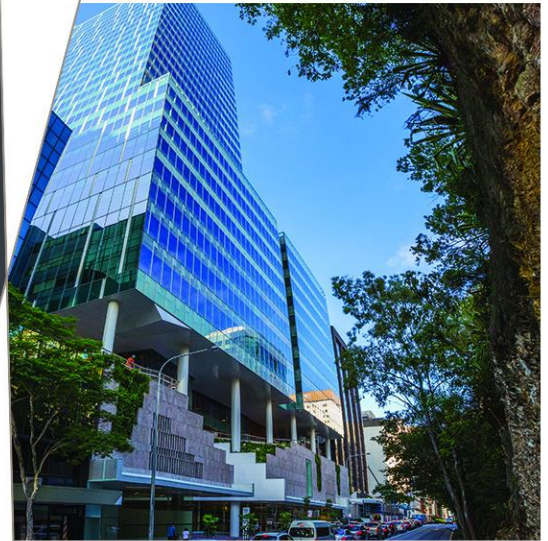


Traffic and Transport Plan

Willoughby Local Centres

80020036



Prepared for
Willoughby City Council

17 January 2020

Contact Information

Cardno (NSW/ACT) Pty Ltd

ABN 95 001 145 035

Level 9 - The Forum

203 Pacific Highway

St Leonards NSW 2065

Australia

www.cardno.com

Phone +61 2 9496 7700

Fax +61 2 9439 5170

Document Information

Prepared for Willoughby City Council

Project Name Willoughby Local Centres

File Reference 200117 Draft Report.docx

Job Reference 80020036

Date 17 January 2020

Version Number 3

Author(s):



Rusiru Wanasinghe / Lukas Labutis
Graduate Transport Planner / Senior Transport
Planner

Effective Date 17/01/2020

Approved By:



Chris Slenders
Transport Planning Team Leader

Date Approved 17/01/2020

Document History

Version	Effective Date	Description of Revision	Prepared by	Reviewed by
1	13/11/2019	Stage 1 summary	Rusiru Wanasinghe Lukas Labutis	Chris Slenders
1.1	19/11/2019	Results for all local centres included	RW / LL	Chris Slenders
2	30/11/2019	Draft report	RW / LL	Chris Slenders
2.1	05/12/2019	Appendices and 75% development results added	RW / LL	Chris Slenders
3	17/01/2020	Final report	RW / LL	Chris Slenders

© Cardno. Copyright in the whole and every part of this document belongs to Cardno and may not be used, sold, transferred, copied or reproduced in whole or in part in any manner or form or in or on any media to any person other than by agreement with Cardno.

This document is produced by Cardno solely for the benefit and use by the client in accordance with the terms of the engagement. Cardno does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by any third party on the content of this document.

Our report is based on information made available by the client. The validity and comprehensiveness of supplied information has not been independently verified and, for the purposes of this report, it is assumed that the information provided to Cardno is both complete and accurate. Whilst, to the best of our knowledge, the information contained in this report is accurate at the date of issue, changes may occur to the site conditions, the site context or the applicable planning framework. This report should not be used after any such changes without consulting the provider of the report or a suitably qualified person.

Executive Summary

Purpose

Willoughby City Council engaged Cardno to prepare a Traffic and Transport Plan to support the *Willoughby Local Centres Strategy*. The purpose of this study is to assess the existing and future transport networks of each local centre identified for future development within the strategy, and demonstrate how residential and employment growth can be accommodated by the transport networks.

The study includes a high level review of the pedestrian, cycling, public transport and private vehicle networks in the immediate vicinity of each centre, accompanied by SIDRA intersection modelling of the road network. Issues, gaps and deficiencies of the networks are identified and a range of options to address these are considered.

The following centres were assessed, each with a corresponding section in this report:

1. Artarmon;
2. Castlecrag;
3. East Chatswood;
4. High Street;
5. Naremburn;
6. Northbridge;
7. Penshurst Street; and
8. Willoughby South.

The *Willoughby Local Centres Strategy* provides a framework to guide development and growth for each local centre over the next 20 years. The Willoughby Local Government Area (LGA) currently has a population of approximately 78,000 residents and is forecast to reach approximately 91,800 residents in 2036, as well as to accommodate significant increases in employment.

Transport vision

The transport vision for the local centres is to provide walkable, well-connected local centres with high quality active and public transport links to encourage high density development within each centre and accommodate the forecast residential and employment growth. The aim is to facilitate successful people and place experiences within each centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists in alignment with the *Local Centres Strategy*.

The recommendations identified in this study aim to propose improvements to achieve this vision and improve the place experience as well as accommodate additional demand and movement.

Existing conditions

The local centres have established transport networks, however, there are numerous issues, challenges and opportunities for improvement, particularly to encourage liveable and vibrant centres in line with the vision of the *Local Centres Strategy*. Some of the key issues include:

- > A lack of pedestrian crossing opportunities and potential for vehicle-pedestrian conflict;
- > Gaps and deficiencies in the cycling network;
- > Insufficient threshold / gateway treatments to support high pedestrian activity environments;
- > Poor public transport connectivity / availability in some areas;
- > Non-compliant kerb ramps and lack of provision for accessibility; and
- > A focus on private vehicles and intersection performance over pedestrian amenity and experience.

The existing conditions of each centre are reviewed and detailed in the corresponding sections of this report.

SIDRA intersection modelling was undertaken to assess the existing performance of the road network at each local centre, and the following issues were identified:

- > **Artarmon:** the intersections of Hampden Road / Brand Street and Hampden Road / Francis Street operate near capacity in most peak periods, generally operating at Level of Service (LoS) D;

- > **Castlecrag:** the intersection of Edinburgh Road / Eastern Valley Way operates at capacity in the weekday AM peak (LoS F), and near capacity in the weekday PM and Saturday peaks (LoS D);
- > **East Chatswood:** the intersection of Victoria Avenue / Penshurst Street operates at capacity in the Saturday peak (LoS F), and near capacity in the weekday PM peak (LoS D);
- > **Penshurst Street:** the intersection at Mowbray Road / Willoughby Road operates near capacity in the weekday PM peak (LoS D); and
- > **Willoughby South:** the intersections of Willoughby Road / Harris Street and Willoughby Road / Julian Street operate at capacity (LoS F) in all peaks.

Other intersections generally operate satisfactorily with spare capacity, and no issues were identified at High Street, Naremburn or Northbridge.

Future conditions

Potential improvement options were recommended for each local centre to address issues identified as part of the existing conditions analysis, as well as to generally improve experience and amenity. Recommendations were high level and focused on active and sustainable transport, in alignment with the transport vision for the local centres.

Key recommendations were focused on the following:

- > Implementing reduced speed limits and / or shared zones where appropriate to improve safety;
- > Introducing threshold / gateway treatments to promote safe and amenable local centre road networks;
- > Improving compliance and accessibility of pedestrian crossings, footpaths and kerb ramps;
- > Providing bicycle infrastructure to fill gaps, implement continuous and convenient cycling networks and accommodate cycle parking demand;
- > Advocating for Transport for NSW (TfNSW) to review and optimise bus routes and service frequencies;
- > Minor reconfigurations to the road network to improve intersection performance and address safety concerns; and
- > Revising parking restrictions to better serve surrounding land uses and accommodate parking demand without providing additional parking.

Traffic generation of the proposed future developments was estimated in accordance with former Roads and Maritime guidelines and used to inform the SIDRA modelling of the future 2036 With Development scenarios. Key findings of the future modelling without any mitigation measures included the following:

- > **Artarmon:** deteriorated performance at the intersections of Brand Street, Francis Road and Broughton Road with Hampden Road, generally operating at LoS F;
- > **Castlecrag:** poor performance of the Edinburgh Road / Eastern Valley Way intersection in line with the 2019 existing base model;
- > **East Chatswood:** deteriorated performance at all intersections, including LoS F at Victoria Avenue / Penshurst Street in the Saturday peak, LoS E at Penshurst Street / Macmahon Street in the weekday PM peak and LoS D at Victoria Avenue / Royal Street in the weekday PM peak;
- > **Naremburn:** minor deterioration of performance at the intersection of Willoughby Road / Merrenburn Avenue to LoS D in the weekday PM peak;
- > **Northbridge:** minor deterioration of performance at the intersections of Sailors Bay Road / Eastern Valley Way to LoS D in the weekday PM and Saturday peaks, as well as Sailors Bay Road / Harden Avenue to LoS D in the weekday PM peak;
- > **Penshurst Street:** deterioration of performance at the intersection of Penshurst Street / Mowbray Road to LoS D in the weekday PM and Saturday peaks, as well as Mowbray Road / Willoughby Road to LoS F in the Saturday peak; and
- > **Willoughby South:** poor performance at the intersection of Willoughby Road / Harris Street in line with the 2019 existing base model, and minor deterioration of performance at the intersection of Willoughby Road / Frenchs Road to LoS D in the Saturday peak.

Although a range of issues were identified, the results should be considered with the following factors:

- > Many issues identified are consistent with the 2019 existing base models, with either consistent performance or a minor deterioration;
- > Background traffic growth was included and is a key driver of future performance compared to the proposed development;
- > Intersection performance at LoS D is acceptable and signifies the intersection operates near capacity, and typically at these intersections all vehicles are able to clear the intersection within one signal cycle;
- > Mitigation measures are expected to improve the performance at some local centres, including Artarmon and Willoughby South; and
- > The local centres assessed are likely situated in the best locations within the LGA for future development as they are well connected to public transport services, and offer a range of services and land uses within walking distance, minimising the potential traffic impact.

Recommendations to address the issues identified, as well as proposed general improvements to the transport networks, are provided in each section of this report.

Table of Contents

1	Introduction	1
	1.1 Background	1
	1.2 Traffic and Transport Plan purpose	2
2	Strategic context	4
	2.1 Strategies and community plans	4
	2.2 Current travel behaviour	6
	2.3 Proposed land use changes	9
3	All Centres	10
	3.1 Existing transport networks	10
	3.2 Existing parking analysis	10
	3.3 Parking requirements	11
	3.4 Trip generation	11
	3.5 Traffic modelling	12
	3.6 Recommendations	13
4	Artarmon	14
	4.1 Land use	14
	4.2 Existing transport networks	16
	4.3 Future transport network review and recommendations	32
5	Castlecrag	43
	5.1 Land use	43
	5.2 Existing transport networks	45
	5.3 Future transport network review and recommendations	59
6	East Chatswood	67
	6.1 Land use	67
	6.2 Existing transport networks	68
	6.3 Future transport network review and recommendations	85
7	High Street	93
	7.1 Land use	93
	7.2 Existing transport networks	94
	7.3 Future transport network review and recommendations	109
8	Naremburn	117
	8.1 Land use	117
	8.2 Existing transport networks	118
	8.3 Future transport network review and recommendations	133
9	Northbridge	143
	9.1 Land use	143
	9.2 Existing transport networks	145
	9.3 Future transport network review and recommendations	160
10	Penshurst Street	168

	10.1	Land use	168
	10.2	Existing transport networks	170
	10.3	Future transport network review and recommendations	184
11		Willoughby South	192
	11.1	Land use	192
	11.2	Existing transport networks	194
	11.3	Future transport network review and recommendations	208

Appendices

Appendix A SIDRA MODELLING RESULTS

Appendix B PARKING ANALYSIS

Tables

Table 2-1	Key travel behaviour statistics	7
Table 3-1	Car parking rates adopted	11
Table 3-2	Trip generation rates adopted	12
Table 3-3	RMS traffic volume viewer data	12
Table 3-4	Level of Service Criteria for Intersections	13
Table 3-5	Recommendations for all local centres	13
Table 4-1	Artarmon land use mix	14
Table 4-2	Key roads	17
Table 4-3	Crash summary by severity	20
Table 4-4	Crashes locations	20
Table 4-5	Artarmon train services	26
Table 4-6	SIDRA intersection modelling results - Artarmon	32
Table 4-7	Opportunities and constraints	32
Table 4-8	Apartment mix and occupancy - Artarmon	33
Table 4-9	Non-residential floor space assumptions - Artarmon	33
Table 4-10	Minimum car parking requirements - Artarmon	33
Table 4-11	Bicycle parking requirements	34
Table 4-12	Future traffic generation	34
Table 4-13	Inbound / outbound splits	34
Table 4-14	Inbound and outbound additional traffic generated	35
Table 4-15	Directional assumptions	35
Table 4-16	Future intersection performance (100 per cent development) – Artarmon	36
Table 4-17	Future Intersection Performance (75 per cent Development) - Artarmon	37
Table 4-18	Issues and recommendations	40
Table 5-1	Castlecrag land use mix	43
Table 5-2	Key roads	45

Table 5-3	Crash summary by severity	47
Table 5-4	Crash locations	47
Table 5-5	Bus routes serving the Castlecrag local centre	52
Table 5-6	SIDRA intersection modelling results - Castlecrag	58
Table 5-7	Opportunities and constraints	59
Table 5-8	Apartment mix and occupancy - Castlecrag	59
Table 5-9	Non-residential floor space assumptions - Castlecrag	59
Table 5-10	Minimum car parking requirements - Castlecrag	60
Table 5-11	Bicycle parking requirements	60
Table 5-12	Future traffic generation	60
Table 5-13	Inbound / outbound splits	61
Table 5-14	Inbound and outbound additional traffic generated	61
Table 5-15	Directional assumptions	61
Table 5-16	Future intersection performance – Castlecrag	62
Table 5-17	Intersection Performance – Castlecrag	62
Table 5-18	Issues and recommendations	65
Table 6-1	East Chatswood land use mix	67
Table 6-2	Key roads	69
Table 6-3	Crash summary by severity	71
Table 6-4	Crash locations	71
Table 6-5	Bus routes serving the East Chatswood local centre	78
Table 6-6	SIDRA intersection modelling results – East Chatswood	84
Table 6-7	Opportunities and constraints	85
Table 6-8	Apartment mix and occupancy – East Chatswood	85
Table 6-9	Non-residential floor space assumptions – East Chatswood	85
Table 6-10	Minimum car parking requirements – East Chatswood	86
Table 6-11	Bicycle parking requirements	86
Table 6-12	Future traffic generation	86
Table 6-13	Inbound / outbound splits	87
Table 6-14	Inbound and outbound additional traffic generated	87
Table 6-15	Directional assumptions	87
Table 6-16	Future intersection performance – East Chatswood	88
Table 6-18	Issues and recommendations	91
Table 7-1	High Street land use mix	93
Table 7-2	Key roads	95
Table 7-3	Crash summary by severity	97
Table 7-4	Bus routes serving areas near the High Street local centre	103
Table 7-5	SIDRA intersection modelling results – High Street	109
Table 7-6	Opportunities and constraints	109
Table 7-7	Apartment mix and occupancy – High Street	109
Table 7-8	Non-residential floor space assumptions – High Street	110

Table 7-9	Minimum car parking requirements – High Street	110
Table 7-10	Bicycle parking requirements	110
Table 7-11	Future traffic generation	111
Table 7-12	Inbound / outbound splits	111
Table 7-13	Inbound and outbound additional traffic generated	112
Table 7-14	Directional assumptions	112
Table 7-15	Future intersection performance – High Street	113
Table 7-17	Issues and recommendations	115
Table 8-1	Naremburn land use mix	117
Table 8-2	Key roads	119
Table 8-3	Crash summary by severity	121
Table 8-4	Crash locations	121
Table 8-5	Bus routes serving the Naremburn local centre	127
Table 8-6	SIDRA intersection modelling results – Naremburn	133
Table 8-7	Opportunities and constraints	133
Table 8-8	Apartment mix and occupancy – Naremburn	133
Table 8-9	Non-residential floor space assumptions – Naremburn	134
Table 8-10	Minimum car parking requirements – Naremburn	134
Table 8-11	Bicycle parking requirements	134
Table 8-12	Future traffic generation	135
Table 8-13	Inbound / outbound splits	135
Table 8-14	Inbound and outbound additional traffic generated	136
Table 8-15	Directional assumptions	136
Table 8-16	Future intersection performance – Naremburn	137
Table 8-17	Intersection performance – Naremburn	137
Table 8-18	Issues and recommendations	140
Table 9-1	Northbridge land use mix	143
Table 9-2	Key roads	145
Table 9-3	Crash summary by severity	147
Table 9-4	Crash locations	147
Table 9-5	Bus routes serving the Northbridge local centre	153
Table 9-6	SIDRA intersection modelling results – Northbridge	159
Table 9-7	Opportunities and constraints	160
Table 9-8	Apartment mix and occupancy – Northbridge	160
Table 9-9	Non-residential floor space assumptions – Northbridge	160
Table 9-10	Minimum car parking requirements – Northbridge	161
Table 9-11	Bicycle parking requirements	161
Table 9-12	Future traffic generation	162
Table 9-13	Inbound / outbound splits	162
Table 9-14	Inbound and outbound additional traffic generated	162
Table 9-15	Directional assumptions	163

Table 9-16	Future intersection performance – Northbridge	163
Table 9-17	Intersection performance – Northbridge	164
Table 9-18	Issues and recommendations	166
Table 10-1	Penshurst Street land use mix	168
Table 10-2	Key roads	170
Table 10-3	Crash summary by severity	172
Table 10-4	Crash locations	172
Table 10-5	Bus routes serving the Penshurst Street local centre	178
Table 10-6	SIDRA intersection modelling results – Penshurst Street	183
Table 10-7	Opportunities and constraints	184
Table 10-8	Apartment mix and occupancy – Penshurst Street	184
Table 10-9	Non-residential floor space assumptions – Penshurst Street	184
Table 10-10	Minimum car parking requirements – Penshurst Street	185
Table 10-11	Bicycle parking requirements	185
Table 10-12	Future traffic generation	185
Table 10-13	Inbound / outbound splits	186
Table 10-14	Inbound and outbound additional traffic generated	186
Table 10-15	Directional assumptions	186
Table 10-16	Future intersection performance – Penshurst Street	187
Table 10-18	Issues and recommendations	190
Table 11-1	Willoughby South land use mix	192
Table 11-2	Key roads	194
Table 11-3	Crash summary by severity	196
Table 11-4	Bus routes serving the Willoughby South local centre	202
Table 11-5	SIDRA intersection modelling results – Willoughby South	207
Table 11-6	Opportunities and constraints	208
Table 11-7	Apartment mix and occupancy – Willoughby South	208
Table 11-8	Non-residential floor space assumptions – Willoughby South	208
Table 11-9	Minimum car parking requirements – Willoughby South	209
Table 11-10	Bicycle parking requirements	209
Table 11-11	Future traffic generation	209
Table 11-12	Inbound / outbound splits	210
Table 11-13	Inbound and outbound additional traffic generated	210
Table 11-14	Directional assumptions	210
Table 11-15	Future intersection performance – Willoughby South	211
Table 11-17	Issues and recommendations	214

Figures

Figure 1-1	Willoughby LGA state and regional roads	1
------------	---	---

Figure 2-1	Mode share for people working in Willoughby	7
Figure 2-2	Mode share for residents living in Willoughby	7
Figure 2-3	Trip purposes and travel distances	8
Figure 2-4	Destination of residents in Willoughby	8
Figure 2-5	Origin of workers in Willoughby	8
Figure 4-1	Artarmon local centre	14
Figure 4-2	Potential development at Artarmon – preferred scenario	15
Figure 4-3	Key roads in the Artarmon local centre	17
Figure 4-4	Road hierarchy map	19
Figure 4-5	Crash map	21
Figure 4-6	Lack of footpaths on Hampden Lane	22
Figure 4-7	Pedestrian underpass between Hampden Road and Burra Road	22
Figure 4-8	Steep ramp leading to the station from Elizabeth Street	23
Figure 4-9	Constrained footpath on Hampden Road	23
Figure 4-10	Walking routes	24
Figure 4-11	Bicycle network	25
Figure 4-12	Public transport map	27
Figure 4-13	Parking availability	29
Figure 4-14	Artarmon weekday parking profile	30
Figure 4-15	Artarmon weekend parking profile	30
Figure 4-16	Artarmon peak parking demand	30
Figure 4-17	Artarmon future non-residential parking demand weekday profile	38
Figure 4-18	Artarmon future non-residential parking demand weekend profile	38
Figure 4-19	Recommendations map	42
Figure 5-1	Castlecrag local centre	43
Figure 5-2	Potential development at Castlecrag – preferred scenario	44
Figure 5-3	Road hierarchy	46
Figure 5-4	Footpaths on Edinburgh Road	48
Figure 5-5	Pedestrian refuge at the eastern end of Edinburgh Road	48
Figure 5-6	Steep grades at The Postern	48
Figure 5-7	Walking routes	49
Figure 5-8	Bike signage on Edinburgh Road	50
Figure 5-9	Bike racks on Edinburgh Road	50
Figure 5-10	Bicycle network	51
Figure 5-11	Public transport map	53
Figure 5-12	Parking availability	55
Figure 5-13	Castlecrag weekday parking profile	56
Figure 5-14	Castlecrag weekend parking profile	56
Figure 5-15	Castlecrag peak parking demand	57
Figure 5-16	Castlecrag future non-residential parking demand weekday profile	63
Figure 5-17	Castlecrag future non-residential parking demand weekend profile	63

Figure 5-18 Recommendations map	66
Figure 6-1 East Chatswood local centre	67
Figure 6-2 Potential development at East Chatswood – preferred scenario	68
Figure 6-3 Road hierarchy	70
Figure 6-4 Crash map	72
Figure 6-5 Footpath width reduced by vegetation strip	73
Figure 6-6 Vehicles encroaching footpath at Royal Street	73
Figure 6-7 Large crossing distance on Crick Street	73
Figure 6-8 Large crossing distance at Patrick Street	74
Figure 6-9 Missing crossing at Penshurst St / Macmahon St intersection	74
Figure 6-10 Walking routes	75
Figure 6-11 Bicycle network	77
Figure 6-12 Public transport map	79
Figure 6-13 Parking availability	81
Figure 6-14 East Chatswood weekday parking profile	82
Figure 6-15 East Chatswood weekend parking profile	82
Figure 6-16 East Chatswood peak parking demand	83
Figure 6-17 East Chatswood future non-residential parking demand weekday profile	90
Figure 6-18 East Chatswood future non-residential parking demand weekend profile	90
Figure 6-19 Recommendations map	92
Figure 7-1 High Street local centre	93
Figure 7-2 Potential development at High Street – preferred scenario	94
Figure 7-3 Looking south west along Glover Street	95
Figure 7-4 Looking south east along High Street	95
Figure 7-5 Road hierarchy	96
Figure 7-6 Crash map	98
Figure 7-7 Kerb ramp on the western side of High St	99
Figure 7-8 Lack of kerb ramp on the eastern side of High St	99
Figure 7-9 Walking routes	100
Figure 7-10 On-road visually separated bike path on High St	101
Figure 7-11 Bike hoops on High St	101
Figure 7-12 Bicycle network	102
Figure 7-13 Public transport map	104
Figure 7-14 Parking availability	106
Figure 7-15 High Street weekday parking profile	107
Figure 7-16 High Street weekend parking profile	107
Figure 7-17 High Street peak parking demand	107
Figure 7-18 High Street future non-residential parking demand weekday profile	114
Figure 7-19 High Street future non-residential parking demand weekend profile	114
Figure 7-20 Recommendations map	116
Figure 8-1 Naremburn local centre	117

Figure 8-2	Potential development at Naremburn – preferred scenario	118
Figure 8-3	Road hierarchy map	120
Figure 8-4	Crash map	122
Figure 8-5	Walking routes	124
Figure 8-6	Shared path towards Artarmon and Chatswood	125
Figure 8-7	Shared path towards Cammeray and North Sydney	125
Figure 8-8	Bicycle network	126
Figure 8-9	Faunce Lane cul-de-sac	127
Figure 8-10	Bike hoops adjacent to Willoughby Road	127
Figure 8-11	Public transport map	128
Figure 8-12	Parallel parking on Willoughby Road	129
Figure 8-13	Angle Parking on Willoughby Road	129
Figure 8-14	Accessible parking space next to shops	129
Figure 8-15	Parking availability	130
Figure 8-16	Naremburn weekday parking profile	131
Figure 8-17	Naremburn weekend parking profile	131
Figure 8-18	Naremburn peak parking demand	131
Figure 8-19	Naremburn future non-residential parking demand weekday profile	138
Figure 8-20	Naremburn future non-residential parking demand weekend profile	138
Figure 8-21	Recommendations map	142
Figure 9-1	Northbridge local centre	143
Figure 9-2	Potential development at Northbridge – preferred scenario	144
Figure 9-3	Road hierarchy	146
Figure 9-4	Crash map	148
Figure 9-5	Hedging at Northbridge Plaza	149
Figure 9-6	Missing crossing at Sailors Bay Rd / Harden Ave	149
Figure 9-7	Missing crossing at Sailors Bay Rd / Strathallen Ave	149
Figure 9-8	Walking routes	150
Figure 9-9	Bicycle network	152
Figure 9-10	Public transport map	154
Figure 9-11	Parking availability	156
Figure 9-12	Northbridge weekday parking profile	157
Figure 9-13	Northbridge weekend parking profile	157
Figure 9-14	Northbridge peak parking demand	158
Figure 9-15	Northbridge future non-residential parking demand weekday profile	165
Figure 9-16	Northbridge future non-residential parking demand weekend profile	165
Figure 9-17	Recommendations map	167
Figure 10-1	Penshurst Street local centre	168
Figure 10-2	Potential development at Penshurst Street – preferred scenario	169
Figure 10-3	Road hierarchy	171
Figure 10-4	Crash map	173

Figure 10-5 Lack of pedestrian protection from vehicles	174
Figure 10-6 Missing pedestrian crossing at Penshurst St / Oakville Rd	174
Figure 10-7 Walking routes	175
Figure 10-8 Laurel Street cycleway	176
Figure 10-9 Bicycle network	177
Figure 10-10 Public Transport map	179
Figure 10-11 Penshurst Street weekday parking profile	180
Figure 10-12 Penshurst Street weekend parking profile	180
Figure 10-13 Parking availability	181
Figure 10-14 Penshurst Street peak parking demand	182
Figure 10-15 Penshurst Street future non-residential parking demand weekday profile	188
Figure 10-16 Penshurst Street future non-residential parking demand weekend profile	188
Figure 10-17 Recommendations map	191
Figure 11-1 Willoughby South local centre	192
Figure 11-2 Potential development at Willoughby South – preferred scenario	193
Figure 11-3 Road hierarchy	195
Figure 11-4 Crash map	197
Figure 11-5 Footpath on Frenchs Road	198
Figure 11-6 Transition from wide to standard footpath	198
Figure 11-7 Walking routes	199
Figure 11-8 Bike signage directing cyclists on Willoughby Road into Julian Street	200
Figure 11-9 Bike signage on Frenches Road	200
Figure 11-10 Bicycle network	201
Figure 11-11 Public transport map	203
Figure 11-12 Taxi zones on Frenchs Road	204
Figure 11-13 Mail zone on Frenchs Road	204
Figure 11-14 Parking availability	205
Figure 11-15 Willoughby South weekday parking profile	206
Figure 11-16 Willoughby South weekend parking profile	206
Figure 11-17 Willoughby South peak parking demand	206
Figure 11-18 Willoughby South future non-residential parking demand weekday profile	212
Figure 11-19 Willoughby South future non-residential parking demand weekend profile	212
Figure 11-20 Recommendations map	215

1 Introduction

1.1 Background

1.1.1 Willoughby Council Local Government Area

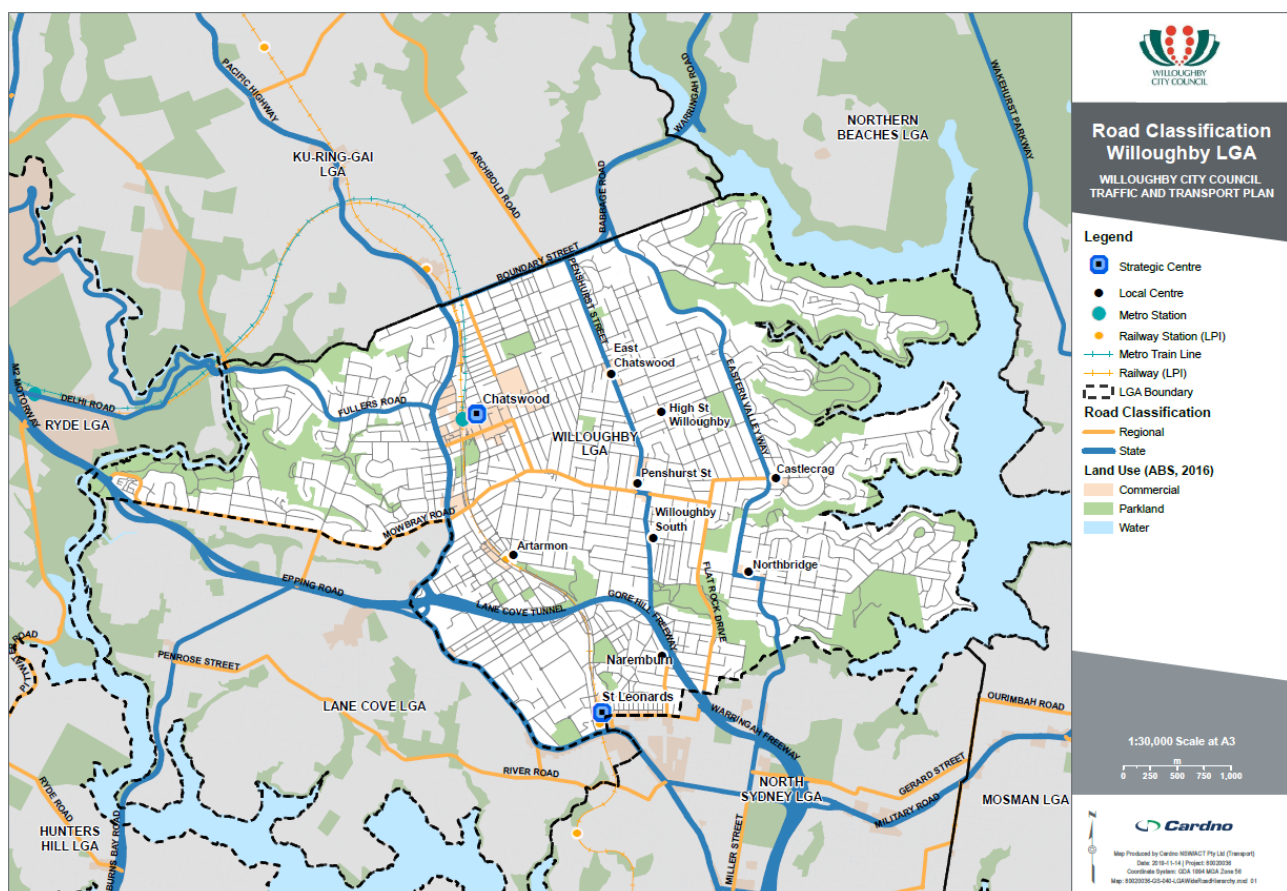
The Willoughby Local Government Area (LGA) is located 8.5 kilometres northwest of the Sydney CBD and covers an area of approximately 23 square kilometres. As of 2018, the region was home to approximately 80,000 people originating from various backgrounds. The region is expected to grow at a steady rate in the coming decades, with a projected population of 91,000 by 2036.

Chatswood and St Leonards operate as the LGA's strategic centres. They drive commercial growth within the region and provide high-density residential housing. Two shopping centres and a shopping district make Chatswood a major retail destination for the Willoughby LGA and the surrounding regions. The LGA also contains eight local centres, each supporting their respective communities with housing, local businesses and amenities.

The Willoughby Council area contains a network of highways and arterial roads. The M1 motorway connects the LGA to destinations in western Sydney and the Sydney CBD. The Pacific Highway functions as the region's main vehicle corridor connecting the LGA with the M1 motorway to the north and providing a route to Sydney's northern suburbs and central coast to the north. The LGA's arterial roads such as Victoria Avenue, Penshurst Street, Mowbray Road and Willoughby Road connect local and strategic centres.

The LGA's state and regional road network is presented in **Figure 1-1**.

Figure 1-1 Willoughby LGA state and regional roads



Public transport services within the LGA include train and bus. There are two train lines, the T1 North Shore line and Western Line, and the Metro Northwest. The T1 line services the local centre of Artarmon, and the strategic centres of Chatswood and St Leonards. The line provides a public transport connection to Sydney's CBD and North Sydney to the south, and Hornsby and the Central Coast to the north. Chatswood operates

as a transport interchange, connecting the LGA with Sydney's north west suburbs via the Sydney Metro Northwest.

1.1.2 Local Centres Strategy

The Willoughby City Council produced the *Draft Willoughby Local Centres Strategy* as a framework to guide future planning controls and public domain improvements for eight local centres identified in the LGA. The draft strategy builds on directions and objectives identified in the *Greater Sydney Region Plan, North District Plan, Willoughby Community Strategic Plan, Willoughby Housing Strategy* and *Willoughby Local Centres and Housing Position Statements*.

The strategy aims to examine the function and character of eight local centres in Willoughby to identify opportunities for growth in residential and employment land uses. It includes a focus on retaining the character of the local centres and promoting thriving, attractive and distinctive neighbourhoods throughout the LGA.

The strategy analyses each local centre and discusses:

- > Local context, character and place;
- > Existing planning controls and land uses;
- > Strengths of the centre;
- > Community feedback on the scenarios identified;
- > Key directions for future development;
- > A vision for the centre;
- > A preferred development scenario;
- > Recommendations for the *Local Environmental Plan* (LEP) and *Development Control Plan* (DCP);
- > An indicative master plan for the development scenario; and
- > Potential yield of the preferred scenario.

The Draft Strategy has been used to inform this study and provide guiding principles for the assessment of the transport networks.

1.1.3 Community feedback

A total of 192 submissions were received on the *Draft Local Centres Strategy*, which included a range of concerns relating to the character, identity and scale of the local centres, land uses (particularly inclusion of specific retail uses) and existing traffic and parking issues. The general feedback on traffic and transport related matters was that every local centre is already congested and existing issues needed to be addressed. The community was apprehensive in regards to developing West Chatswood due to congestion issues.

Further detail of community feedback for specific centres is provided later in the report under the relevant local centre.

1.2 Traffic and Transport Plan purpose

The key purpose of the Traffic & Transport Plan is to guide future growth for the local centres and demonstrate how the forecast land uses can be accommodated by the transport networks. The plan will identify and analyse existing traffic and transport issues, assess future potential impacts of the proposals contained in the *Draft Local Centres Strategy* and support development of the *Final Local Centres Strategy*. The plan will include a review of public transport (rail and bus), active transport (bicycles and pedestrians), taxi, ride share services, parking and freight services. The key objectives of the Traffic & Transport Plan include:

- > To establish the traffic and transport objectives, performance indicators and outcomes for each local centre;
- > To establish the current and planned transport system design, operation and capacity in each Local Centre;
- > To identify pedestrian, cycling and traffic management issues in each Local Centre;

- > To recommend actions to provide more efficient and effective traffic and transport arrangements for each Local Centre that will create a healthy, socially cohesive place that meets the current and likely future demands of the community; and
- > To establish measures required to support proposed land use changes foreshadowed in the *Draft Willoughby Local Centres Strategy*.

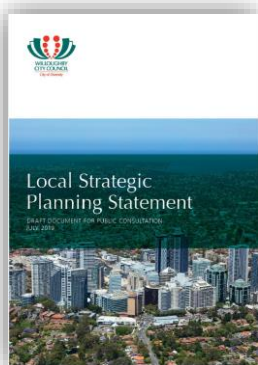
Safety and amenity will be key focuses of the plan, aligning with the objectives of the *Draft Local Centres Strategy* and allowing future growth to be accommodated without detracting from the character of each local centre to accommodate demand. Consideration of movement and place priorities will be applied to provide for future travel demands while retaining amenable, attractive and activated centres. Active and sustainable transport improvements and initiatives will also be prioritised where possible to promote these travel modes and reduce the need for road space allocated to private vehicles.

2 Strategic context

2.1 Strategies and community plans

As well as the *Draft Local Centres Strategy*, there are a number of strategies and community plans that aim to guide future development within the Willoughby LGA and provide direction for traffic and transport considerations.

2.1.1 Local Strategic Planning Statement



The *Draft Willoughby Local Strategic Planning Statement* (LSPS) sets a 20-year vision for land use planning in the Willoughby LGA, including a range of directions, priorities and actions aligning with the Greater Sydney Commission's *Greater Sydney Region Plan* and *North District Plan*. The key themes include a liveable city, productive city, sustainable city and a city that aligns infrastructure with growth. Key directions and Council priorities that relate to traffic and transport include:

- > Enhancing walking and cycling connections;
- > Developing Chatswood's role as a true transport hub for Willoughby and the North Shore; and
- > Connecting Willoughby's network of centres with each other and with Greater Sydney by mass transit.

2.1.2 Local Environmental Plan and Development Control Plan

The *Local Environmental Plan* (LEP) and *Development Control Plan* (DCP) are the key planning instruments guiding development within the Willoughby LGA. The LEP establishes a planning framework for the LGA and provides planning controls to manage development. The plan aims to enable sustainable, socially equitable and economically viable development to manage impacts and risks to the environment. In relation to traffic and transport matters, the LEP aims to:

- > Provide for regional and local transport needs while promoting the use of active and public transport;
- > Provide appropriate levels of car parking in connection with the location of development and managing the demand for ancillary car parking where there is good access to public transport nodes and services; and
- > Provide integrated development design of pedestrian and vehicular access, parking, loading and delivery facilities.



The DCP provides detailed guidelines and environmental controls to guide development within the Willoughby LGA and supports the objectives and planning provisions contained within the LEP. The DCP also aims to encourage the use of active and public transport, as well as providing safe, convenient and efficient movement and accommodation of vehicles.

2.1.3 Community Strategic Plan



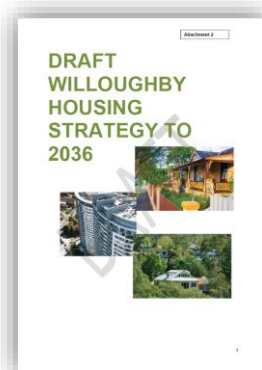
The *Community Strategic Plan* (CSP) identifies the community's aspirations and priorities for the future, and presents a series of outcomes to achieve the overall community vision for Willoughby as a diverse, liveable and prosperous city. Five outcomes are presented and include a city that is green, connected and inclusive, liveable, prosperous and vibrant, and effective and accountable. The outcome of a connected and inclusive city is most relevant for this study and includes the key priorities to:

- > Enhance transport choices and connections throughout the city;
- > Reduce parking and traffic congestion; and
- > Promote accessible services for the community.

A key measure of the connected and inclusive outcome is an increase in the number of journeys to work that do not use a motor vehicle, which aligns with the objectives of the planning framework and LSPS.

2.1.4 Draft Housing Strategy

The *Draft Housing Strategy to 2036* aims to guide the quantity, location and type of future residential development with Willoughby. The strategy indicates that additional residential development should be located close to business and service centres and public transport to promote sustainability. It identifies Chatswood CBD around the commercial core as the key focus due to the significance as a strategic centre and the presence of a train station, however notes that local centres have also been identified for extra dwellings close to services and transport to disperse growth across the LGA. The strategy also provides indicative master plans for the local centres to indicate how development could be achieved.



Feedback on the Housing Strategy included concerns about traffic and parking issues, with mixed sentiment about the proposition to develop local centres. However, most submissions could not say whether increased housing growth could be located in other areas of Willoughby. Chatswood West was proposed as an alternative location and considered as a potential local centre, however this was discontinued due to congestion concerns of its own.

2.1.5 Street Parking Strategy



The *Street Parking Strategy* provides a framework for efficient and equitable use of street parking in the Willoughby LGA. It uses an evidence-based approach to guide decisions about where and when pricing and time restrictions need to be introduced or adjusted based on surrounding land uses. The strategy notes that on-street parking is important for economic and social wellbeing, but acknowledges that the trend for rising parking demand cannot be sustained and that provision of additional parking will induce traffic into already congested roads. It aims to achieve a balance between supply and demand and encourage mode shift to active and public transport. Key objectives of the strategy include to:

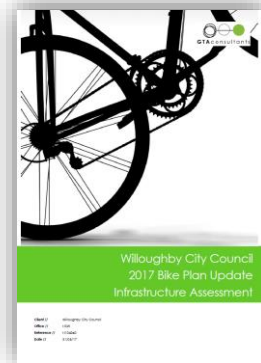
- > Optimise available street space in a fair and transparent manner;
- > Maintain access to local businesses, services and amenities;
- > Balance the needs of residents with those of local workers, businesses, shoppers and commuters through managed travel-demand and mode choice; and
- > Balance the competing interests between parking demand and environmental amenity.

The strategy includes extensive analysis of parking within Willoughby and presents a range of potential solutions to the issues identified. Six strategic directions were proposed to address the issues:

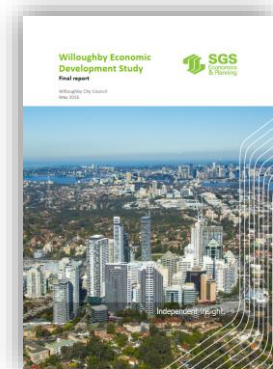
9. Adopt a framework of time and pricing restrictions;
10. Apply parking controls that support the land use context;
11. Develop an integrated transport strategy;
12. Promote car share;
13. Maximise available street and road space for parked cars; and
14. Promote alternative transport choice for non-essential car journeys.

2.1.6 2017 Bike Plan Update Infrastructure Assessment

A bike plan was adopted by Council in 2006, with a review of its implementation undertaken in 2012. This review also identified cycling infrastructure projects required and presented an implementation plan, including a map setting out the existing network and proposed upgrades. The *Willoughby 2017 Bike Plan Update Infrastructure Assessment* provides an audit of existing cycling infrastructure throughout the LGA to determine how the actions identified in 2012 have been implemented, as well as identifying additional projects and re-prioritising all projects. The plan also integrates feedback from the neighbouring LGAs to ensure sufficient inter-LGA connectivity. The update aims to guide investment in cycling infrastructure and support other state and local government policy documents such as the CSP, LEP and Sydney's Cycling Future.



2.1.7 Economic Development Study



The *Willoughby Economic Development Study* was developed to understand the key economic drivers of Willoughby, identify economic trends, analyse the existing economic structure, assess implications economic growth on traffic, transport, environment, community needs and infrastructure, and review planning controls to facilitate opportunities for economic growth. The study examines the strategic centres of Chatswood and St Leonards as well as other centres including the local centres at Artarmon and East Chatswood. The study focuses on supply and demand for industries but identifies some challenges related to traffic and transport such as:

- > Traffic congestion in Chatswood impacting retail business;
- > The rail line posing a barrier for access to the retail core of Chatswood from the Pacific highway; and
- > Expected increases in parking demand associated with future development.

Directions to address the issues include:

- > Facilitating mixed uses in areas other than Chatswood to reduce pressure and congestion;
- > Introducing car parking reforms and innovative parking policies such as shared parking between different land uses;
- > Maintaining but not increasing road network capacity;
- > Reducing parking provision over time to relieve traffic congestion; and
- > Promoting the amenity and public transport offering of Chatswood.

2.2 Current travel behaviour

Existing data sources were analysed to examine current travel patterns within the Willoughby Local Government Area (LGA), including the Household Travel Survey (HTS) and Australian Bureau of Statistics (ABS) Census 2016 data. The HTS is collected by Transport Performance and Analytics (TPA) as part of Transport for NSW (TfNSW) and gathers simple information of key travel statistics over a typical weekday for a sample of respondents, which is extrapolated to estimate travel behaviour for the Greater Sydney region. The ABS Census data is gathered using an enumerative method for all people in Australia on census night, and provides detailed travel information for a much larger sample than the HTS. Both datasets were analysed to extract key information and travel statistics.

2.2.1 Demographics

Key demographic data and statistics for the Willoughby LGA are presented in **Table 2-1** and compared to the Greater Sydney statistics.

Table 2-1 Key travel behaviour statistics

Statistic	Willoughby LGA	Sydney GMA
Residential population	74,300 ¹	4,824,000
Households	28,480	1,759,923
Average people per household	2.6	2.7
Area (km ²)	22.4	12,370.0
Population density (people per km ²)	3,317	390
Average vehicles per household	1.4	1.6
Average vehicles per person	0.5	0.5

Data source: ABS 2016 Census

¹The Estimated Resident Population was approximately 77,900 for 2016, and was estimated to be approximately 80,300 in 2018 (according to .id). The census data shown in the table underestimates the population due to the less than 100% response rate (among other factors), but was used to obtain accurate ratios when combined with vehicle ownership.

The average household in Willoughby owns 1.4 private vehicles, slightly less than the Greater Sydney average, which reflects a slightly lower dependence on cars. The population density of Willoughby is also much greater than the Sydney average (almost 10 times higher).

2.2.2 Mode share

Mode share data was analysed to determine the key Journey to Work travel modes, and the results are presented in **Figure 2-1** and **Figure 2-2**.

Figure 2-1 Mode share for people working in Willoughby

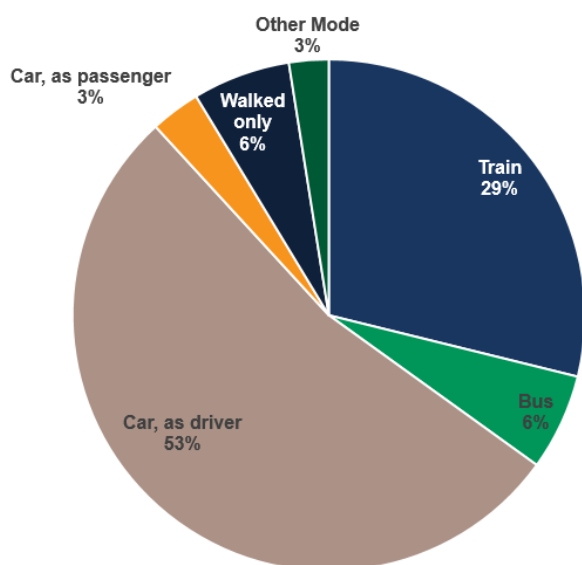
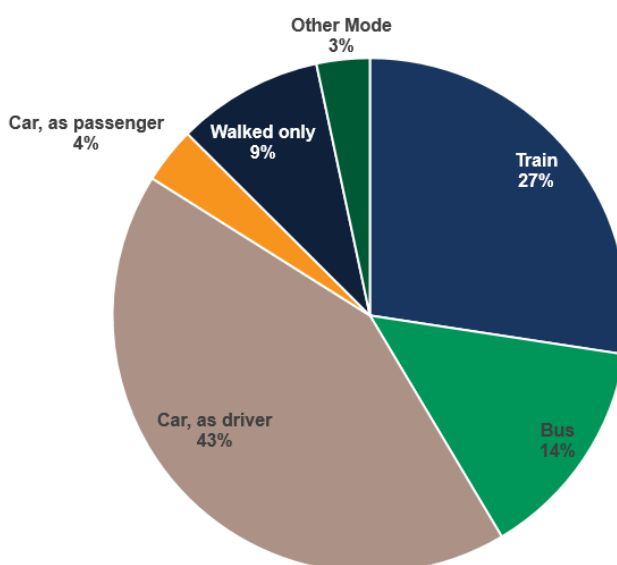


Figure 2-2 Mode share for residents living in Willoughby



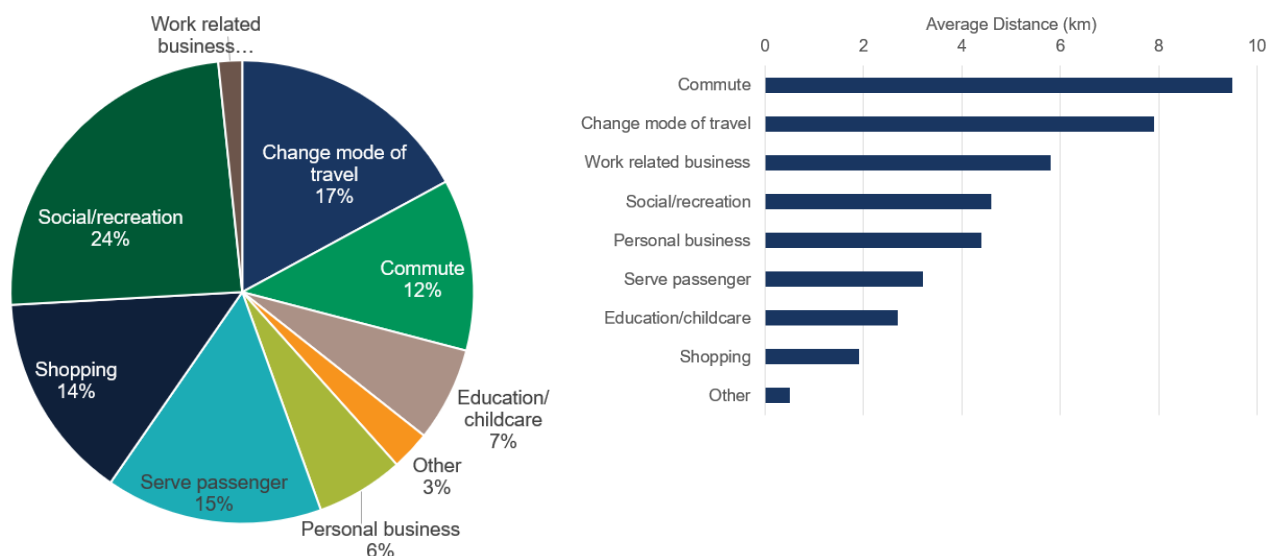
Data source: ABS 2016 Census

The data indicates that the area is moderately reliant on private vehicles, with approximately half of all trips utilising private cars for travel to work. Approximately 35 – 40 per cent of trips are taken using public transport, especially for residents of Willoughby, reflecting the connectivity of bus and train routes to centres such as North Sydney and the CBD. Active transport represents 10 per cent or less of all trips and may be a result of the limited walking and cycling catchments as well as constraints of the active transport networks.

2.2.3 Trip purpose and travel distance

Household Travel Survey (HTS) data was analysed to determine the purpose of trips made, and the results are presented in **Figure 2-3**. Note these are purposes for trips throughout the entire day, and the peak hours are likely to reflect a different mix of trips.

Figure 2-3 Trip purposes and travel distances



Data source: HTS 2017 / 2018

The data shows that trips are undertaken for a wide range of purposes, including recreation (24 per cent), interchanging (17 per cent), taking a passenger (15 per cent), shopping (14 per cent) and commuting (12 per cent), among other purposes. Trip distances were highest for commuters (approx. 9.5 kilometres), interchanging and work-related business, while shorter trips were generally associated with shopping or other purposes. This indicates that the immediate catchments of the local centres are likely to attract residents visiting retail and various ancillary land uses (e.g. post offices), which aligns with the community feedback received and the planned direction for the local centres.

2.2.4 Origins and destinations

The top origins and destinations for workers (split by residents in Willoughby and people travelling to Willoughby to work) are presented in **Figure 2-4** and **Figure 2-5**. The results also include mode share to understand the connectivity of travel modes and relationship to origin-destination pairs.

Figure 2-4 Destination of residents in Willoughby

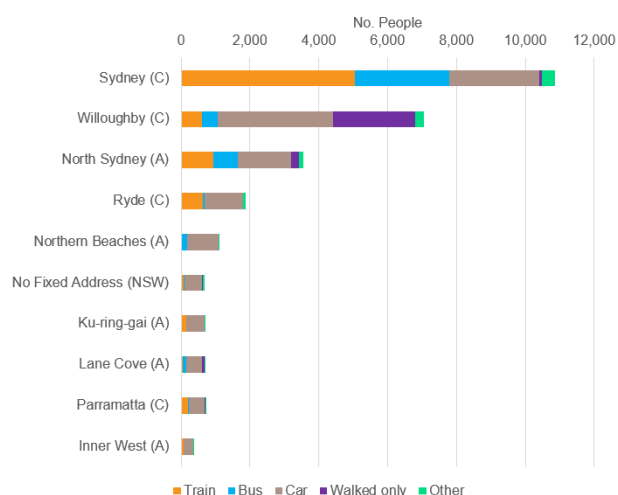
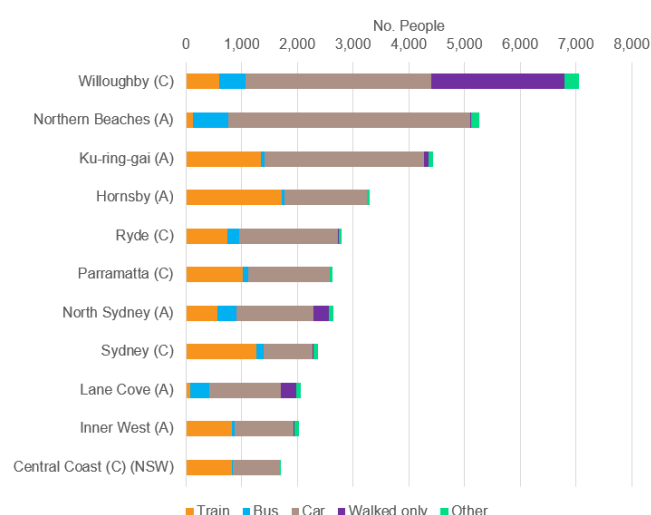


Figure 2-5 Origin of workers in Willoughby



Source: ABS 2016 Census Data

The results show that the top destinations of workplaces for residents of Willoughby are Sydney (inner city), internal trips within Willoughby, and North Sydney. Other trips are generally scattered throughout other

destinations in surrounding suburbs. The top origins for people who travel to Willoughby to work are much more diverse and include internal trips within Willoughby, the northern beaches, Ku-ring-gai, Hornsby, Ryde and various other suburbs throughout the north shore and inner west.

The results also indicate that Willoughby is reasonably well connected to the CBD and North Sydney by public transport, with the majority of trips taken by train and bus. A large portion of internal trips within Willoughby are also taken by walking only. Most other destinations are reliant on private vehicles, particularly for outbound trips. Although some key origins / destination include public transport connections such as railway stations (e.g. Hornsby, Parramatta), many trips are still taken by car, which may reflect the limited ability to interchange and could present an opportunity to improve bus-rail connectivity.

2.2.5 Opal data

Opal data was received from TfNSW and analysed to determine key insights in relation to bus and train trips throughout the LGA. Note that many trips were redacted for privacy reasons, and the magnitude of trips is likely to be underestimated. Some key findings included the following:

- > 11 per cent of bus and train trips within the LGA are internal trips (commencing and finishing within the LGA itself).
- > The remainder of the trips are inbound and outbound trips which are roughly evenly balanced (43 per cent and 46 per cent respectively).
- > Of the interchange trips within the LGA, approximately 20 per cent of trips use buses to access a train station to continue their journey. Another 20 per cent use a train to access a bus service to continue their journey. The remaining 60 per cent interchange between train services at Chatswood station.

2.3 Proposed land use changes

A range of land use changes are proposed including intensification of existing land uses and addition of new land uses, largely composed of shop-top housing as well as various improvements to the public domain. Three possible development scenarios were considered and presented to the community for feedback before a preferred scenario was selected.

Key land use and planning changes under the preferred scenario include:

- > Rezoning, increased Floor Space Ratios (FSRs) and increased height limits to allow higher density land uses;
- > An additional 147,089 sqm GFA of residential land use across all local centres (an uplift of 238 per cent);
- > An additional 28,068 sqm GFA of non-residential land use across all local centre (an uplift of 26 per cent), mostly composed of retail and business use;
- > Provision of new public plazas and green space;
- > Additional through-site links; and
- > Various improvements to the public domain and pedestrian amenity.

Further details of key land use changes for each local centre are provided in the following sections.

3 All Centres

This section contains common elements and rationale for analysis generally for all centres.

3.1 Existing transport networks

3.1.1 Desktop study and site visit

A desktop analysis was undertaken to review the existing transport networks within the local centre, which included pedestrian, cycling, public transport, the road network, traffic, freight and servicing, car and ride share services, and parking.

A site visit was also undertaken over two days on Thursday 24 and Friday 25 October 2019 to take observations of existing conditions. The site visit was used to identify key characteristics of the transport networks, constraints, opportunities and current travel behaviour for each local centre to inform the study. Data collected included existing infrastructure, desire lines, travel routes, observations of intersection performance, interaction of different road users and any other general characteristics of the proposed development locations.

The data obtained through the site visit complemented the desktop analyses, and the findings of both analyses are summarised in the relevant sections for each local centre. A full audit, Pedestrian Access and Mobility Plan or Bike Plan was not undertaken, and the resulting recommendations are high level based on gaps identified and likely requirements due to planned growth.

3.1.2 Public transport

There are two loop buses which operate within the LGA, including:

- > “The Loop” – a free bus servicing Castle Cove, Chatswood and Northbridge between approximately 10:30am – 3:00pm, operating as follows:
 - Mondays and Tuesdays: Castle Cove to Chatswood;
 - Wednesdays and Fridays: Chatswood to Northbridge;
 - Thursdays: Castle Cove to Northbridge; and
- > The ‘Artarmon Loop’ – a free shuttle servicing the Artarmon industrial area and St Leonards station, as well as the Royal North Shore Hospital and Artarmon station during off-peak periods. The service operates every 10 minutes during peak times and every 30 minutes during off-peak times between 6am – 7pm.

3.2 Existing parking analysis

The supply and demand for parking within each local centre was analysed to determine the sufficiency of current parking provision and identify issues and recommendations. A general review of existing parking conditions, policy and management was undertaken, as well as detailed analysis of the theoretical demand for parking at each local centre based on the existing land uses.

Parking supply data was obtained via a desktop analysis using aerial imagery and Google Street View. Due to the scale and timeframe of this study, a full survey of occupancy was not undertaken and the demand was calculated from standard rates, therefore the analysis is theoretical. The land uses within and surrounding each local centre were identified, as well as the provision of off-street and on-street parking spaces, to collect the supply and demand data required for the analysis.

A full report of the theoretical parking analysis is provided in **Appendix B**, which includes a review of Willoughby’s parking policy, a discussion on the principles of parking management, recommendations to improve equity and efficiency of parking, and a review of existing parking conditions for each local centre with associated recommendations. A summary of the key findings and recommendations is provided in the following sections.

3.2.1 General parking review

The general parking characteristics within the LGA, Council parking policies and management strategies were reviewed and the following recommendations apply generally to all local centres within the LGA:

- > Establish a parking fund to collect parking fees and infringement revenues;

- > Review existing parking wayfinding and signage facilities;
- > Implement a consistent parking wayfinding and signage strategy within each centre;
- > Prepare precinct-specific parking management plans and expand paid parking using the 'demand-responsive pricing' methodology;
- > Establish an internal business unit to oversee all aspects of parking management, infrastructure and enforcement; and
- > 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.

Each centre was then reviewed in detail, with the analysis for each centre presented in the relevant section.

3.3 Parking requirements

The required car parking provision for the proposed development at each local centre was estimated based on the parking rates provided within the Willoughby DCP, which specifies minimum car parking requirements for various land uses.

Parking rates for the residential areas were based on those specified for 'shop-top housing', which comprises most of the residential development in all local centres, and provides the lowest car parking rates for apartments.

Parking rates for the non-residential uses were based on the relevant rates within the DCP, with a 30 per cent discount factor applied to the retail and hospitality land uses to account for passing trade / linked trips within the local centre. This is a conservative estimate based on a review of former RMS surveys for similar land uses. The Willoughby DCP also provides lower car parking rates for certain land uses within railway precincts and major public transport corridors, which applies to residential, office and restaurant land uses. Council provided direction to use the lower rates for all local centres given the proximity to public transport routes.

The minimum car parking requirements are presented in **Table 3-1**. The total requirements for each local centre were rounded down as per the DCP.

Table 3-1 Car parking rates adopted

Land use		Rate
Residential (non-adaptable units)	Studio	0.5 / dwelling
	1 bedroom	1 / dwelling
	2 bedroom	1 / dwelling
	3 bedroom	1 / dwelling
	Visitors	0.25 / dwelling
Commercial	Retail	36 sqm / space
	Hospitality	107 sqm / space
	Office	110 sqm / space
All	Motorbike parking	1 / 25 car parking spaces

3.4 Trip generation

Future trips expected to be generated by the proposed developments were estimated based on the *RMS Guide to Traffic Generating Developments* (GTGD) and the technical direction *TDT 2013/04a Updated Traffic Surveys* (TD 2013/04a). Traffic generation rates for each land use adopted for each land use are presented in **Table 3-2**, also using the following assumptions:

- > The residential traffic generation rates are well defined in the weekday AM and weekday PM peaks in TD 2013/04a, and the Saturday peak generation rate was estimated based on the survey results for each Sydney Metropolitan Area site analysed as part of this technical direction;
- > Retail traffic generation rates are provided in the GTGD for the weekday PM and Saturday peaks. For the weekday AM peak, it is assumed that employees would arrive comparably with office areas. Retail areas are also assumed to be fast trade;

- > Hospitality areas are assumed to be equivalent to 'specialty shops', which includes uses such as general stores and takeaway food. Traffic generation rates for the weekday PM and Saturday peak are provided in the GTGD, and the rate for the AM peak was assumed to be similar to that of offices;
- > Traffic generation rates for offices are provided in TD 2013/04a for the weekday AM and weekday PM peaks. For the Saturday midday peak, offices were assumed to not generate any trips; and
- > A discount factor of 30 per cent was applied to the retail and hospitality land uses to reflect linked trips (trips with a secondary component, e.g. a resident purchasing a coffee on the way to work), a conservative estimate based on TfNSW survey results of similar land uses.

Table 3-2 Trip generation rates adopted

Land use	Traffic generation rate adopted (no. trips)		
	AM peak	PM peak	Saturday peak
Residential	0.19 / unit	0.15 trips / unit	0.19 trips / unit
Retail	1.12 / 100 sqm GLFA	3.57 / 100 sqm GLFA	0.91 / 100 sqm GLFA
Hospitality	1.12 / 100 sqm GLFA	3.92 / 100 sqm GLFA	7.49 / 100 sqm GLFA
Office	1.6 / 100 sqm GFA	1.2 / 100 sqm GFA	Nil

3.5 Traffic modelling

3.5.1 Intersection counts

Traffic surveys were undertaken on Thursday 24 October and Saturday 26 October to obtain intersection counts for typical weekday AM and weekday PM peak periods and a typical Saturday midday peak period. The counts were undertaken between 6:00am – 10:00am for the AM peak, 3:00pm – 7:00pm for the PM peak and 10:00am – 2:00pm for the Saturday midday peak.

The surveys counted light vehicles, heavy vehicles and pedestrians, as well as vehicle queues in some key locations. The weather was overcast and no unusual occurrences were noted.

3.5.2 Background traffic

TfNSW (formerly RMS) Traffic Volume Viewer count stations were reviewed to understand trends in background traffic throughout the area and included a review of count stations on Eastern Valley Way, Willoughby Road and Penshurst Street. An analysis of the data over a 10-year period from 2009-2019 is presented in **Table 3-3**.

Table 3-3 RMS traffic volume viewer data

Location	AM peak avg. growth ¹	PM peak avg. growth	Saturday peak avg. growth
Eastern Valley Way (south of Sunnyside Cr)	-3%	-3%	-1%
Penshurst Street ² (south of Warrah Ln)	3%	6%	5%
Willoughby Road (south of Small St)	0%	0%	1%

¹Growth is presented as a per annum rate

²The Penshurst Street count station experienced an unusually high spike in 2019, which wasn't reflected in any other year and skewed the growth estimates

Traffic volumes were generally found to be roughly stable or even declining over this period in the weekday AM, weekday PM and Saturday peaks. An exception is the count station at Penshurst Street, which experienced an unusually high spike of northbound traffic in 2019. This growth (+25 per cent from 2018-2019) is not considered sustainable and would already be incorporated into the surveyed intersection counts (undertaken in October 2019), therefore this growth is not expected to continue into the future.

On this basis a growth rate of 0.5 per cent per annum to 2036 was applied to background traffic through movements to reflect potential future development in areas other than Willoughby utilising these corridors for movement. This growth rate was applied to the following roads:

- > Eastern Valley Way;

- > Penshurst Street;
- > Willoughby Road;
- > Victoria Ave;
- > Mowbray Road; and
- > Hampden Road.

3.5.3 Interpretation of modelling results

The intersection performance assessment was undertaken using SIDRA Intersection version 8 software. This software identifies several parameters to identify the performance of intersections. These parameters include Degree of Saturation (DoS), Average Delay in seconds and Level of Service (LoS).

Level of Service (LoS) is the standard measure used to assess the operational performance of the network and intersections. Level of Service is ranked from LoS A to LoS F, with LoS A representing the best performance and LoS F the worst. The assessment of intersection operation is based on criteria defined by TfNSW (formerly RMS) as outlined in **Table 3-4**.

Table 3-4 Level of Service Criteria for Intersections

Level of Service	Average Delay per Vehicle (sec / veh)	Traffic Signals, Roundabout	Give way & Stop Signs
A	< 14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near Capacity & accident study required
E	57 to 70	At capacity, at signals incidents will cause excessive delays Roundabouts require other control mode	At capacity, requires other control mode
F	> 70	Unsatisfactory and requires additional capacity.	Unsatisfactory and requires additional capacity.

Source: *Guide to Traffic Generating Developments (RMS, 2002)*

Average Delay (Delay) provides a measure of the operational performance of an intersection and determines the LoS when applying the TfNSW method. It should be noted that the delay should be taken as a guide only as longer delays could be tolerated in some locations (i.e. inner-city conditions) and on some roads (i.e. minor side street intersecting with a major arterial route). For traffic signals, the weighted average delay over all movements is used. For roundabouts and priority control intersections (sign control) the critical movement for assessing LoS should be the movement with the highest average delay.

Degree of Saturation (DoS) is another measure of the operational performance of individual intersections. It is ideal to operate with a DoS of less than 0.9, with DoS of up 0.8 considered satisfactory. Intersections are considered to be close to capacity as the DoS approaches 1.0, with queue lengths increasing.

3.6 Recommendations

Recommendations for all local centres are presented in **Table 3-5**.

Table 3-5 Recommendations for all local centres

Issue	Recommendation	Item
Car parking rates in the Willoughby DCP may encourage excessive parking provision for future development.	Review the car parking rates specified in the Willoughby DCP with the intention to reduce the rates and limit parking provided in future development proposals.	Parking policy

4 Artarmon

4.1 Land use

4.1.1 Existing

The Artarmon local centre is situated around Artarmon train station, approximately 1.8 kilometres from Chatswood CBD and St Leonards CBD, and approximately 10 kilometres from the Sydney CBD. The centre is focused on the south-western side of the rail line with a range of shops along Hampden Road including a post office, banking services, health services, fast food, cafes and restaurants. Beyond the centre are residential areas including houses and apartments with density concentrated to the southwest.

An overview of the Artarmon local centre study area and land use mix is presented in **Figure 4-1** and **Table 4-1**.

Figure 4-1 Artarmon local centre



Table 4-1 Artarmon land use mix

Town Centre	
Office / Commercial	3,300 m ²
Medical	1,150 m ²
Shopping / Retail	2,900 m ²
Restaurant	375 seats
Health / Fitness	200 m ²
Attached Housing	9 dwellings
Parking	
Off-Street Supply	200 spaces
On-Street Supply	85 spaces
Peak Non-Residential Parking Demand	200 spaces
Surrounds (400m)	
Aged Care	120 beds
Retirement	40 dwellings
Attached Housing	3,000 dwellings
Detached Housing	300 dwellings

The Artarmon Local Centre includes a number of key pedestrian-generating land uses including:

- > Artarmon train station;
- > North of the train station: Elizabeth Street shops and restaurants, Artarmon Library, Artarmon Car Park and residential areas; and
- > South of the train station: Hampden Street shops and restaurants, Artarmon Public School and residential areas.

The majority of all pedestrian movement within Artarmon is directed towards Artarmon station from the surrounding residential areas. Movements were also observed from Hampden Road heading south towards the Artarmon Public School.

4.1.2 Planned

Forecast development, land uses and uplift were obtained from the *Willoughby Local Centres Strategy* and discussions with Council. Total figures were provided for residential and non-residential floor space under the preferred scenario, as well as an indicative overview of the vision for the local centre.

