Cycling Aspects of Austroads Guides

Austroads

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This is the third edition of *Cycling Aspects of Austroads Guides*. This edition has been revised to ensure its currency and to clarify and highlight links to other Austroads Guides. Key updates include:

- improving cross-references to other Austroads guidance, including summary cross-reference tables at the beginning of each section and sourcing material of each section in the margins of the document
- updating the report to reflect new editions of the Guide to Traffic Management (Parts 4, 7, 8, 10 and 11), Guide to Road Design (Parts 4, 4B, 4C, 6A and 6B).

Abstract

Cycling Aspects of Austroads Guides contains information that relates to the planning, design and traffic management of cycling facilities and is sourced from Austroads Guides, primarily the *Guide to Road Design*, the *Guide to Traffic Management* and the *Guide to Road Safety*.

The document is intended as a guide for engineers, planners and designers involved in the planning, design, construction and management of cycling facilities. Throughout the document practitioners are referred to relevant Austroads Guides for additional information.

The report provides:

- an overview of planning and traffic management considerations and cross-references to other Austroads Guides and texts for further detailed information
- a summary of design guidance and criteria relating to on-road and off-road bicycle facilities together with a high level of cross-referencing to the relevant Austroads Guides for further information
- information and cross-references on the provision for cyclists at structures, traffic control devices, construction and maintenance considerations and end-of-trip facilities.

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About Austroads

Austroads is the peak organisation of Australasian road transport and traffic agencies.

Austroads' purpose is to support our member organisations to deliver an improved Australasian road transport network. To succeed in this task, we undertake leading-edge road and transport research which underpins our input to policy development and published guidance on the design, construction and management of the road network and its associated infrastructure.

Austroads provides a collective approach that delivers value for money, encourages shared knowledge and drives consistency for road users.

Austroads is governed by a Board consisting of senior executive representatives from each of its eleven member organisations:

- Roads and Maritime Services New South Wales
- Roads Corporation Victoria
- Queensland Department of Transport and Main Roads
- Main Roads Western Australia
- Department of Planning, Transport and Infrastructure South Australia
- Department of State Growth Tasmania
- Department of Infrastructure, Planning and Logistics Northern Territory
- Transport Canberra and City Services Directorate, Australian Capital Territory
- Australian Government Department of Infrastructure and Regional Development
- Australian Local Government Association
- New Zealand Transport Agency.

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Summary

This publication contains key information that relates to the planning, design and traffic management of cycling facilities and is sourced from Austroads Guides, primarily the *Guide to Road Design*, the *Guide to Traffic Management* and the *Guide to Road Safety*.

Cycling Aspects of Austroads Guides has been produced to ensure that key information is readily available for practitioners who have a specific interest in cycling issues and facilities. However, users of the report should be aware that:

- The design guidance is summarised for the convenience of practitioners and reference may have to be made to the relevant Austroads Guide for important details relating to particular topics or situations. Consequently this report provides a high level of cross-referencing to Austroads Guides.
- It is highly recommended that practitioners who are less experienced in the planning and design of bicycle facilities refer to the original Austroads Guides.

While the report provides an overview of planning and traffic management considerations, practitioners will need to refer to other Guides and texts for detailed information on these subject areas, some of which are referenced in the Austroads Guides.

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1. Introduction

1.1 General

This document is intended as a guide for engineers, planners and designers involved in the planning, design, construction, maintenance and management of cycling facilities. It consolidates and summarises the information in current Austroads Guides, in particular the *Guide to Road Design* and the *Guide to Traffic Management* and *Guide to Road Safety*, so that the information on bicycle facilities is readily available for persons with a particular interest in the topic. Throughout the document practitioners are referred to relevant Austroads Guides for additional information. Although this document focuses on the Guides noted above, it cross-references material in a number of other Austroads Guides.

1.2 How to use this Document

The *Cycling Aspects of Austroads Guides* consolidates information relating to on-road bicycle facilities and provides a summary of key design information for cyclist paths, including intersections of paths with roads.

Practitioners should use this document to support national and state cycling strategies (Section 2.2) so that communities can obtain environmental, health and transport benefits that are derived from increased cycling. Cycling can be encouraged by the provision of bicycle access into and through all new land developments, the provision of treatments that assist bicycle travel and the provision of suitable showers and secure parking facilities in the workplace.

Cycling should be considered in all road planning, design, construction and maintenance activities. It is important that cyclists are provided with a smooth hazard-free riding environment and, where they share roads, they need sufficient space to operate alongside motor vehicles. As far as practicable, roadsides and roadside objects should also be designed to provide a forgiving environment for errant bicycles (e.g. the surface provided on a shoulder or berm should not trap bicycle tyres).

As bicycle riders include people with a very wide range of skills and ages (from novices to experts), who also travel for a variety of reasons, it is important to cater for this range of skills even though this may result in more than one type of bicycle facility along a given route (Section 2.7).

1.3 Role of Cycling in Transport

Cycling currently fulfils an important transport role within communities. It is the most sustainable, reliable, effective and efficient form of transport. It allows people to travel large distances at low cost and is very reliable.

Efficient transportation of people and goods in cities is essential if the economic and social needs of society are to be met. Whilst the car is a more prevalent mode (by the community at large) for most trips in cities, it has undesirable aspects in relation to traffic congestion, road safety, noise, and air pollution. Modes of transport which could play a greater role in offsetting these issues include walking, cycling, trains, trams and buses.

Cycling produces minimal greenhouse gases, creates no significant congestion and is well suited to many of the trips currently made in cars, particularly in inner urban areas. Many car trips, including travel to work, are less than 5 km, a distance that can be covered in many inner urban areas as quickly on a bicycle as in a car.

Cycling offers significant environmental and health benefits for communities and must therefore be considered in all planning activities ranging from the development of cities and new towns to relatively small infrastructure developments. The recognition of cyclist needs will ensure that current planning decisions do not limit the ability of responsible authorities to provide satisfactory networks and facilities for bicycle riders in the future.

1.4 Safe System Approach

Safe System principles have been acknowledged in successive national road safety strategies and action plans since 2003 as the guiding principles for road safety programs in Australia. The commitment is continued in the current strategy, *National Road Safety Strategy 2011–2020* (Australian Transport Council 2011). Safe System principles are also central to *Safer Journeys,* New Zealand's Road Safety Strategy 2010–2020 (Ministry of Transport 2010).

Safe System recognises that there are limits to the forces the human body can withstand in a collision, and seeks to ensure that no road user is subjected to forces in a collision which will result in death or an injury from which they cannot recover. It must be recognised that human error is a feature of the road transport system and that while much can be done to reduce it, it cannot be eliminated.

Practitioners should be aware of and through the design process actively support the philosophy and road safety objectives covered in the *Guide to Road Safety*. The philosophy and objectives are as relevant to cycling facilities as they are to roads in general.

For additional guidance on the Safe System approach, refer to the Austroads *Guide to Road Safety Part 1* (AGRS01) (Austroads 2013a) and the Austroads *Guide to Traffic Management Part 13* (AGTM13) (Austroads 2015f).

AGRD 06A
S 2.1

2. Planning and Traffic Management for Cycling

2.1 General

Cycling and walking have significant roles in transport systems throughout Australia and New Zealand and are expected to make an important contribution to the well-being and transportation of people in future.

The *Australian National Cycling Strategy 2011–2016* (Austroads 2010b) acknowledges that Australia currently faces a multitude of transport, health and environmental challenges and that there is a need to:

- provide for the safe, affordable and enjoyable movement of people and goods
- reduce the environmental and health impacts of transport, for instance by reducing motor vehicle tailpipe (including greenhouse gas) and noise emissions
- increase physical activity by Australian people
- combat rising traffic congestion, which is increasing travel times and industry costs.

The strategy recognises that in order to meet these needs society needs to:

- reduce dependence on the private motor vehicle
- increase the use of 'active transport' (walking, cycling and public transport)
- provide a transport system that offers attractive choices for travel other than by the private vehicle – including cycling.

The national strategy in New Zealand is *Getting there – on foot, by bicycle: A strategy to advance walking and cycling in New Zealand Transport* (Ministry of Transport 2005). This strategy aims to ensure that supportive walking and cycling environments are provided in New Zealand communities, that safety is improved for pedestrians and cyclists, and that people walk and cycle more as part of their day-to-day transport mix.

The development of walking and cycling is integral to achieving the five key objectives of the New Zealand Transport Strategy, which comprise:

- improving access and mobility
- protecting and promoting public health
- ensuring environmental sustainability
- assisting economic development
- assisting safety and personal security.

When planning or designing a path in a road, rail, river or coastal reservation it is important that road planners and designers have a broad view of the transport network and identify connections to other paths and facilities that should be provided as part of the design or accommodated in plans for the future.

It is important also to recognise the broad range of performance and skill that exists among pedestrians and cyclists due to factors such as age, experience, physical ability, cognitive skill and vision, and the need to provide paths to satisfy the needs of various users and demands.

Bicycle paths and facilities are generally designed for a normal bicycle. However, it is important to understand that there are other forms of human powered vehicles that have a broad range of performance characteristics that may have to be considered. For example, tandem bicycles are generally the least manoeuvrable human powered vehicle, which may have implications for path terminal design.

Planners and designers should establish early in the process whether the path is likely to carry a significant number of human powered vehicles other than bicycles so that paths and facilities are designed to safely accommodate the appropriate design vehicle.

Designers should be aware of local pedestrian or cycling planning and design guides. These guides generally provide the policy and network planning context in which pedestrian facilities are provided within a jurisdiction.

Traffic management aspects and road user considerations in relation to pedestrian and cycling paths are provided in Austroads guides: *Guide to Road Design Part 5: Drainage: General and Hydrology Considerations* (AGTM05) (Austroads 2014a) and *Guide to Traffic Management Part 3: Traffic Studies and Analysis* (AGTM03) (Austroads 2013b). Table 2.1 summarises key cross-references in Section 2.

Table 2.1: Key cross-references related to planning and traffic management for cycling

Series		Part	Section	Reference source
Section 2.1 General				
AGRD	Guide to Road Design	6A	Section 2.1	Austroads (2017c)
Section 2.2: Bicycle Strategies and Strategic Bicycle Plans				
AGTM	Guide to Traffic Management	4	Section 3.6.3	Austroads (2016b)
Section 2.3: Integrated and Multi-modal Planning				
AGRTP	Guide to Road Transport Planning	General	Section 2.5	Austroads (2009a)
Section 2.4: Bicycle Network Management				
AGTM	Guide to Traffic Management	4	Section 3.6 and Appendix B	Austroads (2016b)
Section 2.5: Bicycle Programs				
AGTM	Guide to Traffic Management	4	Section 3.6 and Appendix C	Austroads (2016b)
AGPE	Guide to Project Evaluation	8	Section 3.10	Austroads (2006a)
AGRS	Guide to Road Safety	4	Section 6.2.4	Austroads (2009b)
Section 2.6: Traffic Studies and Bicycle Surveys (also Appendix C)				
AGTM	Guide to Traffic Management	3	Section 2.5.5 and Appendix E.2	Austroads (2013c)
Section 2.7: Type of Bicycle Facility Required				
AGTM	Guide to Traffic Management	4	Section 3.6.3 and Commentary 8	Austroads (2016b)
Section 2.8: Combining Bicycle Travel with Public Transport				
AGTM	Guide to Traffic Management	4	Section 3.6.3	Austroads (2016b)
Section 2.9: Local Area Traffic Management (also Section 4.9)				
AGTM	Guide to Traffic Management	8	Section 7.5.10	Austroads (2016c)
Section 2.10: Traffic Management in Activity Centres				
AGTM	Guide to Traffic Management	7	Section 2.3.2, 3.8.3 and 3.8.4	Austroads (2015e)
Section 2.11: Traffic Impacts of Developments				
AGTM	Guide to Traffic Management	12	Section 3.2.7	Austroads (2016e)

2.2 Bicycle Strategies and Strategic Bicycle Plans

AGTM 04
S 3.6.3

2.2.1 National Cycling Strategy

The Australian National Cycling Strategy 2011–2016 (Austroads 2010b) is a strategic document with a vision to double the number of people cycling over the life of the strategy so that individuals and communities can enjoy the benefits of cycling (e.g. those relating to urban space and traffic congestion, the environment and health). The strategy includes six priorities and associated objectives that are needed to drive progress at the national level, namely:

1. Cycling promotion – promote cycling as a viable and safe mode of transport and an enjoyable recreational activity.
2. Infrastructure and facilities – create a comprehensive and attractive network of routes to cycle and end-of-trip facilities.
3. Integrated planning – consider and address cycling in all relevant transport and land-use planning activities.
4. Safety – enable safer cycling.
5. Monitoring and evaluation – improve monitoring and evaluation of cycling programs and develop a national decision-making process for investment in cycling.
6. Guidance and best practice – develop nationally consistent guidance for stakeholders to use and share best practice across jurisdictions.

The New Zealand Transport Agency Statement of Intent 2015-18 (NZ Transport Agency 2015b) sets out a four year plan outlining the NZ Transport Agency's course of action that will contribute to the delivery of the government's land transport objectives and wider transport vision. This document includes the NZ Transport Agency's strategic framework which identifies making urban cycling a safer and more attractive transport choice by 2019.

The *National Land Transport Programme 2015-18* (NZ Transport Agency 2015a) contains the land transport activities the NZ Transport Agency anticipates funding over the next three years. As part of the programme, investment has been aimed at improving cycling infrastructure (both urban and rural) and support programmes such as cycle skills training, national guidelines for cycling infrastructure design and public education campaigns to promote sharing the road safely. The programmes focus on three key customer and stakeholder groups:

- current and future cyclists: building a strong cycling culture means lowering real and perceived risks of cycling in New Zealand
- other network users: all road users need to be part of the solutions to increase cycling
- decision makers: a case needs to be built with a vision that includes the whole transport system.

2.2.2 State or Territory Bicycle Strategies

State or territory strategies on cycling are necessary to set a direction and provide a framework within which various responsible agencies can plan and work. They also specify important strategic action areas and items and nominate responsible 'lead agencies'.

It is desirable that the specific aims of a state or territory strategy:

- establish a key group to administer and coordinate the implementation of the strategy
- ensure that planning for cycling is integrated within overall transport and land use planning, urban development, building rules, traffic management and community planning
- give priority to those areas where the existing or potential demand for cycling is highest
- ensure that cyclists have suitable and legitimate access to roads and paths, where appropriate
- ensure the development of programs promoting cycling as a legitimate form of transport

- ensure the development of behavioural and safety awareness programs aimed at improving cyclist safety in general
- ensure support for key promotional activities e.g. Bike Week, Ride to Work
- ensure an appropriate legislative framework for cycling having regard to safety, good traffic engineering practice and credibility of the law
- encourage cycling for the environmental, recreational and health benefits to cyclists and the wider community
- reduce the frequency of bicycle crashes and the severity of injuries resulting from crashes
- coordinate the provision of cycling facilities and programs across relevant agencies and organisations
- develop, implement and maintain a state wide bicycle route network incorporating metropolitan routes, interregional routes and routes within regional centres and municipalities
- ensure cycling facilities and programs are readily accessible
- ensure cycling facilities serve the needs of the relevant categories of cyclists
- provide guidance to encourage a high level of compliance by cyclists with traffic laws, and by other road and path users in relation to cyclists, covering both educational and enforcement needs
- encourage the establishment of a strong and pro-active cycling industry, including manufacturers, traders and the tourism industry operators
- ensure the systematic measuring, auditing or evaluation, of programs and facilities
- facilitate ongoing research and investigation of new initiatives.

2.2.3 Local Strategic Bicycle Plans

Local strategic bicycle plans can be developed on a municipal basis or regional basis where a number of municipalities share resources. The purpose of these plans is to translate many of the aims of the state wide strategy into practical programs and projects at the local level.

Local strategic bicycle plans should, however, concentrate on the development of solutions to problems that exist within the municipality or region rather than deal with general issues. Local strategies should be aligned with state or territory priorities and national objectives.

The actions required to develop local strategic bicycle plans would usually include:

- a survey of the extent and nature of cycling within the municipality or region
- determination of the cycling requirements of the community
- identification of factors that inhibit cycling
- identification of a practical bicycle route network with appropriate links to adjacent regions or networks
- development of engineering measures and programs to overcome problems including estimated costs, time frame and an implementation plan
- development of bicycle network support requirements (e.g. bicycle parking, kerb ramps, drinking water fountains, signage)
- development of encouragement and other appropriate behavioural programs, with an aim of increasing the use of cycling facilities as well as the safety of cycling, in the local area
- review of law enforcement and compliance with local bylaws
- review of the requirements for development applications in regard to cycling (e.g. bicycle parking and shower facilities)
- review of construction and maintenance practices and education of staff responsible for these tasks, so they accommodate the needs of cyclists in their work (e.g. landscaping, roadworks and irrigation).

For the community to derive maximum benefit from its local strategic bicycle plan it is essential that the plan produce positive, practical and affordable outcomes that meet user needs.

It is suggested that the development of local strategic bicycle plans should be overseen by a steering committee comprised of representatives of:

- local government councillors
- local government engineering, urban planning and recreation staff
- the state road agency
- the local police
- local schools
- cyclists
- bicycle industry
- local industry
- the local community.

States and territories have a role to ensure that local strategies complement each other to create a State or territory network through means such as the development of local bicycle plan guidelines.

2.3 Integrated and Multi-modal Planning

AGRTP S 2.5

Bicycle planning needs to consider that transport planning will be at its most effective if it is integrated with other types of planning. Planning in sectors such as transport, regional development, health and education should be considered to ensure decisions complement rather than conflict with each other. Consistent land-use planning decisions also need to be made across regions and jurisdictions (Austroads 2009a).

Multi-modal transportation planning is a multi-faceted approach that considers all modes/options. The bicycle network needs to be separated from, yet integrated with the main road, pedestrian and public transport systems. This will necessitate regular crossings in order to sustain the coverage and continuity of the network for cyclists.

The measures which can be adopted to facilitate movement will be influenced by functional road hierarchy considerations such as the access and movement functions of the road. Cycling facilities can be provided more cost-effectively by planning and making provision for these facilities as part of larger initiatives. Note, however, that facilities will also often be shared between cyclists and other modes such as motorised traffic.

For further guidance on integrated and multi-modal planning, practitioners are referred to the *National Guidelines for Transport System Management in Australia* (Australian Transport Council 2006).

2.4 Bicycle Network Management

2.4.1 Introduction

AGTM 04 S 3.6.1

This section is based on the Austroads *Guide to Traffic Management Part 4: Network Management* (AGTM04) Section 3.6 (Austroads 2016b) which covers traffic management at a network level. It addresses network needs of the various categories of user (including cyclists), the characteristics of various types of network and, importantly, describes a planning process for balancing or prioritising the competing needs of different users.

The purpose of a bicycle network is to enable people of a wide range of abilities and skill levels to cycle. The basis of a bicycle network is the road network (made up of local and arterial roads), augmented by special (in some cases separated or coloured) on-road facilities together with dedicated infrastructure such as off-road paths, and footpaths (where permitted). In addition the bicycle network may be augmented by the public transport network.

AGTM 04
S 3.6.2

2.4.2 Role of a Bicycle Network

Table 2.2 details features that are important to form a good bicycle network.

Table 2.2: Bicycle network features

Route feature	Comments
Safety	Minimal risk of traffic-related injury, low perceived danger, space to ride, minimum conflict with vehicles
Coherence	Infrastructure should form a coherent entity, link major trip origins and destinations, have connectivity, be continuous, signed, consistent in quality, easy to follow, and have route options
Directness	Route should be direct, based on desire lines, have low delay through routes for commuting, avoid detours and have efficient operating speeds
Attractiveness	Lighting, personal safety, aesthetics, integration with surrounding area, access to different activities
Comfort	Smooth skid-resistant riding surface, gentle gradients, avoid complicated manoeuvres, reduced need to stop, minimum obstruction from vehicles

Source: Austroads (2016b) Table 3.10.

Infrastructure for cycling should:

- improve cycling safety
- improve cycling comfort
- improve cycling efficiency
- encourage people who do not currently cycle.

The bicycle network should accommodate a range of rider experience and skill levels. In some instances, it may be warranted to provide more than one cycling facility on the same route to allow for differing skill levels. For example, a shared-use path may be provided to allow primary and secondary students to cycle in an environment separated from motor vehicles and yet the same road may have an on-road bicycle lane for more experienced riders. The varying cyclist types and their characteristics and riding environments are outlined in Section 2.4.5.

There should be a relationship between the functions of the component parts of a bicycle network and the functions of the road network hierarchy. Where bicycle routes run along or cross the road network, the operational facilities should reflect the network functions for both the road and the bicycle route cycleway. Table 2.3 outlines the functions of various types of routes that make up the bicycle network hierarchy and aligns the various route types with movement and place functionality.

Table 2.3: Bicycle network functions

Network	Movement and place type	Network function	Cyclist operating speed
Regional bicycle network[1]	Significant movement with some place aspects	High-quality, high-priority routes to permit quick, unhindered travel between the major regions of cities, towns or urban areas	25–40 km/h
Local bicycle routes	Some movement with some place aspects	High-quality routes with seamless connections to regional routes. These routes connect the local street system to the major regional routes	20–30 km/h
Mixed environments	Some movement with some place aspects	Low speed, low volume local access to residential destinations in a ‘low stress’ shared environment	< 20 km/h
	Significant movement with significant place aspects	Low speed, high volume access to key destinations (such as within a CBD) often shared with other users such as pedestrians and motorised vehicles	
	Some movement with significant place aspects	Low speed, high volume access to key destinations often used for other uses (e.g. strip shopping centre)	

1 *Principal or strategic bicycle network in some jurisdictions.*

Source: Austroads (2016b) Table 3.11, adapted from NSW Bicycle Guidelines (Roads and Traffic Authority 2005).

2.4.3 Management Principles of a Bicycle Network

S 3.6.3

The objectives outlined in Section 3.6.3 of AGTM04 (Austroads 2016b) that are relevant to the planning, design and operation of bicycle networks include:

- a designated regional network of roads and paths that serves longer-distance commuter and recreational trips
- designated local networks and routes designed to provide low-stress routes, to feed the regional network and to provide for shorter local trips to shopping centres, recreational activities, public transport hubs
- full construction of route sections between origins and destinations consistent with the route purpose
- convenient access into and through residential, commercial and industrial subdivisions, and major developments
- access and facilities to travel with a bicycle on public transport
- secure long and short-term parking facilities at major destinations
- safer routes to schools
- well-defined bicycle facilities on arterial roads where significant cyclist demand exists including specifically for commuter trips
- appropriate maintenance practices which result in smooth surfaces
- calming in local streets
- paths which are interesting, that include rest areas at appropriate intervals on regional routes, and are designed to appropriate geometric standards
- implementation of regulatory, warning and guidance signage on paths.

These objectives are generally outlined in bicycle strategies and plans which then influence the type of facility required as outlined in the following sub-sections.

