wharf Rd	L	0			0		
					T	0			0		
					R	3	1.8	A	0		
			E	Balmain Rd	L	152	3.7	A	260	5.9	A
					T	207	4.8	A	120	5.7	A
					R	7	4.0	A	11	5.5	A
			S		L	19	2.6	A	15	3.5	A
					T	22	2.7	A	15	3.8	A
					R	200	3.6	A	211	5.0	A
			W	Perry St	L	12	6.8	A	13	9.7	A
					T	250	8.4	A	264	9.7	A
					R	20	5.9	A	11	12.6	A
			Total			**892**	**5.3**	**A**	**920**	**6.8**	**A**
8	City-West Link Road / The Crescent	S	E	The Crescent	L	824	14.1	A	785	17.7	B
					T	1828	6.5	A	1558	6.6	A
			S		L	46	47.3	D	49	36.0	C
					R	0	0.0	A	0	0.0	A
			W	City-West Link Rd	T	490	9.0	A	409	11.5	A
					R	250	89.8	F	280	84.0	F
			Total			**3438**	**15.3**	**B**	**3081**	**17.6**	**B**
9	City-West Link Road / Norton Street	S	N	Norton St	L	53	24.5	B	24	40.7	C
					T	97	55.1	D	73	60.7	E
			E	City-West Link Rd	L	308	25.8	B	342	22.9	B
					T	1700	57.7	E	1614	52.2	D
					R	3	113.0	F	4	39.1	C
			S	Norton St	L	63	183.7	F	55	251.1	F
					T	141	199.5	F	94	290.1	F
					R	237	201.7	F	230	273.3	F
			W	City-West Link Rd	L	3	2.7	A	4	5.2	A
					T	1424	14.1	A	1371	15.6	B
					R	205	70.7	F	181	78.2	F
			Total			**4234**	**55.5**	**D**	**3992**	**59.4**	**E**
10	City-West Link Road / Brenan Street / Balmain Road	S	N	Balmain Rd	L	48	31.3	C	41	36.2	C
					T	59	19.9	B	30	23.9	B
					R	47	32.5	C	256	21.4	B
			E	City-West Link Rd	L	58	7.1	A	51	15.5	B
					T	1884	7.9	A	1650	17.5	B
					R	152	19.8	B	170	27.4	B
			S	Balmain Rd	L	39	75.5	F	33	66.9	E
					T	155	57.0	E	165	60.1	E
					R	181	53.4	D	275	48.4	D
			W	City-West Link Rd	L	508	16.8	B	528	20.6	B
					T	1205	25.4	B	1114	33.1	C
			Total			**4336**	**19.2**	**B**	**4313**	**26.7**	**B**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
11	City-West Link Road / Brenan Street / Catherine Street	S	N	Catherine St	L	204	43.1	D	142	44.8	D
					T	328	33.0	C	358	37.9	C
					R	87	32.9	C	46	39.2	C
			E	City-West Link Rd	T	1751	25.3	B	1547	26.5	B
			S	Catherine St	L	155	42.4	C	174	47.4	D
			W	City-West Link Rd	T	1444	19.3	B	1449	29.6	C
			Total			**3969**	**25.5**	**B**	**3716**	**30.7**	**C**
13	Catherine Street / Moore Street	S	N	Catherine St	L	216	18.0	B	272	78.3	F
					T	118	40.7	C	144	49.5	D
					R	1	2.1	A	5	55.5	D
			E	Moore St	L	21	8.7	A	21	12.8	A
					T	94	13.4	A	110	11.2	A
					R	182	15.6	B	188	14.1	A
			S	Catherine St	L	64	35.9	C	77	39.1	C
					T	141	34.8	C	231	43.5	D
					R	47	38.1	C	51	40.1	C
			W	Moore St	L	17	34.3	C	12	51.2	D
					T	145	28.1	B	143	34.1	C
			Total			**1046**	**25.5**	**B**	**1254**	**42.6**	**D**
14	Styles Street / Catherine Street	S	N	Catherine St	L	5	21.7	B	13	38.5	C
					T	133	59.9	E	156	60.6	E
					R	42	77.1	F	34	53.3	D
			E	Styles St	L	72	17.7	B	56	45.4	D
					T	175	17.8	B	115	27.9	B
					R	24	31.3	C	19	43.3	D
			S	Catherine St	L	50	39.2	C	48	33.3	C
					T	89	42.5	D	149	35.8	C
					R	11	36.9	C	15	45.2	D
			W	Styles St	L	111	26.3	B	168	77.1	F
					T	563	25.6	B	620	86.1	F
					R	33	24.3	B	46	82.9	F
			Total			**1308**	**31.2**	**C**	**1439**	**66.8**	**E**
19	Marion Street / Norton Street	S	N	Norton St	L	90	48.8	D	150	76.0	F
					T	253	46.0	D	262	51.4	D
					R	25	43.0	D	10	48.2	D
			E	Marion St	L	87	24.7	B	49	27.9	B
					T	254	18.4	B	241	20.0	B
					R	42	38.6	C	11	50.3	D
			S	Norton St	L	44	25.8	B	28	24.0	B
					T	94	37.5	C	71	32.5	C
					R	2	44.1	D	30	44.2	D
			W	Marion St	L	20	16.1	B	9	114.1	F
					T	762	20.8	B	702	91.4	F
					R	149	28.1	B	168	99.6	F
			Total			**1822**	**27.8**	**B**	**1731**	**68.3**	**E**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
20	Marion Street / Leichhardt Street / Balmain Road	S	N	Balmain Rd	L	20	173.8	F	34	62.3	E
					R	83	110.1	F	53	58.7	E
			E	Leichhardt St	T	253	16.6	B	210	14.0	A
					R	20	44.8	D	8	28.2	B
			S	Balmain Rd	L	18	76.1	F	3	80.2	F
					T	101	68.1	E	115	80.8	F
					R	28	72.0	F	19	78.1	F
			W	Marion St	L	249	25.9	B	257	52.3	D
					T	771	25.3	B	828	55.2	D
			Total			**1543**	**34.9**	C	**1527**	**51.4**	D
22	Johnston Street / Collins Street	S	N	Johnston St	L	118	10.6	A	140	8.3	A
					T	339	20.0	B	268	20.6	B
					R	148	28.2	B	98	17.8	B
			E	Collins St	L	62	15.0	B	101	16.9	B
			S	Johnston St	L	89	101.5	F	66	36.5	C
					T	475	86.3	F	372	36.2	C
			W	Collins St	L	409	52.4	D	409	27.7	B
					R	204	58.5	E	268	29.8	C
			Total			**1844**	**52.4**	D	**1722**	**26.3**	B
23	Johnston Street / Booth Street	S	N	Johnston St	L	41	95.4	F	28	72.5	F
					T	343	65.5	E	211	64.5	E
					R	60	53.2	D	58	50.1	D
			E	Booth St	L	64	20.5	B	50	14.8	B
					T	279	30.6	C	280	27.4	B
					R	56	52.9	D	44	37.4	C
			S	Johnston St	L	7	121.4	F	10	66.5	E
					T	489	76.9	F	506	56.7	E
					R	316	122.8	F	302	63.3	E
			W	Booth St	L	31	153.4	F	31	226.6	F
					T	417	189.0	F	372	264.3	F
					R	121	222.9	F	190	274.9	F
			Total			**2224**	**103.5**	F	**2082**	**112.7**	F
27	Booth Street / Wigram Road	RB	N	Wigram Rd	L	85	32.8	C	118	82.8	F
					R	65	24.7	B	68	83.3	F
			E	Booth St	T	267	5.0	A	253	4.0	A
					R	237	3.5	A	276	3.6	A
			W		L	263	65.7	E	238	90.7	F
					T	505	74.0	F	421	96.3	F
			Total			**1422**	**74.0**	F	**1374**	**96.3**	F

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28	Minogue Crescent / Wigram Road	S	N	Minogue Cres	L	68	20.1	B	72	13.4	A
					T	480	23.8	B	522	21.4	B
					R	9	22.8	B	52	28.8	C
			E		L	15	24.2	B	12	15.4	B
				Wigram Rd	T	142	17.2	B	128	21.9	B
					R	56	31.0	C	43	28.0	B
			S	Minogue Cres	L	19	20.9	B	24	17.0	B
					T	195	23.7	B	150	22.1	B
					R	22	24.3	B	23	25.4	B
			W	Wigram Rd	L	19	31.7	C	81	28.4	B
					T	216	23.4	B	225	30.1	C
					R	0			0		
			Total			**1241**	**23.2**	**B**	**1332**	**23.4**	**B**
29	Ross Street / Bridge Road	S	N	Ross St	L	43	54.7	D	112	37.2	C
					T	431	45.4	D	402	45.2	D
			E		L	43	10.5	A	69	13.6	A
				Bridge Rd	T	461	10.9	A	443	16.1	B
					R	48	15.0	B	47	17.9	B
			S	Ross St	L	130	50.0	D	117	38.1	C
					T	174	61.4	E	143	53.3	D
			W	Bridge Rd	L	67	35.1	C	52	54.7	D
					T	883	45.2	D	820	64.2	E
					R	23	35.4	C	13	41.8	C
			Total			**2303**	**38.4**	**C**	**2218**	**44.8**	**D**
30	Pyrmont Bridge Road / Booth Street / Mallett Street	S	N	Booth St	L	384	109.6	F	321	130.8	F
					T	492	106.4	F	503	131.2	F
			E	Pyrmont Bridge Rd	L	52	25.3	B	72	18.3	B
					T	214	24.4	B	236	13.6	A
					R	67	67.7	E	72	66.0	E
			S	Mallett St	L	13	7.9	A	23	27.1	B
					T	218	31.1	C	170	44.0	D
					R	119	51.5	D	76	56.3	D
			W	Pyrmont Bridge Rd	L	97	50.4	D	190	37.6	C
					T	390	43.2	D	446	35.8	C
			Total			**2046**	**68.5**	**E**	**2109**	**72.5**	**F**
34	Marion Street / Foster Street	S	N	Foster St	L	5	123.7	F	1	40.2	C
					T	273	90.3	F	297	41.9	C
					R	68	118.9	F	106	64.5	E
			E	Marion St	L	116	27.0	B	36	58.4	E
					T	271	28.2	B	251	54.5	D
			S	Foster St	L	91	63.2	E	107	28.8	C
					T	465	80.3	F	518	37.0	C
					R	73	105.9	F	69	41.0	C
			W	Marion St	L	423	21.1	B	352	72.7	F
					T	649	22.2	B	566	73.1	F
					R	134	27.0	B	105	74.2	F
			Total			**2568**	**47.5**	**D**	**2408**	**56.0**	**D**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
35	Marion Street / Flood Street	S	N	Flood St	L	6	15.1	B	6	9.7	A
					T	212	30.7	C	190	19.4	B
					R	71	39.2	C	41	18.3	B
			E	Marion St	L	121	30.8	C	168	12.0	A
					T	247	28.0	B	182	11.1	A
					R	34	20.3	B	8	37.0	C
			S	Flood St	L	39	31.6	C	44	25.2	B
					T	223	31.9	C	271	19.4	B
					R	270	38.3	C	281	31.6	C
			W	Marion St	L	43	28.0	B	77	45.2	D
					T	851	32.5	C	727	54.1	D
					R	137	43.0	D	118	85.5	F
			Total			**2254**	**32.9**	**C**	**2113**	**36.4**	**C**
36	Marion Street / Ramsay Street	S	N	Ramsay St	L	822	21.9	B	755	18.1	B
					T	9	35.9	C	24	59.1	E
			E	Marion St	L	28	59.8	E	41	15.7	B
					R	301	81.0	F	354	20.5	B
			S	Ramsay St	T	242	7.5	A	208	24.5	B
					R	321	19.0	B	210	36.0	C
			Total			**1723**	**30.4**	**C**	**1592**	**22.4**	**B**
39	Parramatta Road / Liverpool Road (Hume Highway)	S	E	Parramatta Rd	L	337	5.4	A	414	3.5	A
					T	1214	59.4	E	1400	65.9	E
			S	Liverpool Rd	L	58	36.5	C	92	99.5	F
					R	986	55.6	D	956	131.0	F
			W	Parramatta Rd	T	1383	18.1	B	1243	14.3	A
					R	271	75.0	F	270	62.5	E
			Total			**4249**	**41.5**	**C**	**4375**	**60.1**	**E**
41	City-West Link Road / James Street	S	N	City-West Link Rd	L	8	48.2	D	2	98.2	F
					T	87	46.5	D	71	45.5	D
					R	77	50.4	D	51	47.5	D
			E	James St	L	445	1.0	A	417	1.0	A
					T	1320	4.4	A	1251	2.8	A
			S	City-West Link Rd	L	22	81.4	F	26	100.2	F
					T	222	80.6	F	237	114.8	F
					R	519	74.7	F	533	105.5	F
			W	James St	L	224	3.1	A	255	3.3	A
					T	1108	24.7	B	1024	18.8	B
			Total			**4032**	**25.1**	**B**	**3867**	**30.0**	**C**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
42	Tebbutt Street / Lords Road	S	N	Forster St	L	187	20.0	B	174	18.6	B
					T	593	16.4	B	507	8.8	A
			E	Lords Rd	L	73	23.2	B	81	23.1	B
					T	50	22.9	B	49	14.7	B
					R	38	26.2	B	64	31.4	C
			S	Tebbutt St	L	26	45.0	D	22	17.5	B
					T	535	42.1	C	539	13.9	A
					R	264	60.7	E	260	22.9	B
			W	Lords Rd	L	17	22.2	B	35	26.4	B
					T	79	24.3	B	33	34.5	C
					R	26	18.9	B	33	35.4	C
			Total			**1888**	**31.7**	C	**1797**	**16.3**	B
43	Lilyfield Road / James Street	S	N	Mary St	L	82	8.1	A	49	8.1	A
					T	120	42.9	D	68	42.2	C
					R	7	49.5	D	6	50.6	D
			E	Lilyfield Rd	L	23	2.9	A	37	3.0	A
					T	55	5.0	A	52	9.1	A
					R	3	63.2	E	0		
			S	James St	L	18	26.9	B	31	19.1	B
					T	277	26.4	B	312	20.9	B
					R	150	30.6	C	148	20.7	B
			W	Lilyfield Rd	L	15	26.6	B	8	32.6	C
					T	85	27.2	B	99	30.5	C
					R	25	34.6	C	14	16.3	B
			Total			**860**	**26.3**	B	**824**	**21.7**	B
44	Tebbutt Street / Hathern Street	S	N	Tebbutt St	T	77	12.7	A	58	28.8	C
					R	619	19.1	B	569	28.5	C
			S		L	60	9.8	A	42	7.7	A
					T	31	26.8	B	23	29.6	C
			W	Hathern St	L	870	26.2	B	875	19.4	B
					R	184	32.4	C	211	27.9	B
			Total			**1841**	**23.3**	B	**1778**	**23.5**	B
45	Parramatta Road / Sloane Street	S	N	Sloane St	L	29	58.2	E	59	59.9	E
					T	102	53.4	D	92	65.5	E
					R	21	82.7	F	33	67.1	E
			E	Parramatta Rd	L	18	6.6	A	24	14.3	A
					T	1527	6.1	A	1736	10.0	A
			S	Sloane St	L	33	79.8	F	40	81.9	F
					T	273	62.1	E	227	63.1	E
			W	Parramatta Rd	L	251	22.9	B	170	23.2	B
					T	2215	17.5	B	2115	17.7	B
			Total			**4469**	**18.4**	B	**4496**	**19.7**	B

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
47	Parramatta Road / Old Canterbury Road / Tebbutt Street	S	N	Tebbutt St	L	261	31.4	C	279	28.3	B
			E	Parramatta Rd	L	236	32.5	C	296	26.2	B
					T	1402	17.5	B	1581	22.4	B
			S	Old Canterbury Rd	L	126	21.4	B	172	19.6	B
			W	Parramatta Rd	T	2155	35.0	C	2106	31.2	C
			Total			**4180**	**28.4**	B	**4434**	**27.1**	B
49	Old Canterbury Road / Railway Terrace / Longport Street	S	N	Old Canterbury Rd	L	92	21.2	B	72	16.1	B
					T	828	16.3	B	792	14.9	B
			E	Railway Terrace	L	33	63.1	E	16	83.5	F
					T	456	59.3	E	470	111.1	F
			S	Old Canterbury Rd	L	70	45.4	D	58	18.8	B
					T	1075	49.4	D	1098	30.9	C
					R	6	59.6	E	1	54.3	D
			W	Longport St	L	109	42.6	D	126	48.0	D
					T	519	47.1	D	438	49.7	D
			Total			**3188**	**40.9**	C	**3071**	**42.1**	C
50	Parramatta Road / Norton Street	S	N	Norton St	L	195	46.2	D	220	46.9	D
					R	78	61.4	E	78	49.2	D
			E	Parramatta Rd	T	1106	4.1	A	1320	2.7	A
					R	283	113.1	F	261	45.7	D
			W		L	35	19.4	B	31	15.9	B
					T	1780	17.8	B	1706	19.4	B
			Total			**3477**	**23.8**	B	**3616**	**17.5**	B
51	Parramatta Road / Flood Street / West Street	S	N	Flood St	L	13	139.8	F	2	437.8	F
					T	176	163.5	F	129	486.3	F
					R	20	242.5	F	13	1207.4	F
			E	Parramatta Rd	L	16	81.2	F	18	206.4	F
					T	1050	62.2	E	1293	221.2	F
			S	West St	L	342	49.4	D	339	41.7	C
					T	267	71.4	F	342	66.8	E
					R	6	54.2	D	1	94.6	F
			W	Parramatta Rd	L	153	33.0	C	140	29.0	C
					T	1673	33.0	C	1635	28.2	B
					R	588	81.5	F	607	89.7	F
			Total			**4304**	**57.3**	E	**4519**	**113.0**	F
52	Parramatta Road / Crystal Street / Balmain Road	S	E	Parramatta Rd	L	115	67.8	E	211	53.6	D
					T	1093	88.3	F	1346	52.3	D
			S	Crystal St	L	262	54.6	D	213	58.5	E
					T	146	116.4	F	134	181.9	F
					R	260	122.0	F	268	207.3	F
			W	Parramatta Rd	L	4	11.8	A	2	9.8	A
					T	1896	10.2	A	1867	10.1	A
					R	217	89.9	F	185	65.6	E
			Total			**3993**	**51.6**	D	**4226**	**48.6**	D

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53	Parramatta Road / Catherine Street / Phillip Street	S	N	Catherine St	L	4	405.4	F	28	731.0	F
					T	30	661.8	F	64	888.2	F
					R	93	510.8	F	143	881.0	F
			E	Parramatta Rd	L	4	172.9	F	0		
					T	1083	140.9	F	1285	75.6	F
			S	Phillip St	L	26	39.9	C	32	38.5	C
					T	54	41.4	C	53	42.9	D
					R	21	43.6	D	23	48.4	D
			W	Parramatta Rd	L	110	30.8	C	175	20.4	B
					T	2030	16.2	B	1936	12.3	A
			Total			**3455**	**76.0**	F	**3739**	**88.9**	F
56	Crystal Street / Douglas Street / Brighton Street	S	N	Crystal St	L	64	65.1	E	65	88.5	F
					T	253	69.7	E	301	85.6	F
			E	Douglas St	L	249	22.3	B	247	16.2	B
					T	74	87.2	F	107	58.5	E
					R	2	76.4	F	7	65.1	E
			S	Crystal St	L	373	13.8	A	254	12.2	A
					T	683	15.3	B	627	11.8	A
					R	823	32.4	C	705	20.4	B
			W	Brighton St	L	38	28.5	C	25	21.7	B
					T	72	58.0	E	68	63.6	E
					R	132	103.2	F	80	96.3	F
			Total			**2763**	**34.4**	C	**2486**	**32.0**	C
57	Crystal Street / Trafalgar Street	S	N	Crystal St	L	85	23.9	B	162	50.5	D
					T	524	10.0	A	482	44.0	D
					R	73	30.5	C	70	43.5	D
			E	Trafalger St	L	26	38.5	C	69	44.2	D
					T	74	44.1	D	122	48.9	D
			S	Crystal St	L	114	29.7	C	155	36.0	C
					T	1668	33.2	C	1391	40.9	C
			W	Trafalger St	L	212	41.4	C	189	31.6	C
					T	390	45.7	D	480	35.5	C
			Total			**3166**	**31.3**	C	**3120**	**40.7**	C
58	New Canterbury Road / Stanmore Road / Crystal Street / Shaw Street	S	N	Crystal St	L	101	81.9	F	74	157.6	F
					T	299	82.1	F	316	166.1	F
					R	143	62.6	E	152	72.2	F
			E	Stanmore Rd	L	68	29.7	C	96	35.1	C
					T	556	41.9	C	582	47.4	D
					R	360	100.4	F	360	76.7	F
			S	Shaw St	L	9	90.6	F	64	103.6	F
					T	627	79.7	F	526	111.3	F
			W	New Canterbury Rd	L	794	53.3	D	670	42.9	D
					T	893	38.9	C	864	34.3	C
			Total			**3850**	**60.0**	E	**3704**	**69.4**	E

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59	Gordon Street / Trafalgar Street	S	N	Gordon St	T	547	14.3	A	455	10.1	A
			E	Trafalger St	L	39	2.3	A	45	2.0	A
					R	282	34.9	C	261	35.5	C
			S	Gordon St	T	248	35.0	C	275	34.9	C
					R	568	58.8	E	662	52.7	D
				Total		**1684**	**35.5**	C	**1698**	**34.4**	C
60	New Canterbury Road / Gordon Street / Livingstone Road	S	N	Gordon St	L	214	52.4	D	173	43.7	D
					T	385	56.3	D	310	53.2	D
			E	New Canterbury Rd	L	9	25.1	B	8	16.9	B
					T	405	24.9	B	435	19.5	B
					R	290	79.8	F	400	86.4	F
			S	Livingstone Rd	L	41	30.8	C	45	38.1	C
					T	437	32.2	C	434	38.3	C
			W	New Canterbury Rd	L	91	50.5	D	106	41.7	C
					T	1470	48.4	D	1331	35.8	C
			Total			**3342**	**47.1**	D	**3242**	**42.4**	C
62	Ramsay Road / Dalhousie Street	S	N	Dalhousie St	L	279	38.1	C	238	40.4	C
					T	131	35.4	C	135	39.8	C
					R	45	43.6	D	49	38.6	C
			E	Ramsay St	L	99	27.9	B	132	23.3	B
					T	240	22.6	B	285	15.1	B
					R	43	38.5	C	18	31.4	C
			S	Dalhousie St	L	88	47.4	D	74	42.5	D
					T	182	41.1	C	202	37.3	C
					R	113	40.6	C	82	30.9	C
			W	Ramsay St	L	31	33.9	C	21	26.9	B
					T	540	35.0	C	514	23.9	B
					R	124	36.8	C	97	31.8	C
			Total			**1915**	**35.4**	C	**1847**	**29.2**	C
65	Stanmore Road / Liberty Street	S	N	Liberty St	L	297	27.6	B	382	26.5	B
					R	218	54.7	D	229	63.6	E
			E	Stanmore Rd	T	685	8.6	A	706	9.7	A
					R	441	26.3	B	449	23.5	B
			W		L	108	8.9	A	139	20.6	B
					T	963	24.8	B	881	36.5	C
			Total			**2712**	**23.0**	B	**2786**	**27.7**	B

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66	Ross Street / St Johns Road	S	N	Ross St	L	170	13.5	A	135	17.2	B
					T	342	14.4	A	369	17.1	B
					R	22	20.3	B	19	25.1	B
			E	St Johns Rd	L	22	42.0	C	29	37.0	C
					T	15	42.2	C	24	44.8	D
					R	115	49.4	D	100	43.2	D
			S	Ross St	L	105	21.0	B	89	12.4	A
					T	166	22.9	B	139	13.5	A
					R	151	24.8	B	183	13.7	A
			W	St Johns Rd	L	23	64.7	E	15	72.0	F
					T	29	40.5	C	17	45.9	D
					R	5	12.2	A	9	58.0	E
			Total			**1165**	**23.5**	B	**1128**	**20.8**	B
67	Parramatta Road / Young Street / Percival Road	S	N	Young St	L	44	79.0	F	41	112.1	F
					T	142	88.7	F	204	102.1	F
					R	2	112.7	F	1	51.2	D
			E	Parramatta Rd	L	25	81.6	F	14	12.3	A
					T	1084	86.5	F	1129	12.0	A
			S	Percival Rd	L	14	65.4	E	11	95.5	F
					T	184	59.4	E	129	66.4	E
					R	117	67.6	E	114	106.8	F
			W	Parramatta Rd	L	40	45.3	D	11	54.3	D
					T	1992	42.8	D	2027	42.3	C
			Total			**3644**	**60.1**	E	**3681**	**40.0**	C
68	Parramatta Road /Northumberland Avenue / Johnston Street	S	N	Johnston St	L	267	65.6	E	397	154.8	F
					T	318	62.2	E	255	109.6	F
					R	0			0		
			E	Parramatta Rd	L	26	59.6	E	19	18.3	B
					T	1127	52.5	D	1094	12.5	A
					R	95	91.0	F	71	91.9	F
			S	Northumberland Dr	L	23	53.6	D	19	57.3	E
					T	323	53.7	D	225	60.1	E
					R	26	89.2	F	44	255.6	F
			W	Parramatta Rd	L	138	47.9	D	130	42.8	D
					T	1933	43.6	D	2003	41.3	C
			Total			**4276**	**51.1**	D	**4257**	**52.6**	D
69	Parramatta Road / Bridge Road	S	E	Parramatta Rd	L	205	19.9	B	195	18.7	B
					T	1194	15.8	B	1154	16.1	B
			S	Bridge Rd	L	18	167.1	F	15	98.9	F
					R	471	123.6	F	481	96.8	F
			W	Parramatta Rd	T	2045	52.5	D	2163	41.2	C
					R	145	74.3	F	235	59.6	E
			Total			**4078**	**49.6**	D	**4243**	**40.9**	C

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70	Parramatta Road /Pyrmont Bridge Road / Denison Street	S	N	Pyrmont Bridge Rd	L	0			0		
					T	14	46.5	D	22	54.5	D
					R	207	55.5	D	239	59.5	E
			E	Parramatta Rd	L	32	20.5	B	26	17.1	B
					T	1159	3.1	A	1087	1.7	A
			W		L	583	11.6	A	733	5.9	A
					T	2175	13.6	A	2117	6.2	A
			Total			**4170**	**12.6**	**A**	**4224**	**8.3**	**A**
71	Parramatta Road / Mallett Street	S	N	Mallett St	L	103	38.7	C	86	45.7	D
					T	373	49.6	D	472	52.0	D
					R	90	142.5	F	50	58.6	E
			E	Parramatta Rd	L	80	10.9	A	70	9.2	A
					T	1065	4.8	A	1059	1.4	A
			S	Mallett St	L	22	172.5	F	13	279.8	F
					T	267	165.3	F	174	233.4	F
					R	144	224.0	F	106	374.8	F
			W	Parramatta Rd	L	27	39.2	C	59	22.9	B
					T	2131	46.3	D	2094	25.1	B
			Total			**4302**	**51.4**	**D**	**4183**	**41.0**	**C**
72	Parramatta Road / Ross Street / Western Avenue	S	N	Ross St	L	184	88.5	F	177	65.0	E
					T	87	91.2	F	95	68.2	E
					R	99	137.3	F	130	68.9	E
			E	Parramatta Rd	L	27	7.5	A	45	11.1	A
					T	1001	7.2	A	1041	8.2	A
					R	123	194.5	F	103	234.6	F
			S	Western Ave	L	16	311.3	F	15	206.8	F
					T	43	226.7	F	36	164.8	F
					R	19	240.0	F	27	170.5	F
			W	Parramatta Rd	L	248	38.5	C	279	42.2	C
					T	2049	21.9	B	1905	25.4	B
			Total			**3896**	**36.7**	**C**	**3853**	**34.8**	**C**
73	Great Western Highway / Glebe Point Road	S	N	Glebe Point Rd	L	257	30.8	C	244	33.9	C
					R	70	55.7	D	83	58.9	E
			E	Great Western Hwy	T	1114	5.5	A	1188	6.2	A
					R	253	92.9	F	212	76.9	F
			W		L	56	12.1	A	71	18.6	B
					T	2172	17.9	B	2053	25.2	B
			Total			**3922**	**20.7**	**B**	**3851**	**23.3**	**B**

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74	Broadway / City Road (Princes Highway) / Bay Street	S	N	Bay St	L	37	21.3	B	16	18.3	B
			E	Broadway	L	412	14.3	A	402	14.4	A
					T	646	165.8	F	750	155.7	F
			S	City Rd	L	708	15.4	B	656	15.3	B
					T	120	47.2	D	120	42.7	D
					R	778	44.2	D	719	43.7	D
			W	Great Western Hwy	L	153	10.6	A	152	12.3	A
					T	1283	16.0	B	1212	14.7	B
					R	978	37.6	C	932	49.1	D
			Total			**5115**	**43.7**	D	**4959**	**47.4**	D
75	University Avenue / Parramatta Road / Derwent Street / Arundel Street	S	E	Parramatta Rd	L	109	2.1	A	114	3.2	A
					T	1121	2.1	A	1177	3.9	A
			S	University Ave	L	20	67.4	E	27	60.3	E
					R	12	68.1	E	13	106.1	F
			W	Parramatta Rd	T	2218	33.2	C	2113	34.7	C
			Total			**3480**	**22.5**	B	**3444**	**23.6**	B
79	Douglas Street / Percival Road	S	N	Percival Rd	L	49	25.1	B	60	25.6	B
					R	178	32.4	C	175	27.4	B
			E	Douglas St	T	112	102.7	F	131	22.5	B
					R	134	160.5	F	76	36.2	C
			W		L	739	66.3	E	611	20.7	B
					T	96	64.8	E	94	29.9	C
			Total			**1308**	**72.8**	F	**1147**	**24.0**	B
80	Railway Terrace / Victoria Street	P	E	Railway Terrace	L	30	2.8	A	33	24.4	B
					T	488	2.3	A	485	21.0	B
			S	Victoria St	L	77	2.6	A	71	12.9	A
					R	54	5.1	A	50	9.8	A
			W	Railway Terrace	T	617	2.1	A	510	1.6	A
			Total			**1266**	**5.1**	A	**1149**	**24.4**	B
81	Parramatta Road / Dalhousie Street	S	N	Dalhousie St	L	288	40.2	C	266	83.6	F
					R	96	68.5	E	119	135.5	F
			E	Parramatta Rd	T	1166	25.2	B	1355	16.4	B
					R	88	56.1	D	120	48.2	D
			W		L	109	35.0	C	84	36.4	C
					T	1564	34.4	C	1408	34.7	C
			Total			**3311**	**33.3**	C	**3352**	**35.2**	C

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82	Carillon Avenue / Missenden Road	S	N	Missenden Rd	L	86	22.9	B	105	17.1	B
					T	165	31.3	C	164	24.5	B
					R	61	32.1	C	73	30.5	C
			E	Carillon Ave	L	19	64.0	E	25	55.6	D
					T	260	60.7	E	222	54.6	D
					R	72	57.6	E	90	52.7	D
			S	Missenden Rd	L	210	21.9	B	217	19.8	B
					T	221	39.4	C	213	37.8	C
					R	0			0		
			W	Carillon Ave	L	135	87.5	F	150	116.0	F
					T	454	84.6	F	425	120.3	F
					R	36	86.3	F	43	105.5	F
			Total			**1719**	**56.3**	D	**1727**	**64.7**	E
83	Parramatta Road / Missenden Avenue / Lyons Road	S	N	Lyons Rd	L	38	112.5	F	23	110.5	F
					T	174	101.5	F	143	98.6	F
					R	37	119.1	F	7	91.6	F
			E	Parramatta Rd	L	103	22.4	B	124	27.9	B
					T	1001	54.9	D	1059	58.9	E
			S	Missenden Rd	L	72	65.3	E	35	88.9	F
					T	110	82.5	F	136	95.5	F
					R	81	120.5	F	86	134.5	F
			W	Parramatta Rd	L	94	34.8	C	79	29.8	C
					T	2010	27.6	B	1873	30.8	C
					R	127	76.6	F	189	86.5	F
			Total			**3847**	**45.6**	D	**3754**	**49.9**	D

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
1	Victoria Rd / Darling St	S	N	Darling St	L	310	57.0	E	297	46.1	D
					T	138	75.1	F	129	74.4	F
			E	Victoria Rd	L	63	17.9	B	68	29.6	C
					T	362	5.8	A	382	7.1	A
					R	231	53.7	D	263	57.7	E
			S	Darling St	L	225	82.3	F	250	67.0	E
					T	240	129.6	F	228	106.8	F
			W	Victoria Rd	L	74	25.0	B	73	35.4	C
					T	587	27.9	B	652	31.1	C
					R	354	44.2	D	421	40.5	C
			Total			**2584**	**49.2**	D	**652**	**45.0**	D
2	Victoria Road / Evans Street	S	N	Evans St	L	97	64.4	E	106	53.6	D
					T	139	63.7	E	141	63.8	E
					R	54	55.8	D	57	67.5	E
			E	Victoria Rd	L	54	14.6	B	63	11.2	A
					T	573	11.8	A	624	7.0	A
			S	Evans St	L	31	56.8	E	45	52.8	D
					T	114	52.9	D	110	52.9	D
			W	Victoria Rd	L	16	2.5	A	23	1.8	A
					T	888	8.4	A	942	7.6	A
			Total			**1966**	**20.8**	B	**2111**	**18.5**	B
3	Victoria Road / Robert Street	S	N	Victoria Rd	L	46	6.3	A	44	10.7	A
					T	1140	32.1	C	1109	36.5	C
			E	Robert St	L	711	22.2	B	735	25.0	B
					R	12	49.4	D	16	58.0	E
			S	Victoria Rd	T	523	6.9	A	533	11.8	A
					R	888	39.0	C	986	77.5	F
			Total			**3320**	**27.6**	B	**3423**	**41.8**	C
5	Balmain Road / Lilyfield Road	S	N	Balmain Rd	L	160	9.2	A	98	11.0	A
					T	266	8.5	A	387	13.9	A
			E	Lilyfield Rd	L	74	29.6	C	83	30.5	C
					T	54	34.2	C	61	23.6	B
					R	17	26.4	B	18	27.9	B
			S	Balmain Rd	L	117	12.8	A	117	9.8	A
					T	295	7.3	A	244	9.0	A
					R	463	12.3	A	458	10.7	A
			W	Lilyfield Rd	L	1	7.3	A	7	55.0	D
					T	19	35.4	C	30	33.7	C
					R	39	25.1	B	81	77.2	F
			Total			**1505**	**12.8**	A	**1584**	**16.9**	B
6	The Crescent / Victoria Road	S	N	Victoria Rd	L	0	0.0	A	0	0.0	A
					R	0	0.0	A	0	0.0	A
			E		T	1715	24.5	B	1694	23.9	B
					R	825	20.3	B	874	20.8	B
			W	The Crescent	L	1015	37.0	C	1114	36.2	C
			Total			**3555**	**27.1**	B	**3682**	**26.9**	B