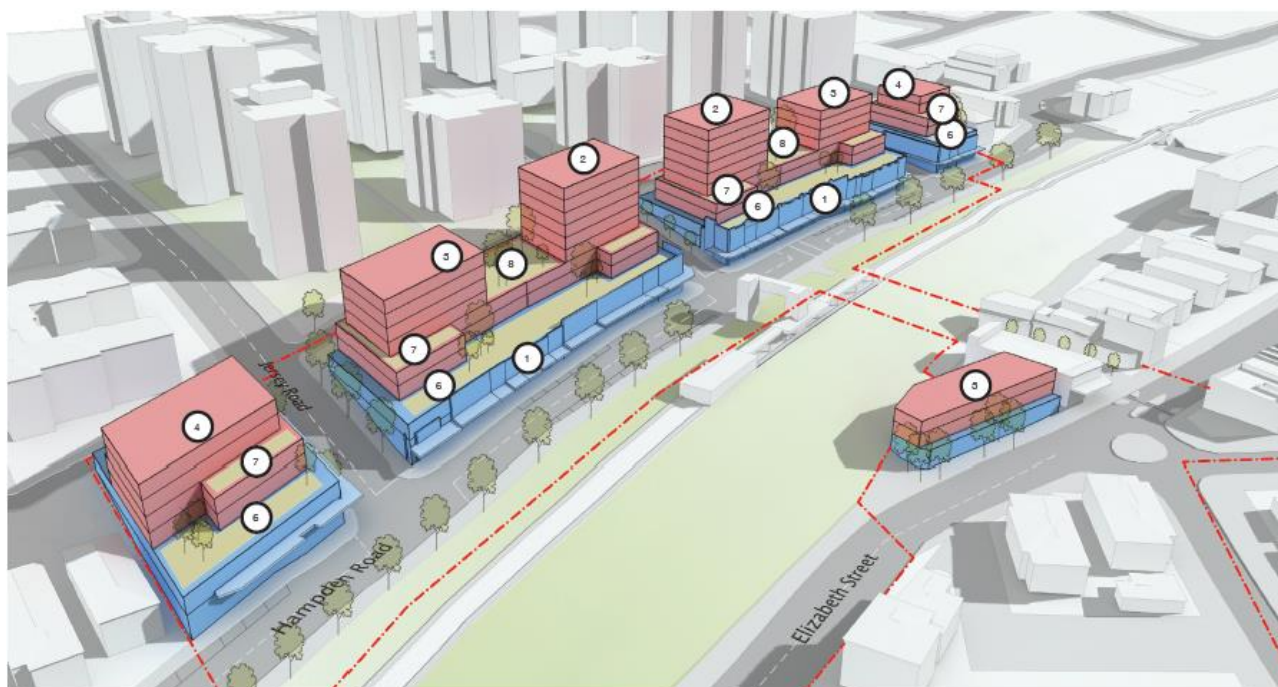
Assumptions will be made in regards to specific uplift of particular blocks and positioning of access points to inform the future network review and traffic modelling.

The Artarmon local centre is forecast for significant uplift in residential and commercial floor space, as well as a range of new offerings and improvements to the public domain. The preferred scenario contains the following key features:

- > A total of 22,379 sqm GFA of residential floor space, representing an uplift of 20,271 sqm or 962 per cent;
- > A total of 20,393 sqm GFA of non-residential floor space, representing an uplift of 6,199 sqm or 44 per cent;
- > New amenities, retail and cycle storage adjacent to the station;
- > Various improvements to the public domain and road network to increase pedestrian priority and safety; and
- > Additional at-grade car parking and access to basement parking from Hampden Lane.

An indicative representation of the scale and distribution of the preferred scenario is presented in **Figure 4-2**.

Figure 4-2 Potential development at Artarmon – preferred scenario



Source: Willoughby Local Centres Strategy

The bulk of the development is proposed to be shop-top housing, with activated street frontages on the ground floor and increased height limits and FSRs accommodating residential growth.

4.1.3 Community concerns

75 people provided feedback about the *Draft Local Centres Strategy* for Artarmon, with people generally supporting the proposal. Many responses related to concerns regarding the proposed heights or suggestions for land uses in the centre. The key community feedback related to traffic and transport issues were focused on the following:

- > Management of limited parking is required;
- > Concern regarding overdevelopment / high-rise; and
- > Support for recommendations about pedestrian and cycling infrastructure.

The train station and surrounding land uses such as retail, restaurants and residential areas compete for on-street and off-street car parking as well as kerbside needs for kiss and ride servicing the station, bus stops, and loading zones. Parking supply is limited and parking restrictions are in place to manage the demand for parking and support the needs of the various land uses.

The road network is also constrained and channels significant vehicle demand through Hampden Road, where there is significant pedestrian-vehicle conflict with people from residential areas accessing the station.

The community concerns are discussed further in the following sections together with the review of the existing and future transport networks.

4.2 Existing transport networks

4.2.1 Road network and traffic

The road network accommodates multiple transport modes within the Artarmon local centre and supports pedestrians, cyclists, public transport, freight / delivery, private vehicle movements and parking. It serves the movement function but also caters for vibrant streets within Artarmon, supporting places for people.

The Artarmon road network supports north-south and east-west trips within the centre as well as access to local destinations and residential areas. Hampden Road is the key movement corridor within Artarmon, allowing north south movement. It serves as a link to the commercial district and train station and provides a connection to the strategic centre of St Leonards. Hampden Lane runs parallel to Hampden Road, catering for parking demand via time restricted parking spaces and delivering a secondary link pedestrian from medium density residential areas to the train station. Traffic calming on Hampden Lane is provided in the form of speed cushions to reduce traffic speeds. Jersey Road, Broughton Road and Francis Road intersect with Hampden Road, allowing vehicle movement into the commercial district of Artarmon from the south and providing access to the residential areas south of the station.

Brand Street passes over the train line operating as a connection between the north east and south west regions of Artarmon. Elizabeth Street runs parallel to the train line, allowing direct access to Artarmon Station from the north.

Key roads within the local centre are detailed in **Table 4-2** and pictures of key roads from the site visit are illustrated in **Figure 4-3**.

Table 4-2 Key roads

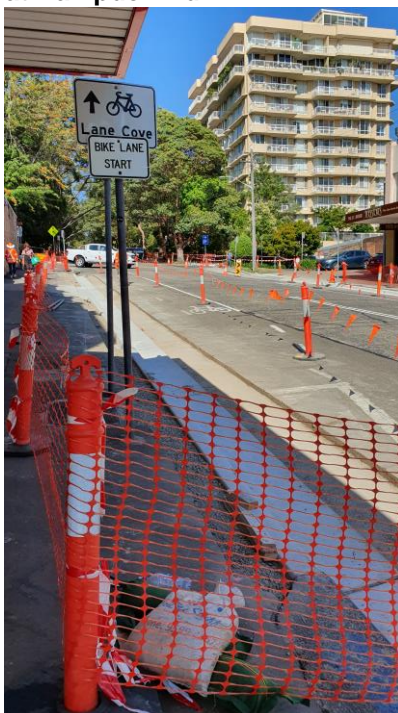
Road name	Road Classification	Managing Authority	Number of Lanes	Speed Limit
Hampden Road	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Elizabeth Street (North of Artarmon Road)	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Elizabeth Street (South of Artarmon Road)	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Broughton Road	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Jersey Road	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Francis Road	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Hampden Lane	Local Road	Willoughby Council	1 (one-way road)	50 km/h

Figure 4-3 Key roads in the Artarmon local centre

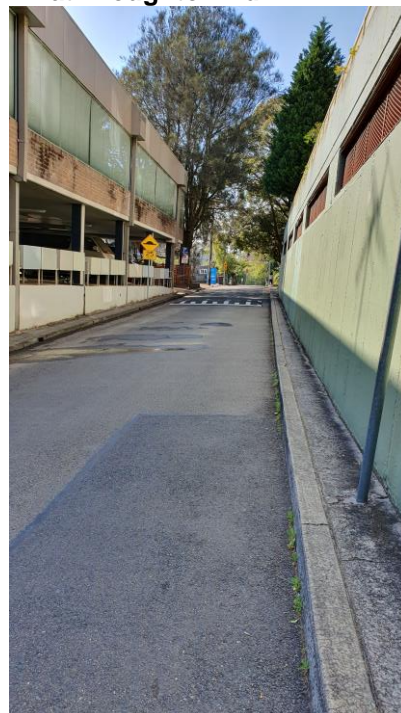
Looking NW along Hampden Rd near Broughton Rd



Looking West along Francis Rd at Hampden Rd



Looking East along Hampden Ln at Broughton Rd



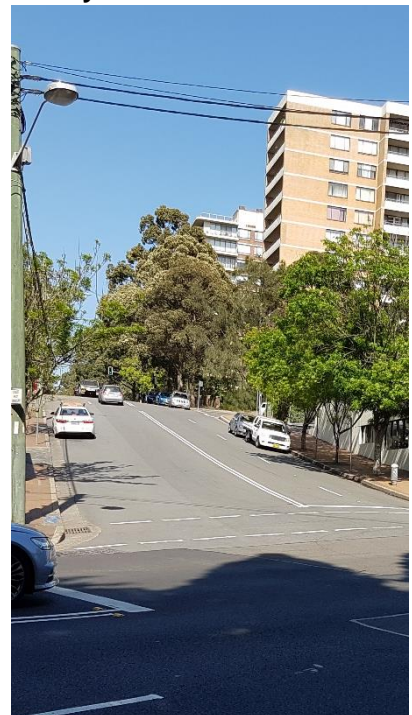
**Looking SE along Elizabeth St
near Tindale Rd**



**Looking North East along
Broughton Road**



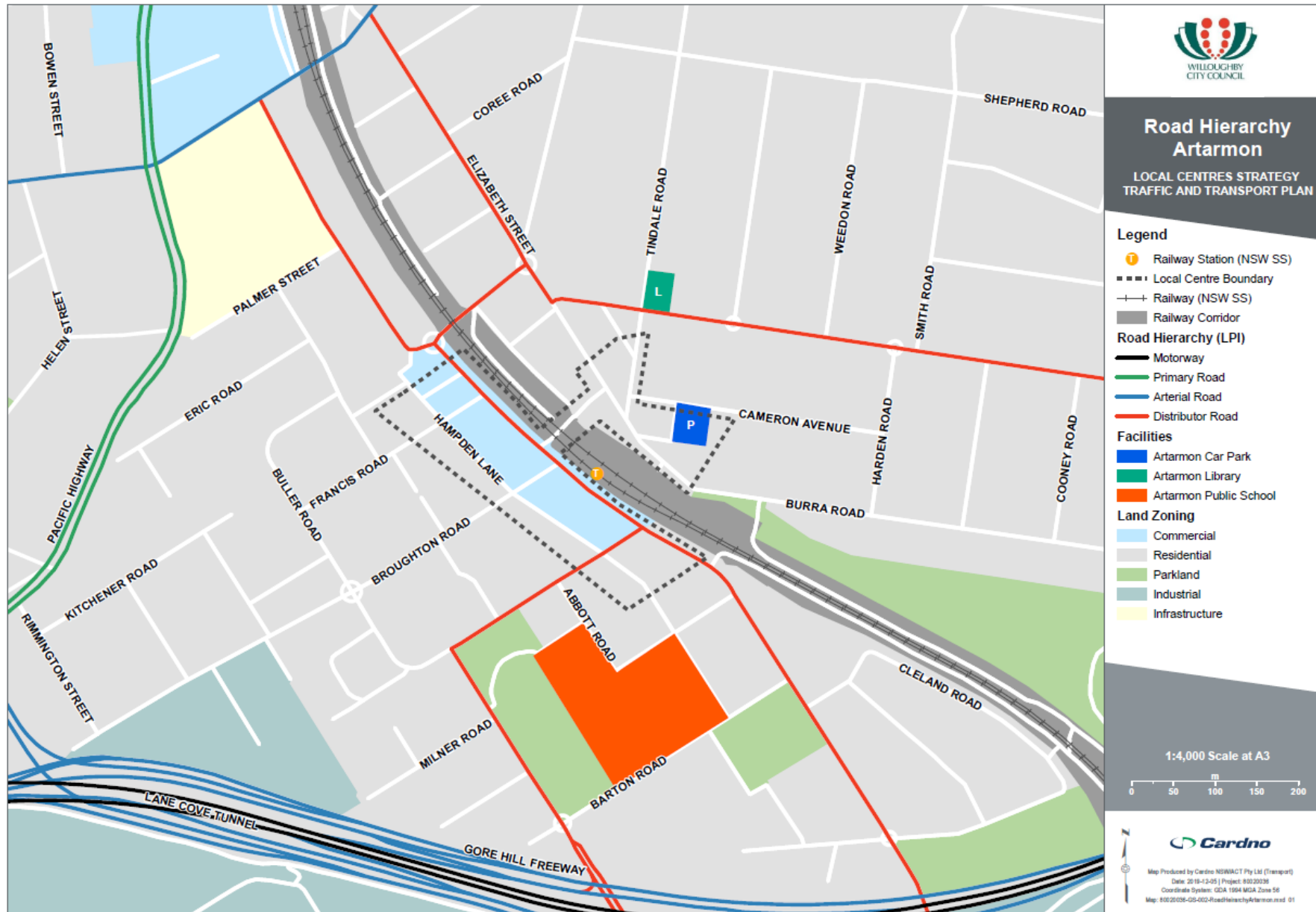
**Looking South West along
Jersey Road**



Hampden Road accommodates the largest traffic volumes, serving as the primary distributor road for north-south movement and providing access to Artarmon train station. The northern side of the station at Elizabeth Street is quiet in comparison. During the site visit, some queuing was observed on Francis Road at the Hampden Road / Francis Road intersection, which resulted in delays as vehicles waited to merge with the main traffic along Hampden Road. Longer queues were observed on Hampden Road due to the volume of traffic, however these were periodic due to the signalised crossing near the station and cleared quickly due to the priority and green time provided for this dominant traffic movement.

The road hierarchy map is shown in **Figure 4-4**.

Figure 4-4 Road hierarchy map



4.2.2 Safety

4.2.2.1 Crash severity and type

Five-year crash data history was analysed from 2014 to 2018 (inclusive). Overall there were 17 reported crashes within the local centre of Artarmon. A summary of crashes by severity is shown in **Table 4-3**.

Table 4-3 Crash summary by severity

Year	Fatal	Serious Injury	Moderate Injury	Minor / Other Injury	TOTAL
2014	0	2	1	1	4
2015	0	1	1	2	5
2016	0	3	2	0	5
2017	0	0	1	0	1
2018	0	1	2	0	3
TOTAL	0	7	7	3	17

There were no fatalities within the local centre during the five-year period, however, seven crashes resulted in serious injury.

4.2.2.2 Crash Locations

Over 50 per cent of all crashes with the town centre occurred on Hampden Road, as shown in **Table 4-4**. This road is classified as an arterial road, with the higher number of crashes being expected due to the higher volume of vehicles. Other notable crash locations include the intersections of Elizabeth Street, Artarmon Road and Tindale Road.

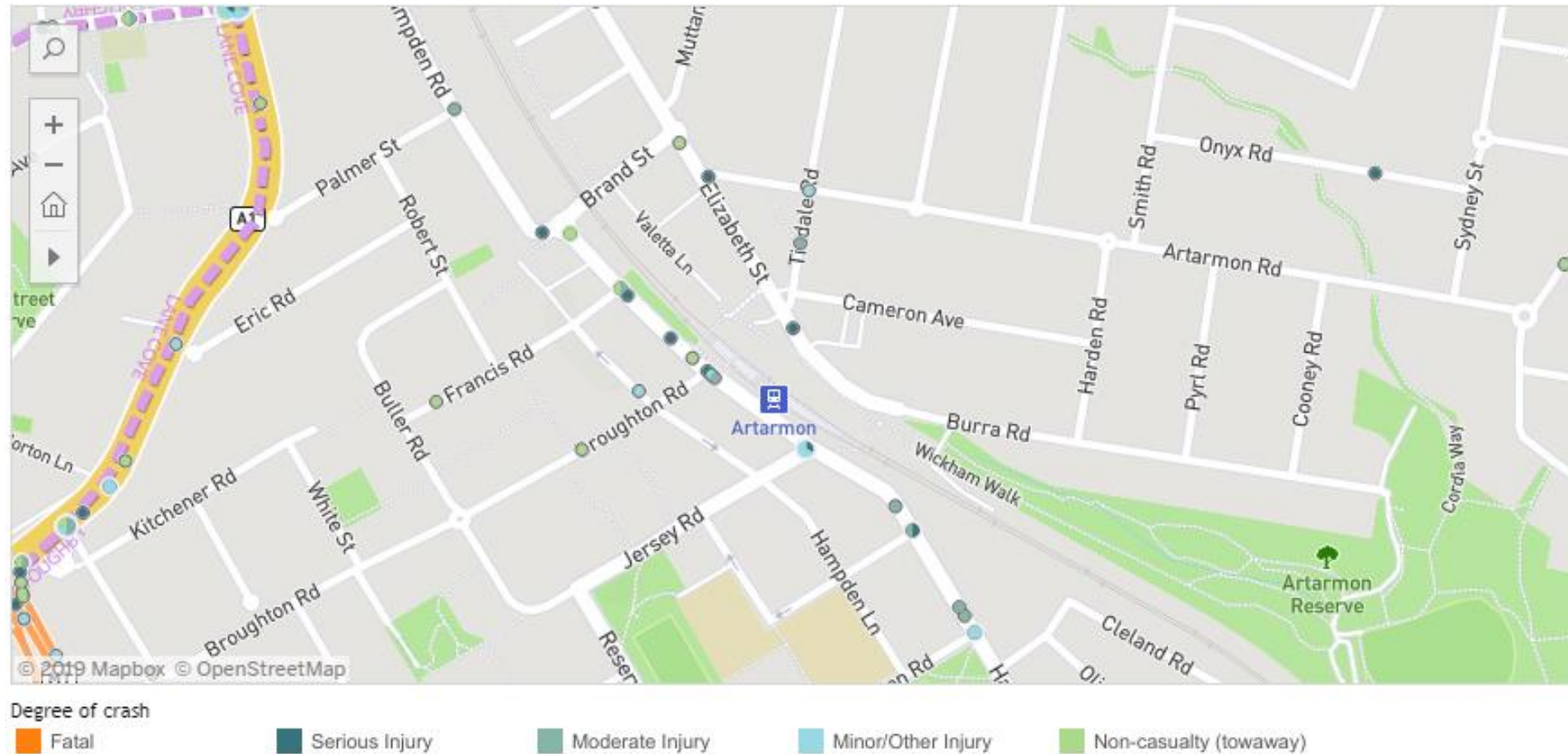
Most crash locations occur near commonly used walking paths to and from Artarmon train station and within the commercial district of Artarmon.

Crash locations within the Artarmon local centre are shown in **Table 4-4** and **Figure 4-5**.

Table 4-4 Crashes locations

Road	2014	2015	2016	2017	2018	Total
Hampden Road	2	3	3	1	3	12
Artarmon Road	2					2
Elizabeth Street		1				1
Tindale Road			1			1
Hampden Lane		1				1
Total	4	4	4	1	3	17

Figure 4-5 Crash map



Source: NSW Centre for Road Safety

4.2.3 Existing pedestrian network and infrastructure

Hampden Road, serving as the centres key walking corridor, provides wide footpaths on both sides of the road. Jersey Road and Broughton Road provide similarly wide footpaths at their connection point with Hampden Road. Hampden Lane, a popular pedestrian connection for local residents, does not provide footpaths, even though this is a desire line for pedestrians. North of Artarmon Station, Elizabeth Street offers wide footpaths adjacent to the station linking quiet suburban streets with local shops, cafes and restaurants. A pedestrian underpass of the railway line accommodates pedestrian movement between Hampden Road and Elizabeth Street and provides access to the train station. Another underpass is located approximately 190 metres to the southeast and provides access between Hampden Road and Burra Road, however this underpass is dimly lit, long and has no surveillance.

Figure 4-6 Lack of footpaths on Hampden Lane



Figure 4-7 Pedestrian underpass between Hampden Road and Burra Road



The width of the footpath on some sections of Hampden Road is reduced as a result of the provision of outdoor dining. Burra Road and Elizabeth Street north east of the station offer footpaths approximately 1.2 – 1.5 metres wide despite being adjacent to a commercial district.

A signalised mid-block crossing is provided on Hampden Road approximately 45 metres northwest of Artarmon Station and provides access from the southwest. The crossing does not align well with the desire lines from Broughton Road or Francis Road and some informal crossing was observed to occur. The footpath on the western side of the crossing is split-level and accessed by stairs, meaning this route is not accessible and footpath space for movement and queuing is reduced. Another signalised pedestrian crossing is provided at the intersection of Hampden Road and Jersey Road, although there is a missing crossing on the eastern leg of this intersection. The distance between the crossings is 150 metres. A pedestrian refuge is located directly opposite the station entrance and aligns with the eastern side of Broughton Road, which provides convenient access across Hampden Road for pedestrians but prioritises vehicles.

Pedestrian fencing is provided on Hampden Road outside the station to prevent informal mid-block crossing by pedestrians entering or exiting the station. This helps direct pedestrians to the nearby crossing, however may trap pedestrian crossing informally from the south since no corresponding fencing is provided on the opposite side of the road.

The local centre provides a through site connection from Elizabeth Street to the station via Wilkes Avenue (a pedestrianised plaza) and to Hampden Road via an underpass west of the station. These links provide improved pedestrian connectivity, however do not appear to provide adequate lighting and remain hidden from surrounding streets and laneways.

There are no signalised crossings provided north of the station, and access is facilitated only by a pedestrian refuge at Cameron Avenue which roughly aligns with the pedestrian underpass of the railway line.

Lift access to the station is provided on Hampden Road, however there is no lift access from Elizabeth Street and there is a steep ramp from Wilkes Avenue to the station. Accessible routes to the station are therefore limited to the south. Commuters with accessible needs from the north of the station would need to cross the underpass from Elizabeth Street, which appears to be DDA non-compliant, to access the lift.

Figure 4-8 Steep ramp leading to the station from Elizabeth Street



Figure 4-9 Constrained footpath on Hampden Road



Some kerb ramps were also observed to be non-compliant, being misaligned with pedestrian crossings and reducing accessibility.

The Artarmon Local centre walking catchment is shown in **Figure 4-10**.

4.2.4 Cycling

Existing cycling infrastructure within the Artarmon local centre is limited but supports on road cycling environments. Current provisions include:

- > On-road shoulder lanes on each side of Francis Road between Hampden Road and Buller Road, connecting the local centre to the Lane Cove LGA; and
- > On-road shoulder lanes on each side of Hampden Road south of Jersey Road, providing access from the local centre to St Leonards.

The routes operate as links connecting the commercial centre of Artarmon and surrounding residential areas to the neighbouring strategic centre of St Leonards and the Pacific Highway. The facilities are marked by painted symbols, visually separated, and do not have medians, reducing safety and increasing the risk of vehicle-cyclist conflict by passing vehicles as well as dooring by parked vehicles. Some limited signage is provided to signify the start and end of the cycleway, as well as wayfinding signage to indicate key destinations.

The road network directly north of the station does not provide any formal provisions for cycling, although roads such as Elizabeth Street are wide and the low traffic levels can accommodate mixed traffic.

Bike lockers and hoops have been installed near the train station, however there may be opportunities to improve the locations of the bike lockers. One locker is provided on the northern side of Hampden Road opposite Francis Road, and one locker is provided on the southern side of Elizabeth Street south of Tindale Road, requiring walks of approximately 100 metres and 60 metres respectively to access the station. Each locker contains four spaces for bicycles which can be rented from TfNSW. Bike racks and hoops are provided adjacent to the station underpass with space for 30 bicycles on the southern side of the station and 6 bicycles on the northern side of the station.

Strava, an online fitness tracking application for cycling, shows popular cycling routes logged via mobile applications and provides indicative data on recreational cycling demand. Strava data was reviewed to identify key routes currently used by cyclists, and the data indicated Hampden Road is the primary north-south movement corridor. Tindale Road and Burra Road are also utilised to reach key corridors such as Mowbray Road and the M1 corridor.

A map of the existing and proposed bicycle network is presented in **Figure 4-11**.

Figure 4-10 Walking routes

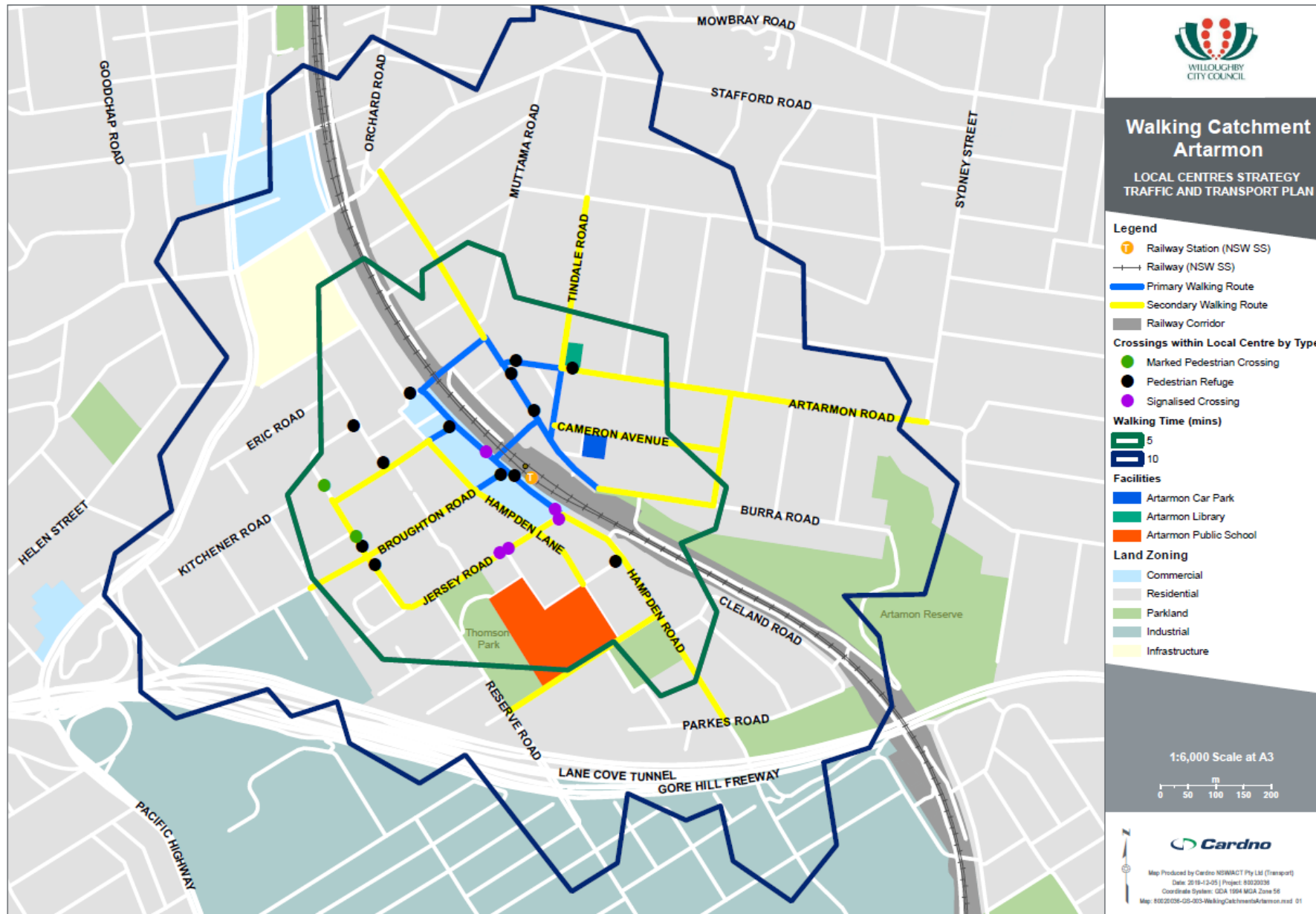
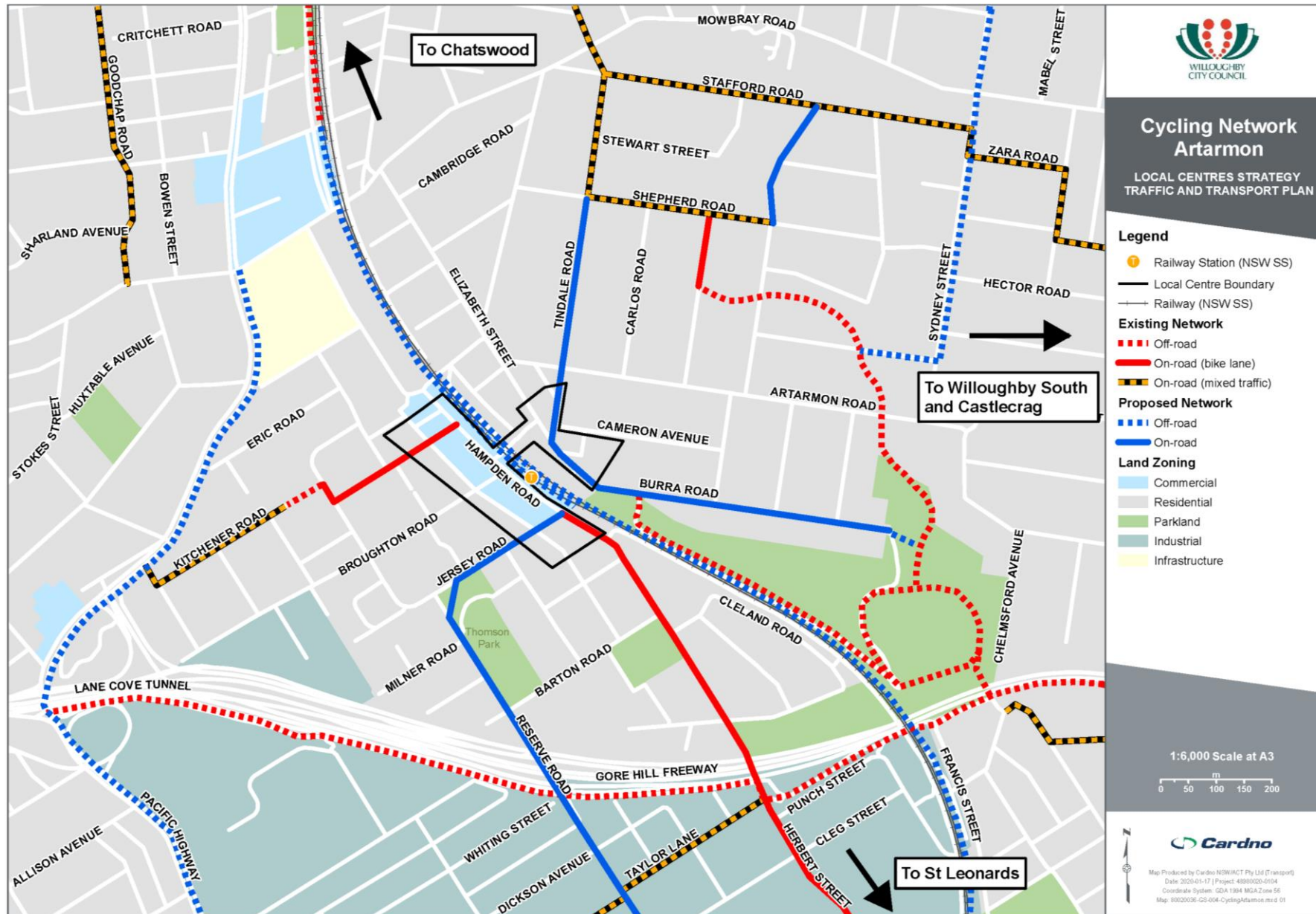


Figure 4-11 Bicycle network



4.2.5 Public Transport

Public transport data was obtained from desktop analyses and TfNSW and included train service information, bus route maps and data relating to service frequency and routes. The data was used to assess the availability and accessibility of public transport to inform the review of the transport networks and guide recommendations.

Public transport within the local centre is provided by rail services at Artarmon train station operated by the State Transit Authority (STA). Train services stopping at Artarmon station operate on the T1 North Shore and Western Line, T9 Northern Line and the Central Coast and Newcastle Line. The station's central location allows a 21 minute commute to the Sydney CBD (Town Hall), 11 minutes to North Sydney and 3 minutes to the Chatswood interchange, where Sydney Metro services and bus services are provided.

The train routes that service Artarmon station are listed in **Table 4-5**.

Table 4-5 Artarmon train services

Route	Frequency (weekday AM peak)	Frequency (weekday PM peak)
T1 City to Berowra via Gordon	3-4 min	3-4 min
T1 Berowra to City via Gordon	3-4 min	3-4 min
T9 Hornsby to North Shore via City	15 min	15 min
T9 North Shore to Hornsby via City	15 min	15 min
CCN Central to Newcastle via Strathfield or Gordon	N/A	15 min
CCN Newcastle to Central via Strathfield or Gordon	15 min	N/A
Total	~ 3 min	~ 3 min

Typical station facilities are provided at Artarmon station as well as provision for accessibility. Key station facilities provided include the following:

- > Kiss and ride stopping area;
- > Taxi rank;
- > Bike racks;
- > Bike lockers;
- > Opal ticket machine;
- > Accessible platform access (from the southern side);
- > Accessible kiss and ride.
- > Accessible toilet;
- > Tactile surfaces;
- > Toilets;
- > Emergency help point;
- > Payphone; and
- > Baby change table.

Bus stops are provided on Hampden Road near the station and bus services operate during the late evening hours and early morning hours, however regular bus services do not operate during daylight hours. There is therefore limited public transport connectivity and interchange options available.

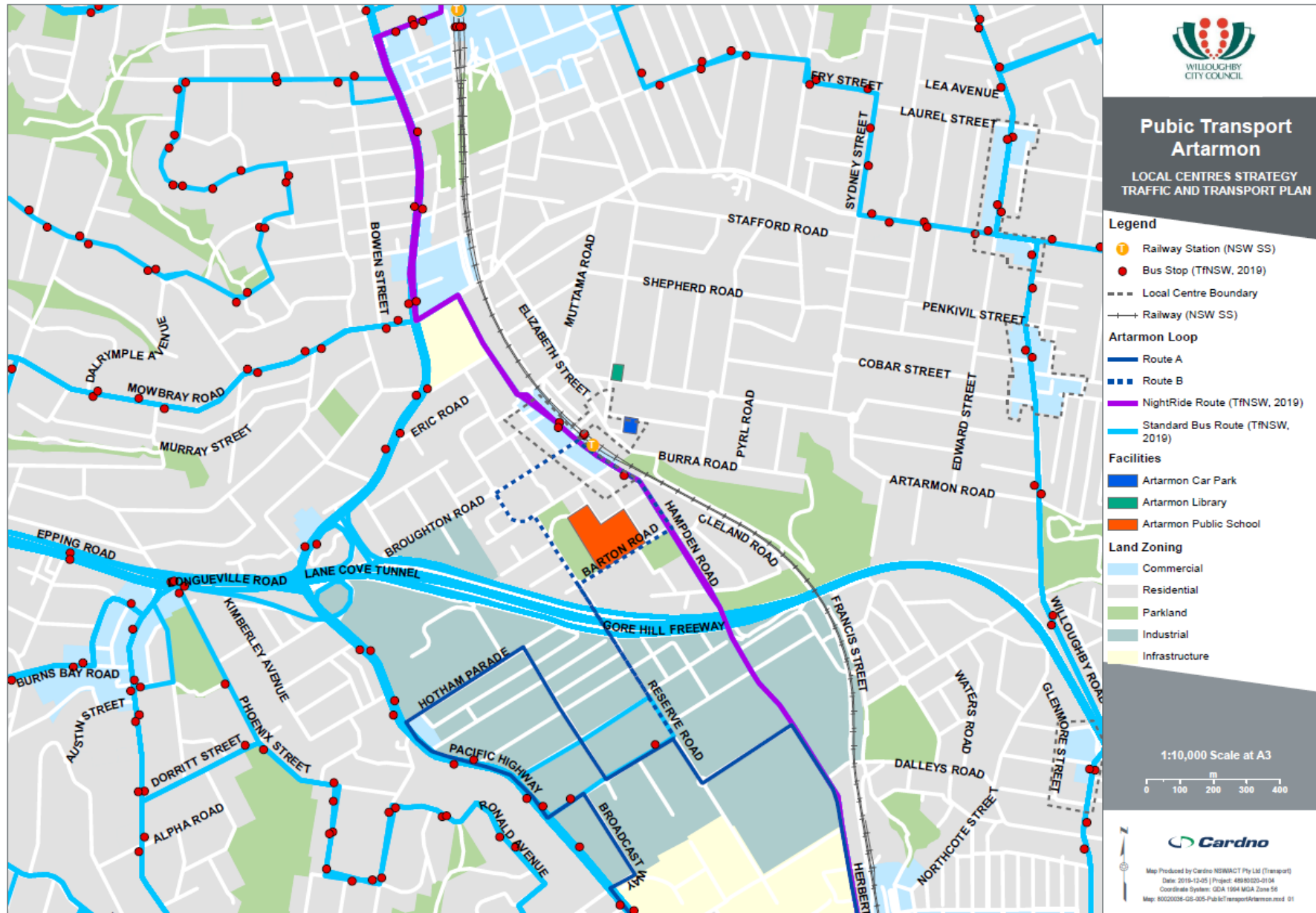
The night buses available at Artarmon station include:

- > N90 Hornsby to City Town Hall via Chatswood;
- > N90 City Town Hall to Hornsby via Chatswood;
- > N91 Bondi Junction to Macquarie Park via City Town Hall; and
- > N91 Macquarie Park to Bondi Junction via City Town Hall.

Each route leaves once every hour during the night while train services are not operating.

A map of the public transport services within and around the Artarmon local centre is provided in **Figure 4-12**.

Figure 4-12 Public transport map



4.2.6 Freight, servicing and loading

The local centre provides three on-street loading zones, one located on Francis Road, operating during the morning peak and two more on Hampden Road available for use without time restrictions. The provision of loading zones is illustrated in **Figure 4-13**. The loading zones are placed at functional locations, catering for cafes, restaurants and shops within Artarmon's commercial district.

A loading zone that appears to be non-compliant is currently operating on Hampden Road, in between Broughton Road and Francis Road. The loading zone is located directly next to a stairway, obstructing access and providing insufficient clearance to safely unload goods.

The local centre does not contain a freight movement corridor, with the closest designated key freight routes being the M1 Gore Hill Freeway and the Pacific Highway.

4.2.7 Ride and vehicle sharing services

Two car share spaces are provided within the local centre, one located on the northern side of Broughton Road at Hampden Road, and one located on the western side of Hampden Lane at Francis Road. These provide spaces for authorised vehicles such as GoGet. Other car share spaces are located outside the local centre, particularly to the southwest within the residential area, along Buller Road and Jersey Road. There do not appear to be any other specific provisions for car or ride sharing, although services such as Uber are able to utilise No Parking zones near the station for convenient drop-off and pick-up. A No Parking zone is located on the northern side of Hampden Road just west of the pedestrian underpass which can facilitate these activities in the AM and PM peaks. Another No Parking zone is located further west in the AM and PM peaks, and becomes 1P parking in the off-peak periods.

A taxi zone is also located on the southern side of Elizabeth Street near Tindale Road and can accommodate two taxis. A visualisation of kerbside facilities is provided in **Figure 4-13**.

4.2.8 Parking provision

Artarmon provides time restricted parking on either side of the side of Artarmon Station, with Hampden Road offering primarily 1/2P parking and Elizabeth Street largely offering 1P parking. Similar restrictions are present along streets adjoining Artarmon Station and Hampden Road. Two small carparks provide time restricted parking along Hampden Lane. All day parking is available via a carpark on Cameron Avenue however spaces are limited and will not cater for a sizeable commuter population.

The station provides No Parking zones in close proximity to the station on Hampden Road, facilitating kiss and ride movements. Additional dedicated Kiss and Ride zones are provided on Elizabeth Road with accompanying signage, and are provided within a 50-metre walking distance to the station.

Accessible parking is catered for on Hampden Road, with a space available adjacent to the station lift and a second space located within 50 metres of the station. An additional accessible space is also provided on Broughton Road, within a 2-minute walk to the station. Accessible parking is also provided north of the station on Elizabeth Avenue, located a short walk to the station.

An overview of parking availability for the weekday AM & PM peak periods is shown in **Figure 4-13**.

Parking profiles indicating the total parking requirement over the course of the day are presented in **Figure 4-14** and **Figure 4-15**. For further details and an explanation of these graphs refer to **Appendix B**.

Figure 4-13 Parking availability

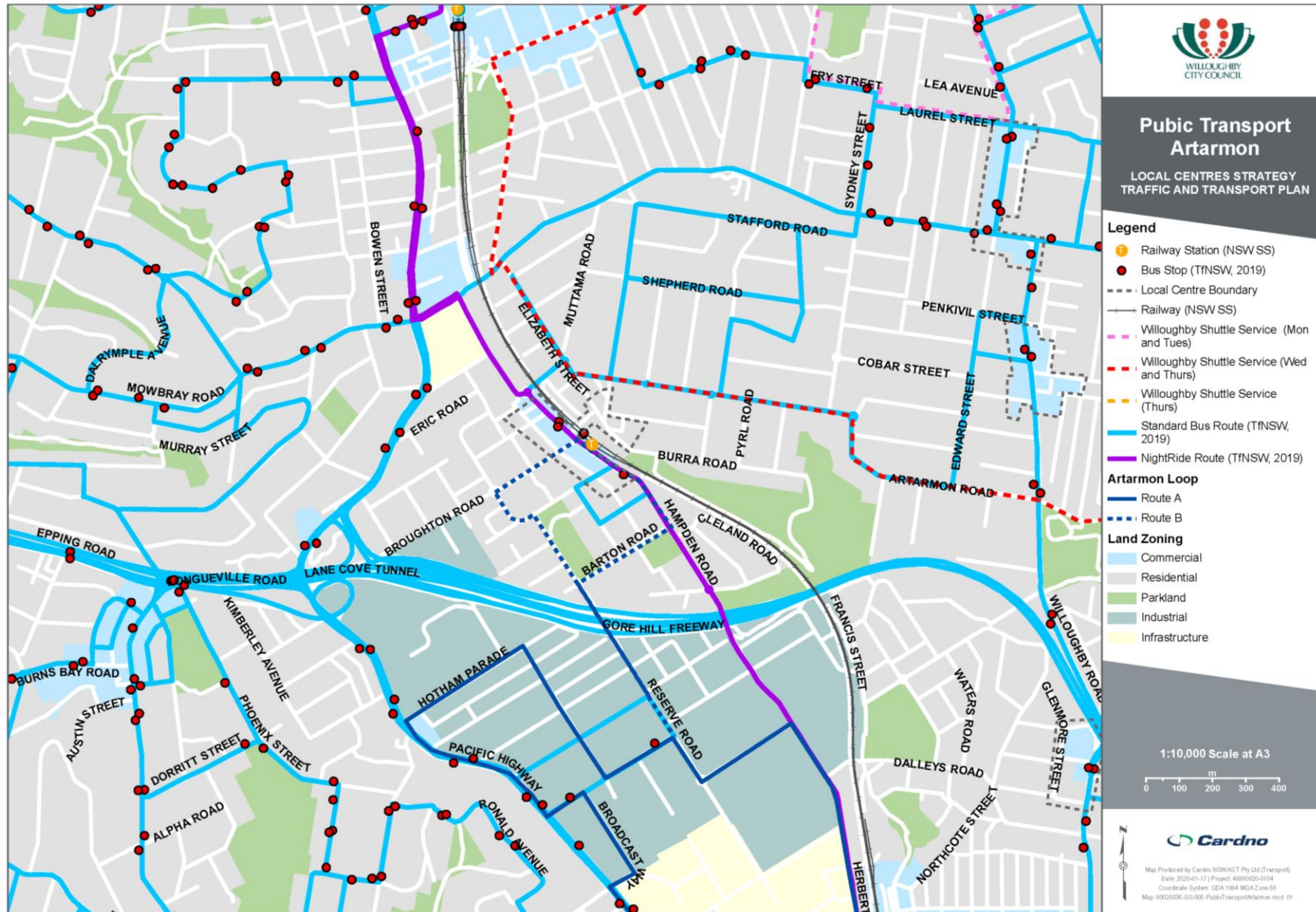


Figure 4-14 Artarmon weekday parking profile

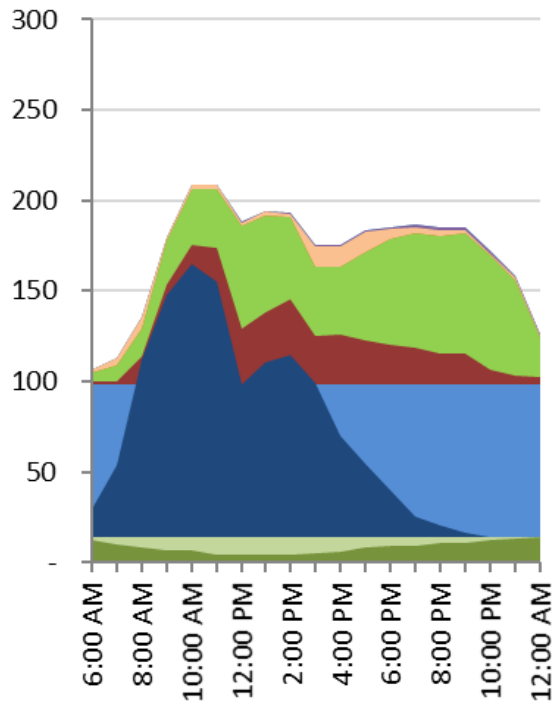
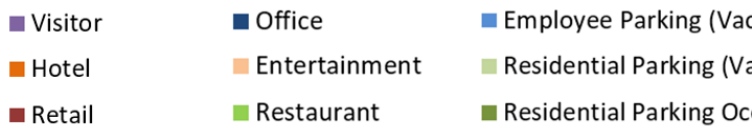
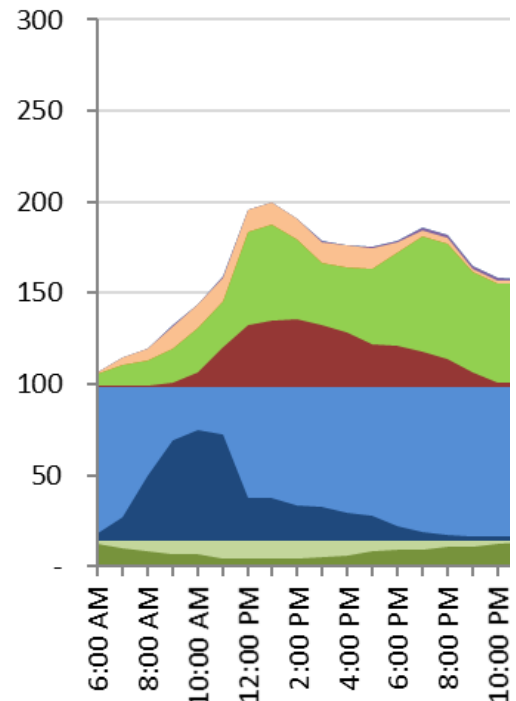
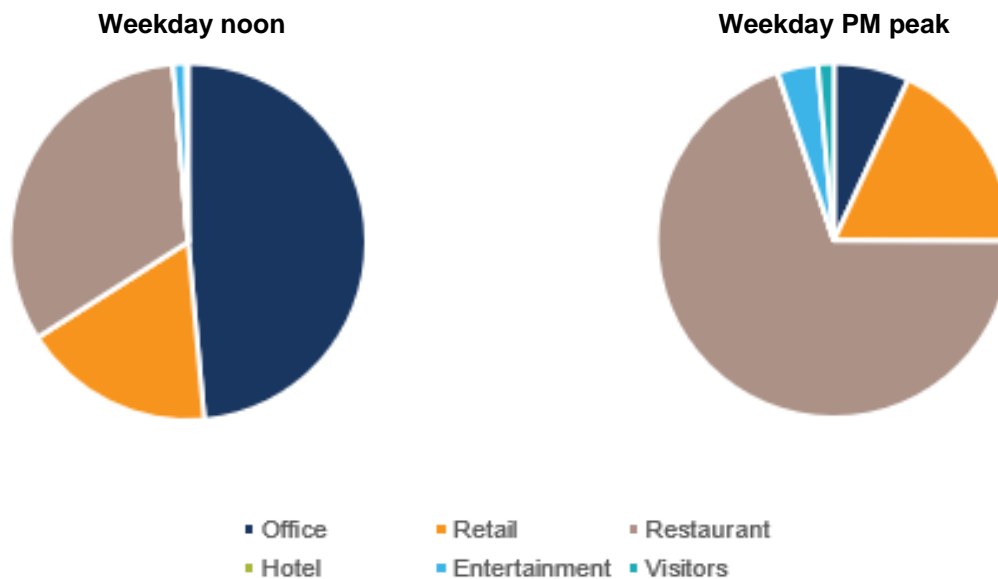


Figure 4-15 Artarmon weekend parking profile



A breakdown of the peak parking demand by land use is presented in **Figure 4-16**.

Figure 4-16 Artarmon peak parking demand



4.2.8.2 Artarmon parking function

Artarmon's Local Centre is divided by the rail line – with pedestrian connection limited to the pedestrian underpass at the Artarmon Station. This makes it unlikely that visitors to the Centre will choose to park on the north side of the rail line.

Short-stay visitor parking demand is largely accommodated within on-street parking zones along Hampden Road and Hampden Lane. This short-stay parking supply is considered to be sufficient to accommodate the majority of the demand, with some minor overspill into the adjacent residential streets.

Long-stay employee parking is which is generally in small on-site parking facilities within individual lots. The inefficiency of this situation is likely to result in overspill onto adjacent streets. Employee parking must compete for convenient spaces with commuters using the network streets as park and ride.

A dedicated long-stay parking facility is provided for commuters to the north of the station. This Artarmon Car Park has 30 bays long-stay 24P bays, plus 24 3P bays. Long-stay demand in this area exceeds the dedicated commuter supply by some margin, with commuter parking extending along Burra Road, Cameron Road and Hampden Road for 300 metres.

Employees are therefore pushed further away from the Centre, up Broughton Road and other minor streets, where they conflict with residents parking surplus vehicles on-street.

4.2.8.3 *Parking recommendations*

The existing 1/2P free parking is likely too short to support many of the uses along Hampden Road, and is difficult to enforce.

Recommendation (Management):

Increase 1/2P duration restrictions along Hampden Road to 1P.

The overlapping requirements for long-stay parking from the Centre employees, commuters to Artarmon Station and residents of the area create a degree of parking scarcity within the Precinct.

One option to rectify this is to introduce a combination of 2P duration restrictions (in residential zones), and paid long-stay parking (within the Artarmon Car Park and key streets adjacent to the Station). The associated fee is expected to be minimal, but enough to establish a price signal which would relocate commuter traffic further from this station.

The impact of this measure would likely require some form of residential permit scheme through a transition period.

Recommendation (Management):

Consider introduction of localised paid parking for long-stay bays in the Precinct.

4.2.9 **Intersection modelling**

4.2.9.1 *Intersection counts*

For the Artarmon local centre, a total of six intersections were surveyed and included:

- > Hampden Road / Jersey Road (signalised intersection);
- > Hampden Road / Broughton Road (priority controlled);
- > Hampden Road / Francis Road (priority controlled);
- > Hampden Road / Brand Street (priority controlled – roundabout);
- > Hampden Road pedestrian crossing (signalised); and
- > Elizabeth Street / Tindale Road / Cameron Avenue (priority controlled).

The peak one-hour periods with the heaviest traffic were identified to be:

- > 7:30am – 8:30am for the weekday AM peak;
- > 4:15pm – 5:15pm for the weekday PM peak; and
- > 11:00am – 12:00pm for the Saturday midday peak.

The data was used to inform the traffic modelling by providing the traffic under existing conditions. Volumes and intersection modelling results are presented in **Appendix A**.

4.2.9.2 *Intersection modelling results*

SIDRA intersection modelling results for key intersections within the Artarmon local centre are presented in **Table 4-6**. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 4-6 SIDRA intersection modelling results - Artarmon

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Hampden Road / Brand Street	0.832	27.4	B	0.898	55.7	D	0.892	48.6	D
Hampden Road / Francis Road	0.386	52.5	D	0.493	48.4	D	0.446	46.2	D
Hampden Road Pedestrian Crossing	0.638	8.3	A	0.791	10.1	A	0.679	6.7	A
Hampden Road / Broughton Road	0.491	36.4	C	0.637	37.7	C	0.461	30.6	C
Hampden Road / Jersey Road	0.662	11.5	A	0.908	24	B	0.572	11.1	A
Elizabeth Street / Tindale Road	0.054	5.7	A	0.023	5.6	A	0.016	5.5	A

The Hampden Road / Brand Street intersection and Hampden Road / Francis Road intersection operate at LoS D for most peak periods. All other intersections operate satisfactorily at LoS C or better for all peak periods.

In the PM peak period, the degree of saturation at the Hampden Road / Brand Street and Hampden Road / Jersey Road intersections is indicating that they are operating at capacity. This suggests that the intersections may experience significant decline in performance with any additional volumes.

4.2.10 Summary of opportunities and constraints

Key opportunities and constraints of the Artarmon local centre are summarised in **Table 4-7**:

Table 4-7 Opportunities and constraints

Opportunities	Constraints
<ul style="list-style-type: none"> High proximity to train services allows development with less pressure on the road network Opportunity to improve pedestrian crossings on Hampden Road Opportunity to improve cycleway provision and connectivity Potential to advocate to TfNSW to provide bus routes connecting the local centre to surrounding strategic centres 	<ul style="list-style-type: none"> The rail line reduces permeability through the centre Grades on Hampden Road limit accessibility A lack of daytime bus services inhibits the potential public transport mode share Consistent traffic along Hampden Road in the peak hours may inhibit vehicles access from future developments without significant upgrades

4.3 Future transport network review and recommendations

4.3.1 Traffic network analysis

4.3.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at Artarmon in accordance with **Table 4-8**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 4-8 Apartment mix and occupancy - Artarmon

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	33	1.7	55
1 bedroom	14%	47	1.7	77
2 bedroom	60%	200	2.3	457
3 bedroom	16%	53	2.8	149
Total	100%	333	-	738

¹Based on ABS 2016 Census Data.

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 4-9**. The employee densities were adopted from TfNSW guidelines for office space and typical employee densities for retail and hospitality.

Table 4-9 Non-residential floor space assumptions - Artarmon

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	30%	1 / 40 sqm	153
Hospitality	45%	1 / 20 sqm	458
Office	25%	4.75 / 100 sqm	242
Total	100%	-	852

Therefore, based on these assumptions the Artarmon local centre is expected to accommodate approximately 740 residents and 850 employees.

4.3.1.2 Parking requirements

The minimum car parking requirements in accordance with the DCP are presented in **Table 4-10**.

Table 4-10 Minimum car parking requirements - Artarmon

Land use		Rate	Proposed development	Spaces required
Residential (non-adaptable units)	Studio	0.5 / dwelling	33 dwellings	17
	1 bedroom	1 / dwelling	47 dwellings	47
	2 bedroom	1 / dwelling	200 dwellings	200
	3 bedroom	1 / dwelling	53 dwellings	53
	Visitors	0.25 / dwelling	333 dwellings	83
			Residential subtotal	399
Commercial	Retail	36 sqm / space	6103 sqm GFA	171
	Hospitality	107 sqm / space	9154 sqm GFA	85
	Office	110 sqm / space	5086 sqm GFA	46
			Commercial subtotal	302
			Development total	701
	Motorbike parking	1 / 25 car parking spaces	701 spaces	28

Note: Table shows rounded values. Subtotals were rounded down in accordance with the DCP.

Based on these calculations, the proposed development would be required to provide a minimum of 701 car parking spaces (including accessible parking spaces) and 28 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 4-11**.

Table 4-11 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	333 units	33
Retail	1 / 450m sqm GFA	6103 sqm GFA	14
Hospitality	1 / 450m sqm GFA	9154 sqm GFA	20
Office	1 / 600 sqm GFA	5086 sqm GFA	8
Total			76

Note Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

The calculations indicate that the proposed development would be required to provide 76 bicycle spaces.

4.3.1.3 Trip generation

Based on the trip generation rates presented in **Section 3.3**, the estimated number of trips generated by the proposed development are presented in **Table 4-12**. An estimate of existing traffic generated by the current land uses is also provided, as well as the additional traffic expected to be generated.

Table 4-12 Future traffic generation

Land use	Total development (existing + proposed)	Traffic generation (veh/hr)		
		AM peak	PM peak	Saturday peak
Residential	333 units	63	50	63
Retail	4,577 sqm GLFA	51	163	42
Hospitality	6,865 sqm GLFA	77	269	514
Office	5,086 sqm GFA	81	61	0
Total		273	543	619
Existing traffic generation		152	349	394
Additional traffic generated		+121	+194	+225

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

On this basis the proposed development is expected to generate an additional 121 vehicle movements in the AM peak hour, 194 in the PM peak and 225 in the Saturday peak.

4.3.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 4-13**.

Table 4-13 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the additional traffic generated to determine the inbound and outbound trips presented in **Table 4-14**.

Table 4-14 Inbound and outbound additional traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	11	46	32	14	29	29
Retail	8	8	25	25	6	6
Hospitality	14	9	49	33	78	78
Office	22	2	2	17	0	0
Total (additional traffic generated)	55	65	107	87	113	113

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 4-15**.

Table 4-15 Directional assumptions

Direction	In %	Out %
North	35%	45%
East	0%	0%
South	52%	26%
West	14%	29%
Total	100%¹	100%

Source: ABS 2016 Census Data

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

4.3.1.5 Intersection modelling results

Intersection modelling was undertaken for key intersections within the Artarmon local centre using SIDRA Network software. The modelling examined the intersection performance for the following scenarios:

1. 2036 With 100 per cent Development; and
2. 2036 With 75 per cent Development.

The 2036 With 100 per cent Development scenario represents a full development case which may be realised in 2036. The 2036 With 75 per cent Development scenario represents a case where the development is not fully achieved, and is presented to understand the impacts of a reduced scale of development which may occur at an earlier point in time. The results and key findings of each scenario are presented in the following sections.

4.3.1.5.1 2036 With 100 per cent Development modelling results

Table 4-16 summarises the intersection performance of the Artarmon local centre for the 2036 with 100 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**

Table 4-16 Future intersection performance (100 per cent development) – Artarmon

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Hampden Road / Brand Street	0.925	41.7	C	0.980	76.9	F	1.093	140.8	F
Hampden Road / Francis Road	0.535	91.6	F	0.661	72.3	F	0.822	102.8	F
Hampden Road Pedestrian Crossing	0.726	9.0	A	0.748	7.6	A	0.791	8.6	A
Hampden Road / Broughton Road	0.819	69.0	E	0.929	81.4	F	0.857	71.9	F
Hampden Road / Jersey Road	0.764	13.1	A	0.885	20.4	B	0.748	13.4	A
Elizabeth Street / Tindale Road	0.056	5.7	A	0.028	5.6	A	0.020	5.5	A

In the 2019 base model, the Hampden Road / Brand Street intersection and Hampden Road / Francis Road intersection operated at LoS D for the PM and Saturday peak periods. With no capacity improvements considered in 2036 and due to the expected increase in demand generated under the full development scenario, the operational performance of these intersections deteriorates to LoS F in the PM and Saturday peak periods. This is due to the expected increase in demand generated on priority roads such as Hampden Road.

The intersection operations worsen at Hampden Road / Broughton Road in all peaks when compared to the 2019 base model. In the weekday AM peak period, the intersection performance deteriorates from LoS C in 2019 to LoS E in 2036. In the weekday PM and Saturday peak periods, the intersection performance deteriorates from LoS C in 2019 to LoS F in 2036. The performance of the Hampden Road / Broughton Road intersection in all peak periods in the future year 2036 is driven by the right turning vehicles from the side street (Broughton Road), which are unable to find a sufficient gap on Hampden Road.

The performance of the Hampden Road / Francis Road intersection in all peak periods in the future year 2036 is due to the right turning vehicles from the side street (Francis Road), which are unable to find a sufficient gap on Hampden Road. This issue was also identified in the existing base model. Due to an increase in volumes on Hampden Road, the opportunity for right-turning vehicles from the side streets is decreased as the headways have decreased further when compared to the existing base model.

4.3.1.5.2 2036 With 75 per cent Development modelling results

Table 4-17 summarises the intersection performance of the Artarmon local centre for the 2036 With 75 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 4-17 Future Intersection Performance (75 per cent Development) - Artarmon

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Hampden Road / Brand Street	0.911	38.9	C	0.976	76.5	F	1.057	116.5	F
Hampden Road / Francis Road	0.469	84.4	F	0.615	64.4	E	0.732	86.1	F
Hampden Road Ped Crossing	0.718	8.9	A	0.759	7.8	A	0.778	8.2	A
Hampden Road / Broughton Road	0.743	58.9	E	0.841	58.9	E	0.833	64	E
Hampden Road / Jersey Road	0.753	12.9	A	0.868	18.7	B	0.676	11.8	A
Elizabeth Street / Tindale Road	0.055	5.7	A	0.027	5.6	A	0.019	5.5	A

Under the 2036 With 75 per cent Development scenario, the Hampden Road / Broughton Road intersection performed better in the PM peak and Saturday peak periods compared to the 2036 With 100 per cent Development scenario, however the intersection is expected to operate at LoS E. The average delay in the PM peak showed a 28 per cent reduction compared to the 2036 With 100 per cent Development scenario, and the Saturday peak showed an 11 per cent reduction. As a result, the intersection performed at LoS E instead of LoS F. This performance is driven by the right turn from Broughton Road (southwest approach), which is the worst-performing movement. There is demand for 76 fewer vehicles at the intersection under the 75 per cent Development scenario compared to the 100 per cent Development scenario.

The Hampden Road / Francis Road intersection also performs better under the 2036 With 75 per cent Development scenario in the PM peak period as the level of service improves to LoS E from LoS F. This is attributed to an 11 per cent decrease in the expected average delay for the worst movement, which is the right turn movement on Francis Road (southwest approach). Under the 75 per cent Development scenario, it is expected that there will be a demand for 30 fewer vehicles at the intersection under the 75 per cent Development scenario compared to the 100 per cent Development scenario.

There are minor performance improvements to the other intersections in the 2036 With 75 per cent Development scenario in comparison to 2036 with 100 per cent Development, although the level of service categories do not change. There were also no significant changes to queue lengths.

4.3.2 Parking analysis

The Local Centres Strategy for Artarmon identifies an opportunity to provide a substantial quantum of shop-top housing in the Centre, supporting a non-residential development increase of almost 50 per cent.

The high proportion of hospitality uses identified in the Local Centres Strategy would tend to increase the potential for conflict between visitors and residents.

In particular, this would exacerbate the insufficiency of parking supply in the Precinct to allow for on-street storage of private vehicles by new residents.

This development increase would need to coincide with an intensification of parking management on the west side of the Station.

As such, a combination of duration / timing restrictions and residential parking permits (see **Appendix B**) in surrounding streets is likely to be necessary to support Centre function. Paid parking may ultimately become necessary as unrestrained demand exceeds the capacity of the local parking catchment.

It is expected that these restrictions would result in a mode shift away from car-as-driver modes. The proximity of the Artarmon Station to the Precinct provides substantial capacity to support this mode shift.

Figure 4-17 Artarmon future non-residential parking demand weekday profile

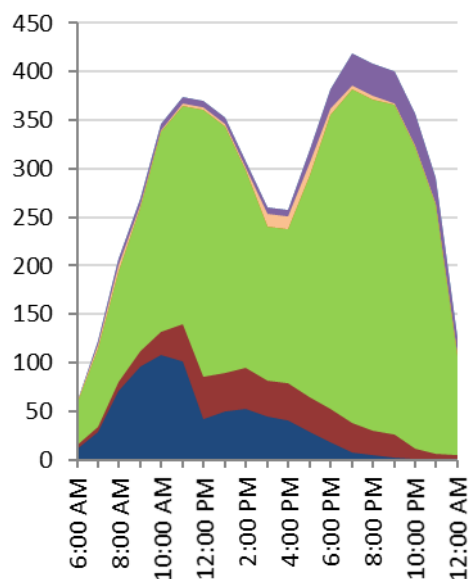
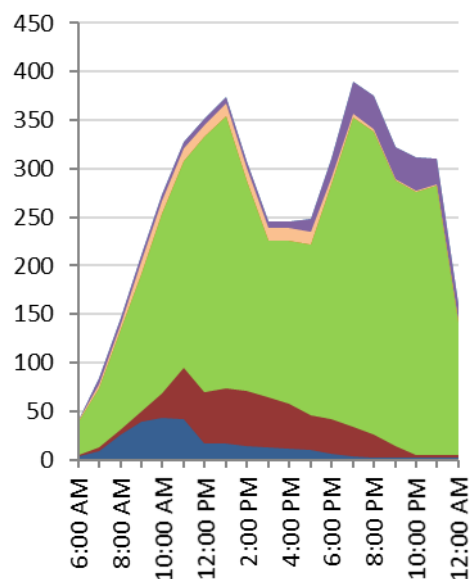


Figure 4-18 Artarmon future non-residential parking demand weekend profile



Visitor
 Office
 Employee Parking (Vacant)
 Hotel
 Entertainment
 Residential Parking (Vacant)
 Retail
 Restaurant
 Residential Parking (Occupied)

4.3.3 Active Transport

Walking and cycling needs within the Artarmon local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

Artarmon already contains an established footpath network with cycling facilities, however some gaps and deficiencies exist and include:

- > Constrained or non-existent footpaths along Hampden Lane and Hampden Road near the signalised pedestrian crossing;
- > A missing pedestrian crossing at the intersection of Hampden Road / Jersey Street;
- > A lack of threshold / gateway treatments at the road network entries to the local centre, as well as a lack of kerb extensions;
- > The potential for vehicle-pedestrian conflict, particularly as the centre is developed;
- > A lack of dedicated cycleway infrastructure along Hampden Road;
- > Non-compliant kerb ramps; and
- > Poor use of pedestrian fencing.

Recommendations to address these issues are summarised in **Section 4.3.5**.

4.3.4 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

Artarmon is well connected by train to surrounding centres and public transport hubs including Chatswood, North Sydney and Sydney CBD. No bus services operate within the local centre during the daytime. The need for bus services is reduced due to the high rail connectivity, but the lack of feeder services to Artarmon station and access to areas not well connected by rail may limit the use of public transport.

There is also the opportunity to provide on-demand services, which may be a viable measure to complement train services given the lack of bus routes serving the centre.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 4.3.5**.

4.3.5 Issues and options

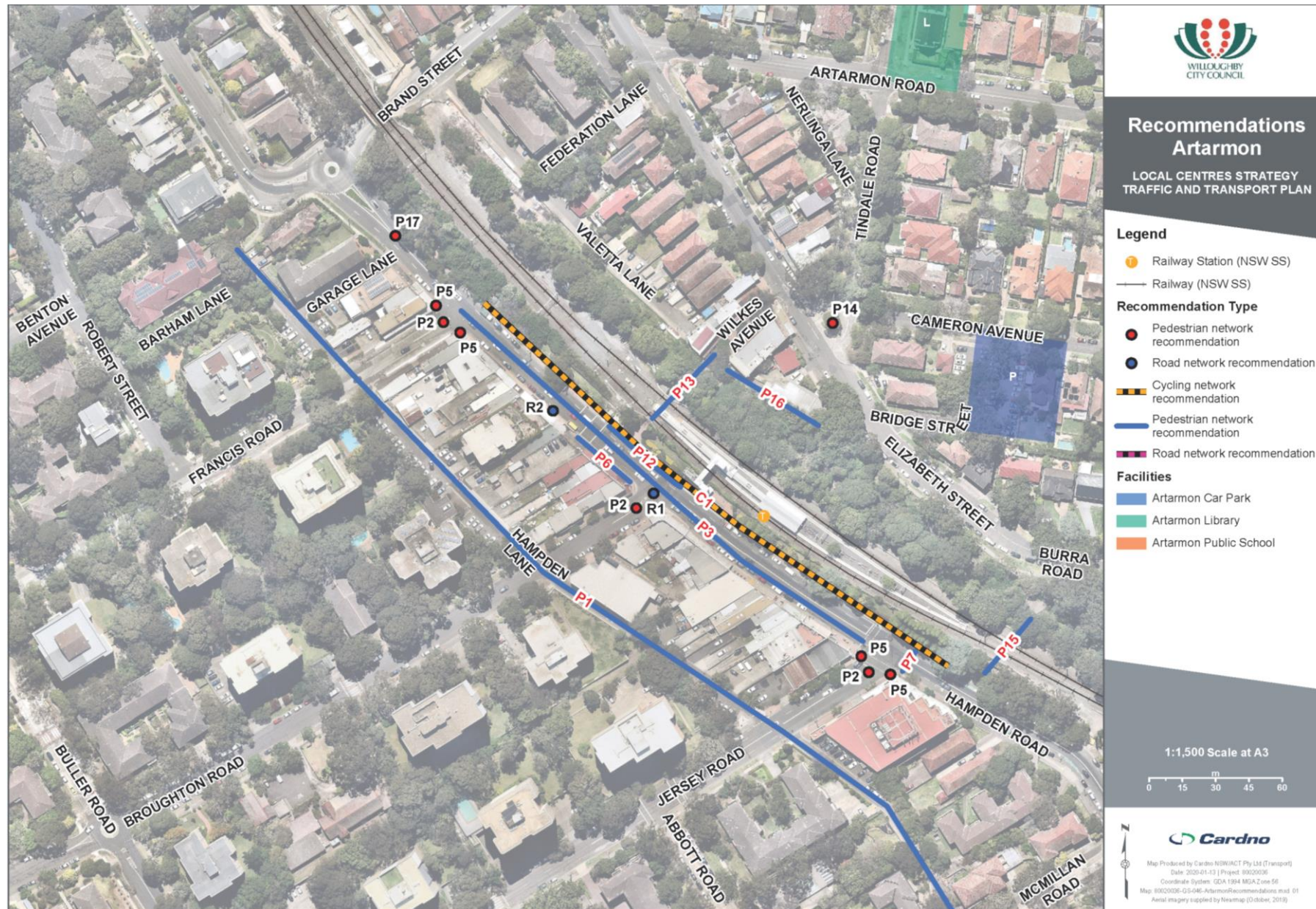
The issues and recommendations for the local centre are summarised in **Table 4-18** and **Figure 4-19**.