AGTM 04
S 3.6.3

2.4.4 Network and Route Mapping

As with any transport system, accurate and comprehensive information concerning the bicycle network is essential. Maps should be available to cyclists showing the route, facilities and points of interest including the relationship to the surrounding road system and community facilities. The scope of bicycle route and network maps can be local or regional but should always adopt a network approach and aim to present through routes and access locations.

AGTM 04
App. B

2.4.5 Categories of Cyclists and Their Trips

The bicycle network should accommodate a range of rider experience and skill levels. In some instances, it may be warranted to provide more than one cycling facility on the same route to allow for differing skill levels. The varying cyclist types and their characteristics and riding environments are outlined in Table 2.4.The same type of bicycle infrastructure may be used for both transport cycling and recreational cycling.

This section contains two tables. Table 2.4 describes cyclist types and their characteristics and riding environments. Table 2.5 describes the various cycling trips and their characteristics.

Table 2.4: Categories of cyclist experience levels and their characteristics

Rider level	Examples	Characteristics	Suitable infrastructure
Immature	• Primary school student	Cognitive skills not developed. Little or no understanding of road rules. Requires supervision	Separation from motor vehicles is more important than speed • shared paths and separated paths • footpaths (where permitted)
Novice	• Secondary school student • Beginner adult rider	Skills are basic. Will seek separation from motor vehicles. Desire off-road paths, but can manage occasional crossing of roads with varying traffic conditions	Separation from motor vehicles is more important than speed • shared paths and separated paths • footpaths (where permitted)
Intermediate	• Advanced secondary school student • Average adult rider	May seek separation from motor vehicles or may be comfortable in mixed traffic environments	Separation from motor vehicles or speed may be important to different riders • shared traffic (low speed/volume) • bicycle lanes • separated bicycle paths
Advanced	• Experienced commuter • Experienced sports rider • Experienced touring rider	Less affected by motor vehicle traffic and will sometimes avoid off-road paths where their travel speed may be reduced. Riders are able to share lanes with vehicles, although are likely to prefer to have dedicated space. Although they may prefer to ride on non-congested roads which can enable undisrupted or minimally disrupted cycling (e.g. long links without traffic signals such as non-metropolitan and/or rural roads) they may be prepared to ride on non-preferred roads (e.g. heavily trafficked routes) to get their preferred route. Facilities should be designed and well maintained to facilitate reasonable and high riding speed	Speed is more important than separation from motor vehicles • shared traffic • bicycle lanes • sealed shoulders

Source: Austroads (2016b) Table B 1.

Table 2.5: Cyclist trip types and their characteristics

Purpose	Function	Definition	Characteristics
Commuting	Transport	A regular trip made to a place of work or study	• Most trips are under 10 km with few over 20 km • Skill levels vary from novice primary school riders to experienced road riders • Commuter trips are generally made alone or in small groups • Riders may be carrying bags with clothes, laptops etc. • Riders may carry repair kits • All-day secure bicycle parking is required • Shower and change facilities are often required • Trips may be combined with a public transport trip to extend the range of the trip
Utility	Transport	A trip made to a particular destination such as a shop restaurant, friend's house etc.	• Most trips are under 5 km with very few over 10 km • Skill levels vary from a novice primary school student to an experienced road rider • Utility trips are generally made alone or in small groups • Riders may be carrying bags with shopping, clothes etc. • Riders are less likely to carry repair equipment • Short-term bicycle parking is required • Shower and change facilities not required • Trips may be combined with a public transport trip to extend range of trip
Training	Recreation	A trip that does not serve a transport purpose and is primarily taken to provide high-intensity training	• Training trips are usually over longer distances, sometimes more than 100 km • Training trips may be taken as an individual rider or in groups known as 'pelotons', where riders tend to ride two-abreast and in multiple rows. Pelotons seek to remain visible and predictable to other road users by placing the group in the centre of travel lanes, particularly if no appropriate road shoulder is available • Training riders usually carry a repair kit but do not tend to carry a bicycle lock. They tend not to use bicycle parking facilities • Training riders tend to be more advanced riders but can also be younger or inexperienced
Touring	Transport recreation	A ride that is conducted over more than one day and has a tourism function	• Most trips are over 20 km with some over 100 km (per day) • Rider skill levels are usually intermediate to advanced • Bicycles are often laden with luggage to allow multi-day travel • Riders will almost always carry a repair kit • Overnight bicycle parking is required at the accommodation • Shower and change facilities are required at the accommodation • Trips may include public transport trips at the start and end or to avoid sections of the route that are impassable by bicycle
Recreation	Recreation	A ride that does not serve a transport function (no destination) but is not used for high-intensity training (e.g. sports riding)	• Trip length may vary greatly depending on the level of experience of the rider • Skill levels vary from a novice primary school student to an experienced road rider • Riders may or may not carry repair equipment • Short-term bicycle parking is sometimes required • Shower and change facilities are not required • Trips may include a car or public transport trip at one or both ends to allow riders to ride to a preferred location

Source: Austroads (2016b) Table B 2.

2.5 Bicycle Programs

AGTM 04 S 3.6.3

Bicycle programs may address a range of 'hard' infrastructure improvements such as bicycle paths or 'soft' improvements such as education, enforcement and encouragement. The objective is to make cycling safer, more convenient and hence an attractive alternative means of transport. Programs generally address issues relating to education, encouragement, enforcement and engineering but these four Es should usually be regarded as interrelated components of the same program, rather than separate programs. For example, as a network of bicycle routes is developed within a city or town (engineering) it will be necessary to:

- promote it through advertising, pamphlets and maps (encouragement)
- teach people who use it how to ride safely and courteously (education)
- insist that relevant laws and regulations be obeyed for the benefit of all users (enforcement).

AGPE 08 S 3.10

An example of a bicycle network evaluation from the Austroads *Guide to Project Evaluation Part 8* (Austroads 2006a) can be found in Appendix A.

2.5.1 Behavioural Programs

AGTM 04 App. C

AGRS 04 S 6.2.4

Bicycle programs will include consideration of many issues relating to the behaviour of cyclists, safer use of the transport network, and the encouragement of cycling. Sub-programs should be developed to address these issues and initiatives that might be taken are listed below. Whilst many of the initiatives are inter-related, for convenience they are divided into Education, Enforcement and Encouragement.

Encouragement programs

A major objective of bicycle programs is to achieve increased levels of community participation in cycling for both transportation and recreation. Initiatives to encourage cycling may include:

- ongoing promotion of the environmental, recreational and health benefits of cycling to the individual and community
- promotion of the opportunities for using the bicycle for recreation, tourism, commuting, social and practical purposes
- development of systems, fare structures and other conditions to make multi-modal travel (e.g. bicycle/train) an attractive alternative to the motor car for appropriate trips
- individualised marketing campaigns such as travel demand management programs
- the organisation of special bicycle rides and other events such as national conferences
- provision of a comprehensive set of education programs

Example of behavioural aspects program (Austroads Guide to Road Safety Part 4 (Austroads 2009b))

In New Zealand there is a growing overlap in encouragement of sustainable transport choices (and mode choice for alternative forms of transport, away from cars) and road safety issues. Promotion of options by both central government and locally by the Rotorua District Council (RDC) is seen as an important move. This project aims to encourage those that may not have the skills, motivation or means to cycle, to learn to do so under controlled, local conditions. It supports this by providing safer cycling facilities.

This project involves advertising and running regular community based cycling courses which include bike maintenance, cycling tuition and instruction on road rules, rights and obligations (usually police). Cycling skills are practised off-road at first, then the group graduates to an on-road site nearby.

An example of the on-road environment is shown in the figure below. Safer on-road cycling facilities have been specially constructed to include cycling infrastructure not usually supplied on low volume roads. This includes interpretive billboards for cyclists, marked cycle lanes, advance cycle boxes at intersections (different types), and a roundabout. Infrastructure was provided by RDC; bike mechanics were supplied by local cycle stores; police provided instructors, and several agencies advertised the project.

Figure 2.1: On-road instruction in safe cycling procedures

The success of the project is to be evaluated by the number of participants, participant feedback, the numbers of cyclists using the road network, and by the safety of the road network for cyclists.

- development of comprehensive engineering programs to provide networks, continuous routes, safer and smoother roads and paths
- provision of adequate end-of-trip facilities such as showers and secure parking
- introduction of ‘change time’ to allow employees to book a certain amount of time to showering and changing when commuting using a bicycle
- provision of information, maps and signs to guide cyclists to appropriate routes and facilities.

Education programs

Initiatives relating to the education of the community regarding cycling may include:

- bicycle safety education programs in primary schools
- bicycle safety education programs in secondary schools including development of on-road skills
- courses for inexperienced adult cyclists
- development of a cyclist code of behaviour
- ongoing education of motorists and cyclists to better understand each other’s needs
- media campaigns on critical issues.

Enforcement programs

Bicycles are defined as vehicles under road traffic regulations and cyclists are therefore required to comply with the law. However, police involvement in cycling should be more constructive than simply penalising offenders. Initiatives relating to enforcement may include:

- seminars to educate police in the role they can play in bicycle strategies and plans to improve cycle safety
- ongoing media promotion of laws, responsible and defensive riding, etc.
- promotion of safer cycling by personal contact with young and adolescent cyclists
- development of police patrols on bicycles in inner city areas and on busy paths
- special promotional campaigns with rewards for safer cycling (e.g. raffle of cycling goods)
- a police-in-schools program as part of general traffic safety education, including bicycle safety checks and basic road law.

2.6 Traffic Studies and Bicycle Surveys

AGTM 04
S 2.5.5
App. E2

The provision of facilities for cyclists has been steadily increasing due to an increased focus on user needs and safety. Data on some of the movements made by cyclists can be collected using methods similar to those used for collecting other traffic data (see Appendix B and AGTM03 (Austroads 2013b) for more detail on designing surveys). The nature of bicycle movements, however, is not as restricted to specific roadways as that of vehicles, hence the greater difficulty in collecting information. Bicycles are defined as vehicles under road traffic regulations and therefore have a right to use virtually all roads.

Studying bicycle movements may also be complicated by the spatial distribution of routes they can choose. For example, cyclists can easily reverse their direction of travel and exit a system where they enter. The main similarities between motor vehicles and cyclists occur when cyclists are constrained to a footpath, road lane or corridor, as this situation is similar to vehicles on a road.

Any study of cyclist behaviour requires a clear statement of the problem to be addressed and a statement of the objectives of the study. This statement should lead to a set of parameters to be measured by the study. The Australian Bicycle Council (2000) recommends that base data be collected in study areas that are consistent with the geographic areas used by the Australian Bureau of Statistics, so as to ensure consistency with population characteristics.

The majority of data collected in bicycle surveys will come from sample surveys. When deciding on the size of the sample, it is necessary to consider confidence limits, levels of confidence and inherent variability. A trade-off exists between the required accuracy of the sample, and therefore the size of the sample, and the cost of the study.

The sampling of cyclists is difficult because information on bicycle ownership is rarely available. The concentration on particular groups such as school children or bicycle clubs will also not provide information on all bicycle users. Interviewing in the field may provide an overall idea of travel characteristics but survey locations need to be selected carefully and in a random manner to ensure a broad spectrum of cyclists is interviewed.

Various ongoing household travel surveys exist, and useful data on bicycle trips can be obtained from them. They include the *Victorian Integrated Survey of Travel and Activity* (Department of Transport 2009) and the *2010/2011 Sydney Household Travel Survey* (Bureau of Transport Statistics 2012). The surveys record daily travel patterns, including bicycle and walking trips, of household members in Melbourne and Sydney respectively. Other databases such as the Bicycle Imports of the Bicycle Industries and Traders Association and the Serious Injury Database of the Australian Transport Safety Bureau (2016) also provide useful bicycling and pedestrian data.

When using existing information, it is necessary to consider the original purpose of the data, the represented population (e.g. were children under ten included?), the treatment of multi-mode trips and the sampling techniques used.

2.7 Type of Bicycle Facility Required

AGTM 04
S 3.6.3
C8

When considering the type of bicycle facility, such as cycle tracks (a physically separated bicycle path facility), bicycle lanes or shared use paths, the two guiding principles are: separating cyclists from motor vehicles and pedestrians, and providing priority for cyclists across driveways and through intersections.

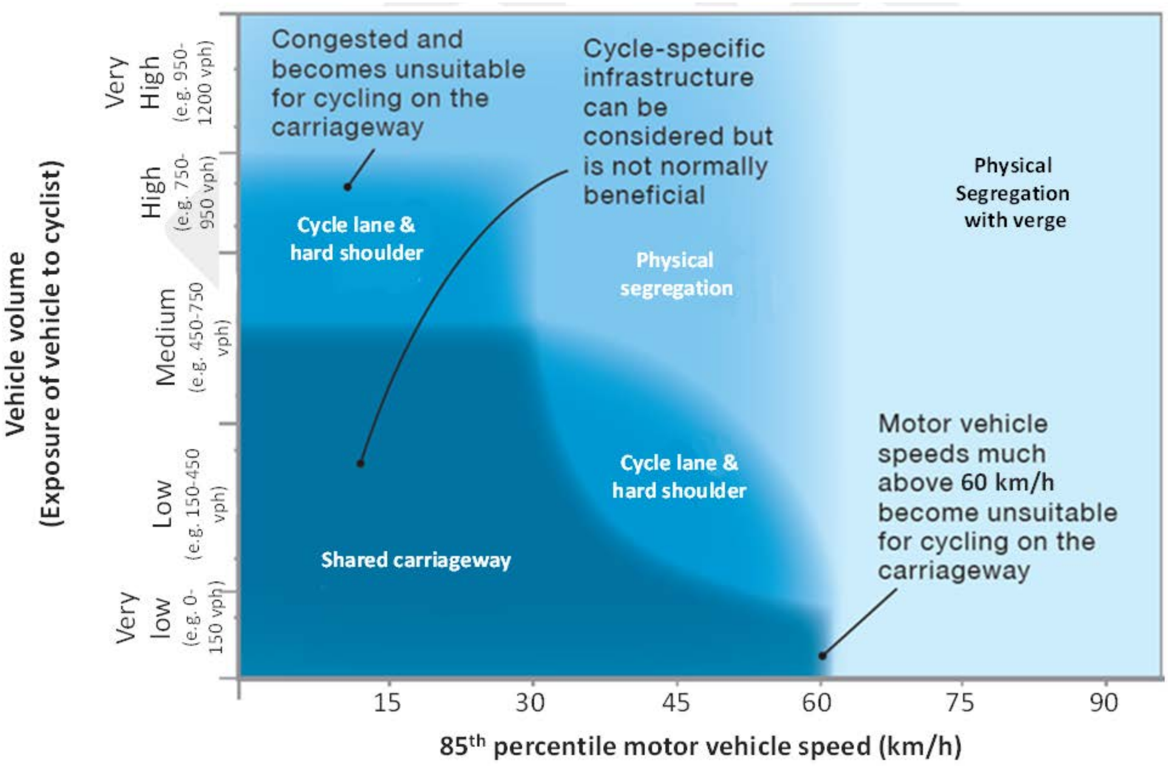
The design of bicycle facilities should be based on context sensitive design principles (outlined in the Austroads *Guide to Road Design: Part 2: Design Considerations* (AGRD02) (Austroads 2015d) with the appropriate bicycle facility determined through a full network operation planning process which takes into account the level of service desired for bicycles based on cyclist demand (both actual and potential), cyclist type, priority granted for cyclists on the particular road and other users of the road including on-street car parking.

While AGTM05 (Austroads 2014a) Section 3.4 outlines various bicycle facilities that could be considered when designing for bicycles, Figure 2.2 provides guidance to practitioners on the separation between bicycles and motor vehicles for the preferred on-road bicycle route. It is based on the road's expected/actual traffic volume and actual or planned 85th percentile speed. Use of Figure 2.2 does not replace the need to design bicycle facilities.

Similarly to car drivers, aspects such as good surface, directness, comfortable gradients and minimal disruptions are key level of service issues for cyclists. The level of service (LOS) framework referred to in Commentary 1 of AGTM04 (Austroads 2016b) provides guidance on the LOS levels achieved for various bicycle facilities applicable to the road environment. Further, experienced road cyclists are unlikely to use off-road facilities as an alternative to routes where the road carries high volume, high speed traffic, unless the off-road route is suitably designed for their needs with appropriate directness and priority, therefore providing a faster alternative. If bicycle facilities such as cycle tracks or bicycle paths are poorly designed without appropriate directness and priority, on-road bicycle lanes or suitable road shoulders may still be required in addition to off-road facilities.

Planners and designers seeking to use Figure 2.2 for guidance should consider the magnitude of exposure cyclists would have to passing vehicles. This will need to take into consideration the vehicle flows in the direction of travel of the cyclists and the ability of vehicles to pass cyclists with adequate clearance. This will be influenced by directional splits, lane configurations and width of lanes. The 85th percentile motor vehicle speed can be based on actual posted speed where the road is existing or planned speed where the road is proposed.

Figure 2.2: Guidance on the separation of cyclists and motor vehicles for the preferred bicycle route



Source: Sustrans (2014).

Pedestrian and cyclist separation also needs to be considered when planning for off-road shared paths. Practitioners should refer to the Austroads *Guide to Road Design Part 6A: Paths for Walking and Cycling* (AGRD06A) (Austroads 2017c), which is currently being updated for further guidance.

2.8 Combining Bicycle Travel with Public Transport

AGTM 04
S 3.6.3

Multi-mode travel, where people cycle to interchanges and transfer to public transport, can substantially increase the range of bicycle travel. Public transport authorities should make provision for the carriage or storage of bicycles, in conjunction with the inclusion of transport hubs at specific destinations within the bicycle route network.

Jurisdictions should consider identifying and designing bicycle routes with key bicycle facilities to encourage people to combine bicycle travel with public transport. The focus for this should be within a defined catchment area of public transport terminals.

Examples of such provision can include easy-to-use on-board storage facilities, easy access to stations with secure long-term weatherproof parking or parking rails for short-term parking. Parking facilities are discussed in Section 11 and Section 7.8.5 of Austroads *Guide to Traffic Management Part 11: Parking* (AGTM11) (Austroads 2017d).

The Australian Bicycle Council website (Appendix B, Australian Bicycle Council 2014) provides a number of examples of methods for integrating cycling and public transport, as well as examples of successful programs.

AGTM 08
S 7.5.10

2.9 Local Area Traffic Management

Guidance for cycling facilities in local areas is provided in the Austroads *Guide to Traffic Management Part 8: Local Area Traffic Management* (AGTM08) (Austroads 2016c).

Bicycle lanes (Figure 4.2) are not often needed in local areas where the speed environment is low and the mixture of bicycle and vehicle traffic works well together.

Advisory treatments are provided to indicate or advise road users of the potential presence of cyclists and of the location where cyclists may be expected to ride on the street. They consist of pavement markings and warning and guide signs, and have no regulatory function. As with bicycle/car parking lanes, collisions between cyclists and opening doors of parked cars are a significant concern to cyclists. The purpose of these treatments is usually to define a bicycle route rather than a type of facility to which specific road rules apply. The form of the treatment is a matter for local jurisdictions.

Bicycle bypasses provide a safer and more comfortable mechanism for cyclists to avoid passing through devices. They are desirable where there is a need to separate cyclists from other traffic to make routes more attractive for travel or to avoid squeeze points, adverse surface conditions, and other obstacles. The design of bicycle bypasses should be done in such a way that they take the cyclist past the device to a separated space or they allow safer reintegration with motorised traffic.

Other bicycle facilities that may be appropriate in local areas include contra-flow bicycle lanes, wide kerbside lanes, bus/bicycle lanes and supplementary street treatments (refer to Section 4.5 and Austroads *Guide to Road Design Part 3: Geometric Design* (AGRD03) (Austroads 2016a)). Table 2.6 describes the use, advantages and disadvantages of bicycle lanes, advisory treatments and bypasses in local area traffic management (LATM) treatments whilst Figure 2.3 shows examples of treatments. Further information on the provision of bicycle lanes, advisory treatments, bypasses and other facilities is provided in Section 4.8.

Table 2.6: Use, advantages and disadvantages of bicycle lanes, advisory treatments and bypasses in LATM schemes

Use	Advantages	Disadvantages
It is appropriate to use bicycle lanes, advisory treatments, and bypasses: • where there is a significant difference in the speed of vehicular and bicycle traffic (i.e. > 20 km/h) • where it is desirable to separate cyclists from other traffic (e.g. for reasons of safety) • anywhere cycling needs to be encouraged (e.g. along major routes near town or city centres). It is inappropriate to use bicycle lanes, treatments and bypasses where they will restrict the movement of buses.	The advantages of bicycle lanes, advisory treatments and bypasses include: • increase in cyclist safety • improvement in accessibility and connectivity of the bicycle network • they can be used to narrow the width of traffic lanes • they promote the use of alternative modes of transport.	The disadvantages of bicycle lanes, advisory treatments and bypasses include: • separate facilities may be expensive • facilities may be incompatible with other LATM devices.

Source: Section 7.5.10 of Austroads (2016c).

Figure 2.3: Examples of bicycle bypasses of LATM devices

City of Gold Coast, Queensland

City of Unley, South Australia

2.10 Traffic Management in Activity Centres

2.10.1 Planning Context for Cycling in Activity Centres

AGTM 07 S 2.3.2

Austroads *Guide to Traffic Management Part 7: Traffic Management in Activity Centres* (AGTM07) (Austroads 2015e) considers the requirements of cyclists in the overall planning of activity centres and practitioners should refer to AGTM07 for further information.

The key planning principle for bicycle travel in relation to activity centres is typically to maximise cyclists' accessibility to centres, services, facilities and employment locations.

Bicycle access to destinations within the centre will comprise the terminal part of a journey. The scale and the nature of the roads and streets through an activity centre will determine the extent to which defined bicycle routes will be required within it. While approach routes to key places such as a railway station will need to be defined and enhanced, it may not be necessary to provide for designated bicycle access to every possible destination. Deciding on where bicycles can be parked, and how bicycles get to those points, is part of the traffic management task.

As a component of sustainable transport policies, bicycle use must be actively encouraged in the planning, design and management of a centre. There are many government policies and guidelines on this subject, and these local sources should be consulted. Typical guiding principles and criteria for bicycle planning are shown in Table 2.7. Where appropriate, these will also influence the management of bicycle movement within centres.