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM			8:15AM - 9:15AM		
						Volume (veh)	Delay (s)	LOS	Volume (veh)	Delay (s)	LOS
7	Balmain Road / Perry Street / Wharf Road	S	N	Wharf Rd	L	18	1.7	A	18	1.7	A
					T	22	1.6	A	33	1.6	A
					R	3	1.7	A	1	1.8	A
			E	Balmain Rd	L	263	3.8	A	431	3.9	A
					T	316	4.3	A	205	4.2	A
					R	11	5.8	A	21	6.2	A
			S		L	46	2.0	A	35	2.1	A
					T	20	1.9	A	19	2.1	A
					R	180	2.6	A	163	2.4	A
			W	Perry St	L	9	3.9	A	14	3.2	A
					T	237	6.1	A	247	4.3	A
					R	124	17.2	B	55	8.1	A
			Total			**1249**	**5.4**	**A**	**1242**	**3.9**	**A**
8	City-West Link Road / The Crescent	S	E	The Crescent	L	905	14.6	B	954	14.5	B
					T	2046	6.7	A	1976	6.9	A
			S		L	262	49.7	D	294	104.3	F
					R	0	0.0	A	0	0.0	A
			W	City-West Link Rd	T	146	55.7	D	141	55.0	D
					R	153	95.4	F	173	92.1	F
			Total			**3512**	**17.9**	**B**	**3538**	**23.1**	**B**
9	City-West Link Road / Norton Street	S	N		L	12	48.6	D	11	6.5	A
				Norton St	T	166	66.6	E	177	61.4	E
			E	City-West Link Rd	L	337	25.0	B	377	26.9	B
					T	2052	48.4	D	2222	47.2	D
					R	7	70.2	E	15	82.2	F
			S	Norton St	L	105	178.8	F	104	142.2	F
					T	125	185.6	F	160	174.2	F
					R	99	199.6	F	90	228.0	F
			W	City-West Link Rd	L	5	5.3	A	0		
					T	1516	6.9	A	1577	9.7	A
					R	185	70.4	E	131	66.6	E
			Total			**4609**	**44.5**	**D**	**4864**	**44.1**	**D**
10	City-West Link Road / Brenan Street / Balmain Road	S	N	Balmain Rd	L	140	41.2	C	193	35.1	C
					T	131	35.8	C	143	45.1	D
					R	252	35.9	C	378	30.4	C
			E	City-West Link Rd	L	134	19.4	B	107	22.4	B
					T	1968	20.4	B	2015	29.6	C
					R	241	33.9	C	198	31.5	C
			S	Balmain Rd	L	135	73.7	F	135	74.9	F
					T	193	66.0	E	192	68.8	E
					R	104	61.8	E	129	53.0	D
			W	City-West Link Rd	L	425	25.5	B	404	33.9	C
					T	1191	63.7	E	1284	81.8	F
			Total			**4914**	**37.9**	**C**	**5178**	**46.7**	**D**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
11	City-West Link Road / Brenan Street / Catherine Street	S	N	Catherine St	L	85	45.8	D	115	68.9	E
					T	429	80.3	F	349	64.5	E
					R	37	63.8	E	14	61.7	E
			E	City-West Link Rd	T	2000	23.4	B	1982	22.8	B
			S	Catherine St	L	147	77.6	F	142	119.2	F
			W	City-West Link Rd	T	1466	21.0	B	1599	28.8	C
			Total			**4164**	**31.2**	**C**	**4201**	**33.2**	**C**
13	Catherine Street / Moore Street	S	N	Catherine St	L	361	3.1	A	318	2.5	A
					T	141	33.2	C	113	34.4	C
					R	13	27.4	B	6	38.3	C
			E	Moore St	L	39	6.9	A	33	16.0	B
					T	313	11.9	A	327	14.5	B
					R	214	14.0	A	160	16.1	B
			S	Catherine St	L	42	31.8	C	41	44.7	D
					T	188	37.3	C	167	34.5	C
					R	31	27.5	B	46	35.8	C
			W	Moore St	L	96	18.6	B	88	18.2	B
					T	118	20.7	B	106	15.9	B
			Total			**1556**	**17.1**	**B**	**1405**	**18.0**	**B**
14	Styles Street / Catherine Street	S	N	Catherine St	L	9	41.8	C	4	28.3	B
					T	175	44.3	D	133	28.0	B
					R	79	42.1	C	68	26.3	B
			E	Styles St	L	115	9.1	A	76	9.5	A
					T	202	10.7	A	287	10.6	A
					R	21	11.8	A	20	21.0	B
			S	Catherine St	L	35	23.1	B	46	31.5	C
					T	44	29.4	C	52	47.9	D
					R	11	51.7	D	30	55.3	D
			W	Styles St	L	139	21.9	B	115	23.3	B
					T	440	21.7	B	504	24.3	B
					R	35	26.5	B	52	24.9	B
			Total			**1305**	**23.8**	**B**	**1387**	**22.8**	**B**
19	Marion Street / Norton Street	S	N	Norton St	L	96	51.7	D	97	73.6	F
					T	230	43.5	D	189	46.7	D
					R	41	76.7	F	29	59.1	E
			E	Marion St	L	171	37.2	C	197	35.7	C
					T	325	23.8	B	324	26.8	B
					R	43	33.8	C	84	35.7	C
			S	Norton St	L	79	37.3	C	64	36.6	C
					T	56	44.0	D	89	42.5	D
					R	4	99.8	F	4	110.9	F
			W	Marion St	L	25	13.4	A	17	25.7	B
					T	482	8.9	A	547	13.7	A
					R	125	14.6	B	143	19.5	B
			Total			**1677**	**27.4**	**B**	**1784**	**30.1**	**C**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
20	Marion Street / Leichhardt Street / Balmain Road	S	N	Balmain Rd	L	10	54.4	D	18	41.6	C
					R	135	50.2	D	128	38.3	C
			E	Leichhardt St	T	321	16.8	B	391	22.2	B
					R	21	25.8	B	28	35.2	C
			S	Balmain Rd	L	2	63.4	E	5	61.3	E
					T	61	70.2	E	65	69.5	E
					R	1	41.5	C	1	50.8	D
			W	Marion St	L	265	26.7	B	203	45.8	D
					T	524	29.1	C	583	48.5	D
			Total			**1340**	**29.9**	**C**	**1422**	**40.6**	**C**
22	Johnston Street / Collins Street	S	N	Johnston St	L	3	21.0	B	7	14.2	A
					T	380	47.8	D	543	24.3	B
					R	169	43.3	D	176	38.8	C
			E	Collins St	L	74	16.1	B	85	17.9	B
			S	Johnston St	L	129	33.7	C	207	37.4	C
					T	536	35.9	C	494	39.7	C
			W	Collins St	L	254	19.1	B	287	22.6	B
					R	206	18.7	B	201	22.8	B
			Total			**1751**	**33.7**	**C**	**2000**	**30.0**	**C**
23	Johnston Street / Booth Street	S	N	Johnston St	L	33	59.9	E	38	77.2	F
					T	479	70.6	F	546	75.2	F
					R	80	57.8	E	126	52.6	D
			E	Booth St	L	118	34.2	C	182	59.1	E
					T	464	51.5	D	414	71.2	F
					R	54	50.1	D	74	82.0	F
			S	Johnston St	L	74	15.8	B	42	68.7	E
					T	493	22.2	B	411	54.5	D
					R	196	23.6	B	292	21.5	B
			W	Booth St	L	37	16.9	B	52	24.4	B
					T	273	31.4	C	212	28.9	C
					R	12	38.2	C	42	57.9	E
			Total			**2313**	**42.1**	**C**	**2431**	**56.9**	**E**
27	Booth Street / Wigram Road	RB	N	Wigram Rd	L	100	2.3	A	84	7.6	A
					R	186	1.6	A	266	7.2	A
			E	Booth St	T	413	6.5	A	422	37.0	C
					R	323	6.2	A	312	29.5	C
			W		L	392	1.9	A	417	1.8	A
					T	240	1.9	A	295	1.9	A
			Total			**1654**	**6.5**	**A**	**1796**	**37.0**	**C**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM			8:15AM - 9:15AM		
						Volume (veh)	Delay (s)	LOS	Volume (veh)	Delay (s)	LOS
28	Minogue Crescent / Wigram Road	S	N	Minogue Cres	L	99	13.9	A	115	17.0	B
					T	223	22.1	B	215	17.9	B
					R	10	26.4	B	12	24.6	B
			E		L	10	23.4	B	8	21.0	B
				Wigram Rd	T	119	22.6	B	135	20.6	B
					R	140	29.6	C	115	27.2	B
			S	Minogue Cres	L	148	12.5	A	220	15.4	B
					T	420	15.2	B	439	18.7	B
					R	56	12.5	A	78	18.6	B
			W	Wigram Rd	L	2	35.1	C	0		
					T	145	44.6	D	126	68.0	E
					R	211	49.4	D	212	66.1	E
			Total			**1583**	**25.0**	B	**1675**	**28.6**	C
29	Ross Street / Bridge Road	S	N	Ross St	L	109	31.2	C	173	34.6	C
					T	322	40.4	C	253	27.9	B
			E		L	40	20.8	B	38	23.0	B
				Bridge Rd	T	662	23.7	B	615	22.4	B
					R	180	26.3	B	217	30.0	C
			S	Ross St	L	185	47.8	D	199	48.6	D
					T	470	45.2	D	536	51.0	D
			W	Bridge Rd	L	94	30.4	C	101	27.8	B
					T	491	37.3	C	432	40.9	C
					R	0			0		
			Total			**2553**	**34.8**	C	**2564**	**35.8**	C
30	Pyrmont Bridge Road / Booth Street / Mallett Street	S	N	Booth St	L	243	32.5	C	240	29.1	C
					T	285	63.6	E	279	49.2	D
			E	Pyrmont Bridge Rd	L	147	15.2	B	150	24.6	B
					T	368	11.9	A	358	18.0	B
					R	161	39.3	C	179	47.1	D
			S	Mallett St	L	19	61.8	E	29	43.9	D
					T	275	41.4	C	264	37.6	C
					R	74	54.6	D	80	55.8	D
			W	Pyrmont Bridge Rd	L	134	42.0	C	135	37.1	C
					T	245	27.0	B	205	19.4	B
			Total			**1951**	**34.8**	C	**1919**	**33.3**	C
34	Marion Street / Foster Street	S	N	Foster St	L	30	48.8	D	16	49.7	D
					T	533	38.4	C	471	39.4	C
					R	177	42.5	C	160	41.5	C
			E	Marion St	L	101	50.5	D	134	40.1	C
					T	371	37.6	C	441	29.5	C
			S	Foster St	L	223	16.5	B	173	24.8	B
					T	392	22.3	B	388	26.5	B
					R	170	26.7	B	147	36.2	C
			W	Marion St	L	125	89.2	F	140	48.1	D
					T	366	81.1	F	401	46.4	D
					R	63	91.5	F	83	48.9	D
			Total			**2551**	**43.9**	D	**2554**	**36.7**	C

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
35	Marion Street / Flood Street	S	N	Flood St	L	24	34.1	C	29	25.5	B
					T	143	25.8	B	203	26.7	B
					R	12	37.1	C	25	37.8	C
			E	Marion St	L	188	12.6	A	179	15.9	B
					T	374	10.2	A	418	14.5	A
					R	58	17.1	B	44	23.8	B
			S	Flood St	L	71	40.4	C	102	30.0	C
					T	190	34.2	C	255	27.7	B
					R	181	45.0	D	231	37.3	C
			W	Marion St	L	70	12.5	A	35	27.2	B
					T	567	16.2	B	585	22.7	B
					R	42	20.0	B	55	33.3	C
			Total			**1920**	**21.1**	B	**2161**	**24.0**	B
36	Marion Street / Ramsay Street	S	N	Ramsay St	L	356	12.1	A	373	15.1	B
					T	89	57.1	E	73	56.2	D
			E	Marion St	L	133	10.9	A	154	11.2	A
					R	481	14.2	A	466	15.3	B
			S	Ramsay St	T	172	29.9	C	220	23.4	B
					R	188	35.1	C	175	28.4	B
			Total			**1419**	**20.7**	B	**1461**	**19.7**	B
39	Parramatta Road / Liverpool Road (Hume Highway)	S	E	Parramatta Rd	L	887	5.1	A	877	6.7	A
					T	1553	37.0	C	1536	35.6	C
			S	Liverpool Rd	L	183	30.9	C	188	53.4	D
					R	485	66.8	E	537	88.6	F
			W	Parramatta Rd	T	1183	6.4	A	1291	6.4	A
					R	408	60.8	E	394	53.6	D
			Total			**4699**	**28.2**	B	**4823**	**30.6**	C
41	City-West Link Road / James Street	S	N	City-West Link Rd	L	13	105.4	F	6	59.0	E
					T	135	92.6	F	85	71.7	F
					R	123	117.4	F	97	87.3	F
			E	James St	L	613	1.1	A	686	1.0	A
					T	1541	8.9	A	1638	10.3	A
			S	City-West Link Rd	L	47	85.9	F	47	109.8	F
					T	141	89.8	F	157	119.3	F
					R	381	75.9	F	424	109.7	F
			W	James St	L	358	3.9	A	363	3.8	A
					T	1299	22.0	B	1276	25.8	B
			Total			**4651**	**25.4**	B	**4779**	**28.7**	C

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
42	Tebbutt Street / Lords Road	S	N	Forster St	L	57	18.5	B	57	16.3	B
					T	786	19.9	B	769	18.2	B
			E	Lords Rd	L	111	34.8	C	140	39.2	C
					T	46	32.2	C	48	30.0	C
					R	93	35.0	C	65	35.1	C
			S	Tebbutt St	L	27	5.5	A	22	7.5	A
					T	587	15.4	B	550	12.0	A
					R	106	19.7	B	146	19.7	B
			W	Lords Rd	L	53	28.5	B	49	32.1	C
					T	6	40.0	C	17	35.1	C
					R	44	26.8	B	33	32.7	C
			Total			**1916**	**20.6**	B	**1896**	**19.5**	B
43	Lilyfield Road / James Street	S	N	Mary St	L	63	7.9	A	73	1.7	A
					T	198	95.1	F	100	81.7	F
					R	26	72.7	F	25	64.2	E
			E	Lilyfield Rd	L	18	11.6	A	18	41.9	C
					T	48	32.2	C	57	30.4	C
					R	23	33.3	C	17	25.7	B
			S	James St	L	45	29.6	C	58	29.1	C
					T	383	41.3	C	340	39.6	C
					R	65	45.8	D	127	53.5	D
			W	Lilyfield Rd	L	39	51.4	D	30	38.1	C
					T	77	50.0	D	72	35.6	C
					R	51	31.8	C	41	38.1	C
			Total			**1036**	**49.6**	D	**958**	**41.8**	C
44	Tebbutt Street / Hathern Street	S	N	Tebbutt St	T	31	20.3	B	22	25.5	B
					R	965	25.1	B	972	32.0	C
			S		L	299	23.9	B	238	16.5	B
					T	40	41.5	C	37	42.8	D
			W	Hathern St	L	703	9.8	A	705	10.5	A
					R	83	39.3	C	121	34.4	C
			Total			**2121**	**20.7**	B	**2095**	**23.3**	B
45	Parramatta Road / Sloane Street	S	N	Sloane St	L	59	59.0	E	35	85.4	F
					T	191	66.3	E	226	63.7	E
					R	131	90.4	F	128	93.1	F
			E	Parramatta Rd	L	61	29.2	C	56	32.3	C
					T	2255	29.1	C	2195	26.0	B
			S	Sloane St	L	61	45.7	D	74	57.0	E
					T	180	48.5	D	167	53.7	D
			W	Parramatta Rd	L	192	15.8	B	243	17.2	B
					T	1671	19.3	B	1742	22.4	B
			Total			**4801**	**29.6**	C	**4866**	**29.7**	C

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
47	Parramatta Road / Old Canterbury Road / Tebbutt Street	S	N	Tebbutt St	L	114	25.0	B	143	9.7	A
			E	Parramatta Rd	L	204	13.1	A	214	14.1	A
					T	2257	12.7	A	2230	6.7	A
			S	Old Canterbury Rd	L	76	20.7	B	53	16.8	B
			W	Parramatta Rd	T	1356	40.4	C	1542	33.5	C
			Total			**4007**	**22.6**	B	**4182**	**17.2**	B
49	Old Canterbury Road / Railway Terrace / Longport Street	S	N	Old Canterbury Rd	L	113	48.3	D	52	30.8	C
					T	1330	54.0	D	1372	35.3	C
			E	Railway Terrace	L	57	32.9	C	52	22.0	B
					T	727	33.8	C	681	28.3	B
			S	Old Canterbury Rd	L	124	71.9	F	152	80.1	F
					T	742	76.1	F	707	87.5	F
					R	1	137.3	F	1	176.7	F
			W	Longport St	L	95	24.1	B	145	38.2	C
					T	610	30.3	C	602	46.8	D
			Total			**3799**	**50.0**	D	**3764**	**47.4**	D
50	Parramatta Road / Norton Street	S	N	Norton St	L	335	136.4	F	212	98.2	F
					R	85	176.1	F	171	161.4	F
			E	Parramatta Rd	T	1692	24.8	B	1586	25.8	B
					R	386	46.0	D	431	60.4	E
			W	Parramatta Rd	L	18	31.4	C	17	56.9	E
					T	942	38.7	C	1090	36.6	C
			Total			**3458**	**45.5**	D	**3507**	**44.5**	D
51	Parramatta Road / Flood Street / West Street	S	N	Flood St	L	12	87.9	F	5	328.3	F
					T	210	134.2	F	181	172.0	F
					R	91	372.5	F	35	625.6	F
			E	Parramatta Rd	L	39	44.8	D	50	48.1	D
					T	1680	59.0	E	1661	59.1	E
			S	West St	L	476	47.4	D	471	63.8	E
					T	273	54.7	D	319	64.8	E
					R	1	126.4	F	1	62.7	E
			W	Parramatta Rd	L	204	23.1	B	235	22.1	B
					T	890	21.4	B	1092	23.6	B
					R	366	227.6	F	357	188.5	F
			Total			**4242**	**72.8**	F	**4407**	**69.0**	E
52	Parramatta Road / Crystal Street / Balmain Road	S	E	Parramatta Rd	L	255	28.9	C	195	48.4	D
					T	1755	37.0	C	1632	55.7	D
			S	Crystal St	L	273	59.8	E	338	66.7	E
					T	62	79.2	F	75	98.8	F
					R	143	84.5	F	168	128.4	F
			W	Parramatta Rd	L	1	27.6	B	0		
					T	1112	16.5	B	1087	17.0	B
					R	247	114.9	F	253	90.2	F
			Total			**3848**	**39.6**	C	**3748**	**51.6**	D

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
53	Parramatta Road / Catherine Street / Phillip Street	S	N	Catherine St	L	12	68.6	E	40	95.2	F
					T	65	67.2	E	35	114.9	F
					R	189	81.8	F	106	154.1	F
			E	Parramatta Rd	L	2	50.0	D	6	184.4	F
					T	1731	39.5	C	1639	94.4	F
			S	Phillip St	L	41	49.4	D	47	49.0	D
					T	50	27.1	B	60	30.1	C
					R	21	43.1	D	12	42.4	C
			W	Parramatta Rd	L	59	27.5	B	93	20.9	B
					T	1159	9.9	A	1119	11.0	A
			Total			**3329**	**32.0**	C	**3157**	**63.0**	E
56	Crystal Street / Douglas Street / Brighton Street	S	N	Crystal St	L	72	59.5	E	45	59.4	E
					T	412	69.8	E	386	66.5	E
			E	Douglas St	L	548	25.0	B	550	30.7	C
					T	62	74.2	F	93	79.6	F
					R	32	65.6	E	51	87.3	F
			S	Crystal St	L	167	19.1	B	179	11.0	A
					T	483	28.6	C	534	12.3	A
					R	411	36.0	C	409	17.3	B
			W	Brighton St	L	31	21.5	B	41	28.6	C
					T	20	92.0	F	29	94.9	F
					R	138	103.8	F	162	104.3	F
			Total			**2376**	**43.0**	D	**2479**	**37.7**	C
57	Crystal Street / Trafalgar Street	S	N	Crystal St	L	27	46.6	D	36	23.6	B
					T	888	34.6	C	914	32.1	C
					R	203	33.3	C	209	30.1	C
			E	Trafalger St	L	67	68.8	E	73	115.8	F
					T	140	68.3	E	139	95.2	F
			S	Crystal St	L	93	18.7	B	120	28.1	B
					T	910	30.4	C	978	29.2	C
			W	Trafalger St	L	153	39.7	C	145	31.0	C
					T	151	51.0	D	208	52.3	D
			Total			**2632**	**36.5**	C	**2822**	**37.4**	C
58	New Canterbury Road / Stanmore Road / Crystal Street / Shaw Street	S	N	Crystal St	L	47	61.4	E	62	86.1	F
					T	497	62.3	E	513	95.1	F
					R	431	96.9	F	423	91.5	F
			E	Stanmore Rd	L	60	91.1	F	132	83.1	F
					T	801	81.7	F	895	75.9	F
					R	323	141.6	F	354	116.8	F
			S	Shaw St	L	28	49.4	D	36	62.2	E
					T	445	53.2	D	444	60.2	E
			W	New Canterbury Rd	L	242	53.7	D	288	59.5	E
					T	778	51.1	D	822	50.9	D
			Total			**3652**	**74.0**	F	**3969**	**75.8**	F

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59	Gordon Street / Trafalgar Street	S	N	Gordon St	T	856	21.2	B	884	26.0	B
			E	Trafalger St	L	51	33.5	C	69	82.6	F
					R	356	89.4	F	330	120.5	F
			S	Gordon St	T	447	36.4	C	418	23.7	B
					R	716	93.8	F	767	51.5	D
				Total		**2426**	**55.7**	**D**	**2468**	**47.8**	**D**
60	New Canterbury Road / Gordon Street / Livingstone Road	S	N	Gordon St	L	316	58.2	E	337	67.4	E
					T	579	63.7	E	608	75.4	F
			E	New Canterbury Rd	L	59	25.0	B	55	17.6	B
					T	903	20.3	B	986	20.2	B
					R	426	53.8	D	424	41.5	C
			S	Livingstone Rd	L	133	33.0	C	112	34.0	C
					T	673	47.0	D	680	34.4	C
			W	New Canterbury Rd	L	85	32.8	C	63	34.5	C
					T	729	33.7	C	753	31.3	C
			Total			**3903**	**41.3**	**C**	**4018**	**39.8**	**C**
62	Ramsay Road / Dalhousie Street	S	N	Dalhousie St	L	73	29.0	C	65	25.6	B
					T	219	25.7	B	207	26.0	B
					R	60	23.2	B	77	29.5	C
			E	Ramsay St	L	109	22.4	B	82	31.3	C
					T	392	23.8	B	438	30.1	C
					R	78	23.9	B	83	33.2	C
			S	Dalhousie St	L	111	41.0	C	144	38.5	C
					T	142	31.6	C	137	37.9	C
					R	113	31.3	C	76	28.9	C
			W	Ramsay St	L	56	22.0	B	50	19.7	B
					T	330	16.6	B	355	13.6	A
					R	80	22.7	B	50	16.7	B
			Total			**1763**	**24.9**	**B**	**1764**	**26.9**	**B**
65	Stanmore Road / Liberty Street	S	N	Liberty St	L	400	26.9	B	369	25.2	B
					R	379	23.5	B	488	25.7	B
			E	Stanmore Rd	T	910	35.5	C	978	40.1	C
					R	396	93.5	F	355	137.3	F
			W		L	169	14.2	A	182	6.5	A
					T	646	31.9	C	692	21.9	B
			Total			**2900**	**38.6**	**C**	**3064**	**41.2**	**C**

#	Intersection	Type	App.	Approach name	Turn	7:15AM - 8:15AM Volume (veh)	7:15AM - 8:15AM Delay (s)	7:15AM - 8:15AM LOS	8:15AM - 9:15AM Volume (veh)	8:15AM - 9:15AM Delay (s)	8:15AM - 9:15AM LOS
66	Ross Street / St Johns Road	S	N	Ross St	L	104	29.5	C	102	18.8	B
					T	301	29.9	C	251	25.0	B
					R	1	10.2	A	2	19.8	B
			E	St Johns Rd	L	73	39.4	C	77	33.7	C
					T	8	39.7	C	9	50.4	D
					R	241	45.0	D	258	42.2	C
			S	Ross St	L	0			0		
					T	338	16.5	B	364	27.2	B
					R	74	25.2	B	88	32.8	C
			W	St Johns Rd	L	76	56.8	E	115	71.5	F
					T	33	57.2	E	28	49.4	D
					R	26	48.2	D	32	64.6	E
			Total			**1275**	**32.2**	C	**1326**	**35.2**	C
67	Parramatta Road / Young Street / Percival Road	S	N	Young St	L	6	82.9	F	13	74.9	F
					T	148	60.7	E	151	64.8	E
					R	0			0		
			E	Parramatta Rd	L	56	8.6	A	48	47.1	D
					T	1624	4.0	A	1578	52.1	D
			S	Percival Rd	L	11	40.8	C	13	46.4	D
					T	89	43.6	D	78	45.9	D
					R	48	61.5	E	29	36.5	C
			W	Parramatta Rd	L	35	16.7	B	23	17.3	B
					T	1172	16.8	B	1150	18.3	B
			Total			**3189**	**13.8**	A	**3083**	**39.5**	C
68	Parramatta Road /Northumberland Avenue / Johnston Street	S	N	Johnston St	L	265	46.4	D	234	58.3	E
					T	294	77.6	F	517	87.0	F
					R	70	135.0	F	103	174.4	F
			E	Parramatta Rd	L	63	19.4	B	97	46.3	D
					T	1587	19.9	B	1518	49.2	D
					R	134	52.9	D	139	82.8	F
			S	Northumberland Dr	L	43	55.0	D	31	57.2	E
					T	390	45.6	D	446	43.9	D
					R	20	81.1	F	30	196.3	F
			W	Parramatta Rd	L	122	27.3	B	87	44.7	D
					T	1047	35.8	C	1023	61.5	E
			Total			**4035**	**36.4**	C	**4225**	**61.8**	E
69	Parramatta Road / Bridge Road	S	E	Parramatta Rd	L	338	38.2	C	241	41.4	C
					T	1650	37.0	C	1699	46.9	D
			S	Bridge Rd	L	16	142.8	F	14	62.1	E
					R	282	122.0	F	313	81.3	F
			W	Parramatta Rd	T	1071	23.2	B	1083	36.1	C
					R	324	120.7	F	225	206.0	F
			Total			**3681**	**47.4**	D	**3575**	**56.3**	D

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70	Parramatta Road /Pyrmont Bridge Road / Denison Street	S	N	Pyrmont Bridge Rd	L	5	118.6	F	5	97.3	F
					T	25	80.7	F	44	212.0	F
					R	316	113.4	F	307	161.7	F
			E	Parramatta Rd	L	41	58.5	E	45	84.8	F
					T	1653	44.1	D	1622	78.1	F
			W		L	415	8.5	A	385	4.2	A
					T	1132	14.1	A	1227	13.9	A
			Total			**3587**	**37.1**	**C**	**3635**	**57.4**	**E**
71	Parramatta Road / Mallett Street	S	N	Mallett St	L	43	89.1	F	74	80.9	F
					T	388	97.0	F	328	74.6	F
					R	17	276.0	F	17	198.9	F
			E	Parramatta Rd	L	211	7.7	A	226	8.0	A
					T	1643	6.9	A	1605	11.7	A
			S	Mallett St	L	42	177.4	F	41	186.1	F
					T	256	190.1	F	196	186.2	F
					R	25	234.2	F	27	171.5	F
			W	Parramatta Rd	L	49	17.5	B	79	5.5	A
					T	1100	9.2	A	1161	4.3	A
			Total			**3774**	**35.0**	**C**	**3754**	**28.9**	**C**
72	Parramatta Road / Ross Street / Western Avenue	S	N	Ross St	L	183	37.7	C	183	62.0	E
					T	87	45.9	D	89	67.1	E
					R	129	68.2	E	84	133.9	F
			E	Parramatta Rd	L	6	69.1	E	14	55.5	D
					T	1640	84.1	F	1624	72.5	F
					R	262	243.2	F	308	163.9	F
			S	Western Ave	L	71	54.9	D	55	154.7	F
					T	75	54.2	D	63	132.7	F
					R	27	57.7	E	34	161.7	F
			W	Parramatta Rd	L	74	53.7	D	94	32.4	C
					T	976	50.1	D	1079	29.6	C
			Total			**3530**	**80.5**	**F**	**3627**	**70.3**	**E**
73	Great Western Highway / Glebe Point Road	S	N	Glebe Point Rd	L	333	30.4	C	339	102.6	F
					R	166	54.9	D	146	105.8	F
			E	Great Western Hwy	T	1753	23.6	B	1757	21.1	B
					R	263	48.9	D	268	41.9	C
			W		L	29	22.7	B	44	11.1	A
					T	1209	30.4	C	1319	38.9	C
			Total			**3753**	**29.5**	**C**	**3873**	**38.8**	**C**

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74	Broadway / City Road (Princes Highway) / Bay Street	S	N	Bay St	L	26	10.9	A	44	9.9	A
			E	Broadway	L	589	8.7	A	576	8.3	A
					T	1200	39.6	C	1183	32.9	C
			S	City Rd	L	832	42.9	D	833	47.8	D
					T	153	55.4	D	195	66.0	E
					R	602	51.0	D	606	58.1	E
			W	Great Western Hwy	L	100	19.1	B	87	23.6	B
					T	727	18.1	B	775	26.5	B
					R	727	77.1	F	787	147.8	F
			Total			**4956**	**40.1**	C	**5086**	**53.3**	D
75	University Avenue / Parramatta Road / Derwent Street / Arundel Street	S	E	Parramatta Rd	L	72	6.4	A	76	5.3	A
					T	1861	3.2	A	1854	4.3	A
			S	University Ave	L	65	74.3	F	69	83.4	F
					R	47	81.4	F	47	104.9	F
			W	Parramatta Rd	T	1210	8.2	A	1294	35.2	C
			Total			**3255**	**7.6**	A	**3340**	**19.3**	B
79	Douglas Street / Percival Road	S	N	Percival Rd	L	52	22.6	B	63	21.4	B
					R	375	23.6	B	438	30.3	C
			E	Douglas St	T	72	33.7	C	88	31.8	C
					R	121	43.0	D	117	45.3	D
			W		L	414	13.3	A	405	13.1	A
					T	75	38.6	C	72	29.8	C
			Total			**1109**	**23.5**	B	**1183**	**25.5**	B
80	Railway Terrace / Victoria Street	P	E	Railway Terrace	L	117	1.9	A	98	1.8	A
					T	783	2.1	A	733	1.6	A
			S	Victoria St	L	22	3.7	A	17	3.3	A
					R	34	10.3	A	27	9.9	A
			W	Railway Terrace	T	718	13.3	A	662	35.5	C
			Total			**1674**	**13.3**	A	**1537**	**35.5**	C
81	Parramatta Road / Dalhousie Street	S	N	Dalhousie St	L	192	338.1	F	205	411.1	F
					R	159	395.0	F	187	413.8	F
			E	Parramatta Rd	T	1512	15.3	B	1473	14.3	A
					R	211	65.9	E	239	66.9	E
			W		L	143	55.2	D	105	38.2	C
					T	1577	54.5	D	1660	34.6	C
			Total			**3794**	**68.2**	E	**3869**	**67.2**	E

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82	Carillon Avenue / Missenden Road	S	N	Missenden Rd	L	110	19.9	B	121	21.4	B
					T	215	30.1	C	206	30.3	C
					R	83	37.0	C	78	42.6	D
			E	Carillon Ave	L	32	48.6	D	45	47.8	D
					T	410	53.8	D	318	67.3	E
					R	108	50.7	D	133	57.3	E
			S	Missenden Rd	L	183	20.7	B	165	27.0	B
					T	207	35.6	C	268	38.0	C
					R	4	21.2	B	1	64.4	E
			W	Carillon Ave	L	107	103.2	F	94	136.5	F
					T	352	92.2	F	399	124.2	F
					R	64	91.6	F	61	153.9	F
			Total			**1875**	**54.1**	D	**1889**	**68.7**	E
83	Parramatta Road / Missenden Avenue / Lyons Road	S	N	Lyons Rd	L	21	125.6	F	45	109.9	F
					T	171	102.3	F	185	139.4	F
					R	71	158.4	F	36	323.7	F
			E	Parramatta Rd	L	114	45.2	D	109	169.6	F
					T	1679	66.3	E	1610	168.5	F
			S	Missenden Rd	L	116	64.2	E	142	335.7	F
					T	191	78.5	F	209	334.8	F
					R	50	83.1	F	32	395.6	F
			W	Parramatta Rd	L	77	8.1	A	74	14.7	B
					T	985	7.2	A	1058	12.4	A
					R	120	66.1	E	142	62.1	E
			Total			**3595**	**52.9**	D	**3642**	**133.3**	F

Parking policy and rate review: Camperdown, Leichhardt and Taverners Hill

Parramatta Road Corridor Urban Transformation Strategy

80018116

Prepared for

Department of Planning, Industry & Environment and Inner West Council

10 March 2022

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Introduction

This Report details a Parking Strategy for Parramatta Road, as part of the PRCUTS project. The study area considered in this Strategy includes the core precincts of Taverners Hill, Leichhardt and Camperdown, as well as land uses immediately adjacent to the Parramatta Road corridor.

1.1 PRCUTS parking principles

PRCUTS proposed the following hierarchy of parking strategies:

1. Minimise parking
2. Minimise underground parking
3. Unbundle parking from dwelling and building ownership
4. Share parking
5. Decouple parking

The Department of Planning, Industry and Environment (DPIE) and Inner-West Council (IWC) have expanded on the Parking Principles which form the basis of this Parking Recommendations Report to include:

- Parking provision should be minimised to encourage the use of sustainable transport, except for where it is required to achieve equity of mobility.
- Parking is provided off-street as much as possible to dedicate more space for walking. Parking provision should be consolidated, and driveways minimised, to reduce the impact on the streetscape.
- Freight and land use servicing must be provided to support the growth of the corridor.
- Co-ordinate the management of all forms of parking in the public and private domains.

1.2 Study objectives

The scope of this study is to:

- Recommend parking policies and rate requirements which align with the overall vision and objectives outlined in the IWC Precincts Transport Study and validate how these support the PRCUTS vision and principles.
- Describe the link between recommendations and their reliance on other transport initiatives including active and public transport modes.
- Compare the advantages and disadvantages of existing and recommended parking controls.
- Outline sustainability and urban benefits of restricted parking.
- Provide specific recommendations for:
  - Physical/ geometric and economic considerations of car parking;
  - Dual occupancies and townhouses;
  - Residential flat buildings and shop top housing; and
  - Out of centre commercial uses.

1.3 PRCUTS parking rate recommendations

PRCUTS defines the location of Camperdown, Leichhardt and Taverners Hill as "Category 1" parking locations. These rates are reproduced from the strategy in **Table 1-1**. These rates are lower than existing DCP rates in each respective location.

The PRCUTS proposed residential and business rates are maximums. The strategy indicates the provision of car share spaces, unbundled parking and decoupled + unbundled parking will result in a reduction in maximum parking provision.

Table 1-1 PRCUTS proposed maximum parking rates

Proposed parking provisions and policies							
Residential (max spaces per dwelling):					**Business land uses max (1 space per G.F.A):**		
Studio	1-bed	2-bed	3-bed	Visitor	Commercial	Retail	Industrial
0	0.3	0.7	1	0	150	100	150
Car share spaces:							
Residential Car Share Rate/ dwellings					Car share rate to reduce car parking provision		
1 per 20 dwellings					1 in lieu of 5 parking spaces.		
Unbundled parking:							
Maximum parking rate reduction of 20%							
Decoupled, unbundled parking:							
Maximum parking rate reduction of 40%							
Minimum bicycle parking rates:							
Resident		*Commercial*		*Retail*		*Industrial*	
Resident	Visitor	Employee	Visitor	Employee	Visitor		
1 per dwelling	1 per 10 dwellings	1 per 150sq.m	1 per 400sq.m	1 per 250sq.m	2 spaces + 1 per 100sq.m	1 per 10 staff.	
End of trip facilities:							
Personal lockers	*Showers and Change cubicles*						
	Up to 10 bicycle spaces	11 – 20 bicycle spaces	Each 20 additional bicycle spaces over 20.				
1 per space	1* (assumed rate)	2* (assumed rate)	2				

This report considers the PRCUTS planning principles and proposed rates and considers this with a strategic understanding of existing travel patterns and the practical application of policies and parking rates.

Summary of recommendations

The recommendations provided within this report are summarised as follows:

Driveway recommendation:

A maximum of one driveway per site or two one-way pairs in special circumstances.

Parking space adaptability recommendations:

> Prepare design guidelines that include development requirements for car parking which supports adaptive reuse of parking areas for future development.

> Consider changes to parking policies that allow for off-site communal parking (unbundled from development).

Car share recommendations:

Assist and support the location of car share spaces adjacent to dense residential development. Encourage on-site car share for residential and business developments, particularly where parking construction costs would impose high costs on tenants and reduce affordability.

Electric vehicle recommendations:

> As the EV fleet grows, market forces will govern the installation of EV charging units. Policy measures including community title for parking facilities, unbundled and decoupled supplies can be used to provide flexibility for developers and residents, and thereby reduce the opportunity cost of installation.

> Electric vehicle charging points should be provided in off-street locations in the same way petrol stations are off-street for a range of safety and amenity reasons.

> Introduce development requirements to ensure all high-density residential development has access to EV charging bays for new applications. This should include provision of conduit to allow residents to reticulate power to individual bays, and to ensure electrical infrastructure is sized to support a charging demand.

> Introduce development requirements to ensure slow-charge EV charging points are provided for a percentage of long-stay employee parking (~10%, increasing as demand rises).

> Introduce development requirements to ensure future ability to supply EV charging points at a minimum of 50% of total bays.

> Policy support for conversion of public off-street parking spaces to EV fast-charging, through an expedited approval process.

Bicycle recommendation:

Given the current journey-to-work cycling mode share of less than one per cent, and with the assumption that increasing bicycle mode is consistent with Council objectives**, a minimum bicycle parking rate to satisfy 2.5 per cent of employee mode share**, plus additional spaces for visitors/ customers. This creates capacity for additional bicycle mode share.

Bicycle parking demand should be monitored in the locality and Council should host find or request a new bike parking space on their website.

Motorcycle recommendation:

Motorcycle parking should be provided for at a minimum of 1 space per 1,500sq.m of employment land use, with a minimum of one space where on-site parking is provided.

Servicing, delivery and loading recommendation:

Site loading and servicing facilities are provided on site, appropriate to the size and scale of the development.

Residential parking recommendations:

The PRCUTS residential parking rates represent a significant reduction in on-site parking, compared with existing ownership behaviour. It is recommended that these rates be employed only where effective parking management mechanisms are in place for surrounding public parking provision.

The alternative maximum parking rates are considered feasible for implementation without substantial interventions, while still representing a substantial downward pressure on private parking supply.

Land use	Bedrooms	Alternative maximum parking rates (consistent with existing transport environment)	PRCUTS maximum rate recommendations
House/ Townhouse	1	1.0 per townhouse	0.3
	2	1.0 per townhouse	0.7
	3+	1.0 per townhouse	1
Apartment	0	0.15	0
	1	0.5	0.3
	2	1.0	0.7
	3+	1.2	1
	Visitor	0.1 space per dwelling, unless this can be provided on-street.	0

Residential parking permits recommendation:

Expand the residential permit scheme and price permits at a rate consistent with the opportunity cost of parking infrastructure, with a transition period to support behaviour change by residents.

(Key) Non-residential land use parking recommendation:

The PRCUTS recommended parking rates are considered to be appropriate under the future public transport provisions identified in the PRCUTS Plan. A series of alternative parking rates has been identified which would be sustainable even without significant capital works upgrades of public transport.

. Land use	Alternative maximum parking rates (consistent with existing transport environment)	PRCUTS maximum parking rate recommendations
Student housing/ Boarding house	0.15 space per dwelling	No recommendation
Health/ Medical centre	2 spaces per consulting room	No recommendation
Hospital	3 spaces per bed	No recommendation
Commercial/ office	1 space per 100 sq.m. (1.00 spaces/ 100sq.m) of floor area	1 per 150sq.m (0.67 space/ 100sq.m)
Retail/ shop	1 space per 50sq.m (2 spaces/ 100sq.m) of floor area.	1 per 100sq.m.
Restaurant	1 space per 50sq.m (2 spaces/ 100sq.m) of floor area	1 per 100sq.m.
Bulky goods	1 per 100sq. Must include an off-street loading zone for customers.	No recommendation
Industrial	1 per 150sq.m (0.67 space/ 100sq.m)	1 per 150sq.m (0.67 space/ 100sq.m)
Out of centre uses along the Parramatta Road corridor	General rate (Not a maximum): 1 space per 40 square metres (2.5 per 100 square metres)	Differentiated by suburb only.

Existing land use

PRCUTS Camperdown, Leichhardt and Taverners Hill each are unique in terms of land use, demographics and transport opportunities. These differences will need to be examined to identify any need for differences in the parking policies, rates and mechanisms imposed on development to ensure that Council's Objectives can be realised across these locations.

To provide context for the parking requirements across each precinct, the existing land uses and parking facilities have been characterised as follows.

3.1.1 Parramatta Road corridor

Between the designated Precincts, Parramatta Road operates as a frontage for a wide variety of highway retail, specialty and restaurant businesses. Very little parking is associated with these land uses, which rely heavily on nearby on-street parking and some small rear-loaded private car parks.

3.1.2 Camperdown

The Camperdown Precinct is divided by the major road corridor of Parramatta Road, and extends a significant distance east-west from the outskirts of the University of Sydney (UoS).

There is a mixture of office, restaurant, retail and residential uses within the Precinct, somewhat localised within individual sub-precincts. Against this background is the impact of the UoS campus, with its own parking demand that extends across the study area.

3.1.3 Leichhardt

Leichhardt is the retail and civic centre for the Inner-West Council. While it has few office developments beyond the Council itself, it acts as a key destination for a large catchment of residents in the surrounding suburbs.

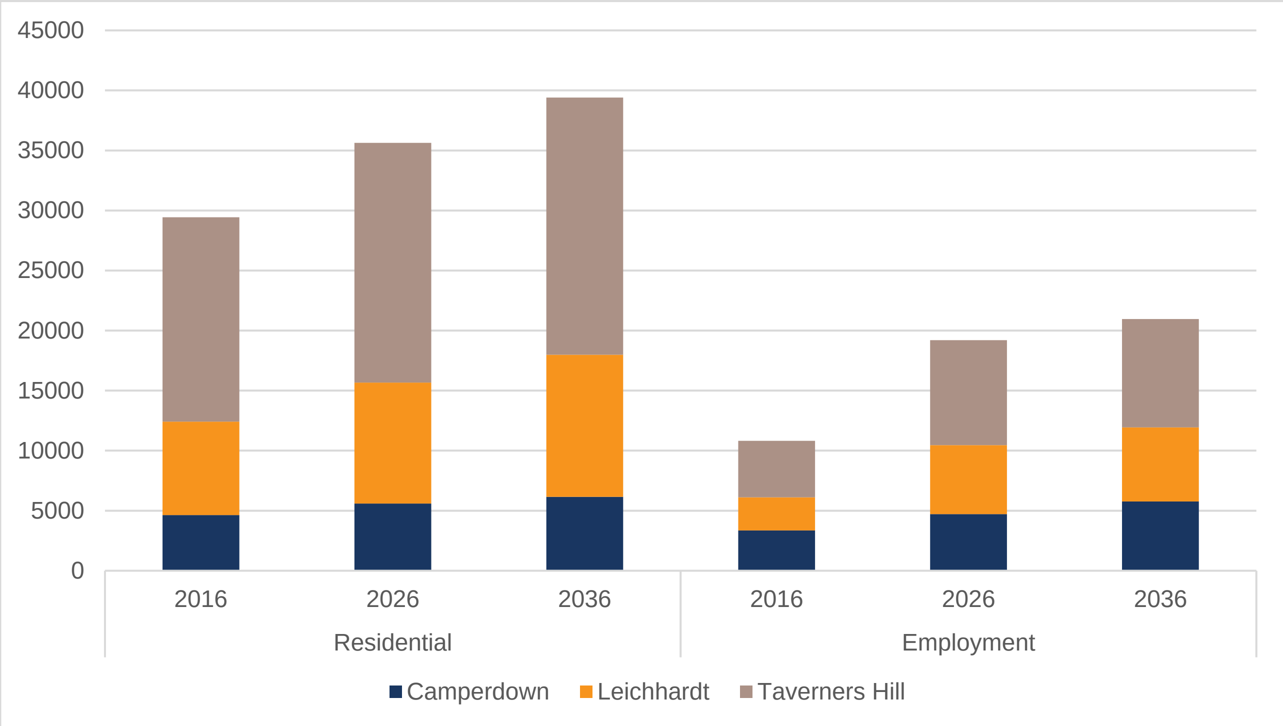
3.1.4 Taverners Hill

The Taverners Hill Precinct currently comprises a commercial precinct with a high density of showrooms and bulky goods stores, surrounded by medium-density housing. It is therefore a key origin and destination for commuter trips, but likely has little self-containment apart from retail trips to Marketplace Leichhardt at the northern edge of the study area.