Table 4-18 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P1	Lack of footpath along Hampden Lane.	Implement a 10 km/h shared zone along the full length of Hampden Lane to improve pedestrian safety.	Shared Zone	580 metres
P2	Lack of threshold / gateway treatments.	Provide threshold / gateway treatments to improve pedestrian amenity and safety within the centre, including raised pavements and kerb extensions at the intersections of Francis Road, Broughton Road and Jersey Street with Hampden Road.	Pavement treatment	
P3	High pedestrian activity with potential for conflict with vehicles.	Submit a proposal to TfNSW to implement a 40 km/h High Pedestrian Activity Area along Hampden Road between Francis Road and Jersey Street.	Speed limit amendment	
P5	Non-compliant kerb ramps.	Re-align kerb ramps to correct orientations at the intersections of Francis Road, Broughton Road and Jersey Street with Hampden Road.	Kerb ramp and tactile indicators	4 ramps
P6	Limited footpath width and accessibility on the southern side of Hampden Road at the signalised crossing.	Provide a kerb extension on the southern side of Hampden Road at the signalised pedestrian crossing to increase circulation and storage space, and ensure the ramp towards Broughton Road is DDA compliant.	Footpath	
P7	Missing pedestrian crossing at the intersection of Jersey Street / Hampden Road.	Provide a signalised pedestrian crossing on the eastern leg of the Jersey Street / Hampden Road intersection.	Signalised crossing	
P12	Poor use of pedestrian fencing.	Provide landscaping or other high quality urban design treatments to encourage pedestrians to use formal crossing points and prevent pedestrians from being trapped on the road.	Barrier treatment	
P13	Underpass from Wilkes Avenue to Artarmon station is not DDA compliant.	Investigate the feasibility of a re-grade of the footpath / ramp from Wilkes Avenue to Artarmon station to provide DDA compliance.	Footpath	55 metres
P14	Narrow footpaths and an informal crossing point on the island at the intersection of Elizabeth Street, Cameron Avenue and Tindale Road.	Remove the redundant east-west footpath leading to an informal crossing point without a kerb ramp. Widen the north-south footpath and install new compliant kerb ramp to direct pedestrians to the pedestrian refuge to the northwest.	Footpath widening, kerb ramp realignment	6 metres footpath, 1 kerb ramp
P15	Underpass from Hampden Road to Burra Road is poorly lit and may have possible safety concerns.	Provide additional lighting and consider urban design treatments to enhance the underpass and facilitate safe pedestrian movement.	Lighting	
P16	Pedestrian path adjacent to the rail corridor from Elizabeth Street to Wilkes Avenue is poorly lit and without passive surveillance, posing a potential safety risk.	Provide lighting for improved safety and install a footpath to facilitate pedestrian movement.	Lighting and footpath	

No.	Issue	Recommendation	Item	Length / no.
P17	Pedestrians observed crossing informally on Hampden Road near Brand Street.	Install a pedestrian refuge on Hampden Road north of Francis Road to facilitate pedestrian movement from the north west.	Pedestrian refuge	
P65	Lack of Tactile Ground Surface Indicators at kerb ramps.	TGSIs to be provided for all kerb ramps within the local centre.	TGSIs	
Bicycle				
C1	Lack of cycleway infrastructure along Hampden Road.	Provide a shared path on the northern side of Hampden Road between Francis Road and Jersey Street, including path widening over the existing vegetation strip.	Shared path signage & linemarking, footpath widening	240 metres
Public transport				
PT3	Although Council runs limited bus services during the daytime, there are no state-run buses in the area.	Advocate for TfNSW to review bus routes and consider providing services which could feed Artarmon Station or service destinations not well connected by rail (e.g. Ryde and other parts of Willoughby).	Bus services	
Road network				
R1	A poor level of service (LoS D) is experienced at the Hampden Road / Broughton Road intersection.	Ban the right turn from Broughton Road onto Hampden Road to increase performance and reduce safety risks (note that vehicles can turn around at the roundabout at Brand Street).	No Right Turn treatment	
R2	Loading facility on Hampden Road opposite the station loads onto a narrow footpath with stairs.	Relocate the loading zone to a location south of Broughton Road with direct access to a level footpath.	Loading zone relocation	
R20	Overlapping requirements for long-stay parking create a scarcity of parking within the precinct.	Consider the introduction of localised paid parking for long-stay bays in the precinct.	Parking restrictions	
R21	Existing 1/2P free parking is likely too short to support many users on Hampden Road	Increase the 1/2 restriction along Hampden Road to 1P		

Figure 4-19 Recommendations map



5 Castlecrag

5.1 Land use

5.1.1 Existing

The Castlecrag local centre is situated to the east of the Willoughby LGA, adjacent to Eastern Valley Way and Edinburgh Road. The centre is a gateway to the Castlecrag peninsula and contains a range of cafes, restaurants, health services, shops and other businesses focused in the Quadrangle Shopping Village, as well as some houses. Beyond the centre are residential areas mainly composed of houses.

An overview of the Castlecrag local centre study area and land use mix is presented in **Figure 5-1** and **Table 5-1**.

Figure 5-1 Castlecrag local centre

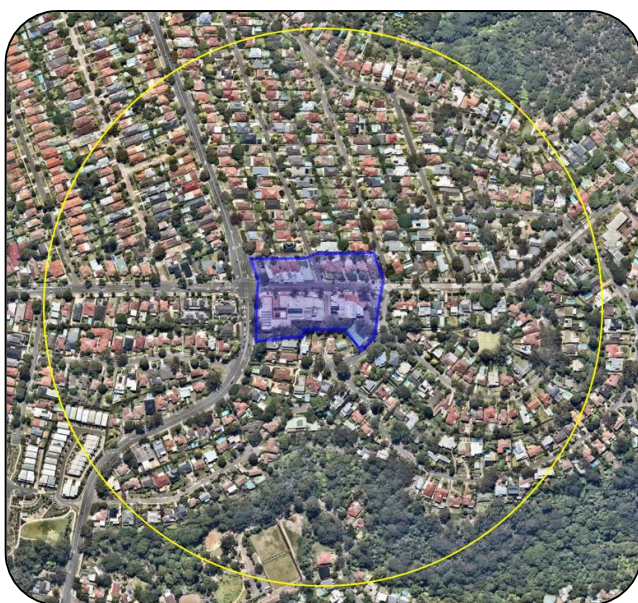


Table 5-1 Castlecrag land use mix

Town Centre	
Office / Commercial	1,700 m ²
Medical	300 m ²
Shopping / Retail	2,700 m ²
Restaurant	350 seats
Health / Fitness	150 m ²
Detached Housing	4 dwellings
Parking	
Off-Street Supply	55 spaces
On-Street Supply	35 spaces
Peak Non-Residential Parking Demand	140 spaces
Surrounds (400m)	
Detached Housing	530 dwellings
Attached Housing	30 dwellings

The Castlecrag Local Centre is within a number of key pedestrian-generating land uses including:

- > The Quadrangle Shopping Village;
- > Edinburgh Street shops and restaurants;
- > Eastern Valley Way bus stops; and
- > Glenaeon Rudolf Steiner School.

The majority of all pedestrian movement within Castlecrag occurs on Edinburgh Road, operating as both a destination for people and as a movement corridor. Edinburgh Road allows direct access to Castlecrag's shopping precinct. Site based observations also showed that Edinburgh Road forms a popular route to reach surrounding destinations such as the local bus stops to the city and the local school east of the centre.

5.1.2 Planned

Forecast development, land uses and uplift were obtained from the *Willoughby Local Centres Strategy* and discussions with Council. Total figures were provided for residential and non-residential floor space under the preferred scenario, as well as an indicative overview of the vision for the local centre.

Assumptions will be made in regards to specific uplift of particular blocks and positioning of access points to inform the future network review and traffic modelling.

The Castlecrag local centre is forecast for significant uplift in residential and commercial floor space, as well as a range of new offerings and improvements to the public domain. The preferred scenario contains the following key features:

- > A total of 10,248 sqm GFA of residential floor space, representing an uplift of 6,655 sqm or 185 per cent;
- > A total of 6,287 sqm GFA of non-residential floor space, representing an uplift of 1,527 sqm or 32 per cent;
- > A new plaza and additional pedestrian links within and to the Quadrangle Shopping Village;
- > A new park / green space at the corner of Edinburgh Road / The Postern; and
- > Improvements to pedestrian crossings and footpaths to increase amenity and safety.

The scale of development at Castlecrag is yet to be finalised.

An indicative representation of the scale and distribution of the preferred scenario is presented in **Figure 4-2**.

Figure 5-2 Potential development at Castlecrag – preferred scenario



Source: Willoughby Local Centres Strategy

The development is proposed to be a mixture of shop-top housing capitalising on retail and commercial opportunities for the Quadrangle Shopping Village, as well as some lots dedicated to residential dwellings.

5.1.3 Community concerns

186 people provided feedback about the *Draft Local Centres Strategy* for Castlecrag, with mixed views about the proposed development. Many people were concerned about the scale of the proposed development, and particularly the potential impact on traffic and parking, which is already perceived to be an issue.

The key community feedback related to traffic and transport issues were focused on the following:

- > Concerns about increased traffic density, particularly in relation to the constrained Castlecrag peninsula;
- > Requirements for careful traffic management;
- > Concern regarding overdevelopment / excessive heights; and
- > Support to ensure the local centre is accessible and safe.

The intersection at Edinburgh Road / Eastern Valley Way is the key access point for the Castlecrag peninsula to the east and is already perceived to be an issue for traffic congestion. It is understandable that increased development in the local centre may exacerbate this and be of concern to local residents.

The community concerns are discussed further in the following sections together with the review of the existing and future transport networks.

5.2 Existing transport networks

5.2.1 Road network and traffic

The road network of Castlecrag accommodates multiple transport modes within the Castlecrag local centre and supports pedestrians, cyclists, public transport, freight, private vehicle movements and parking.

The Castlecrag road network supports both east-west trips within the centre and to access the Castlecrag peninsula, as well as north-south through movements. Edinburgh Road functions as the east-west link between surrounding low density residential housing and the commercial district within the local centre. Eastern Valley Way functions as a regional north-south corridor, primarily serving Crows Nest, North Sydney and the Sydney CBD.

Raeburn Avenue, Rutland Avenue and The Postern intersect with Edinburgh Road to provide local access within the Castlecrag precinct.

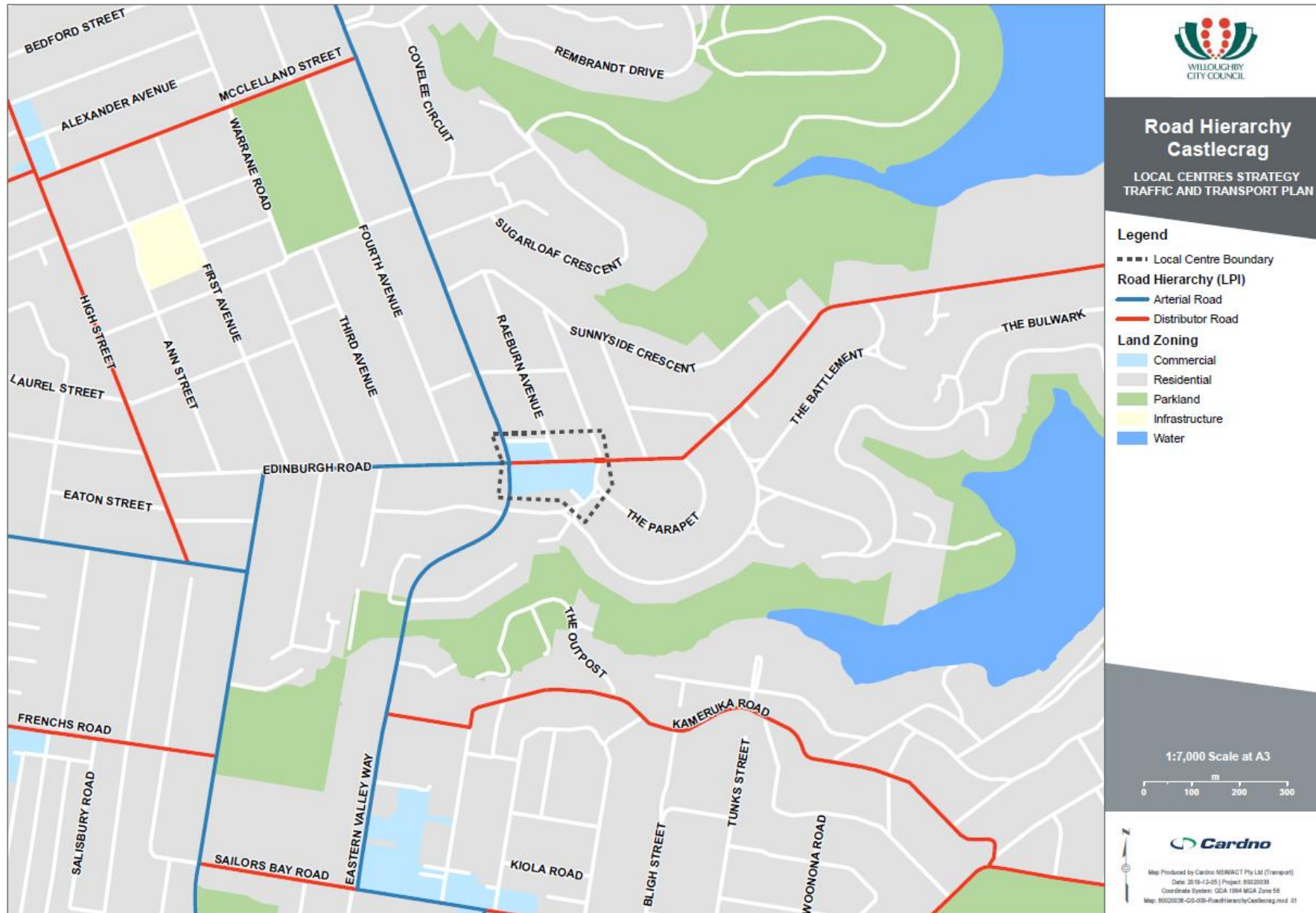
Edinburgh Road accommodates the greatest traffic volumes within the Castlecrag centre precinct, and has a pinch point at the intersection with Eastern Valley Way. Intersection volumes are far lower but still significant where Raeburn Avenue and Rutland Avenue meet Edinburgh Road. During the site visit, queuing was observed on Edinburgh Road at the roundabout intersection with Rutland Avenue. This site survey was conducted during the afternoon and hence queuing was likely a result of school pick-up trips.

Table 5-2 Key roads

Road name	Road Classification	Managing Authority	Number of Lanes	Speed Limit
Edinburgh Road	Local	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Eastern Valley Way	State	TfNSW	4 lanes	60 km/h
Raeburn Avenue	Local	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Rutland Avenue	Local	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
The Postern	Local	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h

The road hierarchy map is shown in **Figure 5-3**.

Figure 5-3 Road hierarchy



5.2.2 Safety

Five-year crash data history was analysed from 2014 to 2018 (inclusive). Overall there were 19 reported crashes within the local centre of Castlecrag. A summary of crashes by severity is shown in **Table 5-3**.

Table 5-3 Crash summary by severity

Year	Fatal	Serious Injury	Moderate Injury	Minor / Other Injury	Non-Casualty (tow away)	TOTAL
2014	0			1	2	3
2015	0	2	5			7
2016	0	3	1	1		5
2017	0		1	0		1
2018	0	2		1		3
TOTAL	0	7	7	3	2	19

There were no fatalities within the local centre during the five-year period, however 7 crashes resulted in serious injury.

5.2.2.2 Crash Locations

The majority of crashes within the local centre occurred on Edinburgh Road and Eastern Valley Way, with a crash cluster evident at the Edinburgh and Eastern Valley Way intersection. A total of six crashes involving pedestrians were recorded from 2014 to 2018. There were three accidents involving pedestrians at the Edinburgh Road / Eastern Valley Way intersection during the five-year study period. A higher concentration of crashes at this location is expected due to the higher traffic volumes through the Eastern Valley Way corridor. The Edinburgh Road / Raeburn Avenue intersection contained another crash cluster and included two crashes involving pedestrians recorded at the intersection.

Crash locations within the Castlecrag local centre are shown in **Table 5-4** and **Table 5-4**.

Table 5-4 Crash locations

Road	2014	2015	2016	2017	2018	Total
Edinburgh Road	1	4	1		2	8
Eastern Valley Way		1	4	2		7
Rutland Avenue		1				1
The Postern	1		1			2
Total	2	7	6	2	2	18

5.2.3 Existing pedestrian network and infrastructure

Edinburgh Road, serving as the centre's key walking corridor, provides wide footpaths along the shopfront transitioning to footpaths approximately 1.2 – 1.5 metres wide where low density housing is present as shown in **Figure 5-4**. Raeburn Avenue and Rutland Avenue offer footpaths approximately 1.2 – 1.5 metres wide, despite providing direct connections to the Castlecrag commercial district. The Parapet, a nearby residential street, does not have footpaths.

The centre contains pedestrian refuges present at the roundabout intersection of Edinburgh Road, Rutland Avenue and The Postern. A site observation conducted during the afternoon peak showed traffic congestion in the vicinity of this roundabout. A congestion hotspot is shown in **Figure 5-5**. Signalised pedestrian crossings are available at the western end of the local centre at the intersection of Edinburgh Road and Eastern Valley Way, however the next pedestrian facility is a refuge at the intersection of Edinburgh Road / Rutland Avenue / The Postern, and the distance between these pedestrian crossing facilities is 170 metres, which is not ideal and is likely to encourage informal mid-block crossing.

The commercial district provides accessible paths of travel, however steep footpath grades are present on connecting streets such as The Postern, as shown in **Figure 5-6**.

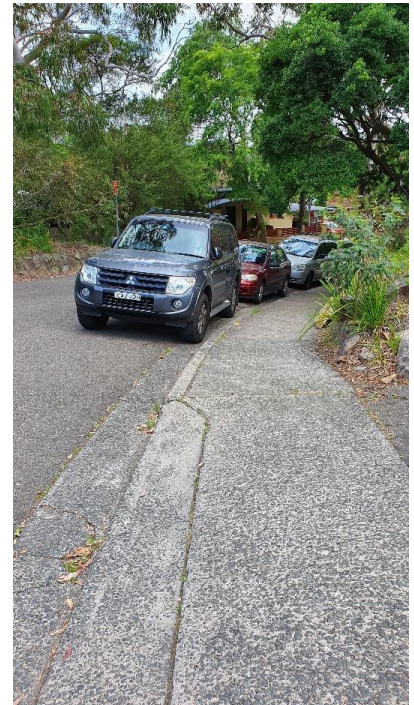
Figure 5-4 Footpaths on Edinburgh Road



Figure 5-5 Pedestrian refuge at the eastern end of Edinburgh Road

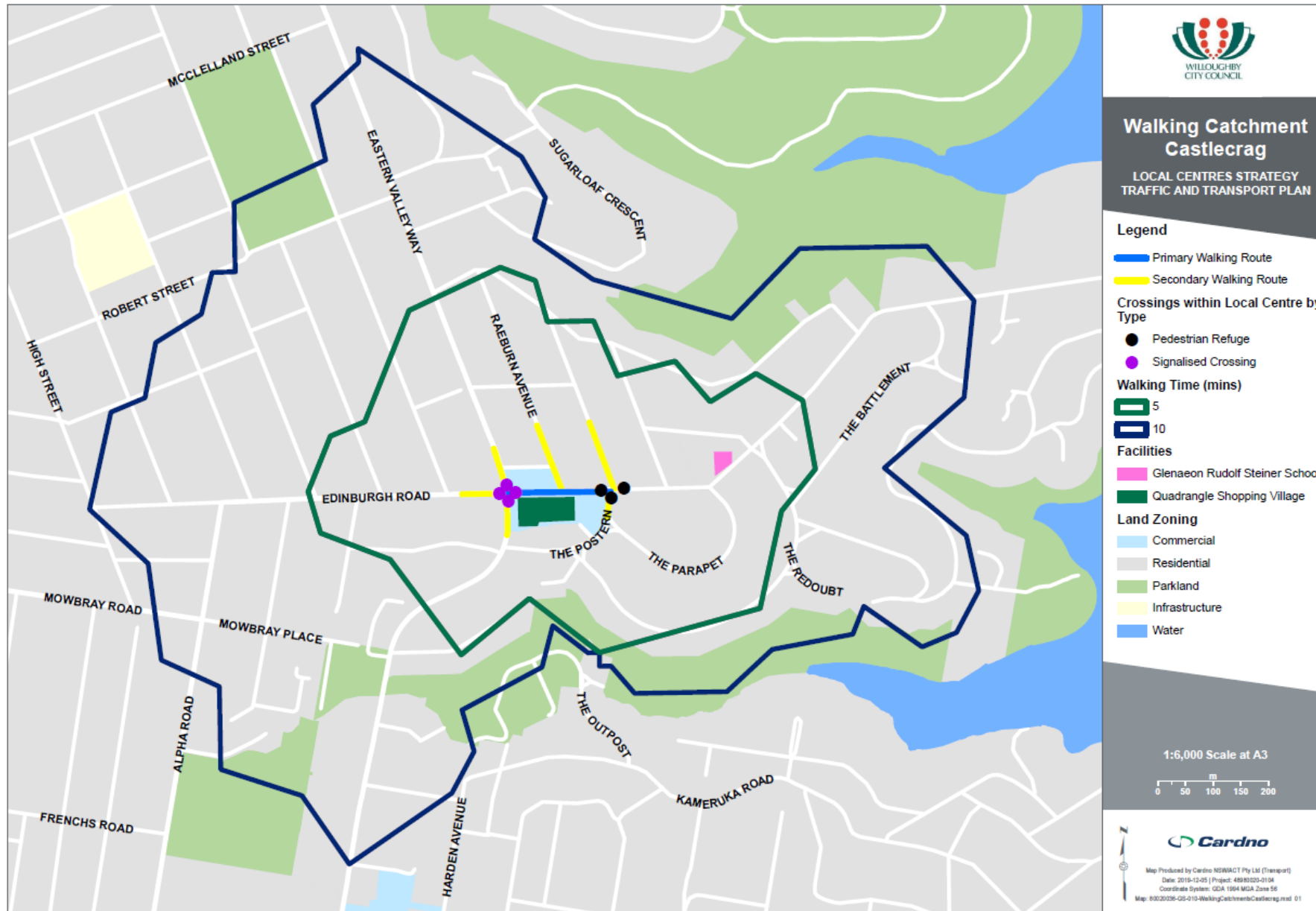


Figure 5-6 Steep grades at The Postern



The Castlecrag local centre walking catchment is shown in **Figure 5-7**.

Figure 5-7 Walking routes



5.2.4 Cycling

The Castlecrag local centre contains an existing on-road cycle route on Edinburgh Road in the form of mixed traffic. The Willoughby Bike Plan illustrates that the bike route runs along the entirety of Edinburgh Road, however site observations showed no formal bike infrastructure or linemarking between Eastern Valley Way and The Postern / Rutland Avenue. The route introduces visually separated shoulder lanes for a short length further to the west of Eastern Valley Way. This route operates as a local link, connecting the local centre of Castlecrag to other cycle routes and nearby local centres to the west such as High Street, Penshurst Street and Willoughby South. Further cycling infrastructure is also present on Edinburgh Road east of The Postern / Rutland Avenue in the form of visually separated shoulder lanes providing access to residential areas and other land uses on the peninsula.

Strava, an online fitness tracking application for cycling, shows popular cycling routes logged via mobile applications and provides indicative data on recreational cycling demand. Strava data was reviewed to identify key routes currently used by cyclists, and the data indicated cyclists use Edinburgh Road as the primary east-west movement corridor. Eastern Valley Way is also a popular north-south corridor, however there is no cycling infrastructure present here.

Bike racks, although provided, are only available on the southern side of Edinburgh Road between Eastern Valley Way and The Postern. These provide space to accommodate six bicycles.

Figure 5-8 Bike signage on Edinburgh Road

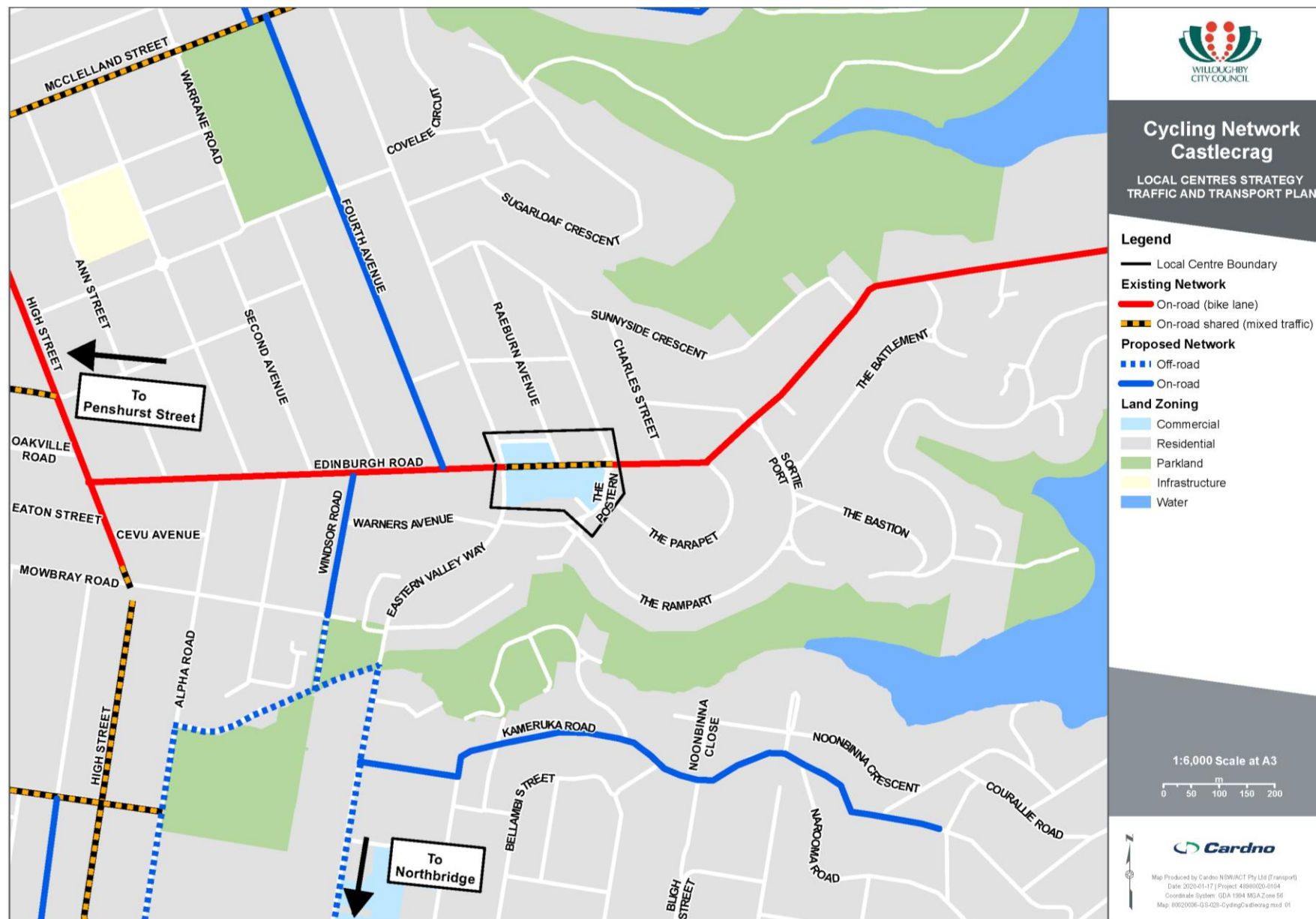


Figure 5-9 Bike racks on Edinburgh Road



A map of the existing and proposed bicycle network is presented in **Figure 5-10**.

Figure 5-10 Bicycle network



5.2.5 Public Transport

Public transport within the local centre is provided by bus services operated by the STA. Bus stops are located on Eastern Valley Way at the intersection with Edinburgh Road with two additional stops on Edinburgh Road. The Eastern Valley Way bus stops accommodate regular services to the city during the morning peak and regular services to East Lindfield and Willoughby during the afternoon peak. Bus stops on Edinburgh road provide connections to Chatswood, however services are not regular and do not operate outside the morning peak period. The centre is generally inaccessible by public transport outside of peak periods.

The bus routes servicing the local centre are outlined in **Table 5-5**.

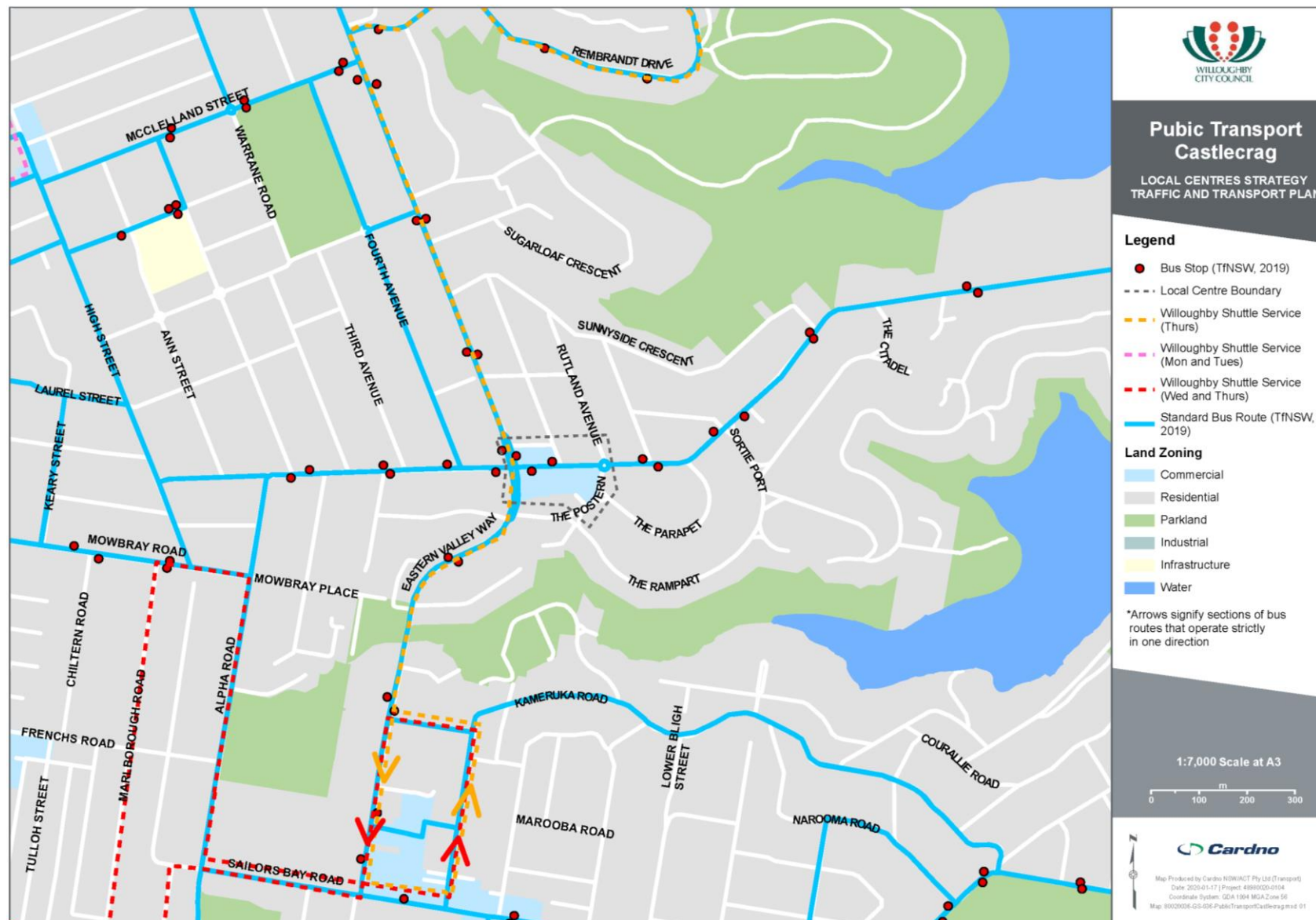
Table 5-5 Bus routes serving the Castlecrag local centre

Bus route	Route description	Areas served
203	Castlecrag to North Sydney	Northbridge, Castlecrag, Cammeray, North Sydney
205	East Willoughby to City Bridge St (Freeway)	East Willoughby, Northbridge, Castlecrag, Cammeray, Sydney CBD (Bridge St)
206	East Lindfield to City Bridge St via Freeway	East Lindfield, East Willoughby, Northbridge, Castlecrag, Cammeray, Sydney CBD (Bridge St)
207	East Lindfield to City Bridge St via North Sydney	East Lindfield, East Willoughby, Northbridge, Cammeray, Castlecrag, North Sydney, Sydney CBD (Bridge St)
208	East Lindfield to City Bridge St via Northbridge & North Sydney	East Lindfield, East Willoughby, Northbridge peninsula, Castlecrag, Cammeray, North Sydney, Sydney CBD (Bridge St)
209	East Lindfield to Milsons Point via North Sydney	East Lindfield, East Willoughby, Northbridge, Castlecrag, Cammeray, North Sydney, Milsons Point
267	Chatswood to Crows Nest	Chatswood, Mowbray Road, Castlecrag, Northbridge, Cammeray, Crows Nest
275	Castlecrag to Chatswood	Chatswood, North Willoughby, East Willoughby, Castlecrag

'The Loop' bus from Castle Cove to Northbridge via Middle Cove also serves the local centre on Thursdays, running every 45 minutes between approximately 10:30am – 3:00pm. This service operates as a loop between the Castle Cove peninsula and the Northbridge Plaza via Eastern Valley Way.

A map of the public transport services within and around the Castlecrag local centre is provided in **Figure 5-11**.

Figure 5-11 Public transport map



5.2.6 Freight, services and loading

The town centre provides one on-street loading zone, located on Raeburn Avenue, operating all day without time restrictions. The loading zone is placed at a functional location, adjacent to retail and restaurants. The westbound lane on Edinburgh Road does not contain any loading zones despite a concentration of shopping destinations.

Eastern Valley Way is designated as a Short Combination route as part of the Higher Mass Limits (HML) network and provides a freight corridor adjacent to the local centre.

5.2.7 Ride and vehicle sharing services

The local centre does not cater for ride or vehicle sharing services.

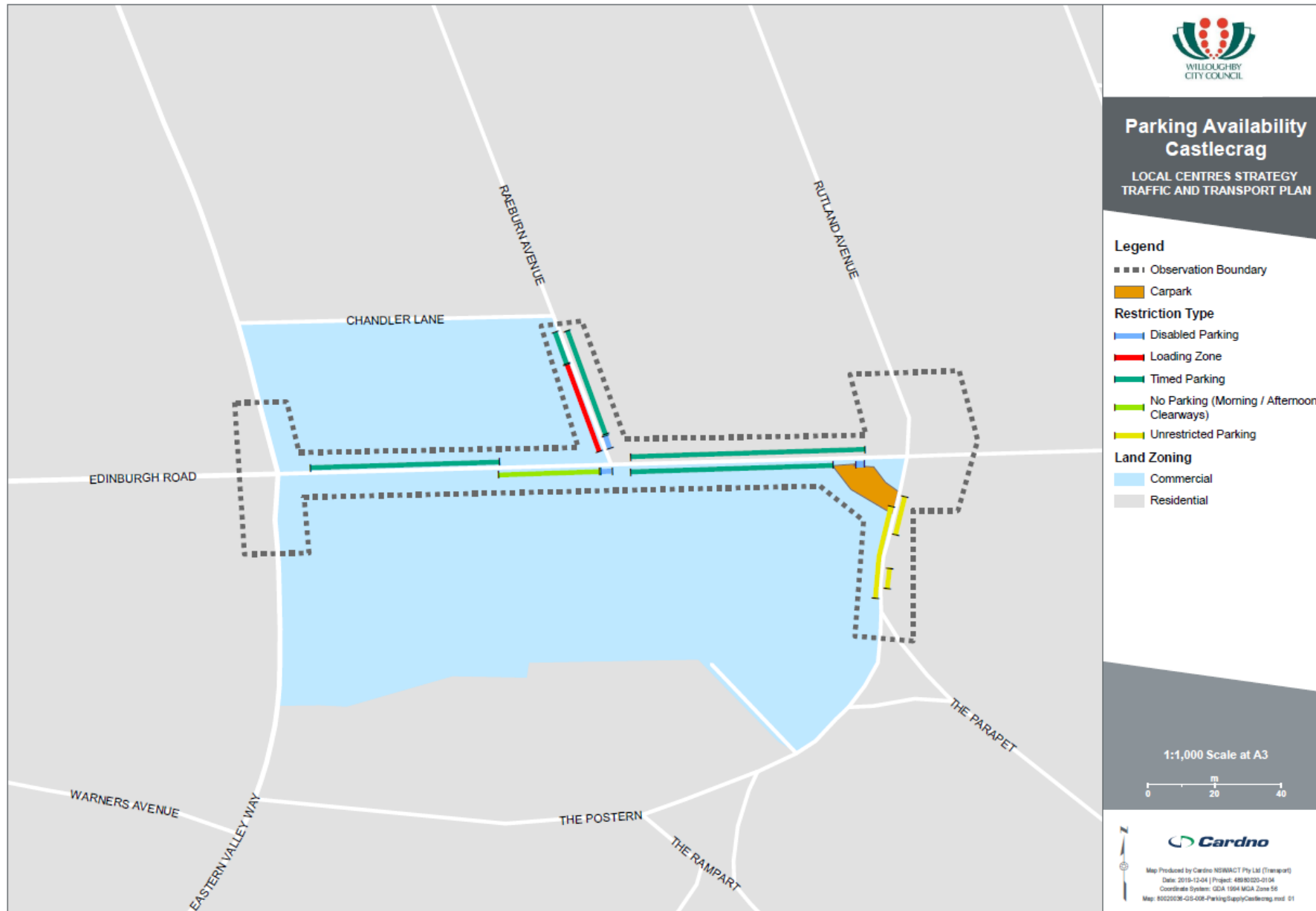
5.2.8 Parking provision

Castlecrag provides time restricted parking along Edinburgh Road with primarily 1P parking restrictions. Adjoining streets such as Raeburn Avenue offer similar time restricted parking. Rutland Avenue and The Postern offer parking without restrictions however availability is limited during the afternoon peak as observed on site. A small carpark at the corner of Edinburgh Avenue and The Postern offers time restricted parking at an optimal location for shopping and retail. The shopping village also offers off-street underground parking.

Accessible parking is provided on The Postern immediately south of the intersection with Edinburgh Road, offering direct access to the Castlecrag commercial district. No accessible parking spaces are provided on Edinburgh Road.

An overview of parking availability for the weekday AM & PM peak periods is shown in **Figure 5-12**.

Figure 5-12 Parking availability



Parking profiles indicating the total parking requirement over the course of the day are presented in **Figure 5-13** and **Figure 5-14**. For further details and an explanation of these graphs refer to **Appendix B**.

Figure 5-13 Castlecrag weekday parking profile

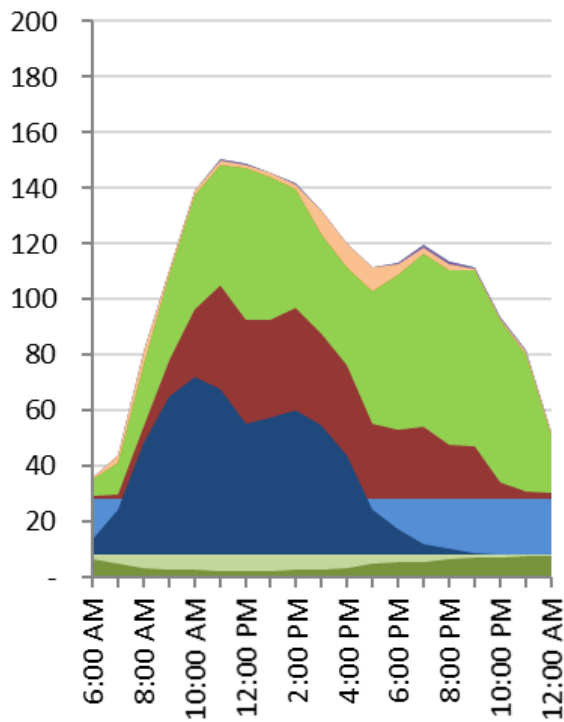
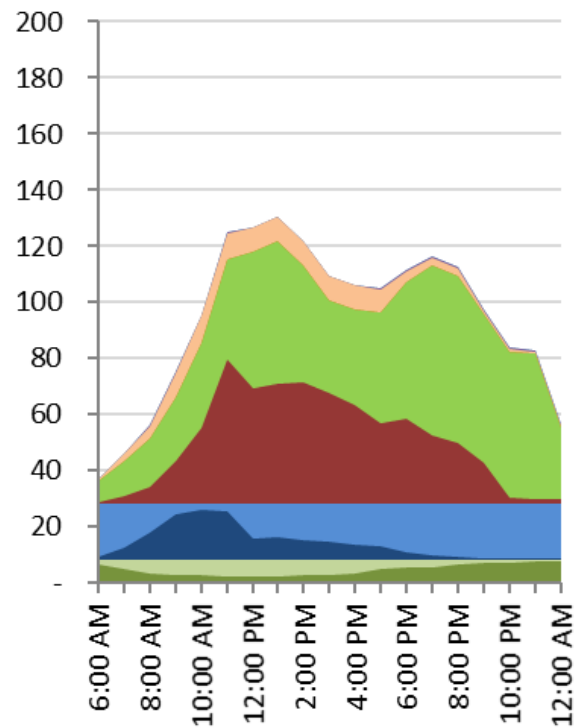


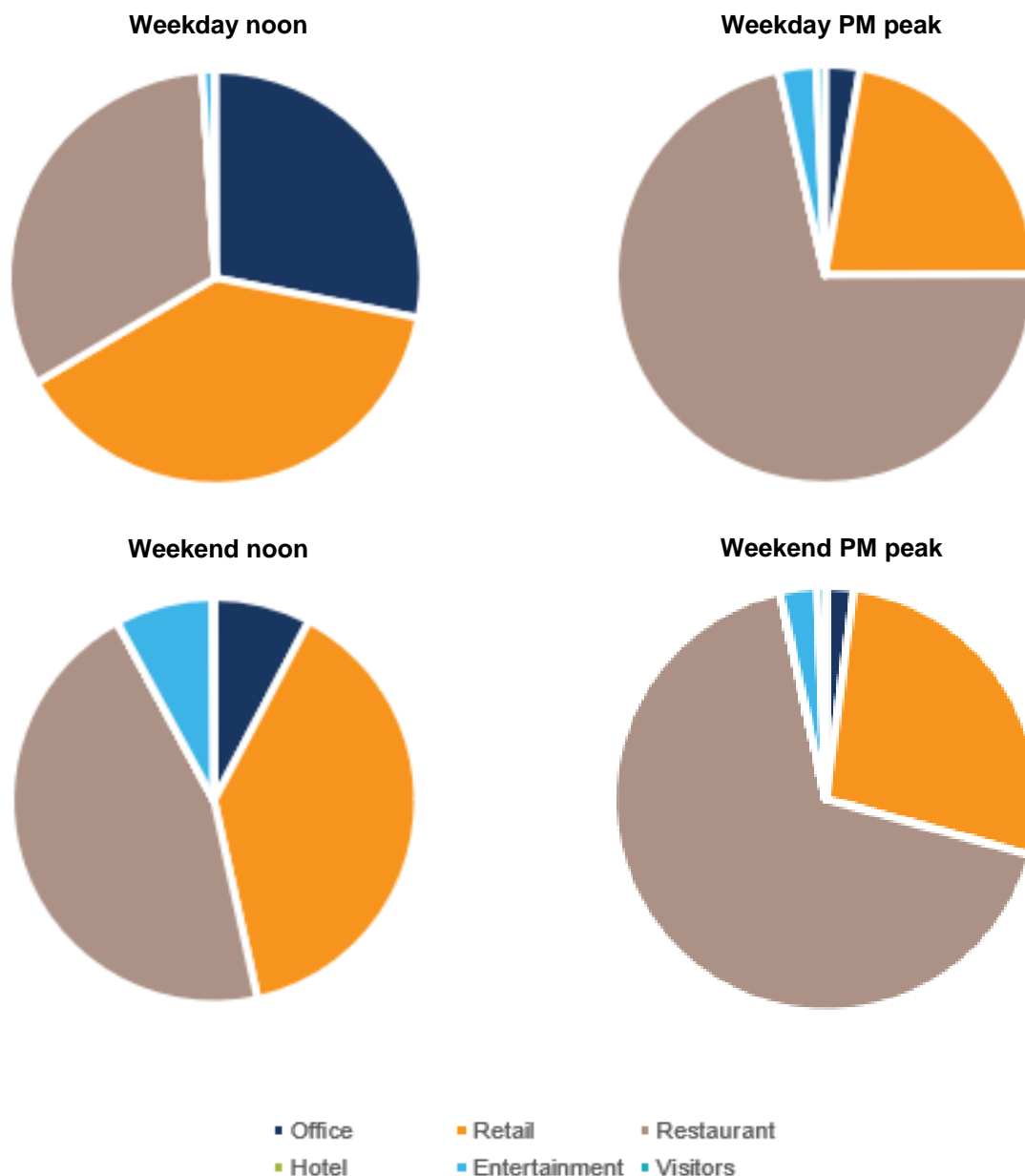
Figure 5-14 Castlecrag weekend parking profile



Visitor Office Employee Parking (Vacant)
 Hotel Entertainment Residential Parking (Vacant)
 Retail Restaurant Residential Parking Occupied

A breakdown of the peak parking demand by land use is presented in **Figure 5-15**.

Figure 5-15 Castlecrag peak parking demand



5.2.8.2 Castlecrag parking function

A significant majority of parking demand in this Local Centre is associated with the restaurant / café uses along Edinburgh Road.

This demand is facilitated by on-street parking here and on Redburn Avenue, and by a small off-street car park accessed via Chandler Lane. However, the primary supply of visitor parking is located within the Quadrant Shopping Village, with 117 2-hour car parking bays.

Overall, this short-stay supply is considered sufficient to accommodate peak demand.

Employee parking, in contrast, is scarce – limited to a dedicated off-street car park accessed via The Postern. This creates significant overspill into the adjacent residential streets, including along The Postern, Rutland Road and Edinburgh Road east to Charles Street.

5.2.8.3 Parking recommendations

Recommendation (Infrastructure):

Improve wayfinding signage to the Quadrant Shopping Village car park on the approach to Castlecrag.
Explore possibilities to provide additional parking for employees.

5.2.9 Intersection modelling

5.2.9.1 Intersection counts

For the Castlecrag local centre, a total of three intersections were surveyed and included:

- > Edinburgh Road / Eastern Valley Way (signalised intersection);
- > Edinburgh Road / Rutland Avenue / The Postern (priority controlled – roundabout); and
- > Edinburgh Road / Raeburn Avenue (priority controlled).

The peak one-hour periods with the heaviest traffic were identified to be:

- > 8:15am – 9:15am for the weekday AM peak;
- > 4:45pm – 5:45pm for the weekday PM peak; and
- > 11:30pm – 12:30pm for the Saturday midday peak.

The data was used to inform the traffic modelling by providing the traffic under existing conditions. Volumes and intersection modelling results are presented in **Appendix A**.

5.2.9.2 Intersection modelling results

SIDRA intersection modelling results for key intersections within the Castlecrag local centre are presented in **Table 5-6**. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 5-6 SIDRA intersection modelling results - Castlecrag

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Edinburgh Road / Eastern Valley Way	1.244	76.1	F	0.929	47.6	D	0.973	50.4	D
Edinburgh Road / Raeburn Avenue	0.245	10.6	A	0.179	8.4	A	0.173	8.5	A
Edinburgh Road / Rutland Avenue / The Postern	0.617	10.0	A	0.191	9.8	A	0.187	10.1	A

The Edinburgh Road / Eastern Valley Way intersection operates unsatisfactorily at LoS F in the AM peak period. The delays associated with this are due to the vehicle demand at Eastern Valley Way (southern approach) and Edinburgh Road (eastern approach) that exceed the current capacity resulting in residual queues that don't clear every signal cycle.

Both the other intersections perform at LoS A which suggests the intersections have spare capacity.

The Edinburgh Road / Eastern Valley Way intersection is over-saturated (DoS is greater than 1.0) in the AM peak period, indicating that it is congested. In the PM peak and Saturday peak periods, the degree of saturation is greater than 0.9. This suggests that the intersection may experience significant decline in performance with any additional volumes.

5.2.10 Summary of opportunities and constraints

Key opportunities and constraints of the Castlecrag local centre are summarised in **Table 5-7**:

Table 5-7 Opportunities and constraints

Opportunities	Constraints
<ul style="list-style-type: none"> Potential to provide a through-site link and increase pedestrian permeability Potential for pedestrian improvements and traffic management on Edinburgh Road to improve pedestrian safety and amenity Potential for a left-out only access point from the Quadrangle on Eastern Valley Way to bypass the intersection at Edinburgh Road 	<ul style="list-style-type: none"> The Edinburgh Road / Eastern Valley Way intersection is a pinch point for traffic accessing the Castlecrag peninsula Limited public transport accessibility outside peak periods

5.3 Future transport network review and recommendations

5.3.1 Traffic network analysis

5.3.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at Castlecrag in accordance with **Table 5-8**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 5-8 Apartment mix and occupancy - Castlecrag

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	15	1.7	25
1 bedroom	14%	21	1.7	35
2 bedroom	60%	92	2.3	210
3 bedroom	16%	25	2.8	68
Total	100%	153	-	339

¹Based on ABS 2016 Census Data.

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 5-9**. The employee densities were adopted from TfNSW guidelines for office space and typical employee densities for retail and hospitality.

Table 5-9 Non-residential floor space assumptions - Castlecrag

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	40%	1 / 40 sqm	63
Hospitality	40%	1 / 20 sqm	126
Office	20%	4.75 / 100 sqm	60
Total	100%	-	248

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

Therefore, based on these assumptions the Castlecrag local centre is expected to accommodate approximately 340 residents and 250 employees.

5.3.1.2 Parking requirements

The minimum car parking requirements in accordance with the DCP are presented in **Table 5-10**.

Table 5-10 Minimum car parking requirements - Castlecrag

Land use		Rate	Proposed development	Spaces required
Residential (non-adaptable units)	Studio	0.5 / dwelling	15 dwellings	8
	1 bedroom	1 / dwelling	21 dwellings	21
	2 bedroom	1 / dwelling	92 dwellings	92
	3 bedroom	1 / dwelling	25 dwellings	25
	Visitors	0.25 / dwelling	153 dwellings	38
			Residential subtotal	183
Commercial	Retail	36 sqm / space	2,515 sqm GFA	70
	Hospitality	107 sqm / space	2,515 sqm GFA	23
	Office	110 sqm / space	1,257 sqm GFA	11
			Commercial subtotal	105
			Development total	288
	Motorbike parking	1 / 25 car parking spaces	288 spaces	11

Note: Table shows rounded values. Subtotals were rounded down in accordance with the DCP.

Based on these calculations, the proposed development would be required to provide a minimum of 288 car parking spaces (including accessible parking spaces) and 11 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 5-11**.

Table 5-11 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	153 units	15
Retail	1 / 450m sqm GFA	2,515 sqm GFA	6
Hospitality	1 / 450m sqm GFA	2,515 sqm GFA	6
Office	1 / 600 sqm GFA	1,257 sqm GFA	2
Total			29

The calculations indicate that the proposed development would be required to provide 29 bicycle spaces.

5.3.1.3 Trip generation

Based on the trip generation rates presented in **Section 3.3**, the estimated number of trips generated by the proposed development are presented in **Table 5-12**. An estimate of existing traffic generated by the current land uses is also provided, as well as the additional traffic expected to be generated.

Table 5-12 Future traffic generation

Land use	Total development (existing + proposed)	Traffic generation (veh/hr)		
		AM peak	PM peak	Saturday peak
Residential	153 units	29	23	29
Retail	1,886 sqm GLFA	21	67	17
Hospitality	1,886 sqm GLFA	21	74	141
Office	943 sqm GFA	20	15	0
Total		91	179	188
Existing traffic generation		57	126	130
Additional traffic generated		+34	+53	+57

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

On this basis the proposed development is expected to generate an additional 34 vehicle movements in the AM peak hour, 53 in the PM peak and 57 in the Saturday peak.

However, the mode share for the sites surveyed by TfNSW averaged out to approximately 30 per cent for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the Castlecrag local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 46 per cent for residents and 60 per cent for workers. This represents a higher mode share than those surveyed for the TfNSW traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis and for a conservative estimate, a mode share discount of 10 per cent was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 36 per cent for residents and 50 per cent for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

5.3.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 5-13**.

Table 5-13 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the additional traffic generated to determine the inbound and outbound trips presented in **Table 5-14**.

Table 5-14 Inbound and outbound additional traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	5	25	13	7	11	16
Retail	3	4	10	14	3	3
Hospitality	4	3	13	12	21	28
Office	5	1	0	5	0	0
Total (additional traffic generated)	17	34	36	38	34	48

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 5-15**.

Table 5-15 Directional assumptions

Direction	In %	Out %
North	6%	28%
East	0%	0%
South	52%	26%
West	42%	46%
Total	100%	100%

Source: ABS 2016 Census Data

5.3.1.5 Intersection modelling results

Intersection modelling was undertaken for key intersections within the Castlecrag local centre using SIDRA Network software. The modelling examined the intersection performance for the following scenarios:

1. 2036 With 100 per cent Development; and
2. 2036 With 75 per cent Development.

The 2036 With 100 per cent Development scenario represents a full development case which may be realised in 2036. The 2036 With 75 per cent Development scenario represents a case where the development is not fully achieved, and is presented to understand the impacts of a reduced scale of development which may occur at an earlier point in time. The results and key findings of each scenario are presented in the following sections.

5.3.1.5.1 2036 With 100 per cent Development modelling results

Table 5-16 summarises the intersection performance of the Castlecrag local centre for the 2036 With 100 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 5-16 Future intersection performance – Castlecrag

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Edinburgh Road / Eastern Valley Way	1.354	88.7	F	0.998	55.3	D	0.980	53.4	D
Edinburgh Road / Raeburn Avenue	0.249	10.9	A	0.204	8.7	A	0.209	8.8	A
Edinburgh Road / Rutland Avenue / The Postern	0.619	10.0	A	0.214	10.0	A	0.189	10.1	A

In the 2019 base model, Edinburgh Road / Eastern Valley Way intersection operated unsatisfactorily at LoS F in the AM peak period. With no capacity improvements considered in 2036 and due to the expected increase in demand generated, the operation issue at Edinburgh Road / Eastern Valley Way is expected to remain the same with the unsatisfactory level of service consistent with the 2019 base model. The performance is driven by the vehicle demand on Eastern Valley Way (Southern Approach) and Edinburgh Road (Eastern Approach) that exceed the capacity resulting in residual queues that don't clear every signal cycle. It should be noted that the Edinburgh Road / Eastern Valley Way intersection is already over-saturated (DoS is greater than 1.0) in the 2019 base AM peak period, indicating that the intersection will experience a significant decline in performance with any additional volumes.

Both of the other intersections (Edinburgh Road / Raeburn Avenue and Rutland Avenue / The Postern) perform at LoS A in the 2036 future year which suggests the intersections will have spare capacity.

5.3.1.5.2 2036 With 75 per cent Development modelling results

Table 5-17 summarises the intersection performance of the Castlecrag local centre for the 2036 With 75 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix B**.

Table 5-17 Intersection Performance – Castlecrag

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Edinburgh Road / Eastern Valley Way	1.317	85.5	F	0.996	54.8	D	0.978	53	D
Edinburgh Road / Raeburn Avenue	0.248	10.8	A	0.198	8.6	A	0.199	8.7	A
Edinburgh Road / Rutland Avenue / The Postern	0.618	10	A	0.213	10	A	0.189	10.1	A

Based on the 2036 With 75 per cent Development results compared to the 2036 With 100 per cent Development results, there are minor improvements to the average delay and degree of saturation. However, there were no major changes to the intersection performance across all peak periods. There were also no significant changes to queue lengths.

5.3.2 Parking analysis

Demand projections for Castlecrag indicate that non-residential parking would increase by approximately 100 spaces. The ultimate demand of 250 spaces could include as many as 100 employees, which cannot be accommodated by the current provision.

As such, any redevelopment will need to consider reallocation of on-street or off-street parking provision to provide for employees. Given that the primary non-residential demand is expected to be hospitality-related, there is also potential for additional conflict between residents and restaurant patrons in the evenings.

As such, a combination of duration / timing restrictions and residential parking permits (**Appendix B**) in surrounding streets is likely to be necessary to support Centre function.

As visitor demand intensifies, this may also trigger the need for paid parking along Edinburgh Street under a 'demand responsive pricing' methodology to incentivise alternative transport.

Figure 5-16 Castlecrag future non-residential parking demand weekday profile

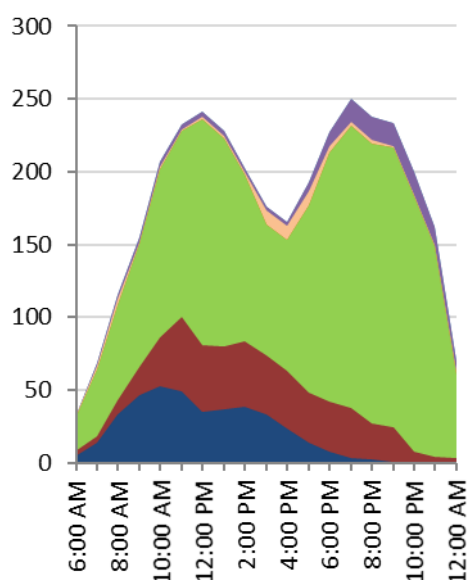
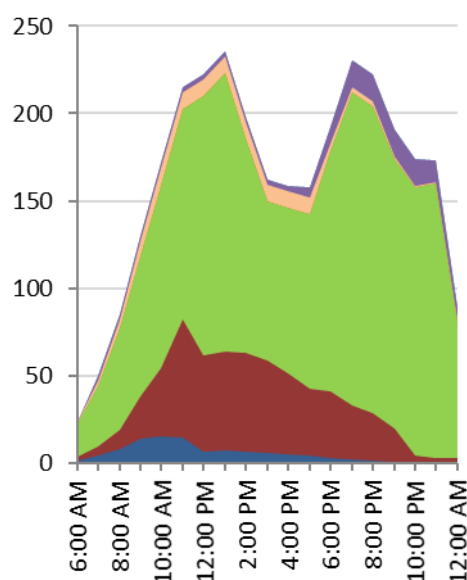


Figure 5-17 Castlecrag future non-residential parking demand weekend profile



5.3.3 Active Transport

Walking and cycling needs within the Castlecrag local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

Castlecrag already contains an established footpath network, however some gaps and deficiencies exist and include:

- > Narrow footpaths on Edinburgh Road;
- > Steep grades on The Postern;
- > A lack of threshold / gateway treatments;

- > Long distances between pedestrian crossings;
- > A lack of Tactile Ground Surface Indicators provided;
- > A lack of bike parking within the centre; and
- > Missing bicycle signage & linemarking on Edinburgh Road.

Recommendations to address these issues are summarised in **Section 5.3.5**.

5.3.4 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

Castlecrag is not close to any train stations, however it is well connected by bus services on Eastern Valley Way. These services provide access to surrounding centres and public transport hubs including Chatswood, North Sydney and the Sydney CBD, though there is opportunity to increase the frequency of these services to improve convenience.

There is also the opportunity to provide on-demand services, which may help service the Castlecrag peninsula.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 5.3.5**.

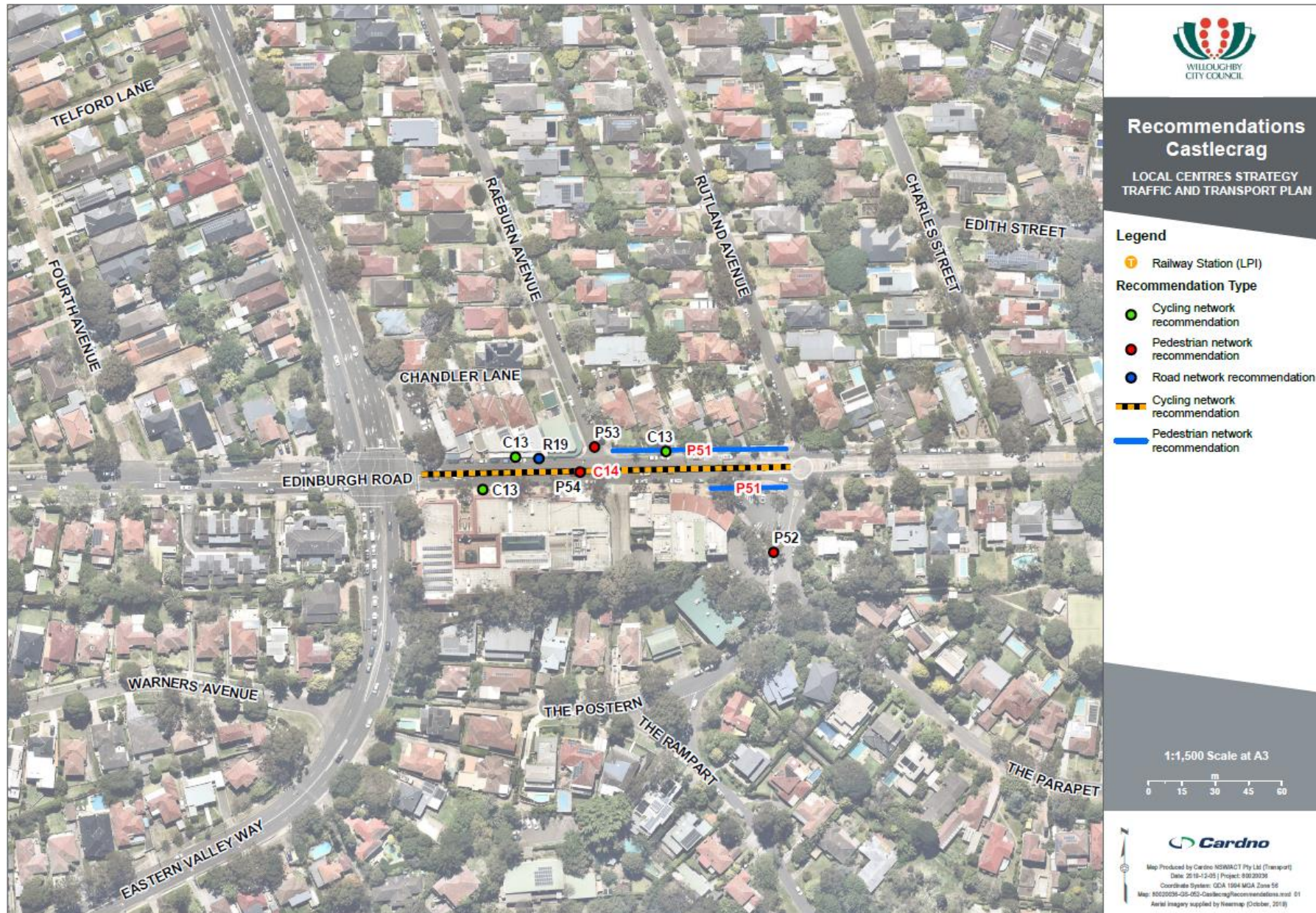
5.3.5 Issues and options

The issues and recommendations for the local centre are summarised in **Table 5-18** and **Figure 5-18**.

Table 5-18 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P51	Narrow footpaths on Edinburgh Road between Raeburn Avenue and Rutland Street.	Widen the footpath on the northern side of Edinburgh Road between Raeburn Avenue and Rutland Street, and the footpath on the southern side from The Postern 35m to the west.	Footpath	120 metres
P52	Steep grades on The Postern leading to the retail centre.	Provide an accessible path of travel from The Postern to future development at the Castlecrag retail centre.	Accessible ramp	
P53	Lack of threshold / gateway treatments.	Provide threshold / gateway treatments to improve pedestrian amenity and safety within the centre, including raised pavements and kerb extensions intersection of Raeburn Avenue and Edinburgh Road	Crossing	
P54	Long distance between pedestrian crossings (170 metres) on Edinburgh Road.	Investigate implementation of a pedestrian crossing facility, with consideration of a raised marked pedestrian crossing on Edinburgh Road at the intersection with Raeburn Avenue.	Pedestrian crossing	
P60	Lack of Tactile Ground Surface Indicators at kerb ramps.	TGSIs to be provided for all kerb ramps within the local centre.	TGSIs	
Bicycle				
C13	Lack of bike racks within the centre.	Provide additional bike racks along the north side of Edinburgh Road.	Bike racks	
C14	Missing bike signage on Edinburgh Road.	On-road painted bicycle symbols and signage to be provided on Edinburgh Road in accordance with the Willoughby Bike Plan.	Linemarking & signage	
Public transport				
PT4	Bus services are limited during the daytime outside of weekday commuter peaks.	Advocate for TfNSW to review bus routes and frequencies, with consideration given to providing additional services and increased connectivity to additional destinations.	Bus services	
Road network				
R19	Inadequate signage for local carparks	Improve wayfinding signage to the Quadrant Shopping Village car park on the approach to Castlecrag	Signage	
R22	High pedestrian activity with potential for conflict with vehicles.	Submit a proposal to TfNSW to implement a 40 km/h High Pedestrian Activity Area along Edinburgh Road between Eastern Valley Way and Rutland Avenue.	Speed limit amendment	

Figure 5-18 Recommendations map



6 East Chatswood

6.1 Land use

6.1.1 Existing

The East Chatswood local centre is situated at the intersection of Victoria Avenue and Penshurst Street, approximately 1.5 kilometres to the east of Chatswood train station and town centre. The centre contains various business frontages on the main roads composed of retail, restaurants, health services and real estate agents as well as residential houses and apartments to the south. The surrounding area beyond the local centre is largely composed of more houses and apartments.

An overview of the East Chatswood local centre study area and land use mix is presented in **Figure 6-1** and **Table 6-1**.

Figure 6-1 East Chatswood local centre



Table 6-1 East Chatswood land use mix

Town Centre	
Office / Commercial	2500 m ²
Shopping / Retail	7,600 m ²
Service Station	8 pumps
Restaurant	700 seats
Detached Housing	15 dwellings
Attached Housing	120 dwellings
Parking	
Off-Street Supply	165 spaces
On-Street Supply	130 spaces
Peak Non-Residential Parking Demand	255 spaces
Surrounds (400m)	
Detached Housing	470 dwellings
Attached Housing	880 dwellings

The majority of all pedestrian movement within the East Chatswood local centre occurs on Penshurst Street and Victoria Avenue, both roads providing access to destinations for people as well as acting as a movement corridor. The two roads accommodate north-south and east-west movement through the heart of the Willoughby LGA, providing access between various land uses as well as offering an alternative route to the Pacific Highway. Site observations also showed that Victoria Avenue received additional foot traffic due to its bus stops serving destinations such as Sydney CBD and Chatswood.

6.1.2 Planned

Forecast development, land uses and uplift were obtained from the *Willoughby Local Centres Strategy* and discussions with Council. Total figures were provided for residential and non-residential floor space under the preferred scenario, as well as an indicative overview of the vision for the local centre.

Assumptions will be made in regards to specific uplift of particular blocks and positioning of access points to inform the future network review and traffic modelling.

The East Chatswood local centre is forecast predominantly for residential uplift with ground floor commercial land use. The preferred scenario contains the following key features:

- > A total of 44,299 sqm GFA of residential floor space, representing an uplift of 28,570 sqm or 182 per cent;
- > A total of 27,632 sqm GFA of non-residential floor space, representing an uplift of 5,586 sqm or 25 per cent;

- > New public spaces and through-site links including a pedestrianised or traffic-calmed plaza at the corner of Sydney Street / Penshurst Street; and
- > Improved pedestrian crossings, footpath treatments and amenity.

An indicative representation of the scale and distribution of the preferred scenario is presented in **Figure 6-2**.

Figure 6-2 Potential development at East Chatswood – preferred scenario



Source: Willoughby Local Centres Strategy

The bulk of the development is proposed to be shop-top housing to maintain activated street frontages along Victoria Avenue and Penshurst Street, with increased height limits and FSRs accommodating residential growth.

6.1.3 Community concerns

62 people provided feedback about the *Draft Local Centres Strategy* for East Chatswood, with people generally supporting the development of this area but opposed to the specific heights and FSRs proposed. The key community feedback related to traffic and transport issues were focused on concerns regarding traffic impacts from increased land use density, particularly given the perception of existing traffic congestion and parking issues.

6.2 Existing transport networks

6.2.1 Road network and traffic

The East Chatswood road network consists of two key movement corridors, Victoria Avenue and Penshurst Street. The two roads intersect within the centre to provide east-west trips and north-south trips respectively. The two key roads function as a link between surrounding low density residential housing and the commercial district of East Chatswood. Victoria Avenue provides a direct connection to the strategic centre of Chatswood while Penshurst Street connects the centre to major corridors such as Boundary Street and Mowbray Road.