Table 2.7: Example of guiding principles and criteria for bicycle plans

Principle	Criteria
Coherence	Continuity of routes Consistent quality of routes and facilities Easy to follow Freedom of choice of routes
Directness	Efficient operating speed Delay time Detour factor*
Safety	Minimum risk of accidents on routes Minimum risk of conflict with car traffic Minimum risk of unsafe infrastructure
Attractiveness	Support for the system Attractiveness of environment Perception of social safety System attractiveness
Comfort	Smoothness of ride Comfortable gradient Minimum obstruction from vehicles Reduced need to stop (number of stops per km) Protection from adverse climate
End-of-trip facilities	Provision of secure bicycle parking in convenient locations Provision of change facilities for commuters/workers

** Detour factor is the actual route length on the road/bicycle network divided by the distance measured in a straight line between the trip origin and the trip destination. Source: Austroads (2015e) Table 2.5, adapted from Roads and Traffic Authority NSW (2005).*

Inevitably, there will be a degree of compromise within many activity centres, for instance in terms of stops and delays. Traffic management also needs to allow for the reality that bicycles are not compatible with pedestrian spaces, especially where pedestrian movement is moderate to intense, and to that extent the two modes must be considered separately in detailed design and management of the centre. In addition, it is not generally expected that bicycle movement from one part of the centre to another must always be accommodated in planning and management.

Matters concerning planning for cyclists in centres that may impact on traffic management include the following:

- provision for direct and convenient bicycle access into the centre from surrounding areas, and thus the way in which the centre’s internal networks integrate with routes used by cyclists to access the centre
- provision for bicycle movement through the centre and to bicycle parking/storage locations, which will affect road cross-section design, and the location of bicycle parking facilities and how access to them is provided
- bicycle parking arrangements (Figure 2.4), especially at places of employment and at rail stations.

Figure 2.4: Bicycle storage facility in main street shopping precinct (Clarence Street, Sydney)

Source: The Australian Bicycle Council.

2.10.2 Bicycles in Activity Centres

AGTM 07 S 3.8.3

In order to satisfy policy intentions that positive steps are to be taken to encourage bicycling, and to provide the necessary physical conditions, traffic management can play a supportive role to the planning and urban design measures that are taken (Section 3.8.3 AGTM07 (Austroads 2015e)). In terms of bicycle network and movement performance, the ability to provide bicycle facilities and a safe road and traffic environment will play important roles in the effective management of cyclists.

Key objectives, from a traffic management point of view, are to:

- maximise cycling accessibility to centres and the services, facilities and employment they contain
- design streets that comfortably and safely accommodate cyclists
- ensure that vehicle traffic does not compromise a good cycling environment
- ensure that cycling does not compromise a good walking environment.

A number of issues related to bicycles in activity centres arise from these objectives, which traffic management can influence or determine:

- bicycle planning as it relates to activity centres
- bicycle access within the centre
- bicycle facilities
- interaction with pedestrians
- interaction with other traffic
- bicycle parking.

2.10.3 Cycling Implications for Traffic Management Practice in Activity Centres

AGTM 07 S 3.8.4

The following guidance on these matters is derived from the Department of Infrastructure, Planning and Natural Resources (2004); Department of Urban Affairs and Planning (2001); Roads and Traffic Authority NSW (2005).

Bicycle planning for activity centres

Implications include:

- Cycling catchments can be mapped in the same way as pedestrian catchments. As bicycles travel three to four times faster than a person on foot, the bicycle catchment for a five-minute ride is around 1.5 km. This potentially puts a large population within easy reach of the centre. Path detours can be calculated to identify indirect paths that need attention.
- Ideally, the centre will have a 'transport plan' (or 'mobility and access plan'), which forms the basis of bicycle provisions and management in the centre.
- Bicycle plans are not static, but are continually updated and considered in all planning and management processes and work programs.
- Bicycle (and pedestrian) plans for the centre are integrated with planning instruments to give them legal and policy effect.
- Conversely, traffic management, pedestrian and town centre improvement plans are aligned with bicycle plans to ensure that cyclist facilities and routes complement the physical form and needs of the centre.
- Public transport stops or nodes and local services, including primary schools, are co-located in and around local centres to maximise trip efficiency.
- Audits of 'bikeability' will assist in identifying elements of bicycle infrastructure that need attention (Bicycle Federation of Australia 2007, Cluster for Physical Activity and Health 2007; Pedestrian and Bicycle Information Center 2008).

Access within the centre

- Within the centre, bicycle access should be safe, direct and comfortable between different locations.
- Some judgment is required to decide if cycling is to be expected (and catered for) between every destination within the centre. (See following remarks concerning bicycle parking.)

Bicycle facilities in activity centres

- The primary aim is to create traffic conditions (primarily speeds) within the centre that are compatible with bicycle use on the same carriageway. Thus, measures to reduce the volume and speed of traffic should be considered first. These may reduce the potential for conflict sufficiently and thus minimise or even avoid the need for separate provisions for bicycles on the centre's streets.
- Where slow speeds and low volumes cannot be achieved, or depended upon, dedicated bicycle lanes can be considered where appropriate under bicycle planning guidelines. It will rarely be feasible or appropriate to provide separate bicycle paths within activity centres.
- Employ suggested guidance on bicycle facility selection, design, signing, integration with public transport and end-of-trip facilities
- Clearly signpost off-street car parks, bicycle paths, public transport stops and footpath connections.

Interaction with pedestrians in activity centres

Many of the principles for walk-based activity centres (Section 2.3.2, AGTM07 (Austroads 2015e)) apply to cycle access and circulation. However, bicycles and pedestrians can be an uncomfortable mix in some circumstances. Therefore, some degree of separation is often justified:

In pedestrian activity spaces, bicycles can be threatening and intrusive. It may be necessary to avoid shared paths and surfaces in the centre, where the volume of pedestrian traffic will usually be too great for cycling to be safely and comfortably accommodated. For example, it would not be appropriate to allow a footpath to be shared by pedestrians and cyclists along a ribbon/strip style shopping area on an arterial road.

Interaction with other traffic

- Include design elements that legitimise and elevate awareness of the presence of cyclists, particularly at intersections.
- Create slow-speed conditions on streets where cyclists mix with traffic within the centre.
- Exploit opportunities to use streetscaping, pedestrian and cycling facilities, and parking layouts to help restrain vehicle speeds.
- Manage traffic volumes and lower speeds through traffic calming, parking design and intersection design measures (see AGTM08 (Austroads 2016c)).
- Where appropriate, introduce shared zones (see Section 3.6 of AGTM07).
- As noted above, separate bicycle lanes can be considered where it is unsafe for cyclists to share the road with motorised traffic.
- Whatever arrangements for integration with, or separation from, vehicular traffic is adopted, there should be no ambiguity about where the cyclist and other road users are situated on the road and what their mutual obligations and expectations are.
- Safe crossing points across busier roads may be necessary to minimise the disruption of cyclists travelling to activity centres. Cycle road crossings are an integral part of cycle routes, and intersection and crossing design should favour cyclists' convenience and safety within centres.

Bicycle parking in activity centres

Not all bicycle parking needs are the same. Bicycle parking facility design should reflect the needs of several different cycling trip types (Roads and Traffic Authority NSW 2005):

- Collection and delivery of items: Providing 'ride-in' facilities may reduce the risks caused by bikes clustered around entrances to buildings or obstructing pedestrian paths. Parking for such short stay users does not necessarily need to be highly secure, but should be near the entrance, or inside, the place visited.
- Shopping-type visits: Racks should be located at regular intervals to ensure that the bicycle is reasonably close to the destination and under observation.
- Meetings and appointments: Use is generally irregular and can be long-stay – up to a whole day. Users favour locations where lighting and surveillance are perceived to be good, usually at or near to main building entrances.
- Workplace: This is all-day use on a regular basis and can be expected to be combined with end-of-trip facilities such as showers, lockers etc. Demand for such parking is more likely to justify grouping of racks, often within areas where there is controlled access, such as in basement car parks, CCTV and casual monitoring by security staff. Individual bicycle lockers may be appropriate.
- Residential parking: This requires a high level of security, and bikes should not need to be taken a long distance into the building. This category generally includes higher density residential buildings such as apartment buildings and university residential colleges.

Further guidance on bicycle parking is provided in Section 11 of this document and AGTM11 (Austroads 2017d).

Factors to consider when determining bicycle parking rates to be applied include (Roads and Traffic Authority NSW 2005):

- current levels of bicycle parking provided and their usage rates
- a visual inspection to identify locations where bicycle parking is in demand, paying particular attention to informal parking
- consultation with bicycle users, bicycle user groups and bicycle planning professionals
- current and expected number of employees or residents and their likely or desired use of bicycles
- current and expected number of visitors and their likely or desired use of bicycles for visiting the premises
- mode split targets included in a mobility management plan, bicycle plan or other local authority plan.

2.11 Traffic Impacts of Developments

AGTM 12
S 3.2.7

Depending on the nature and scale of a development, cyclists will access it via the adjacent road system from more distant locations, from nearby residential areas or from nearby bicycle routes. Where there are nearby bicycle facilities (off-road bicycle paths or on-road bicycle lanes) bicycle links into the development need to be considered. Convenient, safe and attractive cycle access should be provided.

Austroads *Guide to Traffic Management Part 12: Traffic Impacts of Development* (AGTM12) (Austroads 2016e) is designed to help traffic and transport practitioners identify and manage the impacts on the road system arising from land use developments, and contains information on the consideration of cyclist needs in assessing access requirements to and within developments.

Secure bicycle parking is an essential part of a network of bicycle facilities. Bicycle parking needs to be provided in a location that is convenient, and visible to the public for security reasons. In some planning schemes there are specific requirements for bicycle parking at developments in particular land use zones. Australian Standard AS 2890.3-2015 outlines the requirements for bicycle parking. Parking facilities are discussed in Section 11 of this document and AGTM11 (Austroads 2017d).

AGRD 03
C9.1
AGTM 05
S 3.4
AGRD 06A
S 4.2

3. Bicycle Rider Requirements

3.1 General

The basic bicycle rider requirements that are generally considered necessary for convenient, efficient and safe travel by bicycle are presented in this section. These requirements should be designed from the outset for new streets and roads, and a complete on-road cycling network should be provided for cyclists. While the lack of on-road cycling links should not preclude the use of on-road cycle lanes, nearby links will be helpful to cyclists.

Information on rider requirements is provided in AGRD03, Commentary 9 (Austroads 2016a), AGTM05, Section 3.4 (Austroads 2014a) and AGRD06A, Section 4.2 (Austroads 2017c). Specific sections of these guides relevant to this section are shown in Table 3.1.

Table 3.1: Key cross-references related to bicycle rider requirements

Series		Part	Section	Reference source
Section 3.1: General				
AGRD	Guide to Road Design	3	Commentary 9.1	Austroads (2016a)
AGTM	Guide to Traffic Management	5	Section 3.4	Austroads (2014a)
AGRD	Guide to Road Design	6A	Section 4.2	Austroads (2017c)
Section 3.2: Space to Ride (also Sections 4.2.3 and 7.5)				
AGRD	Guide to Road Design	3	Commentary 8.2	Austroads (2016a)
AGRD	Guide to Road Design	6A	Section 3.2.2	Austroads (2017c)
Section 3.3: Smooth Surface (also Section 10.2 and Appendix E.4)				
AGRD	Guide to Road Design	3	Commentary 8.3	Austroads (2016a)
AGRD	Guide to Road Design	6A	Section 3.2.2	Austroads (2017c)
Section 3.4: Speed Maintenance (also Section 7.5.2)				
AGRD	Guide to Road Design	3	Commentary 8.4	Austroads (2016a)
AGRD	Guide to Road Design	6A	Section 3.2.2	Austroads (2017c)
Section 3.5: Sight Lines (also Sections 4.2 and 7.5.8)				
AGRD	Guide to Road Design	6A	Section 3.2.2 and 5.7	Austroads (2017c)
AGRD	Guide to Road Design	3	Section 5	Austroads (2016a)
AGRD	Guide to Road Design	4A	Section 3	Austroads (2017b)
Section 3.6: Connectivity (also Section 4.2)				
AGRD	Guide to Road Design	3	Commentary 8.5	Austroads (2016a)
Section 3.7: Information (also Sections 2.4.5 and 9.2.1)				
AGRD	Guide to Road Design	3	Commentary 8.6	Austroads (2016a)

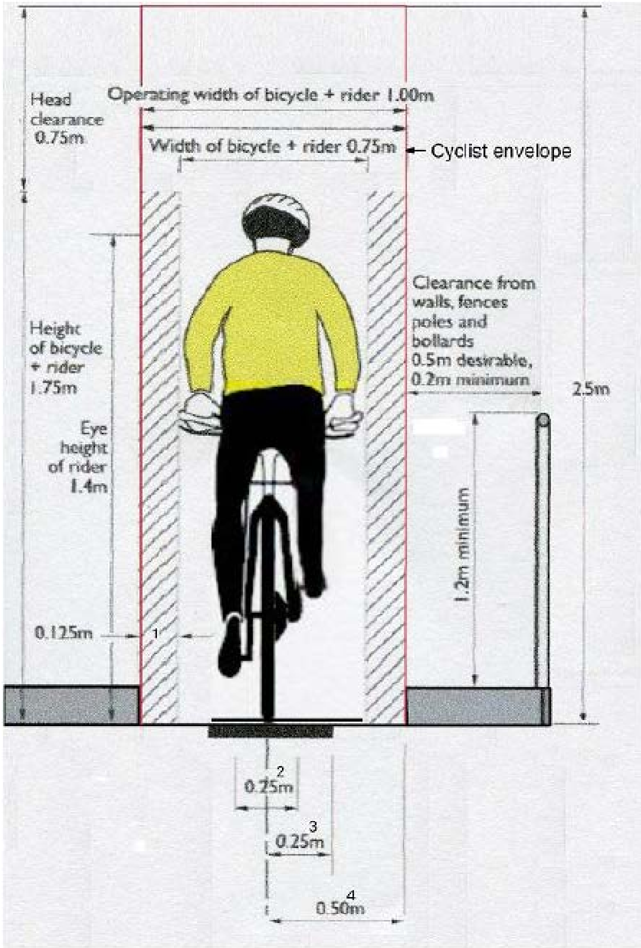
A very important requirement of many cyclists, in addition to those described below, is separation from motor vehicles because it enhances their safety and comfort, provided that the treatment results in a satisfactory level of service and does not result in a loss of priority at intersections and driveways. Commuter cyclists, for example, are unlikely to use a separated facility that results in a significantly greater travel time than alternative on-road routes.

AGRD 03
C8.2

3.2 Space to Ride

The bicycle design envelope and clearances shown in Figure 3.1 and Figure 3.2 provide the basis for the design of the bicycle facilities described in later sections of this document. It is important for designers to understand the basis of the design including clearance requirements so that they can make judgements in difficult situations where knowledge of minimum space requirements is needed. The envelope is relevant to the design of lanes on roads, off-road paths and bicycle parking facilities.

Figure 3.1: Cyclist envelope

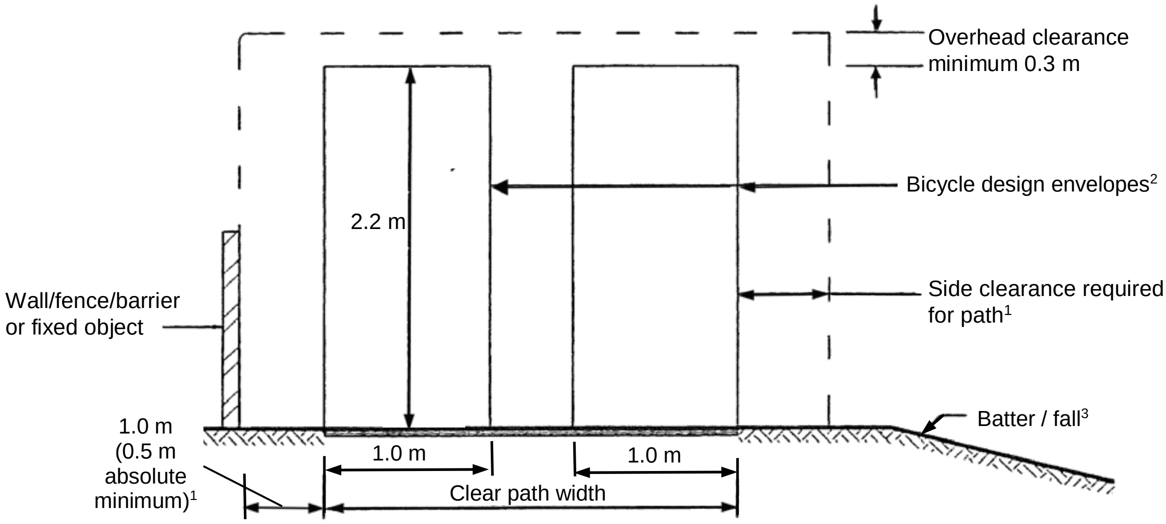


1 *Space for sideways motion while riding due to deviations in course caused by exertion, wind, surface variations and sudden shock reactions.*
2 *Tracking width resulting from deviations described in Keynote 1.*
3 *Clearance from obstacles at same level as road surfacing (grass verges etc.) or kerbing lower than 0.05 m.*
4 *Clearance with kerbing 0.05 m or higher.*

Notes: Bicycle length can be taken as 1.75 m. Bicycles may be longer than 1.75 m (e.g. tandems, recumbents) and wider than the design envelope (e.g. trailers, tricycles). This is particularly important in the design of chicanes and in considering the width of paths and storage areas (e.g. on the approaches to bridges on busy paths).

Source: Roads and Traffic Authority (2005).

Figure 3.2: Road clearances



1 This may be reduced to 0.3 m where a fence or obstacle has smooth features.
2 Refer to Section 3.2.2 of Austroads 2017c for guidance on bicycle design envelopes.
3 Refer to Section 5.5.2 of Austroads 2017c for guidance on batters and need for a fence.

The 1 m wide envelope allows for the width of a bicycle and for variations in tracking. Not all bicycle riders can steer a straight line and when riding uphill experienced riders work the bicycle from side to side whilst the inexperienced may wobble. Bicycle riders also need adequate clearances to fixed objects and to passing vehicles in addition to the 1 m envelope.

AGRD 06A S 3.2.2

In some situations it may be appropriate to provide for alternative forms of bicycles in the design of facilities. Appendix D provides information on the operational characteristics and designing for `human powered vehicles' (HPVs) in the event that a route or facility is anticipated to be used by a large number of these vehicles.

In general the least manoeuvrable HPV served by these guidelines is a tandem bicycle.

3.3 Smooth Surface

AGRD 03 C8.3

AGRD 06A S 3.2.2

Many bicycles have narrow tyres inflated to high pressure to reduce drag and have no suspension system. A smooth (albeit skid resistant) surface is therefore desirable for bicycles to be used effectively, comfortably and safely. Surfaces used for cycling should desirably be smoother than those acceptable for motor vehicles and persons responsible for road and path construction and maintenance should be made aware of this requirement. Detailed advice on surface tolerances is provided in AGRD06A (Austroads 2017c). Also, designers should be aware of the potential for debris to wash onto paths from adjacent land and that this can negate the provision of a smooth surface. Designs should minimise the likelihood of debris washing onto paths. For further guidance on the maintenance of cycling facilities and pavements, refer to Section 10.

Bovy and Bradley (1985) found that surface quality and trip length were about equal in importance and both were twice as important to cyclists as traffic volumes and the availability of bicycle facilities in cyclists' route choice.

3.4 Speed Maintenance

AGRD 03 C8.4
AGRD 06A S 3.2.2

For bicycles to be most effective as a means of transport cyclists must be able to maintain speed without having to slow or stop often. Cyclists typically travel at speeds between 20 km/h and 30 km/h although they may reach in excess of 50 km/h down hills. Once slowed or stopped it takes considerable time and effort to regain the desired operating speed.

Bicycle routes, especially off-road, should be designed for continuous riding, minimising the need to slow or stop for any reason including steep gradients, rough surfaces, sharp corners, obscured sight lines, intersections, or to give way to other people because the width available is too narrow. On many roads cyclists are confined to the extreme left side by motor vehicles and a rough surface prevents cyclists from maintaining an acceptable speed.

3.5 Sight Distance

AGRD 04 S 3
AGRD 03 S 5
AGRD 06A S 3.2.2 and 5.7

It is important that appropriate sight distance are provided between a cyclist's eye height and pedestrians to assist in minimising conflict, and between a cyclist's eye height and the path surface so that cyclists can stop in the event that a hazard exists on the path (e.g. mud deposited during inundation, potholes due to washouts, broken glass, and fallen tree limbs).

Designers should ensure that roads are designed to meet the sight distance requirements of Section 5 of AGRD03 (Austroads 2016a), Section 3 of the Austroads *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections* (AGRD04A) (Austroads 2017b) and AGRD06A (Austroads 2017c). For further explanations please refer to Section 7.5.8 of this report.

Designers should therefore resist the temptation to provide curves that are smaller than necessary (e.g. to create an artificially winding path for aesthetics or urban design reasons). It is much better for the safety of path users if larger curves with greater sight distance are provided.

3.6 Connectivity

AGRD 03 C8.5

Connectivity is that quality of a bicycle route or route network, describing the continuous nature of facilities or of the continuous nature of desired conditions. Practitioners should refer to Commentary C8, Section C8.5 of AGRD03 for further information on connectivity.

Cyclists need to be able to undertake and complete meaningful trips by bicycle. For recreation it may be from a residential area to a picnic spot, or for a specific purpose trip from home to work or the shops. Bicycle routes comprising roads and paths should combine to form an effective, convenient and safe network.

Connectivity is an important aspect of the construction of effective bicycle routes. Before a route is constructed its purpose should be identified as well as the routes which cyclists are likely to use in travelling to and from the paths, bicycle lanes and roads forming the network.

A route for cyclists which starts and ends abruptly is undesirable and may be hazardous, as it may lure inexperienced cyclists to a point where they are at risk, e.g. having to ride along or across busy roads to complete their intended trip.

On-road bicycle facilities may take the form of:

- dedicated unprotected bicycle lanes including full-time or part-time operation with or without adjacent parking
- contra-flow bicycle lanes
- protected bicycle lanes using kerbs and medians to physically separate motor vehicles and cyclists
- wide sealed road shoulders
- advisory treatments
- wide kerb side motor vehicle traffic lanes.

More information is contained in Section 4.

Off-road bicycle facilities may take the form of:

- bicycle paths
- separated paths – bicycle and pedestrian
- shared use paths.

More information is contained in Section 7.

3.7 Information

Bicycle routes should be signposted to indicate both destinations and the distances to them.

AGRD 03
S C8.6

Maps should be available showing the route, showing any facilities and points of interest, its relationship to the surrounding road system, and its relationship to relevant community facilities. The map and the signposting should provide consistent information in terms of destination names and other information.

4. Bicycle Facilities On-road (Mid-block)

4.1 General

AGRD 03 S 4.8

The aim in the management of a road network or road section is to achieve a balance in the competing needs of road user groups. It is desirable (although not always possible) that a road design should provide adequate operating space and appropriate treatments for all road users so that they can move safely and efficiently throughout the network.

AGRD03 (Austroads 2016a) provides guidance on the provision of on-road facilities that may be provided for cyclists. Other related Austroads guidance is summarised in Table 4.1.