Population forecast

Within the Inner West PRCUTS areas, there is a forecast of an additional 10,000 residents and 10,000 workers in the period 2016 – 2036. The breakdown is shown in **Figure 4-1**.

Figure 4-1 Residential and employment forecast



Data source: PRCUTS land use review, SGS, 31/05/2021

Built environment considerations

5.1 Urban form

Car parking impacts urban landscapes through the space they take up, which otherwise could be used for productive purposes, local amenity (street trees, public open space, landscaping etc.). The impervious form of parking effects stormwater runoff, increases the volume pollutants entering waterways and exacerbates urban heat island effects.

The impact of parking is greatest where it is constructed in at-grade facilities, which artificially increase the distance between activities; reducing the viability of walking and reinforcing the need for access by private car. This in turn can reduce the demand for public transport, preventing service improvements in the future.

The substantial cost of parking also influences urban form, by making some mid-scale development unviable, the result can be either an under-development of key lots or an incentive to maximise density to recoup the financial cost of parking provision.

5.2 Crossovers (driveways)

Where parking is provided on-site, it requires access via one or more crossovers. The density of these crossovers has an overall impact on the function and safety of the road network, as well as on the amenity of residents and visitors. Key impacts of crossovers are outlined in **Table 5-1**.

Table 5-1 Impacts of crossovers

Category	Driveway considerations	Benefit of reduced driveways
Pedestrian	Driveways operate across pedestrian priority zones and in all cases, pedestrians retain priority over vehicles crossing a path. Conflicts between pedestrians and cars are common, and these are exacerbated by sightline obstructions such as walls and trees. Cars parking in driveways often encroach on pedestrian paths, reducing amenity and impeding accessible travel.	Improve pedestrian safety through reduced path conflict points.
Vegetation	Reduction in nature areas for plantings.	Increased opportunity for vegetation and trees, including urban cooling, improvement to pedestrian amenity and
On-street parking	Sterilises other kerbside uses.	Opportunity to use kerbside for parking and other uses.
Road safety	Each location is a conflict point with a variance in geometry and sightlines.	Improved predictability of road environment and rationalise driveways to safer areas.

Recommendation:

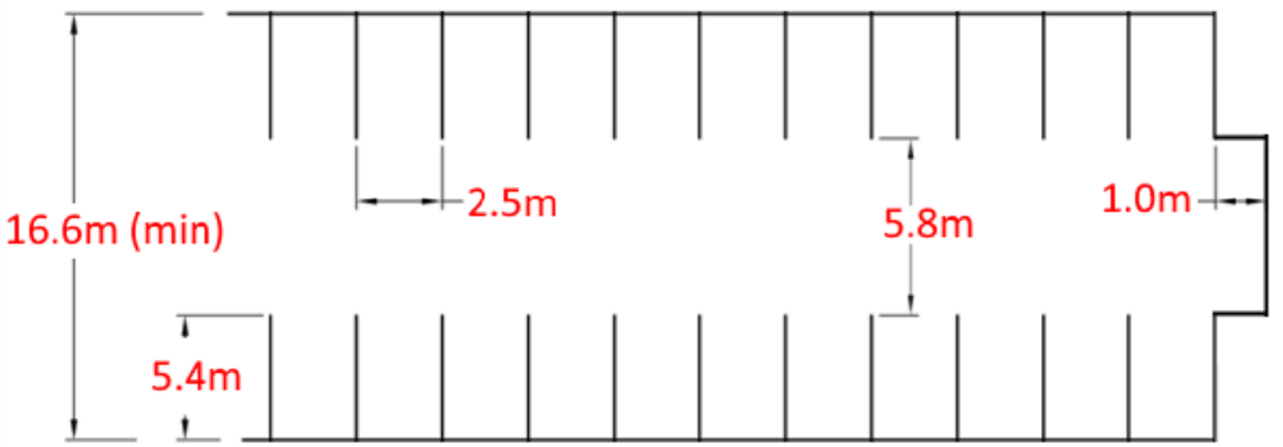
Sites should have a maximum of one crossover where on-site parking is provided, or a maximum of two if each driveway is one-way. I.e. a hotel porte cochere.

5.3 Geometric design – Australian Standards

The ideal car park geometry (minimum dimensions) is wholly determined by the requirements of Australian Standards. Efficient parking design has perpendicular parking on both sides of the access aisle.

The minimum dimensions for an efficient office or residential car park, where every space is allocated to an individual vehicle, shown in **Figure 5-1** (adapted from AS2890.1 Figure 2.4). This is sufficient only where parking is provided in a single parking level, as there is no space for ramping.

Figure 5-1 Typical efficient car parking layout.



This design gives a minimum floorplate dimension of 16.6m, below which parking cannot be supplied in an efficient manner. For example, a single-sided aisle requires approximately 40% more area per bay, with an equivalent cost increase.

This effect is largely governed by the requirement for an access aisle. Arrangements which use the frontage road to provide access to public on-street parking require significantly less space, which makes this an attractive option where only a few parking spaces are required.

The spaces are enough to fit a range of common vehicles outlined in **Table 5-2**, noting larger vehicle may require more than one-movement to enter and exit a space.

Table 5-2 Popular vehicles dimensions - millimetres

Vehicle class	Example make and model 2021	Length	Width	Height
Australian Standard car space for office and residential	User class 2	**5400**	**2500**	**2200 minimum**
Light Car	MG 3	4055	1729	1504
Small Car	Toyota Corolla Hatch	4375	1790	1435
Mid-SUV	Toyota RAV4	4615	1865	1690
Large SUV	Toyota Kluger	4966	1930	1755
Large passenger van	Kia Carnival	5155	1995	1775
Utility	Toyota HiLux Double Cab Pick-up	5350	1935	1700

Source: www.toyota.com.au, www.kia.com.au and www.mgmotor.com.au

Table 5-2 shows a 5.4 metre long x 2.5 metre wide x 2.2 metre high car parking space is large enough to accommodate a range of popular large vehicles noting that an incentive remains for smaller vehicles which will be easier to park due to their smaller dimensions.

5.4 Multi-level structures

5.4.1 Columns

Structure is often built over the top of the parking, the layout of any development located over parking is driven to a large extent by the requirements of AS2890.1. The aisle widths and parking modules dictate column spacing, while the above-ground structure determines the size of those columns.

Good design places the columns outside of the parking modules, increasing the floorplate requirements.

5.4.2 Ramping

Spiral and scissor ramps are the most common configurations, and provide a good benchmark for standard geometric requirements. These are discussed as follows:

Split-level internal spiral (ramped floor)

This has the following key requirements:

> The isle to back onto itself to construct the spiral; and
> Enough length and therefore space to achieve the required level difference.

The ramp grade is set by the maximum slope of the parking spaces, and therefore limited to a grade of 1:16. If floor-to-floor height is set at 3 metres, then a total ramp length of 48 metres (using both aisles) is necessary. Adding in the end aisle creates the following minimal envelopes:

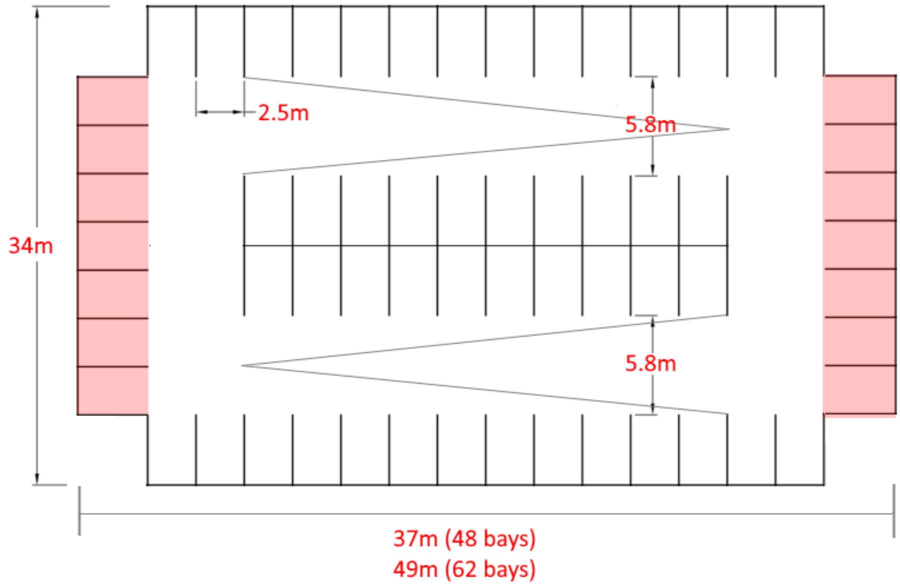
> 29m x 37m for 38 bays;
> 34m x 37m for 48 bays;
> 29m x 49m for 48 bays; and
> 34m x 49m for 62 bays.

The access ramping, fire stairs, lifts etc. reduce the efficiency of this arrangement, but on average, an internal spiral geometry can provide parking at a ***theoretical limit of about 30 square metres per bay***.

The lack of a flat floor precludes future adaptation to other land uses. This form of parking is therefore more appropriate for basement parking, where conversion opportunities are limited.

An indicative layout plan is shown in **Figure 5-2**.

Figure 5-2 Indicative spiral ramp multi-level car park layout



5.4.3 Scissor ramp

Scissor ramps can be used either in a split-floor arrangement or a full-floorplate flat deck, with examples show in **Figure 5-3** and **Figure 5-4**. The floor-to-floor heights define the geometry of the floor plates, since the minimum ramp length is set by Australian Standards at 9 metres (1.5 metre half-floor level change) or 16.5 metres (3 metre full-floor level change).

Figure 5-3 Half level floors and ramps

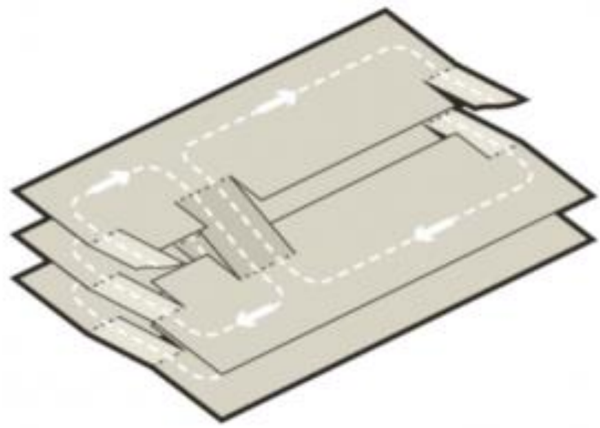
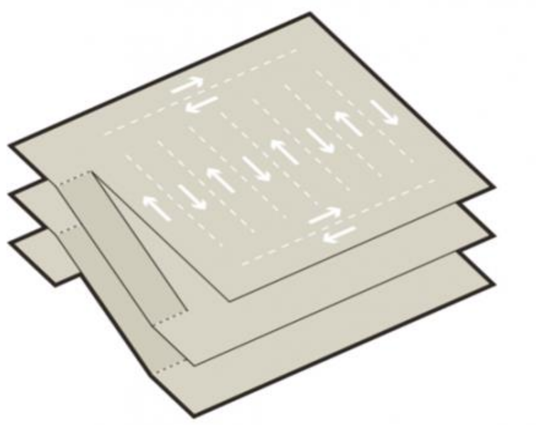


Figure 5-4 Full level floor and ramps



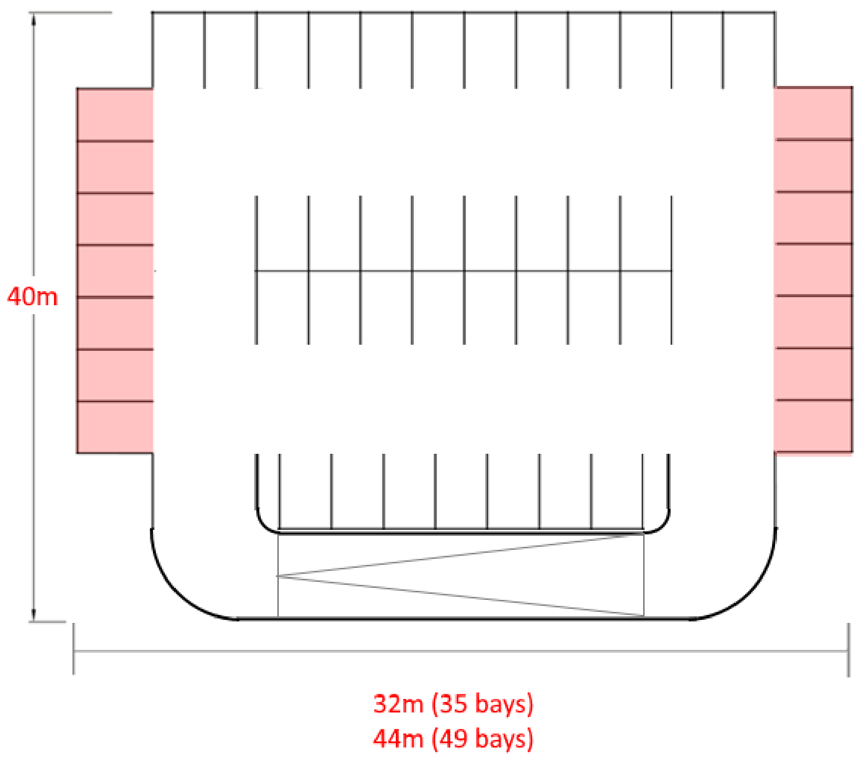
Source: https://www.steelconstruction.info/Car_parks#Circulation_design, viewed 03/03/2021

A theoretical construction of a minimum efficient envelope for a flat floorplate uses a ramp parallel to the circulating aisles and creates the following options:

- 35m x 32m for 23 bays;
- 40m x 32m for 35 bays;
- 35m x 44m for 37 bays; and
- 40m x 44m for 49 bays.

The requirements for up and down circulation ramps further reduce the efficiency of these car parks, but provide opportunities for flat floors and better constructability. An indicative layout is shown in **Figure 5-5**.

Figure 5-5 Indicative scissor ramp car park layout



If geometric and financial effects are considered to be a key determinant of parking provision, then the following can be recommended:

Recommendation:

- A lot that is less than 16.6m wide in its narrowest dimension cannot provide efficient single-level car parking
- A lot that is less than 29m in its narrowest dimension cannot provide efficient multi-deck car parking
- Where on-site parking is provided, it should be as efficient as possible and limited to 1 or 2 levels only.

5.5 On-site parking

The available space for parking is governed by a number of planning restrictions that define its form:

- **At grade parking** consumes land area that would otherwise be available for development.
- **Podium (or undercroft) parking** is limited by setback and landscaping requirements, which reduces the extent of the site that can be used for parking.
- **Sleeved parking** (behind habitable land uses) further reduces the available parking space due to the need for active frontages.
- **Basement parking** may be constructed up to the boundary on all sides, but this limits the opportunity for deep soil planting. In the NSW context the envelope is generally restricted to the building footprint.

These limitations should be considered along with the density of development proposed, to determine whether on-site parking can be supplied in a cost-effective manner.

There is an important relationship between the intensity of development and the form of parking constructed. These parameters may differ according to the design guidelines for an individual location or Precinct. The variability in requirements around development site coverage, setbacks, landscaping and deep soil planting, etc. as well as the different forms that parking can take suggest that a fixed maximum rate for parking is difficult to determine.

The following discussion illustrates some of the geometric issues associated with parking construction, and provides recommendations for parking limits based on these geometric constraints.

5.5.1 Basement parking

Basement parking is often selected due to the minimal impact that it has on land use and urban structure. By placing parking underneath productive land uses, the at-grade ‘footprint’ is almost eliminated.

Basement parking is ideally accessed from a minor road to mitigate the impacts of queuing on corridor function and to reduce the potential for conflict with pedestrians along the active frontage.

Due to the desire for basement parking to be located below grade, the building design must be compromised to create a portal for the access ramp. AS2890.1 requires that the first six metres of the car park access be a maximum grade of 1:20, increasing the total ramp length to at least 21 metres before the first basement level. This limits the applicability of basement parking to locations where a long approach ramp can be constructed.

An estimate of construction costs for basement parking was undertaken by ptc[1]. in 2017 across Australia. They found a construction cost range of $1,150 - $1,900 per square metre. This equates to $35,000 - $55,000 construction cost for every basement car space built.

5.5.2 Above ground/ podium level parking

Stand-alone parking structures operate as single-use spaces, though there is potential for ground-floor activation, with car parking levels above. This form of parking supply is highly flexible, and has the most utility for public parking, catering for a wide array of businesses within walking distance.

The management of dedicated above-ground parking can also be highly reactive.

Parking duration and fee structure can be used to support specific trip purposes, and modified to maintain very efficient operation. The ability for these car parks to accept a wide variety of users means that they can

[1] https://www.ptcconsultants.co/construction-costs-car-parks-2017/

adapt to the surrounding changes in activity and, if they are no longer viable, be demolished or readapted for more productive uses.

Podium parking places the parking structure behind frontage uses, retaining pedestrian-scale activity at ground-floor level, and elevating the primary development uses (residential, office etc). In these installations, ground floor uses may be as sparse as a lift lobby, or might include retail/ restaurant spaces.

The additional levels of podium parking increase reduces the development potential due to height restrictions.

Podium parking has the most potential for adaptation to productive land uses, and so policy measures that support this conversion can assist in improving the resilience of a Precinct.

Above-ground parking construction costs are generally lower than basement parking, The ptc. review of above-ground multi-deck car park costs showed a range of $800 - $1,200 per square metre. This calculates to about $25,000 - $35,000 per parking space.

5.5.3 Car stackers

Car stackers use mechanical systems to reduce the space required to store cars. An indicative schematic is shown in **Figure 5-6**.

Depending on the technology used, this method can be much more efficient than standard multi-level parking structures. This efficiency is achieved by eliminating parking aisles and reducing floor-to-ceiling heights.

Car stackers tend to operate as follows: a driver enters the portal and stops on a platform, then leaves the vehicle while the car stacker 'parks' the car in a vacant space.

Due to the reduced space requirements, car stackers can be used on sites that cannot provide efficient parking, particularly where the lots are narrow or otherwise geometrically constrained.

There are a number of factors that require consideration before selecting car stackers, including:

> **Maintenance**: There is an ongoing maintenance requirement for the stacker machinery. Because every installation is proprietary, this adds risk to the development.

> **Breakdown**: In the event that the stacker system fails, vehicles will be effectively 'trapped' either inside or outside of the car park.

> **Vehicle Size**: The majority of car stackers are designed to suit a given vehicle size, they can be configured to allow a certain quantum of tall vehicles (SUVs and 4x4s), but may not accept long vehicles.

The restrictions are not markedly different from standard car parks, which have restrictions on vehicle height and length, but the parameters are generally more restrictive.

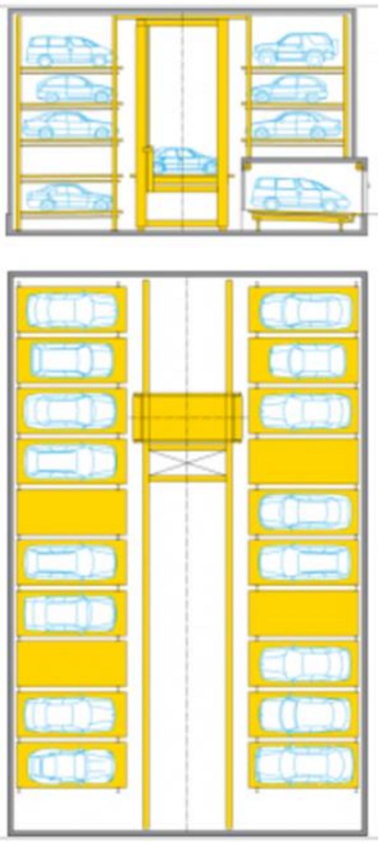
> **Queuing**: The cycle time for a stacker system is slow, in the order of 45-90 seconds for a typical car storing/ retrieval, and this increases with the size of the system. This translates into long wait times during peak periods, and queues of vehicles particularly during inbound peaks.

Car stackers are therefore used primarily for low-intensity functions (residential use).

> **Familiarity**: The operation of these systems may not be intuitive for new users. Unfamiliarity increases cycle times and exacerbates queuing issues.

> **Space adaptability**: Due to the unusual geometry of the stacker envelope, the space is virtually useless for anything else. Car stackers therefore create a legacy issue when the system comes to the end of its useful life, or if parking demand declines.

Figure 5-6 Car stacker schematic



Source: worhr.com.au, viewed 27/02/2021

Despite some issues, car stackers may present the best option for on-site car parking where lot geometry does not support efficient car parking. Car stackers installations should be accompanied by supportive documentation that details any limitations on vehicle use, how spaces will be allocated, the operational framework, queuing projections and mitigation measures.

5.6 Off-site parking

5.6.1 Public parking

The most common alternative to on-site parking is parking in the public realm, either in large-scale off-street car parks or on-street parking.

This allows the supply and demand to be managed (mostly by Council) through a combination of duration restrictions and pricing.

It is important that where parking concessions apply, transparent and equitable governance is applied to manage supply and community critique.

5.6.2 Reciprocal parking

A reciprocal parking Agreement is a formal legal document to permit parking on third-party private land. This ***usage agreement*** may be used to reduce the burden of providing parking by a proposed development. These agreements are maintained on Titles, with administration from Council.

The degree of reciprocal parking occurring depends on the type of land use in the vicinity and the time of day. The most important component to determine the rates of reciprocal parking is the proximity of the land use pairs. Reciprocal parking generally results in lower total parking supply required to satisfy demand.

The feasibility and function of a reciprocal parking proposal should be assessed on the same basis as for mixed-use development under a shared parking system. Shared parking supply is discussed in **Section 10.3**.

5.6.3 Unbundled parking

Unbundled parking differs from reciprocal parking in that it represents a change in ***ownership*** instead of ***use.*** It is a process by which tenants can choose whether or not to rent/ purchase parking with their unit. The unbundling of parking can be introduced in several different ways:

- Site managers can unbundle parking when renting building space (i.e. rent or sell parking facilities separately);
- Developers can make some or all parking optional when selling buildings;
- Renters can be offered a discount on their rent for not using some or all of their allocated parking spaces; and
- Parking costs can be listed as a separate line item in the lease agreement to show tenants the cost and enable them to negotiate reductions.

Providing tenants or owners with the opportunity for unbundled parking is also likely to create a market for available parking spaces. The market is limited to spaces within a reasonable walking distance between car parking space and destination (residence or employment).

If an unbundled parking policy is introduced, it is important to consider the cost of alternative parking in the nearby area. Where there is a supply of free or low-cost parking nearby, this creates an incentive for tenants or owners to preference these spaces, resulting in spill-over effects and diluting the market.

The elements required for unbundled parking to be feasible include:

- A consistent and longer term market demand and willingness to pay for car parking that cannot be supplied nearby in another location;
- A comprehensive management scheme of all other nearby publicly accessible parking facilities within a convenient walking distance. This should consider the trade-offs between walking distance and price to rent a parking space;
- Investors willing to adopt the risk and dedicate effort into such a facility and/ or a property willing to supply and manage a supply.

Anecdotal evidence suggests this already happens to some degree in dense Sydney zones, where residents will lease car parking spaces through online classifieds or third party managers.

5.6.4 Decoupled Parking

In addition to unbundling parking from land uses parking can also be located off-site, either in public facilities funded through developer contributions or cash-in-lieu, or in private facilities with ownership decoupled from the associated development.

This form of parking has the advantage that it can accommodate ongoing future growth as demand declines, or be demolished to make way for new development. One of the key advantages of decoupled parking is that it reduces the risk of under-supply, since excess parking can be leased or sold to a wider catchment as required. This also establishes a local market rate for parking that reflects the relative scarcity of supply.

One particular location where this would be beneficial is Camperdown, which has a unique mix of student accommodation, as well as dense residential, education and commercial uses. Decoupled parking mechanisms can be used in this environment to support residential developments with zero on-site bays, as well as fluctuating demand.

Supportive zoning regulations and policy frameworks are necessary to provide comfort to developers that consolidated private parking schemes will not form an impediment to Precinct planning. Permitting decoupled parking within dense residential and commercial zones reduces the need for Council provision of parking infrastructure.

Recommendation:

> Consider development of a parking policy that supports off-site communal parking (decoupled and unbundled from development) under the Community Titles Act.

> Investigate the opportunities and appropriate planning mechanisms for implementation within Camperdown.

Technology

Technology change is already impacting a wide variety of different modes, including private vehicles, public transport, and cycling. Future changes in transport technology are likely to have an ever-increasing impact on travel behaviour. Specific emerging technologies in transport include autonomous and connected vehicles, electrified transport, car and bike sharing, ride sourcing, and mobility-as-a-service.

These technologies will have a range of different effects on transport networks and development planning, and ability to achieve desired mode share targets, as well as Council’s ability to achieve other related environmental, social and economic goals. Depending on the manner in which the technology enters the market, uptake of new technologies in the transportation space may impact congestion in either positive or negative ways.

Upcoming and recent transport technology is anticipated to lower private vehicle trips and parking demand in cities. Some key considerations are outlined as follows:

> **Mobility as a Service (MaaS)** provides the means to integrate all potential transport options to travel. i.e. this may compare the time and cost between a bike share, ride share, public transport, car share or a combination.

> **Bike sharing** allows people to located and use a bike for shorter trips. This service can help to reduce vehicle trips.

> **Ride hailing services** like taxis, do not use traditional destination parking, and so this change in travel behaviour may reduce the need for a range of private parking supplies. However, there is a corresponding cost in the requirement for public and private waiting bays, as well as high turn-over pick-up/drop-off parking.

> **Car sharing** allows multiple people to share vehicles and can reduce the overall demand of car parking, particularly in managed parking environments. This is discussed more in **Section 6.2**.

> **Connected and autonomous technology** (still being developed). This has the potential to reduce parking demand and allow efficient use and sharing of the vehicle fleet. The full effects are yet to be

determined and is dependent on pricing and policy measures that will impact travel choice. There is a risk that people may choose to use an autonomous vehicle instead of mass public transport resulting in road network congestion.

6.1 Parking space adaptability

Due to the expected downward demands for car parking through technology and declining car ownership rates, it is recommended to plan and construct car parking space that can be adapted in the future for other uses.

Recommendations:

> Prepare design guidelines that include development requirements for car parking which supports adaptive reuse of parking areas for future development.

> Consider changes to parking policies that allow for off-site communal parking (decoupled and unbundled from development).

6.2 Car share

Car sharing includes traditional daily rental, by-the-hour services (such as GoGet) and one-way car sharing (carpool). Changing consumer preferences provides for an increased focus on travel objectives rather than vehicle ownership.

In Australia, research has indicated that between 11 and 65 per cent of car share members reduce their car ownership. While this is a wide variance and has been determined from a range of circumstances, a typical industry benchmark is that for every 20 members, 10 cars can be replaced with a single share-car. This represents a reduction in parking supply of approximately 40 to 45 per cent.

Evidence from commercial car-share systems in Australia and overseas suggest that where car-share services are embedded within a development (i.e. for the benefit of residents, employees or institutions), this can result in a significant reduction in parking requirements.

Recommendation:

(Infrastructure) Assist and support the location of car share spaces adjacent to dense residential development. Encourage on-site car share for residential and business developments, particularly where parking construction costs would impose high costs on tenants and reduce affordability.

6.3 Electric vehicles

Electric vehicles provide the opportunity to reduce the environment impacts of vehicle trips. They still present all other private vehicle car trip issues (traffic generation, occupy space) have on the transport network. In coming years, parking demand is expected to be dominated by electric vehicles, and this should be supported in appreciation that some trips are most appropriately served in private vehicles than other modes. The following is recommended to support electric vehicle adoption:

Electric vehicle recommendations:

> As the EV fleet grows, market forces will govern the installation of EV charging units. Policy measures including community title for parking facilities, unbundled and decoupled supplies can be used to provide flexibility for developers and residents, and thereby reduce the opportunity cost of installation.

> Electric vehicle charging points should be provided in off-street locations in the same way petrol stations are off-street for a range of safety and amenity reasons.

> Introduce development requirements to ensure all high-density residential development has access to EV charging bays for new applications. This should include provision of conduit to allow residents to reticulate power to individual bays, and to ensure electrical infrastructure is sized to support a charging demand.

> Introduce development requirements to ensure slow-charge EV charging points are provided for a percentage of long-stay employee parking (~10%, increasing as demand rises).

> Introduce development requirements to ensure future ability to supply EV charging points for every parking bay. This ensures maximum flexibility to accommodate the future EV fleet.
> Policy support for conversion of public off-street parking spaces to EV fast-charging, through an expedited approval process.

Traffic impacts

While parking itself does not generate vehicle traffic, a constrained parking environment (where supply is less than demand) will result in a change in travel behaviour. This is caused by the increased costs (both financial and time) imposed on the parking component of the trip.

Various trip types interact with the road network and parking supply in different ways. For the purpose of this discussion, consider the following peak periods along Paramatta Road:

> **AM Peak**: Precinct traffic is predominantly related to outbound residential and inbound employees

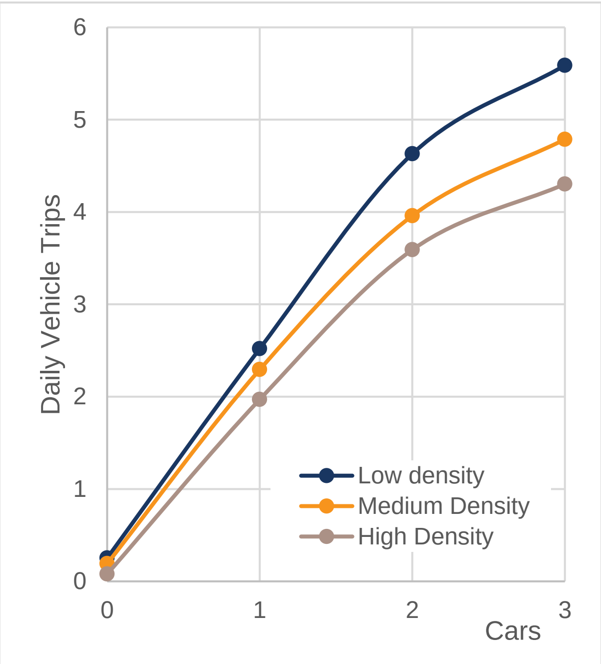
> **PM Peak**: Precinct traffic is predominantly related to inbound residential, outbound employees, plus retail and entertainment visitors

> **Saturday Midday**: Precinct traffic is predominantly related to inbound and outbound residential movements (non-commuting) and retail/entertainment visitors.

Across all of these periods, there is another key demographic of demand: Regional traffic, which is unrelated to any of the land uses within the Study Area but will be affected by decisions made in the surrounds.

Each of the components of the parking system (residential, employee and visitor parking) can be adjusted as necessary to mitigate the impacts of congestion caused by development. This can be translated into policy and management measures within each Precinct and surrounds.

Figure 7-1 Vehicle Trip Generation Per Household



Source: Victorian Integrated Survey of Travel and Activity

> **Residential traffic (Origin in the Precinct)**: traffic impact decreases significantly when vehicle ownership is constrained by maximum parking limits. A household with 2 cars generates approximately 80% more vehicle trips than a 1-car household (and zero car households generate few, if any vehicle trips). This is shown indicatively in **Figure 7-1**.

> **Employee traffic (Destination in the Precinct)**: traffic is generated proportional to the supply of long-stay parking.

Employees tend to have the best opportunities to access high-frequency public transport. In addition, employee parking is one of the least productive land uses, as these vehicles essentially lie idle through the entire activity peak. Restricting employee parking is a direct way of reducing car-as-driver mode share for this trip purpose. This includes both statutory supply maximums applied to key development areas and active management of public parking to limit long-stay use.

> **Visitor traffic**: traffic is generated proportional to the availability of short-stay parking *during peak period.*

Retail, restaurant and entertainment activity is important for the function of the Precinct. Visitors tend to park for a short period of time and hence these parking bays are usually the most valuable for the Precinct. Public parking remains the most effective way of fulfilling visitor parking demands, due to the efficiency increases that are unlocked through shared use of a common resource.

> **Regional traffic**: unaffected by parking supply, but may be redirected to alternative routes or shifted to public transport modes if congestion is high

The parking ecosystem

Parking should be considered as an ecosystem consisting of public and private, on-street and off-street, and considering all of the many needs of those people who use those bays. The optimal parking system would be one where all parking is used efficiently, with the minimum amount of space devoted to parking activities. After all, parking itself only facilitates activity; it does not create any of its own.

An effective parking system must therefore consider the impacts of parking policies on behaviour, and whether there is sufficient capacity across all parking facilities and alternative transport to fulfil the mobility needs of a location's employees, residents and visitors.

> **Private parking supply**: when parking is provided primarily on individual lots, the financial burden of constructing and maintaining that facility is borne by the owners, tenants and customers. This is not necessarily equitable, as that cost may be passed onto users who don't drive.

  Private parking is also inherently inefficient, in that it can only be used by a select group of people (usually, the employees, residents or customers of that development).

> **Public parking** has the intrinsic advantage that it can be accessed by the greatest number of users, and is therefore a more efficient method of delivery. In addition, public parking can be priced to reflect the demand and to induce behaviour change in high-demand areas to alternative locations, or alternative transport modes.

When Council sets high ***minimum*** parking rates, this can impose a financial burden on private development, raising the cost of construction – which must be then passed onto tenants and customers in the form of higher prices.

If Council sets very low ***maximum*** parking rates, this shifts the burden of delivering parking to Council. This can be beneficial, where the public supply is effectively managed and priced in a manner that is responsive to demand. But where parking is provided free of charge or significantly below 'fair value', the use of public parking represents a significant subsidy to car owners, and to the detriment of people using other transport modes.

Setting parking rates

The 2016 Ashfield, 2011 Marrickville and 2013 Leichhardt DCPs provide developers with an indication of the required parking bays to be included in all types of development across the LGA. These rates are given as a flat rate (Ashfield DCP), as target rates (Marrickville DCP) and as banded rates (Leichhardt DCP).

The Marrickville DCP provides guidance on how variations can be accepted. The use of target rates in this area, rather than minimum or maximum rates, establishes a 'deemed to comply' value for development. For this type of rate, strategic intent of the target is explained within the DCP. The Leichhardt DCP rates are more flexible, allowing developers to choose the appropriate supply of parking within a band acceptable to Council.

Council's updated DCP parking rates should be designed so that all types of development meet strategic planning objectives. It is challenging to determine rates that will suit all land uses and changing needs, and other forms of parking requirements may be better suited to support Council's strategic planning needs. The different types of parking rate types are discussed in **Table 9-1**.

Table 9-1 Off-street parking requirement types

Parking requirement type	Detail
Minimum parking rates	Minimum rates are used to ensure that developments provide more than zero parking spaces. The lack of an upper limit ensures that developers may increase supply but cannot reduce without a concession from Council. Minimum rates can be used to prevent overspill of parking into on-street spaces, and tend to be used in suburban areas where public parking is limited. ***Reduced minimums*** accept that a given overspill will be accommodated in public parking. This creates opportunities for improved efficiency and management control (pricing and duration restrictions), as well as reducing the economic burden on development, all of which can be beneficial to the local community. Historically, most minimum parking rates are set ***above*** the natural demand – i.e. more parking bays than developers want to build.
Maximum parking rates	Maximum rates are used to ensure that parking is not oversupplied, and are usually enforced in centres where traffic congestion is an issue and alternative public and active transport modes are highly accessible. This form of rates control leaves the decisions regarding on-site supply to developers and businesses. It acknowledges that developers may not provide parking spaces on-site, and so is usually accompanied by a fixed contributions scheme related to intensity of development. Most maximum parking rates are set below the natural demand – i.e. fewer bays may be constructed than developers want on-site.
Banded parking rates	Banded parking rates, set a lower and upper limit, provide developers with a range of acceptable parking ratios. They are generally used when developers are encouraged to make their own decisions on parking supply, no provision of parking. This type of rate is generally used when there is a lack of sufficient on-street public parking controls. By setting both maximum and minimum rates, banded rates allow developers an opportunity to interrogate their needs and select the parking supply that suits market demands.
Target parking rates	The 2011 Marrickville DCP utilises target parking rates, which provide no explicit flexibility to developers in determining parking supply. The application of discretionary policies effectively enables modifications to these rates based on a number of factors. In application, target parking rates function like banded rates, but with an opaque range for appropriate supply. This reduces certainty for developers and represents a potential barrier to sustainable development.
Parking caps	Parking caps are used when traffic congestion or other constraints in CBD areas require restrictions on a local area basis. This form of parking restriction is usually applied to a dense city centre precinct, and applied as an area rate (i.e. parking spaces per hectare).
Hybrid caps	Hybrid caps are used when a combination of these restrictions are necessary to support Council's strategic objectives. *For example: The City of Stirling in Western Australia requires commercial parking (independent of category) within the Mirrabooka City precinct to between 2 and 4 spaces per 100m^2, up to plot ratio 1.0. Beyond this density, parking is limited to 200-400 spaces per hectare.*

Parking requirement type	Detail
	This gives developers the ability to choose a rate that suits their business, but maintains a long-term cap on parking supply (and trip generation) through to the development horizon.

Parking rate concessions

DCP controls in the Marrickville DCP (2011) list a range of potential factors that may be considered for the purpose of evaluating a proposal for reduced parking supply. These include:

1. **Shared Parking**: "Peak parking and traffic activity occurs during periods where surrounding parking demand is lowest".
2. **Geometric Constraints:** "Existing site and building constraints make provision of car parking impractical".
3. **Transit Accessibility**: "Located adjacent to high-frequency public transport services and/or urban services".
4. **Demand Reduction:** "Includes management regimes to minimise car use, such as workplace travel plans or on-site carshare schemes", "Development targeted to demographic sector with low car use/ ownership".
5. **Public Benefit:** "Provides a business or social service that benefits the local community and contributes to the vitality of the area", "Parking for the development is consistent with the aims and objectives of this section of MDCP 2011."
6. **Safety:** "Safety of motorists, pedestrians and cyclists is unduly compromised by provision of parking.
7. **Heritage:** "Development contributes to heritage conservation of the building and setting".