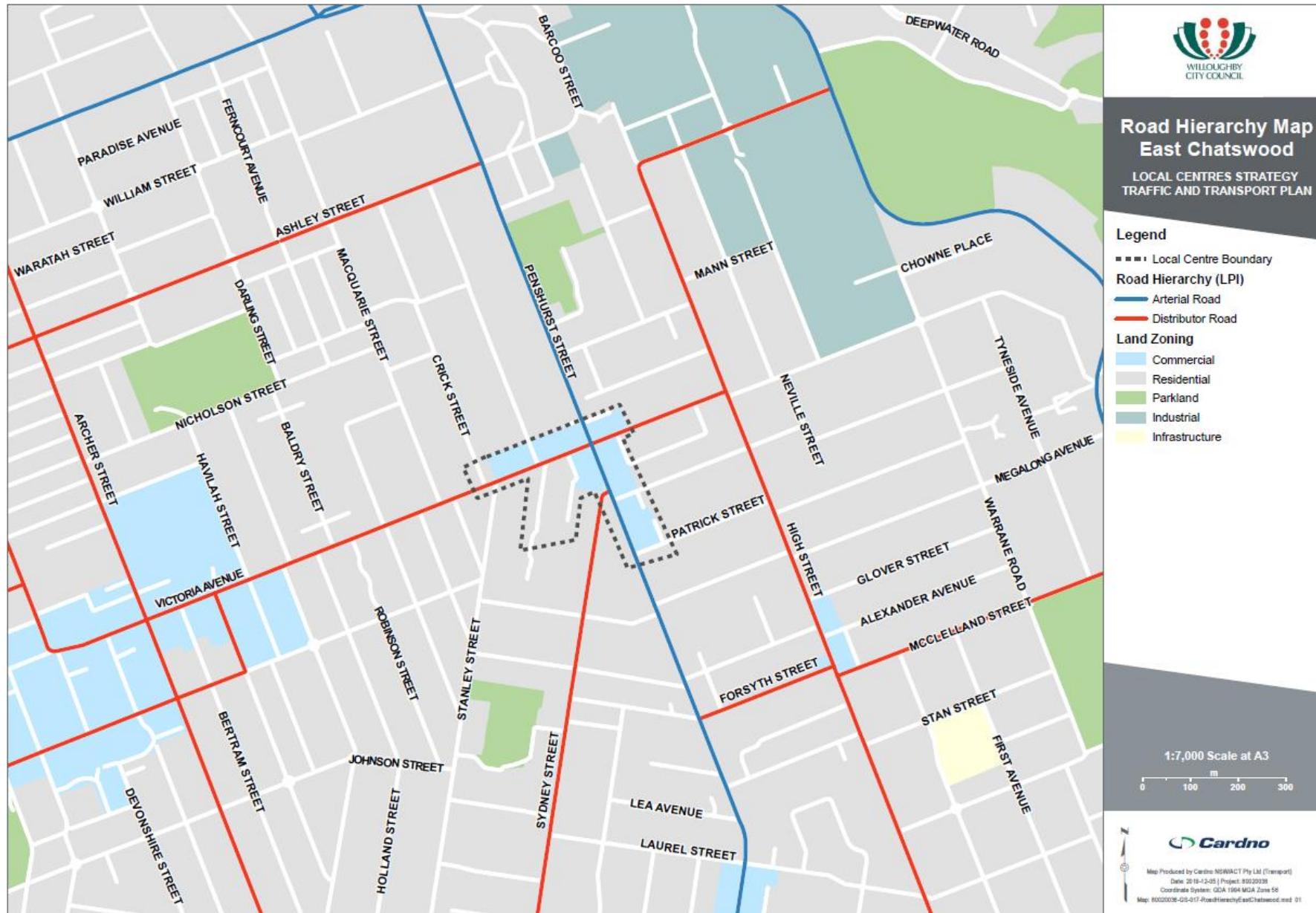
Penshurst Street accommodates the greatest traffic volumes within the East Chatswood precinct. Intersection volumes are greatest where Penshurst Street meets Victoria Avenue. Other intersections that receive notable traffic volumes during peak times include the Penshurst Street / Sydney Street and Royal Street / Victoria Road intersections.

Table 6-2 Key roads

Road name	Road Classification	Managing Authority	Number of Lanes	Speed Limit (within centre)
Penshurst Street	State Road	TfNSW	4 travel lanes and 1-2 parking lanes	60 km/h
Victoria Avenue	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Sydney Street	Local Road	Willoughby Council	2 travel lanes and 1 parking lane	50 km/h
Royal Street	Local Road	Willoughby Council	2 travel lanes, 1 parking lane and 90-degree angle parking	50 km/h

The road hierarchy map is shown in **Figure 6-3**.

Figure 6-3 Road hierarchy



6.2.2 Safety

Five-year crash data history was analysed from 2014 to 2018 (inclusive). Overall there were 26 reported crashes within the local centre of East Chatswood. A summary of crashes by severity is shown in **Table 6-3**.

Table 6-3 Crash summary by severity

Year	Fatal	Serious Injury	Moderate Injury	Minor / Other Injury	Non-Casualty (tow away)	Total
2014		1	2	1	4	8
2015				3		3
2016		2		2	1	5
2017		1	1	2	2	6
2018		1	2		1	4
Total		5	5	8	8	26

There were no fatalities within the local centre during the five year period, however 5 crashes resulted in serious injury.

6.2.2.2 Crash Locations

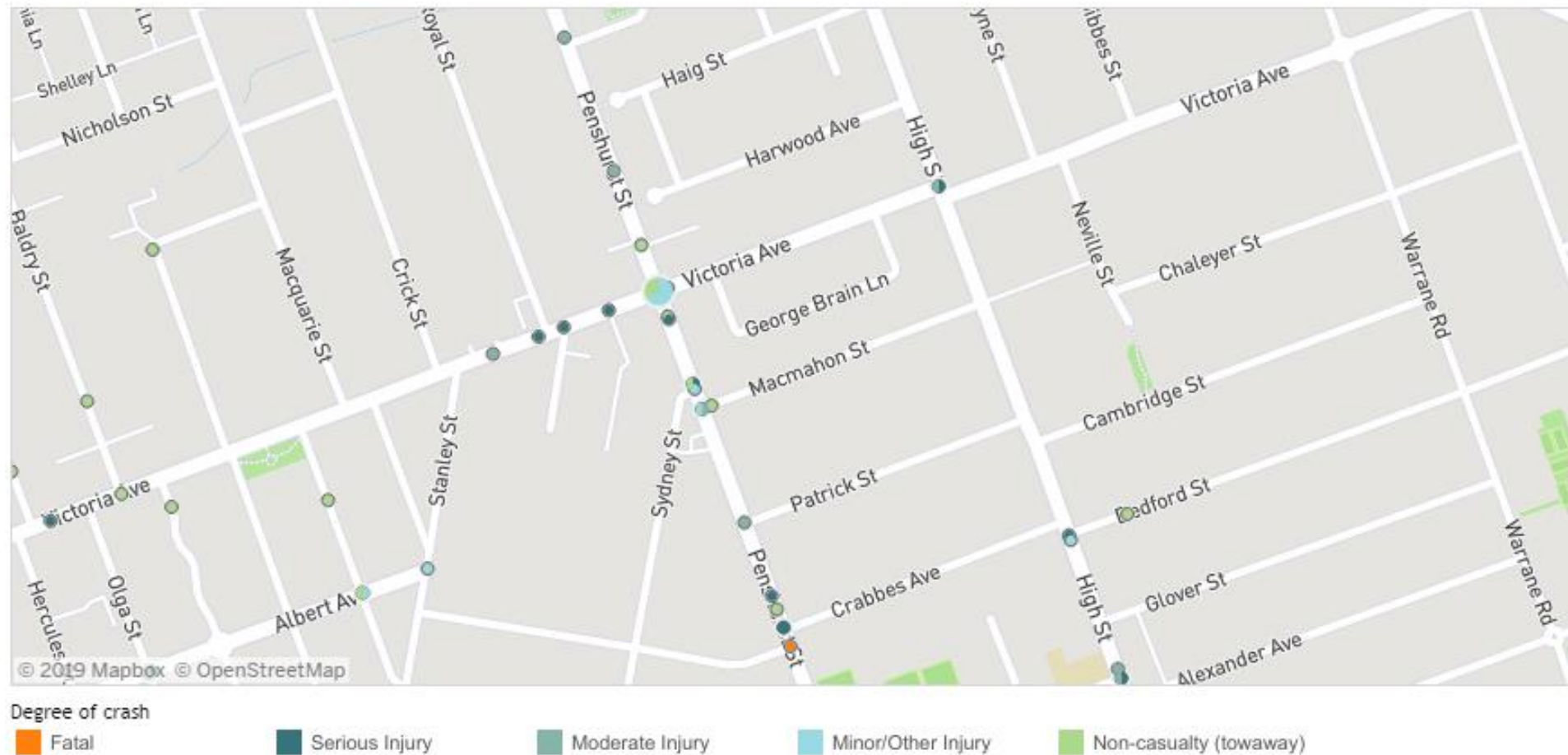
Crash clusters are evident at the intersection of Victoria Avenue / Penshurst Street (as expected), Sydney Street / Penshurst Street and Macmahon Street / Penshurst Street. There were no crashes involving pedestrians within the East Chatswood local centre.

Crash locations within the East Chatswood local centre are shown in **Table 6-4** and **Figure 6-4**.

Table 6-4 Crash locations

Road	2014	2015	2016	2017	2018	Total
Victoria Avenue	1	2	1	2	2	8
Penshurst Street	7	1	4	3	2	17
Macmahon Street	1					1
Total	9	3	5	5	4	26

Figure 6-4 Crash map



Source: NSW Centre for Road Safety

6.2.3 Existing pedestrian network and infrastructure

Victoria Avenue and Penshurst Street, operating as the centre's key walking corridors, provide wide footpaths, however they are not consistent throughout both corridors. Narrow footpaths are present on sections of Victoria Avenue due to wide vegetation strips as shown in **Figure 6-5**. Footpaths approximately 1.2 – 1.5 metres wide are present on Victoria Avenue just east of Crick Street. Penshurst Street contains similar footpaths at the southeast end of the centre. Paving treatments are also not consistent, with large sections of concrete transitions implemented to support vehicle thoroughfare. Crick Street, Patrick Street, Stanley Street, Royal Street and Kooringa Road all offer footpaths approximately 1.2 – 1.5 metres wide, despite providing direction connections to the East Chatswood commercial district. Parked cars on Royal Street were also observed to be encroaching on footpaths, due to a lack of wheel stops as shown in **Figure 6-6**.

Figure 6-5 Footpath width reduced by vegetation strip

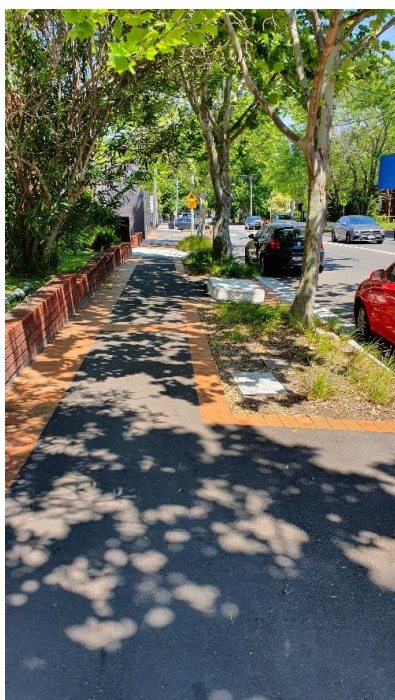
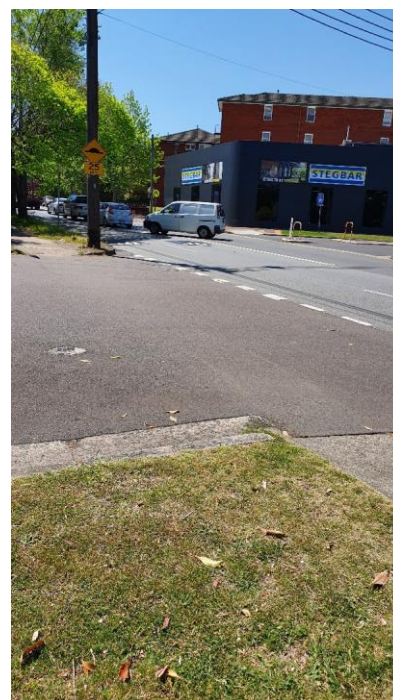


Figure 6-6 Vehicles encroaching footpath at Royal Street



Figure 6-7 Large crossing distance on Crick Street



Pedestrian crossing facilities in the centre include a combination of pedestrian refuges, signalised crossings and a zebra crossing. Pedestrian refuges support connectivity in locations such as Stanley Street and Sydney Street. Both Kooringa Road and Patrick Road require a considerable crossing distance as shown in **Figure 6-7** and **Figure 6-8**. Signalised crossings are available at the Penshurst Street / Victoria Road intersection and the Penshurst Street / Macmahon Street intersection. However, there is a missing pedestrian crossing link on the north-western leg of the intersection as shown in **Figure 6-9**.

The centre offers a marked pedestrian crossing located on Victoria Avenue near Stanley Street, facilitating movement for pedestrians commuting from the south of the commercial district. However, the crossing spans three travel lanes and is therefore non-compliant with TfNSW policy. The distance between pedestrian crossings is not ideal to support pedestrian thoroughfare with crossings spaced 190 metres apart on Victoria Avenue and 110 metres apart on Penshurst Street.

The East Chatswood Local centre walking catchment is shown in **Figure 6-10**.

Figure 6-8 Large crossing distance at Patrick Street

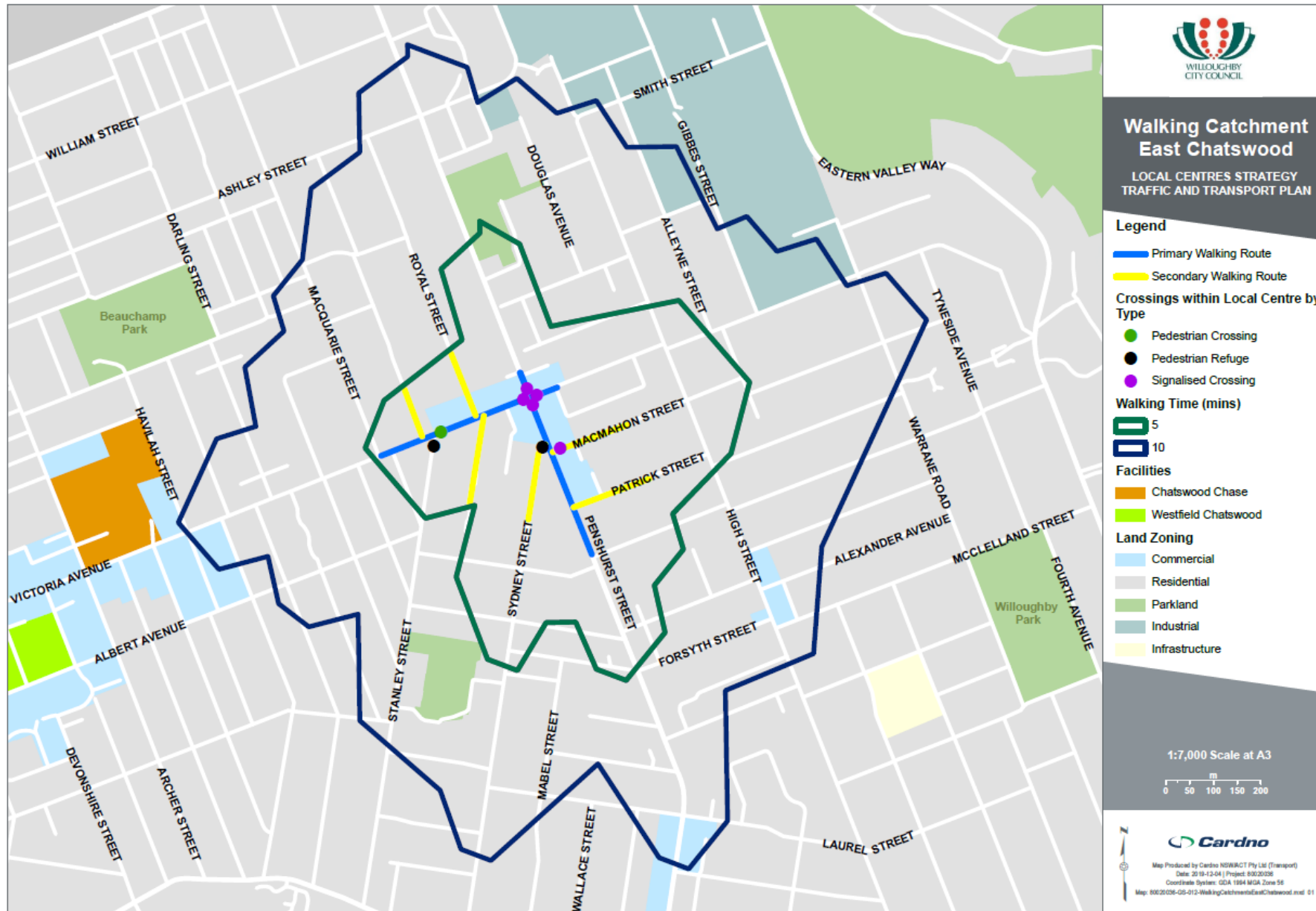


Figure 6-9 Missing crossing at Penshurst St / Macmahon St intersection



The East Chatswood local centre walking routes are shown in **Figure 6-10**.

Figure 6-10 Walking routes



6.2.4 Cycling

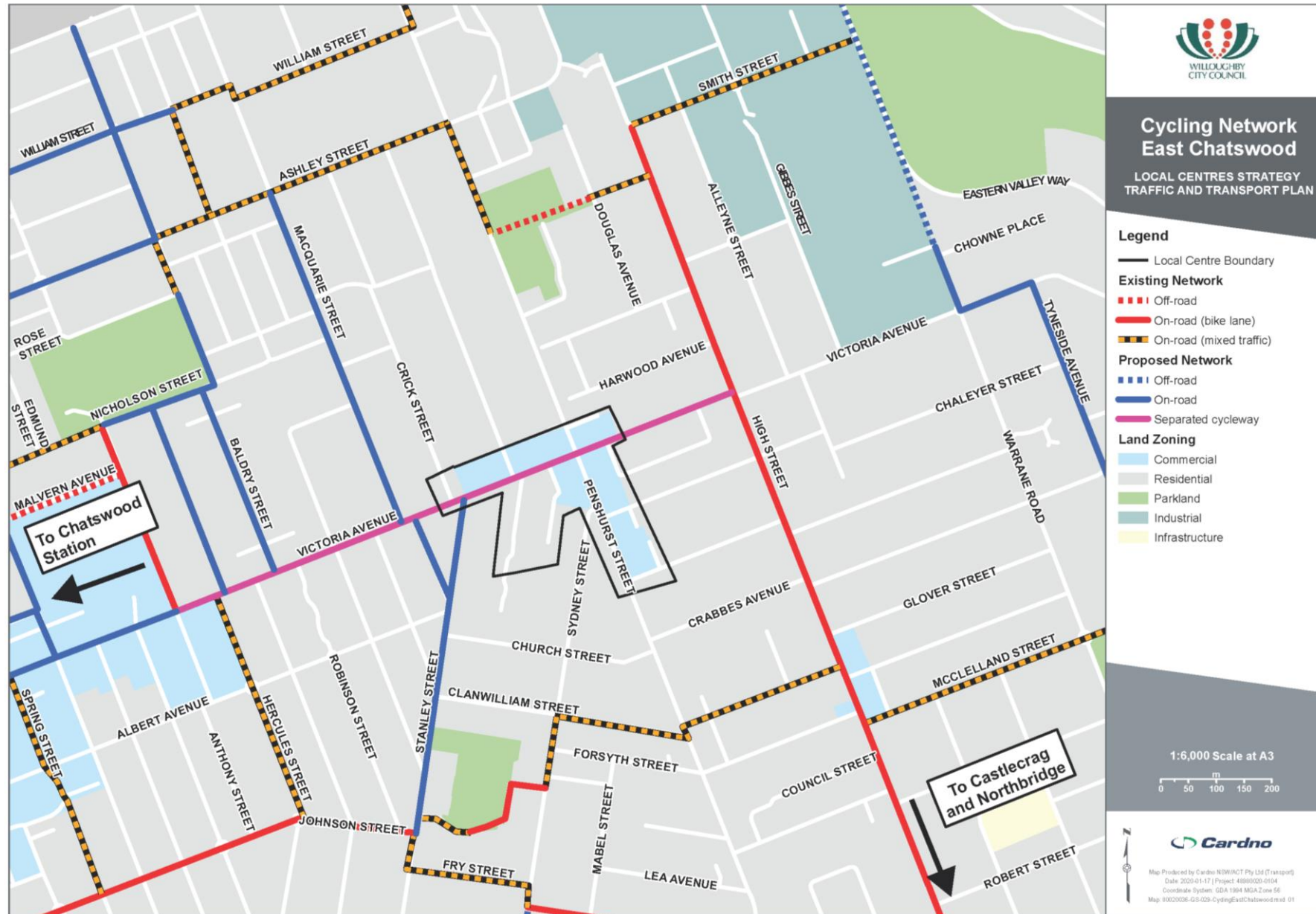
At present the East Chatswood local centre does not provide on-road or off-road cycleway infrastructure. As a result, cyclists must merge with traffic to access the nearby strategic centre of Chatswood or surrounding local centres. The *Willoughby Bike Plan* indicates that a separated cycleway is proposed for Victoria Avenue between High Street and Havilah Street, which would provide access to the Chatswood strategic centre and nearby local centres and connecting cycle routes.

Strava, an online fitness tracking application for cycling, shows popular cycling routes logged via mobile applications and provides indicative data on recreational cycling demand. Strava data was reviewed to identify key routes currently used by cyclists, and the data indicated cyclists currently use the Victoria Avenue and Penshurst Street corridors to make east-west and north-south movements respectively.

Cycle parking is generally very limited within the centre with only one bike rack provided on the northern side of Victoria Avenue west of Penshurst Street.

A map of the existing and proposed bicycle network is presented in **Figure 6-11**.

Figure 6-11 Bicycle network



6.2.5 Public Transport

Public transport is available within the centre through the provision of bus services operated by the STA via the Victoria Avenue and Penshurst Street corridors. Bus stops on Victoria Avenue and Penshurst Street provide services every 10 minutes to destinations such as the Sydney CBD, Chatswood, Manly, Bondi Junction and Kingsford during the peak time. Services reduce to every 15 minutes during the off peak. Buses also connect East Chatswood to Mosman with services operating every 20 minutes during peak and 30 minutes during the off peak. An additional service connects East Chatswood to the nearby local centre of Castlecrag however services are not regular with one service operating every hour between the morning and early afternoon. Commuters will be required to interchange at Chatswood if they wish to travel north or west of the Willoughby LGA.

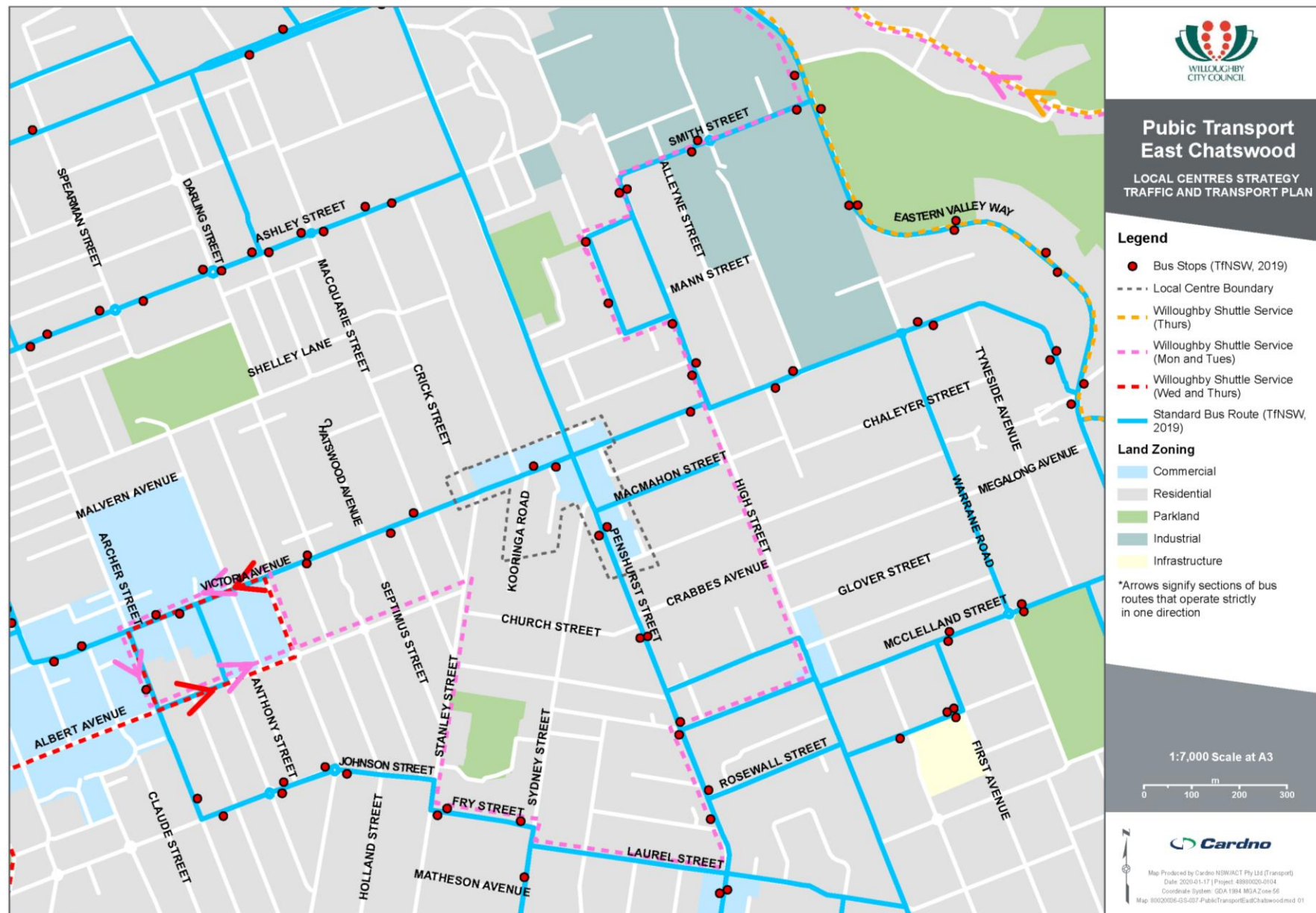
The bus routes servicing the local centre are outlined in **Table 6-5**.

Table 6-5 Bus routes serving the East Chatswood local centre

Bus route	Route description	Areas served
136	Chatswood to Manly	Chatswood station, North Willoughby, Roseville Chase, Forestville, Frenchs Forest, Beacon Hill, Narrabeen, Dee Why, Freshwater, Queenscliff, Manly
137	Chatswood to Bantry Bay	Chatswood station, North Willoughby, Roseville Chase, Forestville, Frenchs Forest
257	Chatswood to Balmoral via Crows Nest	Chatswood station, Willoughby, Naremburn, Crows Nest, Neutral Bay, Mosman, Balmoral Beach
272	North Willoughby to City Wynyard	North Willoughby, South Willoughby, Sydney CBD (Wynyard)
275	Castlecrag to Chatswood	Chatswood, North Willoughby, East Willoughby, Castlecrag
340	Bondi Junction to Chatswood	Chatswood station, North Willoughby, South Willoughby, Sydney CBD, Paddington, Bondi Junction
343	Kingsford to Chatswood	Chatswood station, North Willoughby, South Willoughby, Naremburn, Crows Nest, North Sydney, Sydney CBD, Surry Hills, Waterloo, Rosebury, Kingsford

A map of the public transport services within and around the East Chatswood local centre is provided in **Figure 6-12**.

Figure 6-12 Public transport map



6.2.6 Freight, services and loading

The local centre does not provide on-street spaces for dedicated loading at any time during the day. This is a potential limitation for both Victoria Avenue and Penshurst Street if sufficient on-site loading is not provided as part of development.

Penshurst Street is designated as a Short Combination route as part of the Higher Mass Limits (HML) network and provides a freight corridor running through the local centre.

6.2.7 Ride and vehicle sharing services

The local centre does not cater for ride or vehicle sharing services.

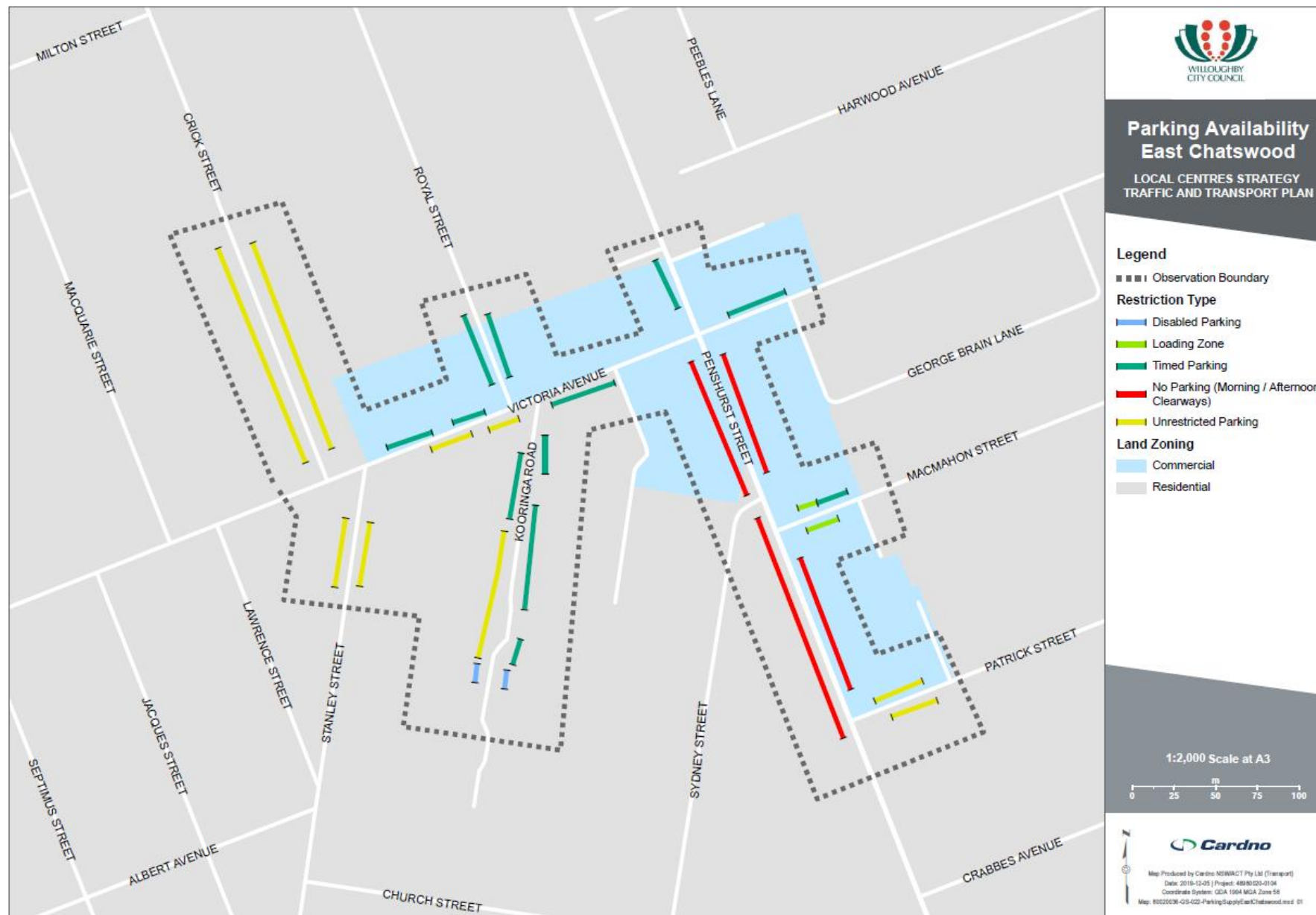
6.2.8 Parking provision

East Chatswood provides time restricted parking along Victoria Avenue and Penshurst Street operating primarily 1P and 1/2P parking restrictions. In the weekday AM peak, clearways apply on Penshurst Street. Adjoining streets such as Kooringa Road and Royal Street supporting additional timed parking through the provision of angle parking spaces.

Accessible parking is available close to shops on Royal Street. Accessible spaces are also provided at the far end of Kooringa Road however there is opportunity to introduce a space closer to the commercial district. Macmahon Street and Patrick Street do not offer accessible parking however provide ample room to do so. There are no accessible parking spaces available on Victoria Avenue or Penshurst Street.

An overview of parking availability for the weekday AM & PM peak periods is shown in **Figure 6-13**.

Figure 6-13 Parking availability



Parking profiles indicating the total parking requirement over the course of the day are presented in **Figure 6-14** and **Figure 6-15**. For further details and an explanation of these graphs refer to **Appendix B**.

Figure 6-14 East Chatswood weekday parking profile

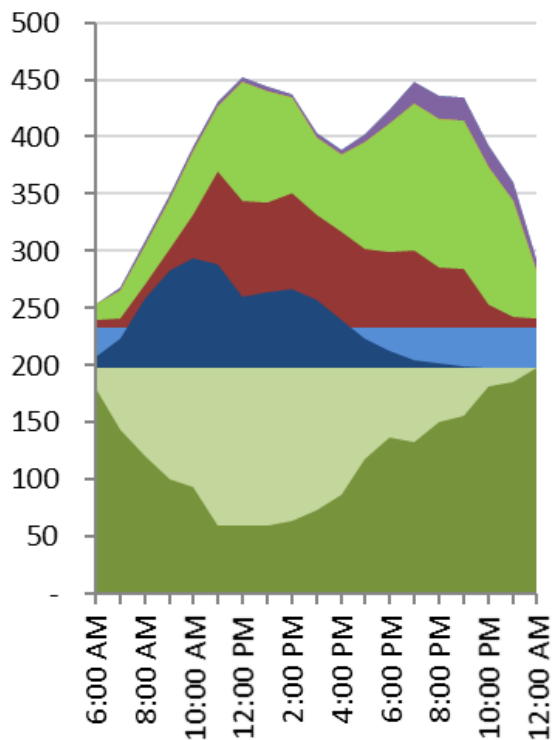
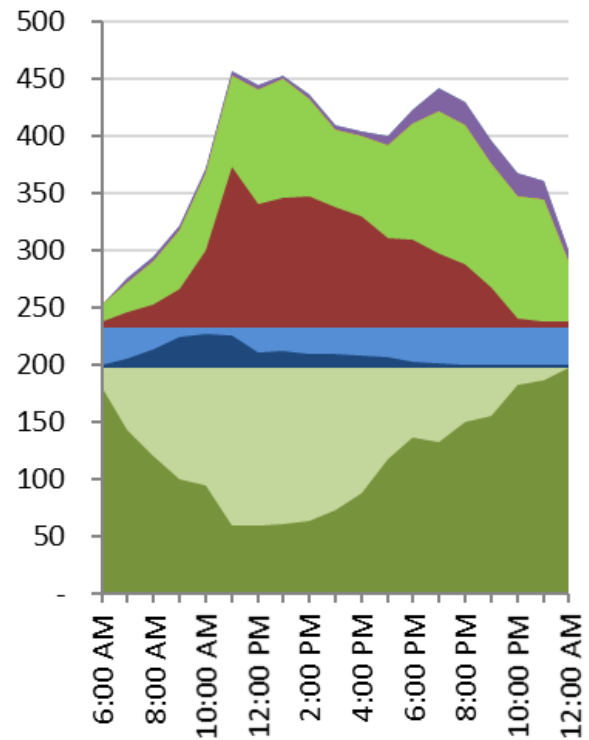


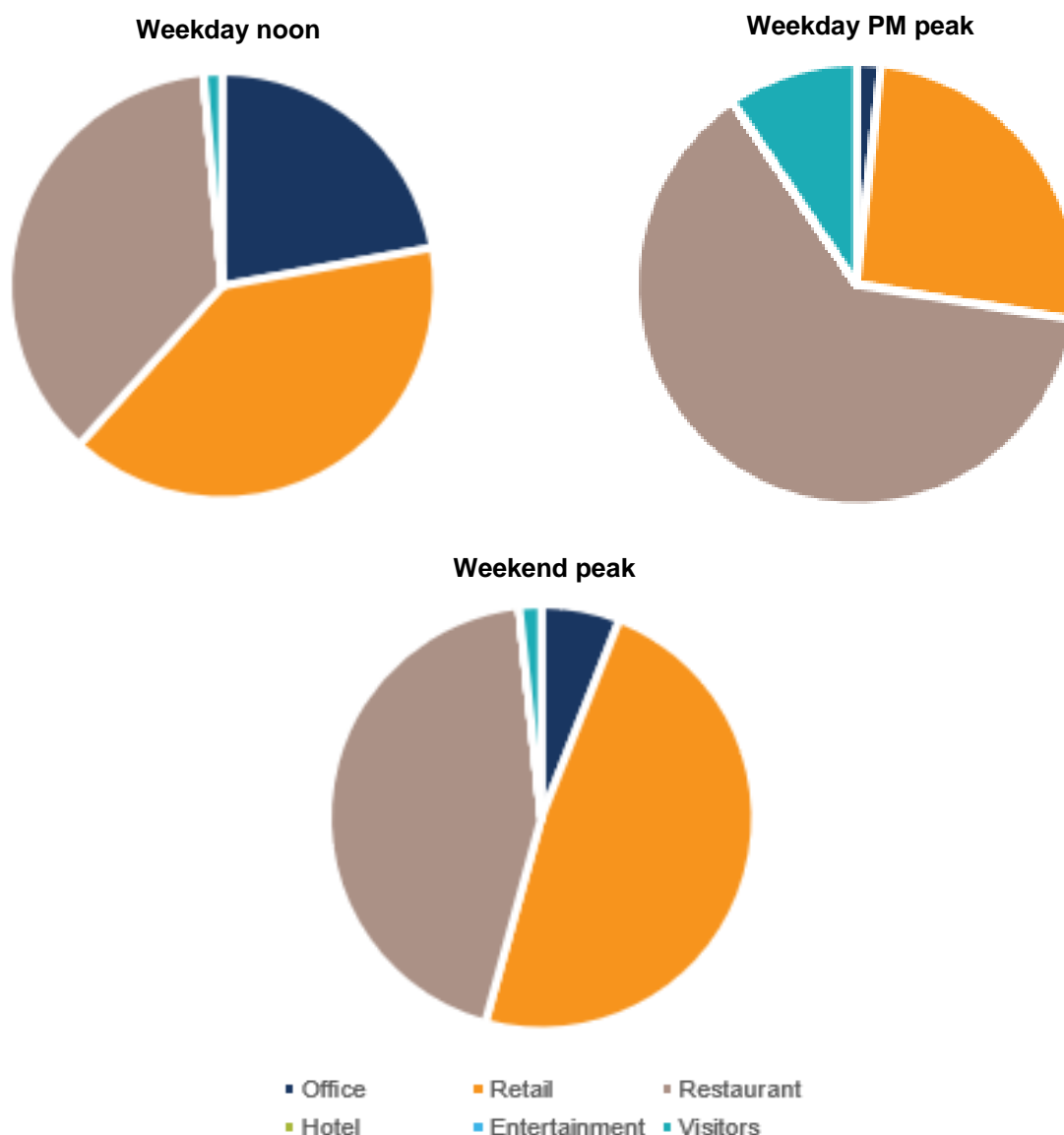
Figure 6-15 East Chatswood weekend parking profile



- Visitor
- Office
- Employee Parking (Vacant)
- Hotel
- Entertainment
- Residential Parking (Vacant)
- Retail
- Restaurant
- Residential Parking Occupied)

A breakdown of the weekday peak parking demand by land use is presented in **Figure 6-16**.

Figure 6-16 East Chatswood peak parking demand



6.2.8.2 East Chatswood parking function

Parking in this area is dominated by retail and restaurant parking, particularly during the evenings and the weekend peak.

Employee parking demand is understood to be in the order of 80 spaces per day, representing almost 1/3 of the total supply. Only a small proportion of this parking is accommodated on-site, with the majority provided for in the adjacent streets.

Visitation to this Local Centre is likely to exceed the availability of parking during the midday and evening peaks, resulting in overspill into the nearby residential area.

This effect is exacerbated by the use of on-street parking by residents, particularly in the evenings, as well as in high-demand locations (e.g. Macmahon Street) where residential permits allow for parking on-street all day. This results in cars occupying valuable spaces throughout the weekday, even while their owners use alternative modes to access employment.

6.2.8.3 Parking recommendations

The combination of residential on-street parking and restaurant uses has the potential to place some stress on the local supply during the evening and weekend periods. Nevertheless, alternatives exist in the surrounding network and there are few opportunities for consolidated parking in this area.

The existing 1/2P free parking is likely too short to support many of the uses along Penshurst Street, and is difficult to enforce.

Recommendation (Management):

Standardise parking along Penshurst Street and Victoria Avenue (within the Centre) to a 1P standard.

On-street parking in other streets within the Centre should be 2P, with unrestricted parking beyond.

6.2.9 Intersection modelling

6.2.9.1 Intersection counts

For the East Chatswood local centre, a total of three intersections were surveyed and included:

- > Victoria Avenue / Royal Street / Koorunga Road (priority controlled);
- > Victoria Avenue / Penshurst Street (signalised intersection); and
- > Penshurst Street / Macmahon Street (signalised intersection).

The peak one-hour periods with the heaviest traffic were identified to be:

- > 7:30am – 8:30am for the weekday AM peak;
- > 5:15pm – 6:15pm for the weekday PM peak; and
- > 10:15am – 11:15pm for the Saturday midday peak.

The data was used to inform the traffic modelling by providing the traffic under existing conditions. Volumes and intersection modelling results are presented in **Appendix A**.

6.2.9.2 Intersection modelling results

SIDRA intersection modelling results for key intersections within the East Chatswood local centre are presented in **Table 6-6**. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 6-6 SIDRA intersection modelling results – East Chatswood

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Victoria Avenue / Royal Street / Koorunga Road	0.305	17.7	B	0.722	34.4	C	0.320	29.9	C
Victoria Avenue / Penshurst Street	0.963	33.7	C	0.953	44.7	D	1.153	86.3	F
Penshurst Street / Macmahon Street / Sydney Street	0.886	4.9	A	0.954	25	B	0.778	5.2	A

The Victoria Avenue / Penshurst Street intersection is performing unsatisfactorily at LoS F in the Saturday peak period. The delays associated with this are due to the through and right-turning vehicles from Victoria Avenue (western approach) where the demand exceeds the current capacity, resulting in residual queues that don't clear every signal cycle. In the AM and PM peak periods, this intersection is performing at a LoS C and D respectively.

The Victoria Avenue / Penshurst Street intersection is also over-saturated (DoS is greater than 1.0), indicating that it is congested. In the AM peak and PM peak periods, it is above 0.9. The intersection may experience congestion due to the demand exceeding the capacity.

Similarly, the degree of saturation at the Penshurst Street / Macmahon Street / Sydney Street intersection is above 0.9 in the PM peak period. The degree of saturation at the intersections in the other peak periods are satisfactory across all peak periods.

The other two intersections are performing at a LoS C or better, which indicate that the intersections are operating satisfactorily or have spare capacity.

6.2.9.3 Summary of opportunities and constraints

Key opportunities and constraints of the East Chatswood local centre are summarised in **Table 6-7**:

Table 6-7 Opportunities and constraints

Opportunities	Constraints
<ul style="list-style-type: none"> Potential for improved pedestrian connections and treatments 	<ul style="list-style-type: none"> No existing cycling infrastructure Traffic constraints at the Victoria Avenue / Penshurst Street intersection

6.3 Future transport network review and recommendations

6.3.1 Traffic network analysis

6.3.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at East Chatswood in accordance with **Table 6-8**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 6-8 Apartment mix and occupancy – East Chatswood

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	66	1.7	110
1 bedroom	14%	93	1.7	153
2 bedroom	60%	397	2.3	908
3 bedroom	16%	106	2.8	296
Total	100%	662	-	1,467

¹Based on ABS 2016 Census Data

Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 6-9**. The employee densities were adopted from TfNSW guidelines for office space and typical employee densities for retail and hospitality.

Table 6-9 Non-residential floor space assumptions – East Chatswood

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	30%	1 / 40 sqm	207
Hospitality	40%	1 / 20 sqm	553
Office	30%	4.75 / 100 sqm	394
Total	100%	-	1,154

Therefore, based on these assumptions the East Chatswood local centre is expected to accommodate approximately 1,470 residents and 1,150 employees.

6.3.1.2 Parking requirements

The minimum car parking requirements in accordance with the DCP are presented in **Table 6-10**.

Table 6-10 Minimum car parking requirements – East Chatswood

Land use		Rate	Proposed development	Spaces required
Residential (non-adaptable units)	Studio	0.5 / dwelling	66 dwellings	33
	1 bedroom	1 / dwelling	93 dwellings	93
	2 bedroom	1 / dwelling	397 dwellings	397
	3 bedroom	1 / dwelling	106 dwellings	106
	Visitors	0.25 / dwelling	662 dwellings	166
			Residential subtotal	794
Commercial	Retail	36 sqm / space	8,290 sqm GFA	232
	Hospitality	107 sqm / space	11,053 sqm GFA	103
	Office	110 sqm / space	8,290 sqm GFA	75
			Commercial subtotal	410
			Development total	1,204
	Motorbike parking	1 / 25 car parking spaces	1,204 spaces	48

Note: Table shows rounded values. Subtotals were rounded down in accordance with the DCP.

Based on these calculations, the proposed development would be required to provide a minimum of 1,204 car parking spaces (including accessible parking spaces) and 48 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 6-11**.

Table 6-11 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	662 units	66
Retail	1 / 450m sqm GFA	8,290 sqm GFA	18
Hospitality	1 / 450m sqm GFA	11,053 sqm GFA	25
Office	1 / 600 sqm GFA	8,290 sqm GFA	14
Total			123

The calculations indicate that the proposed development would be required to provide 123 bicycle spaces.

6.3.1.3 Trip generation

Based on the trip generation rates presented in **Section 3.3**, the estimated number of trips generated by the proposed development are presented in **Table 6-12**. An estimate of existing traffic generated by the current land uses is also provided, as well as the additional traffic expected to be generated.

Table 6-12 Future traffic generation

Land use	Total development (existing + proposed)	Traffic generation (veh/hr)		
		AM peak	PM peak	Saturday peak
Residential	662 units	126	99	126
Retail	6,217 sqm GLFA	70	222	57
Hospitality	8,290 sqm GLFA	93	325	621
Office	8,290 sqm GFA	133	99	0
Total		421	746	803
Existing traffic generation		280	551	585
Additional traffic generated		+141	+195	+218

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

On this basis the proposed development is expected to generate an additional 141 vehicle movements in the AM peak hour, 195 in the PM peak and 218 in the Saturday peak.

The mode share for the sites surveyed by TfNSW averaged out to approximately 30 per cent for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the East Chatswood local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 39 per cent for residents and 55 per cent for workers. This represents a higher mode share than those surveyed for the TfNSW traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis, a mode share discount of 10 per cent was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 29 per cent for residents and 45 per cent for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

6.3.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 6-13**.

Table 6-13 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the additional traffic generated to determine the inbound and outbound trips presented in **Table 6-14**.

Table 6-14 Inbound and outbound additional traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	16	97	44	29	40	61
Retail	7	11	22	34	6	9
Hospitality	11	11	38	39	61	94
Office	24	4	2	27	0	0
Total (additional traffic generated)	57	123	106	129	106	164

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 6-15**.

Table 6-15 Directional assumptions

Direction	In %	Out %
North	6%	28%
East	0%	0%
South	52%	26%
West	42%	46%
Total	100%	100%

Source: ABS 2016 Census Data

6.3.1.5 Intersection modelling results

Intersection modelling was undertaken for key intersections within the East Chatswood local centre using SIDRA Network software. The modelling examined the intersection performance for the following scenarios:

1. 2036 With 100 per cent Development; and
2. 2036 With 75 per cent Development.

The 2036 With 100 per cent Development scenario represents a full development case which may be realised in 2036. The 2036 With 75 per cent Development scenario represents a case where the development is not fully achieved, and is presented to understand the impacts of a reduced scale of development which may occur at an earlier point in time. The results and key findings of each scenario are presented in the following sections.

6.3.1.5.1 2036 With 100 per cent Development modelling results

Table 6-16 summarises the intersection performance of the East Chatswood local centre for the 2036 With 100 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 6-16 Future intersection performance – East Chatswood

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Victoria Avenue / Royal Street / Kooronga Road	0.401	21	B	0.911	50.8	D	0.378	39.6	C
Victoria Avenue / Penshurst Street	1.04	63.3	E	1.036	58.4	E	1.295	140.5	F
Penshurst Street / Macmahon Street / Sydney Street	0.916	7.5	A	1.066	63.4	E	0.913	11.3	A

In the 2019 base model, the Victoria Avenue / Penshurst Street intersection was performing unsatisfactorily at a LoS F in the Saturday peak period. It was noted that delays associated with LoS F were due to the through and right-turning vehicles from Victoria Avenue (western approach), where the demand exceeded the capacity, creating residual queues after each cycle. With no capacity improvements considered in 2036, the existing operation and issue at Victoria Avenue / Penshurst Street intersection worsens. In the AM and PM peak periods, the intersection performance deteriorates from a LoS C and D respectively in 2019 to a LoS E in 2036.

In 2036, the intersection operation worsens at the other two intersections, however, the level of service is consistent with the 2019 base model except in the PM peak period. In 2036 compared to 2019, the Victoria Avenue / Royal Street / Kooronga Road intersection deteriorates to a LoS D from LoS C, the Victoria Avenue / Penshurst Street intersection worsens to LoS E from LoS D and the Penshurst Street / Macmahon Street / Sydney Street intersection worsens to a LoS E from LoS B. This is due to the expected increase in demand generated by the proposed development.

The results from the 2019 base model indicated that the Victoria Avenue / Penshurst Street intersection is over-saturated (DoS is greater than 1.0) in the Saturday peak period but operates satisfactorily in the other peak periods. By 2036, it is expected to be over-saturated across all peak periods. The Penshurst Street / Macmahon Street / Sydney Street intersection reaches a DoS greater than 1.0 in the PM peak period, and in the other peak periods the degree of saturation is above 0.9. Similarly, the Victoria Avenue / Royal Street / Kooronga Road intersection DoS is expected to be above 0.9 in the PM peak period while the degree of saturation remains below 0.9 in the other peak periods.

6.3.1.5.2 2036 With 75 per cent Development modelling results

Table 6-17 summarises the intersection performance of the East Chatswood local centre for the 2036 With 75 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix B**.

Table 6-17 Intersection Performance – East Chatswood

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Victoria Avenue / Royal Street / Kooringa Road	0.388	20.7	B	0.894	48.5	D	0.355	38.3	C
Victoria Avenue / Penshurst Street	1.033	61.8	E	1.029	57.4	E	1.294	136	F
Penshurst Street / Macmahon Street / Sydney Street	0.902	6.9	A	1.052	57.6	E	0.902	10.4	A

Across all peak periods, the intersection performance is consistent with the 2036 With 100 per cent Development scenario. There are minor improvements in the average delay and degree of saturation, including a 10 per cent decrease in the average delay in the PM peak at the Penshurst Street / Macmahon Street / Sydney Street intersection from the 100 per cent Development scenario. There was also a reduction of 30 metres of the average back of queue from the 75 per cent Development scenario when compared to the 100 per cent Development scenario, however there were no changes to the level of service.

6.3.2 Parking analysis

Parking demand in East Chatswood is expected to double within the time horizon, assuming business-as-usual travel behaviour.

This demand is projected to include as much as 250 long-stay employees, with a maximum peak occupancy of over 500 bays. This suggests that the supply for employee parking would need to increase significantly; either in the form of shared public parking in multi-deck facilities / basement parking or through reallocation of on-street peripheral parking for long-stay purposes (e.g. along streets radiating away from the Centre: Royal Street, Macmahon Street etc.).

The much higher proportion of restaurant land uses in the Centre indicates that there may be an increase in conflicts between visitors and residential on-street parking in the surrounding catchment, making this Centre a good candidate for the expanded parking permit regime described in **Appendix B** and the implementation of 'demand responsive pricing' along key roads such as Victoria Street and Penshurst Street.

Figure 6-17 East Chatswood future non-residential parking demand weekday profile

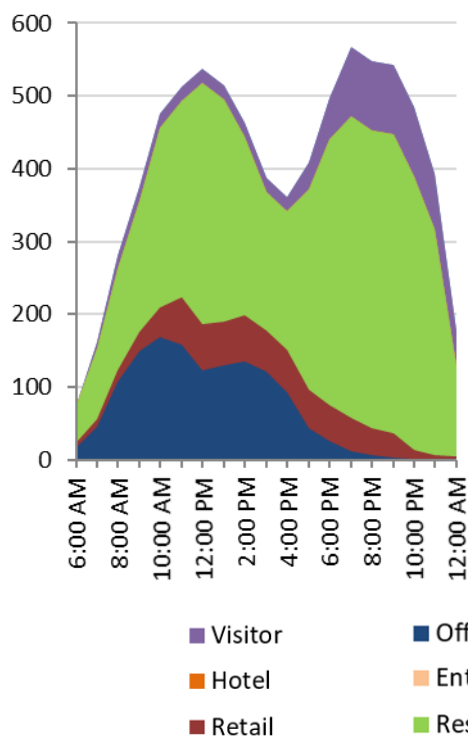
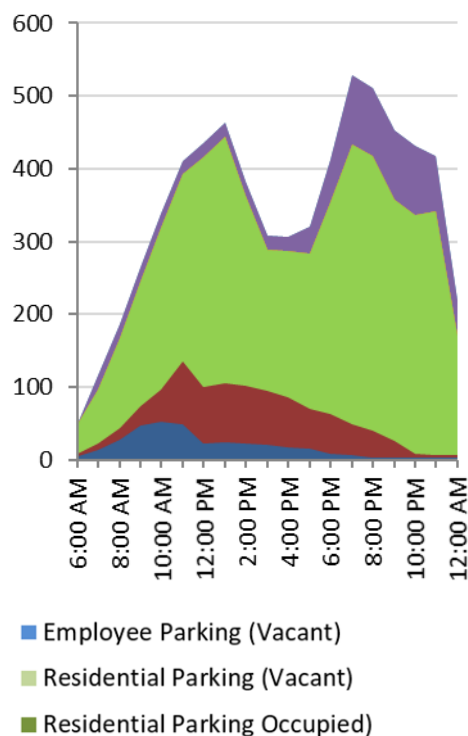


Figure 6-18 East Chatswood future non-residential parking demand weekend profile



6.3.3 Active Transport

Walking and cycling needs within the East Chatswood local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

East Chatswood already contains an established footpath network, however there are a range of opportunities for improvement and limited cycling infrastructure. These issues are summarised in **Table 6-18**, along with recommendations to address them.

Recommendations to address these issues are summarised in **Section 6.3.5**.

6.3.4 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

East Chatswood is well connected by bus to surrounding centres and public transport hubs including Chatswood, North Sydney and the Sydney CBD. Victoria Avenue and Penshurst Street accommodate a range of services and link to Chatswood station where rail access is provided. Opportunities for improvement are limited but may include additional services and a review of bus routes to optimise connectivity and access.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 6.3.5**.

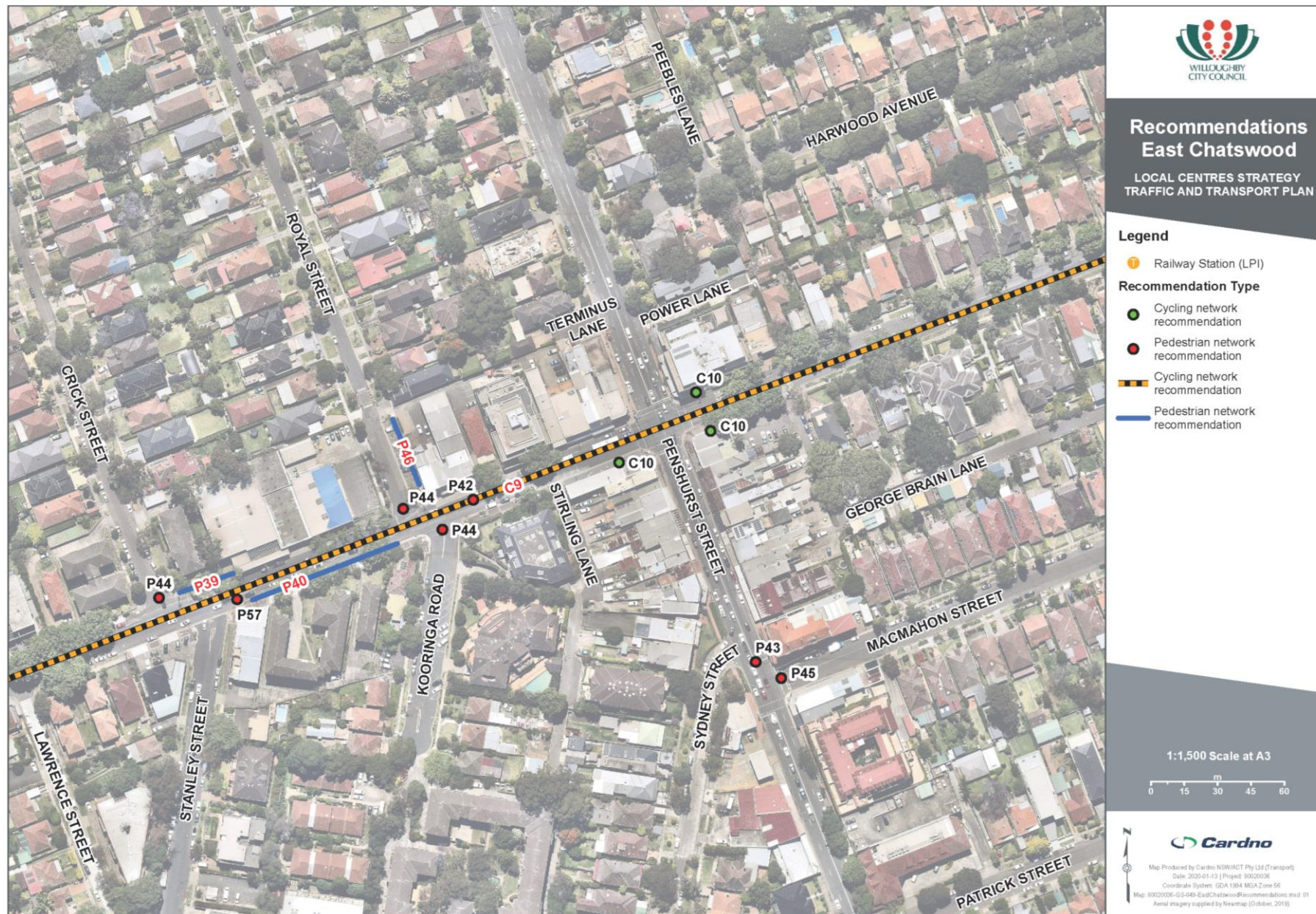
6.3.5 Issues and options

The issues and recommendations for the local centre are summarised in **Table 6-18** and **Figure 6-19**.

Table 6-18 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P39	Narrow footpath on the northern side of Victoria Avenue between Crick Street and the pedestrian crossing.	Widen the footpath on the northern side of Victoria Avenue between Crick Street and the pedestrian crossing to minimum 2m where possible.	Footpath	30 metres
P40	Inconsistent paving treatments on the southern side of Victoria Avenue.	Implement continuous footpath pavement treatments across driveways to clearly mark pedestrian priority.	Footpath	100 metres
P42	A distance of almost 200 metres between pedestrian crossings on Victoria Avenue.	Investigate implementation of a pedestrian refuge on Victoria Avenue between Koorunga Road and Stirling Lane.	Pedestrian refuge	
P43	Missing pedestrian crossing at the intersection of Penshurst Street with Macmahon Street.	Provide a signalised pedestrian crossing on the northern leg of the Penshurst Street / Macmahon Street intersection.	Signalised pedestrian crossing	
P44	Long pedestrian crossing distances on Koorunga Road, Crick Street and Royal Street at Victoria Avenue and Patrick St at Penshurst Street.	Provide kerb extensions or pedestrian refuges to reduce pedestrian crossing distances and the potential for conflict.	Kerb extensions / pedestrian refuges	
P45	Incorrect linemarking for the signalised pedestrian crossing on Macmahon Street at Penshurst Street.	Renew pedestrian crossing linemarking with dashed lines in accordance with TfNSW standards.	Linemarking	
P46	Vehicles encroaching onto the eastern footpath of Royal Street.	Provide wheel stops at the car parking spaces on the eastern side of Royal Street.	Wheel stops	12
P57	Non-compliant pedestrian crossing on Victoria Avenue east of Stanley Street.	Provide kerb extensions at the marked pedestrian crossing to reduce the number of travel lanes crossed from three to two.	Kerb extensions	
Bicycle				
C9	Lack of existing cycling infrastructure within the centre.	Provide a separated cycleway on Victoria Avenue between Havilah Street and High Street in accordance with the Willoughby Bike Plan.	Separated cycleway	760 metres
C10	Limited bicycle parking available.	Provide bike racks near the corner of Penshurst Street and Victoria Avenue to facilitate future demand from the proposed cycleway on Victoria Avenue.	Bike racks	10
Road network				
R23	Lack of accessible parking within the local centre.	Provide accessible parking spaces within the local centre at convenient locations on Penshurst Street and Victoria Avenue.	Parking	
R24	Existing 1/2P free parking is likely too short to support many of the uses along Penshurst Street, and is difficult to enforce.	Standardise parking along Penshurst Street and Victoria Avenue (within the Centre) to a 1P standard, and introduce 2P parking in other streets within the centre. Parking beyond the centre should be unrestricted.		

Figure 6-19 Recommendations map



7 High Street

7.1 Land use

7.1.1 Existing

The High Street local centre is situated on High Street, almost halfway between Victoria Avenue and Mowbray Road. The centre contains a small strip of shops and businesses between Glover Street and McClelland Street, as well as St Thomas Primary School at the intersection of High Street / Horsley Avenue. The surrounding area is composed mostly of detached dwellings.

An overview of the High Street local centre study area and land use mix is presented in **Figure 7-1** and **Table 7-1**.

Figure 7-1 High Street local centre

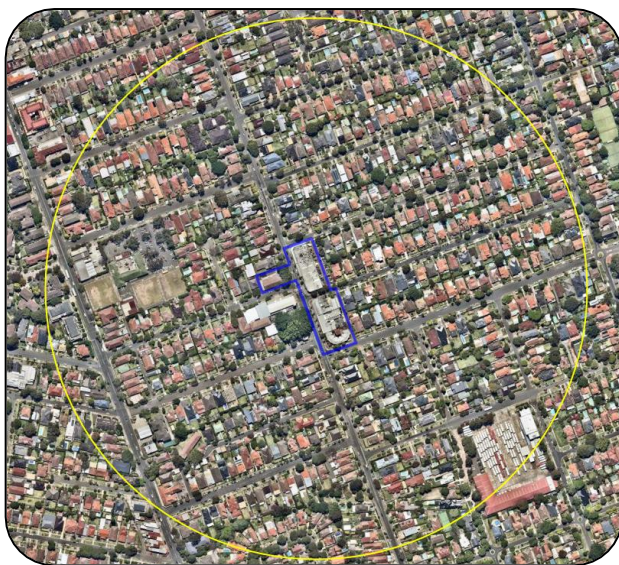


Table 7-1 High Street land use mix

Town Centre	
Office / Commercial	3,300 m ²
Medical	1,150 m ²
Shopping / Retail	2,900 m ²
Restaurant	375 seats
Health / Fitness	200 m ²
Attached Housing	9 dwellings
Parking	
Off-Street Supply	200 spaces
On-Street Supply	85 spaces
Peak Non-Residential Parking Demand	200 spaces
Surrounds (400m)	
Aged Care	120 beds
Retirement	40 dwellings
Attached Housing	3,000 dwellings
Detached Housing	300 dwellings

The majority of all pedestrian movement within the centre occurs along High Street. Adjoining streets such as Glover Street, Horsley Avenue and McClelland Street provide connections from surrounding low density residential areas to the commercial district of High Street.

7.1.2 Planned

Forecast development, land uses and uplift were obtained from the *Willoughby Local Centres Strategy* and discussions with Council. Total figures were provided for residential and non-residential floor space under the preferred scenario, as well as an indicative overview of the vision for the local centre.

Assumptions will be made in regards to specific uplift of particular blocks and positioning of access points to inform the future network review and traffic modelling.

The High Street local centre is forecast for similar and modest uplift in residential and commercial floor space. The preferred scenario contains the following key features:

- > A total of 1,862 sqm GFA of residential floor space, entirely constituting uplift;
- > A total of 5,372 sqm GFA of non-residential floor space, representing an uplift of 1,354 sqm or 34 per cent;
- > Threshold treatments at intersections for increased pedestrian amenity and safety; and

- > Possible relocation of pedestrian crossings and additional crossings.

An indicative representation of the scale and distribution of the preferred scenario is presented in **Figure 7-2**.

Figure 7-2 Potential development at High Street – preferred scenario



Source: Willoughby Local Centres Strategy

The development is relatively small scale, adding to the existing ground floor commercial land uses and providing new residential dwellings above to accommodate housing growth.

7.1.3 Community concerns

58 people provided feedback about the *Draft Local Centres Strategy* for High Street, with mixed views towards the proposal. Similar concerns to other local centres arose surrounding potential traffic and parking impacts. The key community feedback related to traffic and transport issues were focused on the following:

- > Concerns about the increased density and potential traffic and parking impacts;
- > Concerns about a lack of infrastructure provision to accommodate increased development;
- > Support for improving pedestrian crossings, cycleways and safety; and
- > Contention regarding the positioning and provision of access routes, connections and laneways.

The community concerns are discussed further in the following sections together with the review of the existing and future transport networks.

7.2 Existing transport networks

7.2.1 Road network and traffic

The road network of the High Street local centre primarily supports north-south trips within the centre, with provisions for local east-west movements. High Street is the centre's key movement corridor accommodating north-south movement. It functions as a link between surrounding low density residential housing and the commercial district of the local centre, as well as a movement corridor connecting to key roads such as Victoria Avenue and Mowbray Road. East-west movement is supported by local roads such as Alexander Avenue and Horsley Avenue, however east-west connectivity is disjointed at High Street with roads to the west not aligning with roads to the east.

High Street accommodates the greatest traffic volumes within the High Street precinct. Intersection volumes are greatest at the intersection of High Street and Glover Street and at the intersection of High Street and McClelland Street.

Figure 7-3 and **Figure 7-4** show two key roads within the High Street local centre.

Figure 7-3 Looking south west along Glover Street



Figure 7-4 Looking south east along High Street



A summary of key roads within the local centre is detailed in **Table 7-2**.

Table 7-2 Key roads

Road name	Road Classification	Managing Authority	Number of Lanes	Speed Limit (within centre)
High Street	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
McClelland Street	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Glover Street	Local Road	Willoughby Council	2 travel lanes and 1 parking lane	50 km/h
Forsyth Street	Local Road	Willoughby Council	2 travel lanes, 1 parking lane and 90-degree angle parking	50 km/h

The road hierarchy map is shown in **Figure 7-5**.

Figure 7-5 Road hierarchy



7.2.2 Safety

Five-year crash data history was analysed from 2014 to 2018 (inclusive). Overall there were four reported crashes within the local centre of High Street. A summary of crashes by severity is shown in **Table 7-3**.

Table 7-3 Crash summary by severity

Year	Fatal	Serious Injury	Moderate Injury	Minor / Other Injury	Non-Casualty (tow away)	TOTAL
2014						0
2015			1			1
2016			1			1
2017		1			1	2
2018						0
TOTAL	0	1	2	0	1	4

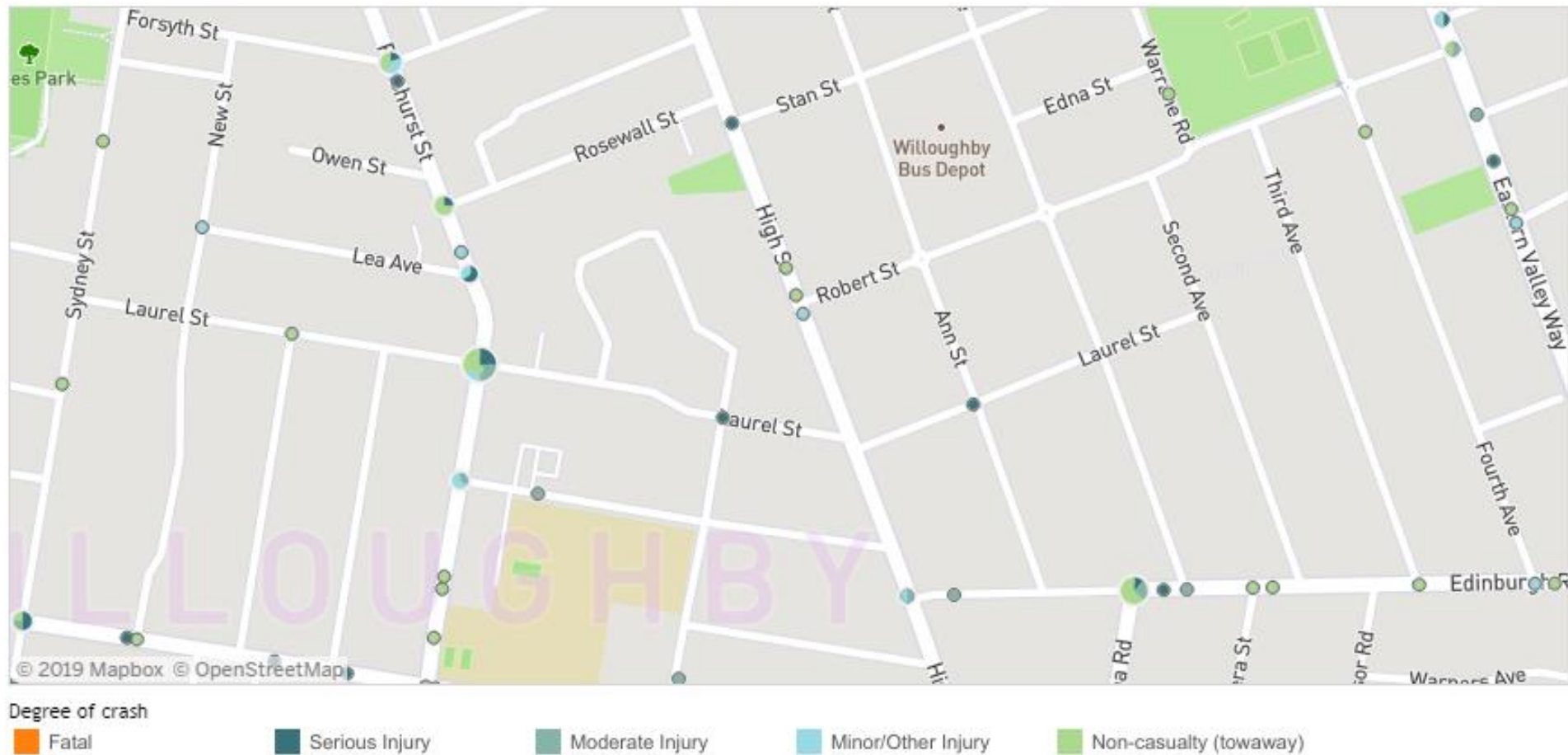
There were no fatalities within the local centre during the five-year period, with one crash resulting in serious injury.