Table 4.1: Key cross-references related to bicycle facilities on-road (mid-block)

Series		Part	Section	Reference source
Section 4.1: General				
AGRD	Guide to Road Design	3	Section 4.8	Austroads (2016a)
Section 4.2: Key Design Criteria and Considerations (also Section 7.5)				
AGRD	Guide to Road Design	3	Section 4.8	Austroads (2016a)
Section 4.3: Provision for Cyclists on Roads				
AGRD	Guide to Road Design	3	Section 4.8	Austroads (2016a)
AGTM	Guide to Traffic Management	5	Section 3.4 and Commentary 11	Austroads (2014a)
Section 4.4: Finding Space for Bicycle Lane Treatments				
AGRD	Guide to Road Design	3	Section 4.8.7 and 4.8.12	Austroads (2016a)
Section 4.5: Supplementary Road Treatments				
AGRD	Guide to Road Design	3	Section 4.8.7	Austroads (2016a)
Section 4.6: Ramps				
AGRD	Guide to Road Design	3	Section 4.8.7	Austroads (2016a)
Section 4.7: Provision for Cyclists on Freeways				
AGRD	Guide to Road Design	4C	Section 14.1 Commentary 5	Austroads (2015b)
AGTM	Guide to Traffic Management	5	Section 3.4	Austroads (2014a)
Section 4.8: Local Area Traffic Management Schemes				
AGTM	Guide to Traffic Management	8	Section 8.12.1	Austroads (2016c)

4.1.1 Types of On-road Bicycle Facilities

AGRD 03 S 4.8.1

In local streets it is usually not necessary to make special provision for cyclists as the lower speed of motor traffic should enable cyclists to safely share the road with other users. On arterial roads and collector roads it is usually necessary to ensure that adequate space exists for cyclists to share the road safely and comfortably, particularly when the road forms part of a principal or regional bicycle network. It may be possible to reduce the widths of other lanes in order to allocate additional space to the left lane for joint use by cyclists.

The provision of cyclist facilities should be based on the hierarchy of needs, delivered in order of level of safety and priority (Austroads 2016a) and depending on the nature of the road, abutting land use, the function of the road in bicycle networks, and the number and types of cyclists using the road, the following types of on-road facilities may be considered:

- off-road bicycle path (within the road corridor)
- on-road segregated bicycle lanes – median or similar separation
- on-road bicycle lane
- on-road peak period bicycle lane
- on-road bicycle/car parking lane
- wide kerbside lane
- narrow kerbside lane.

The facilities described in this section are those applied within the carriageway of new roads or within the established road carriageway in the case of existing roads.

Off-road bicycle facilities typically are shared pathways for use by both cyclists and pedestrians, and these are described in more detail in Section 7, and AGRD06A (Austroads 2017c).

4.2 Key Design Criteria and Considerations

Factors to be considered in the design of the horizontal and vertical alignment (gradients), cross-section and clearances are provided in Sections 4.8.2 to 4.8.4 of AGRD03. Road alignments and gradients are almost always determined by motor vehicle requirements and widths and clearances are therefore the important elements that relate to on-road facilities.

4.2.1 Road Geometry

AGRD 03 S 4.8.2

The vertical and horizontal alignment standard adopted on roads to serve the needs of motor traffic will normally be satisfactory for bicycle riding provided the operational aspects of cycling are understood by road agencies, engineers, planners and designers.

4.2.2 Gradients

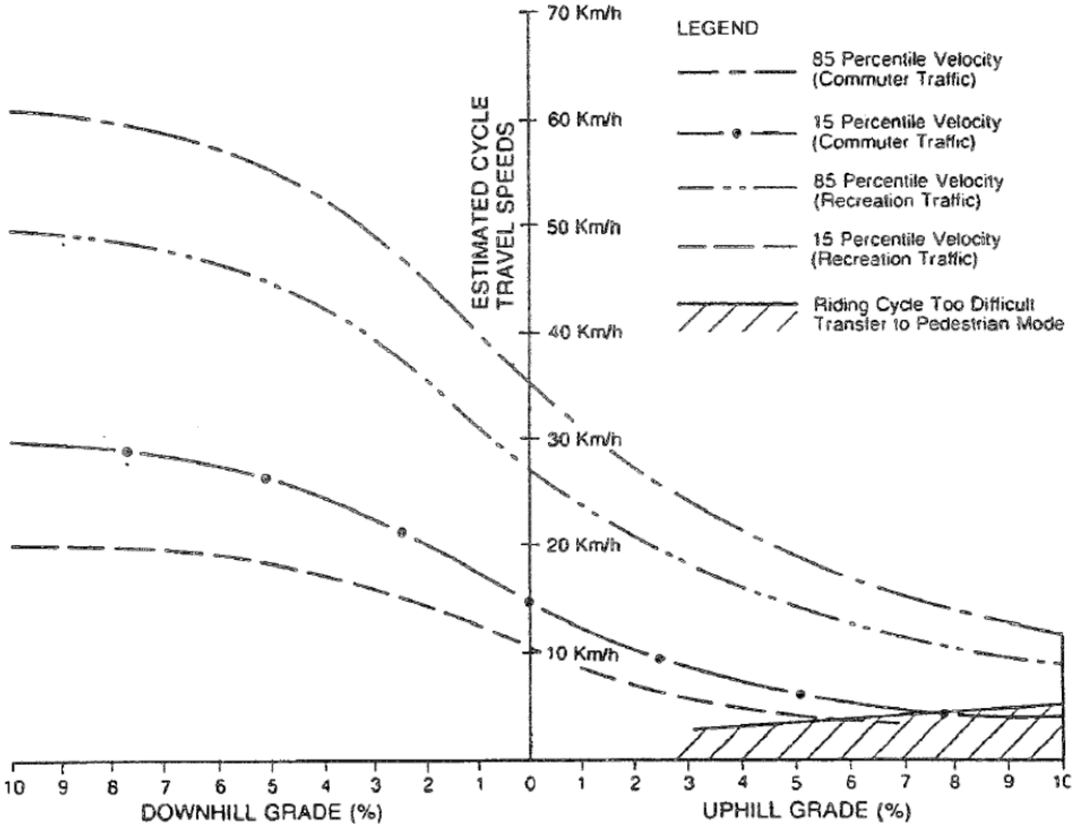
AGRD 03 S 4.8.3

People riding bicycles are very aware of road gradients due to the effort required to climb hills and to minimise effort, they usually select the flattest available route. In climbing steep gradients, experienced cyclists work the bicycle from side to side whilst the inexperienced tend to wobble. In situations where a steep gradient is unavoidable, additional pavement width should be provided to allow for this operating characteristic. The additional width may vary from an extra 0.25 m at regular speed to as much as 0.8 m at low speed (ipv Delft 2015). It is suggested in AGRD06A that the path width be widened by 0.5 m to cater for this requirement.

Because excessive gradients on hills can be unpleasant to cyclists and act as a deterrent to bicycle riding, road planners and designers should strive to minimise gradients on all new works including those in new subdivisions. It may be possible to achieve flatter grades on important collector roads for little additional cost.

Figure 4.1 shows the expected operating speeds for bicycle user group performance on vertical grades. This figure can be used to determine speed differentials between motorised traffic and bicycles which will assist in the selection of bicycle facilities with appropriate separation. Space for climbing cyclists can also be made through the allocation of additional lane width.

Figure 4.1: Bicycle operating speeds



Further information regarding gradients for cyclists on paths can be found in AGRD06A (Austroads 2017c).

4.2.3 Cross-section and Clearances

AGRD 03
S 4.8.4

On local streets that carry less than 3000 vehicles per day, bicycles and motor vehicles can generally share the road. However, where this volume is exceeded and where speeds are higher (e.g. local traffic routes and arterial roads) the width of the left lane should be at least sufficient for cars and bicycles to travel safely side by side. This requirement applies equally along roads and at intersections.

Due to the side wind force exerted on cyclists from heavy vehicles, roads should be designed to provide satisfactory clearances between the bicycle envelope and passing vehicles. Figure 3.1 describes the cyclist envelope whilst Table 4.2 lists the clearances that should be provided between a cyclist envelope and a truck in the adjacent lane in order to enhance cyclist safety.

Bicycle lane width should be measured to the lip of the channel if the channel surface cannot be safely used by cyclists (e.g. the channel surface is not smooth or has excessive cross slope). If the join between the pavement and the lip of the kerb and channel allows a 20 mm bicycle tyre to safely cross over then the lane can be measured to the kerb invert. However, if other road features extend into the bicycle lane, such as some driveway treatments and drain grates, these features should also be considered in the bicycle lane width measurement and designed to allow safe passage by cyclists using the bicycle lane.

Figure 3.2 illustrates both the minimum and preferred clearances that should be provided. Similar minimum clearances to cars should be provided so that cyclists do not feel unduly threatened by general motor traffic. However, the inability to achieve these clearances should not preclude the provision of a facility having a lesser clearance unless a suitable alternative route or means of accommodating cyclists exists within the road reserve.

Table 4.2: Clearance to the cyclist envelope from an adjacent truck

Speed limit (km/h)	60	70	80	100	110
Desirable clearance (m)	1	1.5	1.5	2	2+
Preferred clearance (m)	1.5	2	2	2.5	2.5

Source: Austroads (2016a) Table 4.17.

The following factors should be the subject of careful assessment when choosing the lane or treatment widths:

- parking conditions
- door clearance required to parked cars
- motor vehicle speed
- motor vehicle volume
- bicycle/parking lane width
- bicycle volume
- traffic lane width
- percentage of heavy vehicles
- alignment of road.

The demand for the adjoining general traffic lane is also an important issue in assessing the adequacy of bicycle lanes. Where a road is operating close to capacity and narrow bicycle lanes exist, there may be insufficient opportunities or it may be hazardous, for cyclists to pass each other. Therefore, if a demand for passing within bicycle lanes is likely on congested roads a minimum bicycle lane width of 2 m should be provided. Surface conditions and edge clearances to kerbs need to be considered in the assessment of the capacity of road lanes for bicycles.

It is also most important for cyclist safety that adequate clearance is provided between the cyclists operating space (envelope) and motor vehicles in the adjacent lane (Figure 3.2).

While not a common problem, the capacity of bicycle lanes may need to be considered in certain locations, e.g. priority cycling routes providing access to capital cities. Information provided in Section 7.5 and AGRD06A (Austroads 2017c) is also applicable to bicycle lanes on roads. Surface conditions and edge clearances to kerbs need to be considered in the assessment of the capacity of road lanes for bicycles.

On this basis, it is preferable that wide kerbside lane treatments are avoided where possible along roads with a speed limit in excess of 70 km/h, given the 85th percentile speed of cyclists under free flow conditions is in the order of 30 km/h. Similarly, where hills exist, the lower speed differential between motor and bicycle traffic for downhill travel, and the ‘wobble’ effect for uphill travel, are such that it may be appropriate to provide a bicycle lane treatment in the uphill direction only, where width constraints exist and there is no opportunity for the provision of a bicycle lane in the downhill direction.

4.3 Provision for Cyclists on Roads

4.3.1 General

Under the *Australian Road Rules* (National Transport Commission 2012) cyclists may move along roads in three areas defined in the rules as a bicycle lane, a marked lane or a shoulder. Cyclists may also ride in special-purpose lanes if permitted by the relevant jurisdiction, and are required to obey the relevant rules when using a bicycle lane, marked lane or shoulder.

4.3.2 Bicycle Lanes

AGRD 03

S 4.8.7

Bicycle lanes should be viewed as part of a bicycle network providing the connectivity required to enable convenient and safer trips by bicycle. A bicycle lane is:

- a lane created by 'bicycle lane' signs and delineated by pavement markings (Figure 4.2)
- the preferred treatment for cyclists on roads without any form of physical separation
- generally located at the left side of a road.

Bicycle lanes should be provided on both sides of the road where possible so that use is in the same direction as motor vehicle traffic.

Figure 4.2: An example of a bicycle lane

Note: Green coloured surface treatments should only be used to increase driver and cyclist awareness of a bicycle lane, and to discourage drivers from encroaching into a bicycle lane. The treatment should be used sparingly to maintain its effectiveness. Refer to Section 9.4 and Section 6.6 of AGTM10.

Motor traffic is generally prohibited by traffic regulations from travelling in bicycle lanes except to access property or to turn at intersections. Similarly, parking in bicycle lanes is prohibited. In some cases, bicycle lanes may only operate at certain times of the day, in which case the lane may be available for parking or as a travel lane at other times.

AGTM 05 C11

Bicycle lanes are often necessary in order to provide a safer environment for cyclists, a satisfactory level of service, and positive connectivity of a cycling route. The provision of a painted line between the motor vehicle lane and the bicycle lane together with bicycle pavement symbols at frequent intervals has a number of advantages as it (Commentary 11, AGTM05 (Austroads 2014a)):

- clearly defines the road space provided for use by each mode
- results in motor vehicles generally not blocking the progress of cyclists where traffic queues exist
- provides lateral separation and improved safety when motor vehicles in the adjacent lane are moving
- creates awareness in the minds of motorists that a cyclist may be present (at times when few cyclists are using the lane).

AGTM 05 S 3.4

Segregated or exclusive bicycle lanes:

- are generally the preferred on-road facilities for providing separation between bicycles and other vehicles
- may combine with particular characteristics of the road to form different types of treatment (e.g. in conjunction with parallel or angle parking); (refer to Section 4.3.9)
- may sometimes be installed as part-time facilities by the removal of car parking along arterial roads during certain times (e.g. peak periods); however, an adequate level of parking enforcement is required for the treatment to be effective for cyclists
- can be often very difficult or impracticable to achieve for existing road conditions
  However, there are a range of other forms of lanes and treatments that may be provided to improve the quality of a cyclist's riding experience on the road.
- where required can incorporate coloured surface treatments to increase awareness of exclusive bicycle lanes
- have largely been installed with success in a number of locations, and provide a safer riding environment that non-separated lanes by segregating cyclists from general traffic (possibly except at intersections where drivers may not expect cyclists)
  Separated lanes can be one-way (often referred to as 'Copenhagen' style) or two-way.
- space for bicycle lane treatments can be obtained through a number of techniques, including adjusting the existing carriageway (making use of the general traffic lanes), upgrading service roads, sealing road shoulders, road widening at the verge or median or the removal of parking or traffic lanes
- may be appropriate or highly desirable (depending on site conditions) where
  - bicycle traffic is concentrated (e.g. near schools or along major routes near city or town centres)
  - an existing or future significant demand for bicycle travel can be demonstrated (e.g. where traffic volumes and speeds deter cyclists from using an otherwise favourable route)
  - they are needed to provide continuity within a bicycle route network
  - a road is carrying or is likely to carry more than 3000 vehicles per day and/or a significant percentage of heavy vehicles
- crossings at intersections and changes in road layout can cause a number of problems for cyclists, including squeeze points, vehicles overtaking and immediately turning left into a side street, converge and diverge areas, lack of continuity and connectivity, safely crossing or joining conflicting flows, gaining position to turn right, not being seen by motorists, the speed of cyclists misjudged by motorists and loss of access

- another treatment style has been installed on Swanston Street in inner Melbourne, one of Australia's busiest cycling streets
  Cars are not allowed on Swanston Street, which has a tram line in the middle of the road space. An exclusive bicycle lane is located in between the pedestrian space and the tram line. Bicycles must stop for pedestrians entering and exiting the trams.
- head start and expanded storage areas can be provided at intersections
  They are designed to improve visibility and awareness of cyclists at intersections, improving safety.
- while not a common problem, the capacity of bicycle lanes may need to be considered in certain locations, e.g. priority cycling routes providing access to capital cities
- where the difference between bicycle and motor traffic speeds is less than 20 km/h, full integration may be acceptable, i.e. where bicycles and motor traffic share the road without any special provisions
  Conversely, segregation is most desirable where the differences between bicycle and motor traffic speeds exceed 40 km/h.
- bicycle/car parking lanes comprise a bicycle lane marked between permanent kerbside parking and a traffic lane. They
  - provide a means of improving conditions for cyclists where parking occurs
  - may be provided in conjunction with parallel or angle parking in special circumstances (e.g. low-speed, inner urban) where road and network conditions are suitable
  - require adequate clearance to parked cars (safety strip is desirable) so that doors are not opened into the path of cyclists
    'Dooring' has resulted in a number of recent serious injuries and deaths and the likelihood of this occurring should be examined before installation of this treatment.
  - may be used with angle parking
  - may provide safety and other benefits for other road users due to
    - improved clearances for parking and unparking manoeuvres, and for the entering and exiting of parked cars for drivers
    - provision of greater clearances and increased width for vehicle recovery between roadside hazards and motor vehicles
    - more efficient use of road space on which they are implemented
    - reduced effective motor traffic lane crossing distance for pedestrians
    - improved channelisation of traffic and hence more orderly and predictable traffic flow, and often better sight conditions.

The width adopted for bicycle lanes will vary depending on the:

- number of cyclists
- speed of motor traffic
- volume of large vehicles
- ability to make space available
- needs of other road user groups
- physical constraints and budgetary constraints.

Table 4.3 shows the minimum bicycle lane widths for urban roads posted at various speeds. It should be noted that urban roads with a posted speed greater than 80 km/h (e.g. 100 km/h) will usually be a freeway or expressway that carries a high volume of high speed traffic. In this case it is essential that cyclists are provided with facilities that comply with Safe System principles, namely physically separated bicycle lanes or paths that are protected by safety barriers, and grade separations or controlled crossings at interchanges.

Table 4.3: Exclusive bicycle lane dimensions in urban areas

Road posted speed limit (km/h)(1)	Lane width(2)(3) (m)		
	60	80	100(4)
Desirable	1.5	2.0	2.5
Acceptable range	1.2–2.5	1.8–2.7	2.0–3.0

1 *The posted or general speed limit is used, unless 85th percentile speed is known and is significantly higher.*
2 *Interpolation for different speed limits is acceptable.*
3 *The width of the lane is normally measured from the face of the adjacent left side kerb. The width of road gutters/channels (comprising a different surface medium) should be less than 0.4 m where minimum dimensions are used. The figures in the table presume that surface conditions are to be of the highest standard. Where there are poor surface conditions (see AGRD06A (Austroads 2017c), Appendix B) over a section of road adjacent to the gutter, then the width of the exclusive bicycle lane should be measured from the outside edge of that section.*
4 *Physical separation including safety barriers are essential on urban roads that have a posted speed limit > 80 km/h.*

Source: Austroads (2016a) Table 4.18.

With reference to Note 3 to Table 4.3, it is desirable that the channel should not be included as part of the exclusive bicycle lane width, particularly where there are potential safety concerns, including:

- edge drop-off between the pavement and channel surfaces, particularly when open graded friction course (OGFC) is used
- steep and abrupt change in crossfall slopes to match resurfaced roads to the lips of channels as these slopes can adversely affect the stability of cyclists
- hazards in, and adjacent to, the kerb and channel such as the surface condition of the channel and drainage pit entrances
- the likelihood of the bicycle pedals striking the kerb.

Given the difficulty in many situations to find adequate road space to install an exclusive bicycle lane an assessment should be undertaken to determine if the kerb and channel can or should be incorporated into the bicycle lane width.

4.3.3 Wide Kerbside Lanes

AGRD 03 S 4.8.11
AGTM 05 S 3.4

Wide kerbside lanes may be appropriate on major traffic routes and collector streets, whether divided or undivided, on sections of road where sufficient space is not available to accommodate an exclusive bicycle lane or parking is either minimal or prohibited during peak periods (Figure 4.3). This sharing of lanes is generally appropriate in speed zones of 70 km/h or less, and where exclusive bicycle lanes cannot be installed. The sharing of lanes cannot be legally performed (and hence facilitated) in all states.

Wide kerbside lanes are appropriate on all major traffic routes and collector roads, whether divided or undivided, on sections of road where parking is either minimal or prohibited during peak periods.

Figure 4.3: Wide kerbside lane

Source: VicRoads (2000).

A guide to the width of wide kerbside lanes is provided in Table 4.4.

Table 4.4: Wide kerbside lane dimensions

Road posted speed limit[1] (km/h)	Lane width[2][3] (m)	
	60 km/h	80 km/h[4]
Desirable minimum	4.2	4.5
Acceptable range	3.7–4.5	4.3–5.0

1 The posted or general speed limit is used, unless 85th percentile speed is known and is significantly higher.
2 Interpolation for different speed limits is acceptable.
3 The width of the lane is normally measured from the face of the adjacent left-hand kerb. The width of road gutters/channels (comprising a different surface medium) should be less than 0.4 m where minimum dimensions are used. The figures in the table presume that surface conditions are to be of the highest standard. Where there are poor surface conditions over a section of road adjacent to the gutter, then the width of the wide kerbside lane should be measured from the outside edge of that section.
4 For roads with a posted speed limit of 80 km/h, wide kerbside lanes are only suitable where the demand for parking is low.

Source: Austroads (2016a) Table 4.21.

Table 4.4 indicates the desirable width and acceptable range of width for wide kerbside lanes in 60 km/h and 80 km/h speed zones (unless noted otherwise). Whilst the table suggests that a 4.5 m lane width is desirable in 80 km/h zones designers should understand that it is always preferable to provide a marked exclusive bicycle lane instead of a wide kerbside lane, particularly in higher speed zones (i.e. 70 km/h and 80 km/h). Where space cannot be made available for an exclusive bicycle lane a wide kerbside lane can offer benefit to cyclists in terms of safety and comfort.

Other considerations when using wide kerbside lanes are:

- Where kerbside parking is significant in the off-peak period, the wide kerbside lane should be at least 4 m wide so that the lane will function satisfactorily as a bicycle/parking lane during these periods even though special pavement marking is not provided for guidance.
- Exclusive bicycle lanes are preferred where a road has regular curves or where an unusually high number of heavy vehicles use the road.
- For roads with a posted speed limit of 80 km/h, wide kerbside lanes may be considered where space cannot be made available for a superior treatment (e.g. protected bicycle lane, exclusive bicycle lane or off-road bicycle path) and there is virtually no demand for parking.

4.3.4 Sealed Shoulders

AGRD 03 S 4.8.9
AGTM 05 S 3.4

Where a road is un-erbed and provision for cyclists is required, a smooth sealed shoulder is the preferred treatment. Although warrants do not exist specifically for the provision of sealed shoulders for cyclists there are many instances on rural roads where the sealing of shoulders is justified specifically to make roads safer for cycling. However, where the shoulder is available for use by cyclists, Table 4.3 (for bicycle lanes in urban areas) should be used as a guide to the appropriate width of sealed shoulders.

Table 4.5 of AGRD03 (Austroads 2016a) provides some guidance as to the appropriate standard to be provided for cyclists. This table relates shoulder width to traffic volume and cyclists' requirements are referred to only in note 2 to the table, which states:

> *Where significant numbers of cyclists use the roadway, consideration should be given to fully sealing the shoulders. Suggest use of a maximum size 10 mm seal within a 20 km radius of towns.*

Widths required for sealed shoulders for bicycle usage are generally the same as those required for bicycle lanes, as shown in Table 4.3. Although this table relates the width to speed, the widths are not inconsistent with Table 4.18 in AGRD03. Provision for cyclists should be maintained through intersections, past driveways, and at those locations where the road is kerbed along lengths of road otherwise treated with sealed shoulders. Where a chip seal is used to seal the shoulders, consideration should be given to the use of a maximum size 10 mm stone to provide a smoother and less abrasive riding surface for cyclists.