Some key considerations are identified and discussed, including:

> **Demographics**: Age and household characteristics (students, older people, families etc.);

> **Accessibility**: Proximity to public transport nodes, frequency of public transport, quality and connectivity of pedestrian/ cycling infrastructure;

> **Land use**: Residential and employment density, mixed use activity; and

> **Parking availability**: Off-site public supply, unbundling options, car share etc.

10.1 Availability and accessibility of public parking

Developers should demonstrate the expected parking demand generated by a site. This can be used to determine the level of parking to be provided on-site or if the local parking supply can accommodate the demand. The developer should provide a contribution to the difference of its on-site provision and maximum demand.

10.2 Accessibility of alternative transport

Probable mode of site demand is driven by employees and visitors.

> Parking demand at **employee**-driven land uses is influenced by proximity to public transport and provision of quality end-of-trip facilities. Examples of employee-generated car parking land uses are offices and hospitals, and visitor-generated car parking are medical centres, restaurants, shops and places of assembly.

> Parking demand at **visitor**-driven land uses is influenced by location within a dense urban community and opportunities for on-site mixed-use synergy.

Adjustment factors that can be considered for probable transport mode of users are described in **Table 10-1**.

Where these factors account for the proximity of public transport, an accessibility map indicating the location of high-frequency and high-capacity public transport nodes can assist Council to determine appropriate locations where rate concessions could apply. This would require expansion and review of the Marrickville Parking Areas map to include all of Inner West and PRCUTS.

Table 10-1 Adjustment factors for probable transport mode of users

Category	Criteria for reduction factors	
	Employee-generated parking demand	Visitor-generated parking demand
Public Transport	The development is located within 800 metres of rail station.	No reduction for this component of land use
	The development is located within 400 metres of a high-frequency bus route (i.e. average headway less than 15 minutes)	No reduction for this component of land use
	The development is located within 200 metres of a collector bus route (i.e. any bus route regardless of frequency)	No reduction for this component of land use
Bicycle Parking	Bicycle parking provided in excess of 2x statutory requirements AND high-quality end-of-trip infrastructure provided including showers, lockers and secure parking.	No reduction for this component of land use
Location	No reduction for this component of land use.	The development is located within a Town Centre
Composition	The development proposes a mix of residential and commercial uses, provided at least 50% of the total plot ratio is residential.	
	The development proposes a mix of land uses which would be able to share on-site parking. The extent of parking reduction to be determined through a Parking Demand Assessment and in agreement with Council.	

10.3 Shared parking supply

Shared parking is parking that is used by two or more uses.

If a development consists of multiple land uses where peak demands occur at different times of day, on-site parking can be shared between land uses. This type of parking arrangement is appropriate only for situations where peak demand differs between the constituent land uses. Representative land pairs which can leverage this effect include:

> Residential Visitor Parking and Commercial/ Office; and

> Office/ Entertainment or Office/ Restaurant.

The ability to share parking is related to the types of land uses proposed and how their peak hours of operation differ.

Where this parking is at one location, internal parking management methods can be used to ensure maximum efficiency, while reducing the number of parking spaces.

Where parking spaces are delegated to specific users the supply is less effective. Shared parking takes advantage of the fact that most parking bays are only used part-time by a particular group, and many parking facilities have a significant proportion of unused bays, with utilisation patterns that follow predictable daily, weekly and annual cycles.

Efficient sharing of bays can allow parking requirements to be reduced significantly. Partial sharing occurs when arrangements are made by one facility to use another's parking facilities at certain times.

A method for evaluating the opportunity for shared parking uses a Peak Parking Demand table submitted by the Applicant, as part of a Parking Management Plan (exampled shown in **Table 10-2**), which provides enough evidence to Council to show that demand will not unreasonably coincide.

Table 10-2 Example shared parking peak demand table

Development type	Development users	Shared parking demand assessment				Unshared assessment (peak demand per land use)
		Morning	Midday	Afternoon	Evening	
E.g Office/ Restaurant in Town centre	Office Staff	150	150	150	0	160
	Office Visitors	10	10	10	0	
	Restaurant Staff	5	10	10	20	120
	Restaurant Customers	25	50	20	100	
	Total	**190**	**220**	**190**	**120**	**280**

Note: This assessment supports a peak parking demand of 220 spaces, instead of the 280 spaces that would be required if evaluated separately.

Any application for parking supply reduction based on internal shared parking arrangements should be justified through a Parking Assessment.

10.4 Cash-in-lieu of parking

Cash-in-lieu of parking is a policy mechanism by which developers give Council cash instead of providing car parking This is accompanied by a fee sufficient to offset the impact of this parking, either through the provision of public car parking, or improvements to alternative transport.

Cash-in-lieu payments can be an attractive alternative for developers when construction of parking on-site is very challenging and they specifically wish to have a provision associated with their development. It can also benefit the wider community through the supply of publicly and equitably managed parking for the use of high-value or highest-need parkers.

Current DCP documentation does not have any capacity to allow developers to voluntarily increase their contribution to offset higher impacts. The current provisions allow Council to either require a given private parking supply, or to waive that requirement, creating equity issues.

The success of cash-in-lieu parking arrangements is compromised if Council approves parking concessions in order to relieve developers from any obligation to provide car parking. Concessions should only be approved where the applicant can clearly demonstrate that the parking requirement is excessive.

If Council approves a concession because it is technically justifiable, the applicant should still have the ability to use the cash-in-lieu program to further reduce the amount of parking required on-site.

The cash-in-lieu amount should be set at a discount to the actual cost of providing the parking to:

- Provide a financial incentive for developers to contribute to the creation of strategically located public parking facilities;
- Recognise that Council will be able to recover some of the costs through user fees;
- Recognise that parking spaces are not allocated to specific users on a reserved basis, although the general supply will be available to meet demand;
- Recognise that the contributor will not have an ownership interest in the public parking facilities;
- Recognise that the parking may not be as conveniently located to a specific development compared to on site or other nearby parking facilities;
- Recognise that all or a portion of the parking may not be constructed at the same time as the development, and
- Recognise that the developer/ owner will not have any control over parking fees and use regulations.

The decision to accept cash-in-lieu should remain at the discretion of Council and not become an automatic right. This will allow Council to ensure that if it accepts cash-in-lieu payments, there is a reasonable expectation that:

- Municipal parking is already available to serve the development;
- Council will be able to provide a supply increase in the short term; or
- That alternative transport options can be used instead.

It is also necessary to ensure that planning for the provision of future parking structures is transparent and that contributors to the cash-in-lieu fund are given clear indication as to what their payments are funding. This will ensure that developers continue to see benefits in contributing towards public parking. This usually involves the establishment of a site-specific car parking infrastructure fund, into which cash-in-lieu payments are directed, and out of which the planning, upgrading and management of car parking facilities is funded.

A broader delivery model allows cash-in-lieu funds to be used to support sustainable public infrastructure, including upgrades to pedestrian, cycling and public transport facilities, can support a more flexible use of cash-in-lieu.

Regardless of the mechanism for funding - either through developer contributions, parking fees and fines or other public monies - it is important that the revenues and costs from parking-related activities be accounted for centrally. This allows for reasonable modifications to the management structure, pricing regimes, infrastructure and maintenance, enforcement and compliance activities to be resolved in a transparent system with full accounting of the costs and benefits provided. This will form the foundation for assessment of the requirements for cash-in-lieu payments by developers as well as determining and varying parking restrictions and pricing schemes based upon location, time of day and seasonal factors.

Accounting for all financial aspects of parking will enable a much greater appreciation for the real costs of providing this service.

10.4.1 Off-site parking

Cash-in-lieu is primarily used as a mechanism for funding off-site public parking, where construction of parking supply within a development is partly or wholly infeasible. This requires Council to deliver parking within relatively close proximity and inside a given timeframe. For these reasons, it may not be possible or appropriate for Council to accept cash-in-lieu funds, where planning is not sufficiently progressed to identify a suitable location for public parking.

Nevertheless, there can be significant benefit to both the developer and Precinct function where parking is provided in consolidated public facilities. A mechanism that allows developers to contribute towards a communal off-site parking structure in-lieu of on-site provision is therefore recommended.

Currently, zoning limitations can affect the opportunities for consolidated off-site car parking, particularly in areas abutting residential zones. Changes to zoning restrictions would be necessary to allow developers to construct nearby off-site parking structures, in lieu of on-site facilities. Ideally, these structures form part of large-scale Precinct redevelopment planning, with coordination between several developers. Because this requires co-ordination between multiple developers, potentially over an extended timeframe, off-site car parking is often only feasible where a large site area is being redeveloped.

An alternative market-led structure is possible if parking requirements are set at a low maximum rate, or abolished altogether. In this case, where parking demand significantly exceeds private supply, there is the potential for a standalone car park to be developed by a commercial third-party.

To progress the construction of off-site communal parking, Council intervention may be required (see further discussion in Section 5.6.4). This method of delivery uses essentially the same structure as cash-in-lieu, but on a completely voluntary basis. That is, developers contribute towards off-site parking infrastructure to be delivered by Council based on an understanding of their own individual needs, and (preferably) at a reduced cost compared to on-site delivery.

Any and all parking rate concessions should be assessed and justified on a case by case basis.

Bicycle, motorcycle and site servicing recommendations

11.1 Bicycles

The presence of cycling routes alone is not enough to secure modal shift from private vehicles. In order for cycling to be a viable mode of transport to an increased number of people, routes must be safe, separated from vehicles and pedestrians and be accessible for everyone. High quality end-of-trip facilities and wayfinding must also be provided.

A minimum of one bicycle parking space should be provided for each new land use dwelling/ business. Best practice bicycle parking supplies enough spaces to cater for the target cycling mode share across all development sites.

Current bicycle mode share indicates this represents a low percentage approximately 1 -2 per cent of all trips and 1 per cent of journey to work trips.

Bicycle parking for businesses should be linked to mode share targets. As an example, based on a general land use assumption of 20sq.m of floor space per employee (e.g. office commercial) and a maximum attendance of approximately 80 per cent of employees are on-site at any time, there would be approximately 1 employee per 25sq.m of employment land use.

The bicycle parking space requirement would be calculated by the greater of ***100/(Mode share target percent/ assumed sq.m area per on-site employee)*** or one.

Based on the relationship between mode share target and spaces per unit of floor area indicative percentages and floor areas per one space is shown in **Table 11-1:**

Table 11-1 Mode share space relationship of one on-site employee per 25sq.m of floor area

Bicycle mode share target percent	1	2	2.5	5	10	15	20	25
Square metres of floor area per 1 bicycle space	2,500	1,250	**1,000**	500	250	167	125	100

Similar to public vehicle parking provisions, publicly accessible and conspicuous facilities provides an opportunity to use and share visitor parking more effectively. Bicycle parking opportunities should be provided in the public domain as part of public space improvement projects and can also be provided by adapting car spaces to bicycle parking spaces in locations where there is sufficient demand or evidence of ad hoc bicycle parking.

The City of Sydney provides a web portal to find or request new bicycle parking.
https://www.cityofsydney.nsw.gov.au/transport-parking/request-new-bike-parking-space-or-find-existing

Recommendation:

> Given the current journey-to-work cycling mode share of less than one per cent, and with the assumption that increasing bicycle mode is consistent with Council objectives**, a minimum bicycle parking rate to satisfy 2.5 per cent of employee mode share**, plus additional spaces for visitors/ customers. This creates capacity for additional bicycle mode share.

> Bicycle parking demand should be monitored in the locality and Council should host request a new bike parking space on their website.

11.1.2 End of trip facilities

End of trip facilities (EOTF) will typically be required to accommodate long-stay trips for land uses such as offices. EOTF should include change rooms, showers and lockers to store clothing and towels. These facilities can be integrated with toilets and for use of all employees on-site. Recommendations for the provision of EOTF are outlined in **Table 11-2**.

Table 11-2 Recommendations for provision of EOTF

No. showers	No. change rooms	No. lockers
One shower per 5 employee bicycle parking spaces	One change room per shower	Two lockers per employee bicycle parking space

Note: where more than one shower or change room is required, separate male and female facilities must be provided

11.2 Motorbike/ scooter

Census data indicates motorcycles represent approximately five per cent of the vehicle fleet in Australia, however within the PRCUTS IWC, motorcycle JTW represents around 1 – 1.5 per cent of mode share.

Recommendation:

Motorcycle parking be provided at 1 space per 1,500sq.m of floor area, with a minimum of one space where on-site parking is provided.

11.3 Servicing, delivery and loading

The provision of on-site service/ delivery and loading is generally related to the scale of development, the intensity of use and the availability of public on-street facilities. The likely requirement for deliveries in new commercial developments should be considered and enabled where appropriate through an increase in on-street **loading zone** areas, particularly in 'main street' precincts where demand for parking is high, and where smaller office/ retail development is located. **Loading bays/ zones** should be flexible/ shared where possible between businesses, and have timed restrictions (usually 15 minutes), and designed to accommodate larger and heavier vehicles as appropriate.

Car parks designed to accommodate these vehicles must have shallower ramps, higher ceilings and wider circulation aisles.

Due to these additional geometric requirements, it is recommended servicing and waste collection occurs at ground level, unless the lot dimensions can support the needs of the design vehicle of site topography optimises another arrangement.

Recommendation:

Site loading and servicing facilities should be provided on site, appropriate to the size and scale of the development.

Residential land use car parking recommendations

12.1 Residential vehicle ownership and parking demand

ABS 2016 Census data for Inner West Council found there were:

> 1.21 vehicles per household (on average);
> 11,931 households which own zero vehicles;
> 33,604 households which own one vehicle; and
> 1,165 households which own more than four vehicles.

Household vehicle ownership varies substantially. In particular, the proximity of the University of Sydney (UoS) influences the demographics of households in the area, with a higher proportion of students living in apartment dwellings without cars.

Data from ABS Census 2016 has been used to show the relationship between dwelling size and vehicle ownership, for two housing types: single unit dwellings/ townhouse and apartment dwellings, and for the suburbs of Leichhardt (**Figure 12-1** and **Table 12-1**) and Camperdown (**Figure 12-2** and **Table 12-2**).

Figure 12-1 Leichhardt suburb household characteristics – bedrooms vs vehicle ownership

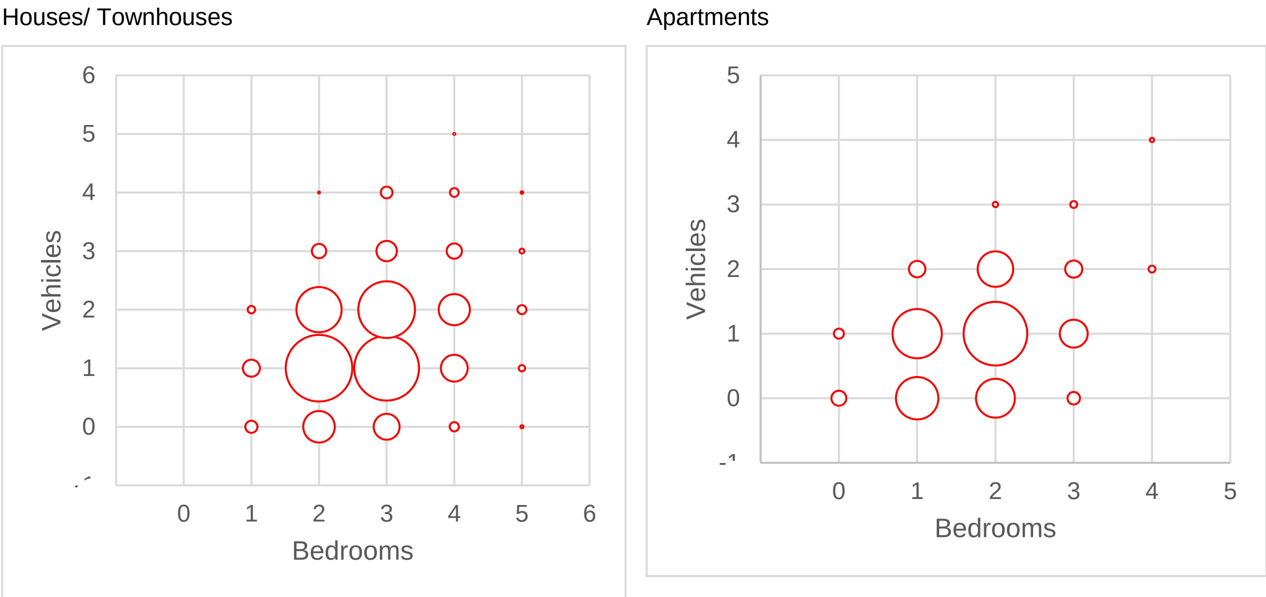


Table 12-1 Leichhardt suburb household characteristics – dwelling type vs vehicle ownership

	Separate House	Terrace/Townhouse		Apartment		
Cars	-	1 Storey	2+ Storeys	2 Storeys	3 Storeys	4+ Storeys
0	179	142	103	119	84	124
1	883	619	491	217	190	207
2	644	370	318	72	50	52
3	100	52	58	10	5	0
4	28	8	23	3	0	0
5	3	0	0	0	0	0
Total Cars	**2,598**	**1,547**	**1,393**	**403**	**305**	**311**
Dwellings	1,837	1,191	993	421	329	383
Avg. Cars	1.41	1.30	1.40	0.96	0.93	0.81
	1.41	**1.35**		**0.90**		

Figure 12-2 Camperdown suburb household characteristics – bedrooms vs vehicle ownership

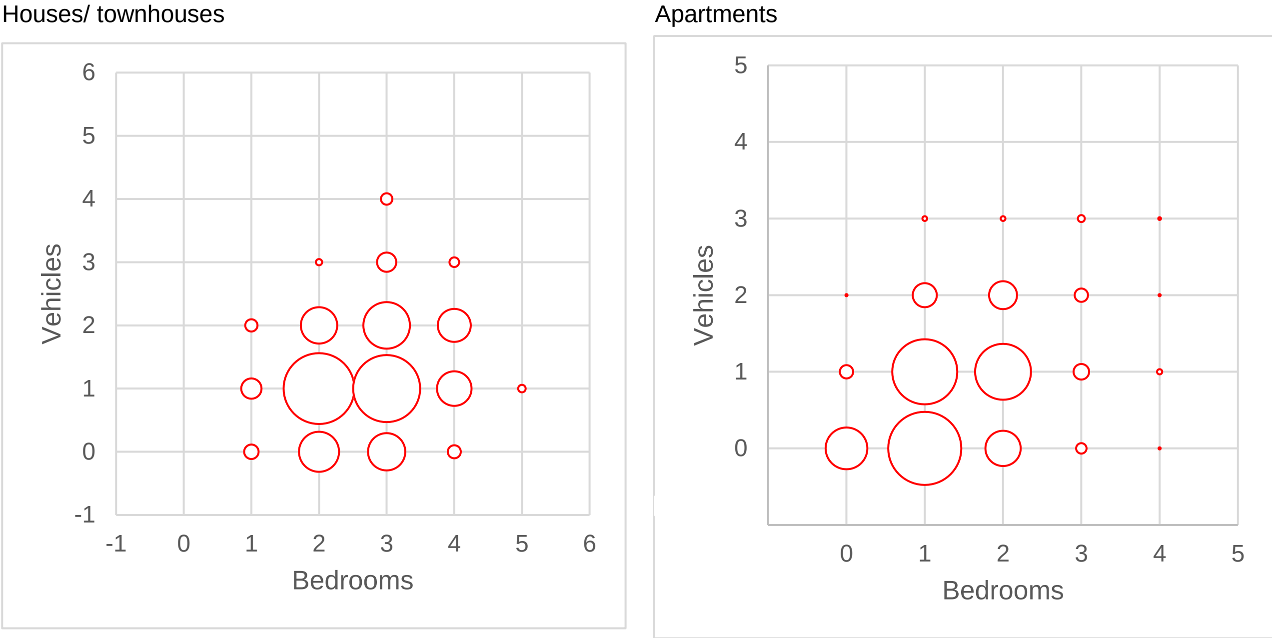


Table 12-2 Camperdown suburb household characteristics – dwelling type vs vehicle ownership

	Separate House	Terrace/Townhouse		Apartment		
Cars	-	1 Storey	2+ Storeys	2 Storeys	3 Storeys	4+ Storeys
0	7	72	89	71	147	1370
1	48	252	241	26	276	1122
2	20	98	124	9	68	229
3	0	12	22	0	3	19
4	0	0	4	0	0	6
5	0	0	0	0	0	0
Total Cars	88	484	571	44	421	1661
Dwellings	75	434	480	106	494	2,746
Avg. Cars	1.17	1.12	1.19	0.42	0.85	0.60
	1.17	**1.15**		**0.64**		

As this Census data figure shows, vehicle ownership differs significantly between house/ townhouse and apartment dwellings. This is reflected in the difference in recommended parking maximums shown below (**Table 12-3**).

Townhouse developments tend to be subdivided into strata lots which include on-site parking – this means that parking requirements must generally be in whole numbers, rather than fractions, to match the physical form of delivery.

The recommended PRCUTS parking rates (**Table 12-3**) for residential land uses have been assessed against current behaviour and future transport opportunities. This comparison shows that the PRCUTS *maximum* parking rates tend to be 30-50% less than the current *average* for the area. Nevertheless, they can be considered achievable provided substantial improvements to the public transport environment eventuate (as envisaged by the PRCUTS plan).

A series of recommended parking rates have been provided which considers existing and future transport opportunities, as well as existing parking requirements. To this end, where current Council requirements are below identified parking generation, the *lower* of the Marrickville and Leichhardt DCP rates has been applied. The intent of this is to ensure that the process of parking restraint continues into the future.

However, the significant reduction of on-site parking supply implied by the PRCUTS rates needs to be supported through consistent parking management processes in the adjacent public network. In particular, managed on-street parking with a robust permit system that disincentivises the use of on-street parking in residential zones. Without this additional form of management, it is considered likely that residents will continue to own cars well in excess of private supply, shifting the burden of storage onto Council (see below, **Section 12.4**).

An alternative set of rates has also been provided, which reflect a set of sustainable rates consistent with existing transport opportunities. These rates could be employed irrespective of the capital works detailed in the PRCUTS plan and are designed to incentivise developers to use more efficient methods of parking allocation within development, while simultaneously providing downward pressure on vehicle ownership in dense residential areas.

Table 12-3 Bedrooms, DCP parking rate, cars owned and recommendations

Bedrooms	DCP rate	Average cars owned	PRCUTS maximum recommended rate	Alternative maximum parking rates (consistent with 2021 transport environment)
Leichhardt/ Taverners Hill				
House/ Townhouse				
1	0 – 2.0	0.83	0.3	1.0 per townhouse
2		1.20	0.7	1.0 per townhouse
3+		1.45	1	1.0 per townhouse
Apartment/ Shop top Housing				
0	0 - 0.5	0.33	0	0.15
1	0.33 – 0.5	0.67	0.3	0.5
2	0.5 – 1.0	0.98	0.7	1.0
3+	1.0 – 1.2	1.31	1	1.2
Visitor		-	0	0.1 space per dwelling, unless this can be provided on-street.
Camperdown				
House/ Townhouse				
1	1.0	0.93	0.3	1.0 per townhouse
2		0.98	0.7	1.0 per townhouse
3+		1.24	1	1.0 per townhouse
Apartment/ Shop top Housing				
0	0.2 - 0.6	0.12	0	0.15
1	0.4 – 0.8	0.55	0.3	0.5
2	0.8 – 1.2	0.93	0.7	1.0
3+	1.1 - 1.2	1.32	1	1.2
Visitor		-	0	0.1 space per dwelling, unless this can be provided on-street.

12.2 Student housing/ Boarding house

Student and boarding houses are generally managed residences with occupants typically having low rates of car ownership. It is recommended a maximum car parking rate of **0.15 per dwelling be provided**, subject to on-site management of parking.

It is noted that due to the delivery model for student accommodation, developers are likely to provide parking in line with their expectations of demand – in contrast to many other forms of multi-unit residential development.

12.3 Dual occupancy residences

The form of dual occupancy dwellings is consistent with that of single unit development and should therefore be subject to the same parking rate applied to house/townhouse above.

12.4 Resident parking permits – model scheme

Inner West Council operates a number of residential parking permit schemes to allow limited on-street vehicle storage by residents. The cost of these permits is set at a rate sufficient only to recoup the cost of administration, with a small factor applied where multiple permits are sought. This cost is nominal (free for the first permit and $50 -$100 for the second permit); which is significantly less than the value of those spaces.

These permit schemes signal an acceptability for eligible households to own two cars, irrespective of the number of parking spaces available.

This creates inequity in the system – functionally identical households, with the same needs and characteristics may be disadvantaged due to the age of their building.

In general, the uptake of a residential permit system is primarily dependent on the fee charged, and the supply of on-site parking available.

This results in the following behaviour:

> Residents parking their vehicles on-street do so either because the number of vehicles owned is greater than on-site car parking, access to their on-site parking is less convenient or that parking has been appropriated for other uses (a home gym, extra bedroom/ workroom, additional storage etc.).

> A permit user receives a financial benefit proportional to the value of the land or construction cost of the parking space (a secure garage may cost $30,000 - $40,000 to construct, and provides an equivalent value). As such, an on-street parking bay represents a benefit to the vehicle owner of approx. $1,500-$2,000 p.a. Recent investigations into the cost of on-site parking confirm that this figure is consistent across all the areas where studies have been completed, which includes cities across the Netherlands, San Francisco in California, and Darebin in Victoria.

An annual parking permit fee functions as a price signal to residents. It allows vehicle owners to adequately account for the cost of parking infrastructure and consider storage as part of the real cost of ownership.

Where residents have insufficient parking, this permit scheme provides an opportunity to shift the burden of storage onto Council, but provides funds for the maintenance of that infrastructure at an equivalent market rate. Users may choose to retain their vehicles wholly on-site and reconsider the need for vehicles that do not fit on-site.

This form of management has the following advantages:

> It allows the parking restrictions to support the desirable use of on-street parking;

> The pricing regime can be ramped up to market rates over time;

> The price can signal that it would be cheaper to use other forms of transport such as car share; and

> It retains equity for all residents, existing and future.

It is expected that any form of on-street parking permit model would involve a relatively low introductory price, with gradual increases over time to manage uptake and on-street demand.

Recommendation:

(Policy) (In order to implement PRCUTS recommended parking rates) Expand the residential permit scheme and price permits at a rate consistent with the opportunity cost of parking infrastructure, with a transition period to support behaviour change by residents.

There is an opportunity to incentivise low-emissions vehicles through the residential parking permit scheme. This type of concession is used some European jurisdictions (for example, the cost of a residential parking permit in Copenhagen ranges between AUD45 p.a. for an electric vehicle, up to AUD850 p.a., based on its fuel-efficiency).

Recommendation:

Provide concessions for the cost of a residential parking permit based on emissions.

Non-residential land use car parking recommendations

13.1 Journey to Work travel behaviour

Census 2016 data from the Australian Bureau of Statistics is used to estimate employee mode choice to places of work in the study precincts and shown as percentages in **Table 13-1**.

Table 13-1 Journey to Work mode share by precinct

Suburb	Public transport	Car (passenger)	Walk	Bike	Motorbike/ Scooter	Other, not stated, truck
Taverners Hill	18%	71% (4%)	5%	1%	1%	1%
Leichhardt	23%	62% (4%)	9%	1%	1%	1%
Camperdown	20%	63% (4%)	9%	3%	2%	2%
Average	**20%**	**66% (4%)**	**7%**	**2%**	**1%**	**2%**

Source: Census, Australian Bureau of Statistics, 2016

Note: 13.5% of employees either did not work, or worked from home on the day of the Census – and therefore generated no journey-to-work trips.

13.2 Office

The current office parking rates applied through the Marrickville DCP (MDCP) and Leichhardt DCP (LDCP) are shown in **Table 13-2** to provide context for parking sufficiency in each Precinct and to establish an indicative parking rate.

Table 13-2 DCP office/ business land use parking rates vs. mode share accommodation

Office/ Business Land Uses	MDCP (Area 1) LDCP (Office min)	MDCP (Area 2) LDCP (Office max)	MDCP (Area 3) LDCP (Business Premises max)	Suburban demand
Parking rate (1 per X square metre)	100	80	60	40
Parking rate (spaces per 100 square metres GFA)	1	1.25	1.67	2.5
Assumed Employee occupancy rate (workers per 100square metres)	4	4	4	4
Parking spaces per employee	0.25	0.31	0.42	0.63
Office attendance	80%	80%	80%	80%
Supported driver mode share percentage	31%	39%	52%	78%

Comparing these results to the mode share percentages in each of the precincts, shows the following requirements if on-site parking supply were to match existing journey to work behaviour.

- Taverners Hill: one space per 44 square metres (2.27 spaces/ 100 square metres); and
- Leichhardt/ Camperdown: one space per 50 square metres (two spaces/ 100 square metres).

Where on-site parking is supplied at less than this rate, there would be existing overspill into the surrounding public and shared parking. The benefit for undersupplying parking is to influence the travel behaviour of staff, and to reduce the cost of new development.

Interrogation of existing journey-to-work by public transport has been used as an indication of the effect of public transport accessibility in the Study Area. In this case, public transport mode share ranges from 18% (Taverners Hill) to 23% (Leichhardt). Given that the primary public transport within the Study area is bus transit along Paramatta Road, the observed variations in travel behaviour appear to be aligned more with work type (office/commercial showroom/retail etc.) and employee catchment than accessibility measures.

Future developments in high-quality public transport are likely to increase the propensity for employees to travel by such modes, and this would be reflected in a reduction in the maximum parking rate in the locations affected. The significant improvement in public transport services envisioned by PRCUTS could support the recommendation of 1 space per 150sq.m, when realised.

This parking rate can work as a maximum, without a minimum, where the surrounding catchment of publicly accessible parking is appropriately managed and enforced through parking duration restrictions and paid parking. An alternative rate has also been derived, which is considered achievable in the short term, prior to the significant corridor improvements identified in the PRCUTS plan. This maximum rate is set at approximately 50 per cent of existing demand,. This comparison is outlined in **Table 13-3**.

Table 13-3 Existing and recommended office premise parking rate

Office premises	Marrickville DCP			Leichhardt DCP		PRCUTS recommendation	Alternative maximum parking rates (consistent with existing transport environment)
	Area 1	Area 2	Area 3	Min	Max		
Parking rate	1 per 100sq.m	1 per 80sq.m	1 per 60sq.m	1 per 100sq.m	1 per 80sq.m	1 per 150sq.m	**1 per 100sq.m (max)**
Spaces per 100sq.m	1	1.25	1.67	1	1.25	0.67	**1.00 (max)**

13.3 Retail

PRCUTS recommends 1 space per 100sq.m. Analysis of parking demand generation rates for retail precincts has consistently shown a parking rate of approximately one space per 40 - 50 square metres, declining further where adjacent residential and employment densities are high.

Recommendation:

Retail parking be permitted at a **maximum rate** of **1 space per 50 square metres** which is consistent with the Leichhardt DCP.

This enables retail businesses the opportunity to capture demand on-site, where development intensity is high and the provision of public parking would be insufficient to accommodate demand. It is likely that small-scale developments will provide less parking, relying instead on adjacent on-street supplies.

13.4 Restaurant

In the absence of a specified rate for restaurant land uses in PRCUTS, it is assumed the retail rate of 1 space per 100 square metres applies.

The parking rate for restaurants as defined in the Marrickville DCP and Leichhardt DCP varies between 1 per 50 square metres and 1 per 100 square metres, depending upon location. While the demand for parking by restaurant customers is generally much higher than this, peak demand tends to occur in the evening and can generally be supported by parking opportunities in surrounding streets.

As such, it is appropriate that the maximum requirement be set at less than the anticipated demand. However, a maximum rate of 1 space per 100 square metres may leave some locations unable to provide sufficient service for customers, particularly where adjacent on-street parking is restricted.

Recommendation:

A recommended parking **maximum rate** of **1 space per 50 square metres** is recommended across all locations.

13.5 Health / Medical Centres

The Marrickville DCP considers medical centres as part of the 'Office' category, with a corresponding rate that range from 1 space per 60 square metres to 1 space per 100 square metres by location. The Leichhardt DCP applies a parking requirement of between 0.66 and 2 spaces per consulting room.

The parking needs for medical uses are highly dependent on the nature of the service provided:

> Medical Clinics (e.g. a walk-in GP clinic) generate a greater number of patients and require a higher visitor parking rate;

> Specialist Centres have a greater proportion of non-practitioner staff, but fewer patients; and

> Hospitals with overnight stay generate additional demand by visitors, and a higher proportion of staff members per 'bed'.

These services may be provided in stand-alone facilities or combined on a single site (for more detailed discussion of reciprocal and decoupled parking, see Sections 5.6.2 and 5.6.4). Parking generation is also poorly correlated to floor area, with a wide variation in different configurations and intensities by purpose. Instead, a relationship between 'beds' or 'consulting rooms' and parking is more indicative of baseline demand. Some DCPs specify a parking rate per 'practitioner' but this can be difficult to quantify at the Development Application stage, and may change without any internal modifications.

Proximity of the development to high-density employment or residential nodes can reduce the parking requirement for visitors, but there is only a weak relationship between public transport accessibility and mode share – this reflects the demographic of patients and the fact that patients are often infirm or ill.

13.5.1 Medical Clinics and Specialist Centres

Research into parking demand rates suggests a baseline metric for parking demand at GP clinics is in the order of 5 spaces per consulting room. This rate would be applicable for a site with only a low-density residential walking catchment, poor access to public transport, and limited to no adjacent public parking. As such, it is likely that any destination within the Study Area would be able to achieve a substantially lower trip generation rate than this baseline.

Interrogating current journey-to-work mode shares for medical centres and hospitals in the Inner West shows only a minor variation from baseline rates, see below:

Table 13-4 Journey to Work car-as-driver mode share (all employment vs medical/hospital)

Suburb	Car-as-Driver
Taverners Hill	71%
Leichhardt	62%
Camperdown	63%
Hospitals (Inner West)	76%
Medical and Other Health (Inner West)	69%

This would suggest that the *employee* component of trip generation could operate at the roughly equivalent of the recommended office rate, at least for medical centres (see Section 13.5.2 below for discussion of hospital generation). While the requirements for staffing do vary, a ratio of simultaneous occupancy of around 1 to 1.5 staff per consulting room appears to be representative.

Additional parking provision is necessary to accommodate patients, which accounts for approximately 2/3 of the unconstrained parking demand. This comprises up to 2-3 patients for each consulting room during the highest peak periods (medical centres), but only 1-2 patients per consulting room for specialist clinics, due to the lack of walk-ins and more rigid scheduling requirements.

Based on the above, a representative parking rate for medical centres would be 0.5 spaces per consulting room (staff), plus 1.5 spaces per consulting room (patients).

Patient parking supply could be reduced for specialist clinics to 1 space per consulting room (patients), considering the following:

> Specialists are often on-call or attending a primary hospital where they have admitting rights – this increases their need to have access to a private vehicle (staff parking needs increase), but reduces the numbers of patients on-site at any one time.

Recommendation:

On balance, this would likely result in a similar recommended parking rate for medical centres and specialist clinics, with a maximum rate of **2 spaces per consulting room**.

13.5.2 Hospitals

Hospital sites are complex workplaces with a large number of different activities operating on 24/7 basis. Standard industry metrics put hospital parking requirements at between 3 and 5 spaces per ‘bed’. This variation reflects the wide range of services that can be incorporated into the hospital structure, not all of which are aligned directly with patient care (research, diagnostics, administration etc.).

One key constraint for hospital developments is the impacts of shift start and finish times on the availability of public transport alternatives to driving. Review of hospital rostering data suggests that 30-40% of tertiary hospital staff either arrive or depart outside of core hours (i.e. arriving before 7am, or departing after 7pm). This, combined with the requirements for shift overlap, puts pressure on the on-site parking during the critical noon-3pm period.

One illustrative example for the impacts of parking restraint on behaviour is the QEII Medical Centre campus in Perth, WA. This site substantially reduced parking for staff in 2009, and over the period of 3 years, transitioned from a 75% staff car-as-driver mode share to 43% car-as-driver mode share. This mode shift requires a combination of high-quality, high-frequency direct public transport which operates from 6:30am, and a detailed parking management and allocation model for staff.

Patient/visitor parking demand across multiple hospital sites is approximately 1 space per 1.5-2 beds; which appears to be consistent across multiple locations. Parking demand is higher for some specialities (e.g. children’s hospitals, day surgery) where visitors are more likely to stay throughout the day.

Given the above, and assuming a maximum parking requirement is to be used for hospital sites, based on the number of ‘beds’ within the campus, it is not recommended for the rate to be reduced below 3 spaces per bed. In addition, it is recommended that there be some mechanism, likely through a Parking Assessment, for a hospital redevelopment to capture the additional need for parking associated with on-site research, clinics and ancillary facilities.

Recommendation:

Hospital must prepare include a parking assessment as part of a develop application. This can be included in a transport assessment report.

The unique requirements for hospital uses suggest a maximum parking rate of **3 spaces per bed**.

13.6 Serviced apartment/ hotel

The parking demand for hotels is related to staff and guest requirements, which vary significantly depending upon the location and type of facility. Current parking requirements recognise that the majority of guests do not require access to a car, and therefore the majority of parking is used by staff.

However, staffing levels can fluctuate greatly, and may not be fully determined at the development application stage. Using the average worker proportions indicated in ITE documentation as a benchmark would suggest approximately 1 worker per 4-6 rooms. However, most of those employees would have access to alternative transport. Only early morning, evening and night-staff would require parking for safety and security reasons. Application of standard employee occupancy profiles would suggest that the total parking requirement for employees would be in the order of 1 space per 10 rooms, plus approximately 1 space per 4 rooms for guests.

Recommendation:

Consideration of the needs of guests and employees to service rooms that would require parking for shift work results in a recommendation of **1 space per three rooms**.

13.7 Out of centre uses along the Paramatta Road corridor

Parking maximums are not recommended due to the reduced opportunity of sharing off-street facilities and a general preference by users for on-street parking due to convenience and legibility where available.

The nature of corridor development is that land uses can be expected to change frequently over the lifetime of the building structure. Establishing a single target parking provision allows for simplified change-of-use as appropriate for the needs of the community.

The chosen target rate is consistent with an average mixed-use provision consisting of multiple different land use types.

Recommendation:

A general rate of **1 space per 40 square metres** (2.5 per 100 square metres) is recommended for all out of centre non-residential land uses.

13.8 Summary of non-residential land use recommendations

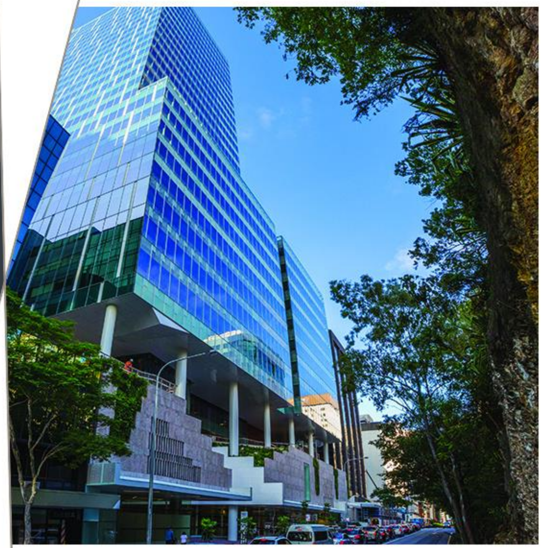
Table 13-5 outlines the PRCUTS recommendations which are only recommended with an appropriate public parking management scheme and recommendation for immediate implementation.