7.2.2.2 Crash Locations

All recorded crashes recorded within the five-year study period occurred on High Street. Crash clusters were not evident at any location within the local centre. A total of two crashes involving pedestrians were recorded from 2014 to 2018. This equates to half of all crashes recorded within the study period, with one pedestrian crash registering as a serious injury.

Crash locations within the High Street local centre are shown in **Figure 7-6**.

Figure 7-6 Crash map



Source: NSW Centre for Road Safety

7.2.3 Existing pedestrian network and infrastructure

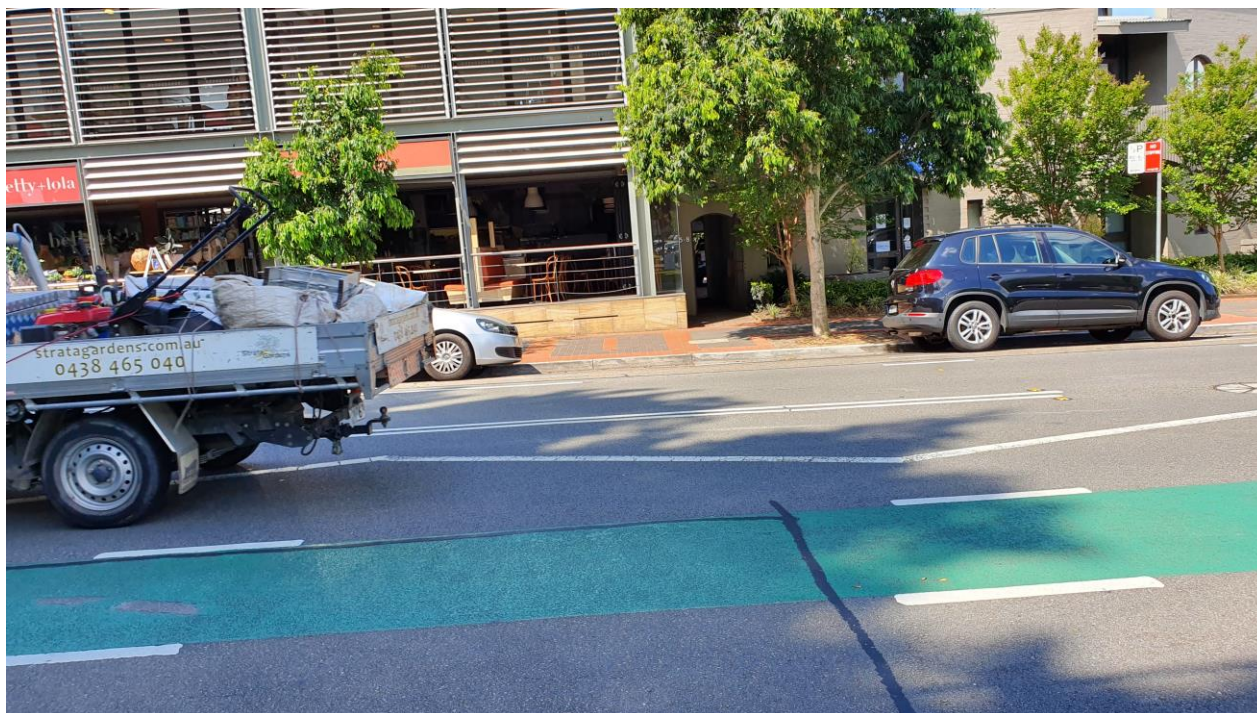
Figure 7-7 Kerb ramp on the western side of High St



High Street operates as the centre's key walking corridor. High street provides wide paved footpaths along the eastern side of the corridor however a significant portion of the western alignment consists of footpaths approximately 1.2 – 1.5 metres wide. Similar width footpaths are present along the northern side of Alexander Avenue, despite providing a direct connection to the High Street commercial district.

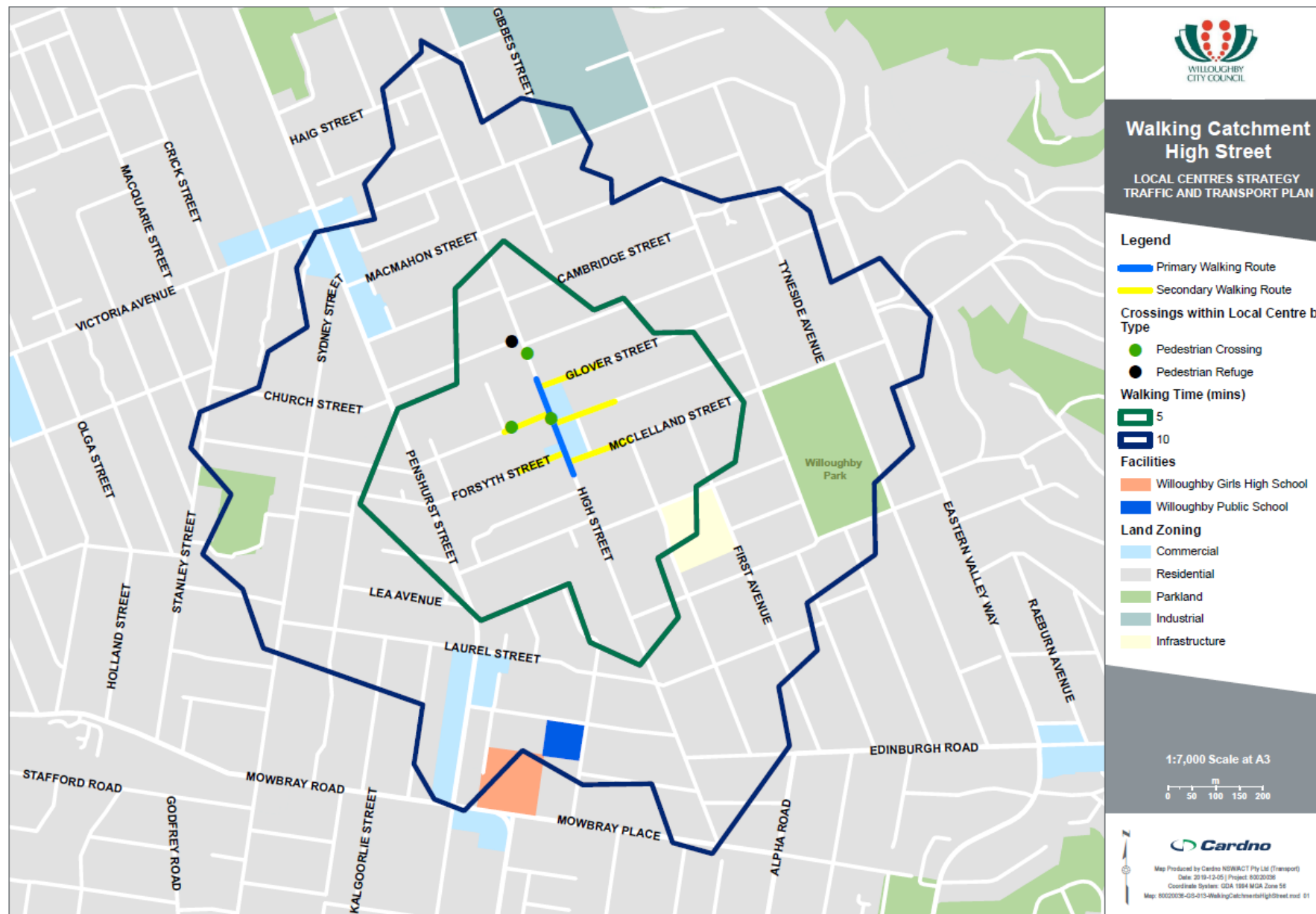
Pedestrian accessibility is supported with the function of a raised pedestrian crossing, implemented at a central location. There are no signalised crossings or pedestrian refuges available. Pedestrian connections could be improved by reducing crossing distances on the side streets including McClelland Street and Forsyth Street, which could be achieved by implementing pedestrian refuges or kerb extensions. An additional crossing could also facilitate pedestrian movement, together with relocation of the existing crossing to better align with pedestrian desire lines through the future development. During the site visit, a kerb ramp, as shown in **Figure 7-7** was observed on the west side of High Street. No kerb ramps are present on the east side of the road, as shown in **Figure 7-8**, to support pedestrian movement.

Figure 7-8 Lack of kerb ramp on the eastern side of High St



The High Street local centre walking catchment is shown in **Figure 7-9**.

Figure 7-9 Walking routes



7.2.4 Cycling

The High Street local centre supports on-road cycling environments, including:

- > Unidirectional cycleways (visually separated) on each side of High Street; and
- > Mixed traffic routes on Horsley Avenue and McClelland Street.

The High Street route operates as a link connecting the commercial centre of High Street to the Penshurst Street and Castlecrag local centres. The separated on-road cycleway on High Street is shown in **Figure 7-10**. This aligns with the Willoughby Bike Plan which designates this as a route.

Strava, an online fitness tracking application for cycling, shows popular cycling routes logged via mobile applications and provides indicative data on recreational cycling demand. Strava data was reviewed to identify key routes currently used by cyclists, and the data indicated cyclists use High Street as a primary north-south movement corridor, connecting with Eastern Valley Way to the north and Mowbray Road to the south.

Bike hoops are available on the eastern side of High Street, between Glover Street and Alexander Avenue as shown in **Figure 7-11**. Other areas in the centre lack cycle parking.

Figure 7-10 On-road visually separated bike path on High St

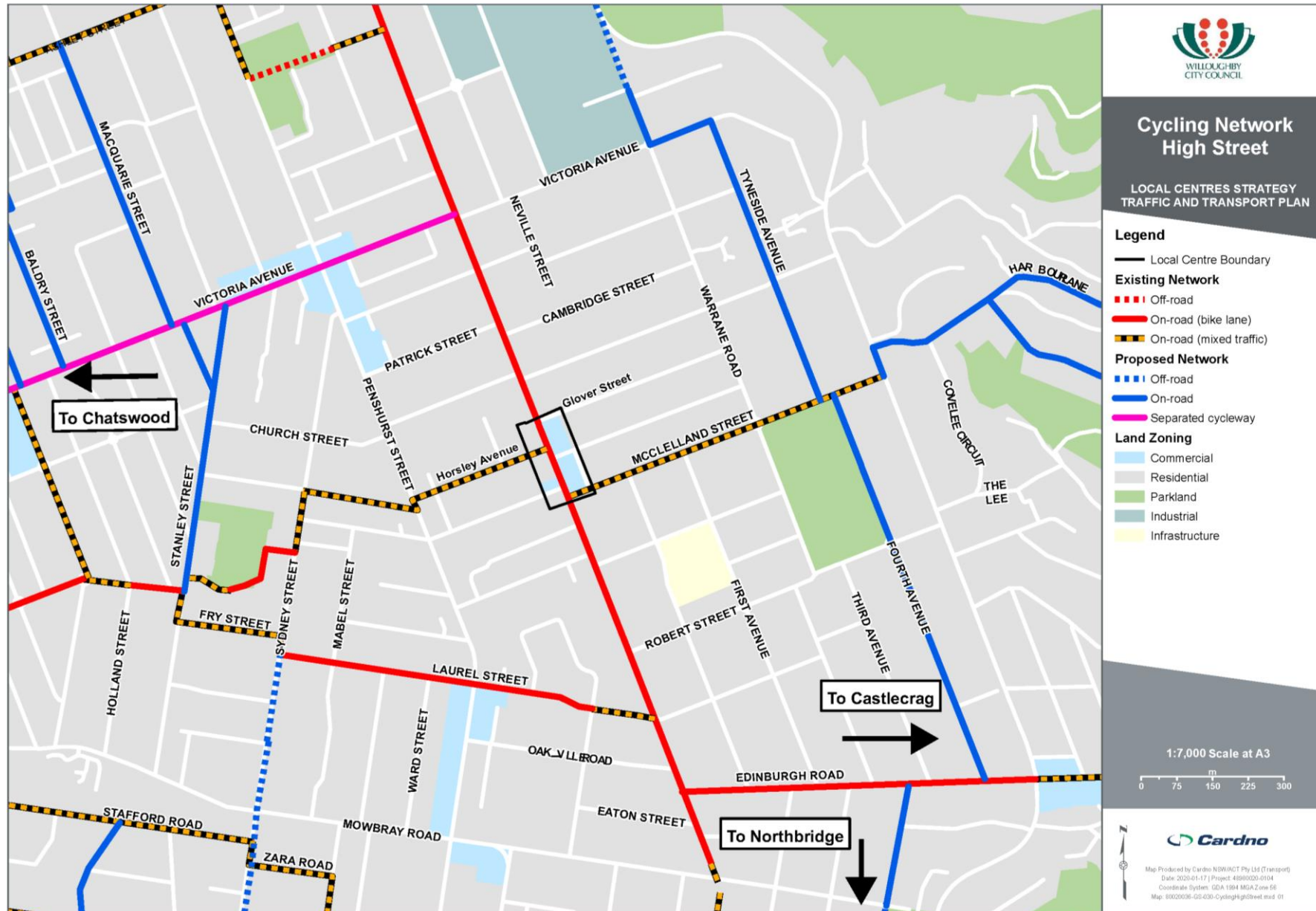


Figure 7-11 Bike hoops on High St



A map of the existing and proposed bicycle network is presented in **Figure 7-12**.

Figure 7-12 Bicycle network



7.2.5 Public Transport

Public transport is not available directly within the centre itself. The closest bus services operated by the STA are available on McClelland Street, located approximately 300 metres north east of the centre. The bus stops provide services to the city every 10-15 minutes during peak times with services every 25 minutes off peak. There is an additional service that connects McClelland Street to Milson's point however operate during the morning and afternoon peaks with services operating no more than once per hour.

STA Buses also operate via the Penshurst Street corridor, with the closest bus stops on Penshurst Street located approximately 500 metres west of the centre. Buses on Penshurst Street operate at greater frequencies than those on McClelland Street with a bus every 10 minutes Sydney CBD Chatswood, Bondi Junction and Kingsford during the peak times. During the off peak period, buses operate to these destinations every 15 – 20 minutes.

The bus routes servicing areas close to the local centre are outlined in **Table 7-4**.

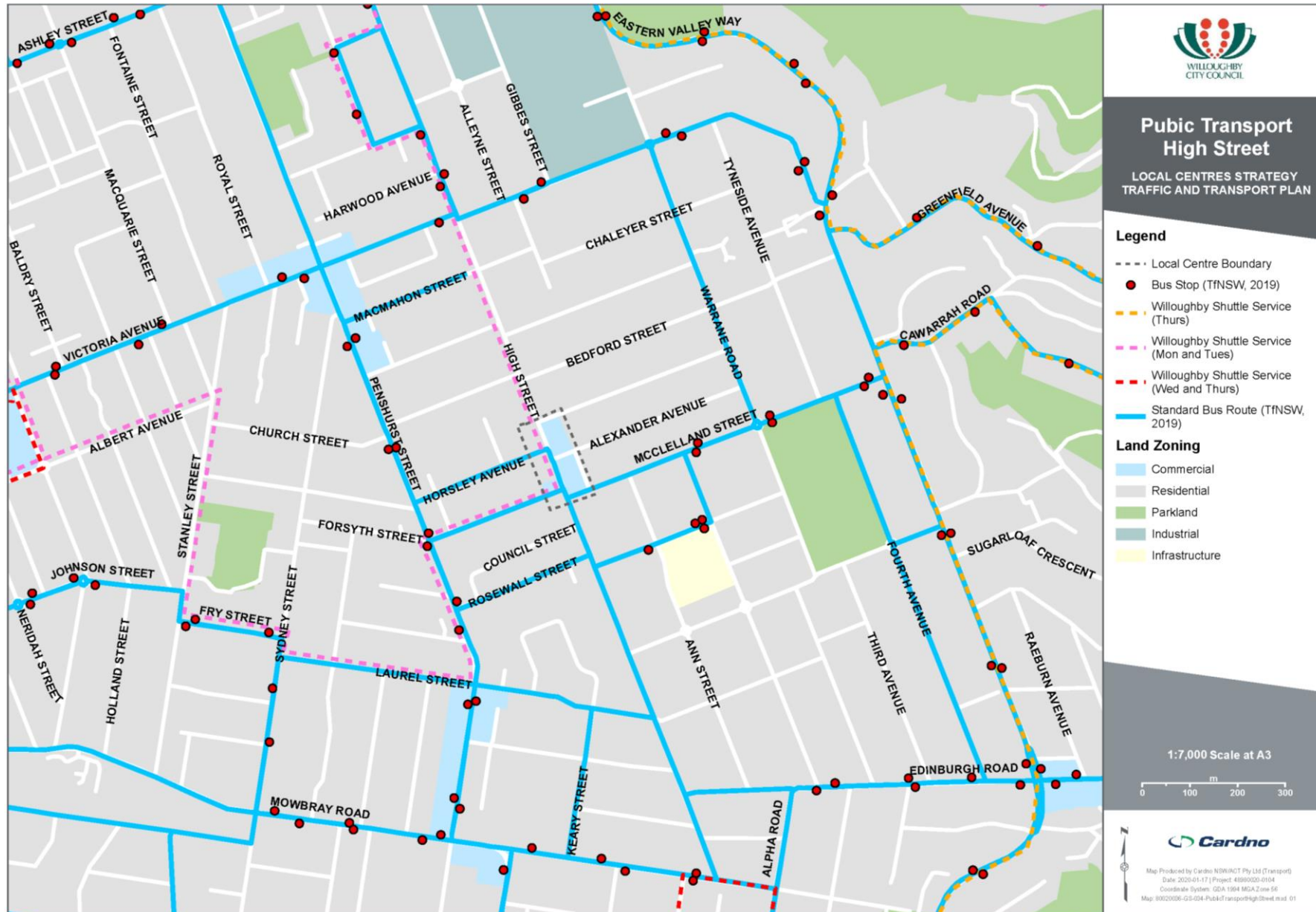
Table 7-4 Bus routes serving areas near the High Street local centre

Bus route	Route description	Areas served
205	East Willoughby to City Bridge St (Freeway)	East Willoughby, Northbridge, Castlecrag, Cammeray, Sydney CBD (Bridge St)
207	East Lindfield to City Bridge St via North Sydney	East Lindfield, Roseville, Willoughby, Northbridge, North Sydney, Sydney CBD (Bridge St)
209	East Lindfield to Milsons Point via Nth Sydney	East Lindfield, Roseville, Willoughby, Northbridge, Cammeray, North Sydney
257	Chatswood to Balmoral via Crows Nest	Chatswood station, Willoughby, Naremburn, Crows Nest, Neutral Bay, Mosman, Balmoral Beach
272	North Willoughby to City Wynyard	North Willoughby, South Willoughby, Sydney CBD (Wynyard)
340	Bondi Junction to Chatswood	Chatswood station, North Willoughby, South Willoughby, Sydney CBD, Paddington, Bondi Junction
343	Kingsford to Chatswood	Chatswood station, North Willoughby, South Willoughby, Naremburn, Crows Nest, North Sydney, Sydney CBD, Surry Hills, Waterloo, Rosebury, Kingsford

'The Loop' bus from Castle Cove to Chatswood also serves the local centre on Mondays and Tuesdays, running every 45 minutes between approximately 10:30am – 3:00pm. This service operates as a loop between the Castle Cove peninsula and the Chatswood town centre via High Street.

A map of the public transport services within and around the High Street local centre is provided in **Figure 7-13**.

Figure 7-13 Public transport map



7.2.6 Freight, services and loading

The local centre does not provide on-street spaces for dedicated loading at any time during the day.

The local centre does not contain a designated freight movement corridor.

7.2.7 Ride and vehicle sharing services

The local centre does not cater for ride or vehicle sharing services.

7.2.8 Parking provision

High Street provides time restricted parking on each side, operating 1/2P and 1P parking restrictions. Adjoining streets such as Forsyth Street, McClelland Street, Alexander Avenue and Glover Street provide additional time restricted parking.

There is an accessible parking space available close to the shops on High Street as shown in **Figure 7-14**. There is potentially an opportunity for an additional accessible space on McClelland Street.

An overview of parking availability for the weekday AM & PM peak periods is shown in **Figure 7-14**.

Parking profiles indicating the total parking requirement over the course of the day are presented in **Figure 7-15** and **Figure 7-16**. For further details and an explanation of these graphs refer to **Appendix B**.

Figure 7-14 Parking availability

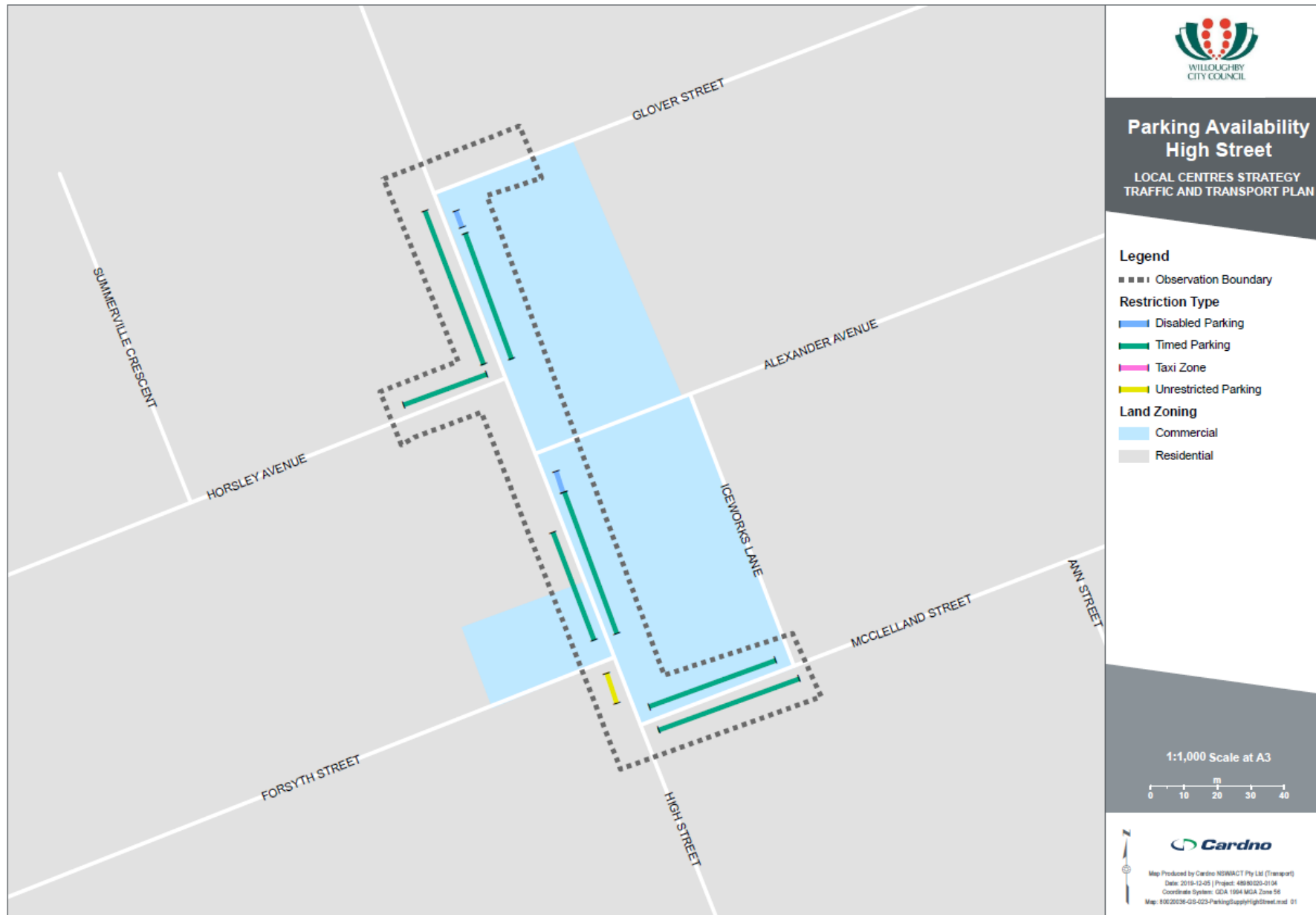


Figure 7-15 High Street weekday parking profile

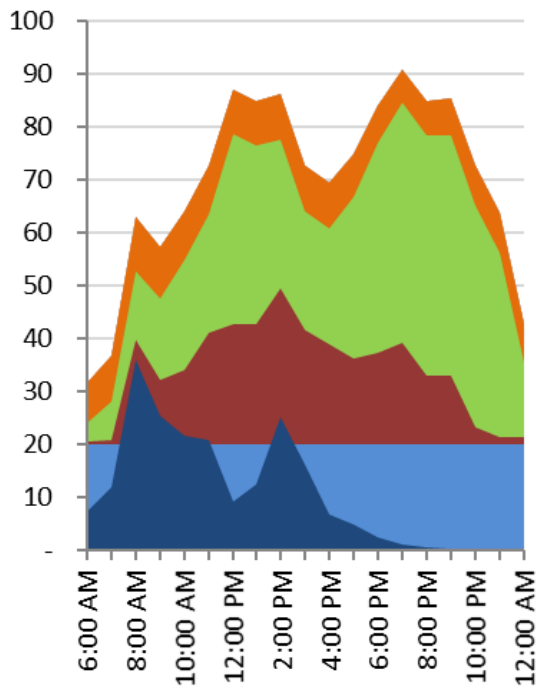
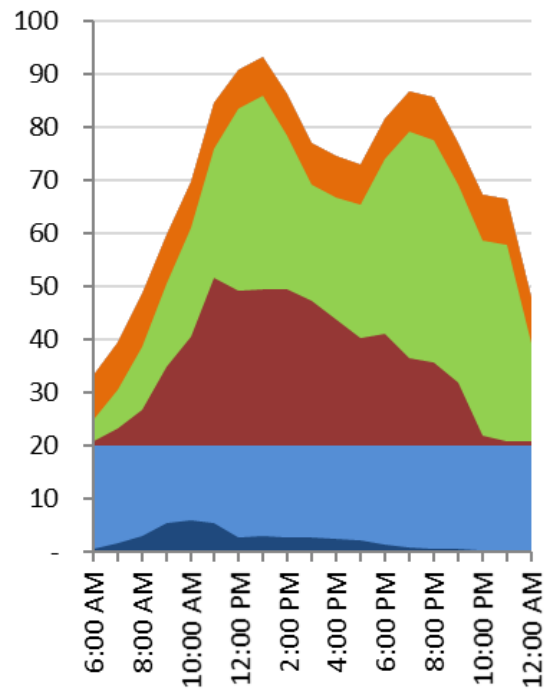


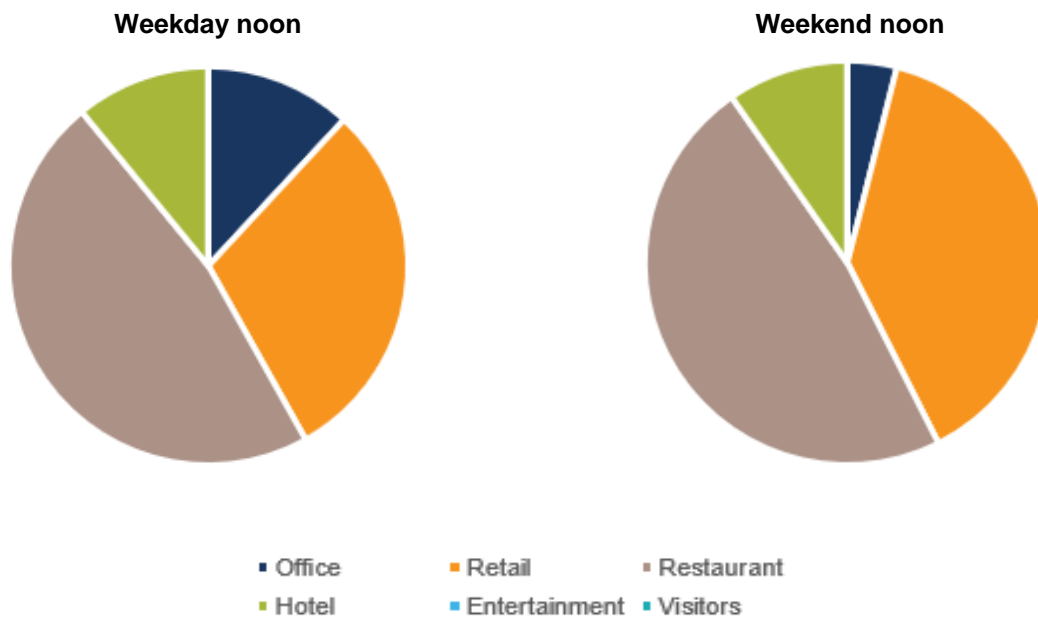
Figure 7-16 High Street weekend parking profile



- Visitor
- Office
- Employee Parking (Vacant)
- Hotel
- Entertainment
- Residential Parking (Vacant)
- Retail
- Restaurant
- Residential Parking Occupied

A breakdown of the weekday peak parking demand by land use is presented in **Figure 7-17**.

Figure 7-17 High Street peak parking demand



7.2.8.2 High Street parking function

This small Local Centre is a well-defined retail / restaurant hub, with consolidated off-street parking and easily accessible on-street supply.

It is expected that visitation will exceed the off-street parking supply, resulting in some level of conflict between residents parking on-street and restaurant parking in the evenings.

The adjacent private Primary School is expected to generate high-intensity short-term peak parking and traffic demands along High Street which may adversely impact the safety of the bike lanes along this corridor. Interventions along minor roads (e.g. Glover Street, Alexander Avenue), suggest that school activities have caused localised issues near High Street in the past.

Employee parking is located in residential on-street facilities, and there is ample parking available to accommodate this demand.

7.2.8.3 Parking recommendations

Despite the relatively small size of the Centre, it is apparent that the immediate vicinity does not have sufficient parking to easily accommodate the visitor demand during the weekday peak.

The existing 1/2P free parking is likely too short to support many of the uses along Penshurst Street, and is difficult to enforce.

Recommendation (Management):

Introduce 1P parking restrictions along Alexander Avenue, McClelland Street and Glover Street (within 100m of High Street).

Increase 1/2P duration restrictions along High Street to 1P.

7.2.9 Intersection modelling

7.2.9.1 Intersection counts

For the High Street local centre, a total of three intersections were surveyed and included:

- > High Street / Glover Street (priority controlled);
- > High Street / Horsley Avenue and High Street / Alexander Avenue (priority controlled); and
- > High Street / McClelland Street and High Street / Forsyth Street (priority controlled).

The peak one-hour periods with the heaviest traffic were identified to be:

- > 7:45am – 8:45am for the weekday AM peak;
- > 5:00pm – 6:00pm for the weekday PM peak; and
- > 12:15pm – 1:15pm for the Saturday midday peak.

The data was used to inform the traffic modelling by providing the traffic under existing conditions. Volumes and intersection modelling results are presented in Appendix A.

7.2.9.2 Intersection modelling results

SIDRA intersection modelling results for key intersections within the High Street local centre are presented in **Table 7-5**. A detailed summary of the SIDRA results is provided in **Appendix A**.

Due to the St Thomas' Art and Craft Show coinciding with the Saturday peak period, the modelling for the Saturday peak period could not be undertaken as the behaviour and volumes obtained will not reflect the typical traffic behaviour on High Street.

Table 7-5 SIDRA intersection modelling results – High Street

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
High Street / Glover Street	0.342	13.8	A	0.354	17.2	B	Special Event		
High Street / Horsley Avenue	0.380	13	A	0.337	14.9	B			
High Street Pedestrian Crossing	0.906	17.9	B	0.797	9.2	A			
High Street / Alexander Avenue	0.362	13.6	A	0.422	17.4	B			
High Street / Forsyth Street	0.349	13.1	A	0.362	14.9	B			
High Street / McClelland Street	0.347	12.3	A	0.433	17.5	B			

All the intersections are performing at a LoS A or B which indicate good intersection operation with acceptable delays and spare capacity.

The degree of saturation at all intersections are below 0.9, except for the High Street pedestrian crossing in the AM peak period. It is observed that the queues propagate from the unsignalised pedestrian crossing during the AM peak period.

7.2.10 Summary of opportunities and constraints

Key opportunities and constraints of the High Street local centre are summarised in **Table 7-6**:

Table 7-6 Opportunities and constraints

Opportunities	Constraints
<ul style="list-style-type: none"> Existing cycleways provide for active transport On-street and off-street car parking provides parking availability 	<ul style="list-style-type: none"> No public transport provision

7.3 Future transport network review and recommendations

7.3.1 Traffic network analysis

7.3.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at High Street in accordance with **Table 7-7**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 7-7 Apartment mix and occupancy – High Street

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	3	1.7	5
1 bedroom	14%	4	1.7	6
2 bedroom	60%	17	2.3	38
3 bedroom	16%	4	2.8	12
Total	100%	28	-	62

¹Based on ABS 2016 Census Data

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 7-8**. The employee densities were adopted from TfNSW guidelines for office space and typical employee densities for retail and hospitality.

Table 7-8 Non-residential floor space assumptions – High Street

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	50%	1 / 40 sqm	67
Hospitality	40%	1 / 20 sqm	107
Office	10%	4.75 / 100 sqm	26
Total	100%	-	200

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

Therefore, based on these assumptions the High Street local centre is expected to accommodate approximately 60 residents and 200 employees.

7.3.1.2 Parking requirements

The minimum car parking requirements in accordance with the DCP are presented in **Table 7-9**.

Table 7-9 Minimum car parking requirements – High Street

Table 10: Minimum car parking requirements - High Street				
Land use		Rate	Proposed development	Spaces required
Residential (non-adaptable units)	Studio	0.5 / dwelling	3 dwellings	1
	1 bedroom	1 / dwelling	4 dwellings	4
	2 bedroom	1 / dwelling	17 dwellings	17
	3 bedroom	1 / dwelling	4 dwellings	4
	Visitors	0.25 / dwelling	28 dwellings	7
			Residential subtotal	33
Commercial	Retail	36 sqm / space	2,686 sqm GFA	75
	Hospitality	107 sqm / space	2,149 sqm GFA	20
	Office	110 sqm / space	537 sqm GFA	5
			Commercial subtotal	100
			Development total	133
	Motorbike parking	1 / 25 car parking spaces	133 spaces	5

Note: Table shows rounded values. Subtotals were rounded down in accordance with the DCP.

Based on these calculations, the proposed development would be required to provide a minimum of 133 car parking spaces (including accessible parking spaces) and 5 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 7-10**.

Table 7-10 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	28 units	3
Retail	1 / 450m sqm GFA	2,686 sqm GFA	6
Hospitality	1 / 450m sqm GFA	2,149 sqm GFA	5
Office	1 / 600 sqm GFA	537 sqm GFA	1
Total			14

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

The calculations indicate that the proposed development would be required to provide 14 bicycle spaces.

7.3.1.3 Trip generation

Based on the trip generation rates presented in **Section 3.3**, the estimated number of trips generated by the proposed development are presented in **Table 7-11**. An estimate of existing traffic generated by the current land uses is also provided, as well as the additional traffic expected to be generated.

Table 7-11 Future traffic generation

Land use	Total development (existing + proposed)	Traffic generation (veh/hr)		
		AM peak	PM peak	Saturday peak
Residential	28 units	5	4	5
Retail	2,015 sqm GLFA	23	72	18
Hospitality	1,612 sqm GLFA	18	63	121
Office	537 sqm GFA	9	6	0
Total		54	146	144
Existing traffic generation		37	106	104
Additional traffic generated		+18	+40	+40

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

On this basis the proposed development is expected to generate an additional 18 vehicle movements in the AM peak hour, 40 in the PM peak and 40 in the Saturday peak.

However, the mode share for the sites surveyed by TfNSW averaged out to approximately 30 per cent for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the High Street local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 47 per cent for residents and 59 per cent for workers. This represents a higher mode share than those surveyed for the TfNSW traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis, a mode share discount of 5 per cent was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 42 per cent for residents and 54 per cent for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

7.3.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 7-12**.

Table 7-12 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the additional traffic generated to determine the inbound and outbound trips presented in **Table 7-13**.

Table 7-13 Inbound and outbound additional traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	1	8	4	2	4	5
Retail	4	5	13	16	3	4
Hospitality	4	3	13	11	21	27
Office	3	0	0	3	0	0
Total (additional traffic generated)	12	16	30	33	28	36

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 7-14**.

Table 7-14 Directional assumptions

Direction	In %	Out %
North	6%	28%
East	0%	0%
South	52%	26%
West	42%	46%
Total	100%	100%

Source: ABS 2016 Census Data

7.3.1.5 Intersection modelling results

Intersection modelling was undertaken for key intersections within the High Street local centre using SIDRA Network software. The modelling examined the intersection performance for the following scenarios:

1. 2036 With 100 per cent Development; and
2. 2036 With 75 per cent Development.

The 2036 With 100 per cent Development scenario represents a full development case which may be realised in 2036. The 2036 With 75 per cent Development scenario represents a case where the development is not fully achieved, and is presented to understand the impacts of a reduced scale of development which may occur at an earlier point in time. The results and key findings of each scenario are presented in the following sections.

7.3.1.5.1 2036 With 100 per cent Development modelling results

Due to the St Thomas' Art and Craft Show coinciding with the Saturday peak period, the modelling for the Saturday peak period could not be undertaken as the behaviour and volumes obtained will not reflect the typical traffic behaviour on High Street.

Table 7-15 summarises the intersection performance of the High Street local centre for the 2036 With 100 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 7-15 Future intersection performance – High Street

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
High Street / Glover Street	0.342	13.9	A	0.361	17.4	B	Special Event		
High Street / Horsley Avenue	0.380	13.0	A	0.336	15	B			
High Street Pedestrian Crossing	0.914	19.1	B	0.800	9.4	A			
High Street / Alexander Avenue	0.363	14.0	A	0.448	18.4	B			
High Street / Forsyth Street	0.352	13.0	A	0.372	15.5	B			
High Street / McClelland Street	0.348	12.7	A	0.442	18.3	B			

In 2036, it is expected that all the intersections will operate at LoS A or B in both the AM and PM peak periods, which indicates satisfactory operation with acceptable delays and spare capacity. This is consistent with the intersection performance in 2019.

The degree of saturation is below 0.9 across all peak periods for all intersections except at the pedestrian crossing between High Street and Alexander Avenue in the AM peak period. It is noted that in the 2019 base model (existing), it was identified that the degree of saturation was greater than 0.9 based on the SIDRA results. It is anticipated that queues will propagate from the unsignalised pedestrian crossing during the AM peak period, similar to the observation noted in the 2019 base model.

7.3.1.5.2 2036 With 75 per cent Development modelling results

Due to the St Thomas' Art and Craft Show coinciding with the Saturday peak period, the modelling for the Saturday peak period could not be undertaken as the behaviour and volumes obtained will not reflect the typical traffic behaviour on High Street.

Table 7-16 summarises the intersection performance of the High Street local centre for the 2036 with 75 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix B**.

Table 7-16 Intersection performance – High Street

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
High Street / Glover Street	0.342	13.9	A	0.360	17.3	B	Special Event		
High Street / Horsley Avenue	0.380	13.1	A	0.336	14.9	B			
High Street Pedestrian Crossing	0.907	18	B	0.799	9.3	A			
High Street / Alexander Avenue	0.363	13.9	A	0.441	18.2	B			
High Street / Forsyth Street	0.351	13.3	A	0.370	15.4	B			
High Street / McClelland Street	0.348	12.4	A	0.440	18.1	B			

In both peak periods under the 2036 With 75 per cent Development scenario, there are no notable changes in the degree of saturation, average delay, level of service or queue lengths. The intersection performance is consistent with the 2036 With 100 per cent Development results.

7.3.2 Parking analysis

The changes to land uses in the High Street Centre are expected to result in only modest growth in parking demand, from 85 spaces to 110 spaces.

This demand can generally be accommodated within the surrounding streets, provided any expansion of the Primary School includes sufficient parking to accommodate staff.

Figure 7-18 High Street future non-residential parking demand weekday profile

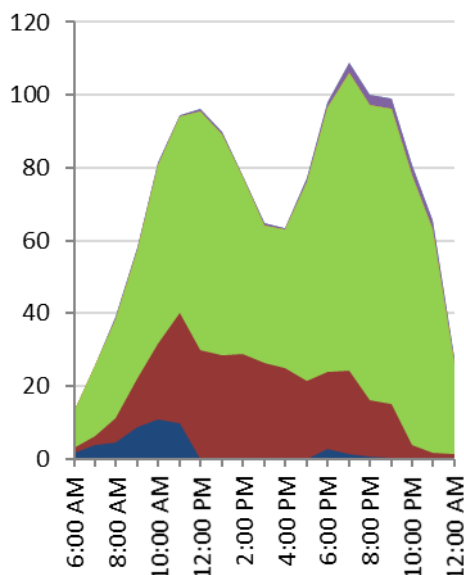
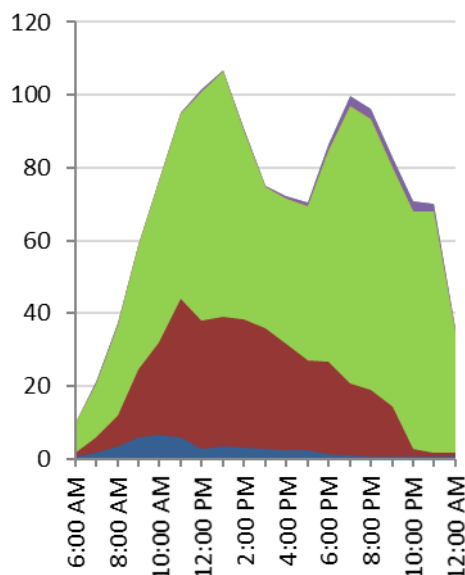


Figure 7-19 High Street future non-residential parking demand weekend profile



7.3.3 Active Transport

Walking and cycling needs within the High Street local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

High Street as a local centre contains wide footpaths along the main shopping strip, however has some opportunities to improve crossing facilities and cycling infrastructure.

Recommendations to address these issues are summarised in **Section 7.3.5**.

7.3.4 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

High Street offers no public transport services within the centre, however services can be accessed on Penshurst Street via a short walk. Opportunities may include promoting and improving access to these services or amending existing routes to operate on High Street to service the local centre.

There is also the opportunity to provide on-demand services, which may be able to service the local centre in lieu of standard bus services.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 7.3.5**.

7.3.5 Issues and options

The issues and recommendations for the local centre are summarised in **Table 7-17** and **Figure 7-20**.

Table 7-17 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P47	A kerb ramp is present on west side of High Street, adjacent to Forsyth Street, however there is no adjoining kerb ramp on the opposite side.	Convert the non-compliant kerb ramp into a raised marked pedestrian crossing. It is noted that this will have a parking impact, reducing the number of on-street spaces available.	Pedestrian crossing	
P48	Long crossing distance on McClelland Street and Forsyth Street.	Provide a pedestrian refuge and/or kerb extensions on McClelland Street and Forsyth Street at High Street to facilitate better pedestrian connectivity in and out of centre.	Pedestrian refuge / kerb extensions	
P57	Poor alignment of the pedestrian crossing on High Street.	Relocate the existing pedestrian crossing on High Street south of Horsley Avenue to align with future pedestrian arcades / through-site links and improve pedestrian access to the centre.	Pedestrian crossing relocation	
P59	Lack of Tactile Ground Surface Indicators at kerb ramps.	TGSIs to be provided for all kerb ramps within the local centre.	TGSIs	
Bicycle				
C11	Limited bike parking within the local centre.	Install additional bike racks on the eastern side of High Street between Alexander Street and McClelland Street.	Bike racks	
C16	Missing bike signage on sections of cycle routes designated in the Willoughby Bike Plan.	Install signage and line marking on McClelland Street and Horsley Avenue in accordance with the Willoughby Bike Plan.		
Public transport				
PT1	Bus stops are provided strictly for school students however are located approximately 160 metres from the school.	Relocate the northbound bus stop south of Forsyth Street to be located adjacent to the St Thomas Primary School, north of Horsley Avenue.	Bus stop relocation	
PT5	Lack of public transport options in the local centre.	Advocate for TfNSW to review bus routes and consider providing services to operate on High Street, providing access to the centre and connections to destinations such as Chatswood and Sydney CBD.	Bus services	
Road network				
R25	Parking restrictions only cater for short stays	Introduce 1P parking restrictions along Alexander Avenue, McClelland Street and Glover Street (within 100m of High Street), and increase 1/2P duration restrictions along High Street to 1P.	Parking	

Figure 7-20 Recommendations map



8 Naremburn

8.1 Land use

8.1.1 Existing

The Naremburn local centre is situated on the western side of Willoughby Road where it meets the M1 off ramp. The centre contains a collection of shops focused on food and beverage services fronting Willoughby Road, with residential dwellings behind and further south. The surrounding area mostly contains detached residential dwellings.

An overview of the Naremburn local centre study area and land use mix is presented in **Figure 8-1** and **Table 8-1**.

Figure 8-1 Naremburn local centre



Table 8-1 Naremburn land use mix

Town Centre	
Medical	170 m ²
Shopping / Retail	1,200 m ²
Restaurant	280 seats
Health / Fitness	440 m ²
Detached Housing	29 dwellings
Parking	
Off-Street Supply	25 spaces
On-Street Supply	100 spaces
Peak Non-Residential Parking Demand	80 spaces
Surrounds (400m)	
Detached Housing	450 dwellings

The Naremburn Local Centre is within a number of pedestrian-generating land uses including:

- > Willoughby Road shops and restaurants
- > Naremburn School
- > St Leonards Catholic Church and Naremburn Anglican Church

The majority of all pedestrian movement within Naremburn occurs on Willoughby Road, operating as both a destination for people and as a movement corridor. Willoughby Road allows direct access to Naremburn's shopping precinct. Site based observations showed foot traffic during the morning was directed towards Naremburn's shopping district via Willoughby Road and the surrounding streets.

8.1.2 Planned

Forecast development, land uses and uplift were obtained from the *Willoughby Local Centres Strategy* and discussions with Council. Total figures were provided for residential and non-residential floor space under the preferred scenario, as well as an indicative overview of the vision for the local centre.

Assumptions will be made in regards to specific uplift of particular blocks and positioning of access points to inform the future network review and traffic modelling.

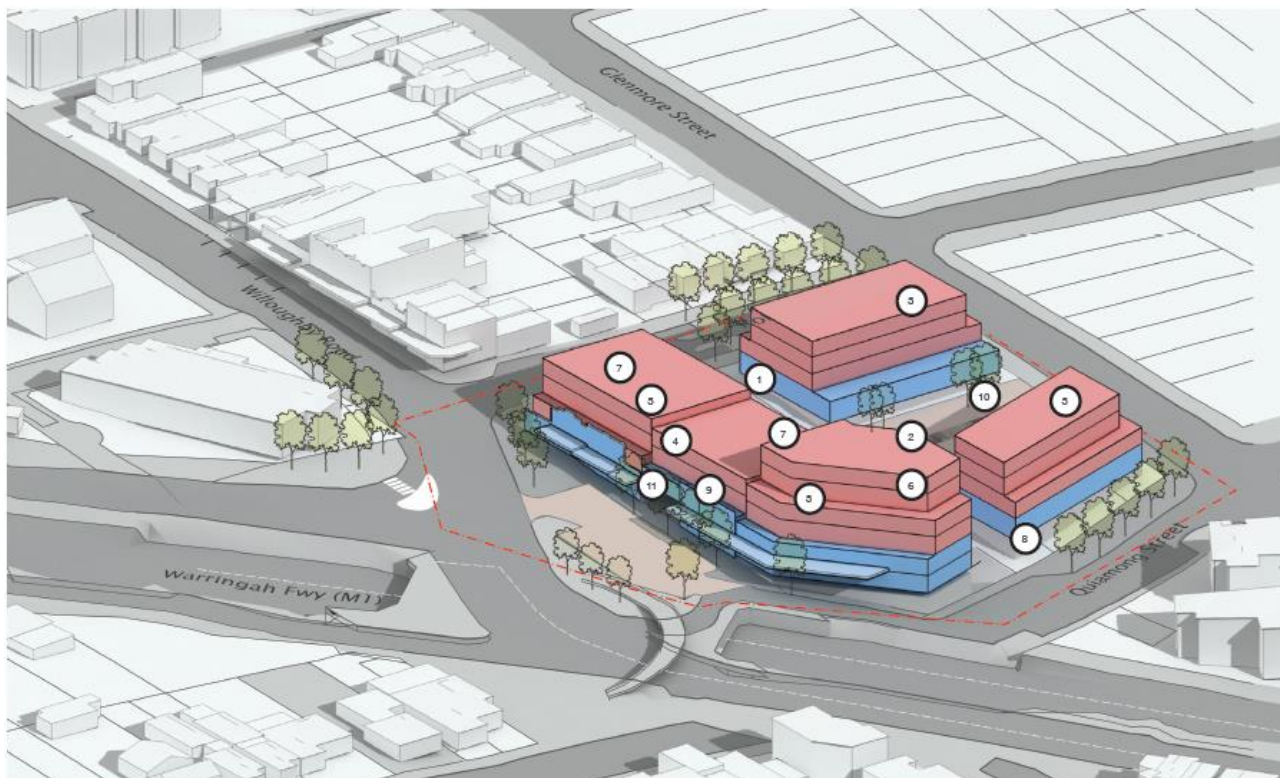
The Naremburn local centre is forecast for a large uplift in residential dwellings and moderate uplift in commercial floor space. The preferred scenario contains the following key features:

- > A total of 6,120 sqm GFA of residential floor space, representing an uplift of 4,951 sqm or 424 per cent;

- > A total of 3,922 sqm GFA of non-residential floor space, representing an uplift of 1,766 sqm or 82 per cent;
- > A new public plaza and through-site link; and
- > Relocation of some parking to a rear laneway to improve public space fronting Willoughby Road.

An indicative representation of the scale and distribution of the preferred scenario is presented in **Figure 8-2**.

Figure 8-2 Potential development at Naremburn – preferred scenario



Source: Willoughby Local Centres Strategy

The bulk of the development is proposed to be shop-top housing to maintain active retail street frontages, with some dedicated residential lots in the southwest corner.

8.1.3 Community concerns

82 people provided feedback about the *Draft Local Centres Strategy* for Naremburn, with people generally supporting development but opposing the scale of the proposal. The key community feedback related to traffic and transport issues were focused on the following:

- > Concerns about traffic and parking impacts, particularly for the viability of businesses in the area; and
- > The need for supporting infrastructure for growth across the area.

The community concerns are discussed further in the following sections together with the review of the existing and future transport networks.

8.2 Existing transport networks

8.2.1 Road network and traffic

The road network of Naremburn accommodates multiple transport modes within the local centre and supports pedestrians, cyclists, public transport, delivery, private vehicle movements and parking.

Willoughby Road is the Naremburn's key movement corridor, supporting north-south movements. The road connects quieter suburban streets in the area with the commercial district of Naremburn. Willoughby Road services as a regional north south movement corridor, connecting the local centre of Naremburn with the local centres of Penshurst Street, Willoughby South and the strategic centre of St Leonards. Willoughby Road receives one-way traffic from the Gore Hill Freeway's Roseville exit.

Quiamong Street, Rohan Street and Merrenburn Avenue intersect with Willoughby Road to provide east-west movements into and out of the Naremburn precinct.

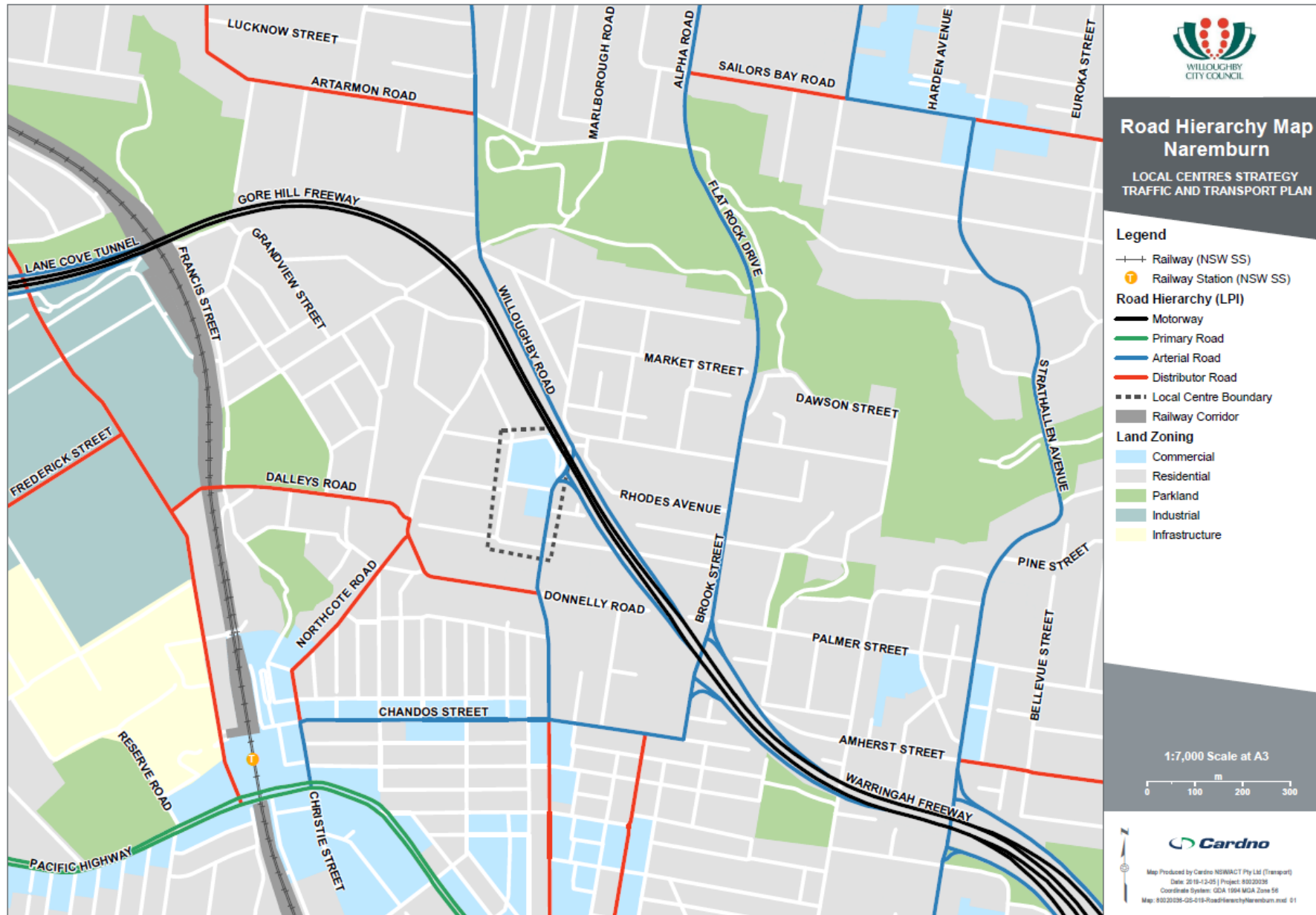
Willoughby Road accommodates the greatest traffic volumes within the local centre of Naremburn. Intersection volumes are highest at the intersection of the Gore Hill Freeway exit with Willoughby Road. Although Willoughby Road receives large volumes from the freeway at this intersection, most traffic is heading northbound, hence contributing little local traffic to the centre. Intersection volumes are relatively small at other intersections such as Willoughby Road / Rohan Street and Willoughby Road / Merrenburn Avenue.

Table 8-2 Key roads

Road name	Road Classification	Managing Authority	Number of Lanes	Speed Limit
Willoughby Road	State Road	TfNSW	2 travel lanes and 2 parking lanes	50 km/h
Merrenburn Avenue	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Rohan Street	Local Road	Willoughby Council	2 travel lanes with angle parking spaces transitioning to 2 parking lanes	50 km/h

The road hierarchy map is shown in **Figure 8-3**.

Figure 8-3 Road hierarchy map



8.2.2 Safety

Five-year crash data history was analysed from 2014 to 2018 (inclusive). Overall there were 9 reported crashes within the local centre of Naremburn. A summary of crashes by severity is shown in **Table 8-3**.

Table 8-3 Crash summary by severity

Year	Fatal	Serious Injury	Moderate Injury	Minor / Other Injury	Non-Casualty (tow away)	TOTAL
2014			1	1		2
2015			0	1		1
2016		1		1	2	4
2017					0	0
2018				2	0	2
TOTAL	0	1	2	5	3	9

There were no fatalities within the local centre during the five-year period, however one crash resulted in serious injury.

8.2.2.2 Crash Locations

The majority of crashes within the local centre occurred on Willoughby Road, with a crash cluster evident at the T-intersection of Willoughby Road and the Gore Hill Freeway exit. A higher concentration of crashes at this location is consistent with high traffic volumes. There were no crashes involving pedestrians within the centre of Naremburn.

Crash locations within the Naremburn local centre are shown in **Table 8-4** and **Figure 8-4**.

Table 8-4 Crash locations

Road	2014	2015	2016	2017	2018	Total
Willoughby Road	2		3		2	7
Glenmore Street		1				1
Faunce Lane			1			1
Total	2	1	4	0	2	9

Figure 8-4 Crash map



Source: NSW Centre for Road Safety

8.2.3 Existing pedestrian network and infrastructure

Willoughby Road, serving as the centre's key walking corridor caters for pedestrian activity by providing wide footpaths. Quiamong Street and Rohan Street offer primarily 1.2 – 1.5 metre wide footpaths despite being adjacent to the commercial district of Naremburn. During the site visit, vehicles were observed to obstruct the northern footpath on Rohan Street by overhanging. Faunce Lane, as shown in **Figure 8-9**, provides a pedestrian link between Willoughby Road and Glenmore Street, with a cul-de-sac for vehicles. The laneway however does not appear to provide sufficient space for vehicles to make an effective U-turn.

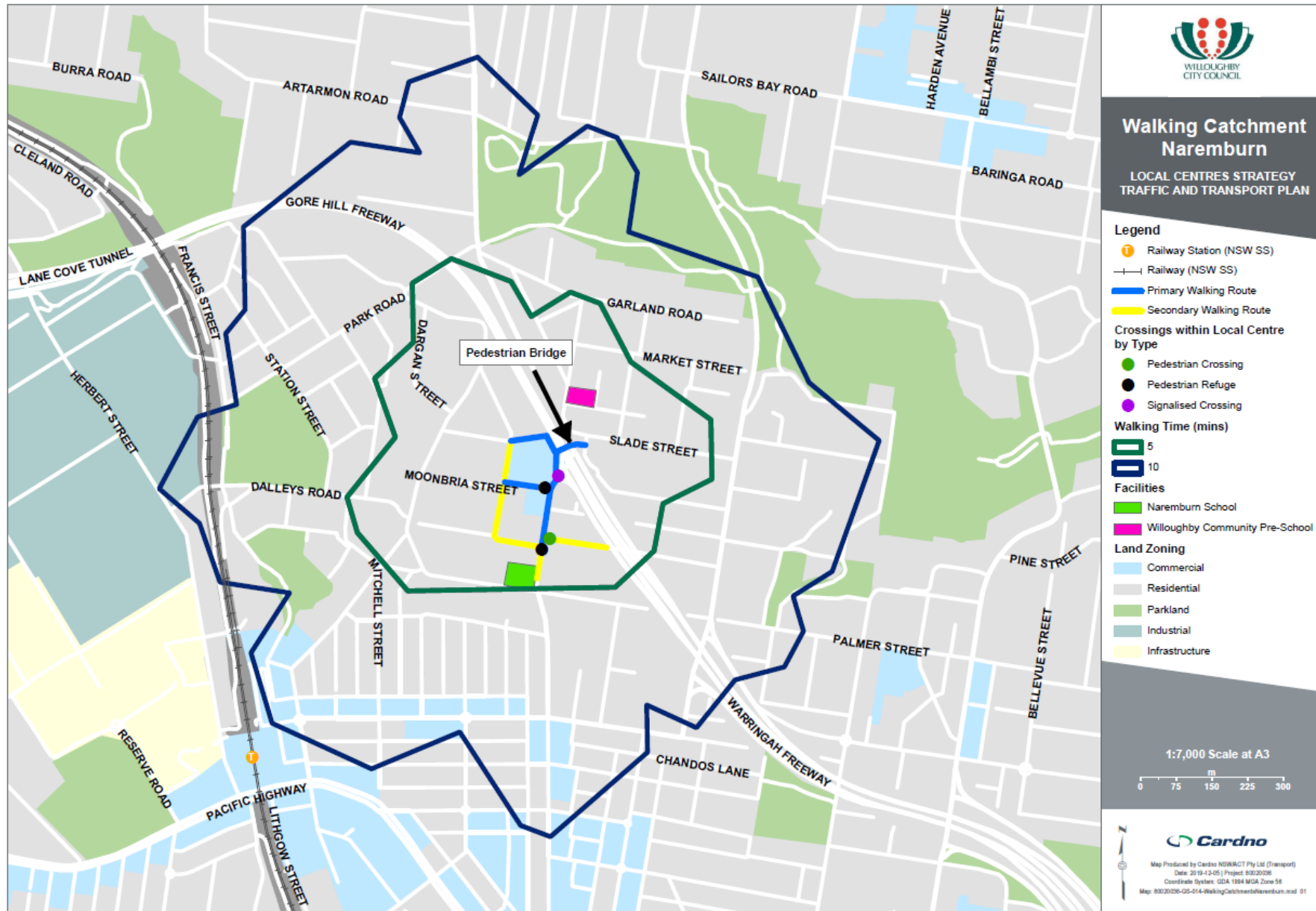
The centre provides a signalised crossing, standard crossings and pedestrian refuges.

A signalised crossing is provided at the busy intersection of Willoughby Road and the Gore Hill freeway exit, allowing pedestrians to cross Willoughby Road and access the local centre. A marked pedestrian crossing is also provided on the slip lane from the M1 off ramp to facilitate pedestrian movement.

Pedestrian refuges are implemented in key locations such as Rohan Street at Willoughby Road and Willoughby Road just south of Merrenburn Avenue to facilitate better pedestrian connectivity throughout the local centre. The distance between pedestrian crossing facilities is significant with the signalised crossing and pedestrian refuge on Willoughby Road spaced 160 metres apart. This may encourage informal mid-block crossing, particularly given the misalignment of the pedestrian refuge on Willoughby Road with Merrenburn Avenue.

The Naremburn local centre walking catchment is shown in **Figure 8-5**.

Figure 8-5 Walking routes



8.2.4 Cycling

The Naremburn local centre supports a combination of on-road separated cycling environments and off-road shared paths. The off-road path shown in **Figure 8-6** is situated at the north of the local centre on the eastern end of Quiamong Street and operates as a link connecting the local centre of Naremburn to the local centre of Artarmon and strategic centre of Chatswood. The shared path provides a bridge connection over the Gore Hill Freeway in the other direction to the neighbouring suburb of Willoughby. The eastbound link, connecting Naremburn with Cammeray and North Sydney is shown in **Figure 8-7**. Site observations show that cycling infrastructure is present on Merrenburn Avenue, in the form of a separated on-road cycleway. This aligns with the Willoughby Bike Plan which illustrates a cycleway running along Merrenburn Avenue.

Figure 8-6 Shared path towards Artarmon and Chatswood



Figure 8-7 Shared path towards Cammeray and North Sydney



Sydney

A shared path is also provided on both sides of Willoughby Road south of Merrenburn Avenue, which are signed but not linemarked.

Strava, an online fitness tracking application for cycling, shows popular cycling routes logged via mobile applications and provides indicative data on recreational cycling demand. Strava data was reviewed to identify key routes currently used by cyclists, and the data indicated cyclists use the shared path at the end of Quiamong Street / Willoughby Road as a primary north-south corridor. Willoughby Road is utilised as a popular movement corridor to reach the Pacific Highway, however no formalised infrastructure is present here. Merrenburn Avenue, which provides on-road cycling infrastructure, sees little traffic movement.

Willoughby Road is a missing link between the northern end of the centre and Merrenburn Avenue, where cycling infrastructure is provided at both ends.

Three bike racks are provided on the footpaths adjacent to the Willoughby Road parking area, one shown in **Figure 8-10**.

A map of the existing and proposed bicycle network is presented in **Figure 8-8**.

The map displays the cycling network for Naremburn, a suburb in Sydney. It shows the intersection of Willoughby South, Artarmon, and North Sydney Local Government Areas (LGAs). The map highlights various roads, including Gorman Street, Artarmon Road, Salisbury Lane, Sailors Bay Road, Marooba Road, Appleton Lane, Baringa Road, Baroona Road, Calbina Road, Grafton Avenue, West Street, Miller Street, Alexander Street, Albany Street, Chandos Street, Ryan Lane, Dalley's Road, Burke Lane, Park Road, Olympia Road, Gore Hill Freeway, Willoughby Road, Glenmore Street, Warringah Freeway, Market Street, and Reserve Road. The map also shows the location of the Naremburn Railway Station (NSW SS) and the Naremburn Local Centre Boundary. The map is color-coded to show land zoning: Commercial (light blue), Residential (light grey), Parkland (green), Industrial (teal), and Infrastructure (yellow). The map includes a legend for the cycling network, showing existing and proposed routes, and a scale bar indicating a scale of 1:7,000 at A3.

Willoughby South

Artarmon

Willoughby LGA

North Sydney LGA

LANE COVE LGA

Cycling Network Naremburn

LOCAL CENTRES STRATEGY TRAFFIC AND TRANSPORT PLAN

Legend

- Railway Station (NSW SS)
- Railway (NSW SS)
- Local Centre Boundary
- LGA Boundary

Existing Network

- Off-road
- On-road (bike lane)
- On-road (mixed traffic)

Proposed Network

- Off-road
- On-road
- Separated cycleway

Land Zoning

- Commercial
- Residential
- Parkland
- Industrial
- Infrastructure

1:7,000 Scale at A3

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (Transport)
 Date: 2020-01-17 | Project: 4880020-0104
 Coordinate System: GDA 1984 MGA Zone 56
 Map: 80020006-GS-002-CyclingNaremburn.mxd 01

Figure 8-9 Faunce Lane cul-de-sac



Figure 8-10 Bike hoops adjacent to Willoughby Road



8.2.5 Public Transport

Public transport is available within the centre through the provision of bus services operated by the STA on Willoughby Road. The Willoughby Road bus stops provide regular peak hour services to the Sydney CBD, Chatswood, Willoughby, Kingsford, Cremorne and Mosman. Commuters travelling from Naremburn towards destinations north and west of the Willoughby LGA must use the Chatswood interchange.

The bus routes servicing the local centre are outlined in **Table 8-5**.

Table 8-5 Bus routes serving the Naremburn local centre

Bus route	Route description	Areas served
257	Chatswood to Balmoral via Crows Nest	Chatswood station, Willoughby, Naremburn, Crows Nest, Neutral Bay, Mosman, Balmoral Beach
272	North Willoughby to City Wynyard	North Willoughby, South Willoughby, Sydney CBD (Wynyard)
340	Bondi Junction to Chatswood	Chatswood station, North Willoughby, South Willoughby, Sydney CBD, Paddington, Bondi Junction
343	Kingsford to Chatswood	Chatswood station, North Willoughby, South Willoughby, Naremburn, Crows Nest, North Sydney, Sydney CBD, Surry Hills, Waterloo, Rosebury, Kingsford

A map of the public transport services within and around the Naremburn local centre is provided in **Figure 8-11**.

Figure 8-11 Public transport map



8.2.6 Freight, services and loading

The town centre provides one on-street loading zone, located on Willoughby Road, operating between the morning and afternoon on weekdays. The loading zone is located adjacent to retail and restaurants.

Willoughby Road is designated as a Short Combination route as part of the Higher Mass Limits (HML) network north of the M1, and provides a freight corridor linking to the local centre.

8.2.7 Ride and vehicle sharing services

The local centre does not cater for ride or vehicle sharing services.

8.2.8 Parking provision

The Naremburn local centre provides time restricted parking on all of its key roads. Willoughby Road offers both parallel parking and 90 degree angle parking adjacent to cafes and shops as shown in **Figure 8-12** and **Figure 8-13**. Similarly, adjoining streets such as Rohan Street and Quiamong Street offer parallel and angle parking close to shops and restaurants.