4.3.5 Bus/Bicycle Lanes

AGRD 03 S 4.9.2
AGTM 05 S 3.4

Whilst it is desirable that bicycles are accommodated in a separate bicycle lane, examples exist where bicycles have successfully shared in the use of bus lanes. In most circumstances cyclists may be permitted to use bus lanes when they are located next to the kerb on arterial or local roads. Considerations for provision of bicycles within bus lanes should be based on:

- the number of cyclists
- frequency of bus services
- the number of bus stops/frequency with which buses stop in a length of road
- time required to set down and pick up passengers
- preferences of cyclists using the route
- speed of buses and other traffic
- location of bus stops
- the available width
- alternative options (e.g. if bicycles are not permitted in the bus lane the cyclists will be legally required to ride in the traffic lane between two higher speed traffic streams).

Generally, buses will overtake cyclists between bus stops and cyclists will catch up and overtake buses at bus stops. This process can lead to 'leap-frogging' along the bus lane.

The key to managing the impact of this process on the level of service to buses and cyclists is to provide a bus lane that is wide enough to accommodate these movements. A guide to the width is provided in Table 4.5. Alternatively, it may be possible to provide a separate on-road bicycle lane or off-road bicycle path adjacent to the bus lane and at bus stops.

Table 4.5: Width of kerbside bus lanes

Speed zone (km/h)	Width of bus lane (m)			Comment
	60	70	80	
Minimum width of bus lane that can be shared with cyclists	3.7	4	4.3	Bus lanes of this width are considered wide kerbside lanes and allow cyclists and buses to share the bus lane. Bus lanes of this width may be acceptable for routes that carry between 50 and 100 cyclists or where bus headways are between 15 and 30 minutes in the peak hour.
Minimum width of separated o--road bicycle lane	1.2	1.5	1.8	It is considered desirable to provide separated on-road bicycle lanes adjacent to bus lanes on routes that carry more than 100 cyclists and where bus headways are 15 minutes or less in the peak hour.
Minimum width of bus lane and separated on-road bicycle lane	4.2	4.6	5.1	This is the minimum width of the bus lane plus the minimum width of a separated on-road bicycle lane to provide the minimum separation between cyclists and buses.

Source: Austroads (2016a) Table 4.23.

4.3.6 Advisory Treatments

Advisory treatments are used to indicate or advise road users of the potential presence of cyclists and of the location where cyclists may be expected to ride on a road. They use pavement markings, warning signs or guide signs, and have no regulatory function. The purpose of these treatments is usually to define a bicycle route rather than a type of facility to which specific road rules apply. The form of the treatment is a matter for local jurisdictions.

4.3.7 Bicycle/Car Parking Lanes

AGRD 03
S 4.8.10

Bicycle/car parking lanes are most appropriate where the street is wide, there is a demand for parking (and where road space and capacity requirements allow parking throughout the day). It is most important to provide a width that is adequate to accommodate parked vehicles, operating space for cyclists and adequate clearance to accommodate the opened door of parked vehicles.

Further discussion is provided in Section 4.8.10 of AGRD03 (Austroads 2016a). Bicycle/car parking lanes may be provided in conjunction with parallel parking or angle parking.

With parallel parking

Table 4.6 provides guidance on widths of bicycle/car parking lanes with parallel parking and the associated layout is shown in Figure 4.4. Also, it should be noted that:

- 4.5 m is the acceptable maximum width as a greater width may result in moving cars attempting to utilise the bicycle lane. It provides acceptable clearances in cases where parking turnover is significant or traffic speeds are in excess of 60 km/h but no greater than 80 km/h
- 4.2 m is the desirable width where speeds are about 60 km/h as it provides comfortable clearance to parked cars
- 4 m is the acceptable minimum width where traffic speeds are about 60 km/h as it enables a cyclist to travel adjacent to parked and moving cars at a reasonable speed with minimum clearances.

Table 4.6: Bicycle/car parking lane dimensions (parallel parking)

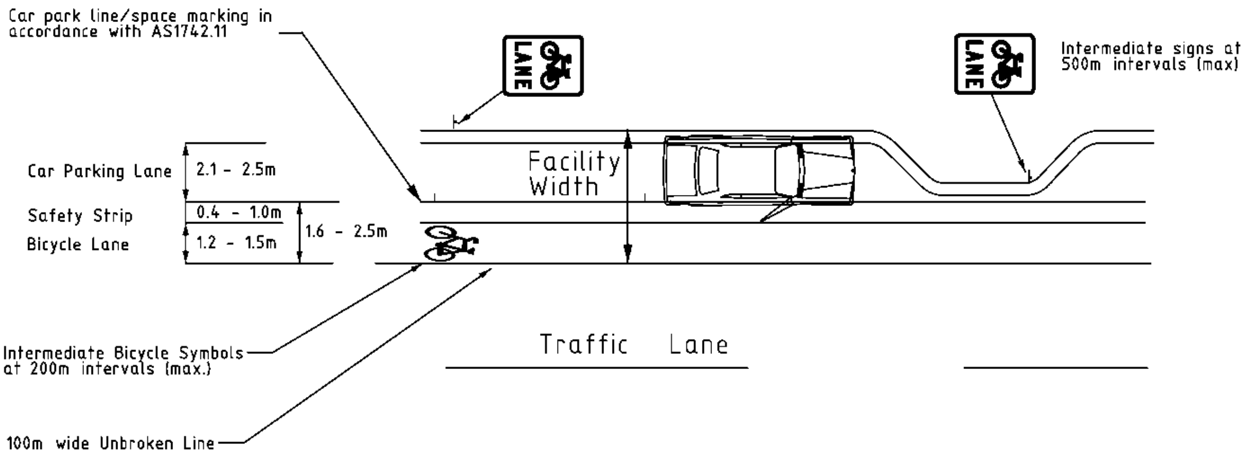
Road posted speed limit (km/h)	Overall facility width (m)	
	60 km/h	80 km/h
Desirable minimum	4	4.5
Acceptable range	3.7–4.5	4–4.7

Notes: The posted or general speed limit is used, unless 85th percentile speed is known and is significantly higher.

Interpolation for different speed limits is acceptable.

Source: Austroads (2016a) Table 4.19.

Figure 4.4: Typical bicycle/car parking lanes layout (parallel parking)



Where sufficient width is available within a carriageway it is desirable to provide a safety strip between the traffic lane and bicycle lane as shown in Figure 4.5.

Figure 4.5: A bicycle/car parking lane with painted separators between cyclists, parked cars and the traffic lane

With parallel parking and bicycle lane between parked cars and kerb

Where sufficient space can be made available the bicycle lane may be placed between the parallel parked cars and the left kerb of the road. In areas where there is a high percentage of parked cars involving driver only trips, this arrangement can reduce the likelihood of cyclists conflicting with a car door or a person exiting the car (car doors opening from the passenger side are less frequent than the driver side due to the number of driver only trips). An inner city example of such a treatment which provides physical separation is shown in Figure 4.6.

Figure 4.6: Separated bicycle lane with physical separation of parking

With angle parking

This treatment is illustrated in Figure 4.7. The entry and exit conditions of angle parking require that a high level of protection is provided to cyclists. The provision of marked bicycle lanes adjacent to angle parking is therefore most desirable. Whilst an opening car door does not pose a threat to cyclists in the case of angle parking, cyclists have to be alert to vehicles reversing (regardless of orientation) into their path. It is most important in cases where parallel parking is being converted to angle parking that the needs of cyclists are given adequate consideration.

This treatment is appropriate only where the posted or general speed limit is less than or equal to 70 km/h. The provision of kerbed projections or other treatments including channelisation is recognised as extremely important. Treatments should be constructed immediately to the left of the bicycle lanes at the start of this type of lane facility and at regular intervals to limit the incidence of vehicles travelling over, or to the left of, the bicycle lane.

Figure 4.7: Typical bicycle/car parking lanes layout (angle parking)

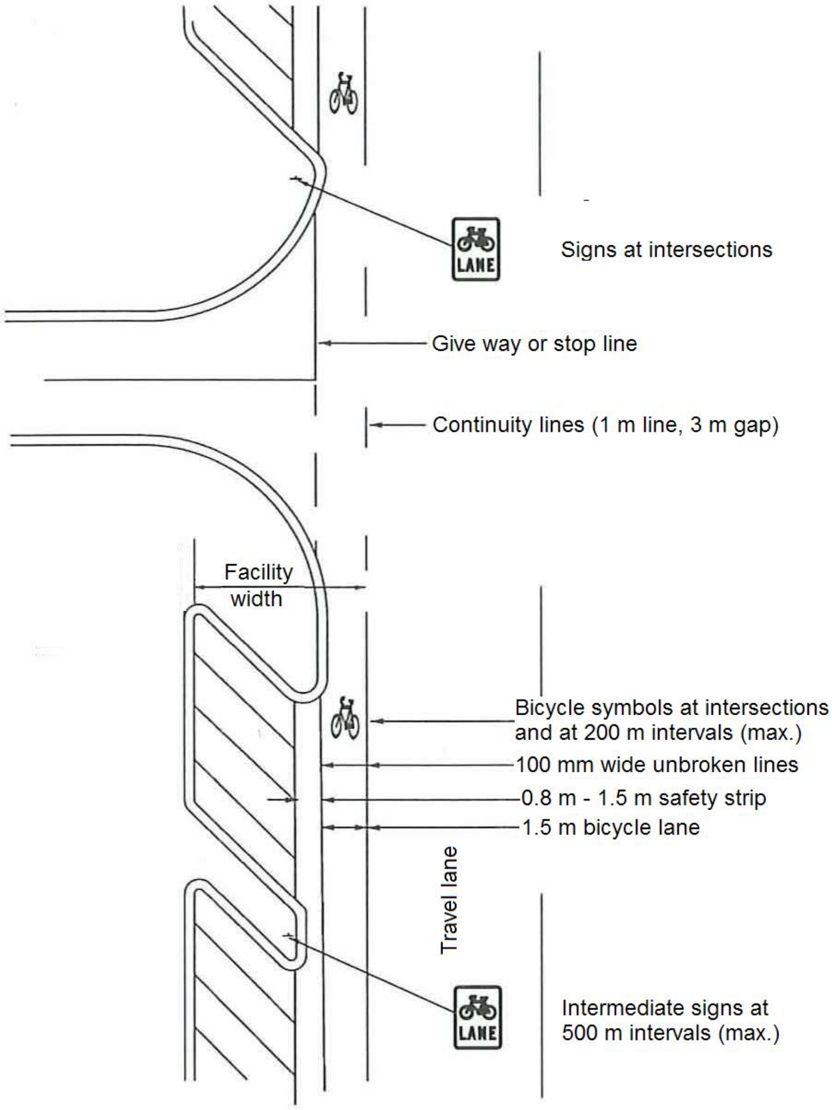


Table 4.7 is a guide to the overall width required to provide a bicycle/car parking lane with angle parking.

Table 4.7: Bicycle/car parking lane dimensions (angle parking)

Parking angle (degrees)	Overall facility width (m)		
	45	60	90
Desirable	7.3	7.6	8
Acceptable range	7.1–7.8	7.4–8.1	7.8–8.5

Notes:

Measured from kerb face to the marked line defining the left edge of the traffic lane. These dimensions assume parked cars can overhang the kerb. An additional 0.6 m should be added where overhanging of the kerb is not possible (i.e. parking to a wall).

This facility should be constructed only where the speed limit is 70 km/h or less, but in general would be inappropriate where the 85th percentile speed in known to be significantly higher.

Source: Austroads (2016a) Table 4.20.

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4.3.8 Contra-flow Bicycle Lanes

Contra-flow bicycle lanes:

- are exclusive bicycle lanes deployed on one side (to the left of the opposing traffic flow) of a one-way road serving cyclists travelling against what is otherwise the legal direction of travel (Figure 4.8)
- are advantageous to cyclists from a network viewpoint
- are acceptable in urban environments to achieve inner city links or routes to schools along lightly trafficked service roads
- should not be provided along the shoulders of rural or outer urban roads without physical separation
- may be provided in special circumstances (e.g. low-speed, inner urban) where road and network conditions are suitable
- in higher speed environments should be physically separated from motor vehicle lanes
- should be considered an acceptable treatment in urban environments where sufficient road widths exist to provide a safer treatment
- should have a width appropriate to the situation (refer to Table 4.3); absolute minimum = 1.5 m; desirable = 1.8 m
- should be physically separated from motor traffic where used in speed zones ≥ 60 km/h by a raised traffic island (preferable) or a safety strip that is desirably 1 m wide (0.6 m minimum)
- without physical separation from the adjacent traffic lane (e.g. a raised island or safety strip) are generally appropriate only in speed zones up to 50 km/h
- may be placed between parked cars and the kerb where bicycle access is important. Although this is not ideal, it may be satisfactory where cyclists do not need to frequently leave or join the facility over its length and cycling speeds are low. In such cases it is imperative to provide a 1 m separator (preferably a raised island) to allow for vehicle overhang or opening car doors.

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There are no warrants for the use of green surfacing in bicycle lanes. It is normally used with discretion (because of the relatively high cost) and only at sites where there is a higher probability of conflict between motor vehicles and bicycles such as the approaches to intersections or through intersections. A road agency may choose to use green pavement surfacing to highlight a contra-flow lane, particularly in situations where traffic speeds exceed 50 km/h and/or the lane is on a traffic route. However, in many cases the use of green pavement surfacing may only be beneficial to provide enhanced warning to motorists where conflicts are likely to arise (e.g. at intersections and where the contra-flow lane terminates).

Figure 4.8: Contra-flow bicycle lane example

4.3.9 Separated Bicycle Lanes

AGRD 03 S 4.8.5

The provision of a separated bicycle lane aims to improve safety for cyclists by providing (physical) separation from other motor traffic whilst maintaining directness of travel and priority at intersections. Separated bicycle lanes are also referred to as:

- protected bicycle lanes
- kerb separated bicycle lanes.

A separated bicycle lane:

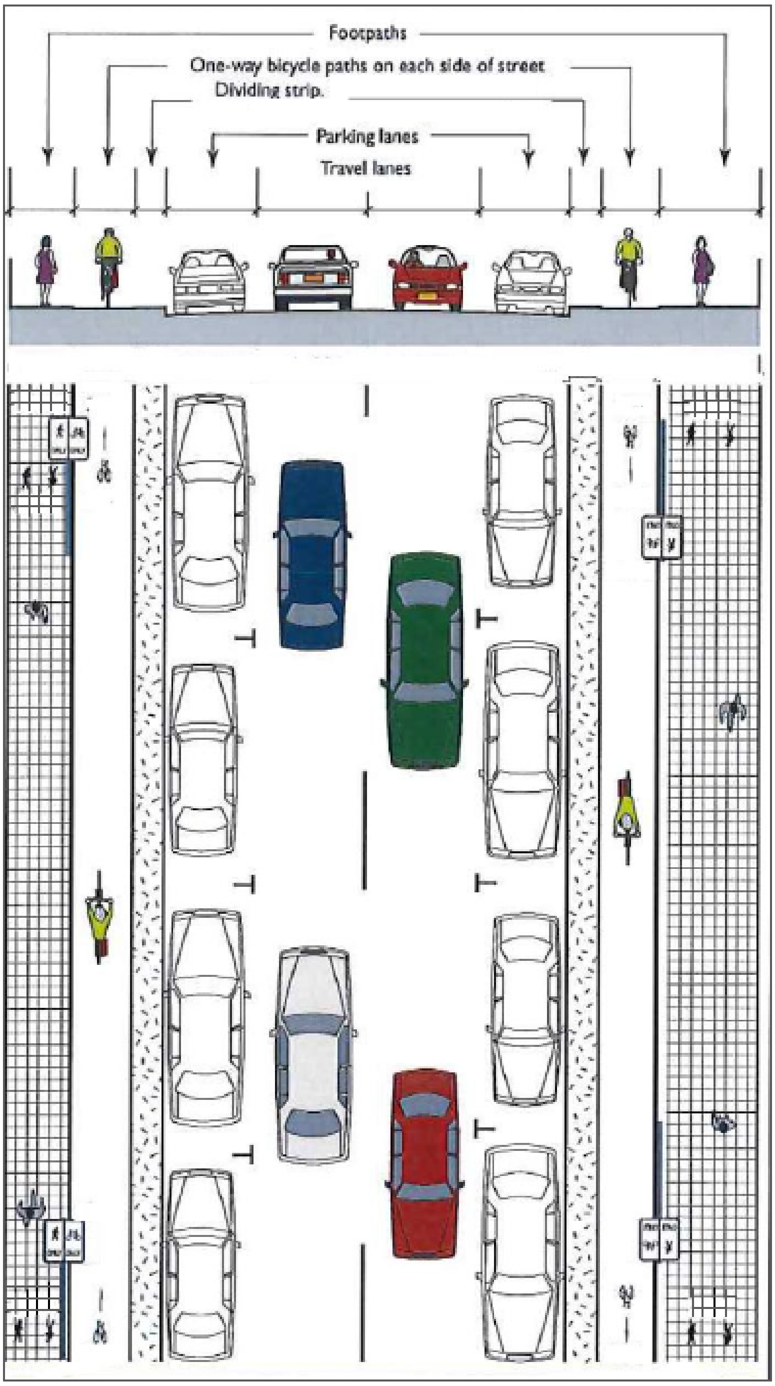
- is usually considered where a substantial length of road is being widened or duplicated and where there are few driveways and intersections
- that crosses minor side roads may be given priority over the side road through the use of raised thresholds and appropriate street signs
- generally provides a higher level of service for cyclists and has been shown to promote increased patronage on cycling routes
- is an option to be considered where a full width off-road path with suitably high levels of directness and priority for cyclists at intersections cannot be achieved within the existing road reservation.

Designers may also refer to road agency publications that may provide additional information, including local requirements and examples of treatments (e.g. Queensland Department of Transport and Main Roads 2015b).

Kerb separated bicycle lanes

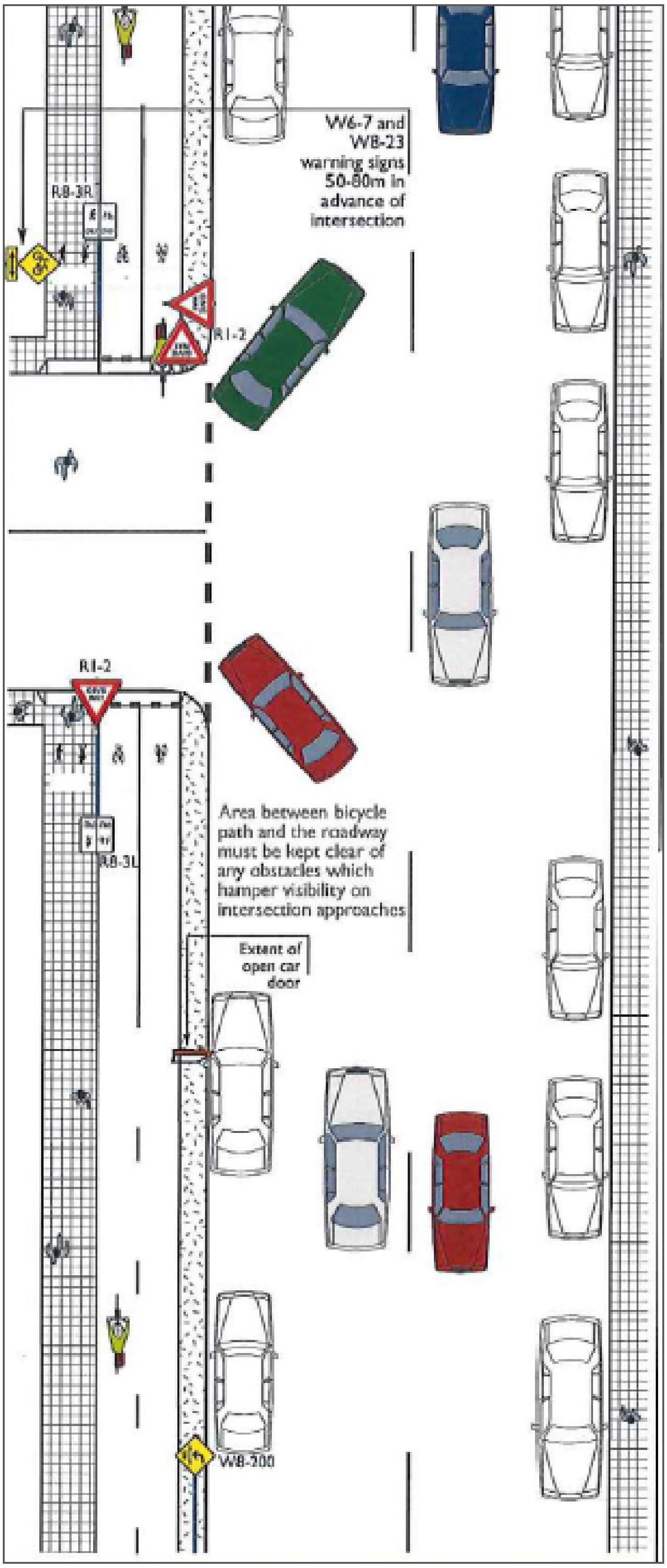
Separated or protected bicycle lanes, located behind the kerb are usually designed for bicycle use only and may be one-way lanes on both sides of the road (travelling in the same direction as the adjacent traffic lane), or two-way on one side of the road (refer to Figure 4.9 and Figure 4.10 respectively).

Figure 4.9: Kerb separated bicycle path/lane (one-way pair) off-road within the road reserve



Source: Roads and Traffic Authority (2005).

Figure 4.10: Bicycle path (two-way) off-road in the road reserve and crossing a side street



Source: Roads and Traffic Authority (2005).

Table 4.8: Considerations in the design of kerb separated bicycle lanes

Aspect	Consideration
Operation	Are designed to operate one-way, for bicycle use only and are required on both sides of the road
Separator	The treatment is raised above the traffic lanes and is usually situated alongside semi-mountable kerb and channel, unless a flush treatment is required for drainage considerations in which case a 600 mm wide flush kerb or edge strip may be used The separation may need to be increased by 1 m from the back of the kerb to provide clearance from car doors where kerbside parking is likely to occur
Transition	The treatment should rejoin the road as an exclusive bicycle lane prior to major intersections to provide a conventional level of directness and priority. This should be accommodated by means of a ramp having a grade no steeper than 10%
Obstructions	Consider obstructions such as street lighting and other utility poles, signs, road safety barriers and any other roadside furniture (Figure 4.11 and Figure 4.12)
Surface	Provide a smooth riding surface. Wherever practicable locate drainage pit lids outside of the lane; otherwise construct with (concrete in-filled) cast iron covers to ensure a flush finish
Pedestrians	The lane is widened to operate as a separated bicycle/pedestrian path or be accompanied by a clearly marked separate footpath if pedestrian demands would otherwise result in the mixing of cyclists and pedestrians in the space immediately adjacent to the through traffic lanes
Bus stops	Consider the treatment of both on-road and indented bus stops to provide a safer facility for both cyclists and bus patrons. The separated bicycle lane can be taken around the back of the bus stop or transitioned back onto the road pavement as an exclusive bicycle lane
Delineation	Appropriate signs and pavement markings should be installed to encourage cyclists to use the facility and to discourage pedestrian use

Source: Austroads (2016a) summarised from Section 4.8.5.