Table 13-5 Key non-residential land uses

<table>
<tr><th>Land use</th><th>Rate application</th><th>DCP rate
(per 100sq.m)</th><th>PRCUTS recommendation maximum rates
(per 100sq.m)*</th><th>Alternative maximum parking rates
(consistent with existing transport environment) (per 100sq.m)</th></tr>
<tr><td colspan="5">Leichhardt DCP (Taverners Hill, Leichhardt and some parts of Camperdown)</td></tr>
<tr><td>Office/ Business</td><td>Minimum</td><td>1 per 100sq.m (1)</td><td rowspan="2">1 per 150sq.m (0.67)</td><td rowspan="3">1 per 100 sq.m (1.)</td></tr>
<tr><td>Office</td><td>Maximum</td><td>1 per 80sq.m (1.25)</td></tr>
<tr><td>Business</td><td>Maximum</td><td>1 per 60sq.m (1.67)</td><td>-</td></tr>
<tr><td>Health/ Medical centre</td><td>Minimum</td><td>2 spaces per 3 consulting rooms</td><td>-</td><td rowspan="2">2 spaces per consulting room</td></tr>
<tr><td>Health/ Medical centre</td><td>Maximum</td><td>2 spaces per consulting room</td><td>-</td></tr>
<tr><td>Retail/ Shop</td><td>General</td><td>1 per 50sq.m (2)</td><td>1 per 100sq.m (1)</td><td>1 per 50sq.m (2)</td></tr>
<tr><td>Restaurant</td><td>Minimum</td><td>1 per 80sq.m (1.25)</td><td>-</td><td rowspan="2">1 per 50sq.m (2)</td></tr>
<tr><td>Restaurant</td><td>Maximum</td><td>1 per 50sq.m (2)</td><td>-</td></tr>
</table>

Land use	Rate application	DCP rate (per 100sq.m)	PRCUTS recommendation maximum rates (per 100sq.m)*	Alternative maximum parking rates (consistent with existing transport environment) (per 100sq.m)
Bulky goods premises	Minimum	1 per 125sq.m (0.8)	-	1 per 100sq.m (1)
Bulky goods premises	Maximum	1 per 100sq.m (1)	-	
Industry	Minimum	1 per 250sq.m (0.4)	1 per 150sq.m (0.67)	1 per 150sq.m (0.67)
Industry	Maximum	1 per 150sq.m (0.67)		
Marrickville DCP (Parts of Camperdown south of Parramatta Road)				
Office (Area 1)	Minimum	1 per 100sq.m (1)	1 per 150sq.m (0.67)	1 per 80sq.m (1.25)
Office (Area 2)	Middle	1 per 80sq.m (1.25)		
Office (Area 3)	Maximum	1 per 60sq.m (1.67)		
Health consulting rooms/ medical centre	As per office	As per Office/ business without banded rates based on floor area.	--	2 spaces per consulting room
Retail/ Shop	As per office	As per Office rates applicable up to 500sq.m	1 per 100sq.m (1)	1 per 50sq.m (2)
Restaurant (Area 1)	Minimum	1 per 100sq.m (1)	-	1 per 50sq.m (2)
Restaurant (Area 2)	Middle	1 per 80sq.m (1.25)		
Restaurant (Area 3)	Maximum	1 per 50sq.m (2)		
Bulky goods premises (Area 1)	Minimum	1 per 150sq.m (0.67)	-	1 per 100sq.m (1)
Bulky goods premises (Area 2)	Middle	1 per 125sq.m (0.8)		
Bulky goods premises (Area 3)	Maximum	1 per 100sq.m (1)		
Industry (Area 1)	Minimum	1 per 300sq.m (0.33)	1 per 150sq.m (0.67)	1 per 150sq.m (0.67)
Industry (Area 2)	Middle	1 per 250sq.m (0.4)		
Industry (Area 3)	Maximum	1 per 200sq.m (0.5)		
Out of centre uses along the Paramatta Road corridor				
All non-residential land uses	General	-	Refer to specific land uses	1 per 40sq.m general rate (2.5)

Transport Plan - Camperdown, Leichhardt and Taverners Hill



Parramatta Road Corridor Urban Transformation Strategy

80018116

Prepared for

Department of Planning, Industry and Environment and Inner West Council

10 March 2022

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3	08/03/2021	Draft 03	Chris Slenders Shobhan Baranwal	Chris Slenders
4	14/09/2021	Draft 04 (Pre confirmation on road infrastructure upgrades)	Chris Slenders Shobhan Baranwal	Chris Slenders
5	18/02/2022	Final	Ivo Pais Elizabeth Muscat	Ivo Pais
6	01/03/2022	Final Rev 2	Ivo Pais Elizabeth Muscat	Ivo Pais
7	10/03/2022	Final Rev 3	Ivo Pais Elizabeth Muscat	Ivo Pais

Glossary

Acronym/ Term	Description
AADT	Annual Average Daily Traffic
ABS	Australian Bureau of Statistics
Active transport	Transport modes powered by human movement, generally walking and cycling.
AS	Australia Standard
BRT	Bus Rapid Transit
CSP	Community Strategic Plan
CUCP	Camperdown-Ultimo Collaboration Precinct
DDA	Disability Discrimination Act 1992
DPIE	NSW Department of Planning, Industry and Environment
EV	Electric vehicle
FT56	Future Transport Strategy 2056 (Transport for NSW state-wide strategy - View at https://future.transport.nsw.gov.au/plans/future-transport-strategy)
GANSW	Government Architect NSW
GETS	Guided Electric Transit System
HTS	Household Travel Survey (View at https://www.transport.nsw.gov.au/data-and-research/passenger-travel/surveys/household-travel-survey-hts)
IWC	Inner West Council
ITS	Integrated Transport Strategy
LGA	Local Government Area (the administrative geographical area)
LRS	Light rail stop
MaaS	Mobility as a Service (mode agnostic): Users plan trips by destination and options are outlined for selection. Refer to FT56 for more information.
PMD	Personal mobility device
PRC	Parramatta Road Corridor
PRCUTS	Parramatta Road Corridor Urban Transformation Strategy
TfNSW	Transport for New South Wales
TGSI	Tactile ground surface indicators
TPA	Transport Performance and Analytics
UAIP	Urban Amenity Improvement Plan
VMS	Variable Message Signs
WSUD	Water-sensitive urban design

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Tables

Figures

1 Introduction

1.1 Transport Plan purpose

This transport plan shows details to support the Parramatta Road Corridor Urban Transformation Strategy (PRCUTS) for Camperdown, Leichardt and Taverners Hill. Overall, it is sought that PRCUTS precincts are desirable places to live, work and visit. In order to support development uplift and improve place value, major change to the function and the way Parramatta Road is used must occur. PRCUTS must:

> Be safer for everyone;

> Support social inclusion and equity;

> Have a diverse and interesting range of land uses;

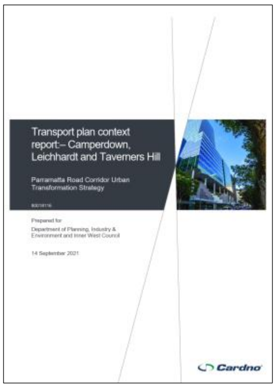
> Be easy and a convenient place to do business;

> Support higher locally originated and destine movement demands of people;

> Be more environmentally sustainable.

The recommendations of this report are informed by studies documented several reports, shown in **Table 1-1**.

Table 1-1 PRCUTS Inner West report set

<table>
<tr><th colspan="3">(This report) Transport Plan:
Transport Plan, Camperdown, Leichhardt and Taverners Hill</th></tr>
<tr><td colspan="3">
</td></tr>
<tr><th>Context report:
Transport plan context report – Camperdown, Leichhardt and Taverners Hill</th><th>Future Modelling Report:
Future Modelling Report Inner West Sydney Suburbs including Parramatta Road Corridor Urban Transformation Strategy.</th><th>Parking Note:
Parking policy and rate review: Camperdown, Leichhardt and Taverners Hill</th></tr>
<tr><td>
</td><td>
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</table>

The recommendations of this plan apply to the PRCUTS areas generally within Inner West Council (IWC) Local Government Area (LGA).

1.2 Background

Opened in 1811, Parramatta Road is one of the oldest roads in New South Wales. Parramatta Road Corridor is a key east-west link between the Sydney CBD and Parramatta, spanning 20 kilometres from Granville to Camperdown.

Parramatta Road was formally a destination in itself, with people visiting for its adjacent businesses and shopping offerings.

Parramatta Road's function as a vehicle movement corridor has gradually taken priority over its place function from previous decades. This has had a reductive effect on its place value and attraction and it can no longer be described as a vibrant high street.

Parramatta Road serves an important function within regional Sydney for public transport and freight vehicles as well as general traffic.

The NSW government has recognised that Parramatta Road and surrounding land uses are not achieving their full potential, and a multitude of studies over the years have proposed various options and solutions to improve conditions.

The Parramatta Road Urban Transformation Strategy (PRCUTS) proposes approximately 27,000 new dwellings along the Parramatta Road corridor between Granville and Camperdown. There are also 50,000 new jobs planned along the corridor.

For IWC PRCUTS precincts, there is forecast to be an additional 10,000 residents and employees in the period 2016 – 2036.

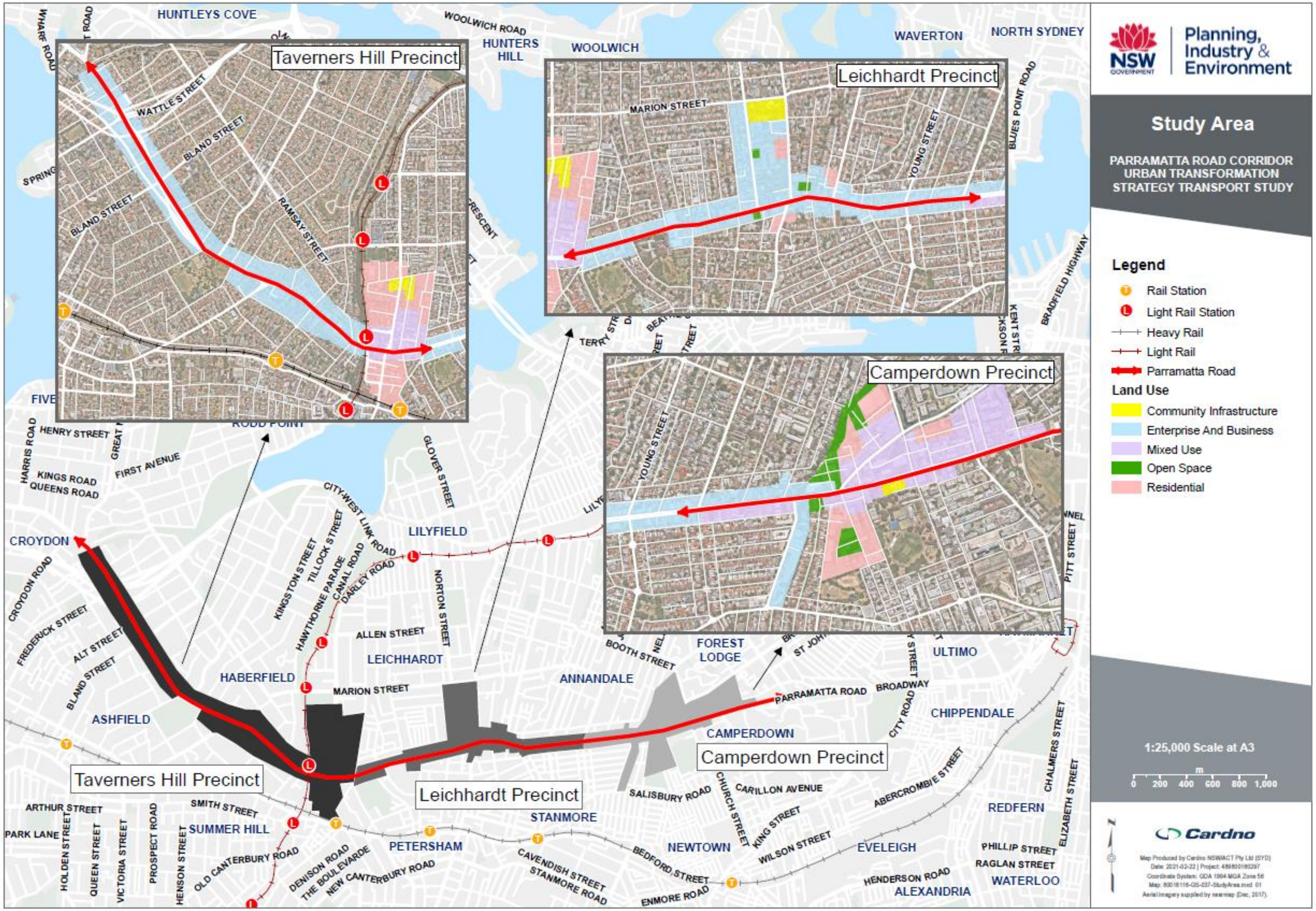
The opening of WestConnex in 2023 will provide the option for some through-traffic to redistribute off Parramatta Road. This will open up opportunities to reimagine how people move along the corridor and the land uses it can support.

The Parramatta Road Urban Corridor Transformation Strategy (PRCUTS) brings together the elements of successful place making to provide a strategy to support population and employment growth, land use and place making and transport to improve the attractiveness and liveability of the corridor and surrounding areas.

1.3 Study precincts

This study has a primary focus on IWC precincts of Camperdown, Leichhardt and Taverners Hill shown in **Figure 1-1**.

Figure 1-1 PRCUTS IWC study precincts



1.4 Population

The key determinate of transport needs is the population it serves. The following section outlines the 2016 population and the forecast to 2036.

1.4.1 Residents and employment

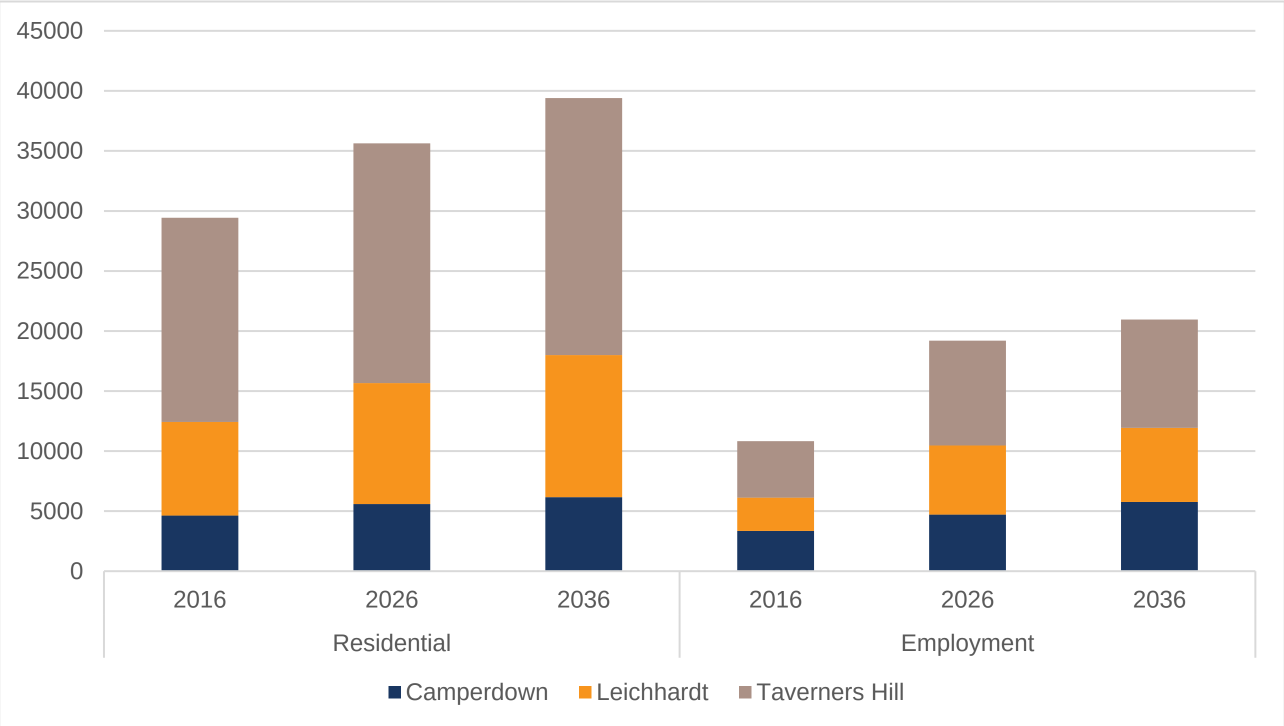
DPIE commissioned a PRCUTS land-use projections review in 2021 to assess the land use in IWC PRCUTS precincts more broadly for traffic modelling analysis. While this review assumed precinct boundaries slightly different to those shown in **Figure 1-1**, it provides a good indication of projected changes to residential and employment numbers. The population and employment forecast is as outlined in **Table 1-2** and graphed in **Figure 1-2**.

Table 1-2 PRCUTS IWC study area residential and employment population

Precinct	Population			Employment		
	2016	2026	2036	2016	2026	2036
Taverners Hill	17,018	19,964	21,409	4,705	8,732	9,025
Leichhardt	7,786	10,075	11,834	2,766	5,748	6,172
Camperdown	4,637	5,589	6,159	3,354	4,716	5,767
Total	**29,441**	**35,628**	**39,402**	**10,825**	**19,196**	**20,964**

Data source: PRCUTS land use review, SGS, 31/05/2021

Figure 1-2 Population – residential and employment forecasts



Data source: PRCUTS land use review, SGS, 31/05/2021

The data in **Table 1-2** Error! Reference source not found.and **Figure 1-2** shows that Taverners Hill will continue to house the most residents and employment.

By 2036, it is anticipated the PRCUTS IWC areas will accommodate approximately 39,400 residents and 22,300 workers. Between 2016 and 2036, the transport network must facilitate the movements for an additional:

> 10,000 residents; and

> 10,000 employees (some of which will be residents).

1.5 Planned projects and initiatives

Major investment in improvements to the transport system is underway across Sydney, with new city-shaping rail projects, motorway links and on-road public transport priority projects all planned to move Sydney's people and goods more efficiently. The following tables summarise regional projects that interact with or are likely to have an influence on the PRCUTS IWC precincts. Projects are categorised as:

> Public domain **Table 1-3**;
> Active transport **Table 1-4**;
> Public transport **Table 1-5**; and
> Major roads **Table 1-6**.

Table 1-3 Public domain

Project	Source/ status & timing	Location	Key details	Transport outcomes for PRCUTS IWC precincts
Parramatta Road Urban Amenity Improvement Plan (PRCUTS UAIP)	Sub-plan from the Parramatta Road Corridor Urban Transformation Strategy produced by UGNSW (now Landcom) *(Construction underway – to be completed by 2023)*	Parramatta Road Corridor (PRC); Works involves Taverners Hill, Leichhardt and Camperdown Precincts. Affects traffic flows and active transport between IWC, City of Sydney and Canada Bay Councils.	▪ New GreenWay connection under Parramatta Road. ▪ New GreenWay connection under Longport Street, Lewisham West. ▪ New public domain improvements to key north-south streets that run perpendicular to Parramatta Road in Leichhardt. ▪ New cycle connection along Dot Lane between Norton Street and Hay Street, Leichhardt. ▪ Conversion of Petersham Street to pocket park between Parramatta Road and Queen Street. ▪ New north-south pedestrian and cycle link along Johnstons Creek, Camperdown Precinct. ▪ Public domain improvements and new cycle connections along Pyrmont Bridge Road. ▪ An east-west regional cycleway from Iron Cove's Bay Run to the M4 cycleway.	Will help reduce conflict between active transit and traffic near the GreenWay and will improve the appeal of active transit through Kings Bay, Taverners Hill, Leichhardt and Camperdown. Improved safety for active transit all round. Regional cycleway provides a continuous east-west link for cyclists between Iron Cove's Bay Run and the M4 cycleway.
WestConnex Local Area Improvement Strategy	WestConnex Local Area Improvement Strategy (2018), IWC. *(To be completed by 2024)*	The strategy covers five areas affected by WestConnex: Ashfield, Haberfield, Leichhardt West, Johnston Street and St Peters	Traffic calming measures in each PRC precinct that WestConnex bypasses	Improved road safety, streetscape amenity plus enhanced pedestrian and cyclist connectivity

Table 1-4 Active transport

Project	Source/ status & timing	Location	Key details	Transport outcomes for PRCUTS IWC precincts
Camperdown–Ultimo Place Strategy	Camperdown – Ultimo Place Strategy, Greater Sydney Commission. Priorities and actions for delivery and review between 2018 and 2036	Stretches from Camperdown to Ultimo, and covers Darlington and Eveleigh; most of Haymarket, Ultimo and Camperdown; and parts of Glebe, Forest Lodge, Newtown, Redfern and Surry Hills.	The Camperdown–Ultimo Collaboration Area Place Strategy will inform public and private policy and investment decisions by identifying and recognising the complex, place-specific issues inhibiting growth and change, bringing together multiple and diverse stakeholders and identifying priorities for growth. The Place Strategy was collectively designed by the stakeholders involved in planning for the Collaboration Area's future. Specifically, it: • establishes a vision and narrative for the Camperdown–Ultimo Collaboration Area • identifies impediments and opportunities • sets priorities for the Collaboration Area • identifies actions to deliver the vision.	Contains actions such as: - Advocate for a mass transit system that strengthens connections between the Collaboration Area and Greater Sydney's economic corridors (**imperative action**); or - Improve public transport, pedestrian and cycling connectivity between the three activity nodes: • Haymarket to Camperdown along the Ultimo axis • Camperdown to Eveleigh along the Darlington axis (particularly Redfern Station to University of Sydney) • Haymarket to Eveleigh along the Surry Hills axis.
NSW Government Strategic Cycling Network	City of Sydney and Future Transport 2056 *Initiatives for Investigation (0-10 years). Listed as a priority initiative by Infrastructure Australia (0-5 years).*	Inner Sydney LGAs.	A plan to build 284 kilometres of inner Sydney radial and cross regional separated bike corridors or shared paths. FT56 focuses on a ten-kilometre radius around the Eastern Harbour CBD.	Has strategic and regional significance for cycling. Allows safer access to the CBD from the neighbouring LGAs and supports the concept of the 30- minute city using active transport.
Cycling connections to strategic centres	Future Transport 2056, Eastern City District Plan. *For investigation (0-10 years).*	Sydney wide, despite no strategic centres within IWC, there are some outside the periphery of IWC which still fall within 5 kilometres of specific IWC areas.	Would see investment in cycling connections within five-kilometre radials of all strategic centres. These connections should be delivered in partnership with local government and integrate with the GSC's Green Grid concept.	Would connect Leichhardt to other strategic centres in Sydney.
GreenWay	IWC: GreenWay Master Plan – Cooks River to Iron Cove (2018), Sydenham to Bankstown Corridor Urban Renewal Strategy, Eastern City District Plan.	Runs parallel to the Inner West light rail line. Offers a north-south link from Iron Cove (at Lilyfield) to the Cooks River Reserve (at Earlwood). Affects IWC, Canterbury Bankstown and Bayside, LGAs. Benefits regional neighbours as well.	Community initiative, now properly funded. Completes major 'missing links' in the committed 5.8-kilometre active shared path and nature corridor. Funding also commits to improving green space and local east-west linkages along the route.	Links through Taverners Hill and forms an opportunity to be a key link in the active transport network.

Project	Source/ status & timing	Location	Key details	Transport outcomes for PRCUTS IWC precincts
GreenWay SouthWest	Part of Sydenham to Bankstown Corridor Urban Renewal Strategy. *(Strategy deferred at present).* *Interest still remains from local governments which might benefit.*	Runs within and along the T3 rail corridor's reservation (Metro South West). This is the part between Dulwich Hill and Bankstown Affects IWC and Canterbury-Bankstown Council LGAs.	Surplus lands within the existing rail corridor would be converted into a second off-road GreenWay, running east-west alongside the operational tracks. This would also be an active link between all future precincts and with all open spaces along the route.	Links through Taverners Hill and forms an opportunity to be a key link in the active transport network.

Table 1-5 Public transport

Project	Source/ status & timing	Location	Key details	Transport outcomes for PRCUTS IWC precincts
Sydney Metro West	Sydney Metro, NSW Government, Future Transport 2056. Infrastructure Australia supported (5-10 years) *Committed (0-10 years)*	Parramatta to Sydney CBD	A new metro line between Parramatta and the Sydney CBD, with stations likely at Westmead, Parramatta, Sydney Olympic Park, The Bays and the Sydney CBD. Hourly capacity is expected to be up to 40,000 people in each direction.	Provide a public transport bypass route of the PRCUTS IWC precinct, reserving public transport capacity in the precincts for people with origins and destinations along the corridor. Stations such as Five Dock and Burwood North provide an opportunity to reshape the bus network.
Public transport improvements for Parramatta Road and Victoria Road	Recommendation 47 and 61, SIS 2018 Eastern City District Plan (ECDP), Future Transport 2056, GSC Parramatta Road Urban Transformation Strategy, *Committed (0-10 years)*	Parramatta Road and Victoria Road	On-road rapid transit and priority infrastructure that caters for buses and high efficiency vehicles. For investigation by Transport for NSW.	More priority for buses and high-efficiency vehicles on these major arterial routes.
Eastern Suburbs to Inner West Rapid Bus Links	Future Transport 2056, Eastern City District Plan, *For investigation (0-10 years).*	Key Inner West arterials (Victoria Road, Parramatta Road, etc.) linked by rapid bus (or similar) with the Eastern Suburbs.	Rapid bus routes would provide high-frequency direct connections, linking Randwick and Sydney University to the Bays Precinct, and from Maroubra Junction to Sydney Airport and Marrickville.	Would help provide better bus access to jobs between the precinct and other parts of the city, in a way that compliments existing public transport with higher frequency options.

Table 1-6 Major roads

Project	Source/ status & timing	Location	Key details	Transport outcomes for PRCUTS IWC precincts
WestConnex	Future Transport 2056, Sydney Motorways Corporation (SMC)/ NSW Government. *Currently under construction; expected completion by 2024.*	Links western Sydney (M4) with the Anzac Bridge and south-western Sydney (M5) via new tunnels that run beneath the Inner West	This is an approved 33-kilometre motorway that is being produced in various stages: ▪ Stage 1 – Widening the M4; ▪ Stage 2 – M5 tunnel Duplication + St Peters Interchange and M4 East tunnel; ▪ Stage 3A – M4-M5 Link; a tunnel that runs beneath the IWC. ▪ Stage 3B - The Rozelle Interchange; linking M4-M5 Link with Drummoyne, the Anzac Bridge, Balmain and the City West Link. Three main interchanges are associated with Stages 3A and 3B. Condition B34 of the WestConnex approval states, *"Consistent with the modelling contained in the documents referred to in condition A2(b), the Sydney CBD to Parramatta Strategic Transport Plan (Transport for NSW, 2015, or as updated) and in consultation with Transport for NSW, at least two lanes of Parramatta Road, from Burwood Road to Haberfield, are to be solely dedicated for the use of public transport unless an alternative dedicated public transport route that provides an improved public transport outcome for the area, when compared to two dedicated public transport lanes on Parramatta Road, is approved by the Secretary[1]."*	Through traffic bypass route providing an opportunity to reallocate road space.
Western Harbour Tunnel and Beaches Link	Future Transport 2056, Roads and Maritime Services. *Committed (0-10 years subject to final business case and funding), planning stage, SEARs issued.*	Starts in Rozelle travels under Balmain and Birchgrove, the Harbour, Waverton and surfaces near Cammeray before diving again and resurfacing in Balgowlah. Project directly affects IWC, North Sydney Council, Willoughby Council and Northern Beaches Council.	Connects WestConnex by a new harbour tunnel to the north shore by extending the Rozelle Interchange stub tunnels under the Balmain Peninsula to an interchange at the M2 in Cammeray. This will provide further access to Balgowlah bypassing the Spit Bridge. Widespread road expansions will be required around every surface portal.	Links to WestConnex and provides a City West Link bypass route to the north shore. City West Link is an existing alternative route to Parramatta Road.

[1] *https://majorprojects.accelo.com/public/ef54d46f64c468f0fbb5f20043057790/M4%20East%20MOD%205%20Consolidated%20Instrument%20of%20Approval.pdf, pg. 18-19, accessed* 6 March 2019

2 Transport vision, principles

2.1 The transport vision

The PRCUTS vision is:

"Incremental renewal of the Corridor will occur over the long term to deliver a high quality, multi-use corridor with improved transport choices, better amenity, and balanced growth of housing and jobs."

The implications of the vision for the corridor and desirable outcomes for the transport network are:

> Pedestrians and cyclists are supported by separated facilities.

> Public or active transport is the first choice for Parramatta Road Corridor users, because it is safe, reliable and efficient for all travellers.

> Parramatta Road is a mass public transit spine linking to major transport hubs of Central Station and Metro West Burwood. This will serve point to point, interchange local and regional public transport services for a diverse range of purposes.

> The corridor must be supported by local public transport services (cross corridor) connecting communities, employees and visitors to where they need to go.

> Private vehicles are deprioritised but still supported by high movement capacity down the centre of the road carriageway.

2.2 Guiding principles

The PRCUTS principles and implications on the Precinct Transport Plan are outlined in **Table 2-1** (and subsequent Principle tables).

Table 2-1 PRCUTS principles and implications for Transport Plan

Principle 1: Housing choice and affordability	
PRCUTS principle statement	**Transport implication**
An additional 56,000 people live in the Corridor in 27,000 new homes.	Transport networks and infrastructure will need to support population growth.
The community is diverse, with key workers, students, seniors and families.	Transport networks and infrastructure will need to be accessible for all community members.
The community's housing needs are met with a mix of dwelling types, sizes and prices.	Transport networks and infrastructure will need to support a variety of household types.
A minimum of five per cent of new housing is Affordable Housing (or in line with Government policy of the day), new housing also caters for single households, older people or different household structures.	Transport services will need to be affordable.

Principle 2: Diverse and Resilient economy	
PRCUTS principle statement	**Transport implication**
$31 billion of development value is realised.	Transport will need to support realisation of development value.
Parramatta Road Corridor is Sydney's 'economic spine' - 50,000 workers across a diverse range of sectors and roles come into the Corridor each day to work.	PRC development should offer reliable, accessible and frequent public transit services to support peak hour travel.
Auburn is recognised as Sydney's large format retail hub and Camperdown is a specialist precinct that supports the world class research, educational and health uses associated with the University of Sydney and the Royal Prince Alfred Hospital.	PRC development should support connectivity for precinct wide collaboration.

Principle 2: Diverse and Resilient economy	
Town centres at Granville and Kings Bay support new residents and workers.	Transport supports easy connections along corridor.
There is new life in the retail areas of Parramatta Road, and the Corridor is home to a variety of businesses, including small and medium enterprises, advanced technologies and creative industries.	IWC precincts support the highest diversity of land uses. Transport supports convenient and quick trips between all land uses for employees and visitors to conduct business and enjoy leisure at various locations along the corridor.

Principle 3: Accessible and connected	
PRCUTS principle statement	**Transport implication**
It is easier to move to, through and within the Corridor in both east-west and north-south directions.	Transport networks should have a high level of north-south and east-west connectivity.
The urban transformation of the Corridor is supported by transit-oriented development. Existing and new desirable and affordable mixed-use environments are enhanced by high-quality, high frequency public transport and safe active transport connections.	Transport infrastructure supports a variety of frequent and reliable transport modes available to the public including active transport.
The Corridor’s inherent social, economic and environmental resources are optimised, including freight generating uses within and supporting the Corridor.	Transport recommendations to leverage on existing strengths of the study area.
Available road and rail capacity are utilised and public investments in transport are optimised.	Transport recommendations to leverage on and integrate with existing transport infrastructure in the study area.
Non-infrastructure initiatives, such as encouraging visitors to use non-car modes of travel to help alleviate congestion, and modifying or altering timing of trips, are well utilised.	Transport recommendations are to be holistic and also consider strategies that are non-infrastructure related.
People choose to walk and/or cycle for local trips along the Corridor’s 34km of new and upgraded links, hop on buses and/or light rail for intermediate trips, and use rail and/or car for regional trips.	Transport networks should have a variety of street types which support various transport modes to facilitate trips of varying lengths.
The integrated transport network contributes to regional resilience and sustainable communities along the Corridor and beyond	Transport networks to be resilient and well-planned for the future and wider context.

Principle 4: Vibrant community places	
PRCUTS principle statement	**Transport implication**
Residents can walk easily to public transport, local shops, schools, parks and open space areas, jobs and a range of community services and facilities that are all close by.	Transport plans to reflect the vision of a 15-minute city.
Neighbourhoods include a mix of old and new buildings sitting well together creating attractive places for people to enjoy.	Transport network does not negatively impact place values.
New development respects and protects existing lower-scale development and heritage.	New transport projects to protect and enhance heritage.
New landmarks and high-quality buildings and spaces are recognised and valued by the community.	New developments to be supported by high quality transport.
Residents and workers can easily access new and upgraded community facilities and services including libraries, community centres, childcare centres, cultural facilities, schools and community health facilities	New developments to be supported by highly accessible transport.

Principle 5: Green spaces and links	
PRCUTS principle statement	**Transport implications**
There is 66ha of new open space areas, linear parks and links along watercourses and infrastructure corridors, linked to pedestrian and cycle connections.	Existing and future communities have good access to the natural environment, particularly through active transport.
Parramatta Road and the surrounding road network is greener and lined with trees.	Road projects to improve public amenity through planting of trees and placemaking.

Principle 6: Sustainability and resilience	
PRCUTS principle statement	**Transport Implications**
Smart parking strategies have reduced people's car dependence and fuel use leading to reduced greenhouse gas emissions. Development is more feasible, meaning savings could be passed on to homebuyers, making housing more affordable and reducing the overall cost of living.	Smart parking strategies to reduce the impact of parking and traffic on liveability. PRCUTS Sustainability Implementation Plan: • Target 30% reduction in car uses. • 17% car share take-up rate in IWC precincts.
Because thinking about parking has changed, the design of buildings transition between different uses ensuring community uses and facilities, or perhaps even open space to occur over time.	Any new car parking space should consider and plan for future repurposing/ adaptation.
A lush tree canopy and vegetation on buildings makes places cooler and greener, and residents and workers can enjoy the outdoors.	Pedestrians and cyclists are supported by shade and cooler temperatures in summer.
Households enjoy improved living costs made possible by significant reductions in water and energy consumption in the Corridor.	Transportation options to be sustainable and energy efficient.

Principle 7: Delivery	
PRCUTS principle statement	**Transport Implications**
There is an effective governance structure in place.	Transport projects are delivered with integrity and in a timely manner. Funding streams include developer contributions and state and local government infrastructure contributions.
Decisions are made in a timely, transparent and coordinated way.	Transport decisions to be aligned with strategy, plans, and the wider community vision in place.
Well understood benchmarks and indicators inform the planning and decision-making processes	Transport planning is evidence based.
There is a clear monitoring, reporting and review process	Transport planning to account for monitoring and improvement measures and pre-defined performance matrices.

2.3 Modal hierarchy

The IWC ITS promotes a modal hierarchy for the IWC LGA with a people-first approach. This aligns with the intent of PRCUTS. At the top of the hierarchy is active transport, along with facilities for people living with a disability and specialist transport services that will support vulnerable people such as older people. Beneath active transport is public transport, followed by deliveries and freight, and at the bottom is private vehicles including motorbikes, taxis and ride share. This approach is shown in **Figure 2-1**. A similar approach is envisioned for the revitalisation of the Parramatta Road Corridor.

Figure 2-1 Modal hierarchy (IWC ITS)*

Priority (Think about first to final)	Modes
1	Walking, facilities for people living with a disability, specialist transport services.
2	Cycling, E-bikes, personal mobility devices, bicycle deliveries.
3	Public transport
4	Delivery services and freight
5	Taxis, ride share, car pool
6	Car share
7	Motorcycles/ scooters
8	Private electric vehicles
9	Private vehicles that generate pollutant emissions.

** Note: Private vehicles/ Private electric vehicles a motor vehicle as described in Road Rules 2014, NSW legislation*.

Parramatta Road currently operates as a major east-west movement corridor for private vehicles, with relatively low foot traffic, cyclists and place function. Revitalisation of the corridor could facilitate road space reallocation that better supports the modal hierarchy, including space for:

> 24-hour public transport/ mass transit lanes with stations at stops for customers;

> Plantings and car parking at mid-block locations; and

> Separated walk and cycle facilities.

Road space reallocation should aim to:

> Provide a barrier effect and spacing for high vehicle volume lanes along the corridor;

> Consider providing a dedicated cycleway on the side of the road that would likely have less interface with waiting public transport customers. It is assumed that most waiting by people numbers would occur on the Sydney CBD bound side; and

> Provide public transport stops adjacent to or within kerbside areas. There is more overflow area and amenity than stops located in the middle of the carriageway.

2.4 Performance indicators

The performance indicators for the Parramatta Road corridor and associated principles from the PRCUTS are shown in **Table 2-2**. Recommended targets adapted for these indicators are also shown.

Table 2-2 Relevant transport indicators for a new Parramatta Road (PRCUTS, 2016)

Category	Indicator	Principle addresses	Target
Parking	Per cent of car spaces less than the current maximum (%)	▪ Accessible and connected. ▪ Resilient and sustainable.	Implementation of the PRCUTS recommended parking rates Setting maximum car parking rates / eliminate minimum requirements
Traffic	Estimated per cent reduction in vehicle kilometres travelled per capita (%)	▪ Diverse housing and jobs. ▪ Accessible and connected. ▪ Resilient and sustainable.	Evidence of this metric trending down
Traffic	Estimated per cent reduction in vehicle hours travelled per capita (%)	▪ Diverse housing and jobs. ▪ Accessible and connected. ▪ Resilient and sustainable.	30% reduction in car use across the PRC
Traffic	Estimated car ownership rates (vehicles per household)	▪ Accessible and connected. ▪ Resilient and sustainable.	Evidence of this metric trending down
Car share	Number of car share spaces provided within the precinct (number)	▪ Accessible and connected. ▪ Resilient and sustainable.	Increased (10-15% car share take-up rate)
Accessibility	Average walk and wait time to frequent public transport (minutes)	▪ Accessible and connected. ▪ Resilient and sustainable.	Evidence of this metric trending down
Active transport	Kilometres of safe, connected cycleways within each precinct (km)	▪ Community and places. ▪ Accessible and connected. ▪ Resilient and sustainable.	PRCUTS Sustainability Plan corridor wide: 31 kilometres of new safe bicycle connections along the Parramatta Road Corridor.
Active transport	Kilometres of safe, connected pedestrian paths within each precinct (km)	▪ Community and places. ▪ Accessible and connected.	Continuous footpath treatments at local access roads
Green	Kilometres of green streets with high tree planting and canopy cover (km)	▪ Community and places. ▪ Resilient and sustainable.	60% canopy cover on streets in PRCUTS precincts.
Green	Amount of open space (ha)	▪ Community and places. ▪ Resilient and sustainable.	Evidence of this metric increasing
Emissions	Estimated greenhouse gas emissions (tonnes CO2 equivalent/ person/ year)	▪ Resilient and sustainable.	20+% reduction

3 Strategies and actions

3.1 Behaviour change

Significant change in public perception of the corridor will lead to a behaviour change by drivers, pedestrians and all road users. Streetscape improvements and prioritisation of active and public transport modes should be used to create a road environment that is comfortable, safe and efficient. Implementation of innovative transport technology would act as a catalyst for revitalisation of the PRC and would encourage a mode shift from private vehicle use.

Initiatives and programs that encourage mode shift and foster better overall travel behaviour should be supported, such as:

> Share the Road;
> Share the Path;
> Walking and Cycling Program;
> Towards Zero;
> Ride to Live;
> Plan B;
> Road Rules Awareness Week;
> Look out before you step out;
> Be Bus Aware; and
> Be Truck Aware.