Accessible parking is available at the northern end of Willoughby Road, as shown in **Figure 8-14**. This space offers direct access to the Naremburn commercial district. No accessible parking spaces are offered on Rohan Street.

An overview of parking availability for the weekday AM & PM peak periods is shown in **Figure 8-15**.

Parking profiles indicating the total parking requirement over the course of the day are presented in **Figure 8-16** and **Figure 8-17**. For further details and an explanation of these graphs refer to **Appendix B**.

Figure 8-12 Parallel parking on Willoughby Road



Figure 8-13 Angle Parking on Willoughby Road



Figure 8-14 Accessible parking space next to shops



Figure 8-15 Parking availability

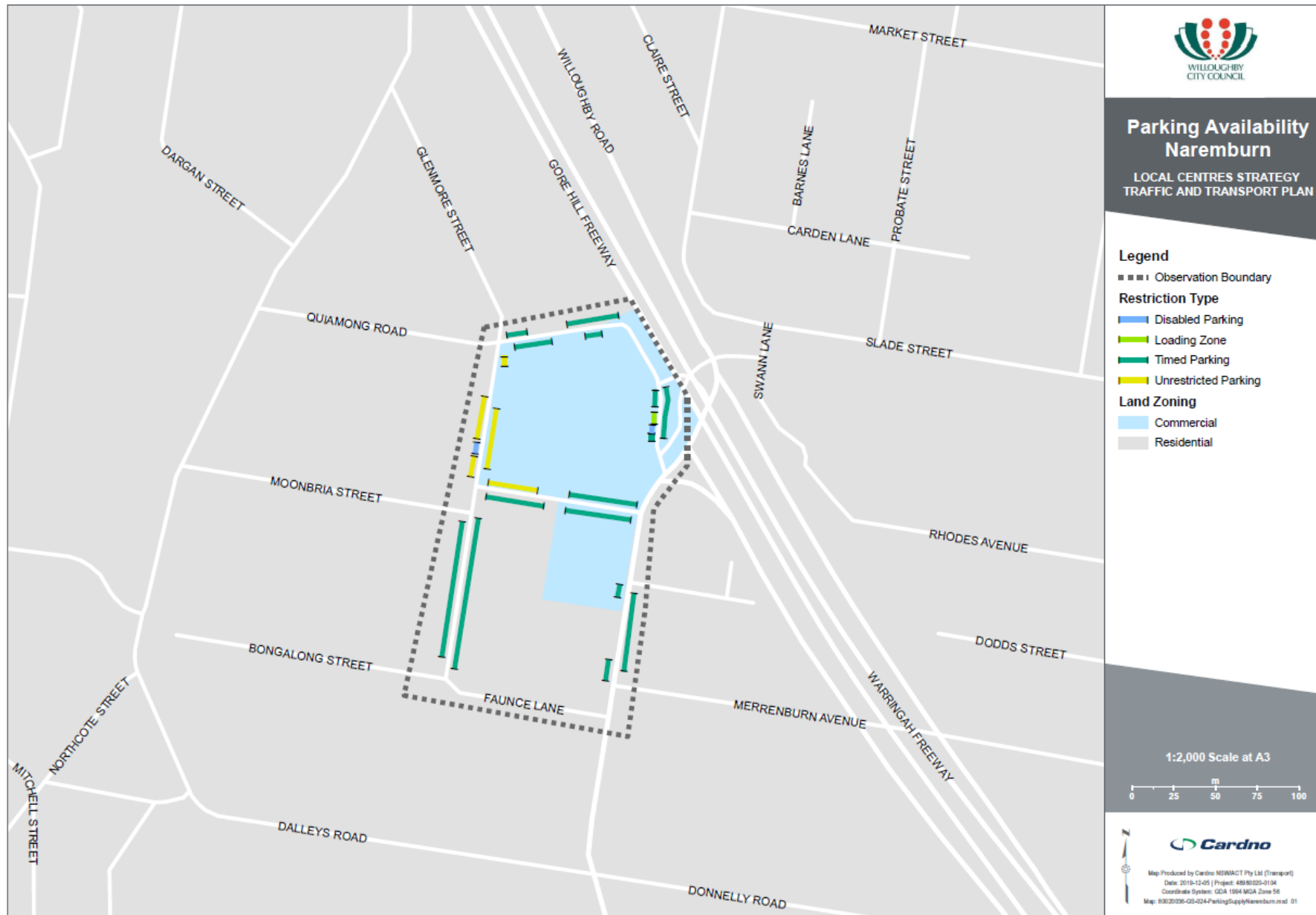


Figure 8-16 Naremburn weekday parking profile

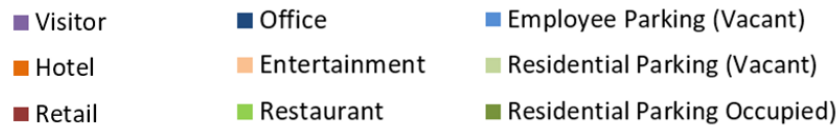
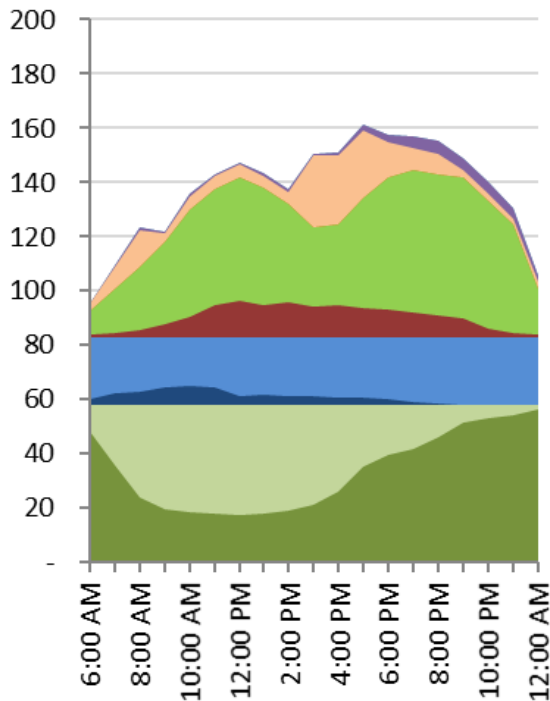
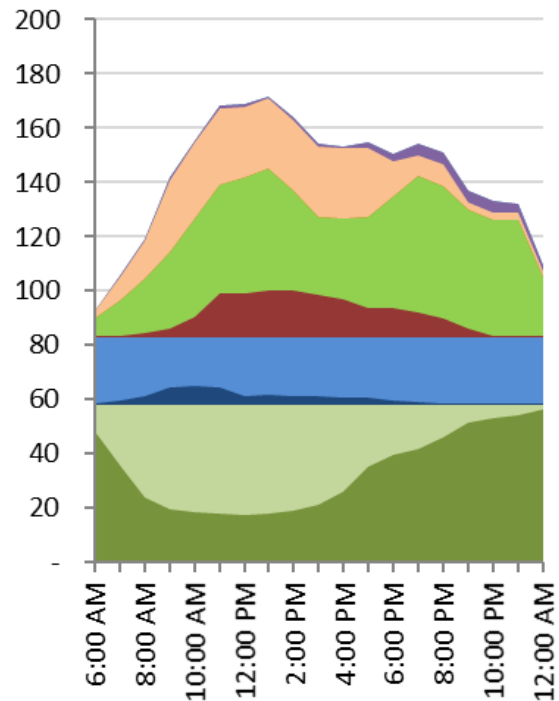
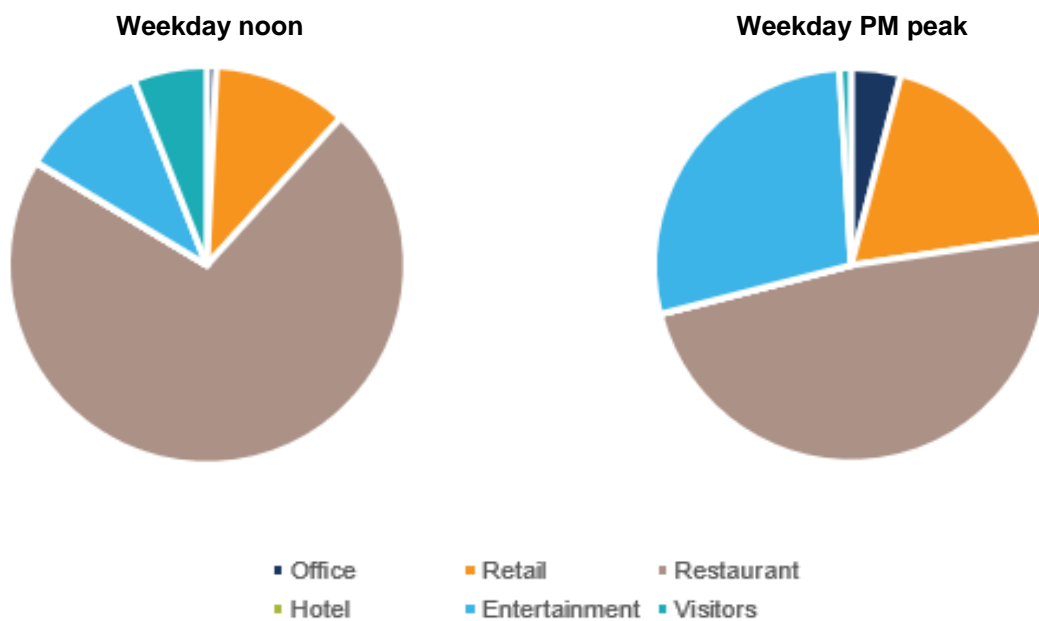


Figure 8-17 Naremburn weekend parking profile



A breakdown of the weekday peak parking demand by land use is presented in **Figure 8-18**.

Figure 8-18 Naremburn peak parking demand



8.2.8.2 Naremburn parking function

This small centre is located immediately adjacent to the Gore Hill Freeway, but is served primarily by quiet residential streets with ample on-street parking supply.

The main parking generators are the restaurants and fitness centre, for which the adjacent supply is considered to be sufficient.

8.2.8.3 *Parking recommendations*

There is a small 11-space car park associated with the Shopping Centre car park, accessed via Willoughby Road at the inside of the bend. Given the complexity of the access arrangement and its proximity to the signalised intersection, this area may be better suited to an alternative use. For example, as a play space, al fresco dining, plaza etc.

It is acknowledged that this parking area is likely to be the most popular spot for customers of the adjacent retail shops. However, a better quality arrangement along Rohan Street and Glenmore Street could provide a reasonable alternative.

Recommendation (Infrastructure):

Consider redevelopment of the Naremburn Shopping Centre car park to reduce conflict potential caused by historic access decisions.

Increase parking along Rohan Street and Glenmore Street to compensate for loss of bays, include streetscape improvements to increase net benefit to businesses.

8.2.9 **Intersection modelling**

8.2.9.1 *Intersection counts*

For the Naremburn local centre, a total of four intersections were surveyed and included:

- > Willoughby Road / Local centre car park entrance (priority controlled);
- > Willoughby Road / Gore Hill Freeway northbound off ramp (signalised intersection);
- > Willoughby Road / Rohan Street (priority controlled); and
- > Willoughby Road / Merrenburn Avenue (priority controlled).

The peak one-hour periods with the heaviest traffic were identified to be:

- > 8:30am – 9:30am for the weekday AM peak;
- > 5:00pm – 6:00pm for the weekday PM peak; and
- > 11:45am – 12:45pm for the Saturday midday peak.

The data was used to inform the traffic modelling by providing the traffic under existing conditions. Volumes and intersection modelling results are presented in **Appendix A**.

8.2.9.2 *Intersection modelling results*

SIDRA intersection modelling results for key intersections within the Naremburn local centre are presented in **Table 8-6**. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 8-6 SIDRA intersection modelling results – Naremburn

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Willoughby Road / Gore Hill Freeway	0.529	19.0	B	0.585	26.0	B	0.451	21.5	B
Willoughby Road / Naremburn Car Park Access	0.156	6.2	A	0.221	3.0	A	0.173	6.4	A
Willoughby Road / Rohan Street	0.556	38.5	C	0.947	115.3	F	0.725	51.6	D
Willoughby Road / Merrenburn Avenue	0.581	25.0	B	0.604	32.9	C	0.479	21.7	B

The Willoughby Road / Rohan Street intersection is performing unsatisfactorily at LoS F in the weekday PM peak period. In the weekday AM peak and weekday PM peak periods, this intersection is performing at a LoS C and D respectively. The other two intersections are performing at a LoS C or better, which indicate that the intersections are operating satisfactorily or have spare capacity.

The driver of the Willoughby Road / Rohan Street intersection performance in the weekday PM peak period is the right turning vehicles from Rohan Street. These vehicles aren't able to find a gap to enter Willoughby Road as the queues from the signalised intersection to the north (Willoughby Road / Gore Hill Freeway) extend beyond the Willoughby Road / Rohan Street intersection.

8.2.9.3 Summary of opportunities and constraints

Key opportunities and constraints of the Naremburn local centre are summarised in **Table 8-7**:

Table 8-7 Opportunities and constraints

Opportunities	Constraints
<ul style="list-style-type: none"> Potential to relocate parking adjacent to Willoughby Road to free up public space Cycleways link to the Principle Bike Network Regular bus services provide public transport connectivity Potential for through-site links to improve permeability 	<ul style="list-style-type: none"> Reduced accessibility to the northeast due to the Gore Hill Freeway

8.3 Future transport network review and recommendations

8.3.1 Traffic network analysis

8.3.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at Naremburn in accordance with **Table 8-8**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 8-8 Apartment mix and occupancy – Naremburn

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	9	1.7	15
1 bedroom	14%	13	1.7	21
2 bedroom	60%	55	2.3	125
3 bedroom	16%	15	2.8	41
Total	100%	91	-	203

¹Based on ABS 2016 Census Data

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 8-9**. The employee densities were adopted from TfNSW guidelines for office space and typical employee densities for retail and hospitality.

Table 8-9 Non-residential floor space assumptions – Naremburn

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	30%	1 / 40 sqm	29
Hospitality	40%	1 / 20 sqm	78
Office	30%	4.75 / 100 sqm	55
Total	100%	-	162

Therefore, based on these assumptions the Naremburn local centre is expected to accommodate approximately 200 residents and 160 employees.

8.3.1.2 Parking requirements

The minimum car parking requirements in accordance with the DCP are presented in **Table 8-10**.

Table 8-10 Minimum car parking requirements – Naremburn

Table 5-15 Minimum car parking requirements - Wareham				
Land use		Rate	Proposed development	Spaces required
Residential (non-adaptable units)	Studio	0.5 / dwelling	9 dwellings	5
	1 bedroom	1 / dwelling	13 dwellings	13
	2 bedroom	1 / dwelling	55 dwellings	55
	3 bedroom	1 / dwelling	15 dwellings	15
	Visitors	0.25 / dwelling	91 dwellings	23
			Residential subtotal	109
Commercial	Retail	36 sqm / space	1,167 sqm GFA	33
	Hospitality	107 sqm / space	1,556 sqm GFA	15
	Office	110 sqm / space	1,167 sqm GFA	11
			Commercial subtotal	57
			Development total	166
	Motorbike parking	1 / 25 car parking spaces	166 spaces	6

Note: Table shows rounded values. Subtotals were rounded down in accordance with the DCP.

Based on these calculations, the proposed development would be required to provide a minimum of 166 car parking spaces (including accessible parking spaces) and 6 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 8-11**.

Table 8-11 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	91 units	9
Retail	1 / 450m sqm GFA	1,167 sqm GFA	3
Hospitality	1 / 450m sqm GFA	1,556 sqm GFA	3
Office	1 / 600 sqm GFA	1,167 sqm GFA	2
Total			17

The calculations indicate that the proposed development would be required to provide 17 bicycle spaces.

8.3.1.3 Trip generation

Based on the trip generation rates presented in **Section 3.3**, the estimated number of trips generated by the proposed development are presented in **Table 8-12**. An estimate of existing traffic generated by the current land uses is also provided, as well as the additional traffic expected to be generated.

Table 8-12 Future traffic generation

Land use	Total development (existing + proposed)	Traffic generation (veh/hr)		
		AM peak	PM peak	Saturday peak
Residential	91 units	17	14	17
Retail	875 sqm GLFA	10	31	8
Hospitality	1,167 sqm GLFA	13	46	87
Office	1,167 sqm GFA	19	14	0
Total		59	105	113
Existing traffic generation		26	53	56
Additional traffic generated		+33	+52	+57

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

On this basis the proposed development is expected to generate an additional 33 vehicle movements in the AM peak hour, 52 in the PM peak and 57 in the Saturday peak.

However, the mode share for the sites surveyed by TfNSW averaged out to approximately 30 per cent for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the Naremburn local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 36 per cent for residents and 47 per cent for workers. This represents a higher mode share than those surveyed for the TfNSW traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis, a mode share discount of 10 per cent was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 36 per cent for residents and 47 per cent for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

8.3.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 8-13**.

Table 8-13 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the additional traffic generated to determine the inbound and outbound trips presented in **Table 8-14**.

Table 8-14 Inbound and outbound additional traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	2	14	7	4	6	9
Retail	2	3	6	9	2	2
Hospitality	3	3	11	10	17	24
Office	7	1	1	7	0	0
Total (additional traffic generated)	14	21	24	30	25	35

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 8-15**.

Table 8-15 Directional assumptions

Direction	In %	Out %
North	35%	45%
East	0%	0%
South	52%	26%
West	14%	29%
Total	100%	100%

Source: ABS 2016 Census Data

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

8.3.1.5 Intersection modelling results

Intersection modelling was undertaken for key intersections within the Naremburn local centre using SIDRA Network software. The modelling examined the intersection performance for the following scenarios:

1. 2036 With 100 per cent Development; and
2. 2036 With 75 per cent Development.

The 2036 With 100 per cent Development scenario represents a full development case which may be realised in 2036. The 2036 With 75 per cent Development scenario represents a case where the development is not fully achieved, and is presented to understand the impacts of a reduced scale of development which may occur at an earlier point in time. The results and key findings of each scenario are presented in the following sections.

8.3.1.5.1 2036 With 100 per cent Development modelling results

Table 8-16 summarises the intersection performance of the Naremburn local centre for the 2036 With 100 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 8-16 Future intersection performance – Naremburn

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Willoughby Road / Gore Hill Freeway	0.582	19.4	B	0.635	26.5	B	0.502	21.9	B
Willoughby Road / Naremburn Car Park Access	0.171	6.3	A	0.234	6.9	A	0.192	6.5	A
Willoughby Road / Rohan Street	0.736	55.3	D	1.334	468.4	F	1.016	194.1	F
Willoughby Road / Merrenburn Avenue	0.673	31.7	C	0.742	44.8	D	0.553	26.8	B

In the 2019 base model, the Willoughby Road / Rohan Street intersection operated unsatisfactorily at LoS F in the PM peak period. With no capacity improvements considered in 2036 and due to the expected increase in demand generated, the intersection performance is expected to be unsatisfactory at LoS F in the PM peak period. In the AM peak period, the intersection performance deteriorates from LoS C in 2019 to a LoS D in 2036 and in the Saturday peak the intersection performance deteriorates from LoS D in 2019 to LoS F in 2036.

The performance of this intersection in all peak periods in the 2036 future year is driven by the left and right turning vehicles from Rohan Street, which are not able to find a sufficient gap to enter Willoughby Road as the queues from the signalised intersection to the north (Willoughby Road / Gore Hill Freeway) extend beyond the Willoughby Road / Rohan Street intersection.

These results are not deemed realistic due to the 'Keep Clear' pavement marking on Willoughby Road at Rohan Street. This type of intersection is not accurately modelled in SIDRA, and videos from the intersection surveys revealed that no significant queuing occurred on Rohan Street since vehicles were able to enter the traffic stream due to gaps created by the pavement marking. The intersection performance is therefore deemed satisfactory, since all traffic movements operate sufficiently well in reality.

This observation is consistent with the 2019 base model and is not caused by the proposed development.

8.3.1.5.2 2036 With 75 per cent Development modelling results

Table 8-17 summarises the intersection performance of the Naremburn local centre for the 2036 With 75 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix B**.

Table 8-17 Intersection performance – Naremburn

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Willoughby Road / Gore Hill Freeway	0.579	19.4	B	0.633	26.5	B	0.499	21.8	B
Willoughby Road / Naremburn Car Park Access	0.171	6.3	A	0.235	0	A	0.191	6.5	A
Willoughby Road / Rohan Street	0.718	53.4	D	1.286	433.2	F	0.976	123.6	F
Willoughby Road / Merrenburn Avenue	0.673	31.6	C	0.739	44.4	D	0.547	26.4	B

Under the 2036 With 75 per cent development scenario, there are no significant changes to the intersection performance when compared to the 2036 With 100 per cent development scenario, except for minor improvements in delay and degree of saturation, which is reflective of the reduced demand between the two development scenarios.

Similarly to the 2036 With 100 per cent Development scenario, it is noted that the Willoughby Road / Rohan Street intersection performance is not deemed realistic due to the 'Keep Clear' pavement marking on

Willoughby Road at Rohan Street not being accurately modelled in the SIDRA software. The intersection performance is therefore deemed satisfactory since all traffic movements operate sufficiently well in reality.

8.3.2 Parking analysis

The increase in parking demand by office / commercial land uses will result in additional employee parking. If this cannot be accommodated on-site, then additional parking may be required along Glenmore Street.

The overall growth of mostly office / commercial parking could increase demand by as much as 80-90 bays. This cannot be accommodated in the current supply.

To address this, either the future commercial uses would construct parking on-site sufficient to accommodate their demand, or there would be an increased pressure on the on-street parking supply to the west of the Centre.

This implies that this Centre could be a candidate for an expanded parking permit regime despite its small scale, to help resolve conflicts between the residential and hospitality uses.

Figure 8-19 Naremburn future non-residential parking demand weekday profile

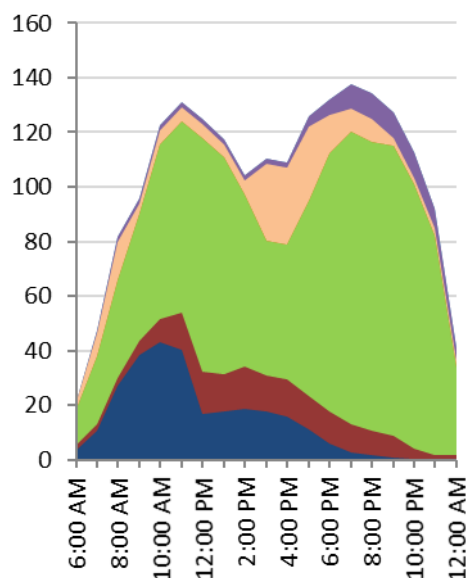
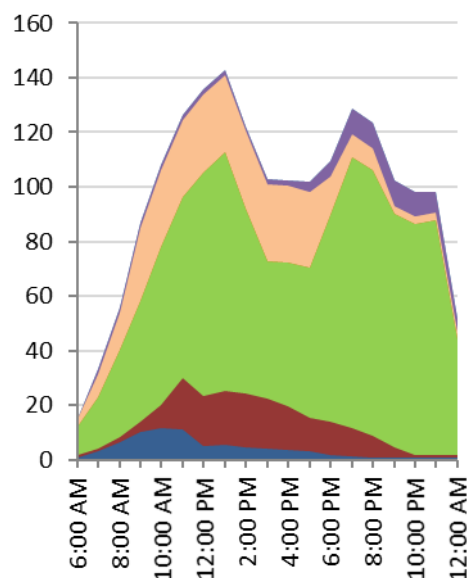


Figure 8-20 Naremburn future non-residential parking demand weekend profile



- Visitor
- Office
- Employee Parking (Vacant)
- Hotel
- Entertainment
- Residential Parking (Vacant)
- Retail
- Restaurant
- Residential Parking (Occupied)

8.3.3 Active Transport

Walking and cycling needs within the Naremburn local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

Naremburn already contains an established footpath and cycle network, however there is a gap in the cycle network along Willoughby Road and various opportunities to improve the pedestrian network.

Recommendations to address these issues are summarised in **Section 8.3.5**.

8.3.4 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

Naremburn is well connected by bus services along Willoughby Road, providing access to areas including Chatswood, Crows Nest, North Sydney and the Sydney CBD. Opportunities to improve public transport may be limited to increasing the service frequency.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 8.3.5**.

8.3.5 Issues and options

The issues and recommendations for the local centre are summarised in **Table 8-18** and **Figure 8-21**.

Table 8-18 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P19	Lack of threshold / gateway treatments.	Provide raised thresholds / gateway treatments at the intersections of Willoughby Road / Rohan Street and Willoughby Road / Car Park Access, including kerb extensions at Rohan Street.	Kerb extension / raised threshold / pavement treatment	2
P20	Non-compliant kerb ramps.	Re-align kerb ramps to correct orientations at the intersections of Willoughby Road / Rohan Street, Glenmore Street / Quiamong Street and Quiamong Street adjacent to the M1.	Kerb ramps	5
P22	Narrow footpaths on Rohan Street.	Widen the footpaths on Rohan Street to a minimum 2 metres to facilitate future growth and pedestrian activity.	Footpath	75 metres
P23	Long crossing distance on Rohan Street at Glenmore Street.	Provide kerb extensions to minimise the crossing distance and act as a gateway treatment to slow traffic speeds.	Pedestrian refuge	
P30	Narrow footpaths on Glenmore Street between Rohan Street and Quiamong Street.	Widen the footpaths on Glenmore Street to a minimum 2 metres to facilitate future growth and pedestrian activity.	Footpath	88 metres
P61	Lack of Tactile Ground Surface Indicators (TGSIs).	Provide Tactile Ground Surface Indicators at kerb ramps within the local centre for DDA compliance.	TGSIs	11
Bicycle				
C6	Lack of bike hoops within the local centre.	Provide additional bike hoops to encourage cycling as a travel mode and accommodate future development.	Bike hoops	5
C7	Missing bicycle signage and linemarking on designated cycle routes.	Install bicycle signage and painted symbols on Glenmore Street and Faunce Lane to match the designated routes on the Willoughby Bike Plan.	Signage & linemarking	
C17	Lack of a continuous cycleway on Willoughby Road.	Provide a shared path on the eastern side of Willoughby Road between the M1 off ramp and Merrenburn Avenue, including cycle aspects at the signalised intersection of Willoughby Road / M1 Off Ramp and regulatory and wayfinding signage.	Shared path	110 metres
Road network				
R6	Vehicles encroaching onto the northern footpath on Rohan Street.	Provide wheel stops at the car parking spaces on the northern side of Rohan Street.	Wheel stops	7
R7	Faunce Lane is narrow and leads to a dead end, which is used by vehicles for parking and manoeuvring.	Convert Faunce lane into a 10 km/h shared zone and enforce parking restrictions.	Shared Zone	88 metres
R9	High pedestrian activity with potential for conflict with vehicles.	Submit a proposal to TfNSW to implement a 40 km/h High Pedestrian Activity Area along Rohan Street and Quiamong Street.	Speed limit amendment	-

No.	Issue	Recommendation	Item	Length / no.
R26	Parking adjacent to Willoughby Road utilising high-value space and creating potential conflict.	Redevelop the Naremburn Shopping Centre car park to relocate car parking to a rear laneway or local streets and reduce conflict potential caused by historic access decisions. Parking could be increased along Rohan Street and Glenmore Street by providing angle parking to compensate for loss of bays, and include streetscape improvements to increase net benefit to businesses.	Parking relocation	-

Figure 8-21 Recommendations map



9 Northbridge

9.1 Land use

9.1.1 Existing

The Northbridge local centre is situated on Sailors Bay Road at Eastern Valley Way and Strathallen Avenue. The centre contains a significant retail centre including a supermarket, as well as specialty land uses and some residential dwellings. A Council car park is located behind the retail frontages to serve the retail centre. The Shore playing fields are located to the west of the local centre, and various sporting fields and parks are located to the southeast. Other areas immediately surrounding the centre contain residential dwellings.

An overview of the Northbridge local centre study area and land use mix is presented in **Figure 9-1** and **Table 9-1**.

Figure 9-1 Northbridge local centre



Table 9-1 Northbridge land use mix

Town Centre	
Office / Commercial	5,400 m ²
Warehouse / Showroom	4,600 m ²
Medical	2,700 m ²
Shopping / Retail	10,000 m ²
Restaurant	450 seats
Health / Fitness	120 m ²
Service Station	10 pumps
Hotel	32 rooms
Detached Housing	16 dwellings
Attached Housing	130 dwellings
Parking	
Off-Street Supply	450 spaces
On-Street Supply	140 spaces
Peak Non-Residential Parking Demand	700 spaces
Surrounds (400m)	
Detached Housing	450 dwellings
Attached Housing	80 dwellings

The Northbridge local centre contains a number of pedestrian-generating land uses including:

- > Northbridge Plaza and retail centre;
- > Sailors Bay Road shops and cafes; and
- > St Philip Neri Primary School.

The majority of all pedestrian movement within Northbridge occurs on Sailors Bay Road, operating as both a destination for people and as a movement corridor. Sailors Bay Road allows direct access to Northbridge's shopping precinct. Site based observations during the morning hours showed that foot traffic was directed from local centre's suburban streets to the Northbridge Plaza and cafes on Sailors Bay Road.

9.1.2 Planned

Forecast development, land uses and uplift were obtained from the *Willoughby Local Centres Strategy* and discussions with Council. Total figures were provided for residential and non-residential floor space under the preferred scenario, as well as an indicative overview of the vision for the local centre.

Assumptions will be made in regards to specific uplift of particular blocks and positioning of access points to inform the future network review and traffic modelling.

The Northbridge local centre is forecast for significant uplift in residential dwellings and moderate uplift in commercial floor space. The preferred scenario contains the following key features:

- > A total of 63,369 sqm GFA of residential floor space, representing an uplift of 42,028 sqm or 197 per cent;
- > A total of 41,504 sqm GFA of non-residential floor space, representing an uplift of 8,209 sqm or 25 per cent;
- > New public space with basement car parking below and increased parking capacity;
- > Various public domain and streetscape improvements; and
- > Potential additional pedestrian crossings at existing intersections and other pedestrian crossing improvements.

An indicative representation of the scale and distribution of the preferred scenario is presented in **Figure 9-2**.

Figure 9-2 Potential development at Northbridge – preferred scenario



Source: Willoughby Local Centres Strategy

The development proposes to reinforce the retail centre with consolidated commercial growth while improving public space. Residential growth is accommodated through shop-top housing to the north of the retail centre as well as on the eastern side of the centre, and some separated lots on the southern side of Sailors Bay Road.

9.1.3 Community concerns

81 people provided feedback about the *Draft Local Centres Strategy* for Northbridge, with people generally supporting the proposal but with some concerns about the proposed heights. The key community feedback related to traffic and transport issues were focused on the following:

- > The desire for improvements to parking, pedestrian access and safety around the plaza;
- > Support for more open space, improved bike paths and pedestrian links;
- > Concerns about existing traffic congestion and the ability of infrastructure to support additional growth during peak times; and

- > The need for improved traffic management and additional parking, however this was mixed with concerns about the potential impact of additional parking and commercial vehicle access associated with development.

The community concerns are discussed further in the following sections together with the review of the existing and future transport networks.

9.2 Existing transport networks

9.2.1 Road network and traffic

The Northbridge road network supports both north-south and east-west trips within and through the centre. The Eastern Valley Way – Sailors Bay Road – Strathallen Road corridor accommodates a key movement from suburbs to the north towards North Sydney, the M1 and the city, while local roads provide access to the retail centre and residential dwellings.

Sailors Bay Road accommodates the greatest traffic volumes within the Northbridge local centre. Intersection volumes are largest the Sailors Bay Road / Eastern Valley Way intersection and the Sailors Bay Road / Strathallen Avenue intersection.

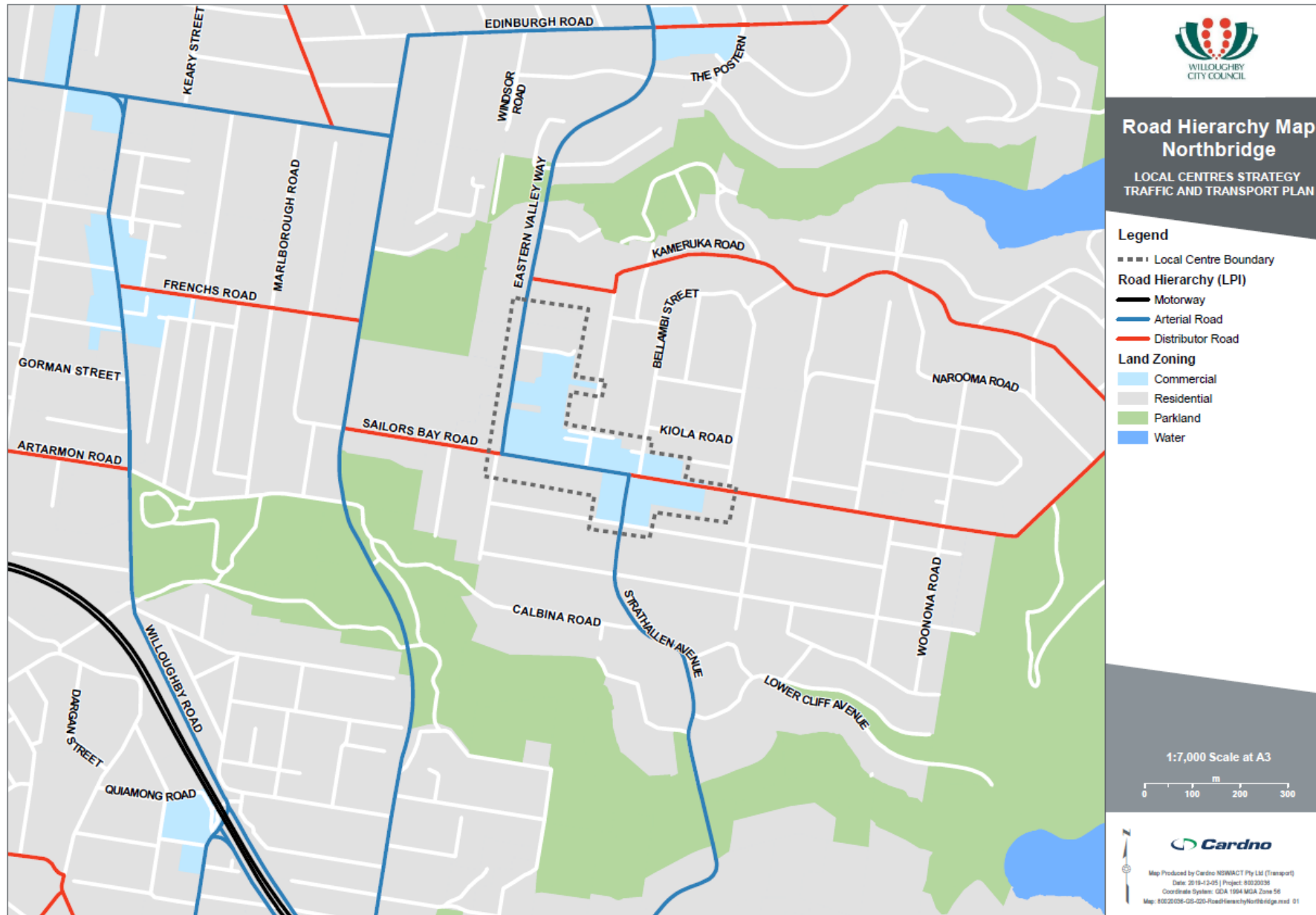
The key roads within the Northbridge local centre are shown in **Table 9-2**.

Table 9-2 Key roads

Road name	Road Classification	Managing Authority	Number of Lanes	Speed Limit
Eastern Valley Way	State Road	TfNSW	4 lanes	60km/h
Sailors Bay Road	State Road (within confines of local centre)	TfNSW	4 lanes	50km/h
Strathallen Avenue	State Road	TfNSW	4 lanes	50km/h
Harden Avenue	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50km/h

The road hierarchy map is shown in **Figure 9-3**.

Figure 9-3 Road hierarchy



9.2.2 Safety

Five-year crash data history was analysed from 2014 to 2018 (inclusive). Overall there were 21 reported crashes within the local centre of Northbridge. No crashes occurred in 2018. A summary of crashes by severity is shown in **Table 9-3**.

Table 9-3 Crash summary by severity

Year	Fatal	Serious Injury	Moderate Injury	Minor / Other Injury	Non-Casualty (tow away)	TOTAL
2014	0	3	1	2	6	12
2015	0		1	2	2	5
2016	0	1			1	2
2017	0			1	1	2
2018	0					
TOTAL	0	4	2	5	10	21

There were no fatalities within the local centre during the five-year period, however four crashes resulted in serious injury.

9.2.2.2 Crash Locations

The majority of crashes within the local centre occur on the Sailors Bay Road / Eastern Valley Way corridor. Crash clusters are evident at the Sailors Bay Road / Eastern Valley Way intersection and the Sailors Bay Road / Strathallen Avenue intersection. A higher concentration of crashes at these locations is consistent with larger intersection volumes and key traffic movements.

A number of crashes also occurred mid-block along Eastern Valley Way and Sailors Bay Road. The crashes on Eastern Valley Way could be related to the retail centre access point providing for movement into and out of the car park.

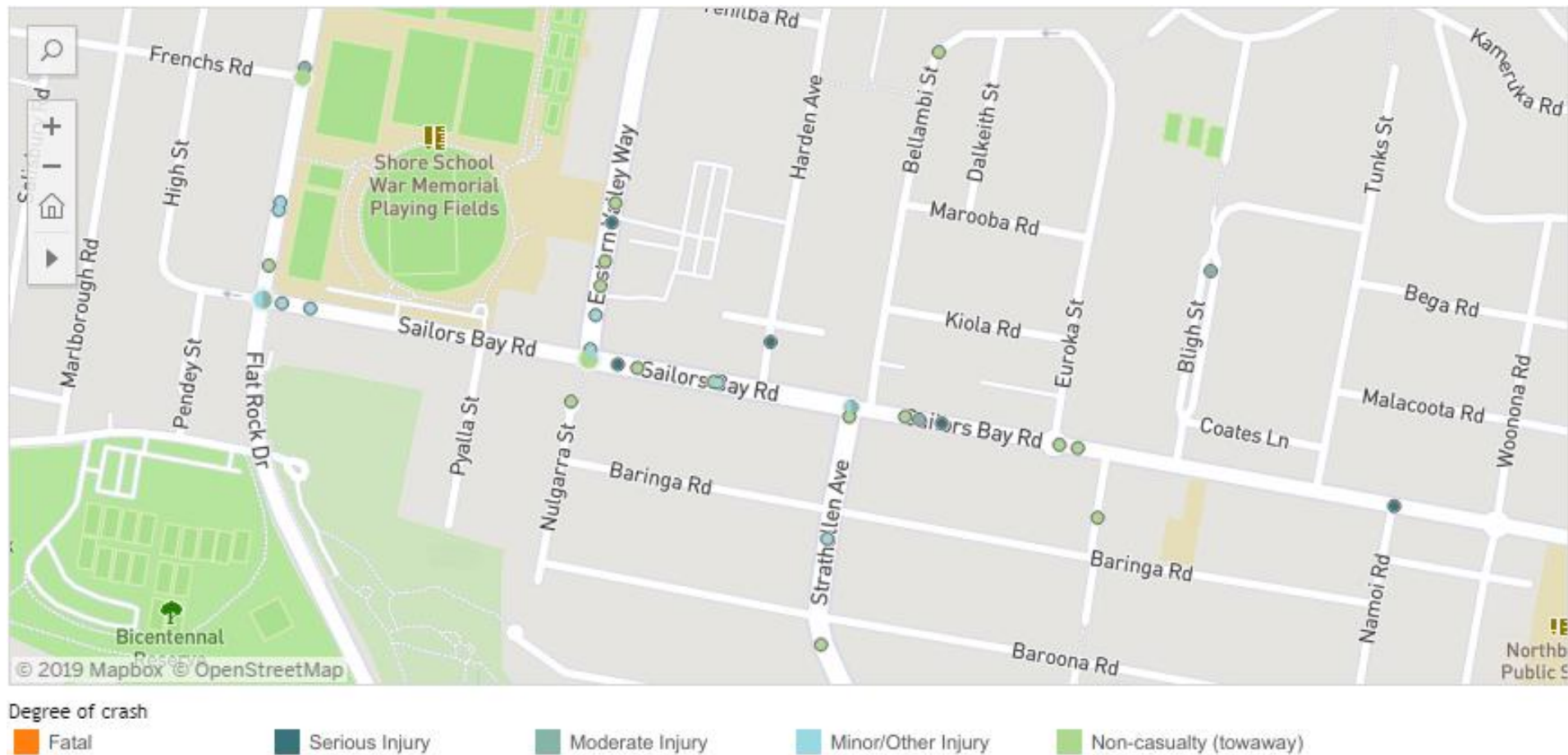
Two crashes involving pedestrians were recorded from 2014 to 2018, one of which resulted in serious injury.

Crash locations within the Northbridge local centre are shown in **Table 9-4** and **Figure 9-4**.

Table 9-4 Crash locations

Road	2014	2015	2016	2017	2018	Total
Eastern Valley Way	6	-	-	-	-	6
Sailors Bay Road	4	5	2	2	-	13
Strathallen Avenue	1	-	-	-	-	1
Harden Avenue	1	-	-	-	-	1
Total	12	5	2	2	0	21

Figure 9-4 Crash map



Source: NSW Centre for Road Safety

9.2.3 Existing pedestrian network and infrastructure

Sailors Bay Road, serving as the centres key walking corridor, supports pedestrian movement with the provision of wide footpaths along shop fronts. Hedging is implemented adjacent to the Northbridge Plaza as shown in **Figure 9-5**. This serves as a barrier between pedestrians and traffic on Sailors Bay Road. The south side of Sailors Bay Road offers footpaths approximately 1.2 – 1.5 metres wide, suitable for quiet residential streets. Eastern Valley Way and Strathallen Avenue support the commercial district of Northbridge by providing wide footpaths for pedestrian traffic. Harden Avenue and Bellambi Street offer an inconsistent combination of wide footpaths and footpaths approximately 1.2 – 1.5 metres wide.

Signalised crossings are provided at the major intersections, allowing pedestrians to cross the high traffic road environments. However, there are several crossings missing, including:

- > The eastern leg of the Eastern Valley Way / Sailors Bay Road intersection;
- > The western leg of the Sailors Bay Road / Harden Avenue intersection (as shown in **Figure 9-6**); and
- > The western leg of the Sailors Bay Road / Strathallen Avenue intersection (as shown in **Figure 9-7**).

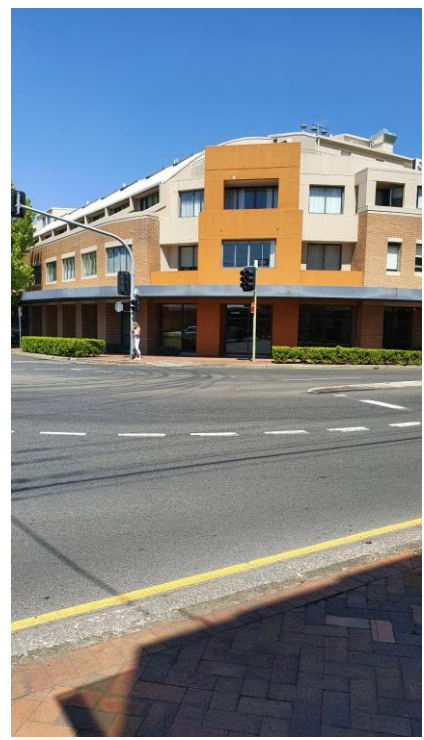
Figure 9-5 Hedging at Northbridge Plaza



Figure 9-6 Missing crossing at Sailors Bay Rd / Harden Ave



Figure 9-7 Missing crossing at Sailors Bay Rd / Strathallen Ave

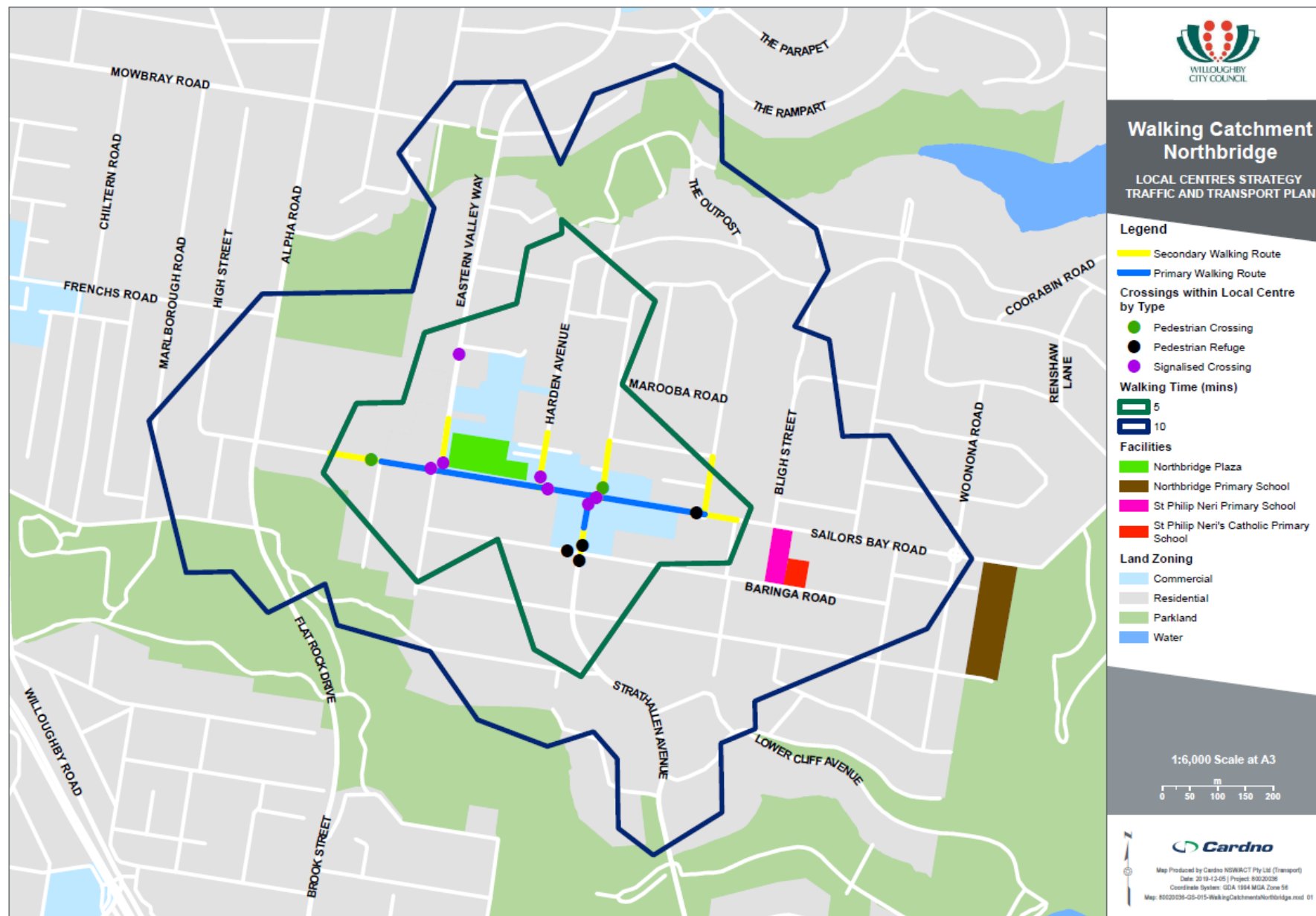


A marked pedestrian crossing is provided on Bellambi Street, accommodating pedestrian movement along the north side of Sailors Bay Road.

The distance between pedestrian crossing facilities does not support regular pedestrian traffic, particularly given the generation potential and desire lines associated with the retail centre, with signalised crossings spaced up to 200 metres apart on sections of Sailors Bay Road.

The Northbridge local centre walking catchment is shown in **Figure 9-8**.

Figure 9-8 Walking routes



9.2.4 Cycling

Northbridge offers on-road cycling environments, with cycling infrastructure including:

- > On-road shoulder lanes (visually separated) on Sailors Bay Road west of Eastern Valley Way;
- > A mixed traffic route along Nulgarra Street between Sailors Bay Road and Baringa Road; and
- > A mixed traffic route along Baringa Road.

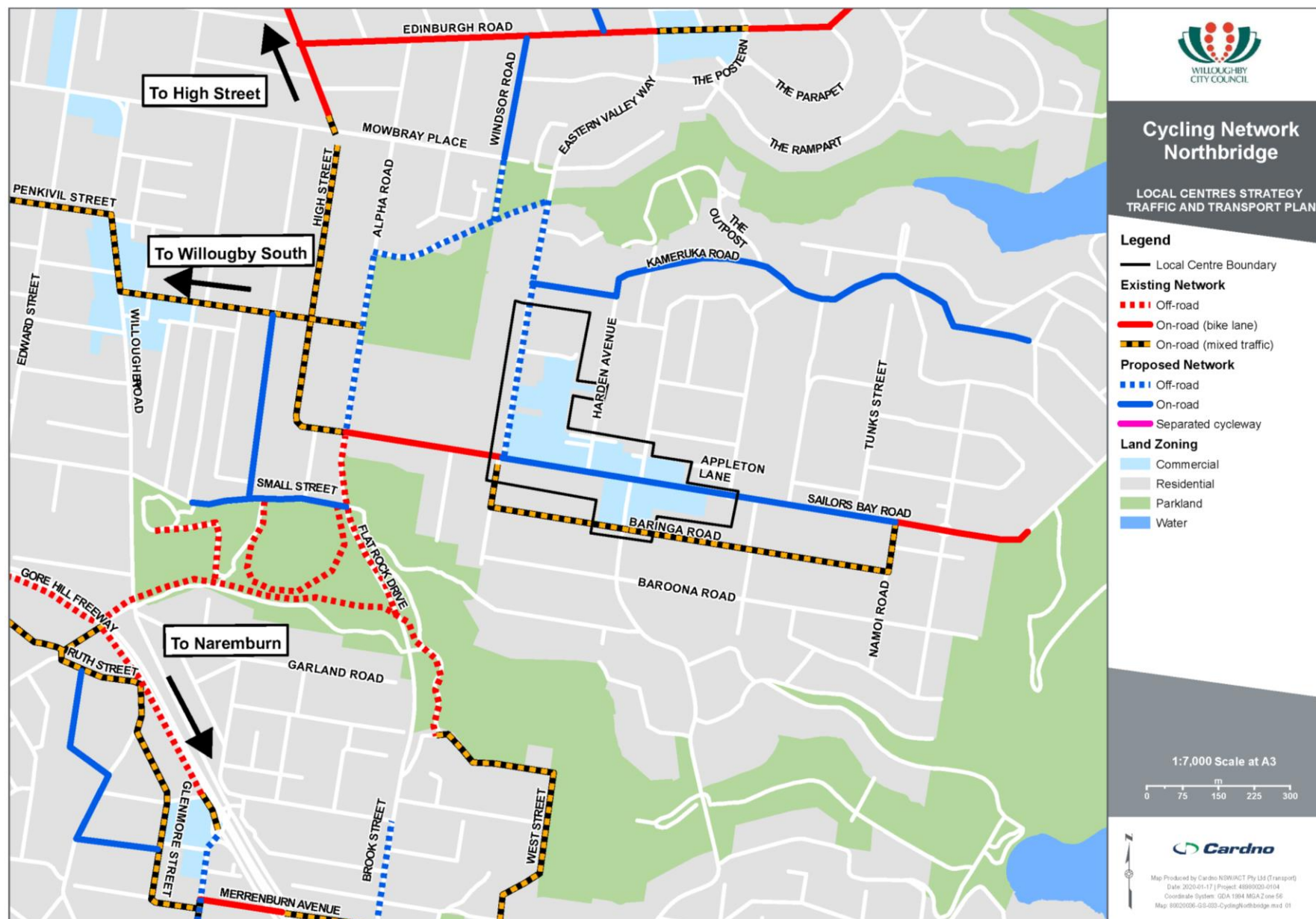
The bike routes connect the local centre of Northbridge with the local centres of High Street, Willoughby South and Castlecrag. On-site observations show bike signage on Sailors Bay Road in the eastbound direction directing cyclists onto the footpath just west of Eastern Valley Way. No shared path signage or linemarking is provided, and no signage indicates that cyclists must dismount. The treatment is therefore ambiguous and does not accommodate cyclists well.

Strava, an online fitness tracking application for cycling, shows popular cycling routes logged via mobile applications and provides indicative data on recreational cycling demand. Strava data was reviewed to identify key routes currently used by cyclists, and the data indicated cyclists use Sailors Bay Road as the primary east-west movement corridor. Strathallen Avenue is utilised as a popular north-south corridor, even though there is no cycling infrastructure present here. Baringa Road, which is designated as a cycle route, sees little cyclist traffic.

Cycle parking is generally limited within the centre. Only one bike rack is provided, available at the corner of Bellambi Avenue and Sailors Bay Road.

A map of the existing and proposed bicycle network is presented in **Figure 9-9**.

Figure 9-9 Bicycle network



9.2.5 Public Transport

Public transport is available within the centre through the provision of bus services operated by the STA on the Sailors Bay Road, Eastern Valley Way and Strathallen Avenue Corridor. The bus stops located on these roads connect the local centre of Northbridge with the Sydney CBD, Chatswood, North Sydney, East Lindfield and Crows Nest. Services to destinations such as the Sydney CBD and East Lindfield are regular during the daytime. Services to Chatswood are only regular during peak periods. The local centre is not facilitated by public transport in the late evening. Commuters must travel to the Chatswood interchange in order to reach destinations to the west and north of the Willoughby LGA.

The bus routes servicing the local centre are outlined in **Table 9-5**.

Table 9-5 Bus routes serving the Northbridge local centre

Bus route	Route description	Areas served
202	Northbridge to City Bridge St via North Sydney	Northbridge peninsula, Cammeray, North Sydney, Sydney CBD (Bridge St)
203	Castlecrag to North Sydney	Northbridge, Castlecrag, Cammeray, North Sydney
204	Northbridge to City Bridge St (Freeway)	Northbridge peninsula, Cammeray, Sydney CBD (Bridge St)
205	East Willoughby to City Bridge St (Freeway)	East Willoughby, Northbridge, Castlecrag, Cammeray, Sydney CBD (Bridge St)
206	East Lindfield to City Bridge St via Freeway	East Lindfield, East Willoughby, Northbridge, Castlecrag, Cammeray, Sydney CBD (Bridge St)
207	East Lindfield to City Bridge St via North Sydney	East Lindfield, East Willoughby, Northbridge, Cammeray, Castlecrag, North Sydney, Sydney CBD (Bridge St)
208	East Lindfield to City Bridge St via Northbridge & North Sydney	East Lindfield, East Willoughby, Northbridge peninsula, Castlecrag, Cammeray, North Sydney, Sydney CBD (Bridge St)
209	East Lindfield to Milsons Point via North Sydney	East Lindfield, East Willoughby, Northbridge, Castlecrag, Cammeray, North Sydney, Milsons Point
267	Chatswood to Crows Nest	Chatswood, Mowbray Road, Castlecrag, Northbridge, Cammeray, Crows Nest

'The Loop' bus also services Northbridge on various days, running every 45 minutes between approximately 10:30am – 3:00pm in accordance with the following:

- > Thursday: the Castle Cove to Northbridge loop, operating as a loop between the Castle Cove peninsula and Northbridge Plaza via Eastern Valley Way; and
- > Wednesday and Friday: the Chatswood to Northbridge loop, operating as a loop between the Chatswood town centre and Northbridge Plaza via Artarmon Road.

A map of the public transport services within and around the Northbridge local centre is provided in **Figure 9-10**.

Figure 9-10 Public transport map



9.2.6 Freight, services and loading

The local centre does not provide any dedicated on-street loading zones. A truck zone is provided on the southern side of Sailors Bay Road, east of Bellambi Street, operating strictly outside of peak in place of a bus zone. During the site visit, trolley collectors were observed parking illegally within the No Stopping zone on Harden Avenue in order to complete trolley collection services.

Eastern Valley Way, Sailors Bay Road and Strathallen Avenue are designated as Short Combination routes as part of the Higher Mass Limits (HML) network, and provide a freight corridor through the local centre.

9.2.7 Ride and vehicle sharing services

The local centre does not cater for ride or vehicle sharing services.

9.2.8 Parking provision

Northbridge provides time restricted parking on a section of Sailors Bay Road, east of Strathallen Avenue. Adjoining streets such as Harden Avenue and Bellambi Street provide parking through the provision of parallel parking and angle parking spaces. A large carpark is provided just north of the retail centre, providing a large amount of parking spaces for the Northbridge Plaza and surrounding shops.

Accessible parking is provided at the southeast corner Harden Avenue, and the southwest corner of Bellambi Street. Both spaces are provided at good locations, within a short walk from shops and cafes on Sailors Bay Road. No accessible parking spaces are provided on Sailors Bay Road.

An overview of parking availability for the weekday AM & PM peak periods is shown in **Figure 9-11**.

Figure 9-11 Parking availability



Parking profiles indicating the total parking requirement over the course of the day are presented in **Figure 9-12** and **Figure 9-13**. For further details and an explanation of these graphs refer to **Appendix B**.

Figure 9-12 Northbridge weekday parking profile

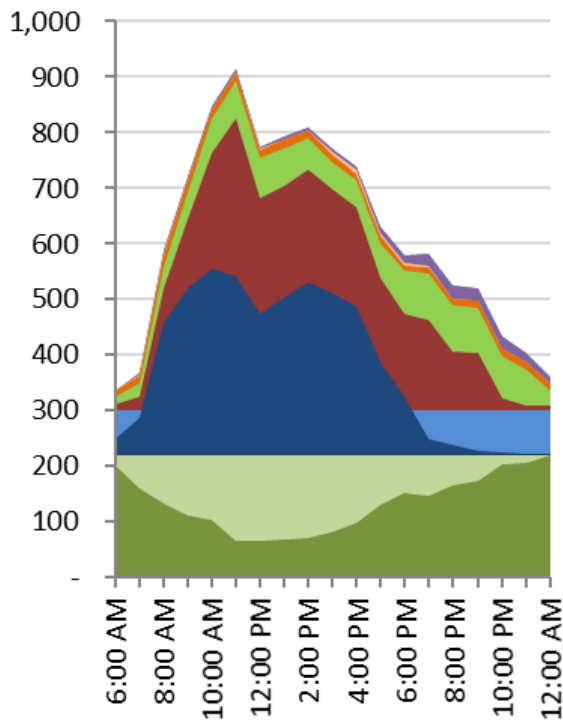
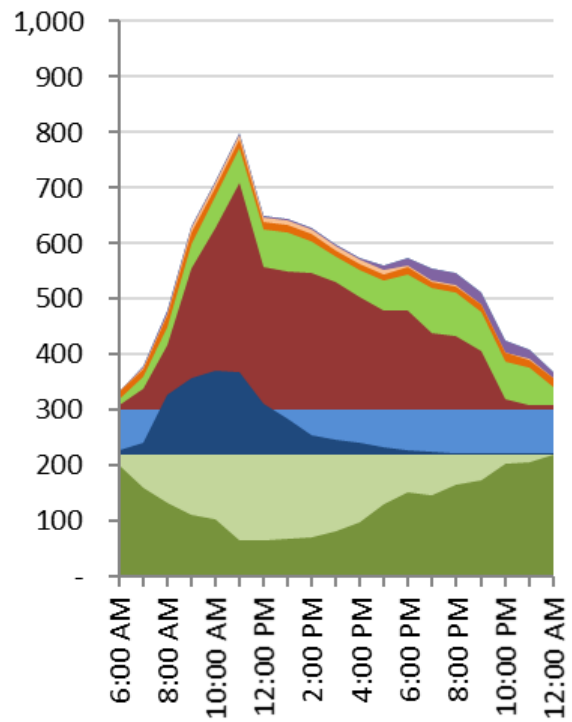


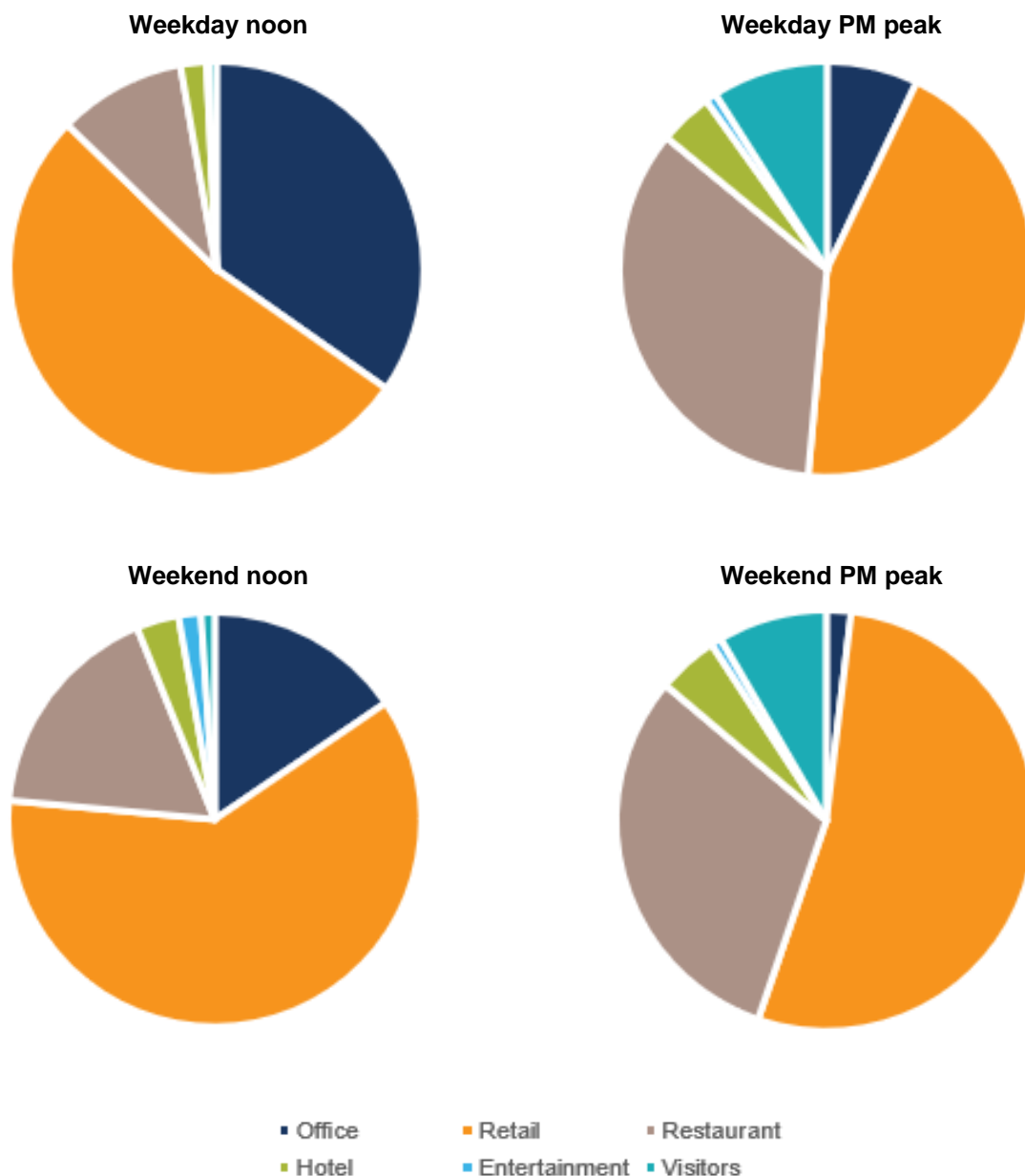
Figure 9-13 Northbridge weekend parking profile



- | | | |
|---------|---------------|--------------------------------|
| Visitor | Office | Employee Parking (Vacant) |
| Hotel | Entertainment | Residential Parking (Vacant) |
| Retail | Restaurant | Residential Parking (Occupied) |

A breakdown of the weekday peak parking demand by land use is presented in **Figure 9-14**.

Figure 9-14 Northbridge peak parking demand



9.2.8.2 Northbridge parking function

Long stay employee parking demand represents approximately 300 spaces during the weekday peak period. Another 400 spaces are required to accommodate short-stay retail and visitor parking.

The primary constituents of the short-stay demand are restaurant visitors, retail shoppers and medical centre patients. 1-hour and 2-hour parking is generally considered to be sufficient to accommodate these groups, though specific treatments may require 4-6 hour parking, though patients are usually dropped-off rather than parking all day.

The 385 combined short-stay parking bays within and adjacent to the Northbridge Plaza provide a consolidated destination for trips to the Local Centre. Improvements to wayfinding signage, including internal wayfinding, may assist to maximise the efficiency of these bays.

Secured employee parking is available within the Northbridge Plaza car park, but this supply represents only a small fraction of the total requirement for the Centre.

With the function of the arterial roads Eastern Valley Way, Sailors Bay Road and Strathallen Avenue all prioritising traffic throughput over parking, and duration restrictions (with permit exceptions) along residential streets, there appears to be insufficient parking to support the level of employee demand.

9.2.8.3 Parking recommendations

The at-grade Council car park adjacent to the Northbridge Plaza shopping Centre is well-located as a site for a future multi-deck car park.

This would necessarily operate as a paid facility, and could be funded through cash-in-lieu contributions as the Centre develops.

The management of such a facility would impact the function of the surrounding private car parking, and this should be considered as part of any business case.

Recommendation (Infrastructure):

Consider redevelopment of the existing Council car park as a consolidated short-stay and long-stay multi-storey facility.

9.2.9 Intersection modelling

9.2.9.1 Intersection counts

For the Northbridge local centre, a total of three intersections were surveyed and included:

- > Sailors Bay Road / Eastern Valley Way (signalised intersection);
- > Sailors Bay Road / Harden Avenue (signalised intersection); and
- > Sailors Bay Road / Strathallen Avenue (signalised intersection).

The peak one-hour periods with the heaviest traffic were identified to be:

- > 7:45am – 8:45am for the weekday AM peak;
- > 5:00pm – 6:00pm for the weekday PM peak; and
- > 11:45am – 12:45pm for the Saturday midday peak.

The data was used to inform the traffic modelling by providing the traffic under existing conditions. Volumes and intersection modelling results are presented in **Appendix A**.

9.2.10 Intersection modelling results

SIDRA intersection modelling results for key intersections within the Northbridge local centre are presented in **Table 9-6**. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 9-6 SIDRA intersection modelling results – Northbridge

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Sailors Bay Road / Eastern Valley Way	0.551	18.2	B	0.685	23.5	B	0.769	22.9	B
Sailors Bay Road / Harden Avenue	0.606	14.3	A	0.661	18.1	B	0.693	17.1	B
Sailors Bay Road / Strathallen Avenue	1.088	28.9	C	0.973	22.5	B	0.923	22.6	B

All the intersections are performing at LoS C or better, indicating that the intersections are operating satisfactorily with acceptable delays and spare capacity.

The Sailors Bay Road / Strathallen Avenue intersection is oversaturated (DoS is greater than 1.0) in the AM peak, indicating that it is congested. In the PM peak and Saturday peak periods, the degree of saturation is greater than 0.9. The intersection may experience congestion due to the demand exceeding the capacity. The degree of saturation at the other intersections are satisfactory across all peak periods.

9.2.11 Summary of opportunities and constraints

Key opportunities and constraints of the Northbridge local centre are summarised in **Table 9-7**:

Table 9-7 Opportunities and constraints

Opportunities	Constraints
<ul style="list-style-type: none"> Bus services provide public transport connectivity to the Sydney CBD, North Sydney and Chatswood Potential to move parking underground to provide public space and improve amenity Potential to improve pedestrian connections and amenity 	<ul style="list-style-type: none"> Traffic constraints on the already-congested Eastern Valley Way – Sailors Bay Road – Strathallen Avenue corridor

9.3 Future transport network review and recommendations

9.3.1 Traffic network analysis

9.3.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at Northbridge in accordance with **Table 9-8**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 9-8 Apartment mix and occupancy – Northbridge

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	95	1.7	157
1 bedroom	14%	133	1.7	219
2 bedroom	60%	568	2.3	1,299
3 bedroom	16%	152	2.8	424
Total	100%	947	-	2,099

¹Based on ABS 2016 Census Data

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 9-9**. The employee densities were adopted from TfNSW guidelines for office space and typical employee densities for retail and hospitality.

Table 9-9 Non-residential floor space assumptions – Northbridge

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	30%	1 / 40 sqm	311
Hospitality	30%	1 / 20 sqm	623
Office	40%	4.75 / 100 sqm	789
Total	100%	-	1,722

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

Therefore, based on these assumptions the Northbridge local centre is expected to accommodate approximately 2,100 residents and 1,720 employees.

9.3.1.2 Parking requirements

The minimum car parking requirements in accordance with the DCP are presented in **Table 9-10**.

Table 9-10 Minimum car parking requirements – Northbridge

Land use		Rate	Proposed development	Spaces required
Residential (non-adaptable units)	Studio	0.5 / dwelling	95 dwellings	47
	1 bedroom	1 / dwelling	133 dwellings	133
	2 bedroom	1 / dwelling	568 dwellings	568
	3 bedroom	1 / dwelling	152 dwellings	152
	Visitors	0.25 / dwelling	947 dwellings	237
			Residential subtotal	1,136
Commercial	Retail	36 sqm / space	12,451 sqm GFA	349
	Hospitality	107 sqm / space	12,451 sqm GFA	116
	Office	110 sqm / space	16,602 sqm GFA	151
			Commercial subtotal	615
			Development total	1,751
	Motorbike parking	1 / 25 car parking spaces	1,751 spaces	70

Note: Table shows rounded values. Subtotals were rounded down in accordance with the DCP.