Figure 4.11: Kerb separated bicycle lane

Figure 4.12: Separated bicycle lane with clearway during peak hours (Albert Street, Melbourne)

Showing peak flow direction with parking prohibited

Showing situation with parking allowed (counter-peak flow direction and off-peak times)

Separated protected bicycle lanes

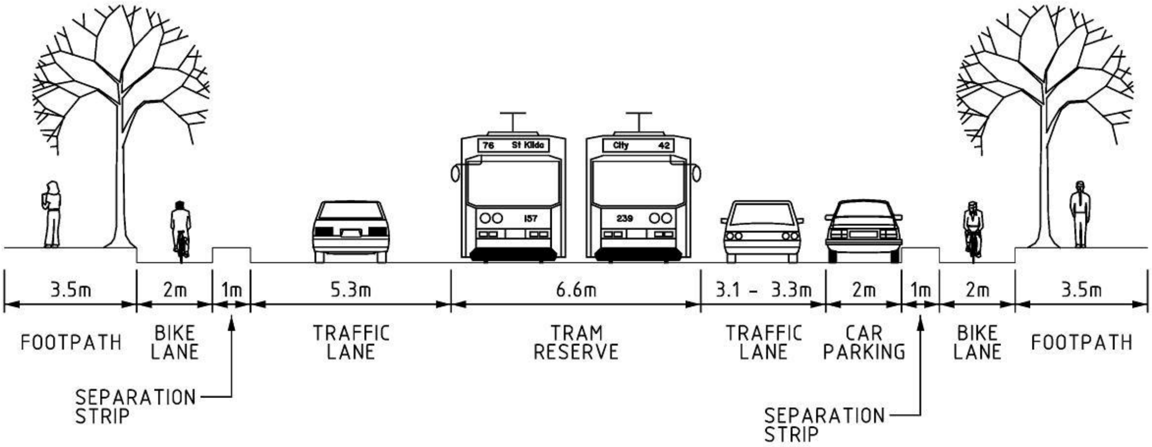
A separated protected bicycle lane (Figure 4.13) is a particular form of separated bicycle lane. This treatment:

- may be applied in urban areas where parking is prevalent
- is characterised by a raised separation strip to physically prevent vehicular access to the bicycle lane and provide clearance for the opening of car doors.

The raised separator generally requires breaks in the kerb to maintain the free drainage of the road (in a retrofit situation) or otherwise a specific drainage system needs to be installed. Regular sweeping of the bicycle lane should be undertaken to ensure debris and litter does not accumulate on the pavement surface.

Where protected bicycle lanes are implemented the minimum width of the bicycle lane should be 2 m to provide for internal passing opportunities by cyclists.

Figure 4.13: Typical cross-section of a separated protected bicycle lane



Note: Example is a typical cross-section constructed in Melbourne with a bicycle lane width of 2 m.

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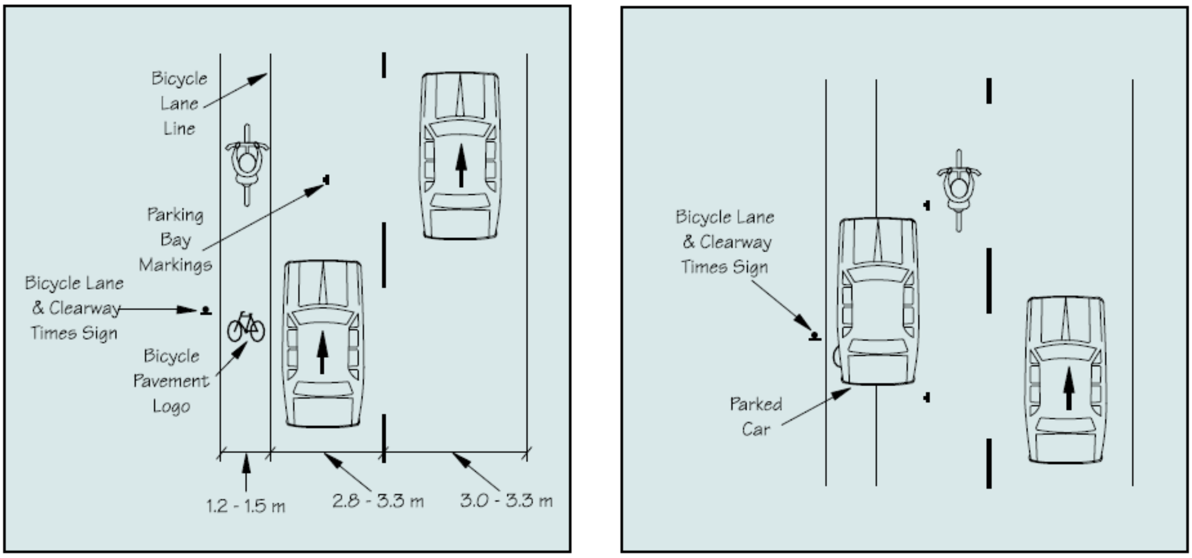
S 4.8.8

4.3.10 'Peak Period' Bicycle Lanes

'Peak period' bicycle lanes are common on roads designated with clearways. The restriction of parking during peak traffic periods usually coincides with peak cyclist numbers. On roads where the adjoining land use is predominantly residential, the installation of bicycle lanes during peak periods can be a compromise between the adjoining residents' desire for on-street parking and cyclists' need for designated road space. Parking restrictions should coincide with peak traffic conditions (i.e. outside of working hours or outside of school hours) to provide an exclusive bicycle lane when it is most needed. The operation of this type of lane is illustrated in Figure 4.14.

Peak period bicycle lanes should only be used when no other option is possible. Often the carriageway layout is such that during off-peak periods, cyclists have to contend with stressful and potentially hazardous conditions when cars are parked at the kerbside. It is important in the design of the bicycle lane that conditions for cyclists are assessed for different periods of the day.

Figure 4.14: Operation of peak period exclusive bicycle lane during and outside clearway times



Source: VicRoads (1999).

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S 3.4

4.3.11 Protected Two-way Lanes

A protected two-way bicycle lane is a bicycle lane treatment installed on one side of a road carriageway. The treatment utilises the existing road surface and is physically separated from adjacent traffic lanes by a raised dividing strip. A protected two-way bicycle lane should only be considered when the road width is insufficient for bicycle lanes on each side of the road and may be appropriate where:

- origins and destinations are on the same side of the road and road crossings can be avoided
- there is no choice other than for a treatment within the road reserve in a length generally consisting of paths and where the need for road crossings by cyclists can be avoided
- relatively few driveway crossings exist, particularly where the route is used by children
- parking demand is low in the area of the treatment, and as a consequence would be removed
- the road is wide such that parking is retained adjacent to (but outside of) the bicycle path area. In this instance the facility is regarded as appropriate only where the parking is long-term.

In general, the regulations applying to bicycle lanes, in relation to travelling or stopping in protected lanes, by motor traffic, pedestrians and others, would also be applicable.

AGRD 03
S 4.8

4.4 Finding Space for Bicycle Lane Treatments

A number of techniques can be used to obtain space in road reserves for the provision of cyclist facilities. These include:

- rearrangement of space by
  - adjustment of the existing carriageway (narrowing adjacent traffic lanes)
  - upgrading service roads
  - sealing road shoulders
- trading space through
  - indented car parking
  - restricting car parking
  - road widening at the verge
  - road widening at the median
  - removing a traffic lane
  - closing a road
- alternative space such as
  - an alternative off-road route.

4.5 Supplementary Road Treatments

4.5.1 Curves and Turns

On the inside of small radii horizontal curves, tight turns and other local area traffic management facilities, cyclists can often be at danger of rear-end/side-swipe collisions from motor vehicles that are travelling too close. The following forms of protection provide safety benefits to cyclists at these locations, and should be considered as part of the application of the various bicycle lane facilities discussed in this guide.

AGRD 03 S 4.8.12

Effective forms of protection include (AGRD03, Section 4.8.12 (Austroads 2016a)):

- a pavement bar island
- raised traffic islands
- fully mountable kerbing at the left side of the carriageway (in the direction of travel of cyclists), to permit access to the footpath at any point along the length of kerb
- closely spaced (e.g. 3 m intervals) raised pavement markers applied outside of bicycle lanes
- short lengths of off-road bicycle lanes to bypass pinch points in the cross-section.

A road agency may consider other forms of protection such as enhanced lane markings to improve delineation and separation.

Where treatments take cyclists off the road, care needs to be exercised to ensure that cyclists travelling at speed are not directed out into the traffic stream at the exit point.

These treatments should be self-cleaning to avoid the accumulation of debris; otherwise a comprehensive maintenance program will be required.

Designers should also ensure that the safety and other needs of pedestrians are provided for, wherever off-road cycling treatments are proposed.

4.5.2 Lane Channelisation

AGRD 03 S 4.8.7

Where there is a need to provide additional protection to, or reinforcement of, bicycle lanes, channelisation treatments can be employed. These treatments assist drivers to identify the space for cyclists and help to minimise vehicle ingress into bicycle lanes. Channelisation treatments can consist of:

- continuity lines
- kerbed projections which also help to guide the path of cyclists to the area of the bicycle lane
- rumble (tactile) edge lines
- low profile rubber kerbing.

4.6 Ramps

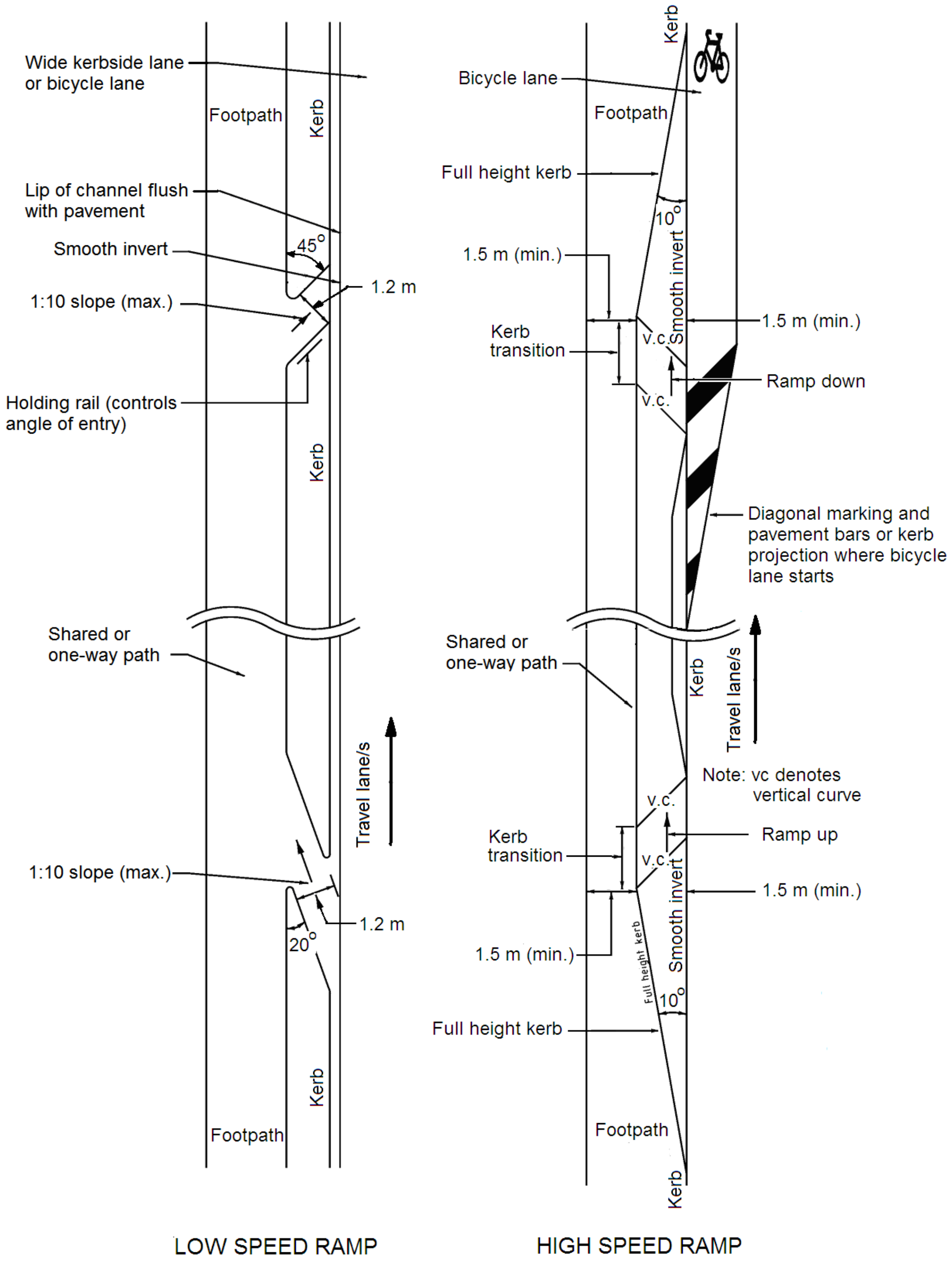
AGRD 03 S 4.8.7

Ramps linking a road carriageway and a path located in the area of the roadside verge may be required in association with treatments to provide protection at curves, narrowing at right-turn lanes and path treatments adjacent to roads.

The exit ramp from the road should be oriented to enable the cyclist to leave the road at a speed appropriate to the abutting development and the level of pedestrian usage of the path. The ramp for re-entering the traffic stream should be placed at an angle that enables cyclists to conveniently view traffic approaching in the left-hand lane. Consideration should also be given to providing a kerb extension to shelter the reintroduction of a bicycle lane.

The gradient of ramps to and from raised path sections should be constructed to avoid an abrupt change of grade (in excess of 5%) and in general should not be steeper than 15:1 where high bicycle speeds are likely. Figure 4.15 provides guidance to assist in the design of ramps for high-angle and low-angle treatments, the high-angle treatment resulting in slower bicycle speeds on the path.

Figure 4.15: Low and high-speed exit and entry ramps



AGRD 04C
S 14.1
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4.7 Provision for Cycling on Freeways

The main issue that should be addressed in deciding whether cyclists may use freeways is road safety. The policy with respect to cyclists using freeways varies between jurisdictions. Where cyclists are permitted to use a freeway it is important that they are provided with information, guidance and road conditions which enable them to use it safely. It is inappropriate for cyclists to use the normal traffic lanes of freeways and safer use of these facilities by cyclists is predicated on providing:

- smooth, debris-free shoulders of adequate width
- safe treatments at interchanges
- an efficient and safer route within the corridor if cyclists are not permitted to use the freeway (e.g. a high-speed exclusive bicycle path, a shared path or an alternative road route).

Because rural freeways usually have relatively low volumes of traffic leaving and entering at interchange ramps cyclists should normally be allowed to use rural freeways, particularly those having sealed shoulders, provided that information and guidance is provided to guide them safely across exit and entry ramps.

The use of urban freeways by cyclists is a matter to be determined by the relevant jurisdiction which may decide to deny cyclists' access to specific freeways because of the difficulties and hazards which would confront them in high-volume, high-speed traffic environments. A number of factors should be considered when assessing the suitability of a freeway and its interchanges for use by cyclists, as summarised in Table 4.9.

Table 4.9: Cyclist use of freeways – factors to consider

Unreasonably hazardous locations	Suitability for use
• Shoulders which are too narrow • Off-ramps and on-ramps which carry very heavy volumes of high-speed traffic throughout the day and night • Sections of freeway where the shoulders are used as bus lanes to provide a relatively high-speed express bus service • High bridges where prevailing crosswinds and turbulence from large motor vehicles can destabilise cyclists • Weaving areas between entry ramps and exit ramps • Places where vehicles stop in the emergency stopping lane (i.e. shoulder)	• The freeway should provide a safer and more convenient route than alternative non-freeway routes • Potential for use of the freeway by children should be low and should be actively discouraged through education programs • Sealed outer shoulders are essential on freeways which carry heavy volumes of motor vehicles and significant numbers of cyclists. For 100 km/h a 3 m width is desirable but a minimum width of 2 m may be used. For 80 km/h the corresponding widths are 2 m and 1.5 m • Adequate gaps should be available in ramp traffic to allow crossing by cyclists; otherwise provide an alternative route through or around the interchange (refer to Section 5.6 and Section 14 of AGRD04C (Austroads 2015b) • All ramps should have an outer shoulder at least 1.2 m wide, preferably sealed • Ramps exiting and entering the freeway from the right-hand lane are likely to be unsuitable for cyclists as they have to cross two lanes of high-speed traffic to access them. Alternative routes have to be examined • Sight distance in accordance with a pedestrian crossing the road: crossing sight distance (CSD; refer to AGRD04A (Austroads 2017b)) should be provided at the location where cyclists are directed to cross freeway ramps • Where very high traffic volumes or difficult geometry would cause serious safety hazards an alternative route or an off-carriageway cycling path may need to be provided

Source: Austroads (2015b) summarised from Commentary 4.

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S 3.4

The following guidelines should be considered when planning bicycle lanes on freeways/motorway/expressway:

- New freeway/motorway/expressway developments should include bicycle network developments alongside but separate from the new road. An example of this is the Eastlink tollway in Melbourne.
- For more information regarding cyclists on freeways/motorways/expressways, refer to Austroads (2012).
- Use of freeways/motorways/expressways by cyclists varies between jurisdictions.
- Cyclists may be permitted on rural freeways/motorways subject to risk assessments where
  - wide, sealed shoulders of freeways provide cyclists adequate clearance from vehicles in the adjacent lane; the shoulder may be marked as a designated bicycle lane
  - there is a good quality riding surface
  - conflict between motor vehicles and bicycles at entry and exit ramps is minimal or is able to be managed through traffic control or design measures (refer to Section 5.6, Austroads *Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings* (AGTM06) (Austroads 2013c) for further information).
- The crossing of interchange entry and exit ramps is an aspect of cyclists' use of freeways/motorways/expressways that requires careful consideration. In rural areas sufficient gaps in ramp traffic will usually be available. Where volumes are relatively high a traffic assessment based on gap acceptance analysis may be necessary (refer to Ove Arup & Partners 1989, *Urban Freeway Cycling*, produced for VicRoads and the Roads and Traffic Authority of NSW).
- Road agency policy often bans cyclists from urban freeways/motorways/expressways.

4.8 Local Area Traffic Management (LATM) Schemes

AGTM 08
S 8.12.1

An underlying principle of LATM is that conditions should be made better for pedestrians and cyclists, by virtue of the intentions of LATM (particularly speed reduction) (Yeates 2000a, b). The consequences of poorly designed LATM schemes are more likely to impact on cyclists than pedestrians.

Factors to consider in regard to cyclists' use of roads that have LATM treatments are provided in Table 4.10. The content of this table is a summary of Section 8.12 of AGTM08 (Austroads 2016c). Other considerations are discussed in Section 2.9 . Practitioners should refer to these sections for further guidance on catering for cyclists in local area traffic management schemes.

Table 4.10: Factors to consider for cycling in regard to LATM schemes

Aspect	Consideration
Principles	• Cyclist needs should be an integral part of the LATM planning and design process rather than treated as a supplementary or post-design check • Unless speeds are quite low (say < 30–40 km/h) some form of separation for cyclists may be desirable (at least on the designated bicycle network • Separation is more critical at intersections and at devices that deflect the travel path (e.g. slow points) than at mid-block locations. Mid-block bicycle lanes should be carried through these more critical locations • On-road lanes are preferred over off-road paths for cyclists in local areas, especially where there is direct access to abutting development as cyclists entering or crossing roads, especially the young, are at increased risk • Ensure that LATM treatments that narrow the road carriageway width do not create safety problems for cyclists • Lane widths should either be wide enough to allow the safe passage of a cyclist and a vehicle side by side (3.7 m or more) or narrow enough to permit the passage of a vehicle or bicycle path (3 m or less). Widths in between these two extremes create squeeze points and result in conflicts. For a narrow lane width, provide an off-road option for young cyclists

Aspect	Consideration
Design considerations	There are three design issues that the treatment selection and design of LATM should take into account: • bicycle/vehicle conflict • bicycle/pedestrian conflict • cyclist service and comfort When adapting the traffic environment, keep in mind: • the dynamic characteristics of the bicycle and rider, which may vary widely according to age, bike type, experience, skill, etc. • the seven broad categories of cyclists and their very specific needs, including primary school children, secondary school children, recreational cyclists, commuter cyclists, utility cyclists, touring cyclists and sports cyclists in training • the sometimes aggressive, and often inconsiderate, attitude of drivers towards cyclists • the youth and inexperience of many local street cyclists, who are nevertheless a legitimate part of the traffic system
General requirements	The following aspects of good LATM design and maintenance are especially important for cyclists: • avoid placing speed control devices in isolation • position devices sufficiently close together to avoid unnecessary acceleration and braking • provide bicycle bypasses of devices – where closely spaced devices could detract from the attractiveness of the route for cyclists – where there is a significant difference in the speed of vehicular and bicycle traffic – where it is desirable to separate cyclists from other traffic – anywhere cycling needs to be encouraged • provide clear signs and visibility • provide adequate street lighting • aim for a speed environment that is sympathetic to cyclists as well as other road users
Route continuity	• Actively improve bicycle route connectivity and continuity through appropriate LATM design • Provide for cyclists to pass through street closures and other treatments that block some or all motorised traffic movements • Where bicycle routes cross traffic routes, islands and refuges should be wide enough to shelter bicycles safely
Vehicle speeds	• The most important contribution to pedestrian and cyclist safety and amenity in local streets comes from effective reduction in vehicle speeds. Aim at speeds below 40 km/h rather than above 50 km/h and a consistently low speed along the route
Surfaces	• Ensure surfaces for cyclists are smooth and free of irregularities that would adversely affect stability of bicycles that have narrow tyres • Maintain areas where debris may accumulate
Squeeze points	• Avoid points where cyclists would be squeezed by motorists. Either separate cyclists from motor vehicles or scale down the roadway so that sharing space is not possible
Vertical devices	• Vertical speed control devices with smooth and gradual surface transitions are generally preferred rather than horizontal devices that create squeeze points. Flat-top road humps with ramps of 1:15 to 1:20 (V:H) relative to the gradient of the road are generally regarded as ‘bicycle friendly’. Side slopes across the line of travel should not be severe. Transitioned ramps (e.g. sinusoidal humps) are recommended (Webster & Layfield 1998). Greater downhill speeds should be anticipated when considering humps on grades

Source: Austroads (2016c) adapted from Section 8.12.1.