The actions that will support the behaviour change strategy are presented in **Table 3-1**.

Table 3-1 Travel demand management actions

Travel demand management actions	
A-TDM1	Develop a Travel Behaviour Change Plan including: ▪ Encouraging public transport use through behavioural change and awareness campaigns; ▪ Developing an educational program that promoted the health, environmental and economic benefit of using sustainable transport; ▪ Requirements for new developments to prepare a Sustainable Transport Plan; ▪ Walking and cycling confidence courses for senior residents; ▪ Support an Active Travel to Schools program; ▪ Communicating footpath and cycleway etiquette; and ▪ Incentivise and encourage cycling for shore, local trips.

3.2 Movement and Place

The Movement and Place framework joins considerations and elements for land use and place and movement and the transport network. It is primarily focused around roads and the places they pass through.

The road network must accommodate the safe and efficient movement of people and goods (Movement), as well as support the adjacent uses and communities that it serves (Place). The key movement functions and place intensities must be carefully considered and balanced to respond to a growing population and increased land use development. The *Practitioner's Guide to Movement and Place* (GANSW & TfNSW, 2020) presents a framework for Movement and Place, and states that an assessment aims to achieve roads and streets that:

> Contribute to the network of public space within a location, where people can live healthy, productive lives, meet each other, interact, and go about their daily activities; and

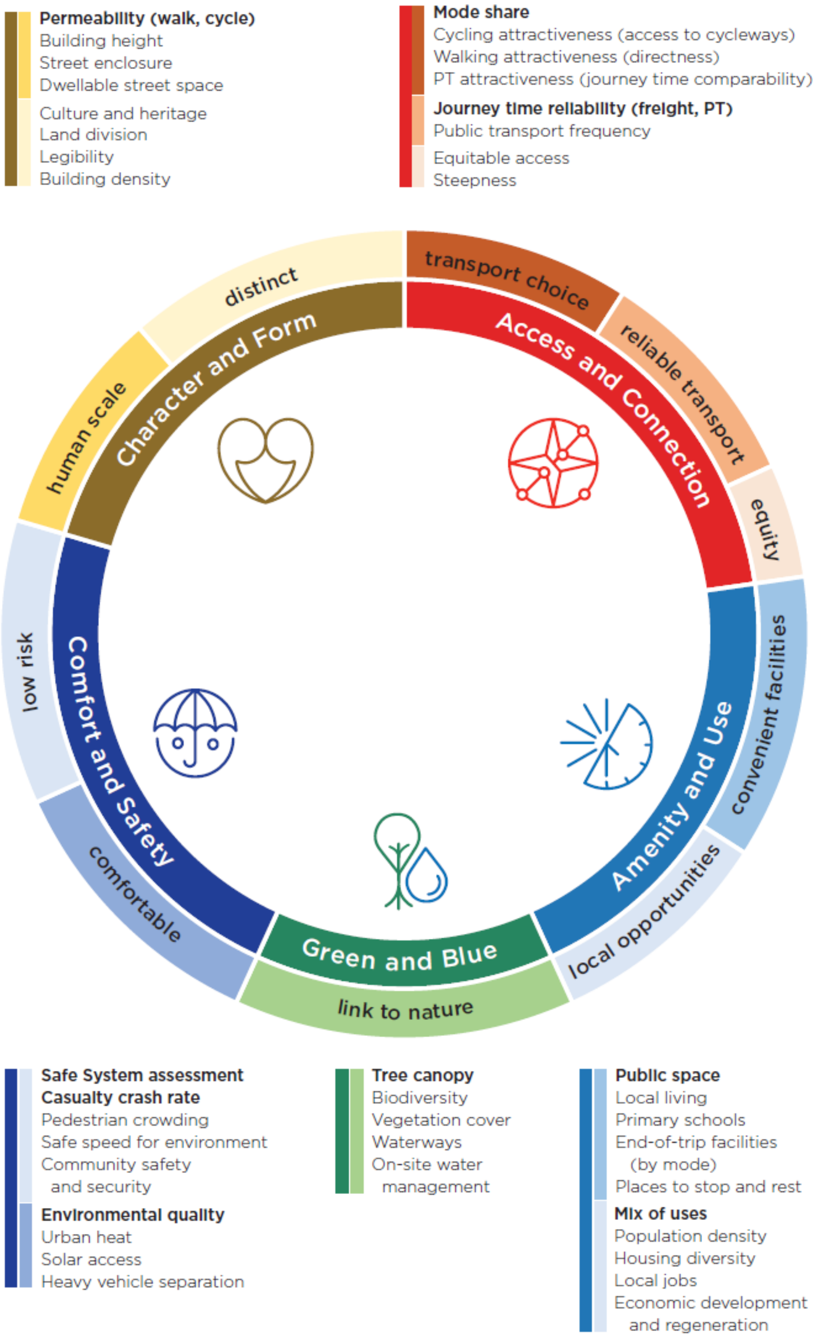
> Are enhanced by transport and have the appropriate space allocation to move people and goods safely and efficiently, and connect places together.

Balancing Movement and Place recognises that trade-offs may be required to achieve a best fit for the objectives.

3.2.1 Built and natural environment themes and performance indicators

Built and natural environment themes, as shown in **Figure 3-1**, provide a framework to evaluate Movement and Place performance and achievement of objectives. Under these five themes, ten outcomes are provided that reflect what a person in the assessed environment may reasonably expect as an outcome of good performance related to that theme. Not all outcomes apply to all places. The framework is designed to be flexible to the context of the location. Built and natural environment indicators can then be used to assess outcomes.

Figure 3-1 Built and natural environment indicators: criteria for evaluating movement and place



Source: Practitioner's Guide to Movement and Place, GANSW & TfNSW, 2020

Potential built and natural environment indicators have been listed to guide the studies at a high level and to measure achievement of the desirable outcomes. These indicators encompass all five themes and have been developed based on their relevance to the study area and desirable outcomes outlined above. Indicators that are relevant for the PRCUTS Transport Plan precincts are shown in **Table 3-2**.

Table 3-2 Built and natural environment indicators for success

Theme	Outcome	Indicators	Performance measure target
Character and form	Human scale	**Permeability (walk, cycle)**	Provide multiple through site links in each precinct
		Dwellable street space	Provide footpaths of at least 2.5 metres wide on roads with major land uses and destinations and seats / rest space within 200 metres
	Distinct	Culture and heritage	Retain and enhance existing culture and heritage
		Legibility	Provide wayfinding to all key active transport junctions and public transport stops along the IWC strategic pedestrian and cycling networks
		Building density	Ensure building density does not exceed transport network capacity and is in line with public transport and public domain improvements.
Access and connection	Transport choice	**Mode share**	Encourage a mode shift from private vehicle travel to sustainable modes for all short-distance trips
		Cycling attractiveness (access to cycleways)	Provide more separated cycleways
		Walking attractiveness (directness)	Provide kerbside buffers and adequate crossing facilities along Parramatta Road
		Public transport attractiveness (journey time comparability)	Retain transit lanes and rationalise bus routes
	Transport reliability	**Journey time reliability (freight, public transport)**	Ease congestion along Parramatta Road
		Public transport frequency	Provide a rapid transit (turn-up-and-go) service on Parramatta Road
	Equity	Equitable access	Ensure all public infrastructure is DDA compliant
Amenity and use	Convenient facilities	**Public space**	Provide at least one significant space for people to meet, rest and socialise in each precinct
		Local living	Ensure local facilities are accessible to support the 30-minute city concept
		End-of-trip facilities (by mode)	Provide end-of-trip facilities for active transport users at all major public transport interchanges
		Places to stop and rest	Provide benches along active transport routes no further than 100 metres from a park/plaza
	Local opportunities	**Mix of uses**	Design public spaces for a mix of uses or for adaptive re-use in the future
		Economic development and regeneration	Activate street frontages on Parramatta Road by providing a safe and comfortable streetscape
Green and blue	Link to nature	**Tree canopy**	Provide a tree canopy cover of 60% over all footpaths
		Vegetation cover	Enhance streetscapes through tree planting
		Waterways	Provide active transport routes along all major waterways and creeks

Theme	Outcome	Indicators	Performance measure target
Comfort and safety	Comfortable	**Environmental quality**	Utilise zero emissions vehicles for public transport
		Urban heat	Provide a tree canopy cover of 60% over all footpaths
		Heavy vehicle separation	Encourage all heavy vehicles to utilise WestConnex where possible
	Safety	**Safe System assessment**	Provide Safe System treatments along Parramatta Road to reduce the casualty crash rate
		Casualty crash rate	Annual crash rate of zero
		Safe speed for environment	Reduce speed limit in High Pedestrian Activity Areas such as main streets and Parramatta Road

3.2.2 Key Movement and Place considerations

Parramatta Road will continue to have a high movement function following the completion of the WestConnex project and resulting reduction in traffic volumes. The Corridor will however become more suited to a Vibrant Street (now named Main Street) function, as described by PRCUTS, 2016. Key Movement and Place considerations from PRCUTS are summarised in **Table 3-3**.

Table 3-3 Movement and Place considerations from PRCUTS

Consideration outlined in PRCUTS	Factor	Theme/ User outcome	Indicator(s)	Targets
Taverners Hill				
Establish a new high amenity local neighbourhood centre along Tebbutt Street/ Upward Street that benefits from the Kolotex/ Labelcraft site redevelopment.	Place	Amenity and Use/ Local Opportunities	Mix of uses	Neighbourhood centre is created consisting of shops, restaurants and open space
Create an activity node around the Taverners Hill Light Rail Stop.	Place	Amenity and Use/ Local Opportunities	Mix of uses	Activated street-level land uses that provided for people's day-to-day needs (i.e. café, corner store)
Parramatta Road, between the Iron Cove Creek and the light rail crossing, will continue to have a high movement function, particularly given the WestConnex entry/ exit portal located near Ashfield Park.	Movement	Access and Connection/ Transport Reliability	Journey time reliability (freight, PT)	Separation of vehicle lanes and footpaths through landscaping buffers
Opportunity for higher kerb-side activity and activated frontages on Parramatta road.	Place	Amenity and Use/ Local Opportunities	Economic development and regeneration	Activated street-level land uses that attract pedestrians and a kerbside buffer (i.e. cycleway, parking or landscaping)
Parramatta Road, between the light rail crossing and Flood street, provides a good opportunity for a vibrant street given the reduced traffic volumes as a result of WestConnex.	Place	Character and Form/ Human Scale	Dwellable street space	48% reduction in car use*
Leichhardt				
Capitalise on new transport connections to rebadge and create a new Norton Street identity.	Place	Character and Form/ Distinct	Culture and heritage	1km of new safe bicycle connections*
Provide a 'Gateway' anchor to Norton Street at Parramatta Road that is mirrored at Marion Street.	Place	Character and Form/ Distinct	Culture and heritage	Gateway signage in the form of a monument in the verge or archway over the road
Identify short to medium term opportunities for new public domain and spaces.	Place	Amenity and Use/ Convenient Facilities	Public space	New green space on Hay Street and public spaces across the precinct such as around Norton Plaza
Enhance side streets including Hay Street, Charles Street and Railway Street as public spaces.	Place	Amenity and Use/ Convenient Facilities	Public space	Implementation of continuous footpath treatment at gateway and reduced speed limit
Reduction in traffic on Parramatta Road due to WestConnex. Ideal environment for a vibrant street.	Place	Character and Form/ Human Scale	Dwellable street space	43% reduction in car use*
Opportunity for higher kerb-side activity and activated frontages on Parramatta road.	Place	Character and Form/ Human Scale	Dwellable street space	Activated street-level land uses that attract pedestrians and a kerbside buffer (i.e. cycleway, parking or landscaping)

Consideration outlined in PRCUTS	Factor	Theme/ User outcome	Indicator(s)	Targets
Opportunities for creating through block links	Movement and Place	Access and Connection	Walking and cycling attractiveness	New pedestrian connections / separation of vehicle lanes and pedestrian areas
Other movement corridors are Johnston Street and Crystal Street, providing local access to suburbs.	Movement and Place	Access and Connection/ Transport Reliability	Journey time reliability	Existing movement function be managed while developing the corridors' place function.
Norton Street – This is the main north-south street with an activated frontage providing access to the town centre.	Movement and Place	Access and Connection/ Equity	Equitable access	Maintain its importance as an active vibrant street with a reduced speed limit and enhanced place function
Camperdown				
Adapt, retain and celebrate the existing industrial heritage character.	Place	Character and Form/ Distinct	Culture and heritage	Industrial heritage is retained and enhanced
Develop Bignell Lane as a lively, fine-grained mixed use area with entertainment and other day/ night 'social' uses.	Place	Amenity and Use/ Local Opportunities	Mix of uses	Hospitality and entertainment land uses are provided between Parramatta Road and Bignell Lane
Reinforce and provide new opportunities for fine grain through the Hordern Place Industrial Area.	Place	Character and Form/ Human Scale	Walking and cycling permeability	2km of new safe bicycle connections*
Create a greener, friendlier and safer Cardigan Lane as an enhanced north-south walking and cycling spine.	Movement	Access and Connection/ Transport Choice	Walking and cycling attractiveness	2km of new safe bicycle connections*
Opportunities for creating through block links	Movement and Place	Access and Connection	Walking and cycling attractiveness	Provision of connectivity through the creation of through site links in addition to 2km of new safe bicycle connections
Create active streets that connect residents and workers to small, diverse, and highly connected local and regional open spaces.	Movement and Place	Amenity and Use/ Convenient Facilities	Places to stop and rest	additional public open space*
Reduction in traffic on Parramatta Road due to WestConnex. Ideal environment for a vibrant street with enhanced north-south connectivity.	Movement and Place	Character and Form/ Human Scale	Dwellable street space	24% reduction in car use*
Pyrmont Bridge Road (west of Booth Street) – This section has a lower movement function and provides an opportunity for an activated frontage as a Vibrant Street connecting south of Parramatta Road and north into Booth Street.	Movement and Place	Character and Form/ Human Scale	Dwellable street space	24% reduction in car use*

Source: PRCUTS, UrbanGrowth NSW, 2016
**Source: Parramatta Road Urban Transformation Sustainability Implementation Plan, UrbanGrowth NSW, 2016*

3.2.3 Land use and place-making

Place-making through landscaping and streetscape improvements encourage a shift towards more sustainable transport modes as they create environments which are more safe, comfortable and attractive within which to walk, ride and wait for public transport services. This should be achieved through planting of greenery such as trees, provision of places to rest and socialise and provision of public art opportunities. Benefits of these initiatives include increased shading through tree canopy cover and a reduction in overall local temperatures, encouraging more walking and longer stays in main streets.

It is important for land use and infrastructure (be that “place making” or predominately supporting movement) to be aligned so that the initiatives identified support land use densification where it can be accommodated. This in line with PRCUTS policy which states the “delivery of new and upgraded transport systems throughout the Corridor in line with growth and development' as an action / responsibility for state and local government agencies.

The actions that will support the vision and principles for PRCUTS are presented in **Table 3-4**.

Table 3-4 Land use and place-making actions

Land use and place-making actions	
A-LU1	Public domain improvements to key north-south streets perpendicular to Parramatta Road including Rofe Street, Renwick Street, Norton Street, Balmain Road, Catherine Street, Crystal Street, Pyrmont Bridge Road and Mallett Street.
A-LU2	Enhance streetscapes through greening and tree planting.
A-LU3	Provide outdoor seating for places to rest and socialise.
A-LU4	Provide wayfinding.
A-LU5	Provide gateway treatments at key intersections with Parramatta Road. This could be in the form of murals by local artists, creating a sense of neighbourhood identity at gateways to local centres.
A-LU6	Enhance streetscapes through WSUD.
A-LU7	Activate shop frontages along Parramatta Road and open up land uses to rear lanes.
A-LU-8	Consider temporal changes where regular road closures of low volume streets could be used for activation by outdoor dining, street markets and active travel.
A-LU9	Consider use of existing off-street car parks as market places or community “nodes”.
A-LU10	Provide EV charging for PMD and e-bikes, built into streetscape elements.
A-LU11	Provide a planted barrier between the footpath and traffic lane where parking cannot be achieved.
A-LU12	Consider the environmental impacts of materials used, and the heat island effect.
A-LU13	Investigate opportunities for innovative transport technology such as GETS that would inspire community confidence and act as a catalyst for revitalisation of the corridor.

Movement actions are covered in the sections below.

3.3 Parramatta Road configuration

As described by PRCUTS, the vision for Parramatta Road is for it to be more aligned with the function of a Vibrant Street / Main Street, acknowledging that it will continue to have a high movement function following the completion of the WestConnex project. In support of this gradual transition, consideration should be given to interventions such as the lowering speed limits, road space reallocation for movement of people (including introducing cycleways), creating an attractive and safe environment for everyone using the corridor including the more vulnerable or improvements to the local amenity and landscaping.

The improvements to the Parramatta Road configuration should be within the existing road space/carriageway and not relying on any additional setbacks being provided as development occurs in the corridor.

The final configuration of Parramatta Road is subject to the investigation by Transport for NSW on the corridor and a business case for a transport initiative scheduled for completion in early 2022.

3.4 Active transport

Active transport supports education, employment, retail, recreational and other high activity locations in and around the PRC. Active transport covers walking (including by wheelchair or other mobility devices), cycling and other micro-mobility options such as scooters and skateboards. Infrastructure and initiatives should be designed to promote active transport as the first choice for shorter trips, resulting in health, economic and sustainability benefits.

The strategic transport vision for PRCUTS promotes active transport as safe, reliable and efficient for people of all ages and abilities. Active transport routes are direct, following desire lines and connecting to where people can access jobs, services, shopping and social activities. Desire lines are supported by formal pedestrian crossings connecting to key land uses. Infrastructure is appropriate to the street or path function in which it is located, including separation of pedestrians from faster moving cyclists where possible. In recognition of the growing demand for active transport and the desire to achieve a significant mode shift it is essential that kerb ramps wider than the currently specified standard be implemented wherever practical Recommendations for best practice design are outlined in **Section 3.4.3**.

The actions that will support the active transport strategy are presented in **Table 3-5**.

Table 3-5 Active transport actions

Active transport network actions	
A-AT1	Construct the missing links in the walking and cycling network as per **Figure 3-4**, **Figure 3-5**, **Figure 3-6** and **Figure 3-7**, including: ▪ Projects as per the PRCUTS Infrastructure Schedule. ▪ New cycle connection running east-west along Nestor Lane connecting Carrington Street to the light rail corridor. ▪ Delivery of (the former Leichhardt bike route) EW-2, along Albion Street and Dot Lane, specifically including the Dot Lane link between Norton Street and Hay Street, As well as the link across Norton Street to the Renwick Lane shared zone. ▪ New cycle connection running east-west along Albion Street between Norton Street and just east of Balmain Road. ▪ New cycle connection running north-south across Parramatta Road connecting Renwick Street in the north to Railway Street in the south. ▪ Traffic protected cycle connection running north-south along Johnston Street. ▪ Delivery of the Johnstons Creek pedestrian and cycle link from Booth Street to Parramatta Road. ▪ Delivery of the Pyrmont Bridge Road pedestrian and cycle link. ▪ Provision of new cycle and walking links within the 2016 – 2021 Release Area, as indicated in the Planning and Design Guidelines.
A-AT2	Investigate and provide pedestrian crossings at the following intersections with Parramatta Road: ▪ Iron Cove Creek; ▪ Alt Street; ▪ Andreas Street; ▪ Rofe Street / Palace Street; ▪ Johnstons Creek; and ▪ Larkin Street. Pedestrian crossings be provided on all legs/approaches of any new signalised intersections. Kerb ramps wider than the specification in AS14.28.1 are to be installed catering for existing demand and population. In recognition of the growing demand for active transport and the desire to achieve a significant mode shift, it is essential that kerb ramps wider than the currently specified standard be implemented wherever practical.
A-AT3	Complete the GreenWay project and key links to the Greenway, including GreenWay connection under Parramatta Road and under Longport Street.
A-AT4	Adjust development controls to ensure that developments within the precincts are designed to have through-site active transport links and active laneways for pedestrians and cyclists.
A-AT5	Improve active transport links to public transport services.
A-AT6	Provide access to Taverners Hill LRS and Marion LRS from the east.
A-AT7	Provide wider signalised crossings on Parramatta Road as a shared crossing or separated facility with a bike lane and bike lanterns as per **Figure 3-3**.
A-AT8	Provide continuous footpath treatments along Parramatta Road as per **Figure 3-4**, **Figure 3-5** and **Figure 3-6**. Additionally, continuous footpath treatments should be included for footpaths along all key side streets (e.g. Johnston St, Norton St, Crystal St, Catherine St)
A-AT9	Provide 30 kilometre per hour speed limits wherever possible to reduce the likelihood and severity of crashes between motor vehicles, pedestrians and cyclists, and in recognition of the existing and likely future high level of pedestrian activity in the corridor.
A-LU1	Public domain improvements to key north-south streets perpendicular to Parramatta Road including Rofe Street, Renwick Street, Norton Street, Balmain Road, Catherine Street, Crystal Street, Pyrmont Bridge Road and Mallett Street.
A-LU2	Enhance streetscapes through greening, tree planting, street lighting, WSUD and public art.
A-LU4	Provide wayfinding signage.
A-LU11	Provide a planted barrier between the footpath and traffic lane where parking cannot be achieved.

3.4.1 Walking

The PRC's pedestrian network should be highly permeable to encourage healthy lifestyles and make walking an attractive way to travel for local trips. Travelling by foot should be the first mode choice for short trips, available to all people of all ages and levels of mobility.

Walking must be safe, easy, direct, enjoyable and comfortable through a connected and legible network, more priority at intersections, comfortable footpath widths, high quality pavement, attractive streetscapes, safe and accessible crossings, separation from cyclists where needed, and active and passive surveillance from engaging places, mixed land uses and street frontages.

High quality pedestrian infrastructure is needed in all locations that would accommodate notable demands. To provide focus and balance resources, a strategic pedestrian network plan is identified in **Figure 3-2**. Pedestrian routes propose footpaths and associated kerb ramps are provided on both sides of the road

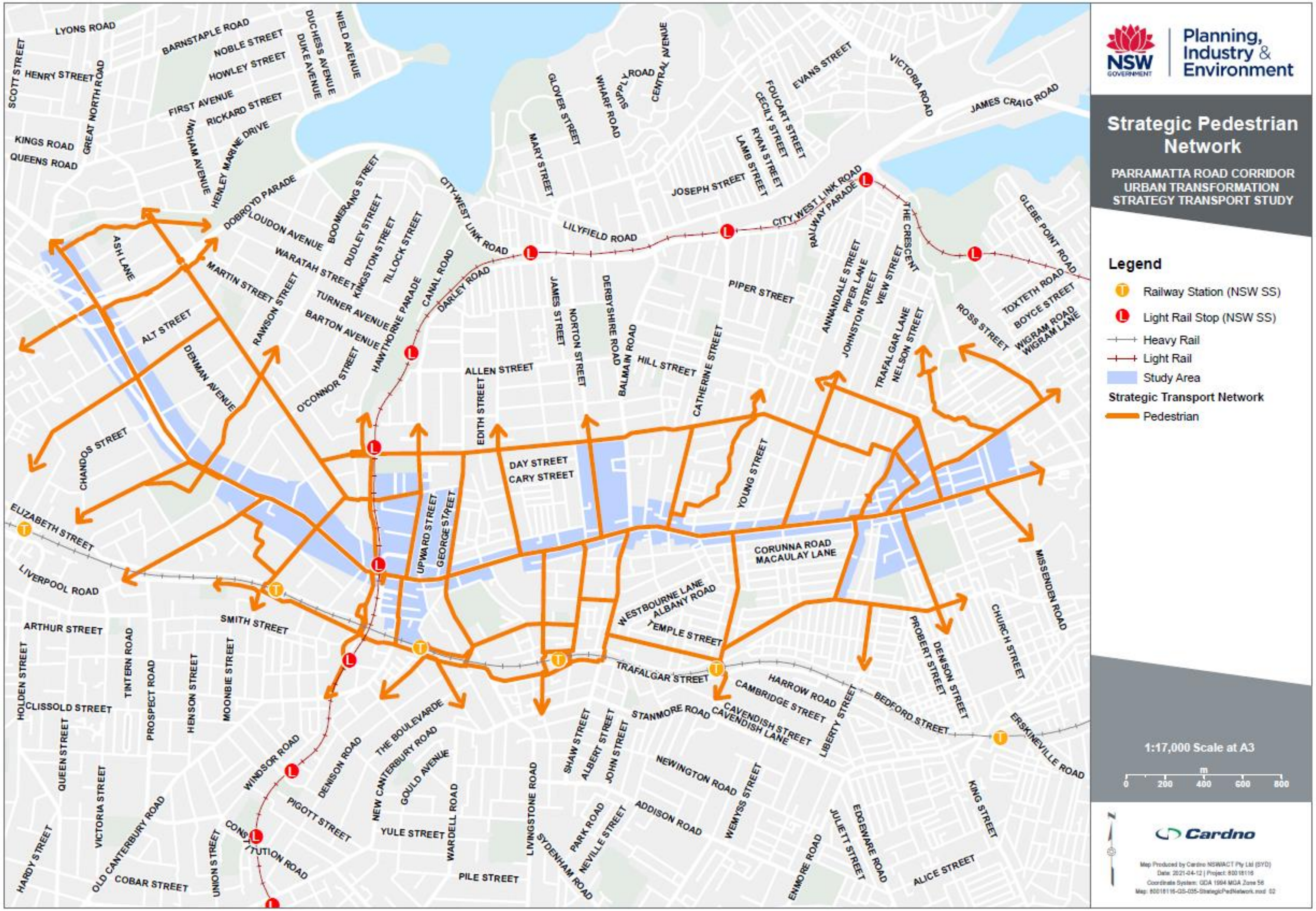
The strategic network rationale is to link all significant pedestrian generating land uses in and around the PRC. Most residents are within 300 metres of the network. Key high demand land uses include:

- **Centres** – where residents access jobs, services, education and shopping opportunities. Centres must have robust active transport links to residential areas to promote walking and cycling.
- **Public transport nodes** – provide access to public transport services including train, light rail and bus. Residents can continue their journey from their walk or cycle to access other areas.
- **Schools** – travel to and from school are essential weekday trips for families. It is important to provide safe, efficient and separated connections to schools so that families can walk or ride together, or older children can independently go to school.
- **Recreational areas** – open spaces for leisure and exercise, including scenic walks and cycling.

Key features should include:

- Paths equal to or greater than 1.8 metres (ideally 2.5 metres) wide clear path of travel, free from utilities, bus shelters/ advertising or other barriers;
- Shared zones or pedestrian priority at crossings;
- A smooth surface that receives regular maintenance, including vegetation trimming;
- Construction from environmentally friendly materials;
- Step free access including DDA compliant kerb-ramps or tactile ground surface indicators (where there is no level change) at all road crossings;
- High priority to links that are less steep;
- A clear and straight (where possible) shoreline (property boundary) for vision impaired people;
- Wayfinding signage;
- Crossing opportunities targeted for every 200 metres or less;
- Signalised or raised crossings at major roads with ample waiting area;
- Use of shared paths should be minimised and where shared paths are the only option they should be introduced with sensitive design measures combined with education and awareness campaigns to slow riders;
- Energy efficient lighting;
- Tree canopy cover and additional cover facilitated with sub-surface root separation;
- Awnings for shopfronts on key streets;
- Separation from high volume/ speed traffic with vegetation, parking lanes; and
- Amenity provisions in centres and recreational areas, including drinking fountains, seating, toilets and weather shelter refuges.

Figure 3-2 Strategic pedestrian network within and near PRCUTS



3.4.2 Cycling

Cycling across and around the PRC is a popular choice for shorter trips as it is safe, convenient and quick. Riding a bike is not limited to those who are avid cyclists; people of all ages and abilities should feel safe enough to ride to work, retail or for recreation.

Cycling infrastructure must reflect the road environment on which it is located; mixing with vehicles should only be allowed only on slower speed streets (recommended 30km/h or less limits on mixed cycling/ vehicle traffic roads). On higher speed roads, cycle lanes should be separated from traffic using on-road infrastructure such as kerbs, or provided off-road in dedicated cycle or shared path links that provide off road space for both pedestrians and cyclists. Cycle lanes must be wide enough to avoid conflict, and should not be placed in parked car door-opening zones that could lead to injury.

Cycle routes connect to local parks, open green spaces and waterways that provide amenity, short cuts and scenic views. Similar to the pedestrian network, the cycling network connects key attractors around the Corridor, however via more appropriate streets. The cycling network avoids higher vehicle volumes and speeds of Hume Highway / Liverpool Road, Old Canterbury Road, Crystal Street and other vehicle movement corridors. Quieter streets have been selected as they provide cyclists a safer option and avoid conflict with high numbers of pedestrians. Existing land use and road space allocation on Parramatta Road also presents challenges to providing separated cycleways.

Bicycle parking should be provided at interchanges with public transport services such as train stations, light rail stops and major bus stops to key destinations. Cyclist journeys do not always start and finish on cycleways. Parking and other end of trip facilities should be provided at journey end locations to further support riders and encourage participation.

The strategic cycling networks is shown in and **Figure 3-3** with future actions shown in **Figure 3-7**. The network displays strategic routes only, without setting specific typologies.

Key features should include:

> Shared paths should be used minimally and be with a width of at least 3.5 metres wide. Narrow points and lengths should be considered on a case by case basis. It is often not feasible to relocate utilities or favourable to cut down trees to achieve desired widths. Shared paths should only be installed where safe on-road facilities, or alternative parallel facilities, can't be provided.

> 30 kilometres per hour speed limits should be introduced on all streets in the corridor that are currently or likely to in the future experience high levels of pedestrian activity.

> Delineated on-road cycle lanes must not be located in parked vehicles door opening zone, within one metre of a parked car.

> On-road bicycle network clearly line-marked, legible and signposted to Austroads standards.

> Direct and connected routes;

> A smooth surface that receives regular maintenance, including vegetation trimming and removal of storm debris;

> Remediation of exiting hazards such as bollards, incorrect signage, uneven surfaces or any other identified safety hazard.

> Equal or high priority at intersections.

> Separated facilities and lanterns at signalised intersections.

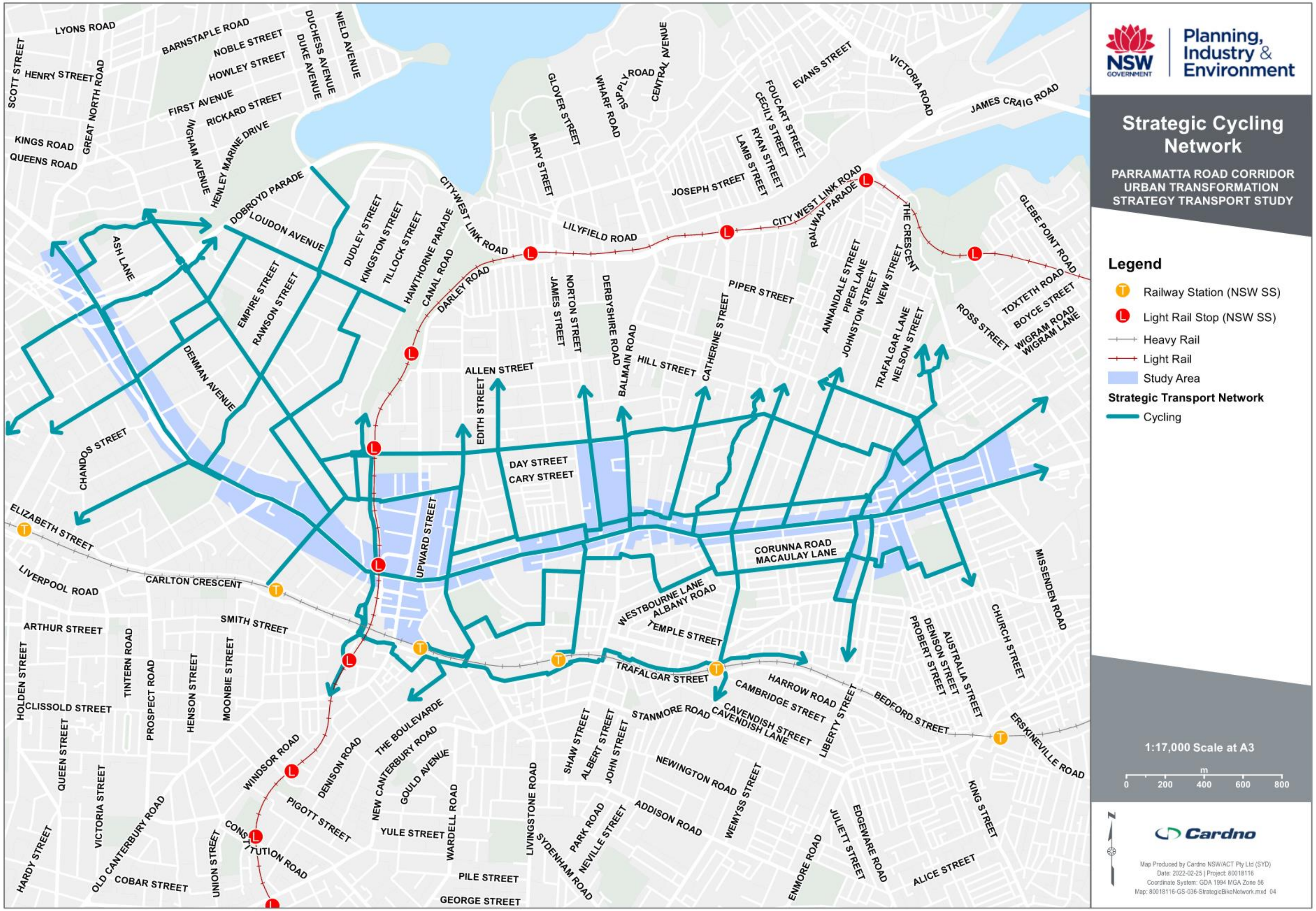
> Energy efficient lighting.

> Wayfinding signage at key decision points.

Wayfinding supports visitors to vibrant centres by clearly articulating and communicating the most efficient and safest route. Signage style for wayfinding should be innovative and consistent throughout the Inner West.

Should a cycling route not be forthcoming on Parramatta Road, consideration should be given to the (former Leichhardt Council's) Route EW 2, running East-West and one block to the north of Parramatta Road using Albion Street, Dot Lane, Renwick Lane, Jarrett Street and Albert Street.

Figure 3-3 Strategic cycling network



3.4.3 Infrastructure standards and recommendations

Infrastructure improvements are recommended for the key walking and cycling networks at a high-level approach. The recommendations were based on rapid assessment of road types and existing infrastructure in comparison with the strategic network. Further examination of the road carriageway environment is needed for more detailed costing purposes.

In line with the active transport strategy, infrastructure is recommended under the following considerations:

> **Shared paths** are recommended adjacent to roads with a higher speed (above 30km/h) and/ or volume environment.

> **On-road mixed** cycling routes are recommended on lower speed (30km/h) road environments with predominantly residential land uses.

> **Footpath construction** are to be provided on both sides of roads in the strategic walking network that are missing footpaths unless physically impossible.

> **Continuous footpath treatment** is recommended as a traffic calming measure where pedestrian priority is desirable but regulatory pedestrian crossing is not warranted.

> **Segregated/ separated bicycle paths** are desired for safety and reduced conflict and sustainability objectives. The provision of this form of infrastructure on Parramatta Road, would provide a key link through PRCUTS and the region. These require strong community and multiple government agency support and coordination. They generally require reallocation of road space and can have impacts to parking which is often why they are not supported. Providing a facility on Parramatta Road is likely to be highly contentious and opposed.

  Given the challenges, this is suggested as a longer-term consideration if community attitudes shift and there is a heightened demand for sustainability.

Infrastructure standards for recommended infrastructure are presented in **Table 3-6**. These are generally advised from Austroads guidelines and informed by the IWC Transport Strategy.

Table 3-6 Active transport infrastructure standards

Item	Standard	Compliance	Consideration
Shared path	Austroads Guide to Road Design Part 6A: Paths for Walking and Cycling (AGRD06A-17); Section 5.1	Minimum 2.5m width, preferred minimum 3.5m for recreational path.	Where space permits and volumes are high, separate pedestrian and cycle paths can be provided in parallel.
On-road bicycle stencils	Australian Standard Manual of uniform traffic control devices Part 9: Bicycle facilities AS 1742.9:2018 Delineation Section 12 - Pavement markings for bicycle facilities, RTA	Faded or missing Position on road min 0.6m from parked cars, typically not closer than 3.0m to kerb.	Cycling in mixed traffic is considered relatively safe where vehicle speeds are 30km/h or less. Implementing a 30km/h limit on streets negates the need for separate bicycle infrastructure (Note: 30km/h limits are yet to be endorsed with legislation by the NSW government).
Cycling infrastructure	Cycleway Design Toolbox: Designing for Cycling and Micromobility (TfNSW, Feb 2021)	An ideal one-way bicycle path should maintain a preferred width of 3.0m, however a suitable width may be 2.0m in locations for up to 150 riders per hour.	The preferred width of 3.0m allows for safe overtaking, caters for future growth in ridership, and accommodates riders of all ages and abilities. A 3.0m width will also allow for higher speeds along the bicycle path to cater for the emergence of innovative forms of micromobility. Where higher bicycle traffic volumes are expected and steeper gradients occur, a wider design should be considered.
Signage	Australian Standard Manual of uniform traffic control devices Part 9: Bicycle	Regulatory signs provided generally in accordance with the standard.	Consider signage clutter, choose carefully based on context and identify opportunities to consolidate signs/ poles/ utility poles.

Item	Standard	Compliance	Consideration
	facilities AS 1742.9:2018		
Bicycle parking facilities	Australian Standard Parking facilities, Part 3: Bicycle Parking AS 2890.3:2015	As per standards or functionally acceptable	Provide in easily accessible, visible locations.
Walking Infrastructure	Walking Space Guide (TfNSW, Aug 2020)	At least 3.1m of Walking Space is needed on every street to comply with Covid-19 walking space requirements	Footpath width recommendations vary depending on street type / environment / classification.
Footpath	Austroads Guide to Road Design Part 6A: Paths for Walking and Cycling (AGRD06A-17); Section 5.1	1.2m minimum for low volume footpaths 2.4m minimum for high volume footpaths	1.8 metres is recommended to allow two prams/ wheelchairs to pass in the opposite direction. If a low amount of cycling is desired, provide a minimum 2.5-metre path.

Footpath and cycleway upgrades are generally in alignment with the strategic active transport network and prioritised walking and cycling links outlined in the PRCUTS *Implementation Tool Kit Infrastructure Schedule*. These were reviewed and enhanced as part of this study.

3.4.4 Adopted infrastructure standards

A recommended footpath width of 2.5 metres has been adopted in-line with the Inner West Transport Strategy for costing purposes. This is reflective of the higher demands anticipated from more active lifestyles and sustainable mode share targets in the precinct.

The 2.5 metre width is recommended where the verge permits. 3.5-metre wide footpaths have been recommended in alignment with IWC detailed design of streetscape improvements in activity areas. These generally represent a property line to kerb sealed treatment.

Active transport infrastructure recommendations are shown in **Figure 3-4**, **Figure 3-5**, **Figure 3-6** and **Figure 3-7**, including the differentiation of the signature active transport projects. The breakdown of each infrastructure type and the total length of the future network improvements is described in **Table 3-8** with unit rates in **Table 3-7**.