Based on these calculations, the proposed development would be required to provide a minimum of 1,751 car parking spaces (including accessible parking spaces) and 70 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 9-11**.

Table 9-11 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	947 units	95
Retail	1 / 450m sqm GFA	12,451 sqm GFA	28
Hospitality	1 / 450m sqm GFA	12,451 sqm GFA	28
Office	1 / 600 sqm GFA	16,602 sqm GFA	28
Total			178

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

The calculations indicate that the proposed development would be required to provide 178 bicycle spaces.

9.3.1.3 Trip generation

Based on the trip generation rates presented in **Section 3.3**, the estimated number of trips generated by the proposed development are presented in **Table 9-12**. An estimate of existing traffic generated by the current land uses is also provided, as well as the additional traffic expected to be generated.

Table 9-12 Future traffic generation

Land use	Total development (existing + proposed)	Traffic generation (veh/hr)		
		AM peak	PM peak	Saturday peak
Residential	947 units	180	142	180
Retail	9,338 sqm GLFA	105	333	85
Hospitality	9,338 sqm GLFA	105	366	699
Office	16,602 sqm GFA	266	199	0
Total		655	1,041	964
Existing traffic generation		442	769	690
Additional traffic generated		+213	+272	+275

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

On this basis the proposed development is expected to generate an additional 213 vehicle movements in the AM peak hour, 272 in the PM peak and 275 in the Saturday peak.

However, the mode share for the sites surveyed by TfNSW averaged out to approximately 30 per cent for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the Northbridge local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 44 per cent for residents and 56 per cent for workers. This represents a higher mode share than those surveyed for the TfNSW traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis, a mode share discount of 10 per cent was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 44 per cent for residents and 56 per cent for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

9.3.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 9-13**.

Table 9-13 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the additional traffic generated to determine the inbound and outbound trips presented in **Table 9-14**.

Table 9-14 Inbound and outbound additional traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	27	145	75	43	68	91
Retail	12	16	37	50	10	13
Hospitality	14	13	49	44	78	105
Office	54	8	4	54	0	0
Total (additional traffic generated)	107	181	166	191	156	208

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 9-15**.

Table 9-15 Directional assumptions

Direction	In %	Out %
North	6%	28%
East	0%	0%
South	52%	26%
West	42%	46%
Total	100%	100%

Source: ABS 2016 Census Data

9.3.1.5 Intersection modelling results

Intersection modelling was undertaken for key intersections within the Northbridge local centre using SIDRA Network software. The modelling examined the intersection performance for the following scenarios:

1. 2036 With 100 per cent Development; and
2. 2036 With 75 per cent Development.

The 2036 With 100 per cent Development scenario represents a full development case which may be realised in 2036. The 2036 With 75 per cent Development scenario represents a case where the development is not fully achieved, and is presented to understand the impacts of a reduced scale of development which may occur at an earlier point in time. The results and key findings of each scenario are presented in the following sections.

9.3.1.5.1 2036 With 100 per cent Development modelling results

Table 9-16 summarises the intersection performance of the Northbridge local centre for the 2036 With 100 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 9-16 Future intersection performance – Northbridge

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Sailors Bay Road / Eastern Valley Way	0.771	20.1	B	1.121	56.4	D	1.108	46.0	D
Sailors Bay Road / Harden Avenue	0.920	27.2	B	1.004	49.1	D	0.866	19.5	B
Sailors Bay Road / Strathallen Avenue	1.164	41.4	C	1.078	31.2	C	1.066	37.6	C

In the 2019 base model, all the intersections were performing at LoS C or better, indicating that the intersections were operating satisfactorily with acceptable delays and spare capacity.

In 2036, due to the increase in demand on Sailors Bay Road, the intersection performance at the Sailors Bay Road / Eastern Valley Way intersection decreases in the PM and Saturday peak periods, where it deteriorates from LoS B in 2019 to LoS D in 2036.

Similarly, due to the increase in the demand on Sailors Bay Road the intersection performance at Sailors Bay Road / Harden Avenue intersection worsens in the PM peak, from a LoS B in 2019 to LoS D in 2036.

9.3.1.5.2 2036 With 75 per cent Development modelling results

Table 9-17 summarises the intersection performance of the Northbridge local centre for the 2036 with 75 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix B**.

Table 9-17 Intersection performance – Northbridge

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Sailors Bay Road / Eastern Valley Way	0.859	21.9	B	0.962	27.3	B	1.050	38	C
Sailors Bay Road / Harden Avenue	0.853	20.3	B	0.842	22.3	B	0.830	19	B
Sailors Bay Road / Strathallen Avenue	1.149	37.9	C	1.051	27.6	B	1.011	31	C

Under the 2036 With 75 per cent Development scenario, there are some improvements to the intersection performance when compared to the 2036 With 100 per cent Development scenario. The Sailors Bay Road / Eastern Valley Way intersection in the PM and Saturday peak periods performs better under the 75 per cent With Development scenario where the level of service improves from LoS D to LoS B in the weekday PM peak and from LoS D to LoS C in the Saturday Peak.

The average delay of the intersection in the weekday PM peak was reduced from 56.4 seconds under the 100 per cent Development scenario to 27.3 seconds in the 75 per cent Development scenario, a 52 per cent reduction in the average delay. During the Saturday peak there was a 17 per cent reduction in the average delay. Under the 75 per cent Development scenario, it is expected that there will be 40 fewer vehicles at the intersection compared to the 100 per cent Development scenario, which also equates to a reduction of 70 metres of the back of queue during the weekday PM peak.

The Sailors Bay Road / Harden Avenue intersection in the weekday PM peak period performs better under the 75 per cent Development scenario than the 100 per cent Development scenario, where the level of service improves from LoS D to LoS B and the average delay at the intersection is reduced by 55 per cent. This is mostly attributed to the decrease in demand on the intersection where there is expected to be a reduction in demand of 55 fewer vehicles on the intersection.

Similarly, the Sailors Bay Road / Strathallen Avenue intersection in the weekday PM peak period performs better under the 75 per cent Development scenario than the 100 per cent Development scenario, where the performance improves from LoS C to LoS B. This is attributed to an approximate 12 per cent decrease in the average delay of the intersection. The worst movement is the right turning movement on Strathallen Avenue (Southern approach). Overall there is a reduction in demand at the intersection of 46 vehicles in the 75 per cent Development scenario when compared to the 100 per cent Development scenario, and a reduction of 20 metres of the critical queue length.

9.3.2 Parking analysis

The increase in parking demand in Northbridge is predominantly in hospitality uses, resulting in a significant growth in short-stay parking demand of up to 200 spaces, particularly during the evening and weekend. However, overall parking demand is not expected to change markedly, as this is largely a reallocation from existing

These short-stay bays would need to be located in areas in close proximity to the Centre, generally constituting large-scale communal multi-deck car parking either stand-alone or integrated into the development.

More impactful is the large increase in residential development predicted by the Local Centres Strategy. There is insufficient on-street parking available to sustain a 200 per cent growth in dwellings if residents continue to use the street for private vehicle storage.

Measures will be necessary to curtail this behaviour, comprising a combination of duration limits, paid parking and appropriately priced residential permits.

Figure 9-15 Northbridge future non-residential parking demand weekday profile

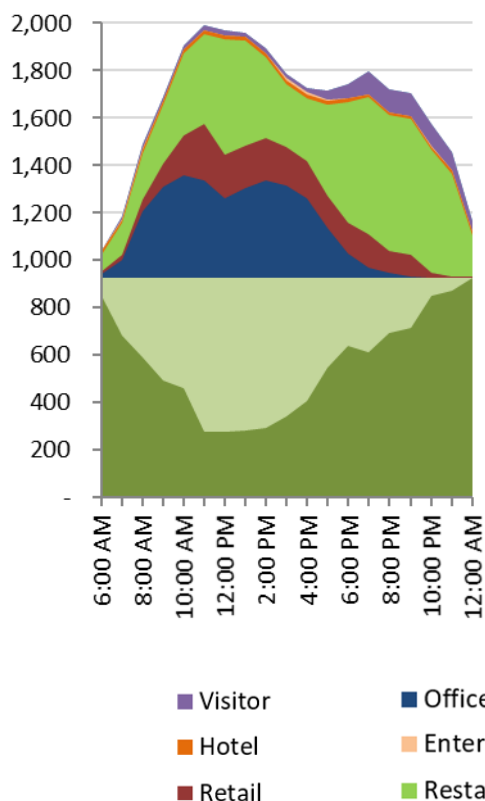
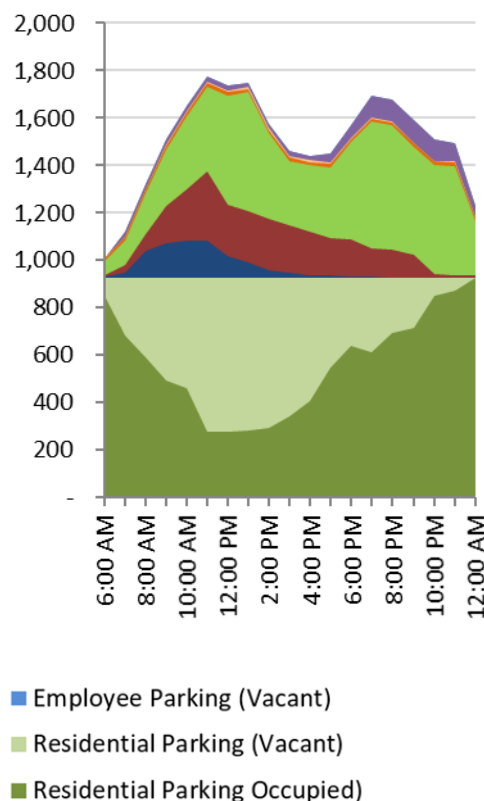


Figure 9-16 Northbridge future non-residential parking demand weekend profile



9.3.3 Active Transport

Walking and cycling needs within the Northbridge local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

Northbridge already contains an established footpath network, however there is a particular lack of cycling infrastructure and several opportunities to improve pedestrian crossings. Northbridge is heavily focused on Eastern Valley Way – Sailors Bay Road – Strathallen Avenue as a vehicle movement corridor and the environment is therefore constrained.

Recommendations to address these issues are summarised in **Section 9.3.5**.

9.3.4 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

Northbridge is well connected by bus services operating along Eastern Valley Way, providing access to surrounding centres including Chatswood and the Sydney CBD via the Warringah Freeway. Opportunities to improve public transport may include increasing the frequency of services.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 9.3.5**.

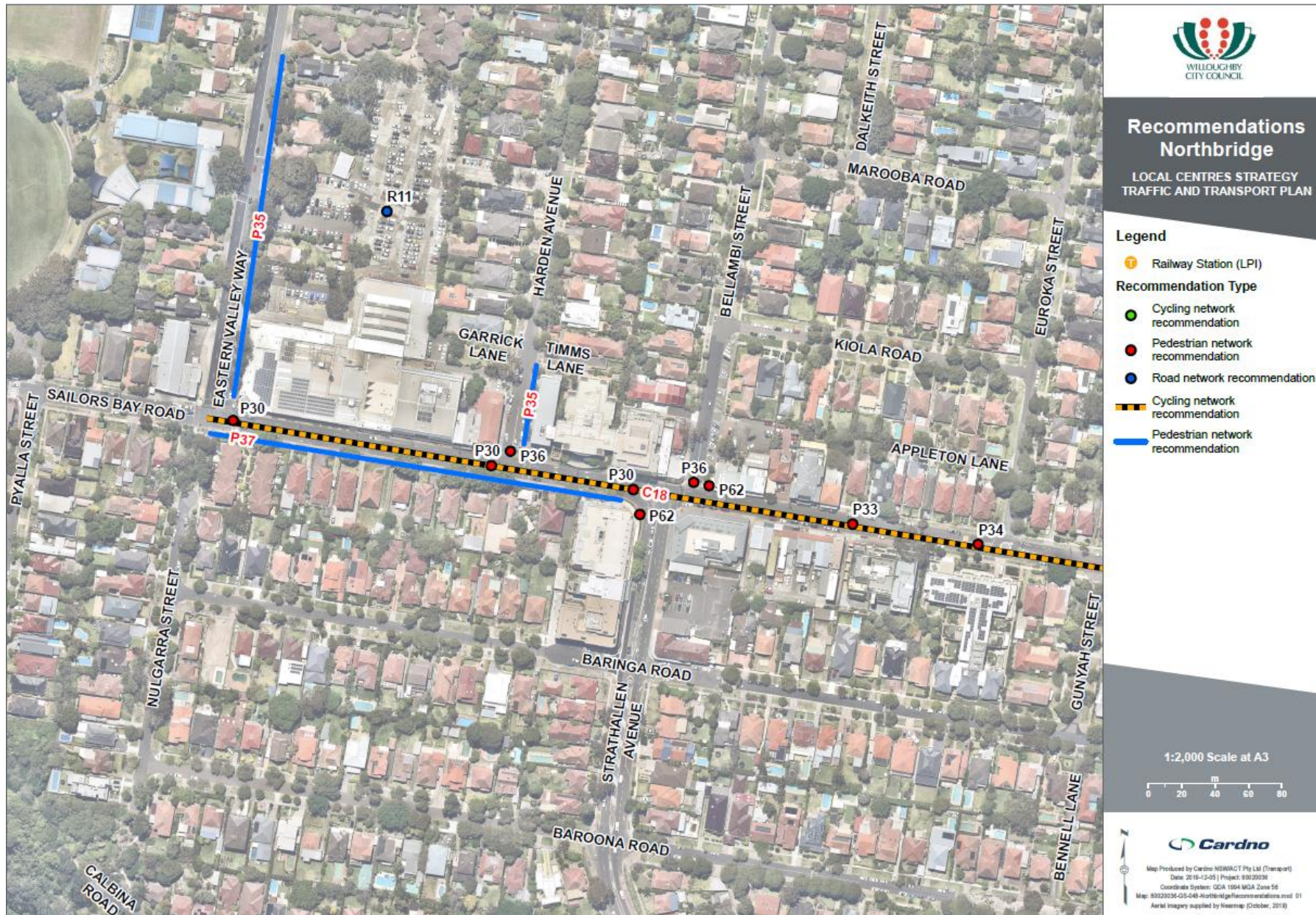
9.3.5 Issues and options

The issues and recommendations for the local centre are summarised in **Table 9-18** and **Figure 9-17**.

Table 9-18 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P30	Missing pedestrian crossings at intersections.	Provide additional pedestrian crossings at the following locations: - Eastern leg of the Eastern Valley Way / Sailors Bay Road intersection; - Western leg of the Sailors Bay Road / Harden Avenue intersection; and - Western leg of the Sailors Bay Road / Strathallen Avenue intersection.	Pedestrian crossings	3
P33	Lack of pedestrian crossings on Sailors Bay Road east of Strathallen Avenue.	Provide a pedestrian crossing facility on Sailors Bay Road between Strathallen Avenue and Euroka Street, with consideration of a marked pedestrian crossing with kerb extensions or a pedestrian refuge.	Pedestrian crossing facility	1
P34	Non-compliant pedestrian refuge at Sailors Bay Road / Euroka Street.	Upgrade the existing pedestrian refuge to a fully compliant pedestrian refuge to facilitate pedestrian movement across Sailors Bay Road.	Pedestrian refuge	1
P35	Narrow footpaths along Eastern Valley Way and Harden Avenue.	Widen the footpaths along the eastern side of Eastern Valley Way and Harden Avenue adjacent to the local centre, to a minimum of 2m.		
P36	Lack of threshold / gateway treatments.	Provide threshold / gateway treatments to improve pedestrian amenity and safety within the centre, including raised pavements and kerb extensions at the intersections of Harden Avenue / Sailors Bay Road and Bellambi Street / Sailors Bay Road.	Kerb extension / raised threshold	2
P62	Non-compliant kerb ramps.	Re-align kerb ramps to correct orientations at the intersections of Sailors Bay Road with Strathallen Avenue and Bellambi Street.	Kerb ramps	4
P63	Lack of Tactile Ground Surface Indicators (TGSIs).	Provide Tactile Ground Surface Indicators at kerb ramps within the local centre for DDA compliance.	TGSIs	14
Bicycle				
C8	Lack of cycle parking.	Provide additional cycle parking within the centre to encourage cycling as a travel mode and accommodate future growth.	Cycle parking	10
C18	Lack of cycleway infrastructure.	Provide an on-road mixed traffic cycle route on Sailors Bay Road between Eastern Valley Way and Naomi Road by implementing painted bicycle symbols.	Painted symbols	-

Figure 9-17 Recommendations map



10 Penshurst Street

10.1 Land use

10.1.1 Existing

The Penshurst Street local centre is situated on Penshurst Street between Mowbray Road and Laurel Street. The centre contains a strip of shops and businesses fronting Penshurst Street and Mowbray Road, including retail, cafes, restaurants, health & fitness services, medical and warehouses / showrooms, as well as a small number of residential dwellings. Surrounding areas contain additional residential dwellings, mostly detached.

An overview of the Penshurst local centre study area and land use mix is presented in **Figure 10-1** and **Table 10-1**.

Figure 10-1 Penshurst Street local centre

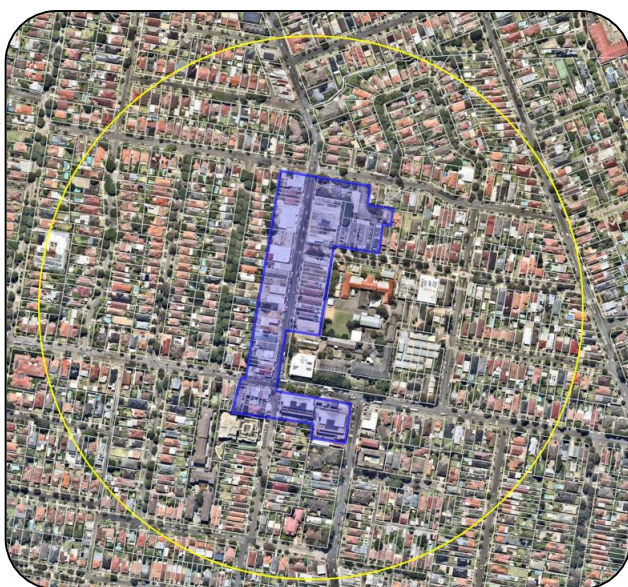


Table 10-1 Penshurst Street land use mix

Town Centre	
Office / Commercial	2,500 m ²
Medical	800 m ²
Shopping / Retail	6,100 m ²
Warehouse / Showroom	1,200 m ²
Restaurant	120 seats
Health / Fitness	460 m ²
Detached Housing	11 dwellings
Attached Housing	8 dwellings
Parking	
Off-Street Supply	160 spaces
On-Street Supply	105 spaces
Peak Non-Residential Parking Demand	240 spaces
Surrounds (400m)	
Detached Housing	580 dwellings
Attached Housing	350 dwellings

The Penshurst Street local centre contains a number of pedestrian-generating land uses including:

- > Penshurst Street shopping district;
- > Mowbray Road shops;
- > Willoughby Girls High School; and
- > Willoughby Public School.

The majority of all pedestrian movement within the local centre occurs on Penshurst Street, operating as both a destination for people and as a movement corridor. Penshurst Street receives pedestrian traffic from connecting streets such as Laurel Street, Oakville Road and Mowbray. Penshurst Street allows direct access to the local shopping precinct. Site based observations also showed significant pedestrian volumes on Oakville Road from Penshurst Street and surrounding residential areas. The observed traffic was due to the afternoon pick up traffic generated by Willoughby Public School.

10.1.2 Planned

Forecast development, land uses and uplift were obtained from the *Willoughby Local Centres Strategy* and discussions with Council. Total figures were provided for residential and non-residential floor space under the preferred scenario, as well as an indicative overview of the vision for the local centre.

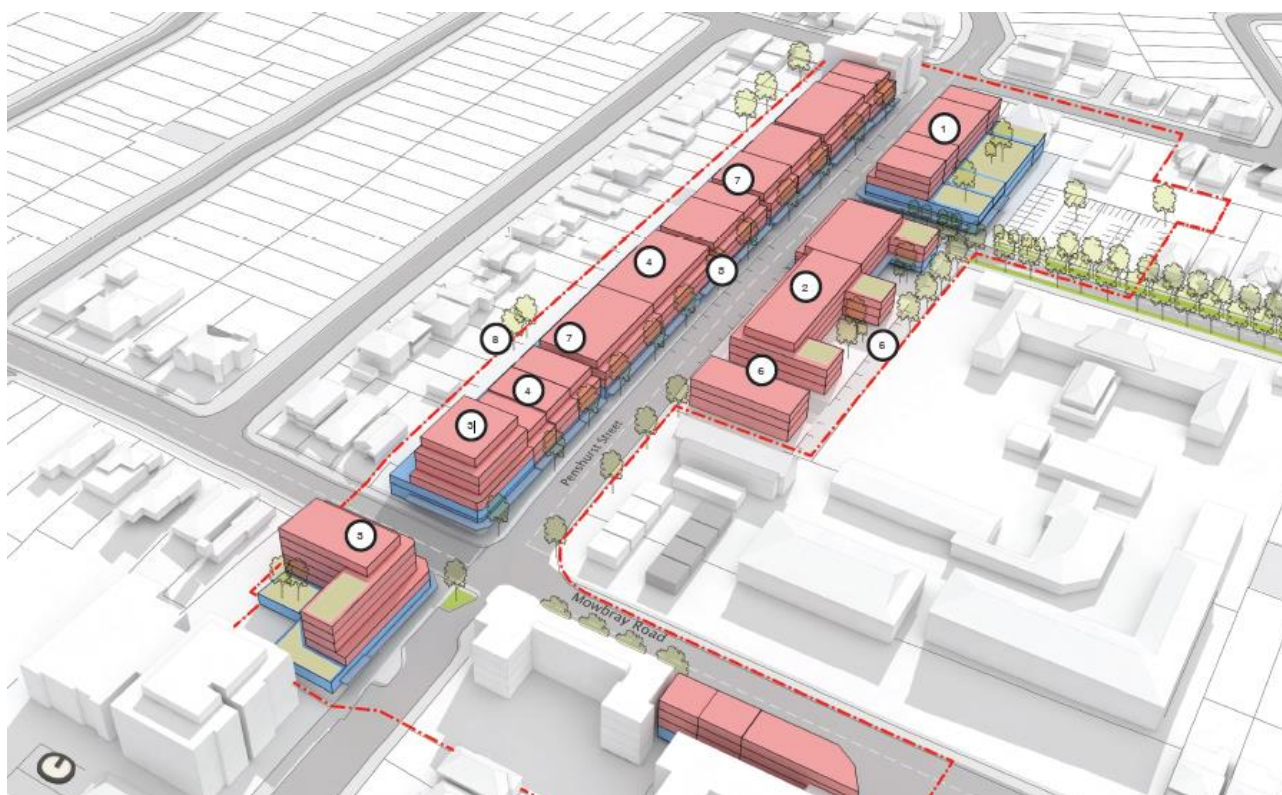
Assumptions will be made in regards to specific uplift of particular blocks and positioning of access points to inform the future network review and traffic modelling.

The Penshurst Street local centre is forecast for significant uplift in residential dwellings and minor uplift in commercial floor space. The preferred scenario contains the following key features:

- > A total of 34,272 sqm GFA of residential floor space, representing an uplift of 21,466 sqm or 168 per cent;
- > A total of 15,303 sqm GFA of non-residential floor space, representing an uplift of 2,208 sqm or 17 per cent;
- > Encouragement of shared access points to reduce the number of driveways on Penshurst Street;
- > Potential new pedestrian crossing at the intersection of Penshurst Street / Oakville Road; and
- > Extension of Mowbray Lane to Penshurst Street.

An indicative representation of the scale and distribution of the preferred scenario is presented in **Figure 10-2**.

Figure 10-2 Potential development at Penshurst Street – preferred scenario



Source: Willoughby Local Centres Strategy

The preferred scenario includes shop-top housing along Penshurst Street to accommodate significant residential growth, with intensification of ground to first floor commercial developments to support employment growth and active street frontages.

10.1.3 Community concerns

46 people provided feedback about the *Draft Local Centres Strategy* for Penshurst Street, with mixed feedback. Some responses supported development but many strongly opposed the height limits and FSRs proposed, and residents generally supported the plans for increased public domain and open space. The key community feedback related to traffic and transport issues were focused on the following:

- > The need for improved transport infrastructure;
- > The need for additional bus services in the peak hours; and
- > Concerns about traffic congestion issues.

The community concerns are discussed further in the following sections together with the review of the existing and future transport networks.

10.2 Existing transport networks

10.2.1 Road network and traffic

The Penshurst Street road network primarily supports north-south trips within the centre, with provisions for east-west movements. Penshurst Street is the centre's key movement corridor, functioning as a link between surrounding low density residential housing and the commercial district of Penshurst Street. Penshurst Street provides a connection to major corridors such as Boundary Street.

Laurel Street, Oakville Road and Mowbray Road intersect with Penshurst Street to provide east-west movement into the Penshurst Street precinct. Mowbray Road serves as a regional east-west movement corridor providing access to destinations such as Lane Cove and Macquarie Park.

Mowbray Road accommodates the greatest traffic volumes within the Penshurst Street centre precinct followed by Willoughby Road. Intersection volumes are greatest where Mowbray Road meets Willoughby Road. Intersection volumes are far lower, but still significant where Penshurst Street meets Laurel Street. During the site visit, substantial queuing was observed on Mowbray Road at the intersection with Willoughby Road. This site survey was conducted during the afternoon and hence queuing was likely a result of school pick-up.

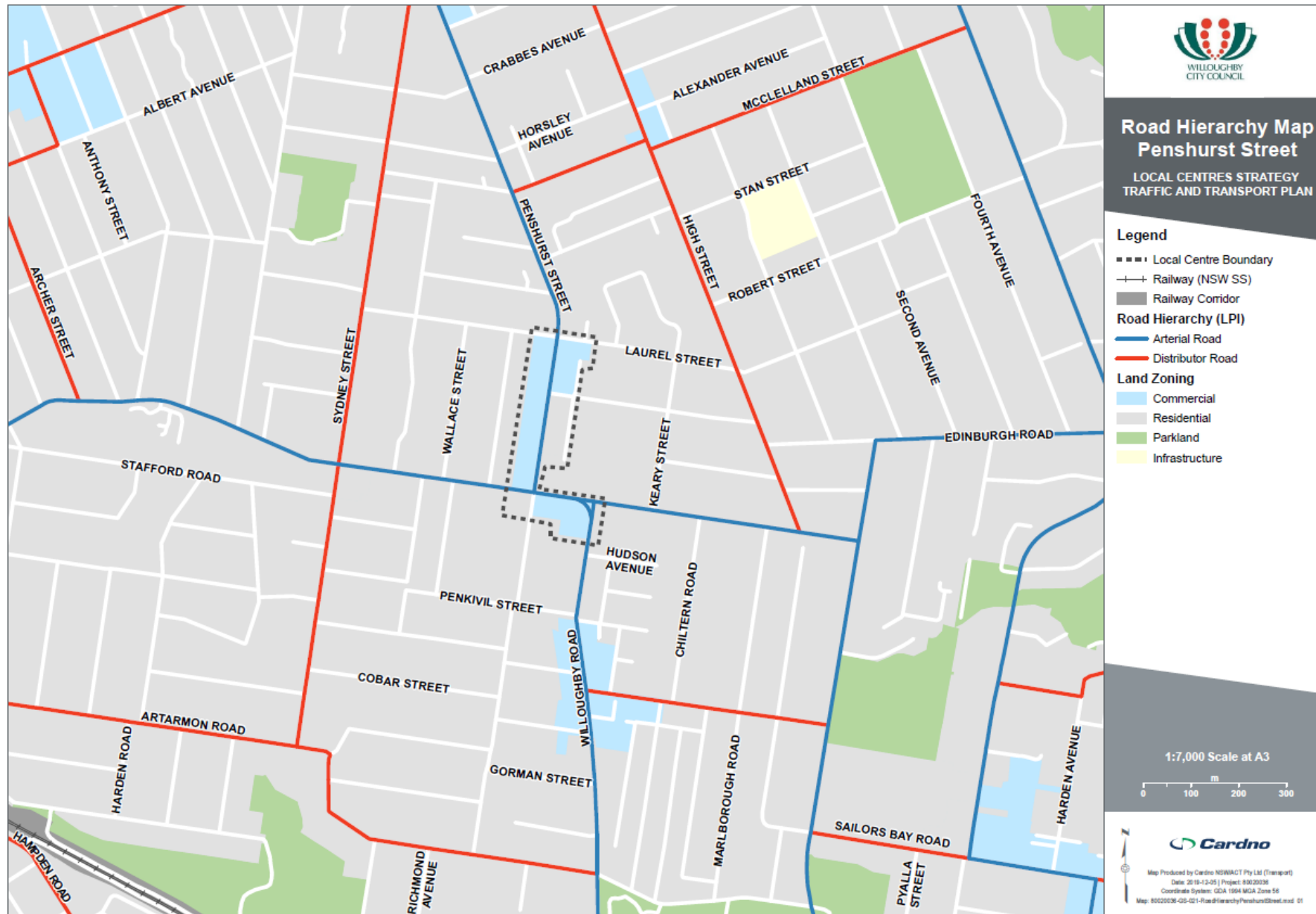
Key roads within the Penshurst Street local centre are shown in **Table 10-2**.

Table 10-2 Key roads

Road name	Road Classification	Managing Authority	Number of Lanes	Speed Limit
Penshurst Road	State Road	TfNSW	Peak: 4 travel lanes Off-peak: 2 travel lanes and 2 parking lanes	60 km/h
Mowbray Road	Regional Road	Willoughby Council	Peak: 4 travel lanes Off-peak: 2 travel lanes and 2 parking lanes	60 km/h
Willoughby Road	State Road	TfNSW	Peak: 4 travel lanes Off-peak: 2 travel lanes and 2 parking lanes	60 km/h
Laurel Street	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Oakville Road	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h

The road hierarchy map is shown in **Figure 10-3**.

Figure 10-3 Road hierarchy



10.2.2 Safety

Five-year crash data history was analysed from 2014 to 2018 (inclusive). Overall there were 29 reported crashes within the local centre of Penshurst Street. A summary of crashes by severity is shown in **Table 10-3**.

Table 10-3 Crash summary by severity

Year	Fatal	Serious Injury	Moderate Injury	Minor / Other Injury	Non-Casualty (tow away)	TOTAL
2014	0	2			8	10
2015	0		2	2	3	7
2016	0		1	1	1	3
2017	0	1	2	1	1	5
2018	0	3			1	4
TOTAL	0	6	5	4	14	29

There were no fatalities within the local centre during the five-year period, however 6 crashes resulted in serious injury.

10.2.2.2 Crash Locations

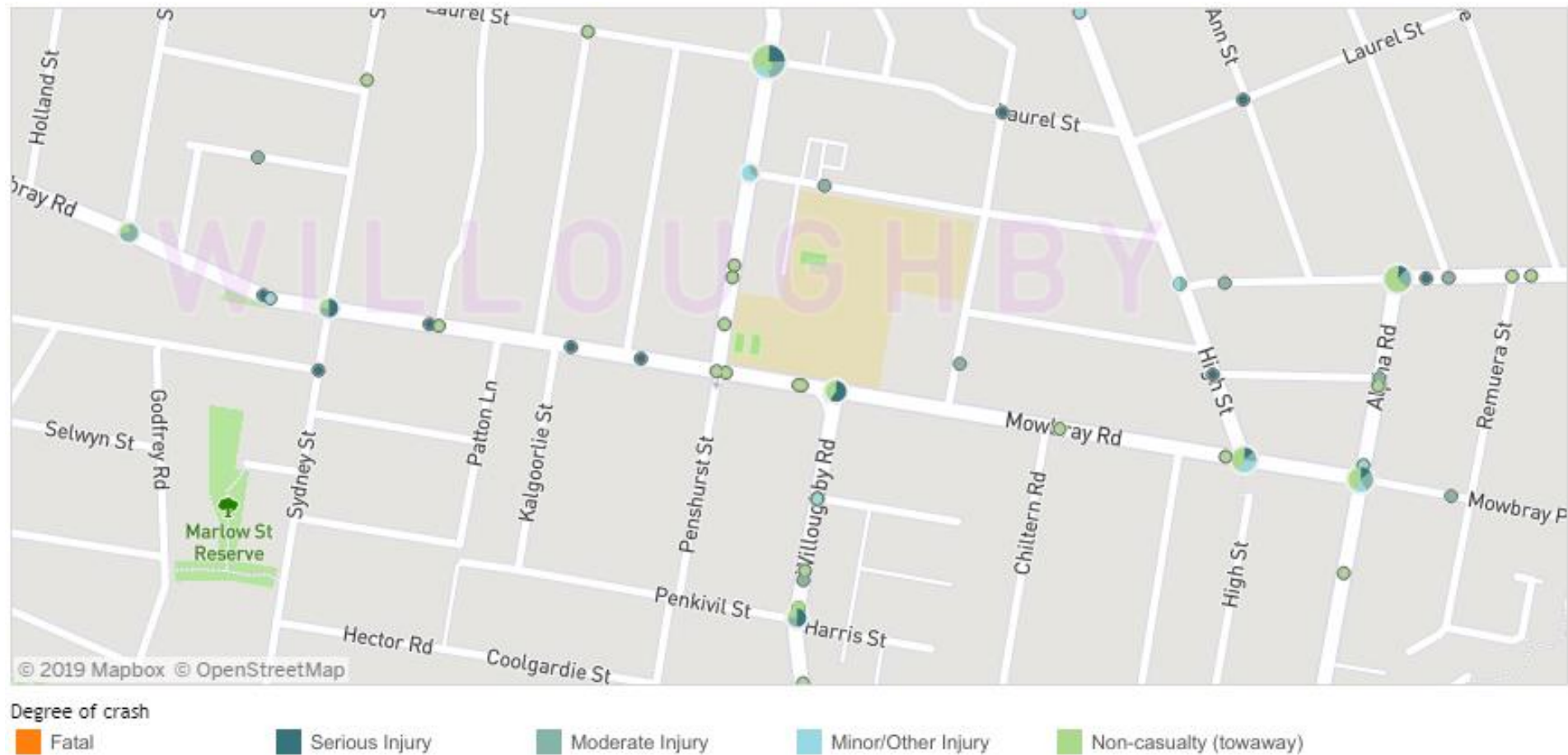
The majority of crashes within the local centre occur on Penshurst Street and Mowbray Road. Crash clusters are evident at the intersection of Laurel Street and Penshurst Street and the intersection of Mowbray Road and Willoughby Road. A total of six crashes involving pedestrians was recorded from 2014 to 2018. Three of these accidents occurred at the intersection of Laurel Street and Penshurst Street. A high concentration of crashes at this location may be caused by high through traffic volumes through the Penshurst Street corridor and high pedestrian thoroughfare at the intersection. The Mowbray Road / Willoughby Road intersection also had two crashes involving pedestrians.

Crash locations within the Penshurst Street local centre are shown in **Table 10-4** and **Figure 10-4**.

Table 10-4 Crash locations

Road	2014	2015	2016	2017	2018	Total
Penshurst Street	4	4	3	3	3	17
Mowbray Road	5	1		2	1	9
Oakville Road		1				1
Laurel Street	1	1				2
Total	10	7	3	5	4	29

Figure 10-4 Crash map



Source: NSW Centre for Road Safety

10.2.3 Existing pedestrian network and infrastructure

Penshurst Street, serving as the centre's key walking corridor, provides wide footpaths. Mowbray Road supports Penshurst Street by providing similarly wide footpaths within the town centre. Laurel Street and the south side of Oakville Road both offer standard width footpaths, despite providing direct connections to the Penshurst Street commercial district. Penshurst Street receives large traffic volumes however, no verge has been implemented to between pedestrians and vehicles as shown in **Figure 10-5**.

The centre supports pedestrian thoroughfare by providing signalised crossings. The signalised crossings are located at each of the centre's major intersections and between Oakville Road and Penshurst Street. The Penshurst Street / Oakville Road intersection has a missing crossing as shown in **Figure 10-6**. The distance between pedestrian crossing facilities is also not ideal with signalised crossings spaced up to 190 metres apart on Penshurst Street. This may encourage informal mid-block crossing and present safety issues, since no landscaping or other barriers are provided to discourage or prevent this movement from occurring.

Figure 10-5 Lack of pedestrian protection from vehicles



Figure 10-6 Missing pedestrian crossing at Penshurst St / Oakville Rd



The Penshurst Street local centre walking catchment is shown in **Figure 10-7**.

Figure 10-7 Walking routes



10.2.4 Cycling

The local centre supports on-road cycling environments through shoulder lanes on Laurel Street. The paths operate as links connecting the local centre of Penshurst Street to nearby local centres at High Street and Castlecrag. The cycling infrastructure present on Laurel Street is shown in **Figure 10-8**. This aligns with the Willoughby Bike Plan, which illustrates an on road cycleway running through Laurel Street.

Strava data was reviewed to identify key routes currently used by cyclists, and the data indicated cyclists use Laurel Street as the primary east-west movement corridor. This reflects the provision of separated cycleways here and allows cyclists to avoid the busy traffic on Mowbray Road. Penshurst Street is also utilised as a popular north-south corridor, however there is no cycling infrastructure present here.

Strava, an online fitness tracking application for cycling, shows popular cycling routes logged via mobile applications and provides indicative data on recreational cycling demand. Cycling infrastructure is generally limited within the centre itself. There is no cycling infrastructure supporting local connections on Penshurst Street or Mowbray Road.

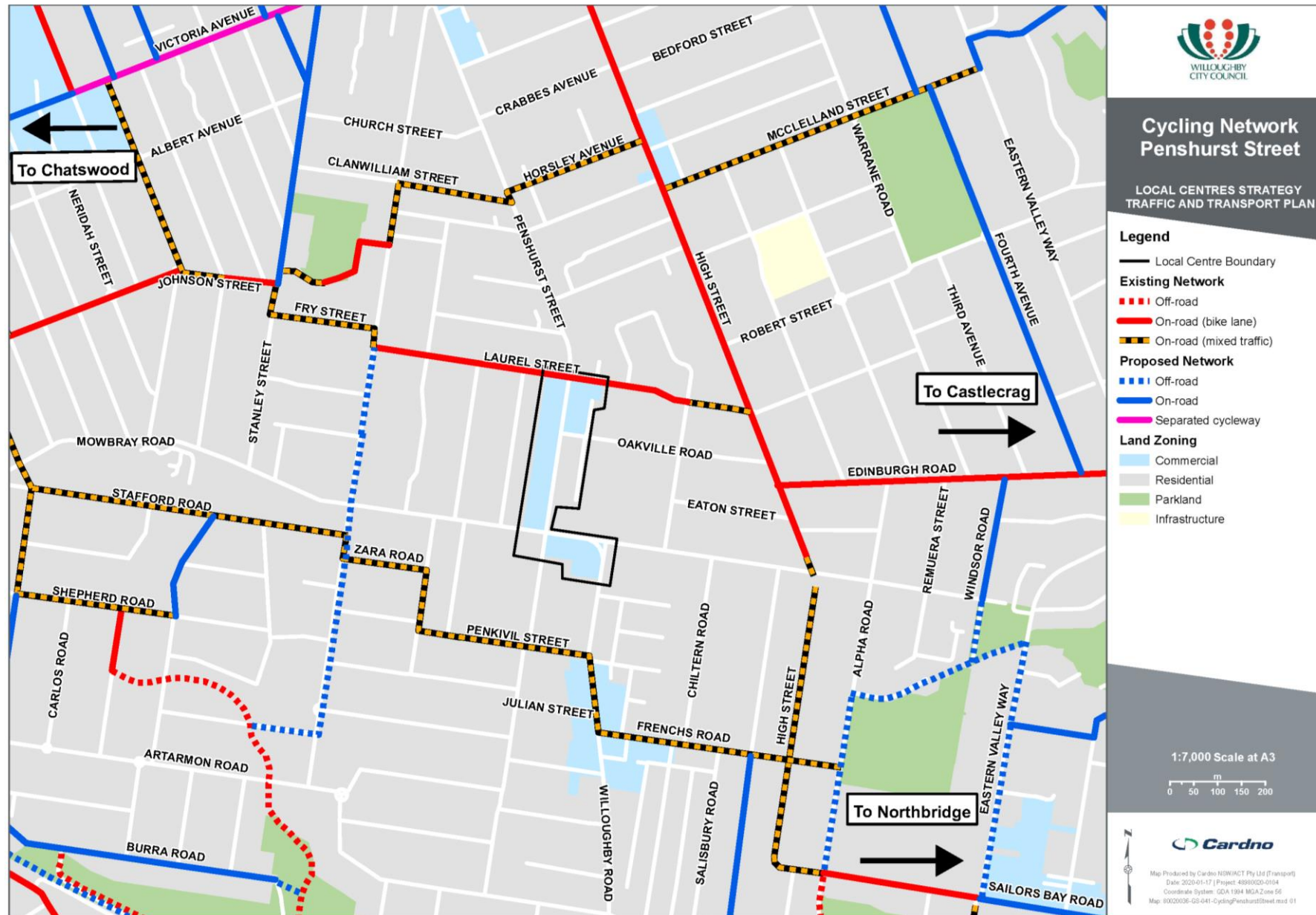
Bike racks are not provided on any street within the local centre.

A map of the existing and proposed bicycle network is presented in **Figure 10-9**.

Figure 10-8 Laurel Street cycleway



Figure 10-9 Bicycle network



10.2.5 Public Transport

Public transport is available within the centre through the provision of bus services operated by the STA through the Penshurst Street and Mowbray Road corridors. Bus stops on Penshurst Street accommodate regular services to the Sydney CBD and the Chatswood interchange. Additional services provide connections to destinations such as Mosman, Bondi Junction and Kingsford. Bus stops on Mowbray Road accommodate morning peak, daytime and afternoon peak services to Chatswood and Crows Nest.

Commuters travelling from Penshurst Street by bus must use the Chatswood interchange to reach destinations west and north of the Willoughby LGA.

The bus routes servicing the local centre are outlined in **Table 10-5**.

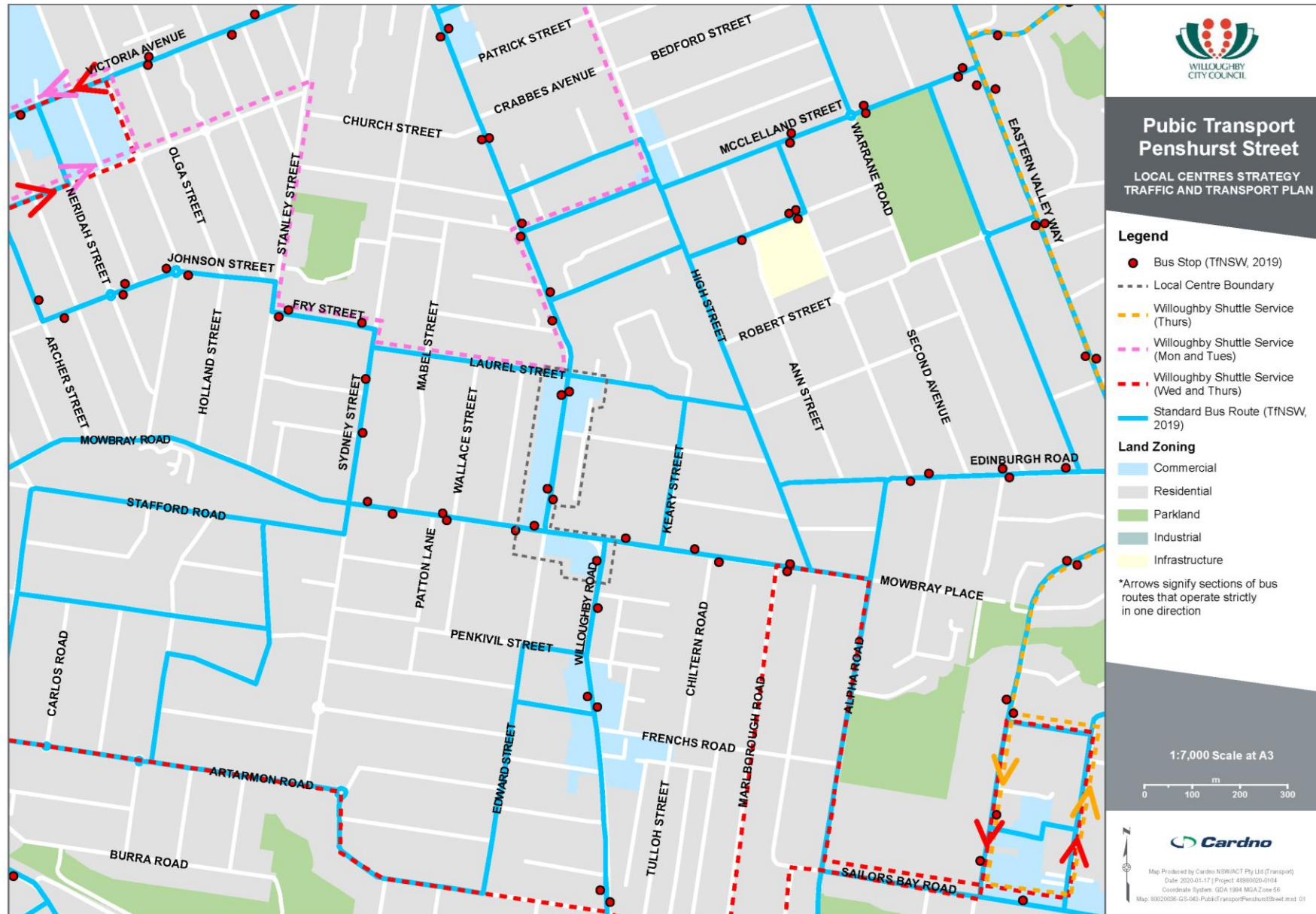
Table 10-5 Bus routes serving the Penshurst Street local centre

Bus route	Route description	Areas served
257	Chatswood to Balmoral via Crows Nest	Chatswood station, Willoughby, Naremburn, Crows Nest, Neutral Bay, Mosman, Balmoral Beach
267	Chatswood to Crows Nest	Chatswood, Mowbray Road, Castlecrag, Northbridge, Cammeray, Crows Nest
272	North Willoughby to City Wynyard	North Willoughby, South Willoughby, Sydney CBD (Wynyard)
340	Bondi Junction to Chatswood	Chatswood station, North Willoughby, South Willoughby, Sydney CBD, Paddington, Bondi Junction
343	Kingsford to Chatswood	Chatswood station, North Willoughby, South Willoughby, Naremburn, Crows Nest, North Sydney, Sydney CBD, Surry Hills, Waterloo, Rosebury, Kingsford

'The Loop' bus from Castle Cove to Chatswood also serves the local centre on Mondays and Tuesdays, running every 45 minutes between approximately 10:30am – 3:00pm. This service operates as a loop between the Castle Cove peninsula and Chatswood Town Centre via High Street.

A map of the public transport services within and around the Penshurst Street local centre is provided in **Figure 10-10**.

Figure 10-10 Public Transport map



10.2.6 Freight, services and loading

The local centre does not provide on-street loading zones at any time of the day.

Penshurst Street is designated as a Short Combination route as part of the Higher Mass Limits (HML) network, and provides a freight corridor running through the local centre.

10.2.7 Ride and vehicle sharing services

The local centre does not cater for ride or vehicle sharing services.

10.2.8 Parking provision

The local centre provides time restricted parking on Laurel Street and Oakville Road, as well as parking after morning clearways on Penshurst Street. A large carpark on Oakville Road provides ample opportunity for 2P parking, adjacent to the local centre on Penshurst Street. Parking is not permitted at the southern end of Penshurst Street and the entirety of Mowbray Road due to clearway restrictions.

Accessible parking is provided after morning clearways on Penshurst Street, just south of Oakville Road. Additional accessible parking spaces are catered for within the Oakville Road carpark. Further opportunities to implement accessible parking exist on Oakville Road if required.

An overview of parking availability for the weekday AM & PM peak periods is shown in **Figure 10-13**.

Parking profiles indicating the total parking requirement over the course of the day are presented in **Figure 4-14** and **Figure 10-12**. For further details and an explanation of these graphs refer to **Appendix B**.

Figure 10-11 Penshurst Street weekday parking profile

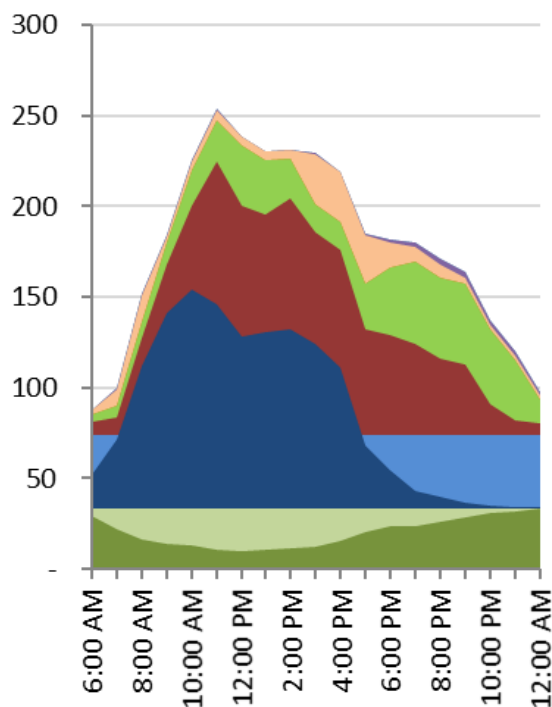
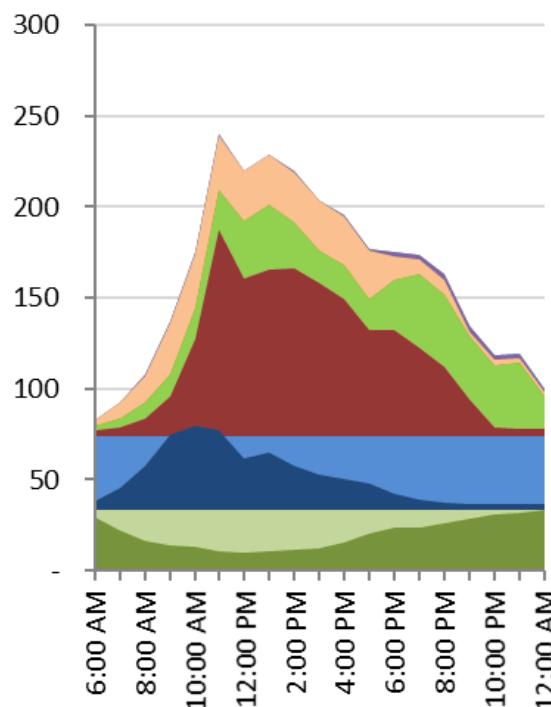
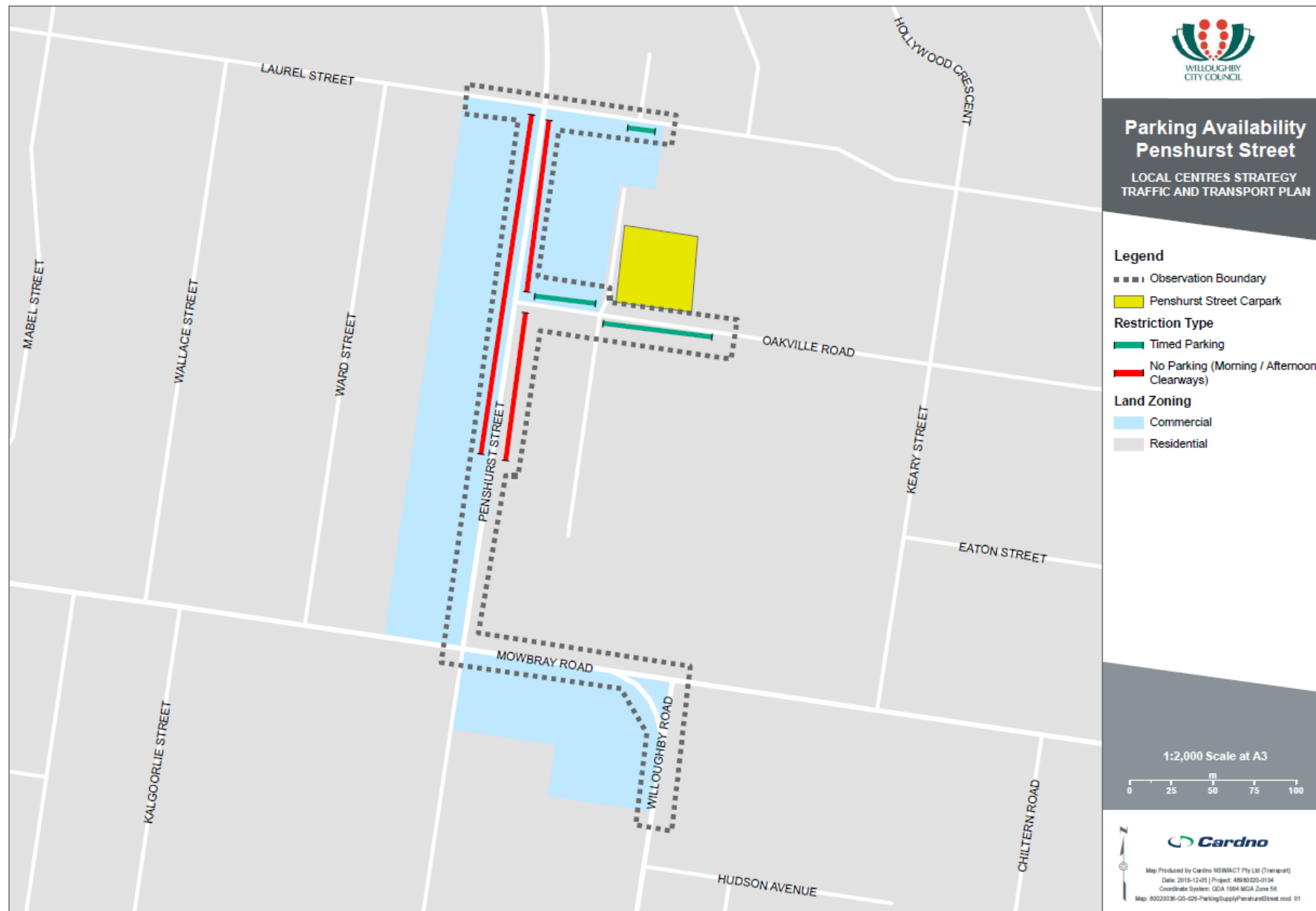


Figure 10-12 Penshurst Street weekend parking profile



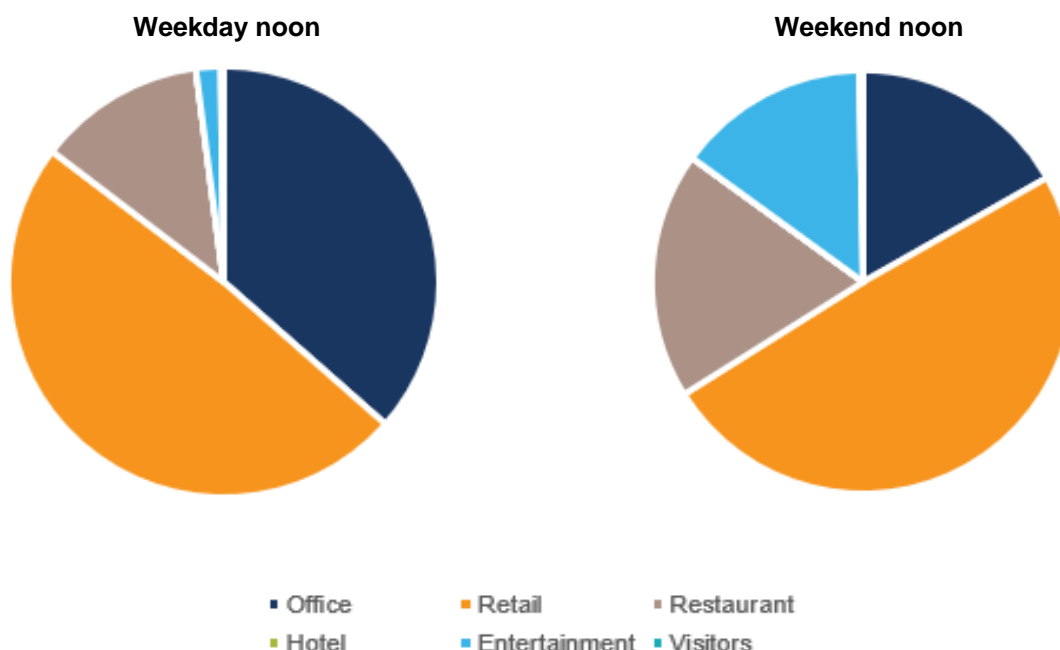
- | | | |
|---------|---------------|--------------------------------|
| Visitor | Office | Employee Parking (Vacant) |
| Hotel | Entertainment | Residential Parking (Vacant) |
| Retail | Restaurant | Residential Parking (Occupied) |

Figure 10-13 Parking availability



A breakdown of the weekday peak parking demand by land use is presented in **Figure 10-14**.

Figure 10-14 Penshurst Street peak parking demand



10.2.8.2 Penshurst Street parking function

The Penshurst Street Local Centre is largely defined by the arterial road function of Penshurst Street itself, as well as Mowbray Road / Willoughby Road.

Off-street car parks to the north (via Oakville Road) and south (via Mowbray Road) are well-utilised but insufficient to accommodate demand.

The centre geometry supports little on-street parking apart from in the Clearways, though there is supplementary on-street supply along Oakville Road, Penshurst Street south of Mowbray Road.

The parallel Ward Street supports additional parking, but accessibility is limited due to the lack of connections mid-block.

Additional peak demands for traffic and parking associated with the Willoughby Girls' High School conflict with the function of the Centre. Ideally, school activity would be focused along Keary Street, to segregate regional and Local Centre traffic from student pick-up / drop-off activity. It is likely that this demand is spread across the Centre, including within the Chaffer Lane Public Car Park during the afternoon school peak.

The type of land uses within the Local Centre point towards a high proportion of all-day employee parking. This type of demand is not well supported by the Centre, beyond rudimentary parking areas at the rear of individual lots. All remaining employee parking demand is satisfied by on-street parking well beyond the Centre boundary (streets such as Laurel Street).

10.2.8.3 Parking recommendations

The existing 1/2P free parking is likely too short to support many of the uses along Penshurst Street, and is difficult to enforce.

The private car park at Laurelbank Function Centre represents a potential opportunity for additional public parking, as its utilisation appears to be extremely low. Given the dearth of supply in this area, an arrangement with the owner to open up access to this parking could be beneficial to all groups.

The lack of long-stay parking in the vicinity of the Centre suggests that additional supply may be required.

Recommendation (Management):

Increase 1/2P duration restrictions along Penshurst Street to 1P.

Formalise Kiss & Ride Parking along Oakville Road and Keary Street to improve compliance.

Consider a partnership with Laurelbank Function Centre to allow for use of this dormant asset.

Relax parking controls along Penshurst Street (south of Mowbray Road) or Weld Street to provide sufficient long-stay parking for employees.

10.2.9 Intersection modelling

10.2.9.1 Intersection counts

For the Penshurst Street local centre, a total of four intersections were surveyed and included:

- > Penshurst Street / Laurel Street (signalised intersection);
- > Penshurst Street / Oakville Road (signalised intersection);
- > Penshurst Street / Mowbray Road (signalised intersection); and
- > Penshurst Street / Willoughby Road (signalised intersection).

The peak one-hour periods with the heaviest traffic were identified to be:

- > 7:15am – 8:15am for the weekday AM peak;
- > 4:45pm – 5:45pm for the weekday PM peak; and
- > 10:15am – 11:15am for the Saturday midday peak.

The data was used to inform the traffic modelling by providing the traffic under existing conditions. Volumes and intersection modelling results are presented in **Appendix A**.

10.2.9.2 Intersection modelling results

SIDRA intersection modelling results for key intersections within the Penshurst Street local centre are presented in **Table 10-6**. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 10-6 SIDRA intersection modelling results – Penshurst Street

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Penshurst Street / Laurel Street	0.830	11.2	A	0.844	15.3	B	0.680	15.3	B
Penshurst Street / Oakville Road	0.590	3.7	A	0.665	7.9	A	0.804	5.4	A
Penshurst Street / Mowbray Road	0.896	27.6	B	0.930	35.6	C	0.911	32.5	C
Mowbray Road / Willoughby Road	0.989	26.4	B	1.282	46.4	D	0.919	38.5	C

The Mowbray Road / Willoughby Road intersection operate near capacity at LoS D for the PM peak period. All other intersections operate satisfactorily at LoS C or better for all peak periods.

The Mowbray Road / Willoughby Road intersection is oversaturated (DoS is greater than 1.0) in the PM peak, indicating that it is congested. This intersection may experience congestion due to the demand exceeding the capacity. The degree of saturation at the other intersections are satisfactory across all peak periods.

10.2.10 Summary of opportunities and constraints

Key opportunities and constraints of the Penshurst Street local centre are summarised in **Table 10-7**:

Table 10-7 Opportunities and constraints

Opportunities	Constraints
<ul style="list-style-type: none"> Regular bus services provide public transport connectivity to Chatswood, Sydney CBD and Bondi Junction Potential to consolidate access points on Penshurst Street Potential for additional pedestrian crossing 	<ul style="list-style-type: none"> Lack of rear access points meaning driveways are located on Penshurst Street

10.3 Future transport network review and recommendations

10.3.1 Traffic network analysis

10.3.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at Penshurst Street in accordance with **Table 10-8**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 10-8 Apartment mix and occupancy – Penshurst Street

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	51	1.7	85
1 bedroom	14%	72	1.7	119
2 bedroom	60%	307	2.3	703
3 bedroom	16%	82	2.8	229
Total	100%	512	-	1,135

¹Based on ABS 2016 Census Data

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 10-9**. The employee densities were adopted from TfNSW guidelines for office space and typical employee densities for retail and hospitality.

Table 10-9 Non-residential floor space assumptions – Penshurst Street

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	45%	1 / 40 sqm	172
Hospitality	10%	1 / 20 sqm	77
Office	45%	4.75 / 100 sqm	327
Total	100%	-	576

Therefore, based on these assumptions the Penshurst Street local centre is expected to accommodate approximately 1,140 residents and 580 employees.

10.3.1.2 Parking requirements

The minimum car parking requirements in accordance with the DCP are presented in **Table 10-10**.

Table 10-10 Minimum car parking requirements – Penshurst Street

Land use		Rate	Proposed development	Spaces required
Residential (non-adaptable units)	Studio	0.5 / dwelling	51 dwellings	26
	1 bedroom	1 / dwelling	72 dwellings	72
	2 bedroom	1 / dwelling	307 dwellings	307
	3 bedroom	1 / dwelling	82 dwellings	82
	Visitors	0.25 / dwelling	512 dwellings	128
			Residential subtotal	614
Commercial	Retail	36 sqm / space	6,886 sqm GFA	193
	Hospitality	107 sqm / space	1,530 sqm GFA	14
	Office	110 sqm / space	6,886 sqm GFA	63
			Commercial subtotal	269
			Development total	883
	Motorbike parking	1 / 25 car parking spaces	883 spaces	35

Note: Table shows rounded values. Subtotals were rounded down in accordance with the DCP.

Based on these calculations, the proposed development would be required to provide a minimum of 883 car parking spaces (including accessible parking spaces) and 35 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 10-11**.

Table 10-11 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	512 units	51
Retail	1 / 450m sqm GFA	6,886 sqm GFA	15
Hospitality	1 / 450m sqm GFA	1,530 sqm GFA	3
Office	1 / 600 sqm GFA	6,886 sqm GFA	11
Total			81

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

The calculations indicate that the proposed development would be required to provide 81 bicycle spaces.

10.3.1.3 Trip generation

Based on the trip generation rates presented in **Section 3.3**, the estimated number of trips generated by the proposed development are presented in **Table 10-12**. An estimate of existing traffic generated by the current land uses is also provided, as well as the additional traffic expected to be generated.

Table 10-12 Future traffic generation

Land use	Total development (existing + proposed)	Traffic generation (veh/hr)		
		AM peak	PM peak	Saturday peak
Residential	512 units	97	77	97
Retail	5,165 sqm GLFA	58	184	47
Hospitality	1,148 sqm GLFA	13	45	86
Office	5,893 sqm GFA	110	83	0
Total		278	389	230
Existing traffic generation		191	296	150
Additional traffic generated		+87	+93	+80

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

On this basis the proposed development is expected to generate an additional 87 vehicle movements in the AM peak hour, 93 in the PM peak and 80 in the Saturday peak.

However, the mode share for the sites surveyed by TfNSW averaged out to approximately 30 per cent for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the Penshurst Street local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 44 per cent for residents and 63 per cent for workers. This represents a higher mode share than those surveyed for the TfNSW traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis, a mode share discount of 5 per cent was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 39 per cent for residents and 58 per cent for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

10.3.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 10-13**.

Table 10-13 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the additional traffic generated to determine the inbound and outbound trips presented in **Table 10-14**.

Table 10-14 Inbound and outbound additional traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	16	95	44	28	40	59
Retail	5	8	17	26	4	7
Hospitality	1	1	5	5	8	12
Office	19	3	2	21	0	0
Total (additional traffic generated)	41	108	68	80	52	78

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 9-15**.

Table 10-15 Directional assumptions

Direction	In %	Out %
North	6%	28%
East	0%	0%
South	52%	26%
West	42%	46%
Total	100%	100%

Source: ABS 2016 Census Data

10.3.1.5 Intersection modelling results

Intersection modelling was undertaken for key intersections within the Penshurst Street local centre using SIDRA Network software. The modelling examined the intersection performance for the following scenarios:

1. 2036 With 100 per cent Development; and
2. 2036 With 75 per cent Development.

The 2036 With 100 per cent Development scenario represents a full development case which may be realised in 2036. The 2036 With 75 per cent Development scenario represents a case where the development is not fully achieved, and is presented to understand the impacts of a reduced scale of development which may occur at an earlier point in time. The results and key findings of each scenario are presented in the following sections.

10.3.1.5.1 2036 With 100 per cent Development modelling results

Table 10-16 summarises the intersection performance of the Penshurst local centre for the 2036 With 100 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 10-16 Future intersection performance – Penshurst Street

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Penshurst Street / Laurel Street	0.852	11	A	0.836	16.2	B	1.066	28.9	C
Penshurst Street / Oakville Road	1.383	16	B	0.99	25.6	B	0.971	17.3	B
Penshurst Street / Mowbray Road	0.958	40.5	C	1.019	51.3	D	1.041	52.1	D
Mowbray Road / Willoughby Road	1.113	40.2	C	1.14	54.3	D	1.075	98.2	F

In 2036, it is expected that all the intersections will operate at LoS D or better, except in the Saturday peak period where the Mowbray Road / Willoughby Road intersection is expected to operate unsatisfactorily at LoS F. Compared to 2019, there is a notably higher delay incurred on Willoughby Road (south approach) for all movements.

The 2019 base model indicated that the Mowbray Road / Willoughby Road intersection is oversaturated (DoS is greater than 1.0) in the PM peak. In 2036, the degree of saturation at all the intersections is oversaturated (DoS is greater than 1) in at least one peak period. This is reflective of the increase in demand which is exceeding the capacity of the intersection. It is noted that the Mowbray Road / Willoughby Road intersection is oversaturated in all peak periods.

10.3.1.5.2 2036 With 75 per cent Development modelling results

Table 10-17 summarises the intersection performance of the Penshurst local centre for the 2036 with 75 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix B**.

Table 10-17 Intersection performance – Penshurst Street

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Penshurst Street / Laurel Street	0.846	11	A	0.832	16.2	B	1.027	19.9	B
Penshurst Street / Oakville Road	0.912	4.7	A	0.947	21	B	0.925	11.3	A
Penshurst Street / Mowbray Road	0.94	38.8	C	1.012	47.8	D	1.029	49.1	D
Mowbray Road / Willoughby Road	1.113	38.5	C	1.14	51.3	D	1.072	97.8	F

Under the 2036 With 75 per cent Development scenario, there are some improvements to the intersection performance when compared to the 2036 With 100 per cent Development scenario. The Penshurst Street / Laurel Street intersection in the Saturday peak period performs better under the 75 per cent development scenario, where the level of service improves from LoS C to LoS B. This is associated with an approximate 31 per cent decrease in the average delay at the intersection, due to some reduction in the demand on Penshurst Street.

Similarly, the Penshurst Street / Oakville Road intersection in the weekday AM and Saturday peak periods performs better under the 75 per cent Development scenario than the 100 per cent Development scenario, where the level of service improves from LoS B to LoS A in both peaks. The average delay in the weekday AM peak period was reduced by 71 per cent, and the average delay in the Saturday peak was reduced by 35 per cent. It is expected that there will be a demand for 19 fewer vehicles at the intersection when compared to the 100 per cent Development scenario, which also equates to a reduction of 50 metres of the back of the critical queue during the weekday AM peak.

There are minor performance improvements to the other intersections in the 2036 With 75 per cent Development scenario in comparison to the 2036 With 100 per cent Development scenario, however the level of service categories remain the same.