Figure 4.16 shows an example of a satisfactory bypass of a road hump in a residential street in the City of Boroondara, Victoria, in a situation where the relatively low motor vehicle volume does not justify a bicycle lane along the street. The surface of the bypass is well delineated to improve awareness of cycle use and conflict between cyclists and motor vehicles is unlikely on the departure from the device.

Figure 4.16: Example of good practice – cycle bypass of a road hump

Source: Courtesy of J. Hondrakis – Booroondara City Council.

5. Provision for Cycling at Road Intersections and Interchanges

5.1 Introduction

This section describes cycling issues and facilities at intersections and interchanges. It presents bicycle treatments for signalised intersections, unsignalised intersections, roundabouts and road interchanges. It provides information on treatments which should be adopted, where necessary and practicable, to improve safety and convenience for cyclists using intersections. Cross-references to the sections of Austroads Guides relevant to this topic are shown in Table 5.1.

Table 5.1: Key cross-references related to the provision of cycling at road intersections and interchanges

Series		Part	Section	Reference source
Section 5.2: Issues at Intersections for Cyclists				
AGTM	Guide to Traffic Management	6	Section 3.4	Austroads (2013c)
Section 5.3: Signalised Road Intersections (also Sections 7.6.3 and 9.5)				
AGTM	Guide to Traffic Management	6	Section 5.3	Austroads (2013c)
AGRD	Guide to Road Design	4	Section 10.6, Appendix A.17, Appendix B.6 and Appendix C.2	Austroads (2017a)
Section 5.4: Unsignalised Road Intersections (also Section 7.6.4)				
AGTM	Guide to Traffic Management	6	Section 2.2	Austroads (2013c)
AGRD	Guide to Road Design	4	Section A.17 and Commentary 1.4	Austroads (2017a)
Section 5.5: Roundabouts				
AGRD	Guide to Road Design	4B	Section 5.3	Austroads (2015a)
AGTM	Guide to Traffic Management	6	Section 4.4.2	Austroads (2013c)
Section 5.6: Road Interchanges (also Section 4.9)				
AGRD	Guide to Road Design	4C	Section 14.2	Austroads (2015b)
AGTM	Guide to Traffic Management	6	Commentary 23 and 24	Austroads (2013c)

Where a bicycle lane exists or is planned on roads leading up to an intersection the design should assist the safe passage of cyclists through the intersection. In rural areas this may simply require an adequate clearance between the islands and left edge of the road to provide continuity of shoulders through the intersection. In urban areas it will often involve a bicycle lane marked through the intersection.

In catering for the needs of cyclists at intersections designs should conform to the standard approach and principles of traffic engineering design for all road users. This practice seeks to provide traffic facilities which clearly indicate the nature and extent of traffic movements and the potential conflicts. All road users, including cyclists, will benefit from a traffic environment which assists the road user to anticipate potential conflicts and encourages traffic awareness and predictable behaviour.

The types of lanes that may have to be incorporated into traffic routes, and therefore intersections, include:

- bicycle lanes
- bicycle/car parking lanes
- wide kerbside lanes.

These and other types of bicycle lanes are discussed in Section 4 in AGRD03 (Austroads 2015a) and Section 4.

Because of the wide range of ages and ability of cyclists, it is often necessary to accommodate off-road paths for young and/or inexperienced cyclists within intersection layouts.

5.2 Issues at Intersections for Cyclists

5.2.1 General

AGTM 06
S 3.4

Common issues faced by cyclists and possible treatments are summarised in Table 5.2. A process to evaluate conflict for cyclists at intersections is provided in AGTM06 (Austroads 2013c).

Table 5.2: Issues for cyclists

Issue	Characteristics	Treatments
Squeeze points	• Road narrows and separation between cyclists and motor vehicles reduces • Non-flush service pit covers, and sumps (New Zealand) that reduce the available width for cyclists	• Local widening(1) or remarking of traffic lanes to achieve a wide kerbside lane (where insufficient width is available for a bicycle lane) • Bicycle lane • Bicycle/car parking lane • Shared path (provide where an on-road facility is impracticable and for use by young and inexperienced cyclists) • Bicycle path • Add 'Watch for Bicycles' sign (AS 1742.9-2000, sign G9-57) • Provide bicycle symbol and short continuity line in wide kerbside lane to increase motorist awareness of the presence of cyclists and to improve cyclist comfort (not permissible in New Zealand)(2) • Ensure that service covers and drainage assets do not reduce the road width available for safe use by cyclists
Vehicle overtaking and immediately turning left into side street or driveway	• Cyclist may crash into vehicle or have to take risky evasive action	• Bicycle lane to increase awareness(3)
Motor vehicle converge and diverge areas	• Cyclists are vulnerable when riding through the taper lengths of converge and diverge areas • Cyclists use left-turn lanes as a refuge from through traffic but cannot legally proceed in the 'through' direction if a left-turn arrow is marked in the lane	• Bicycle lane marked continuously along road and/or converge and diverge areas with a continuity line(4) • Provide green surface treatment for bicycle lane

Issue	Characteristics	Treatments
Lack of continuity and connectivity	• Cyclists continually have to rejoin motor vehicle lanes because bicycle lane is terminated at squeeze points, resulting in hazardous movements	• Continuous bicycle lanes through unsignalised intersections where feasible • Provide green surfacing for bicycle lanes through hazardous areas or complex situations • If practicable, re-allocate road space used by other road users or for other purposes to achieve bicycle lane continuity • Install 'Watch for Bicycles' signs at bicycle lane terminations (AS 1742.9-2000, sign G9-57)
Safely cross or join conflicting flows	• Insufficient gaps in the traffic stream being crossed or joined	• Signalised cyclist crossing • Refuge island • Well-designed transition from shared path or bicycle path to an on-road bicycle lane i.e. physical protection for cyclists through alignment of left-side kerb
Gaining position to turn right	• Unsafe weaving manoeuvres on approach to major intersection • Space to wait and undertake right-turning manoeuvre • Difficult conditions turning right	• Provide a bicycle lane on the left side of the intersection approach and space for cyclists to store whilst making a 'hook turn'(5) • Locate a right-turn bicycle lane between the right-turn lane and through lane for motor vehicles (does not assist with weaving on the approach but provides some refuge) • Provide adequate swept paths for cyclists to turn right with other vehicles, especially heavy vehicles including buses • Provide off-road path on periphery of intersection
Cyclist not seen by motorists, or cyclist speed misjudged	• Cyclist likely to be involved in a crash	• Provide bicycle lanes and logos to increase motorist awareness of the likely presence of cyclists • Install 'Watch for Bicycles' signs (AS 1742.9-2000, sign G9-57) • Reduce vehicle speeds through intersection using a physical device
Loss of access	• Road closure or provision of one-way streets could result in loss of access for cyclists	• Provide access for cyclists to pass through local road terminations and pedestrian malls • Provide contra-flow for cyclists on one-way streets in low speed environments

1 *Local widening or remarking traffic lanes should aim to provide a bicycle lane in the first instance.*
2 *May not be favoured in some jurisdictions; check with relevant road agency.*
3 *Consider the provision of distinctive green surface in bicycle lane (refer to Section 9.4 and Section 6.6 of AGTM10 (Austroads 2016d)).*
4 *Where a bicycle lane cannot be achieved, install 'left lane must turn left, bicycles excepted' signs.*
5 *Provide cyclist indented storage area on the left side of the road to enable protected right-turn manoeuvre.*

Note: This table provides a summary of key issues for cyclists; however, there are other cycling-related issues for cyclists at intersections (refer to the bicycle safety audit checklist in Appendix G).

Source: Austroads (2013d) Table 3.3.

5.3 Signalised Road Intersections

5.3.1 General

Signalised intersections are often associated with traffic routes and are therefore utilised by commuter cyclists. Wherever practicable, traffic routes and signalised intersections should provide the space and operational conditions to support cycling as a viable alternative mode of transport. The needs of cyclists should be considered in relation to detection, signal phasing and timing, and road space. Off-road paths are often provided for non-commuter cyclists (e.g. the young and novice cyclists) and these paths often have to be incorporated into the functional layouts of signalised intersections. Traffic management considerations for cyclists at intersections are also provided in AGTM06 (Austroads 2013d).

The operation of traffic signals to accommodate cyclists is discussed in the Austroads *Guide to Traffic Management Part 9: Traffic Operations* (AGTM09) (Austroads 2014b) and traffic signal displays for cyclists in the Austroads *Guide to Traffic Management Part 10: Traffic Control and Communication Devices* (AGTM10) (Austroads 2016d). These topics are summarised in Section 9.5.

Practitioners are also referred to the *Effectiveness and Selection of Treatments for Cyclists at Signalised Intersections* report (Austroads 2011), which examined the safety impacts of providing cycling facilities, in combination with other features, at signalised intersections. A key finding of this study was the substantial benefit of coloured cycle facilities.

5.3.2 Traffic Management Guidelines

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The following tables provide key traffic management guidelines for consideration when designing signalised intersections. Table 5.3 and Table 5.4 cover cyclist requirements for arterial roads and local roads respectively whilst Table 5.5 covers lane management.

Table 5.3: Cyclist requirements for arterial road signalised approaches

Context	Guidelines
Bicycle lanes at intersection approach and departure	Bicycle lanes should be provided on intersection approaches where: • the route is a designated bicycle route • bicycle lanes are marked mid-block • squeeze points exist for cyclists and it is feasible to develop sufficient space for the bicycle lane • the layout of the intersection results in high traffic volumes or relatively high speed vehicles weaving across the path of cyclists As a guide, consider a bicycle lane where the traffic volume is > 3000 vehicles per day and/or there is a significant percentage of heavy vehicles Where appropriate, consider the provision of an exclusive lane for right-turning cyclists, placed between the right-turn lanes and through lanes for motor vehicles. Consideration should also be given to the manner in which right-turning cyclists may gain access to the bicycle lanes In Australia, cyclists are generally permitted to undertake a 'hook turn' at intersections instead of a conventional right turn (refer to *Australian Road Rules* (National Transport Commission 2012) and Figure 5.12). This option is often used by cyclists at signalised intersections where they can complete the manoeuvre with a green signal, after waiting at the intermediate corner. Provision of a storage area at the corner is not common; however, additional space may be provided by setting back the pedestrian crosswalk lines and stop line on the intersecting approach. This 'head start area' (refer to Section 5.3.5) may be marked with bicycle logos Bicycle lanes should be provided on the departure side of intersections where: • a bicycle lane exists or is planned along a route • cyclists are required to weave through high volumes of traffic merging from the left (i.e. left-turning traffic joining the route) or high-speed merging traffic

Context	Guidelines
Intersection stop-line storage	On bicycle routes a 'head start area' (Section 5.3.5) should be considered, to allow for cyclists to wait at the stop line at a position in advance of the motor vehicles. This facility ensures that cyclists waiting at the red light are visible to the first driver in the queue, particularly drivers of commercial vehicles that may have their view of cyclists impeded by the height of the left door of the vehicle
Bicycle paths, shared paths and separated paths	Where paths exist along a route they should continue through the intersection desirably via shared pedestrian/cyclist crossings that are appropriately marked. The provision of hand rails to assist cyclists to remain mounted whilst waiting for a green signal should be considered

Source: Austroads (2013c) Table 5.2.

Table 5.4: Cyclist requirements for local road signalised approaches

Context	Guidelines
Local streets	Cyclists are expected to share traffic lanes on local streets (typically less than 3000 vpd) except where the street forms part of a designated bicycle route with marked lanes
Collector – distributor roads	Where sufficient width is available, bicycle lanes should be provided on these roads and at the approaches to signalised intersections

Source: Austroads (2013c) Table 5.3.

Table 5.5: Lane management at signalised intersections for on-road bicycle lanes

Context	Guidelines
On-road bicycle lanes	• On-road lanes are designated by standard bicycle lane signs (usually located beside the road but sometimes overhead.). However, in New Zealand road markings without signs can define a bicycle lane; refer to Land Transport Rule: Traffic Control Devices and Land Transport (Road User) Rule (2004) and NZ Transport Agency (2010a) and (2010b) • Are generally delineated with a continuous lane line (except in motor vehicle diverge and merge areas where two continuity lines are used) and bicycle logos • The *Australian Road Rules* (National Transport Commission 2012) limit motor vehicle travel along a bicycle lane to a distance of 50 m, in order to turn left • Pavement arrows may be used to define directional use of a bicycle lane (e.g. right-turn arrow in a bicycle lane that is situated between the through lane and right-turn lane for motor vehicles) • A green surface may be provided to enhance the delineation of a lane in relatively hazardous or complex situations, refer to Section 9.4 , Section 6.6 of AGTM10 and Austroads (2017b)

Source: Austroads (2013c) Table 5.4.

5.3.3 The Six Elements

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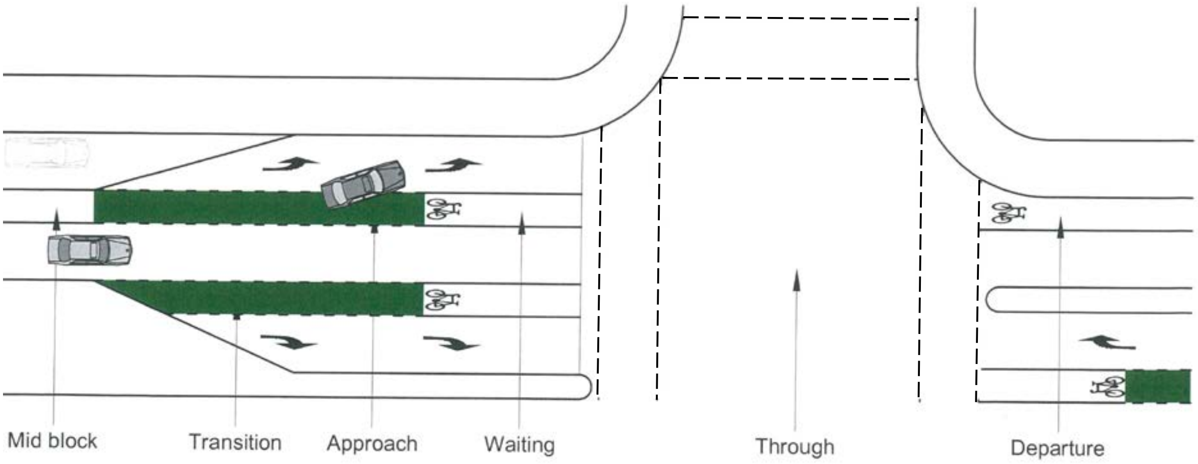
Figure 5.1 illustrates six elements of a signalised intersection where, ideally, visually separated operating space should be provided. However, where space is constrained and all elements cannot be satisfactorily addressed designers should meet as many of the requirements as possible. Design options for the six elements are shown in Figure 5.2 and Figure 5.3.

Figure 5.1: Provision of a bicycle operating space at intersections – the six elements



Source: Austroads (2017a) Figure B 8, adapted from Roads and Traffic Authority NSW (2005).

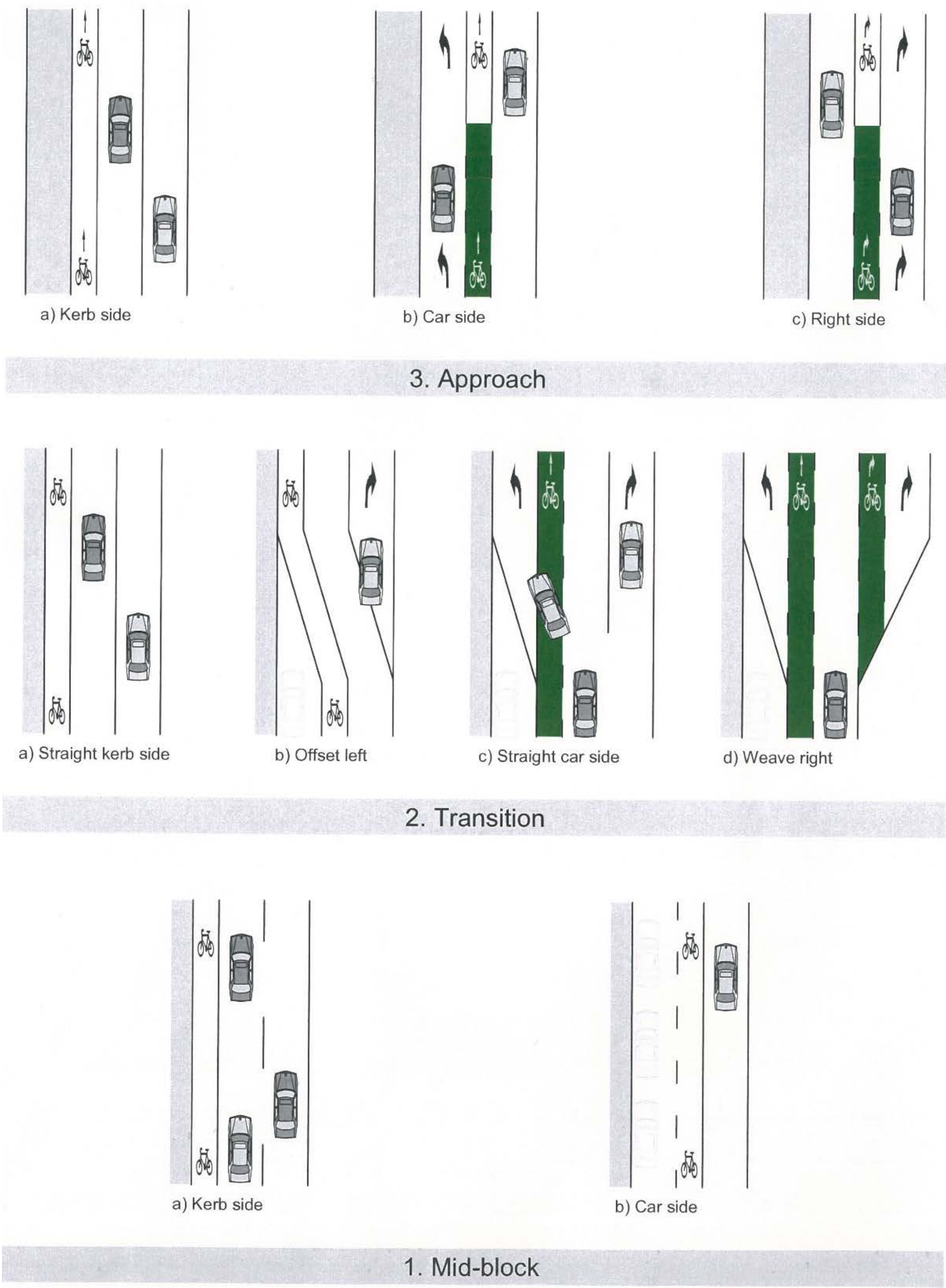
Illustrations of right-turn lanes for cyclists are shown in this section. However, these right-turn lanes are rarely used and should generally not be provided for cyclists at right-turn treatments on arterial roads or busy traffic routes because of the difficulty and crash risk for cyclists moving from the left of the road on an intersection approach to the centre of the road in order to utilise such treatments. Where right turn bicycle lanes are provided for cyclists it is essential that adequate clearance is provided between motor vehicle swept paths to ensure that opposing right-turning cyclists can operate safely and do not come into conflict with each other.

Right-turn lanes for cyclists would only be provided where:

- it can be demonstrated that the volume of traffic on an arterial road/traffic route is low enough for cyclists to be able to safely access the cyclist right-turn lane, and there is sufficient cyclist demand to justify the facility
- the speed environment is low (e.g. 50 km/h limit) and cyclist demand is significant.

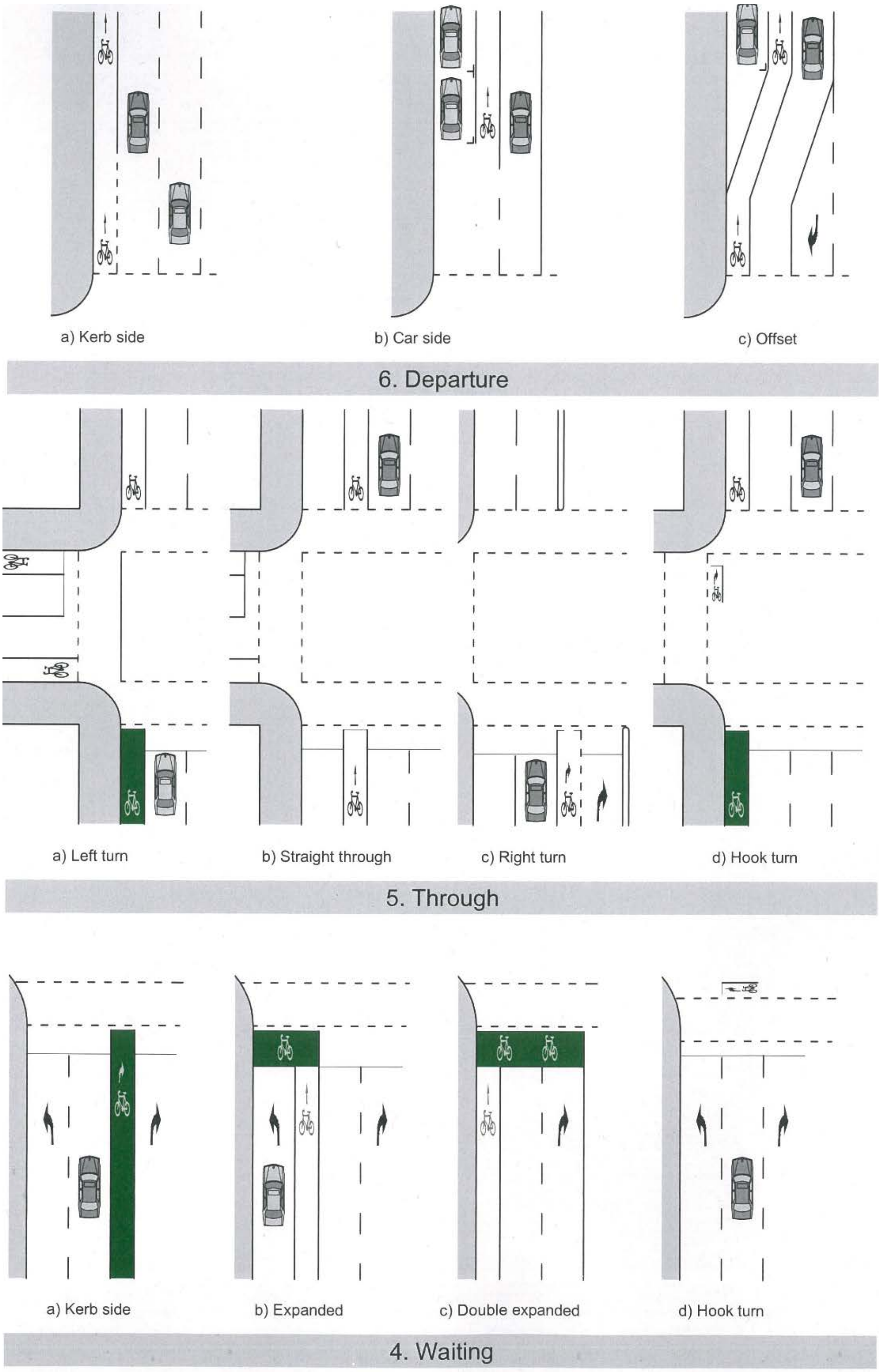
These conditions may exist within the business centres or activity centres and may be associated with particular precincts (e.g. universities or sporting and recreational areas).