The scale or scope of works can vary widely and involve multiple components whereby only broad cost estimates could be made. The estimated costs herein are intended as base costs for strategic guidance only and exclude any relevant utility relocation costs (water, sewer, power and communications). Identified works identified will undergo further adjustment as detailed design scoping and feasibility studies are undertaken. Detailed cost estimates should be sought from a suitably qualified civil engineer or quantity surveyor prior to commencement. The infrastructure costs should be subject of ongoing review whereby cost variations should be assessed and adjusted as necessary.

Table 3-7 Unit rates

Infrastructure type	Rate per unit	Unit	Details
2.5-metre wide footpath	$550	Metre	▪ Provision of footpath treatment
3.5-metre wide footpath	$700	Metre	▪ Provision of footpath treatment
Low priority footpath improvement			▪ Aesthetic resurfacing (streetscape improvement)
Desired through-site link			▪ Private development
Shared zone			▪ Provision of pavements and signage
Continuous footpath treatment	$100,000	Each	▪ Raised wombat crossing ▪ Pavement treatment
Continuous footpath treatment with additional treatment	$125,000	Each	▪ Raised wombat crossing ▪ Pavement treatment ▪ Kerb extension
Continuous footpath treatment with additional treatment and median removal	$150,000	Each	▪ Raised wombat crossing ▪ Pavement treatment ▪ Kerb extension ▪ Removal of median
On-road mixed traffic route	$200	Metre	▪ Bike stencils ▪ Arrow road markings ▪ Wayfinding signage
On-road bike lane	$275	Metre	▪ Linemarking ▪ Bike stencils ▪ Arrow road markings ▪ Pavement treatment at intersections
Separated cycleway	$1,500	Metre	▪ Kerb treatment ▪ Bike stencils ▪ Pavement treatment
3.5-metre wide shared path	$700	Metre	▪ Linemarking ▪ Bike and pedestrian stencils ▪ Signage

Table 3-8 Active transport infrastructure recommendations

Precinct	Infrastructure type	Total length (m)	Total cost ($)
Taverners Hill	2.5-metre wide footpath	3496	$1,922,535.23
	3.5-metre wide footpath	-	-
	Low priority footpath improvement	126	
	Desired through-site link	46	
	Continuous footpath treatment	114	$1,700,000.00
	Continuous footpath treatment with additional treatment	176	$1,875,000.00
	Continuous footpath treatment with additional treatment and median removal	69	$600,000.00
	On-road bike lane	112	$30,886.57
	On-road mixed traffic route	761	$152,108.24
	Separated cycleway	2478	$3,716,482.15
	3-metre wide shared path	516	$361,277.27
			$10,358,289.46
Leichhardt	2.5-metre wide footpath	2508	$1,379,224.32
	3.5-metre wide footpath	374	$261,788.73
	Low priority footpath improvement	565	
	Desired through-site link	220	
	Continuous footpath treatment	133	$1,100,000.00
	Continuous footpath treatment with additional treatment	130	$1,375,000.00
	Continuous footpath treatment with additional treatment and median removal	19	$150,000.00
	On-road bike lane	156	$42,837.27
	On-road mixed traffic route	1731	$346,224.84
	Separated cycleway	1507	$2,260,803.36
	3-metre wide shared path	139	$97,293.16
			$7,013,171.68
Camperdown	2.5-metre wide footpath	1989	$1,093,734.10
	3.5-metre wide footpath	20	$14,333.50
	Low priority footpath improvement	1349	
	Desired through-site link	258	
	Continuous footpath treatment	92	$1,400,000.00
	Continuous footpath treatment with additional treatment	151	$1,850,000.00
	Continuous footpath treatment with additional treatment and median removal	-	-
	On-road bike lane	932	$256,387.83
	On-road mixed traffic route	569	$113,892.19
	Separated cycleway	2369	$3,553,532.80
	3-metre wide shared path	679	$475,325.43
	Shared zone	241	
			$8,757,205.84
All	2.5-metre wide footpath	7992	$4,395,493.65

Precinct	Infrastructure type	Total length (m)	Total cost ($)
	3.5-metre wide footpath	394	$276,122.23
	Low priority footpath improvement	2040	
	Desired through-site link	524	
	Continuous footpath treatment	339	$4,200,000.00
	Continuous footpath treatment with additional treatment	457	$5,100,000.00
	Continuous footpath treatment with additional treatment and median removal	87	$750,000.00
	On-road bike lane	1200	$330,111.67
	On-road mixed traffic route	3061	$612,225.26
	Separated cycleway	6354	$9,530,818.31
	3-metre wide shared path	1334	$933,895.86
	Shared zone	241	
			$26,128,666.98

Figure 3-4 Future pedestrian infrastructure actions – Taverners Hill precinct

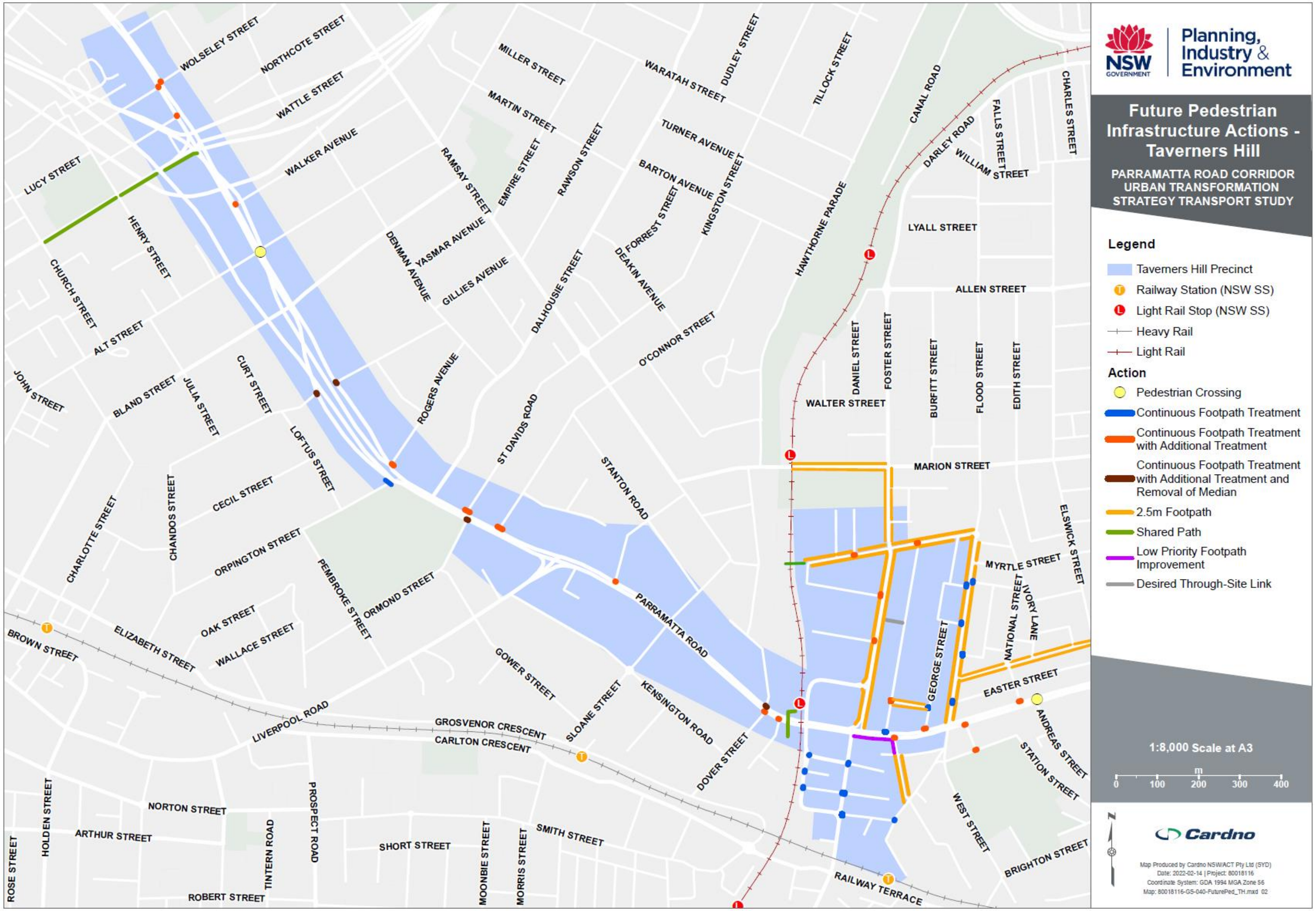


Figure 3-5 Future pedestrian infrastructure actions – Leichhardt precinct

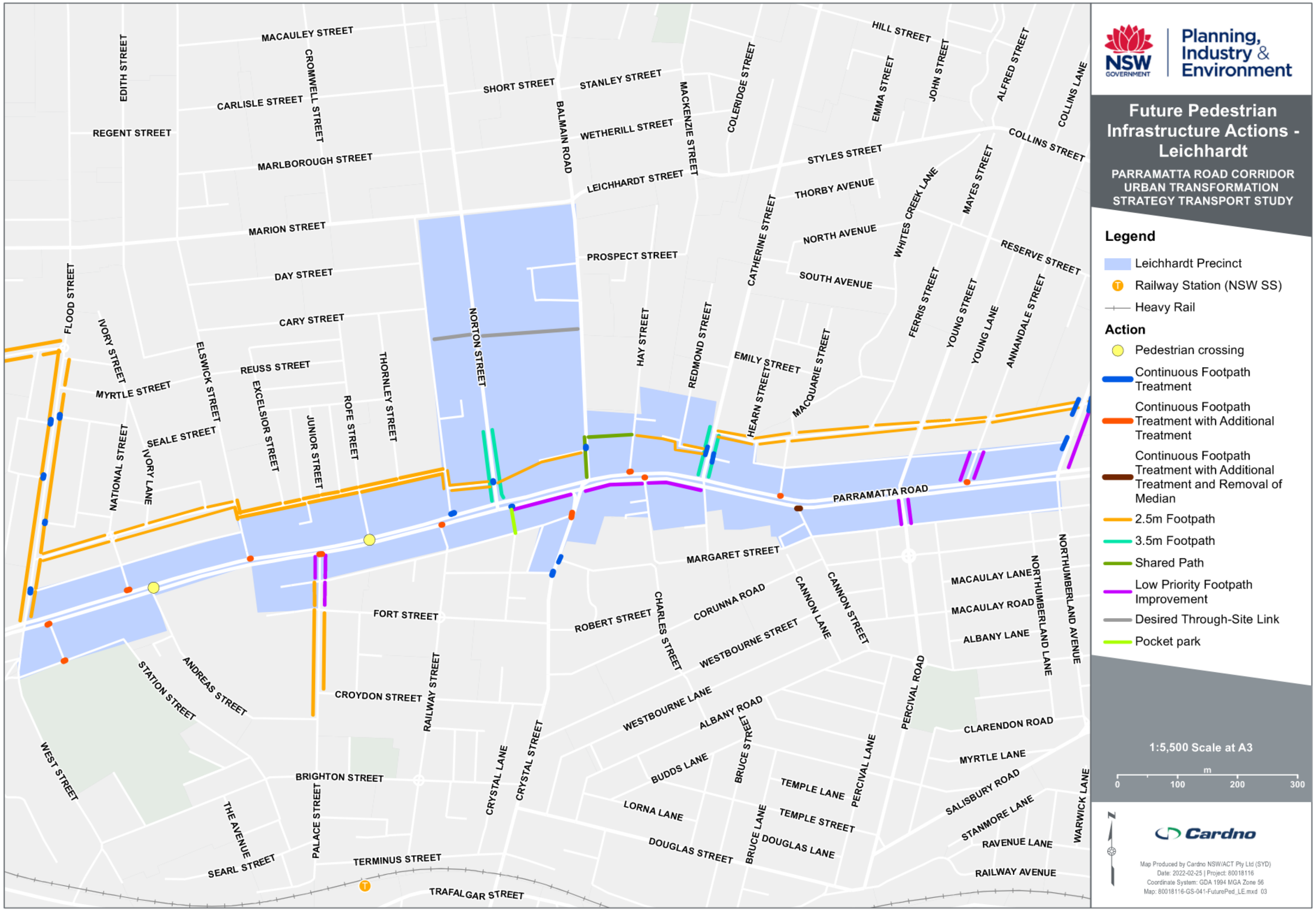


Figure 3-6 Future pedestrian infrastructure actions – Camperdown precinct

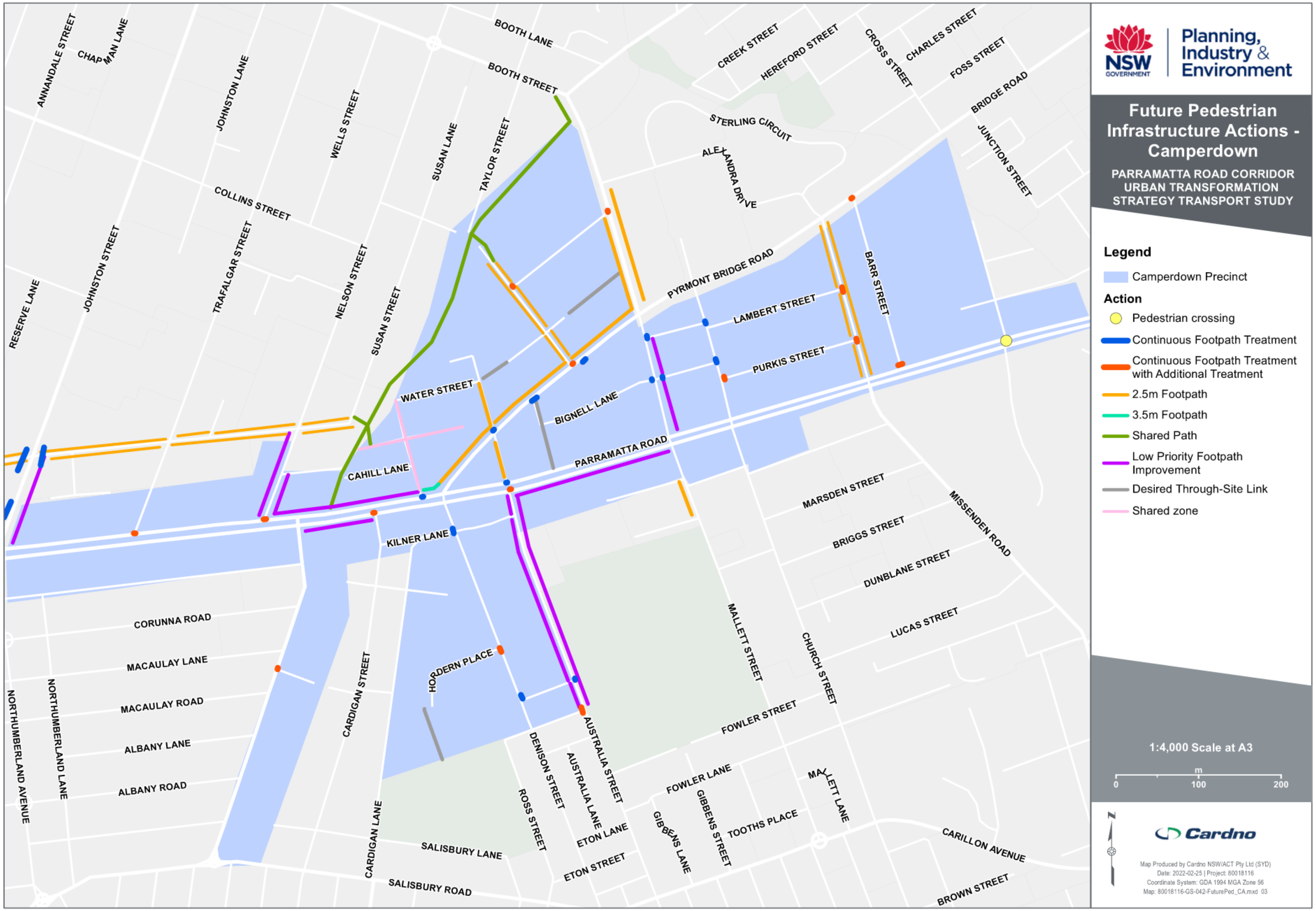
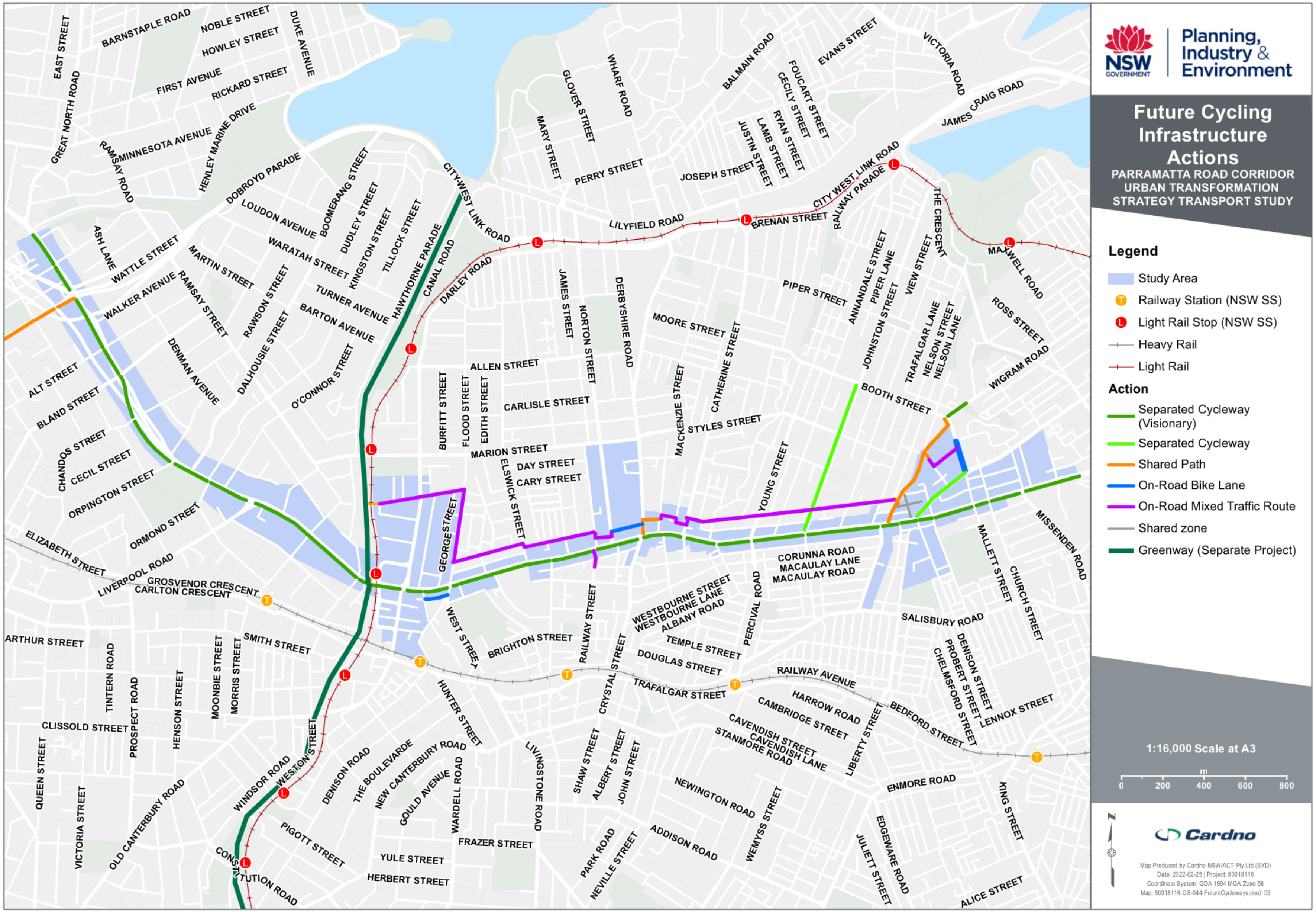


Figure 3-7 Future cycling infrastructure actions



3.5 Public transport

A frequent and rapid mass public transit service along the length of the PRC will contribute to the vibrancy, accessibility and attractiveness of the Precincts and local community area. This extends to reimagining the vibrancy of local businesses along the PRC which currently experience low foot traffic. Improvements to public transport and public domain are documented in the PRCUTS as key measures to support the corridor revitalization and address issues such as congestion and air quality.

It is understood Transport for NSW are preparing a business case for mass transit improvements along Parramatta Road. It is assumed that this will be implemented in an interim period and this will support existing and future populations.

Consideration should be given to the layout for the PRC outlined in the IWC ITS Parramatta Road Revitalisation project idea, shown in **Figure 3-8**. This layout would reduce vehicle traffic capacity on Parramatta Road, while increasing the people movement capacity. It would provide an opportunity to reallocate road space for the following provisions:

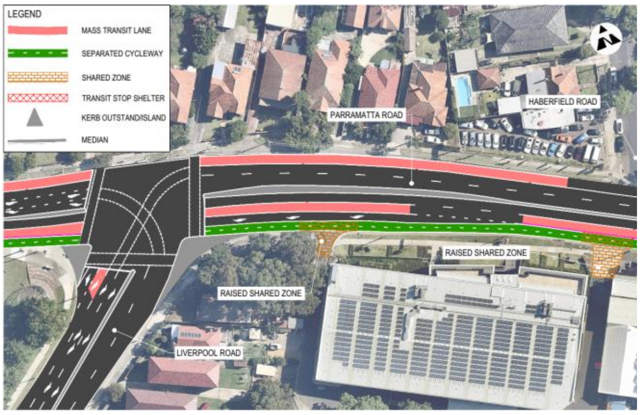
> 24 hour public transport/ mass transit lane with additional space at stops for customers;

> Plantings and car parking at mid-bock locations; and

> Separated cycle facilities (Longer term consideration).

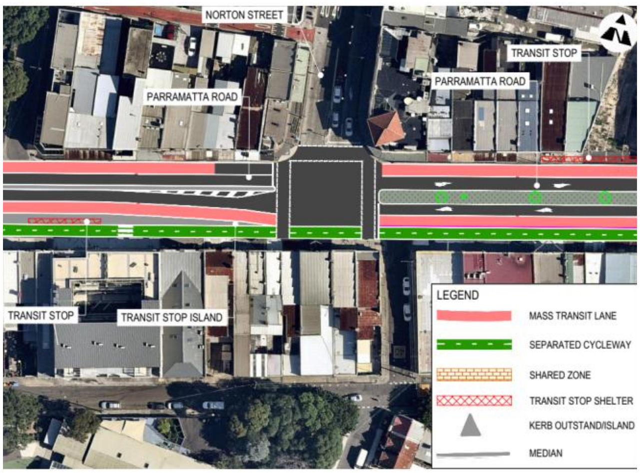
Figure 3-8 Parramatta Road concept layouts

Liverpool Road, Ashfield

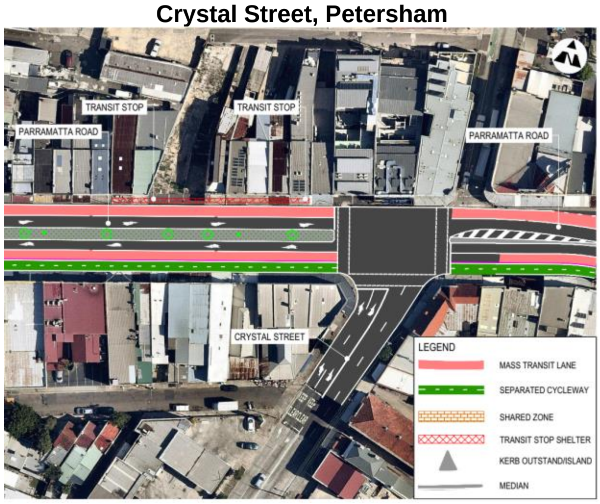


Taverners Hill Light Rail Stop

Norton Street, Lechhardt



Crystal Street, Petersham



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Pyrmont Bridge Road, Annandale

Section 3.5.2 discusses benefits and impacts associated with the various public transport/ mass transit options, including potential impacts to site access, new infrastructure required, interface with other modes, etc.

Key benefits of this layout are increasing people movement capacity with less vehicles, noise and pollution, discouraging through vehicle traffic movements, traffic calming along the PRC and encouraging the increased use of public and active transport. Increased trees/ plants and car parking provisions will improve place/ amenity and create a more vibrant place for people.

Rationale behind the layout is to:

> Provide a barrier effect and spacing for higher vehicle volume lanes along the corridor;

> Locate the cycleway on the side of the road that would likely have less interface with waiting public transport customers; and

> Provide public transport stops adjacent to or within kerbside areas. There is more overflow area and amenity than stops located in the middle of the carriageway.

To support the mass public transit link, a robust and rationalised local bus network connecting to local communities is required. TfNSW is responsible for network and service planning for public transport in NSW, including local bus routes which are responsible for connecting residential areas with high reliability collector public transport routes. These routes should be frequent during peak periods of the day. The IWC ITS proposes a grid bus network of consolidated north-south and east-west routes which Council should continue to advocate for with TfNSW.

Public transport customer experiences must be optimised through efficient interchange where required. An example of this is the potential major interchange at Taverners Hill where light rail and high capacity public transport along Parramatta Road merge. This also extends to interchange between walking and public transport services.

The actions that will help to deliver the public transport strategy are presented in **Table 3-9**.

Table 3-9 Public transport network actions

Public transport network actions	
A-PT1	Provide a 24-hour high-frequency public transport service on Parramatta Road between Parramatta and the Sydney CBD.
A-PT2	Rationalise and complete gaps in the local bus network to better support Parramatta Road which includes rationalisation of: Key east-west routes on: ▪ Parramatta Road; ▪ Ramsay Street/ Marion Street/ Booth Street; ▪ Liverpool Road; and ▪ Stanmore Road/ New Canterbury Road/ Old Canterbury Road. Key north-south routes on: ▪ Crystal Street/ Balmain Road; ▪ Johnston Street; and ▪ Dalhousie Street/ Liverpool Road/ Holden Street. This must take in consideration connectivity to the west (e.g. Parramatta activity centre) and the east (e.g. Sydney CBD), especially in the context of the future Metro route between these destinations. This includes possible link(s) to proposed Metro stations such as Burwood and possible reconfiguration of bus routes in light of the new stations around the precinct (e.g. north-south links to Metro West from Camperdown / north-south links to Five Dock).
A-PT3	Advocate for improved bus schedule to improve services across all times of the day, including: ▪ More daytime off peak connections to local centres, urban hubs and main streets; and ▪ More late night bus services servicing Newtown, Enmore, and other entertainment districts.
A-PT4	Provide public transport priority infrastructure on Parramatta road at intersections and midblock locations.
A-PT5	Enhance interchanges to ensure reliable and short duration interchange between public transport modes (bus, light rail, heavy rail and Metro).
A-PT6	Ensure all public transport services use zero emission vehicles and are net zero emissions.
A-PT7	Improve pedestrian storage, amenity and safety at major bus stops.
A-PT8	Upgrade bus stops that are missing shelter, seating, signage or TGSI, as per **Figure 3-9** and **Table 3-10**.
A-PT9	Solve the frequency limitation of the Inner West Light Rail between Dulwich Hill LRS and Dulwich Grove LRS (capacity is currently restricted due to use of a single track for both directions).
A-PT10	Consider a bus route parallel to Parramatta Road, to the north.
A-PT11	Continue to work with the state government for major public transport investment and improvements along Parramatta Road.
A-PT12	Provide north-south feeder bus services to link the T2 Inner West and Leppington Line, Parramatta Road, Inner West Light Rail and future Sydney Metro West as per **Figure 3-10**.
A-PT13	Review surface road public transport network in response to the introduction of Metro West. This includes the links mentioned in the study (between Metro West stations and the T1/T2 Heavy rail lines linking to Petersham and Redfern) but should not be limited to these two new links.
A-LU4	Provide wayfinding signage.
A-LU13	Investigate opportunities for innovative transport technology such as GETS that would inspire community confidence and act as a catalyst for revitalisation of the corridor.
A-AT6	Provide access to Taverners Hill LRS and Marion LRS from the east.

3.5.1 Bus stop infrastructure upgrades

Bus stop upgrades are subject to review by Transport for NSW and must consider any planned changes to the public transport network to prevent investment in bus stops than may become obsolete in the near future due to transport network changes.

This assessment assumes that all existing bus stops would remain, and be enhanced.

A total of 52 bus stops were analysed (one of which has been permanently closed) as shown in **Figure 3-9**. 20 bus stops provide compliant shelter, seating, signage and tactile ground surface indicators (TGSI). 30 bus stops have been recommended for upgrades.

14 bus stops in the study area lack shelter with most being along the western end of the PRC study area. Eight bus stops do not provide seating. Six bus stops lack both seating and shelter, four of which are located between Chandos Street and St Davids Road. All bus stops provide bus stop signage although only one stop did not provide service information signage. 24 bus stops lack TGSI and one bus stop has damaged TGSI require repair. TGSI should be provided for DDA compliance and with a luminescence contrast of at least 30 per cent as per AS 1428.4.1 (2009). The majority of bus stops in the Leichhardt and Camperdown precincts lack compliant TGSI.

Table 3-10 outlines bus stop upgrade opportunities for further investigation.

Figure 3-9 Bus stops opportunities for further investigation

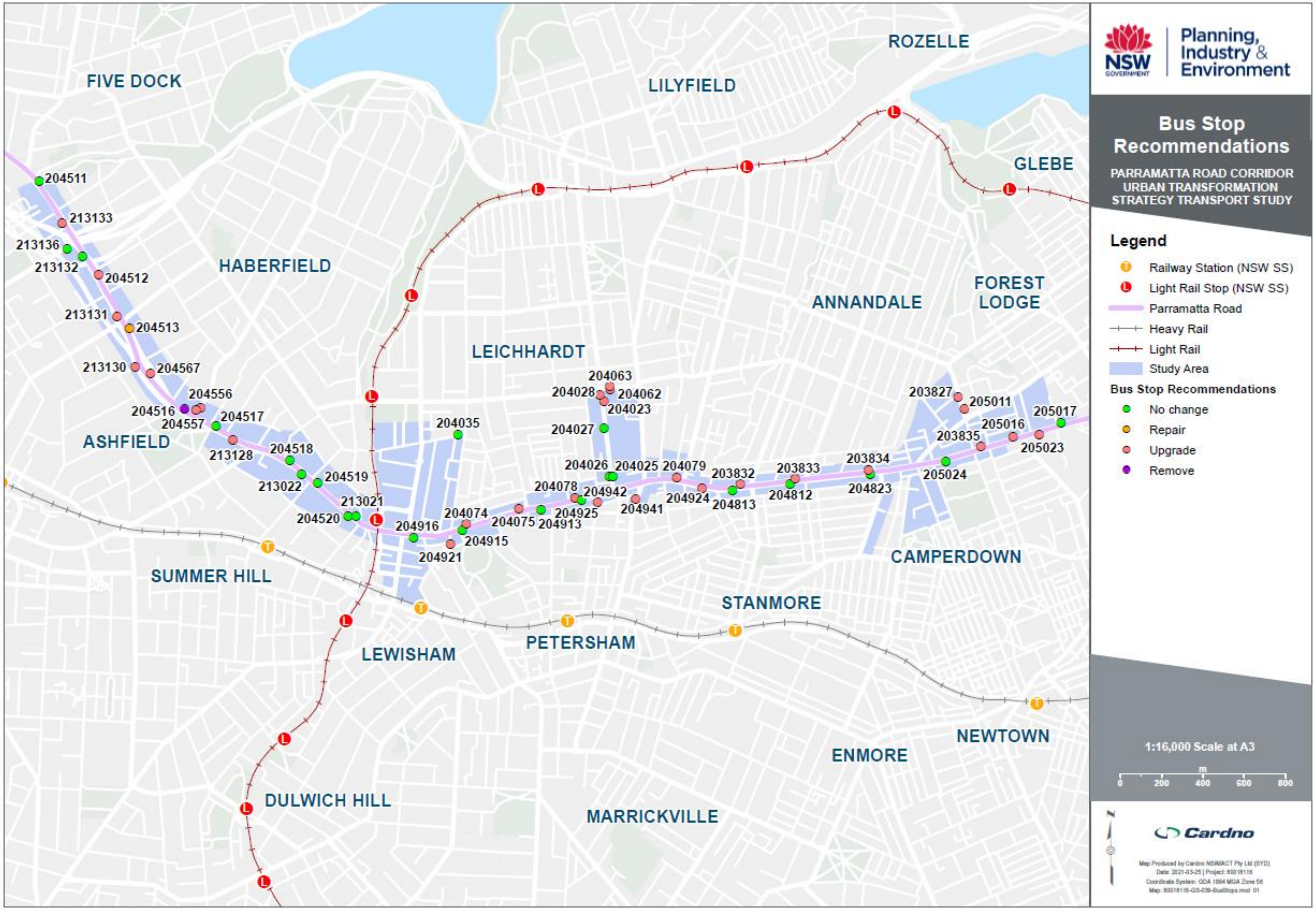


Table 3-10 Bus stop conditions and opportunities for further investigation

Stop ID	Bus Stop	Shelter	Seating	Signs	TGSI	Opportunity for further investigation	Justification	Footpath Width (m)
Taverners Hill precinct								
204511	Parramatta Road at Dobroyd Parade	✔	✔	✔	✔			3.8
213133	Parramatta Road at Earle Avenue	✔	✘	✔	✔	Install seating.	Sufficient footpath width.	3.5
213136	Frederick Street after Parramatta Road	✔	✔	✔	✔			4.0
213132	Parramatta Road before Frederick Street	✔	✔	✔	✔			3.8
204512	Parramatta Road after Walker Avenue	✘	✔	✔	✘	Install shallow bus shelter in place of bench. Install TGSI.	Footpath width narrow. TGSI required for DDA Compliance	3.2
213131	Parramatta Road at Bland Street (Westbound)	✘	✔	✔	✘	Install shallow bus shelter in place of bench. Install TGSI.	Footpath width narrow. TGSI required for DDA Compliance.	3.0
204513	Parramatta Road at Bland Street (Eastbound)	✔	✔	✔	✔	Install TGSI.	TGSI is damaged.	4.2
213130	Parramatta Road at Chandos Street	✘	✘	✔	✘	Install TGSI.	Footpath width narrow. TGSI required for DDA compliance.	2.5
204567	Parramatta Road after Chandos Street	✘	✘	✔	✘	Install shelter, seating and TGSI.	Sufficient footpath width. TGSI required for	4.0

Stop ID	Bus Stop	Shelter	Seating	Signs	TGSI	Opportunity for further investigation	Justification	Footpath Width (m)
							DDA compliance.	
204516	Parramatta Road opposite Ashfield Park	✔	✔	✖	✔	Remove bus stop provisions.	Bus stop permanently closed.	3.6
204557	Dalhousie Street at Parramatta Road	✖	✖	✔	✔	Install shelter and seating.	Sufficient footpath and verge width.	3.5
204556	Dalhousie Street before Parramatta Road	✖	✖	✔	✔	Install seating.	Sufficient footpath width. Installation of shelter may disturb adjacent property.	3.7
204517	Parramatta Road opposite Ashfield Park	✔	✔	✔	✔			3.5
213128	Parramatta Road after Liverpool Road	✖	✔	✔	✔	Install shelter.	Sufficient footpath width.	3.5
204518	Parramatta Road at Haberfield Road	✔	✔	✔	✔			3.5
213022	Parramatta Road after Sloane Street (Westbound)	✔	✔	✔	✔			3.7
204519	Parramatta Road after Sloane Street (Eastbound)	✔	✔	✔	✔			3.7
213021	Parramatta Road after Dover Street	✔	✔	✔	✔			3.5
204520	Parramatta Road at Hawthorne Parade	✔	✔	✔	✔			3.5
204916	Lewisham Hotel, Parramatta Road	✔	✔	✔	✔			3.8
204035	Lords Road at Flood Street	✖	✖	✔	✖		Drop-off only.	3.6
Leichhardt Precinct								
204921	West Street opposite Thomas Street	✔	✔	✖	✖	Provide service information signage and TGSI.	TGSI required for	3.7

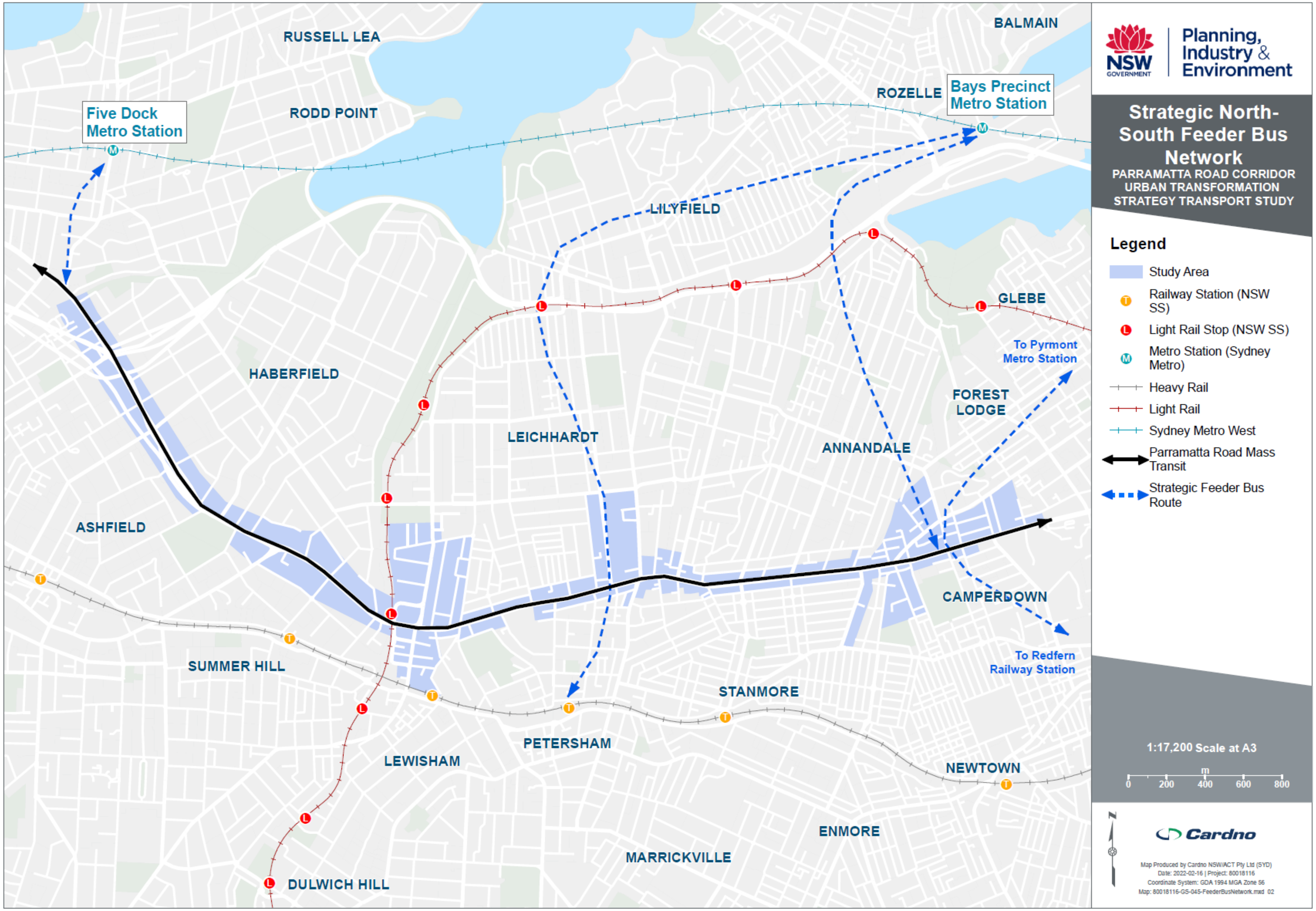
Stop ID	Bus Stop	Shelter	Seating	Signs	TGSI	Opportunity for further investigation	Justification	Footpath Width (m)
							DDA compliance. Signage board provided with shelter but no service information provided.	
204915	Parramatta Road at Park Street	✔	✔	✔	✔			4.0
204074	Parramatta Road after Flood Street	✔	✔	✔	✘	Install TGSI.	TGSI required for DDA compliance.	3.5
204075	Parramatta Road opposite Fort Street High School	✔	✔	✔	✘	Install TGSI.	TGSI required for DDA compliance.	3.5
204913	Fort Street High School, Parramatta Road	✔	✔	✔	✔			3.6
204078	Parramatta Road after Rofe Street	✔	✔	✔	✘	Install TGSI.	TGSI required for DDA compliance.	3.6
204925	Parramatta Road after Railway Street	✔	✔	✔	✔			3.9
204942	Railway Street at Queen Street	✘	✔	✔	✘	Install TGSI.	TGSI required for DDA compliance. Installation of shelter may disturb adjacent café and outdoor dining.	3.0
204026	Norton Street after Parramatta Road	✔	✔	✔	✔			2.7

Stop ID	Bus Stop	Shelter	Seating	Signs	TGSI	Opportunity for further investigation	Justification	Footpath Width (m)
204025	Norton Street before Parramatta Road	✓	✓	✓	✓			3.4
204027	Norton Street opposite Norton Plaza	×	✓	✓	✓		Installation of shelter may disturb adjacent properties and businesses.	3.4
204023	Leichhardt Public School, Norton Street	✓	✓	✓	×	Install TGSI.	TGSI required for DDA compliance.	3.6
204028	Norton Street opposite Leichhardt Public School	✓	✓	✓	×	Install TGSI.	TGSI required for DDA compliance.	3.0
204062	Leichhardt Public School, Marion Street	×	✓	✓	×	Install shelter and TGSI.	Sufficient footpath width. TGSI required for DDA compliance.	3.4
204063	Leichhardt Town Hall, Marion Street	×	✓	✓	×	Install shelter and TGSI.	Sufficient footpath width. TGSI required for DDA compliance.	3.6
204941	Crystal Street at Queen Street	×	×	✓	×	Install shelter, seating and TGSI.	Sufficient footpath width. TGSI required for DDA compliance.	3.3
204079	Parramatta Road before Catherine Street	✓	✓	✓	×	Install TGSI.	TGSI required for	3.4

Stop ID	Bus Stop	Shelter	Seating	Signs	TGSI	Opportunity for further investigation	Justification	Footpath Width (m)
							DDA compliance.	
204924	Parramatta Road before Phillip Street	×	✓	✓	×	Install shelter and TGSI	Sufficient footpath width. TGSI required for DDA compliance.	3.3
204813	Parramatta Road after Percival Road	✓	✓	✓	✓			4.0
203832	Parramatta Road before Young Street	✓	✓	✓	×	Install TGSI.	TGSI required for DDA Compliance.	3.0
204812	Parramatta Road after Northumberland Avenue	✓	✓	✓	✓			3.5
203833	Parramatta Road before Johnston Street	✓	✓	✓	×	Install TGSI.	TGSI required for DDA Compliance.	2.5
Camperdown precinct								
203834	Annandale Hotel, Parramatta Road	✓	✓	✓	×	Install TGSI.	TGSI required for DDA Compliance	2.0
204823	Parramatta Road opposite Annandale Hotel	✓	✓	✓	✓			4.3
205024	Bridge Road School, Parramatta Road	✓	✓	✓	✓			3.7
203827	Booth Street at Guihen Street	✓	✓	✓	×	Install TGSI.	TGSI required for DDA Compliance	3.6
205011	Booth Street before Pyrmont Bridge Road	✓	✓	✓	×	Install TGSI.	TGSI required for DDA Compliance	3.5

Stop ID	Bus Stop	Shelter	Seating	Signs	TGSI	Opportunity for further investigation	Justification	Footpath Width (m)
203835	Parramatta Road after Mallett Street	✔	✔	✔	✖	Install TGSI.	TGSI required for DDA Compliance	3.0
205016	Parramatta Road before Lyons Road	✔	✖	✔	✔	Install seating.	Sufficient footpath width.	3.3
205023	Parramatta Road at Missenden Road	✔	✔	✔	✖	Install TGSI.	TGSI required for DDA Compliance	2.6
205017	Parramatta Road at Larkin Street	✔	✔	✔	✔			2.9

Figure 3-10 Strategic north-south feeder bus network map



3.5.2 Transit considerations

There are numerous options available for the configuration of public transport along the PRC and study precincts. Transit considerations including advantages and disadvantages are outlined in **Table 3-11**.