10.3.2 Parking analysis

Only a minor increase in non-residential uses is expected for the Penshurst Street Local Centre, resulting in an increased parking demand of 20-40 spaces. This can be generally accommodated within the local street network.

However, the quantity of proposed residential development (a 230 per cent increase) *could* stress the on-street parking supply if residents continue to use the street network as private vehicle storage. This impact is not as profound in the Penshurst Street Centre due to the relatively low proportion of hospitality uses.

As such, continued use of duration restrictions should be sufficient to support the Centre through to the development horizon.

Figure 10-15 Penshurst Street future non-residential parking demand weekday profile

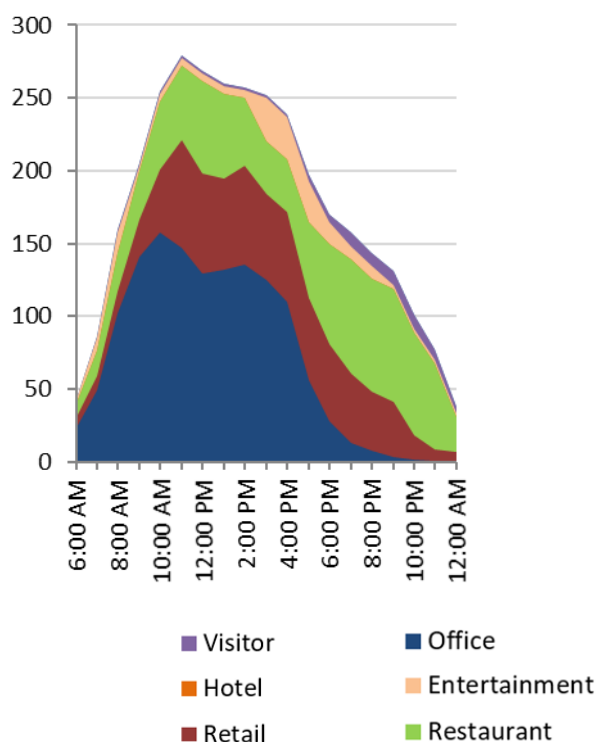
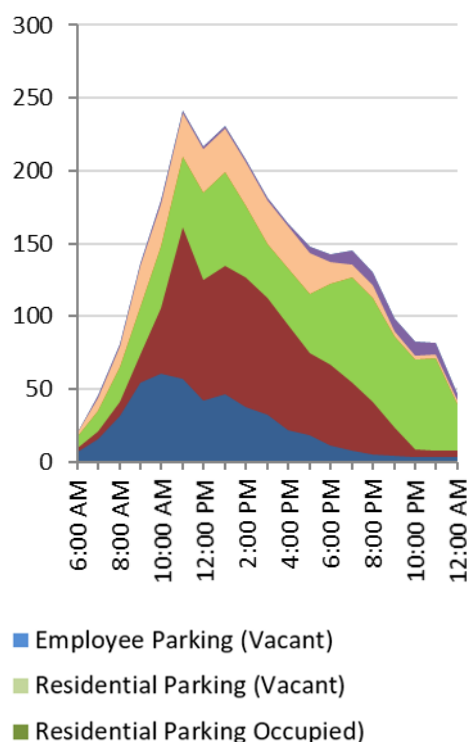


Figure 10-16 Penshurst Street future non-residential parking demand weekend profile



10.3.3 Active Transport

Walking and cycling needs within the Penshurst Street local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place

experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

Penshurst Street contains an established footpath network, although there may be opportunities to improve pedestrian crossings. The centre does not contain cycling facilities, however the Willoughby Bike Plan does not indicate Penshurst Street or Mowbray Road as proposed cycle routes.

Recommendations to address these issues are summarised in **Section 10.3.5**.

10.3.4 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

Penshurst Street is well connected by bus to surrounding centres and public transport hubs including Chatswood, North Sydney and the Sydney CBD. Penshurst Street and Mowbray Road accommodate a range of services and link to Chatswood station where rail access is provided. Opportunities for improvement are limited but may include additional services and a review of bus routes to optimise connectivity and access.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 10.3.5**.

10.3.5 Issues and options

The issues and recommendations for the local centre are summarised in **Table 10-18** and **Figure 10-17**.

Table 10-18 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P49	Missing pedestrian crossing at Penshurst Street / Oakville Road	Provide an additional signalised pedestrian crossing on the northern leg of the intersection at Penshurst Street / Oakville Road.	Signalised pedestrian crossing	1
P50	Lack of pedestrian crossing opportunities across Penshurst Street.	Provide a pedestrian refuge on Penshurst Street between Oakville Road and Mowbray Road.	Pedestrian refuge	1
Bicycle				
C12	Lack of bike parking provision.	Provide bike parking to accommodate demand for cycle parking and encourage cycling as a travel mode.	Bike parking	8
Public transport				
PT2	Lack of a bus shelter on the northern side of Mowbray Road near Penshurst Street.	Provide a bus shelter for the bus stop on the northern side of Mowbray Road immediately west of Penshurst Street (ID: 2068114).	Bus stop shelter	1
Road network				
R13	1/2P parking restrictions likely too short.	Increase 1/2P duration restrictions along Penshurst Street to 1P.	Parking signage	-
R14	Potential non-compliance issues with Kiss and Ride on Oakville Road and Keary Street.	Formalise Kiss & Ride Parking along Oakville Road and Keary Street to improve compliance.	Parking signage	-
R15	Opportunity to make use of underutilised parking at the Laurelbank Function Centre.	Consider a partnership with Laurelbank Function Centre to allow for use of this dormant asset.	Parking management	-
R27	Lack of long-stay parking.	Relax parking controls along Penshurst Street (south of Mowbray Road) or Weld Street to provide sufficient long-stay parking for employees.	Parking signage	-
R28	High number of crashes recorded at the intersection of Penshurst Street / Laurel Street.	Advocate for TfNSW to investigate safety issues at the intersection of Penshurst Street / Laurel Street and explore mitigation measures.	Safety improvements	-

Figure 10-17 Recommendations map



11 Willoughby South

11.1 Land use

11.1.1 Existing

The Willoughby South local centre is situated on Willoughby Road at Frenchs Road. The centre contains a range of commercial uses including retail, restaurants, medical, health / fitness, offices, a service station and a hotel, as well as some attached dwellings. Surrounding areas contain low density detached residential dwellings.

An overview of the Willoughby South local centre study area and land use mix is presented in **Figure 11-1** and **Table 11-1**.

Figure 11-1 Willoughby South local centre

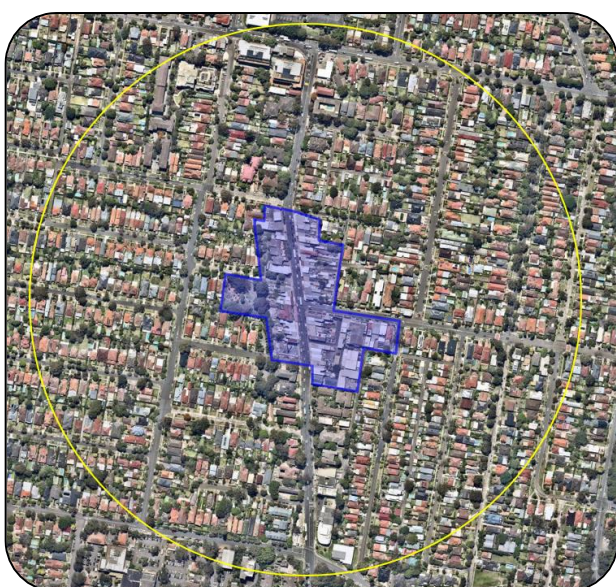


Table 11-1 Willoughby South land use mix

Town Centre	
Office / Commercial	3,300 m ²
Medical	300 m ²
Shopping / Retail	4,850 m ²
Restaurant	350 seats
Health / Fitness	120 m ²
Service Station	9 pumps
Hotel	32 rooms
Attached Housing	30 dwellings
Parking	
Off-Street Supply	130 spaces
On-Street Supply	80 spaces
Peak Non-Residential Parking Demand	250 spaces
Surrounds (400m)	
Detached Housing	680 dwellings
Attached Housing	360 dwellings

The Willoughby South local centre contains a number of pedestrian-generating land uses including:

- > Willoughby Road shops and cafes;
- > Frenchs Road shops and cafes; and
- > St Philip Neri Primary School.

The majority of all pedestrian movement within the Willoughby South occurs on Willoughby Road, operating as both a destination for people and as a movement corridor. Willoughby Road allows direct access to Willoughby South's shopping precinct. Site based observations during the afternoon hours showed that foot traffic was directed from the boundaries of the local centre towards shops on Willoughby Road.

11.1.2 Planned

Forecast development, land uses and uplift were obtained from the *Willoughby Local Centres Strategy* and discussions with Council. Total figures were provided for residential and non-residential floor space under the preferred scenario, as well as an indicative overview of the vision for the local centre.

Assumptions will be made in regards to specific uplift of particular blocks and positioning of access points to inform the future network review and traffic modelling.

The Willoughby South local centre is forecast for significant uplift in residential dwellings and minimal uplift in commercial floor space. The preferred scenario contains the following key features:

- > A total of 26,265 sqm GFA of residential floor space, representing an uplift of 21,286 sqm or 428 per cent;
- > A total of 17,292 sqm GFA of non-residential floor space, representing an uplift of 1,219 sqm or 8 per cent;
- > New laneways from Julian Street to Penkivil Street and Borlaise Street;
- > A new street plaza on Julian Street by closing Julian Street at Willoughby Road or providing a shared left-out only lane;
- > Various landscaping and pedestrian access improvements around Sanders Park; and
- > A kerb extension on the north side of Frenchs Road at the corner of Willoughby Road.

An indicative representation of the scale and distribution of the proposed development is presented in **Figure 11-2**.

Figure 11-2 Potential development at Willoughby South – preferred scenario



Source: Willoughby Local Centres Strategy

The details have not yet been well defined but the development is expected to largely contain first-floor commercial uses with shop-top housing.

11.1.3 Community concerns

47 people provided feedback about the *Draft Local Centres Strategy* for Willoughby South, with people generally supporting revitalisation of the area. Some responses questioned the viability and proposed mix of land uses, as well as the proposed heights and FSRs. The key community feedback related to traffic and transport issues were focused on the following:

- > Concerns about existing traffic and parking issues; and
- > The need for infrastructure improvements before development is undertaken.

The community concerns are discussed further in the following sections together with the review of the existing and future transport networks.

11.2 Existing transport networks

11.2.1 Road network and traffic

The Willoughby South road network primarily supports north-south trips within the centre, with provisions for local east-west movements. Willoughby Road is the centre's key movement corridor and functions as part of a busy corridor connecting to neighbouring centres such as Penshurst Street and Naremburn. It also connects quieter suburban streets with the local centre.

Borlaise Street, Frenchs Road, Julian Street and Penkivil Street intersect with Willoughby Road to provide east-west movement into the local centre from surrounding residential areas.

Willoughby Road accommodates the greatest traffic volumes within the Willoughby South local centre. Intersection volumes are highest at the Willoughby Road / Frenchs Road intersection and the Willoughby Road / Penkivil Street intersection.

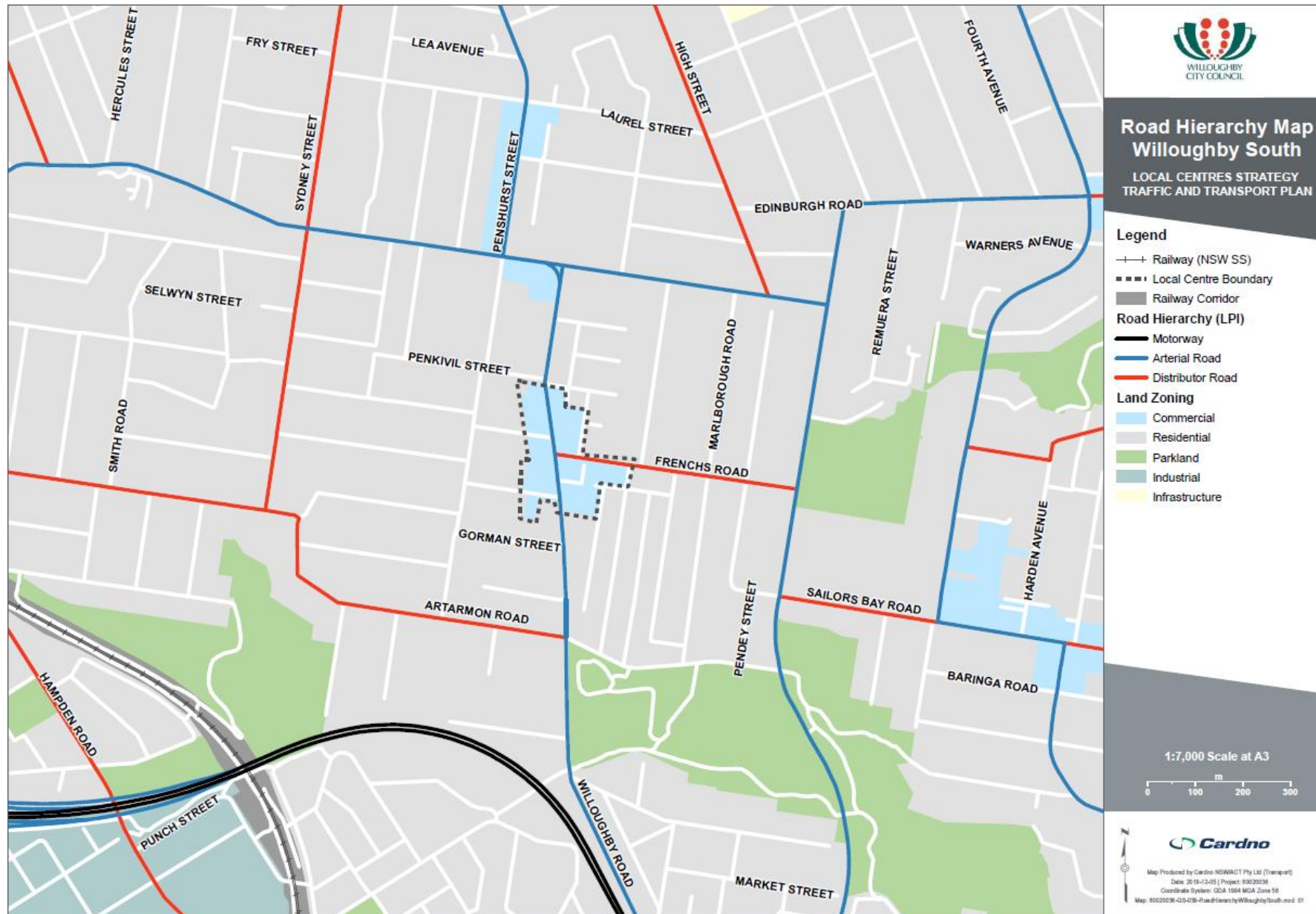
The key roads within the Willoughby South local centre are shown in **Table 11-2**.

Table 11-2 Key roads

Road name	Road Classification	Managing Authority	Number of Lanes	Speed Limit
Willoughby Road	State Road	TfNSW	4 travel lanes during morning clearways (2 travel lanes and 2 parking lanes in the afternoon and off-peak)	60 km/h
Frenchs Road	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h
Penkivil Road	Local Road	Willoughby Council	2 travel lanes and 2 parking lanes	50 km/h

The road hierarchy map is shown in **Figure 11-3**.

Figure 11-3 Road hierarchy



11.2.2 Safety

Five-year crash data history was analysed from 2014 to 2018 (inclusive). Overall there were 14 reported crashes within the local centre of Willoughby South. A summary of crashes by severity is shown in **Table 11-3**.

Table 11-3 Crash summary by severity

Year	Fatal	Serious Injury	Moderate Injury	Minor / Other Injury	Non-Casualty (tow away)	TOTAL
2014	0		2			2
2015	0			2	2	4
2016	0	2			2	4
2017	0			1	1	2
2018	0	1			1	2
TOTAL	0	3	2	3	6	14

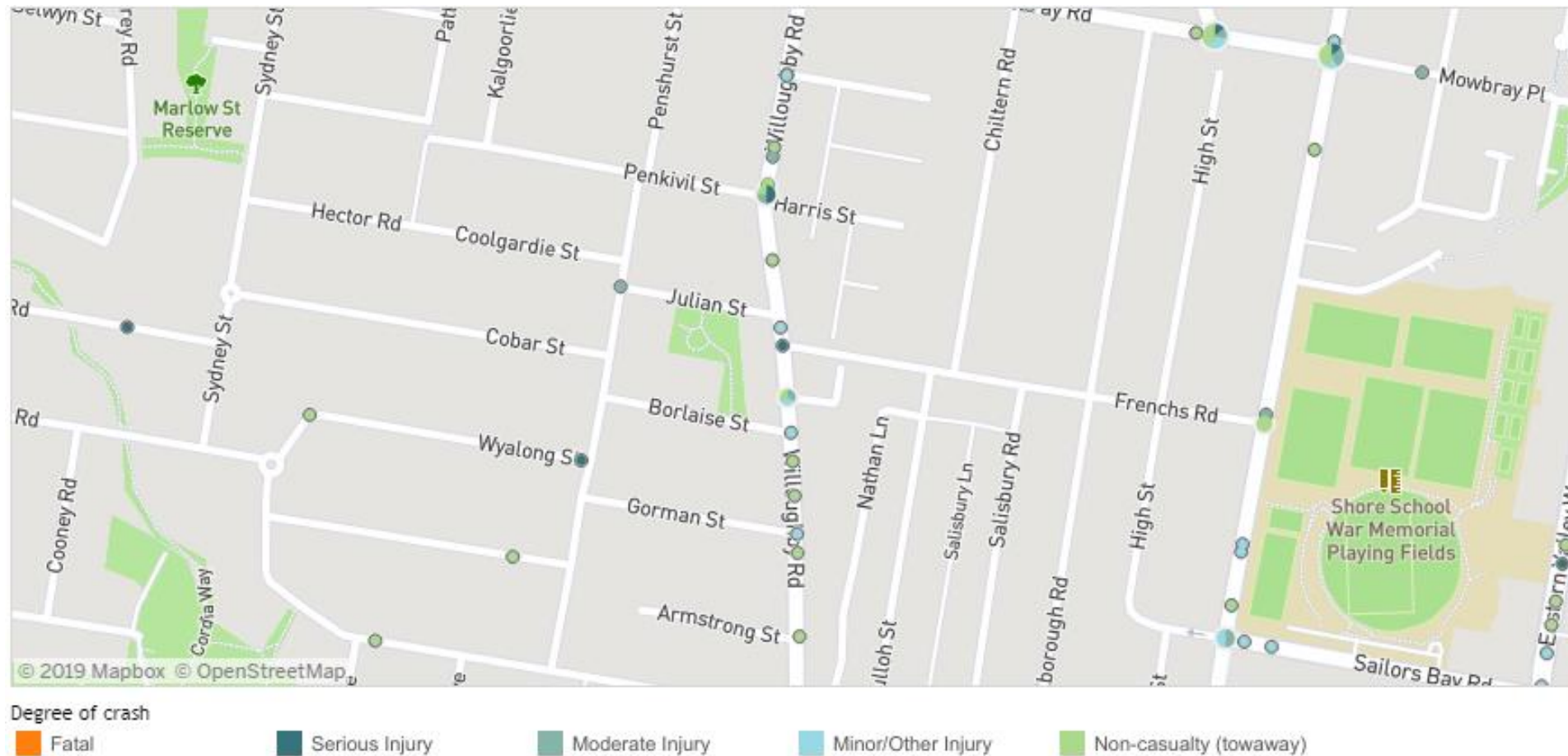
There were no fatalities within the local centre during the five-year period, however three crashes resulted in serious injury.

11.2.2.2 Crash Locations

All crashes recorded within the local centre from 2014 to 2018 (inclusive) occurred on Willoughby Road. Crash clusters are evident at the Willoughby Road / Penkivil intersection and the Willoughby Road / Prentice Lane intersection. One crash involving a pedestrian was recorded and resulted in serious injury.

Crash locations within the Willoughby South local centre are shown in **Figure 11-4**.

Figure 11-4 Crash map



Source: NSW Centre for Road Safety

11.2.3 Existing pedestrian network and infrastructure

Willoughby Road, serving as the centres key walking corridor supports pedestrian movement with the provision of wide footpaths along shop fronts. Wide footpaths are also provided on Frenchs Road as shown in **Figure 11-5**. Adjoining Streets such as Borlaise Street, Julian Street and Penkivil Street offer footpaths approximately 1.2 – 1.5 metres wide, transitioning to wider footpaths at Willoughby Road as show in **Figure 11-6** to the commercial centre of Willoughby South.

The local centre provides signalised crossings at the intersection of Willoughby Road and Frenches Road. The crossings are well located to allow pedestrians to cross the street at a central location within the centre. However, aside from the intersection there are no other pedestrian crossing facilities within the local centre. As a result, pedestrians must walk up to 150 metres to reach a crossing from the northern end of the Willoughby Road.

The Willoughby South local centre walking catchment is shown in **Figure 11-7**.

Figure 11-5 Footpath on Frenchs Road



Figure 11-6 Transition from wide to standard footpath

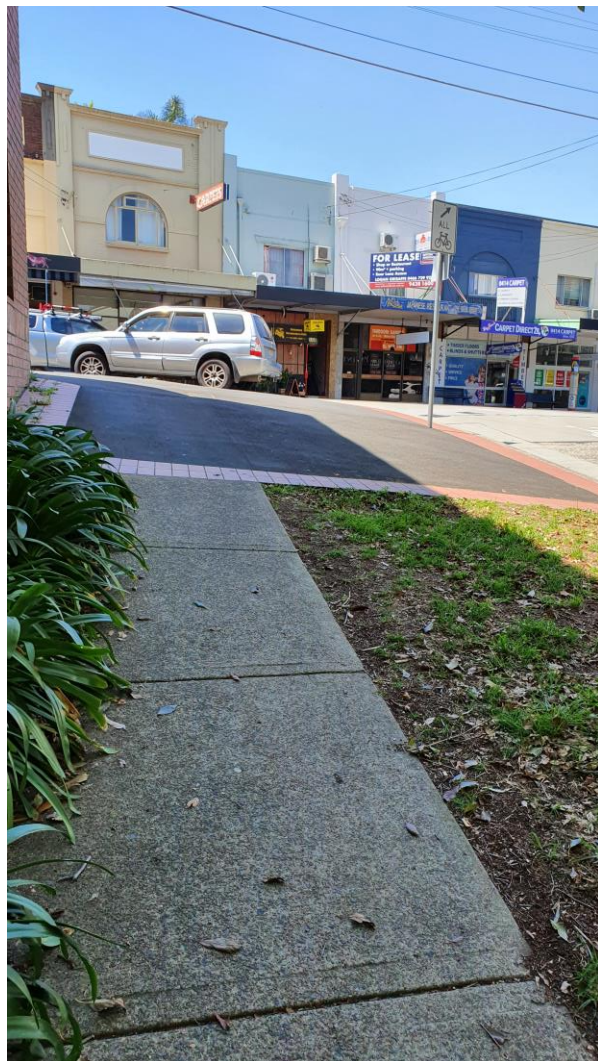
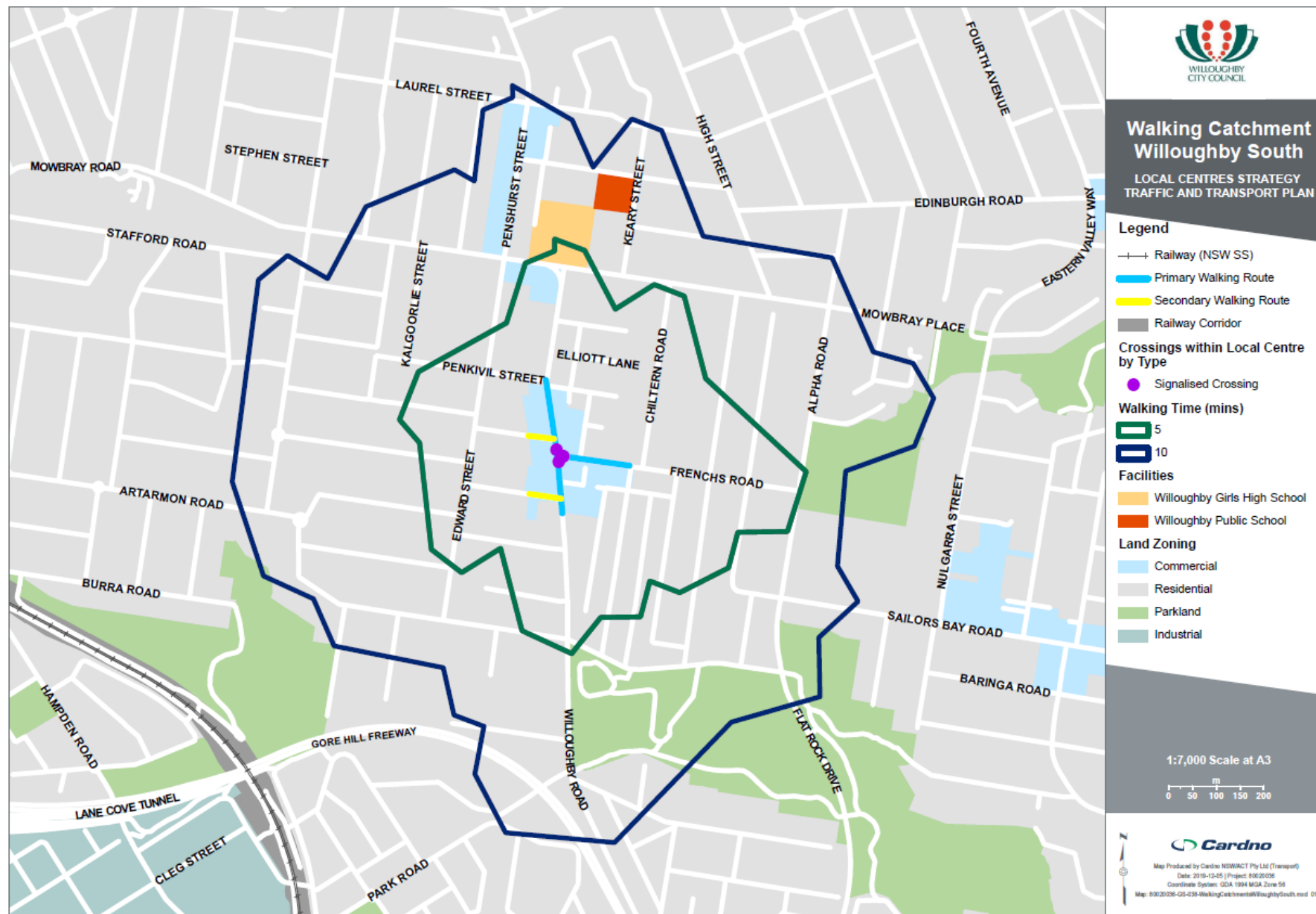


Figure 11-7 Walking routes



11.2.4 Cycling

Willoughby South provides on-road, mixed traffic cycling environments. The bike routes operate as links connecting the local centre of Willoughby South with the local centres of High Street and Castlecrag. On-site observations showed bike signage to be present on Frenchs Road, Willoughby Road and Julian Street, as shown in **Figure 11-8** and **Figure 11-9**. This is not consistent with illustrations within the Willoughby Bike Plan showing an on-road bicycle route that follows the alignment of Willoughby Road and Penkivil Street. No bike signage is provided on Willoughby Road in the southbound direction.

Strava, an online fitness tracking application for cycling, shows popular cycling routes logged via mobile applications and provides indicative data on recreational cycling demand. Strava data was reviewed to identify key routes currently used by cyclists, and the data indicated cyclists use Willoughby road as a primary north south movement corridor. Frenchs Road is utilised as an east-west connection to reach the Alpha Road corridor.

There are no bike racks within the local centre.

Figure 11-8 Bike signage directing cyclists on Willoughby Road into Julian Street

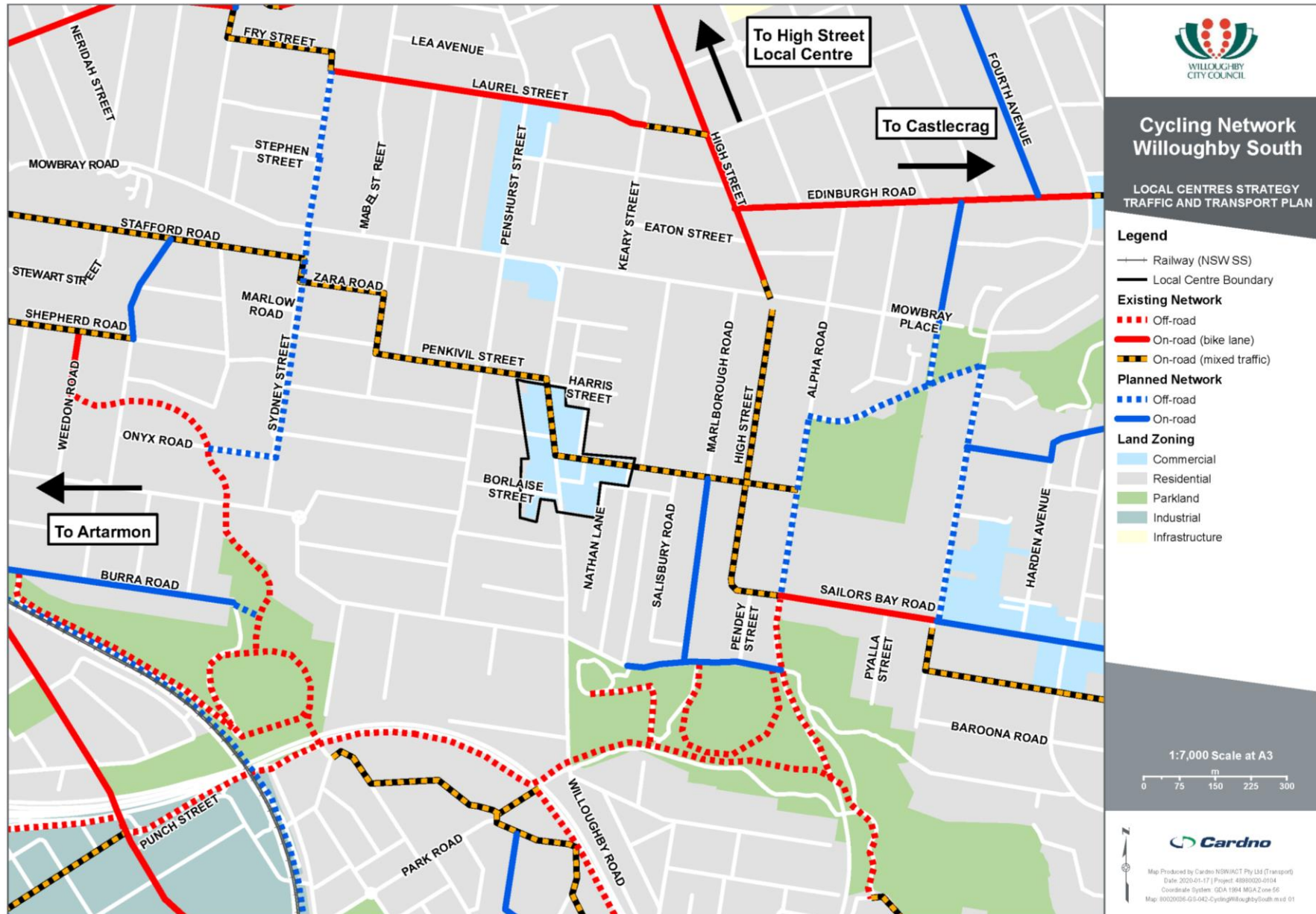


Figure 11-9 Bike signage on Frenchs Road



A map of the existing and proposed bicycle network is presented in **Figure 11-10**.

Figure 11-10 Bicycle network



11.2.5 Public Transport

Public transport is available within the centre through the provision of bus services operated by the STA on Willoughby Road. These services connect the local centre of Willoughby South with the Sydney CBD, Chatswood, Mosman, Bondi Junction and Kingsford. Services to destinations such as the Sydney CBD and Chatswood operate regularly throughout the day. Commuters must travel to the Chatswood interchange in order to reach destinations west and north of the Willoughby LGA.

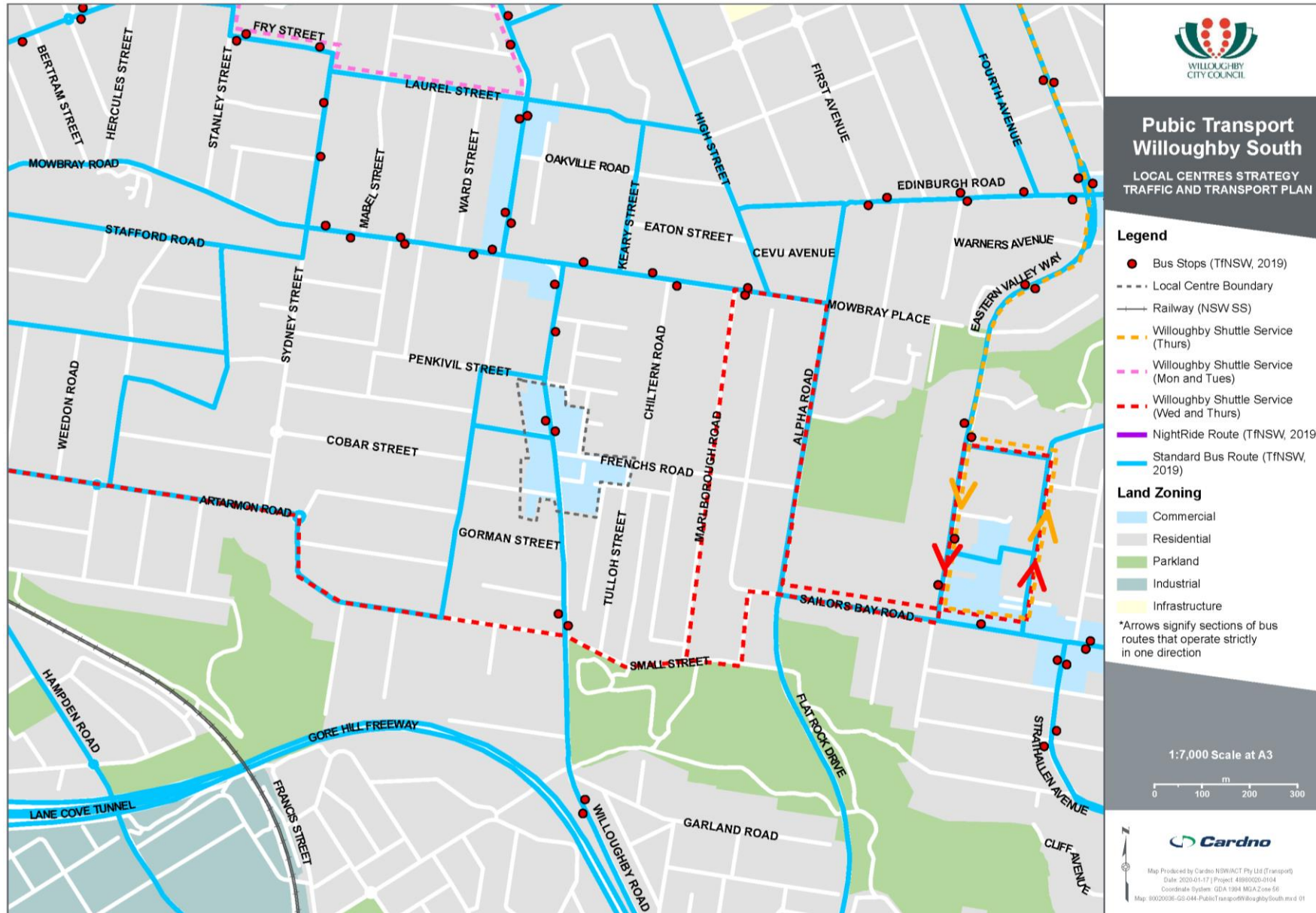
The bus routes servicing the local centre are outlined in **Table 11-4**.

Table 11-4 Bus routes serving the Willoughby South local centre

Bus route	Route description	Areas served
257	Chatswood to Balmoral via Crows Nest	Chatswood station, Willoughby, Naremburn, Crows Nest, Neutral Bay, Mosman, Balmoral Beach
272	North Willoughby to City Wynyard	North Willoughby, South Willoughby, Sydney CBD (Wynyard)
340	Bondi Junction to Chatswood	Chatswood station, North Willoughby, South Willoughby, Sydney CBD, Paddington, Bondi Junction
343	Kingsford to Chatswood	Chatswood station, North Willoughby, South Willoughby, Naremburn, Crows Nest, North Sydney, Sydney CBD, Surry Hills, Waterloo, Rosebury, Kingsford

A map of the public transport services within and around the Willoughby South local centre is provided in **Figure 11-11**.

Figure 11-11 Public transport map



11.2.6 Freight, services and loading

The local centre does not provide any dedicated on-street loading zones.

Penshurst Street is designated as a Short Combination route as part of the Higher Mass Limits (HML) network, and provides a freight corridor running through the local centre.

11.2.7 Ride and vehicle sharing services

The local centre does not have dedicated ride or vehicle sharing services.

11.2.8 Parking provision

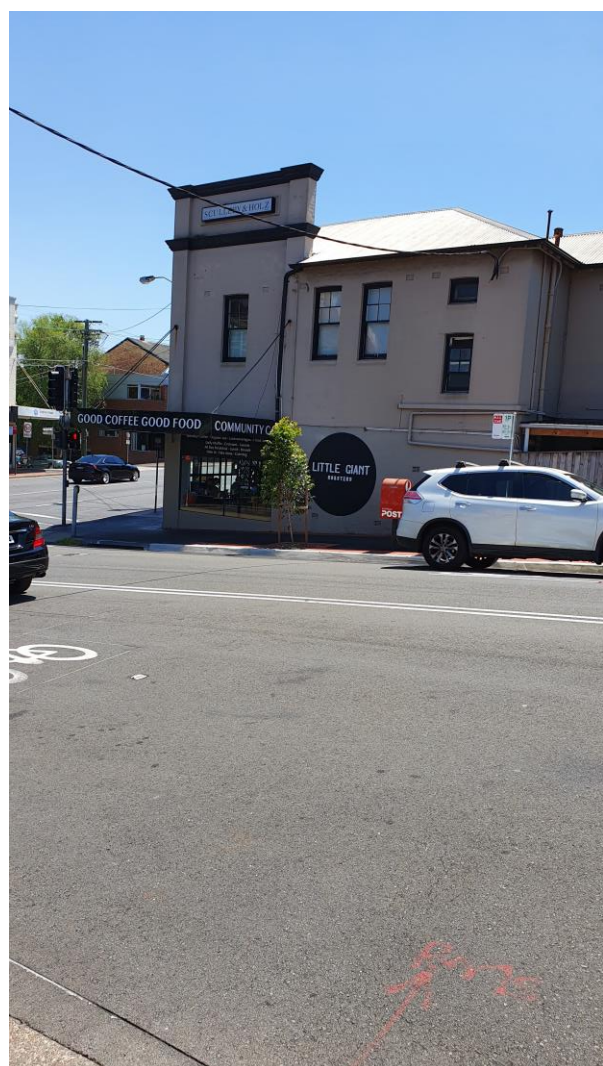
Willoughby South provides time restricted parking on Willoughby Road, with the exception of morning clearways. Additional time restricted parking is also available on Frenchs Road and Julian Street with two carparks provided on Borlaise Street.

Taxi zones accommodating five vehicles are also provided on Frenchs road, at locations close to shops and restaurants as shown in **Figure 11-12**. A mail zone is situated on Frenchs Road, near the intersection with Willoughby Road as shown in **Figure 11-13**.

Figure 11-12 Taxi zones on Frenchs Road



Figure 11-13 Mail zone on Frenchs Road



There are no provisions for accessible parking within the local centre of Willoughby South.

An overview of parking availability for the weekday AM & PM peak periods is shown in **Figure 11-14**.

Parking profiles indicating the total parking requirement over the course of the day are presented in **Figure 11-15** and **Figure 11-16**. For further details and an explanation of these graphs refer to **Appendix B**.

Figure 11-14 Parking availability

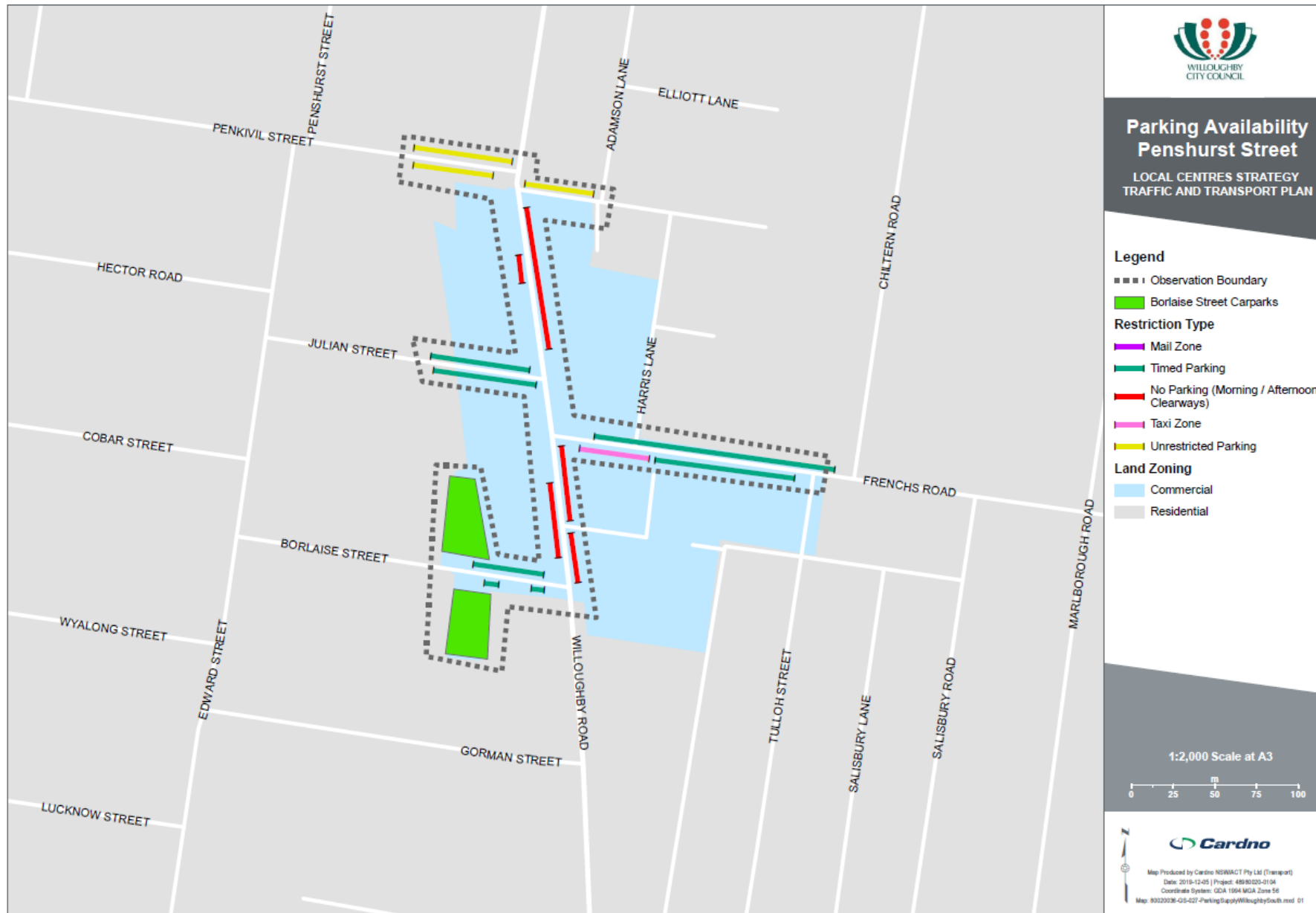


Figure 11-15 Willoughby South weekday parking profile

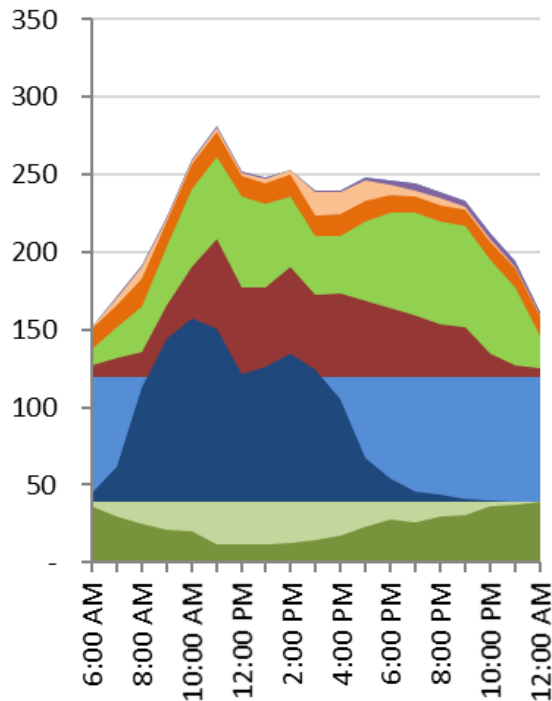
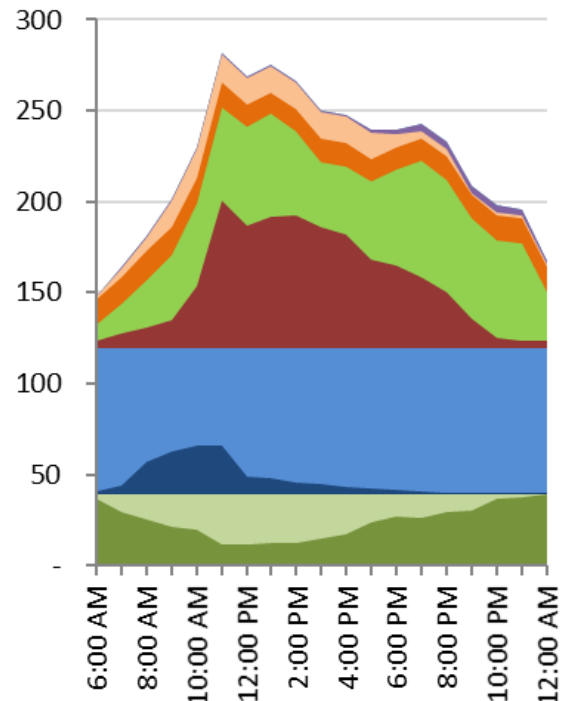


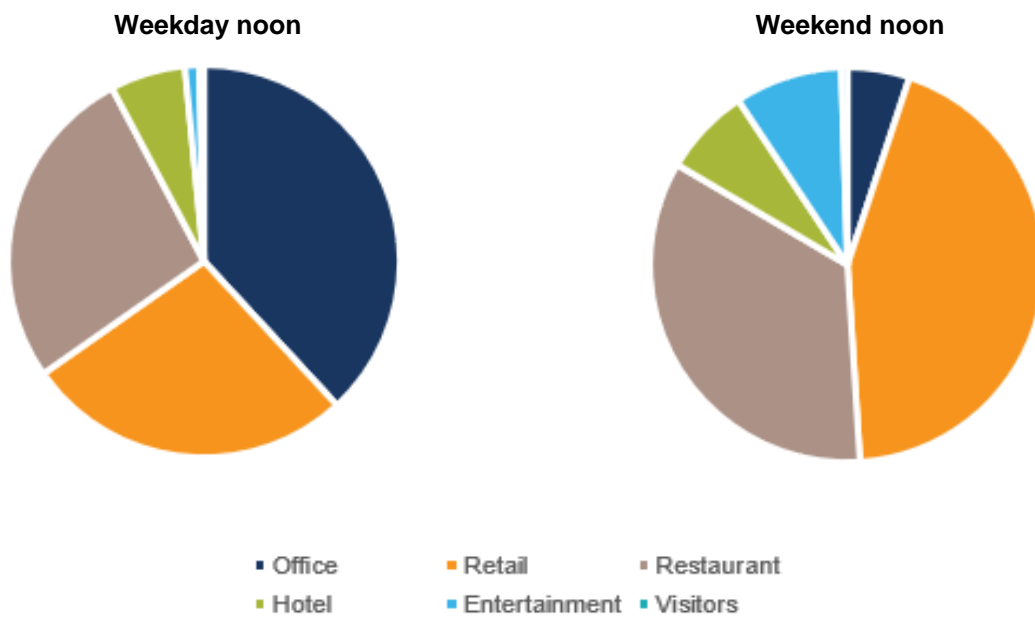
Figure 11-16 Willoughby South weekend parking profile



Visitor Office Employee Parking (Vacant)
 Hotel Entertainment Residential Parking (Vacant)
 Retail Restaurant Residential Parking (Occupied)

A breakdown of the weekday peak parking demand by land use is presented in **Figure 11-17** **Figure 4-16**.

Figure 11-17 Willoughby South peak parking demand



11.2.8.2 Willoughby South parking function

The Willoughby South Local Centre generates approximately 110 spaces in employee parking demand, which is partly contained in small on-site parking facilities within individual lots. This form of parking is intrinsically

inefficient, and likely results in a high degree of overspill into the local road network (Edward Street, Chiltern Road and Tulloh Street).

Short-stay visitor parking has been determined to be in the order of 140 spaces during the peak weekday period, and as much as 200 spaces on the weekend.

The existing provision of short-stay parking is limited to approximately 60-70 off-street parking bays accessed via Borlaise Street, and available on-street parking along minor roads and in Clearway zones along Willoughby Road.

11.2.8.3 Parking recommendations

Recommendation (Infrastructure):

Improve wayfinding signage to the Borlaise Street car parks from both directions along Willoughby Road.

Restrict parking to short-stay (2P) on minor roads connecting with Willoughby Road.

Willoughby Road parking should be standardised to allow 1P outside of clearway periods.

11.2.9 Intersection modelling

11.2.9.1 Intersection counts

For the Willoughby South local centre, a total of two intersections were surveyed and included:

- > Willoughby Road / Julian Street (priority controlled); and
- > Willoughby Road / Frenchs Road (signalised intersection).

The peak one-hour periods with the heaviest traffic were identified to be:

- > 7:15am – 8:15am for the weekday AM peak;
- > 4:45pm – 5:45pm for the weekday PM peak; and
- > 10:15am – 11:15am for the Saturday midday peak.

The data was used to inform the traffic modelling by providing the traffic under existing conditions. Volumes and intersection modelling results are presented in **Appendix A**.

11.2.9.2 Intersection modelling results

SIDRA intersection modelling results for key intersections within the Willoughby South local centre are presented in **Table 11-5**. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 11-5 SIDRA intersection modelling results – Willoughby South

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Willoughby Road / Harris Street	0.680	428.5	F	0.536	198.9	F	0.637	95.9	F
Willoughby Road / Julian Street	0.418	168.7	F	0.885	187.9	F	0.617	87.3	F
Willoughby Road / Frenchs Road	0.607	8.6	A	0.748	5.7	A	0.893	18.5	B

The Willoughby Road / Harris Street intersection is performing unsatisfactorily at LoS F in all peak periods. Similarly, the Willoughby Road / Julian Street intersection is also performing unsatisfactorily at LoS F in all peak periods.

The poor performance of the Willoughby Road / Harris Street intersection in all peak periods is due to the right turning vehicles from the side streets such as Harris Street and Penkivil Street, which are unable to find a gap due to queue spillback in the downstream of Willoughby Road. As result of the queues on Willoughby Road the side road traffic is not able to find a gap in reasonable time as the headways are too small.

Similarly, the poor performance of the Willoughby Road / Julian Street intersection in all peak periods is also due to the right turning vehicles from Julian Street which are unable to find a suitable gap.

The Willoughby Road / Frenchs Road intersection is performing at LoS B or better in all peak periods, which indicates that this intersection is operating satisfactorily and has spare capacity.

11.2.10 Summary of opportunities and constraints

Key opportunities and constraints of the Willoughby South local centre are summarised in **Table 11-6**:

Table 11-6 Opportunities and constraints

Opportunities	Constraints
<ul style="list-style-type: none"> Direct access to Sydney CBD via Willoughby Road and the M1 Potential for improved pedestrian treatments and connections Council car parks on Borlaise Street provide off-street car parking 	<ul style="list-style-type: none"> Clearway restrictions limit on-street parking availability

11.3 Future transport network review and recommendations

11.3.1 Traffic network analysis

11.3.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at Willoughby South in accordance with **Table 11-7**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 11-7 Apartment mix and occupancy – Willoughby South

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	39	1.7	65
1 bedroom	14%	55	1.7	91
2 bedroom	60%	236	2.3	538
3 bedroom	16%	63	2.8	176
Total	100%	393	-	870

¹Based on ABS 2016 Census Data

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 11-8**. The employee densities were adopted from TfNSW guidelines for office space and typical employee densities for retail and hospitality.

Table 11-8 Non-residential floor space assumptions – Willoughby South

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	35%	1 / 40 sqm	151
Hospitality	25%	1 / 20 sqm	216
Office	40%	4.75 / 100 sqm	329
Total	100%	-	696

Based on these assumptions the Willoughby South local centre is expected to accommodate approximately 870 residents and 700 employees.

11.3.1.2 Parking requirements

The minimum car parking requirements in accordance with the DCP are presented in **Table 11-9**.

Table 11-9 Minimum car parking requirements – Willoughby South

Land use		Rate	Proposed development	Spaces required
Residential (non-adaptable units)	Studio	0.5 / dwelling	39 dwellings	20
	1 bedroom	1 / dwelling	55 dwellings	55
	2 bedroom	1 / dwelling	236 dwellings	236
	3 bedroom	1 / dwelling	63 dwellings	63
	Visitors	0.25 / dwelling	393 dwellings	98
			Residential subtotal	471
Commercial	Retail	36 sqm / space	6,052 sqm GFA	169
	Hospitality	107 sqm / space	4,323 sqm GFA	40
	Office	110 sqm / space	6,917 sqm GFA	63
			Commercial subtotal	272
			Development total	743
	Motorbike parking	1 / 25 car parking spaces	743 spaces	29

Note: Table shows rounded values. Subtotals were rounded down in accordance with the DCP.

Based on these calculations, the proposed development would be required to provide a minimum of 743 car parking spaces (including accessible parking spaces) and 29 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 11-10**.

Table 11-10 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	393 units	39
Retail	1 / 450m sqm GFA	6,052 sqm GFA	13
Hospitality	1 / 450m sqm GFA	4,323 sqm GFA	10
Office	1 / 600 sqm GFA	6,917 sqm GFA	12
Total			74

The calculations indicate that the proposed development would be required to provide 74 bicycle spaces.

11.3.1.3 Trip generation

Based on the trip generation rates presented in **Section 3.3**, the estimated number of trips generated by the proposed development are presented in **Table 11-11**. An estimate of existing traffic generated by the current land uses is also provided, as well as the additional traffic expected to be generated.

Table 11-11 Future traffic generation

Land use	Total development (existing + proposed)	Traffic generation (veh/hr)		
		AM peak	PM peak	Saturday peak
Residential	393 units	75	59	75
Retail	4,539 sqm GLFA	51	162	41
Hospitality	3,242 sqm GLFA	36	127	243
Office	6,917 sqm GFA	111	83	0
Total		272	431	359
Existing traffic generation		198	357	278
Additional traffic generated		+74	+74	+80

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

On this basis the proposed development is expected to generate an additional 74 vehicle movements in the AM peak hour, 74 in the PM peak and 80 in the Saturday peak.

However, the mode share for the sites surveyed by TfNSW averaged out to approximately 30 per cent for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the Willoughby South local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 39 per cent for residents and 63 per cent for workers. This represents a higher mode share than those surveyed for the TfNSW traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis, a mode share discount of 5 per cent was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 34 per cent for residents and 58 per cent for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

11.3.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 11-12**.

Table 11-12 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the additional traffic generated to determine the inbound and outbound trips presented in **Table 11-13**.

Table 11-13 Inbound and outbound additional traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	14	94	38	28	34	59
Retail	2	3	7	11	2	3
Hospitality	2	2	6	7	10	17
Office	8	2	1	10	0	0
Total (additional traffic generated)	26	101	51	56	46	78

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 11-14**.

Table 11-14 Directional assumptions

Direction	In %	Out %
North	35%	45%
East	0%	0%
South	52%	26%
West	14%	29%
Total	100%	100%

Source: ABS 2016 Census Data

Note: Table shows rounded values. Totals are obtained directly from calculations and rounded to the nearest whole number.

11.3.1.5 Intersection modelling results

Intersection modelling was undertaken for key intersections within the Willoughby South local centre using SIDRA Network software. The modelling examined the intersection performance for the following scenarios:

1. 2036 With 100 per cent Development; and
2. 2036 With 75 per cent Development.

The 2036 With 100 per cent Development scenario represents a full development case which may be realised in 2036. The 2036 With 75 per cent Development scenario represents a case where the development is not fully achieved, and is presented to understand the impacts of a reduced scale of development which may occur at an earlier point in time. The results and key findings of each scenario are presented in the following sections.

11.3.1.5.1 2036 With 100 per cent Development modelling results

It is noted that in the existing layout, Julian Street allowed traffic to enter and exit. In 2036, it is proposed that Julian Street will be converted to a cul-de-sac for motor vehicles.

Figure 11-17 summarises the intersection performance of the Willoughby South local centre for the 2036 With 100 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 11-15 Future intersection performance – Willoughby South

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Willoughby Road / Harris Street	2.571	1836.9	F	2.281	1836.8	F	0.844	373.6	F
Willoughby Road / Julian Street	0.457	0	A	0.447	0	A	0.486	0	A
Willoughby Road / Frenchs Road	0.778	10	A	0.841	6	A	1.051	43	D

It is expected that the Willoughby Road / Harris Street intersection will perform unsatisfactorily at LoS F in all peak periods, consistent with the 2019 base model. This is associated with the right turn movement on Harris Street and Penkivil Street, which is identified as the worst-performing movement. Due to an increase in volumes on Willoughby Road, the opportunity for right-turning vehicles from the side streets will decrease as the likelihood of the queue spillback in the downstream of Willoughby Road increases. This inhibits the ability of traffic on the side streets to find safe and suitable gaps as the headways have decreased further in comparison to the existing base model. This is also reflected in the degree of saturation, which exceeds 1.0, indicating that it is oversaturated. The delay is excessive and expected to create safety concerns if no mitigation measures are undertaken.

In 2019, the Willoughby Road / Julian Street intersection was also failing due to the right turning vehicles from Julian Street. It is proposed in the *Willoughby Local Centres Strategy* that Julian Street be converted to a cul-de-sac, hence the intersection will longer operate as an intersection.

In the Saturday peak period, the Willoughby Road / Frenchs Road intersection is expected to operate near capacity at LoS D. This is a deterioration in operation from 2019, from LoS B. In the other peak periods, this intersection will perform satisfactorily at a LoS A.

11.3.1.5.2 2036 With 75 per cent Development modelling results

In the existing layout, Julian Street allowed traffic to enter and exit. In 2036, it is proposed that Julian Street will be converted to a cul-de-sac.

Table 11-16 summarises the intersection performance of the Willoughby South local centre for the 2036 with 75 per cent Development scenario. A detailed summary of the SIDRA results is provided in **Appendix B**.

Table 11-16 Intersection performance – Willoughby South

Intersection	Weekday AM Peak			Weekday PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Willoughby Road / Harris Street	2.078	1454.4	F	1.754	1484.4	F	0.729	301	F
Willoughby Road / Julian Street	0.454	0	A	0.446	0	A	0.485	0	A
Willoughby Road / Frenchs Road	0.761	9.5	A	0.836	6	A	1.042	41	C

Under the 2036 With 75 per cent Development scenario, there are improvements to the intersection performance compared to the 2036 With 100 per cent Development scenario. The Willoughby Road / Frenchs Road intersection performs better in the Saturday peak period, where the level of service improves from LoS D to LoS C with a 4 per cent reduction in average delay of the intersection. This is due to a reduction in the demand on Willoughby Road (Southern Approach), where it is expected that there will be five fewer vehicles on the southern approach.

There are minor performance improvements to the other intersections in the 2036 With 75 per cent Development scenario in comparison to the 2036 With 100 per cent Development scenario, however the level of service categories remain the same.

11.3.2 Parking analysis

Only a minor increase in non-residential uses (8 per cent overall growth) is expected for the Willoughby South Local Centre. This can be generally accommodated within the existing parking supply.

The quantity of proposed residential development could stress the on-street parking supply if residents continue to use the street network as private vehicle storage.

Measures will be necessary to curtail this behaviour, comprising a combination of duration limits, paid parking and appropriately priced residential permits, as discussed in **Appendix B**.

Figure 11-18 Willoughby South future non-residential parking demand weekday profile

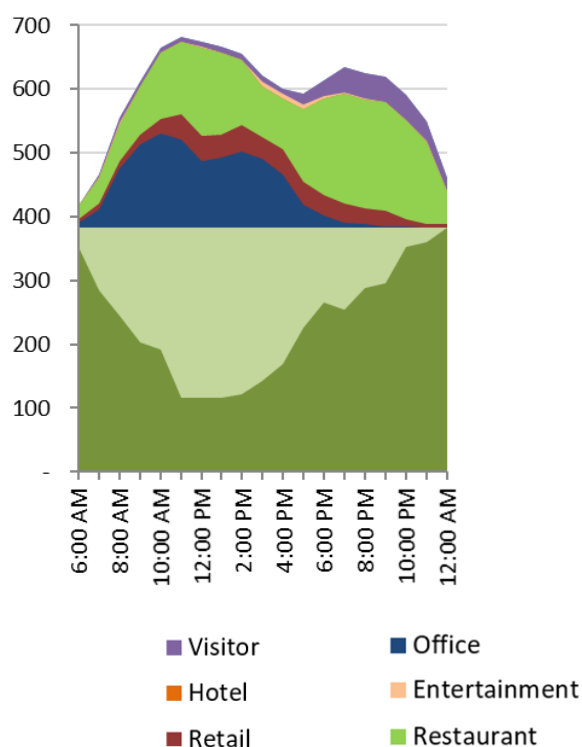
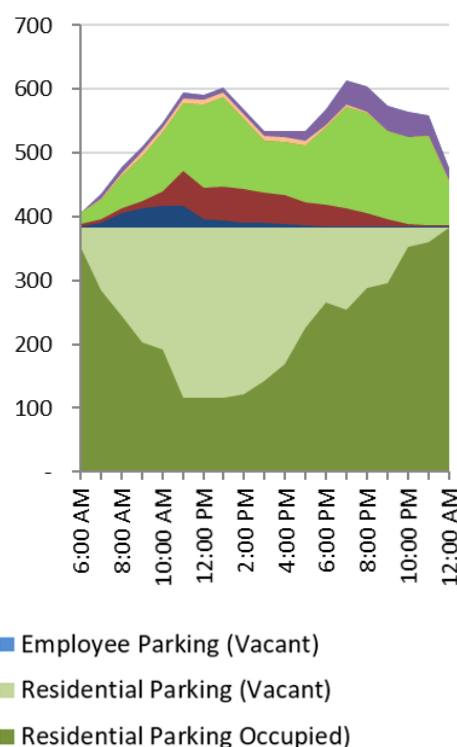


Figure 11-19 Willoughby South future non-residential parking demand weekend profile



11.3.3 Active Transport

Walking and cycling needs within the Willoughby South local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

Willoughby South already contains an established footpath and cycle network, although some opportunities for improvement may be available to improve crossing opportunities for pedestrians and cycle parking within the centre.

Recommendations to address these issues are summarised in **Section 11.3.5**.

11.3.4 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

Willoughby South is well connected by bus services along Willoughby Road, providing access to areas including Chatswood, Crows Nest, North Sydney and the Sydney CBD. Opportunities to improve public transport may be limited to increasing the service frequency.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 11.3.5**.

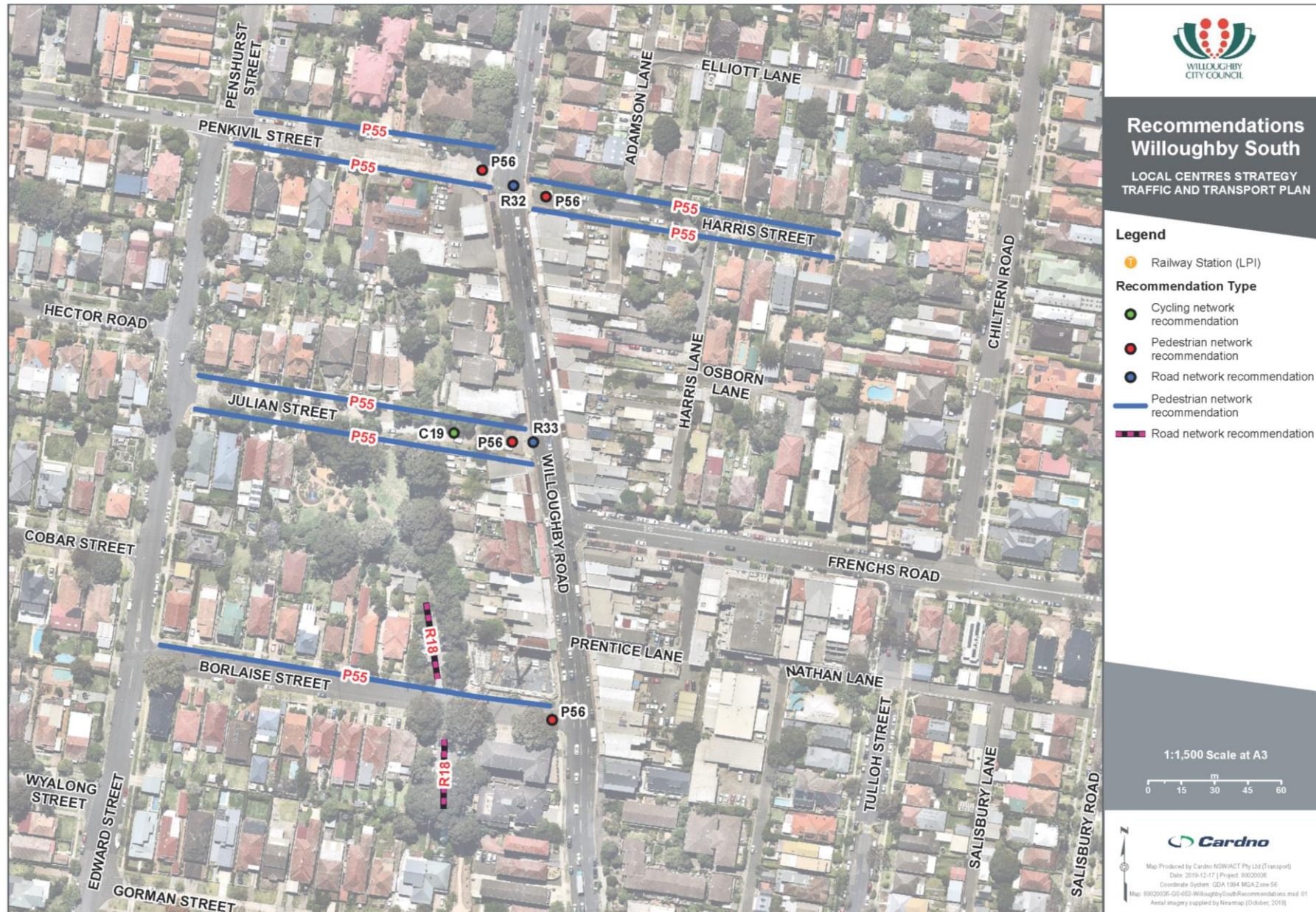
11.3.5 Issues and options

The issues and recommendations for the local centre are summarised in **Table 11-17** and **Figure 11-20**.

Table 11-17 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P55	Narrow footpaths on Julian Street, Harris Street, Penkivil Street and Borlaise Street.	Widen the footpaths on Julian Street, Harris Street, Penkivil Street and the northern side of Borlaise Street to a minimum of 2m.	Footpath	955 metres
P64	Limited crossing opportunities on Willoughby Road.	Investigate opportunities for additional crossings on Willoughby Road.	Crossings	2
Bicycle				
C15	Lack of bike parking provision.	Provide bike parking to accommodate demand for cycle parking and encourage cycling as a travel mode.	Bike parking	8
C19	Incorrect indication of cycle routes in the Willoughby Bike Plan.	Revise the bike plan maps to indicate the correct cycle route to the west of Willoughby Road as Julian Street - Hector Road - Patton Lane - Zara Road (instead of Penkivil Street).	Bike map	1
Road network				
R18	Poor wayfinding signage to the Borlaise Street car parks.	Improve wayfinding signage to the Borlaise Street car parks from both directions along Willoughby Road.	Parking signage	
R30	Insufficient short-stay parking provision.	Restrict parking to short-stay (2P) on minor roads connecting with Willoughby Road.	Parking signage	
R31	Mixed parking restrictions along Willoughby Road.	Willoughby Road parking should be standardised to allow 1P outside of clearway periods.	Parking signage	
R32	Poor intersection performance at Willoughby Road / Harris Street / Penkivil Street (LoS F) in all peaks.	Ban the right turn movements from Harris Street into Willoughby Road and Penkivil Street into Willoughby Road.	Right turn ban	2
R33	Poor intersection performance at Willoughby Road / Julian Street (LoS F) in all peaks.	Convert Julian Street into a cul-de-sac at Willoughby Road in accordance with the <i>Local Centres Strategy</i> .	Intersection reconfiguration	1

Figure 11-20 Recommendations map



APPENDIX

A

SIDRA MODELLING RESULTS

APPENDIX

B

PARKING ANALYSIS