Table 3-11 Transit considerations

Consideration	Advantages	Disadvantages	Commentary/ application to Parramatta Road
Service types			
Existing bus services	▪ Already implemented. ▪ Relatively easy to add more services. ▪ Is supported by bus lanes along some parts of Parramatta Road.	▪ There are finite limits to how many buses can be routed to Sydney CBD. ▪ Majority of bus fleet is diesel fuelled emitting pollutants and noise. ▪ Some parts of Parramatta Road do not have dedicated transit lanes resulting is bus delays and reduced timeliness reliability. ▪ Bus stops do not have dedicated space in the pedestrian realm and path congestion can occur	Bus passenger capacity of 50 – 60 people (standard bus) and 100 – 120 people (high capacity bus) per vehicle of existing fleet. The high number of routes along Parramatta Road can result in services bunching up, especially during peak times.
Local services (stops every 400 metres)	▪ Services a higher catchment.	▪ Slower journeys. ▪ Not attractive for longer trips.	Many of the existing bus services in the corridor operate as local services with the corresponding capacities as noted above. These are generally considered the base service that needs to be provided. Generally provided as lower frequency service and shorter routes. May be suitable for local north-south services linking to rail stations/ stops.
Rapid services (stops generally around 800 – 1,000 metres or more apart) I.e. Northern Beaches B-Line	▪ Higher average speed, more competitive than car. ▪ Tend to have a higher passenger catchment when provided as a high frequency service. ▪ High frequency services improves attractiveness and reduces transfer time penalty.	▪ Requires infrastructure to support rapid services such as dedicated road space.	Rapid services work best with dedicated road space, optimised signal timing, high capacity boarding/ alighting features such as multiple doors and fare payment at stops. Route 461 City to Burwood operates as a Rapid service between Central Station Sydney and Johnson Street Annandale and has local service characteristics between Burwood and Annandale. The capacity is typically in the 100 - 120 people range.
BRT along Parramatta Road	▪ Convenient and direct route. ▪ Encourages passenger movement along Parramatta Road. ▪ Dedicated lanes during peak periods.	▪ Requires new infrastructure to support.	Popular in North America as a means to provide faster service and increase ridership. The capacity can vary depending on the type of fleet adopted but it is generally the same as that of "rapid services".

Consideration	Advantages	Disadvantages	Commentary/ application to Parramatta Road
GETS along Parramatta Road	▪ Convenient and direct route. ▪ High vehicle capacity compared to typical buses. ▪ Supports a higher volume of passenger movement along Parramatta Road. ▪ Improved passenger safety and comfort. ▪ Able to operate in a narrow lane. ▪ Short construction timeframe or impacts due to no tracks or electric wiring. ▪ Cost-effective in comparison to traditional trams and reported greater return on investment than BRT. ▪ Boarding and alighting from multiple doors reduces dwell time. ▪ Increased accessibility due to small gaps with platform and level entry. ▪ Quiet and environmentally friendly vehicles. ▪ Higher potential for mode shift.	▪ Cost to implement compared to currently used buses in Sydney. ▪ Has not been implemented in Australia before.	Brisbane City Council are implemented the “Brisbane Metro” which has common elements with a GETS style public transport offering. Brisbane Metro will have bi-articulated vehicles that can operate along existing bus infrastructure. Each vehicle will be 24.4 metres long, 2.55 metres wide and a comfort capacity of 150 people. The vehicles will have zero tailpipe emissions and be battery electric powered.
Light Rail	▪ High capacity and frequency. ▪ Could connect with existing light rail network. ▪ Can contribute to mode shift. ▪ Typically more attractive compared to buses. ▪ Improved passenger safety and comfort. ▪ Boarding and alighting from multiple doors reduces dwell time.	▪ High cost to implement. ▪ Requires substantial permanent infrastructure changes. ▪ Long planning and construction timeframes ▪ Removes any option to “share” the road space allocated to the light rail vehicle with other modes. ▪ Requires more road width compared with other options (especially for sections of the alignment that are not straight)	A light rail network has been gradually implemented in Sydney and the PRC could be investigated as a new line to be connected to the existing network. Its implementation would be significantly more complex compared to any solution reliant on a bus fleet and attract a higher cost and longer implementation timeframe.
Routes / lines			
Parramatta Road	▪ Highly legible, direct route with relatively straight road alignment. ▪ Dedicated road space would provide the ability to move more people along the corridor	▪ Services currently get caught in general traffic congestion. ▪ Likely to require dedicated road space for high service reliability.	This is part of the PRCUTS principles.
Bus route parallel to	▪ Utilise road network away from Parramatta Road.	▪ Local roads also experience traffic congestion during peak periods.	Should be considered by TfNSW as part of the overall transport network.

Consideration	Advantages	Disadvantages	Commentary/ application to Parramatta Road
Parramatta Road	▪ Implements some service resilience for when one part of the network does not work.	▪ Catchment would vary from the Parramatta Road corridor.	
North-south feeder bus services	▪ Improved public transport accessibility. ▪ Connection between heavy rail, light rail and Metro services would improve the catchment and transport integration. ▪ Interchange between various public transport modes.	▪ Cost to implement and operate.	Can be implemented through a redesign of existing bus route.
Infrastructure treatments			
Transit Streets	▪ High quality transit helps to bring more people to a street using less space. ▪ Transit streets supported activated kerb-side uses for socialising, eating, business and rest. ▪ Transit streets fully integrate and provide for safe pedestrian and cycling infrastructure.	▪ Requires reallocation of road space from private vehicles. At planning stage, these are initially unpopular.	Transit Streets provide high transit priority compared to other streets. They are linear public spaces that combine an attractive place with high people movement by transit vehicles. Transit street principles can be read here: https://nacto.org/publication/transit-street-design-guide/transit-streets/transit-street-principles/
Kerb-side transit lanes	▪ Easy access to services from the footpath. ▪ General through traffic has less conflicts and higher average speeds.	▪ Can preclude kerb-side car parking or precluded at peak-times when lane is operating. ▪ Careful review is required to ensure kerbside infrastructure is sufficiently spaced from active traffic lane. ▪ If stops are located on the intersection approach, there are conflicts with left turning traffic. ▪ General traffic for locality access must seek parking off main corridor.	Useful when general vehicle traffic function is for through movements.
Offset transit lane. (Transit lane is generally one lane out from kerb)	▪ Kerbside can be used for planting, bicycle/ micro-mobility or car parking. ▪ Supports shared used of local and rapid services. Bus stops can be provided on kerb-side to allow rapid/ express buses to overtake local services. ▪ Left turn lanes can be provided in kerbside lane reducing delays to transit vehicles. .	▪ High parking turn-over can delay transit vehicles. ▪ Right turns need special consideration and treatment, i.e. allowing filtered right turn would cause delays to transit vehicles.	This could be used to prioritise mass transit while still providing kerbside parking. This would also support both local and rapid mass transit services along the corridor.
Centre-running transit lanes	▪ Enables the kerb-side traffic lane to be managed for short-term parking outside of	▪ Major redesign of Parramatta Road due to reallocation of road space and	Provides a high priority and higher speed transit link with reduced conflict points.

Consideration	Advantages	Disadvantages	Commentary/ application to Parramatta Road
	peak periods which buffer pedestrians from traffic. ▪ It is easier to provide a longer centre stop. ▪ Crossing across street can be broken up into shorter parts between the kerb side and centre stop. ▪ Provides better access for turning vehicles. ▪ Dedicated lanes can be utilised by light rail later if preferred. ▪ Provides greater traffic demand management options.	construction of platforms and transit stops. ▪ More pedestrian crossing facilities required. ▪ Pedestrians wait/ queue in the middle of the carriageway, which can be noisy and exposed. ▪ Space required on carriageway at stops for boarding and alighting.	Useful when general vehicle traffic function is serving local access and needs.
In lane stops	▪ Transit vehicles do not need to manoeuvre into stops. ▪ In mixed traffic lanes, transit vehicle does not need to pull out back into moving traffic.	▪ Does not allow other transit vehicles to overtake stopped vehicles i.e. Rapid overtaking Local service.	These are suitable when there is only one bus line on a dedicated corridor with consistent stopping patterns. If local and rapid transit is mixed, this would not be optimal.
Stops upgraded to stations	▪ Clearly identifiable in an urban environment providing an anchor in the community and sending a clear signal to land developers. ▪ Can be used as a tool to consolidate several stops to improve transit times. ▪ Can be used in a package to reduce alighting/ boarding time.	▪ Higher cost. ▪ Requires customers to walk further for access for Rapid routes.	Stations have clearly defined elements including shelter, seating, real-time displays and are clearly identifiable. They can also be designed to be integrated with co-located bicycle parking, bicycle and car share. They can be used to balance a trade-off in walking time for a high quality, high frequency service. This would provide a clear signal to developers of government support of high quality transport to support increasing population and employment.
Short intersection signal cycles	▪ Improves opportunities for cross corridor access, particularly for active transport modes. ▪ Can better support public transit with unpredictable dwell times at stops.	▪ Trades off through general vehicle movement capacity on main corridor. ▪ Can result in more vehicle stops.	Parramatta Roads role as a key vehicle movement corridor would need to be reassigned to a transit corridor and realigned to a vibrant place and key people movement corridor through less but high capacity vehicles.

While the final configuration and transit solution is subject to the investigation by Transport for NSW, it is expected that the considerations, advantages and disadvantages summarised above will influence the option assessment and selection process. Any option or combination of options from the above table may be suitable for the PRC provided the chosen configuration achieves the following outcomes:

- Safety;
- Place-making benefits;
- High capacity;
- High frequency;
- Reliability;
- Travel time efficiency; and
- Streetscape improvements.

In order to help achieve the vision for the PRC of a vibrant street with a high movement function, it is expected that an option such as the reconfiguration of local services to rapid services, BRT or GETS will be required to capture the efficiencies documented above, improve attractiveness, reliability and general speeds. Light rail is likely to present challenges difficult to overcome both from an implementation cost and road width perspectives.

A centre-running solution is likely to cause more disruption to other modes (especially at intersections) and would be more suited or justifiable for a GETS or light rail option. Kerb-side options are likely to present greater flexibility for a more conventional bus rapid transit option and also offer alignment with other services already present in Sydney (e.g. Northern Beaches B-Line). Further work is required to understand the “triggers” for a particular transit solution to be adopted over the other (e.g. patronage or other multi modal metrics) and/or to develop an infrastructure staging strategy.

3.6 Road network

The WestConnex project is a catalyst for urban renewal on the PRC, with significant opportunities to enhance local amenity by reducing through-traffic on surface roads and improve connectivity in north and south directions.

The road network supports both movement and place through a range of functions including regional through movements, local access and places for people to meet and conduct business. The future road network should reflect and promote the following functions and trip types:

- Shorter length trips (less than two kilometres): Walking or cycling is the first choice because it is quick, safe and comfortable.
- Medium length trips (two to ten kilometres): Mass transit on the Parramatta Road and the Inner West train line are suitable, except for trips that require goods or people storage which is more suited to a private vehicle.
- Longer length trips (more than ten kilometres): Driving on WestConnex to access regional places, the Inner West train line and the PRC mass transit is suitable.

These road user functions would be enhanced with the prioritisation of people movement as depicted by the concept PRC layouts from the IWC ITS Parramatta Road Revitalisation project idea. This layout prioritises and improves efficiency and safety for public and active transport, as well as north-south access for vehicles. This is supported with car share provisions.

Crashes within the PRC precincts need to reduce in both number and severity, particularly those resulting in fatality or serious injury. The opening of the WestConnex M4-M5 Link tunnels will provide an attractive alternate route for high moving vehicle traffic and heavy vehicles, reducing the amount of through traffic using the PRC. However a number of crash clusters must be investigated and addressed within the three Precincts, including those described in the Transport context report.

The actions that will help to deliver the road network strategy are presented in **Table 3-12**.

Table 3-12 Road network actions

Road network actions	
A-R1	Undertake public domain improvements, including: ▪ Conversion of Petersham Street to a pocket park between Parramatta Road and Queen Street.
A-R2	Reallocate road space on Parramatta Road to prioritise the movement of people.
A-R3	Investigate crash clusters at the following locations: ▪ Parramatta Road between Wolseley Street and Wattle Street; ▪ Parramatta Road between Brown Street and Flood Street; ▪ Parramatta Road between Norton Street and Macquarie Street, and Crystal Street between Parramatta Road and Elswick Street; ▪ Parramatta Road between Australia Street and Bridge Road; ▪ The intersection of Parramatta Road and Liverpool Road; and ▪ The intersection of Parramatta Road, Northumberland Avenue and Johnston Street.
A-R4	Consider reduced speed limits with priority for mass transit
A-LU-8	Consider temporal changes where regular road closures of low volume streets could be used for activation by outdoor dining, street markets and active travel.
A-LU12	Consider the environmental impacts of materials used, and the heat island effect.
A-LU13	Investigate opportunities for innovative transport technology such as GETS that would inspire community confidence and act as a catalyst for revitalisation of the corridor.
A-AT8	Provide continuous footpath treatments along Parramatta Road as per **Figure 3-4**, **Figure 3-5** and **Figure 3-6**.

3.6.2 Private Vehicle Demand and mode Shift

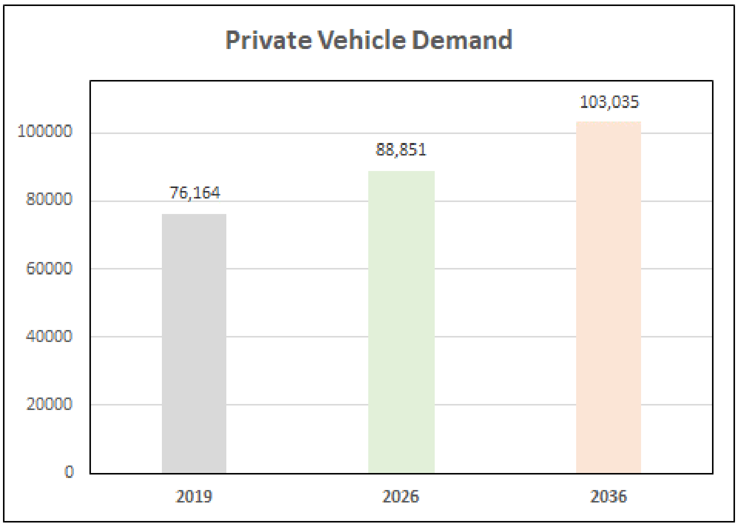
As the vision for the precinct prioritises people movement, sustainable transport options and the place function throughout the PRC and adjacent areas, it is important to quantify the mode shift expected to take place from private vehicle to other modes but also how the forecast traffic volumes can be accommodated on the road network.

Extensive strategic modelling was undertaken by Transport for NSW using PTPM. This included an iterative process to help quantify the number of private vehicles that can be accommodated by the network and consequently, how many tris must be converted to other modes. This is done via the application of the Precinct Parking Module (PPM) which applies additional travel costs to the private vehicle mode to reduce its utility and reflect capacity constraints not otherwise accounted for. It was determined that PPM15 should be applied to the study area (as opposed to the default PPM0 level).

While PTPM modelling only allows assessing AM peak operation and it excludes walking and cycling trips, it provides an indication on the estimated number of trips by mode for the 2026 and 2036 future year scenarios based on the land use forecasts.

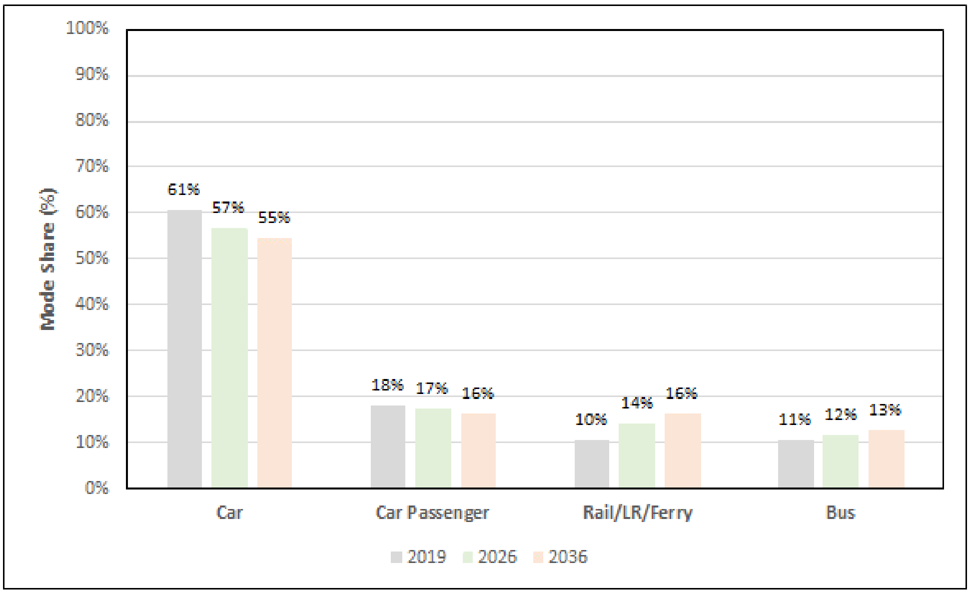
An analysis of PTPM outputs (with PPM15 factor applied) indicates that total AM peak private vehicle demand in the study area is expected to increase from 76,164 vehicles in 2019 to 88,851 vehicles in 2026 and 103,035 vehicles in 2036. This is shown in **Figure 3-11**.

Figure 3-11 PTPM AM Peak Total Demand in the Study Area



As shown in **Figure 3-12**, the PTPM model outputs (with PPM15 penalty applied) indicate that the "private vehicle – driver" mode share is required to reduce from circa 61 per cent in 2019 to 55 per cent by 2036. The "private vehicle – passenger" mode share is required to reduce from circa 18 per cent in 2019 to 16 per cent by 2036. These mode share ranges provide guidance on the targets that must be established to ensure that the changes in land use can be accommodated by the road network. These should be supported by interventions that encourage the gradual transition to sustainable modes such as walking, cycling and public transport.

Figure 3-12 PTPM Mode Share Outputs



The model is reflective of committed road and public transport upgrades. Any interventions to enhance public transport servicing are expected to contribute to an increase to the corresponding mode share. That is, the number of public transport trips assumed in the model is expected to increase as improvements to public transport infrastructure are confirmed and delivered.

In summary, this transport plan has been prepared to develop a series of transport-based initiatives necessary to achieve the PRCUTS Vision of:

"Incremental renewal of the Corridor will occur over the long term to deliver a high quality, multi-use corridor with improved transport choices, better amenity, and balanced growth of housing and jobs."

In order to achieve this Vision, it will be essential to implement a comprehensively integrated approach to transport, public domain, land use and urban design. An important first step in this process is the establishment of measures which will encourage a mode shift away from private car use and so creating a more "liveable" environment in the Corridor.

While the modelling carried out in association with this plan is driven predominantly by traffic-based circumstances, it is considered to provide an adequate baseline for the establishment of mode share targets for the three Inner West Precincts. Based on this modelling it will be essential to achieve a minimum mode shift in private car use (driver and passenger combined), from 79 per cent in 2019 to 71 per cent in 2036 (a 10 per cent reduction of existing car use).

However, noting that this mode shift is required purely to achieve acceptable movement along the corridor, to achieve the desired liveability, PRCUTS proposes a 30 per cent mode shift away from private car use, as an average improvement across the three Inner West Precincts. Consequently, this Plan’s key mode shift target is to reduce private car use by a minimum of 10 per cent, and up to 30 per cent between 2019 and 2036.

3.6.3 Road network upgrades

A bespoke operational model was developed in Aimsun to help understand future year (2026 and 2036) network operation with the traffic demand forecasted by the strategic models and corresponding mode shift. In general, the model shows that the road network can accommodate modelled growth despite congestion being observed on several parts of the network. Some intersection improvements would help improve the efficiency of the road network and several of these possible treatments were tested in Aimsun with the corresponding improvements in level of service / delay quantified in the supporting *Future Modelling Report*. However, the interventions tested are predominantly based on a traffic operation improvement perspective and may not reflect the shared nature of the different urban environments. Changes to intersections need to be considered not just in terms of the vehicle movements but also active transport, public transport and place outcomes. The funding mechanisms for road upgrades / infrastructure contributions will need to be agreed by Council and DPIE.

3.7 Freight

Freight supports thriving and healthy communities by providing goods and services. Efficiency of freight and servicing is often challenged by built form barriers such as lack of safe and separated routes and loading spaces. Safety of other road users is impacted when there is lack of physical and temporal separation of heavy vehicles.

Factors that influence freight and servicing include:

> Balance between movement and place for evolving urban settings;

> Increasing populations resulting in increased freight demand, particularly affecting last mile delivery;

> Changing consumer demands including higher demand for ad-hoc deliveries (which may offset some private trips);

> Increased construction activity resulting in increased demand for larger vehicles; and

> Emergence of alternative vehicles for the delivery of goods and people such as bicycles, scooters, autonomous vehicles and drones.

Key planning principles that aim to maximise performance and benefits for the freight network within the PRC are:

> Design and management of loading facilities should directly reflect the land use and the place making objective of the building or precinct.

> Loading facilities and freight and service vehicle management should be prioritised in the initial design of a new development to maximise amenity and place.

> New buildings and precincts should be self-sufficient and not rely on kerbside loading zones to support their freight demand.

> Optimisation of kerbside activities in the following ways:

  - Appropriate kerbside hierarchies;
  - Time of day demand and kerbside designation;
  - Short-term parking;
  - Evening and overnight loading zones;
  - Parking management systems;

- Role of side streets; and
- Provision of different types of space.

Actions supporting the future freight network are presented in **Table 3-13**.

Table 3-13 Freight network actions

Freight network actions	
A-F1	Larger development controls to ensure the following: ▪ New development should be self-sufficient for loading and servicing, without relying on on-street parking zones to support their freight demand; and ▪ Loading facilities in new development should directly reflect the land use and place making objective of the building or precinct. The development controls will likely need to be tailored to the various development types and sizes. Development size triggers should be investigated
A-F2	Review and consolidate on-street loading/ service zones through the following methods: ▪ Time of day demand and kerbside designation; ▪ Provision of short-term parking in appropriate areas; ▪ Evening and overnight loading zones; ▪ Centralised waste pick-up points; ▪ Parking management systems; and ▪ Side street parking.
A-F3	Review and rationalise waste vehicle movements servicing Parramatta Road.
A-F4	Prohibit or limit delivery access during peak pedestrian activity periods.

3.8 Parking

In order to encourage ready use of more sustainable transport It is proposed that Council's new development control plan should establish maximum, rather than minimum rights of on-site parking provision. The following recommendations are extracted from the supporting Parking Note: *Parking policy and rate review: Camperdown, Leichhardt and Taverners Hill*.

Parking space adaptability recommendations:

> Prepare design guidelines that include development requirements for car parking which supports adaptive reuse of parking areas for future development.

> Consider changes to parking policies that allow for off-site communal parking (e.g. unbundled from individual developments, managed to recognise the temporal variations in parking demand for different land use types and in so doing provide opportunities to share spaces where appropriate)

Car share recommendations:

Assist and support the location of car share spaces adjacent to dense residential development. Encourage on-site car share for residential and business developments, particularly where parking construction costs would impose high costs on tenants and reduce affordability.

Electric vehicle recommendations:

> As the EV fleet grows, market forces will govern the installation of EV charging units. Policy measures including community title for parking facilities, unbundled and decoupled supplies can be used to provide flexibility for developers and residents, and thereby reduce the opportunity cost of installation.

> Electric vehicle charging points should be provided in off-street locations in the same way petrol stations are off-street for a range of safety and amenity reasons.

> Introduce development requirements to ensure all high-density residential development has access to EV charging bays for new applications. This should include provision of conduit to allow residents to reticulate power to individual bays, and to ensure electrical infrastructure is sized to support a charging demand.

> Introduce development requirements to ensure slow-charge EV charging points are provided for a percentage of long-stay employee parking (~10%, increasing as demand rises).

> Introduce development requirements to ensure future ability to supply EV charging points at a minimum of 50% of total bays.

> Policy support for conversion of public off-street parking spaces to EV fast-charging, through an expedited approval process.

Bicycle recommendation:

Given the current journey-to-work cycling mode share of less than one per cent, and with the assumption that increasing bicycle mode is consistent with Council objectives**, a minimum bicycle parking rate to satisfy 2.5 per cent of employee mode share**, plus additional spaces for visitors/ customers. This creates capacity for additional bicycle mode share.

Bicycle parking demand should be monitored in the locality and Council should host find or request a new bike parking space on their website.

Motorcycle recommendation:

Motorcycle parking should be provided for at a minimum of 1 space per 1,500sq.m of employment land use, with a minimum of one space where on-site parking is provided.

Servicing, delivery and loading recommendation:

Site loading and servicing facilities are provided on site, appropriate to the size and scale of the development.

Driveway recommendation:

To minimise conflict with pedestrians and streetscape impacts, the number of driveways should be minimised, with no more than one per site and where possible opportunities for the use of single driveways by multiple sites should be examined.

Residential parking recommendations:

The PRCUTS residential parking rates represent a significant reduction in on-site parking, compared with existing ownership behaviour. It is recommended that these rates be employed only where effective parking management mechanisms are in place for surrounding public parking provision.

The alternative maximum parking rates are considered feasible for implementation without substantial interventions, while still representing a substantial downward pressure on private parking supply.

Land use	Bedrooms	Stage 1 Alternative maximum parking rates (consistent with existing transport environment)	PRCUTS maximum rate recommendations (with improved transport environment)
House	1	1.0 per house	0.3
	2	1.0 per house	0.7
	3+	1.0 per house	1
Apartment	0	0.15	0
	1	0.5	0.3
	2	1.0	0.7
	3+	1.2	1
	Visitor	0.1 space per dwelling, unless this can be provided on-street.	0

Residential parking permits recommendation:

Expand the residential permit scheme and price permits at a rate consistent with the opportunity cost of parking infrastructure, with a transition period to support behaviour change by residents.

(Key) Non-residential land use parking recommendation:

The PRCUTS recommended parking rates are considered to be appropriate under the future public transport provisions identified in the PRCUTS Plan. A series of alternative parking rates has been identified which would be sustainable even without significant capital works upgrades of public transport.

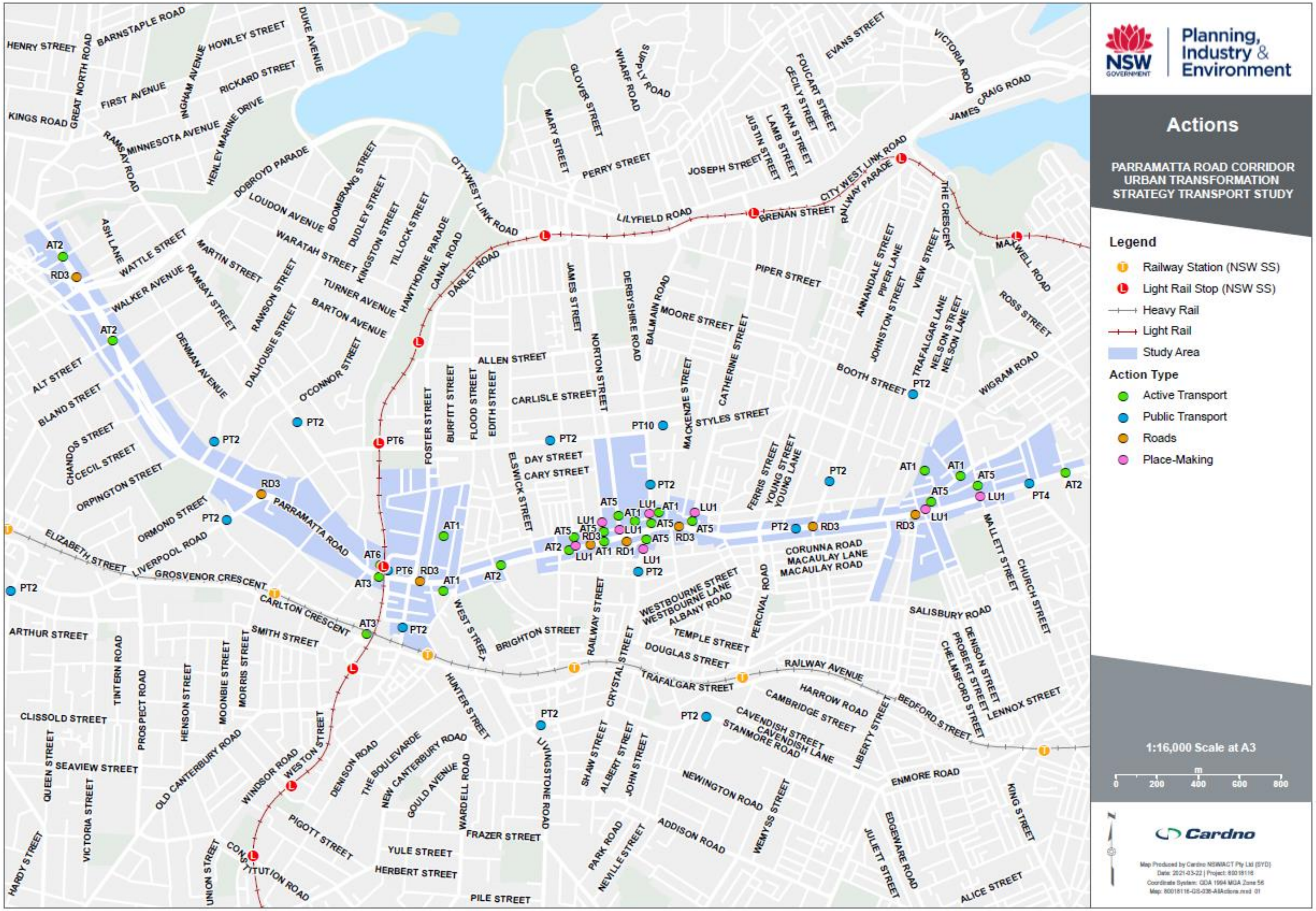
Land use	Stage 1 Alternative maximum parking rates (consistent with existing transport environment)	PRCUTS maximum rate recommendations (with improved transport environment)
Student housing/ Boarding house	0.15 space per dwelling	No recommendation
Health/ Medical centre	2 spaces per consulting room	No recommendation
Hospital	Parking assessment as part of development application	No recommendation
Commercial/ office	1 space per 100 sq.m. (1.00 spaces/ 100sq.m) of floor area	1 per 150sq.m (0.67 space/ 100sq.m)
Retail/ shop	1 space per 50sq.m (2 spaces/ 100sq.m) of floor area.	1 per 100sq.m.
Restaurant	1 space per 50sq.m (2 spaces/ 100sq.m) of floor area	1 per 100sq.m.
Bulky goods	1 per 100sq. Must include an off-street loading zone for customer pick-up..	No recommendation
Industrial	1 per 150sq.m (0.67 space/ 100sq.m)	1 per 150sq.m (0.67 space/ 100sq.m)
Out of centre uses along the Parramatta Road corridor	General rate (Not a maximum): 1 space per 40 square metres (2.5 per 100 square metres)	Differentiated by suburb only.

The actions that will support the parking strategy are presented in **Table 3-14**.

Table 3-14 Parking actions

Parking actions	
A-Pa1	Reduce on-site car parking provision for both origin and destination parking.
A-Pa2	Implement the recommended parking rate and adopted PRCUTS recommendations after notable public transport improvements are committed.
A-Pa3	Provide opportunities for kerbside parking on Parramatta Road outside of peak periods.
A-Pa4	Ensure any new off-street car parking is designed with consideration of adaptive re-use so that these structures can be used for alternative purposes in both the short and long term.
A-Pa5	Introduce unbundled parking for new developments so that multiple users can utilise a single parking space, controlled by likely time of use.
A-Pa6	Establish temporal recognition of demand and provide access to parking in response i.e. parklets on weekends, use of off-street car parks for community spaces such as markets on some weekends.
A-LU9	Consider use of existing off-street car parks as market places or community “nodes”.

Figure 3-13 Actions



4 Implementation plan

To achieve the strategic transport vision, 8 actions have been proposed for the IWC Precincts that address the transport issues and opportunities. These are summarised in **Table 4-1**.

4.1 Timeframes and feasibility

Actions have been assigned an indicative time frame associated with its strategic importance, providing the most impact, and feasibility. Feasibility of proposed actions was determined via criteria relating to funding opportunities such as through development contributions, and alignment with strategic plans.

4.2 Costing and Responsibilities

Pedestrian and cycling infrastructure actions have associated costs based on unit rates and are provided in **Table 3-8**. The funding mechanisms for road upgrades / infrastructure contributions will require discussion and agreement by Council and DPIE. Each action has been assigned responsibility (which are subject to change) for planning and funding, for the following three stages of project program:

> Planning/ designing;

> Construction/ implementing; and

> Maintenance and monitoring.

Table 4-1 Implementation plan

Item	Description	Action	Lead	Timeframe
1	Parking controls	Council to refine and implement parking recommendations through its Development Control Plan aligned with planning proposal to implement PRCUTS	Council and DPIE	Short term
2	Local road improvements *	Council to refine recommended local road improvements through local infrastructure planning and detailed design	Council and DPIE	Short to medium term
3	State road improvements *	TfNSW to refine recommended state road works through TfNSW's road network planning and detailed design	TfNSW	Short to medium term
4	Public Transport improvements	TfNSW implement enhanced public transport solutions through service planning and project business Cases	TfNSW	Short to medium term
5	Local bicycle network and public domain improvements	Council to refine and implement cycle path recommendations through it's capital works and local contributions plans. Opportunities exist for other funding mechanisms.	Council and DPIE	Short to medium term
6	Bicycle network improvements on state roads	TfNSW to implement bicycle network improvements on state roads through infrastructure planning and detailed design and subject to comprehensive Council and community consultation.	TfNSW	Short to medium term
7	Footpath improvements on local roads	Council to refine and implement pedestrian improvements to local roads as part of it's capital works and local contributions plans	Council and DPIE	Short to medium term
8	Footpath improvements on state roads	TfNSW to implement place based recommendation for state roads as part of project business cases	TfNSW	Short to medium term

** road widenings along state and local roads to improve traffic flow and through traffic capacity are not supported on the grounds that these are contradictory to the overarching vision of this report and Parramatta Road Corridor Urban Transformation Strategy. Any state or local road improvements should be focused on improving public transport accessibility and enhancing public domain for attractiveness of walking and cycling only.*

5 Monitoring and review

The monitoring and review of the Transport Plan actions, and reporting against its guiding principles, is a crucial element of implementation. Council and DPIE should review the implementation plan at 5 year intervals and decide if any further transport analysis is required to align with planning horizons (2026, 2031 and beyond).

To assess progress towards achieving the Transport Plan guiding principles in alignment with PRCUTS, a series of performance indicators as extracted from PRCUTS and their recommended targets are shown in **Table 2-2**.

The Transport Plan should also be reviewed and updated following the completion of WestConnex Stage 3 in 2023.

About Cardno

Cardno is a professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage and deliver sustainable projects and community programs. Cardno is an international company listed on the Australian Securities Exchange [ASX:CDD].

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