Figure 5.2: Design options for signalised intersections (mid-block, transition and approach)



Source: Roads and Traffic Authority NSW (2005).

Figure 5.3: Design options for signalised intersections (waiting, through and departure)



Source: Roads and Traffic Authority NSW (2005).

Where practicable, it is desirable that the hook turn storage areas shown in Figure 5.3 are sufficiently wide for cyclists to orientate their bicycles in the intended direction of travel.

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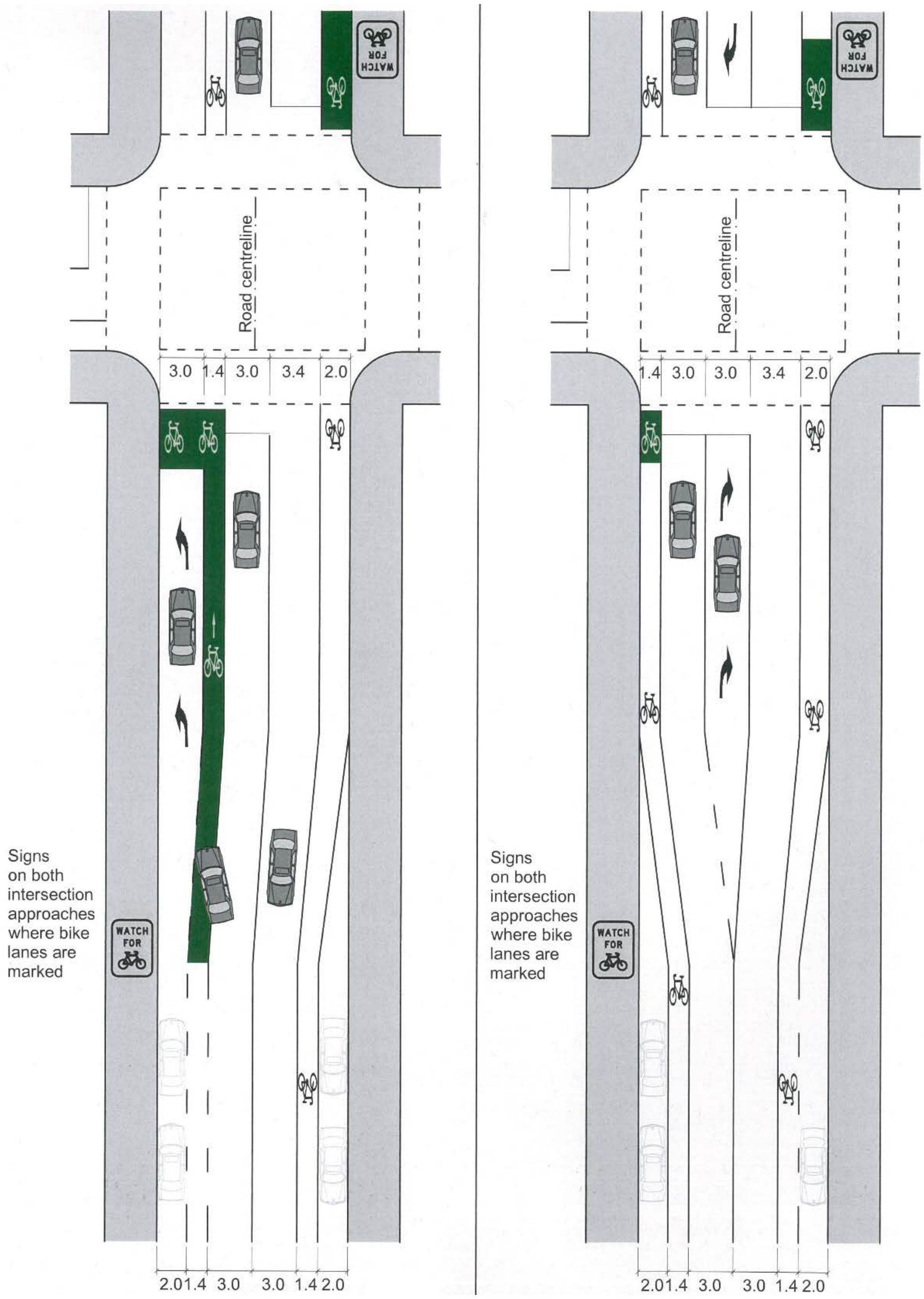
5.3.4 Bicycle Lanes

Figure 5.4 shows two common examples of bicycle lanes marked at signalised intersections where the width between kerbs is approximately 13 m and parking is provided. In the car-side option no separate left-turn lane is provided for cyclists resulting in them having to make the left turn from the vehicle lane and the expanded storage box. Cyclists using the kerbside option can turn left or proceed straight through the intersection from the bicycle lane. Both options can be applied to bicycle/car parking lanes and exclusive bicycle lanes.

Figure 5.4: Bicycle lanes through signalised intersections – car side and kerbside



Source: Roads and Traffic Authority NSW (2005).

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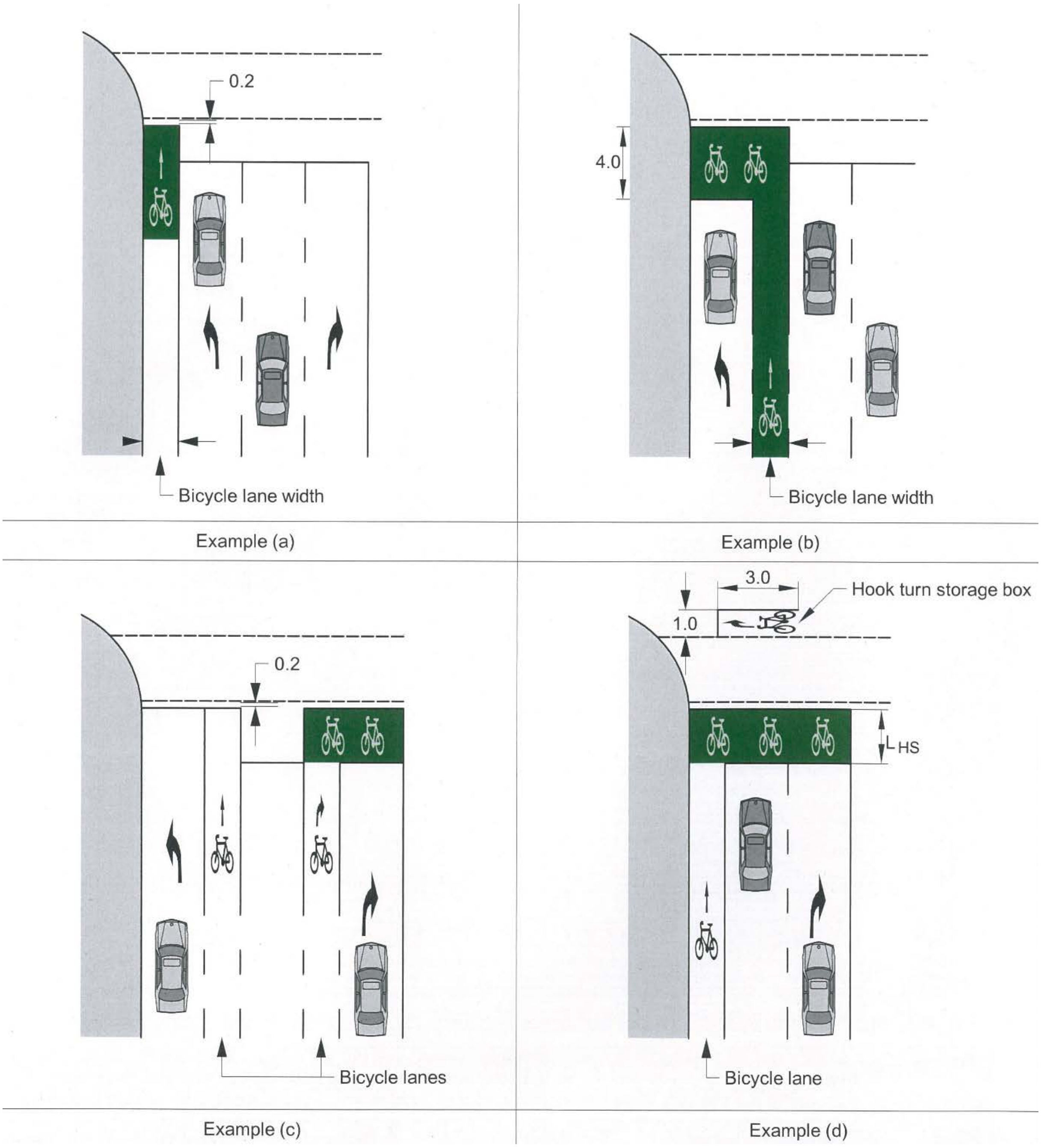
5.3.5 Head-start and Expanded Storage Areas

These storage areas are provided to position cyclists in a highly visible location while they are waiting to proceed through the intersection, thereby improving safety. Figure 5.5 shows four combinations of head-start and expanded storage areas at signalised intersections. The required length of the head-start area (LHS) varies depending on the number of bicycles that need to be stored. The treatments in each of the four examples can be used in isolation or in any combination. A summary of the various treatments is provided in Table 5.6.

Figure 5.5: Head-start and expanded storage areas



Note: LHS denotes length of head-start area.

Source: Roads and Traffic Authority NSW (2005).

Table 5.6: Summary of use of the head-start treatments illustrated in Figure 5.5

Example	Purpose	Comment
Example (a)	The purpose is to store a cyclist in advance of a motor vehicle driver in the adjacent left-turn lane or through lane so that the cyclist can be easily seen by a stationary driver at the stop line. This is particularly important where the vehicle is a van or truck in which case the cyclist would otherwise be hidden from view below the left-hand side window	This treatment: • reduces the potential for conflict between cyclists and traffic using the left lane • is suitable where cyclist numbers are relatively low • allows cyclists to pass on the left side of a queue of vehicles waiting to turn left • has an area that is only as wide as the bicycle lane on the approach • has a bicycle stop line that is located 0.2 m in advance of the pedestrian crosswalk line and 2 m (i.e. storage length for one bicycle) beyond the motor vehicle stop line • may be placed to the left of a left-turn lane, a through lane, or a combined through and left-turn lane
Example (b)	This treatment locates the bicycle lane between the left-turn lane and through lane and as a consequence provides additional storage width and length	Cyclists travelling straight ahead travel to the right of queued or moving left-turning vehicles Left-turning vehicles are required to change lanes across the bicycle lane at the start of the left-turn lane Cyclists intending to turn left should desirably share the left-turn lane with motor vehicles. However, it is likely that some left-turning cyclists will use the bicycle lane to pass the queue and access the storage box
Example (c)	This illustration includes two treatments that provide a head start for through cyclists and right-turning cyclists (with expanded storage)	The first treatment is a bicycle lane for cyclists travelling straight through the intersection. In this case left-turning cyclists are expected to share the left-turn lane with motor vehicles The second treatment is a right-turn expanded storage area for high volumes of bicycle turning traffic. These treatments: • are rarely used and are not intended for use in higher speed zones (> 60 km/h) because of the difficulty and conflict associated with cyclists crossing traffic lanes to access the right-turn bicycle lane • may be appropriate in lower-speed zones (≤ 60 km/h) where bicycle volumes are high and the turn is made into a single-lane mixed function road that does not have marked bicycle lanes (e.g. inner city areas) Where bicycle lanes are provided in the intersecting road and bicycle turning volumes are not high, it is more acceptable to install a head-start storage area only in the right-turn bicycle lane. In this instance it is also necessary to include additional turning lines within the intersection to guide right-turning cyclists and delineate the cyclists' path for drivers
Example (d)	This example also shows two treatments that provide storage expanded across two traffic lanes and a formalised hook-turn treatment	The first treatment is a hook turn storage area, provided to accommodate cyclists in a safer position while they are waiting for a green traffic signal phase for the intersecting road, and can be used generally throughout the road system The second treatment, an expanded storage area shared by left-turning, through and right-turning cyclists is suitable only for lower speed areas (e.g. 50 km/h)

Source: Austroads (2017a) summarised from Section B.6.

In high traffic locations or where the number of bicycle turning movements is significant, or compliance by motor vehicle drivers is poor (i.e. encroachment into the bicycle storage area) it may be necessary to improve the delineation of the storage area by paving it with a green surface. It should be noted that:

- not all jurisdictions use head-start areas across multiple lanes, particularly through lanes
- a head-start area may be used where there is no bicycle lane on the intersection approach.

The treatment in Figure 5.5(a) is not suitable for use where a green left-turn arrow is provided on the approach as the treatment encourages cyclists to store at the stop line. Even without the treatment left-turn phases are problematic for through cyclists waiting in the vicinity of the stop line. The bicycle lane for the through cyclist movement depicted in Figure 5.5(c) can remove this conflict and should be used where a left-turn phase is provided.

In practice many cyclists intending to turn right ride to the left of motor vehicles which are turning or intending to turn right in order to avoid conflict with this traffic stream. This means that they may be exposed to conflict with through motor traffic. The right-turn bicycle lane shown in Figure 5.5(c) creates space for cyclists, providing protection from moving motor vehicles and enabling cyclists to easily advance to the head of the right-turning queue.

If the volume of cyclists is high then consideration may be given to providing a larger storage area as shown in Figure 5.5(c) and (d).

5.3.6 Hook Turn Storage Boxes and Hook Turn Restrictions

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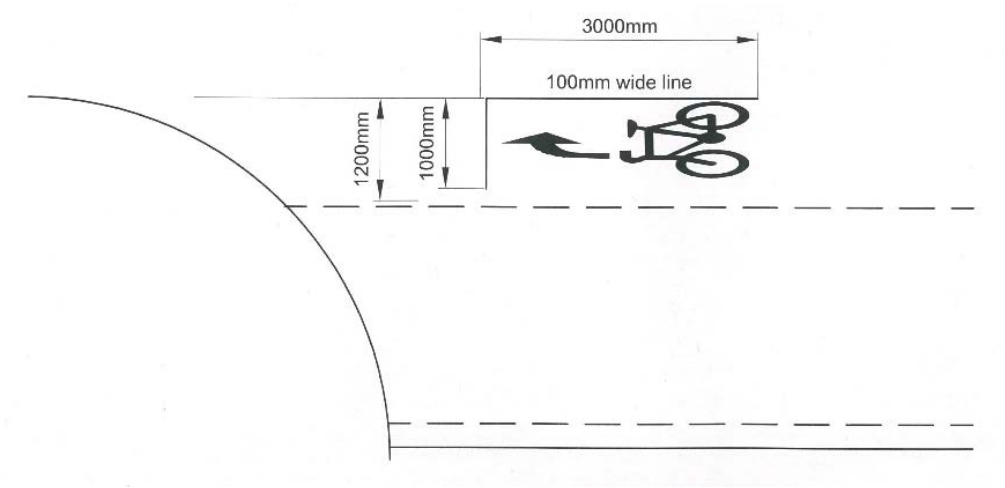
Under the *Australian Road Rules* (National Transport Commission 2012), cyclists on an approach at a signalised intersection can use a hook turn as an alternative to a conventional right turn from the centre of the road. Cyclists undertake a hook turn by travelling straight at the intersection and waiting at the far corner of the intersecting road. Where the aim is to encourage the use of hook turns, or to ban a conventional right turn that may be hazardous to cyclists, a hook turn storage box can be provided as illustrated in Figure 5.5(d) and Figure 5.6.

The hook turn box should not be located as illustrated if the left-turn lane has a signalised left-turn arrow. In this case the box may be placed in front of the adjacent lane if the signal phasing permits. Additional in-ground signal detection in the hook turn box should be considered where the box is placed at a side street approach to a major road to ensure that cyclists can call a phase.

It should be noted, however, that the box turn may be illegal in some jurisdictions and the traffic signal phasing at some intersections may not suit a hook turn. For instance, waiting cyclists who have performed the first stage of a hook turn manoeuvre could be in conflict with an exclusive left-turn phase for the intersecting road (in which case the box should be located to avoid this conflict; refer to notes under Figure 5.6) or a diagonal pedestrian crossing phase.

Figure 5.6: Bicycle hook turn box detail



Notes:

- *In this case the hook turn box is located in the area between the crossing line or vehicle stop line and the crossroad kerb line.*
- *The hook turn box should not be located in this position if the left lane has a signalised turn phase. In this case the bay may be located in front of the adjacent traffic lane if signal phasing permits.*
- *Additional in-ground signal detection should be installed in hook turn boxes where the box is located at a side street entrance to a major arterial road with signal priority.*

Source: Roads and Traffic Authority NSW (2005).

5.3.7 Left-turn Treatments

It is often necessary to provide bicycle lanes as part of channelised left-turn treatments (CHL). High-entry angle or free-flow left-turn treatments may be provided at signalised intersections and bicycle lanes may be required within the layout to provide convenient and safer operating space for cyclists.

High-entry angle treatment

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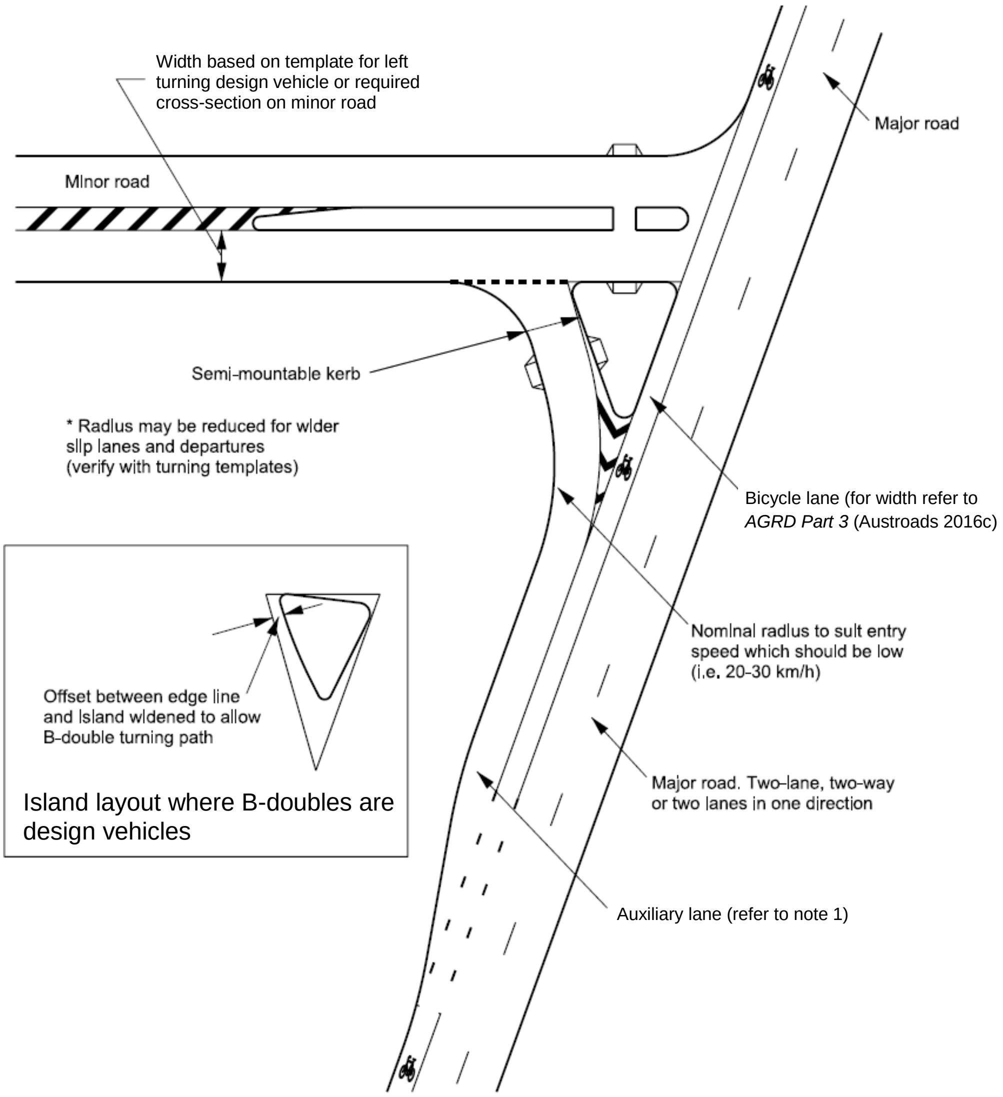
The treatment is illustrated in Figure 5.7 where a bicycle lane provides separation for cyclists through the diverge area on the approach to the intersection and at the stop line. The bicycle lane provides an offset to the island nose and the side of the island is parallel to the adjacent traffic lane. Generally cyclists share the left-turn lane with motor vehicles; however, where the volume of left-turning cyclists is high it may be appropriate to provide a bicycle lane within the left-turning roadway. If a significant number of cyclists turn left at a CHL treatment then provision of a bicycle lane adjacent to the kerb within the left-turn roadway should be considered.

Figure 5.7: Provision for cyclists at a signalised CHL treatment in a low-speed environment



1 *For details for auxiliary lane refer to AGRD04 (Austroads 2017a) Appendix A14.*

Notes: Bicycle lanes on the priority road must be continuous through unsignalised intersections and connect to bicycle facilities on the approach and departure.

In cases where a bicycle route turns the corner bicycle lanes may be accommodated within the minor road and within the left-turn roadway.

Green pavement surfacing may be used where high numbers of cyclists and motor vehicles interact. Where this is not the case normal surfacing, road markings and bicycle logos may be used to delineate the bicycle lane.

A minimum width of 5.0 m is required in the left-turn slip lane to enable vehicles to pass a disabled vehicle by mounting the semi-mountable kerb. It is therefore necessary to have a solid surface immediately behind the kerbs.

Free-flow CHL treatment

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Figure 5.17 in Section 5.4.3 illustrates a free-flow left-turn island at an unsignalised intersection that incorporates a treatment designed to discourage cyclists from travelling in a path between the auxiliary lane and the adjacent through lane and being caught between through traffic and merging traffic. The layout shown can be readily adapted to a signalised intersection by providing stop lines, pedestrian crosswalk lines, pedestrian ramps, continuity lines for that portion of the bicycle lane within the intersection and probably a signalised crossing of the left-turn roadway.

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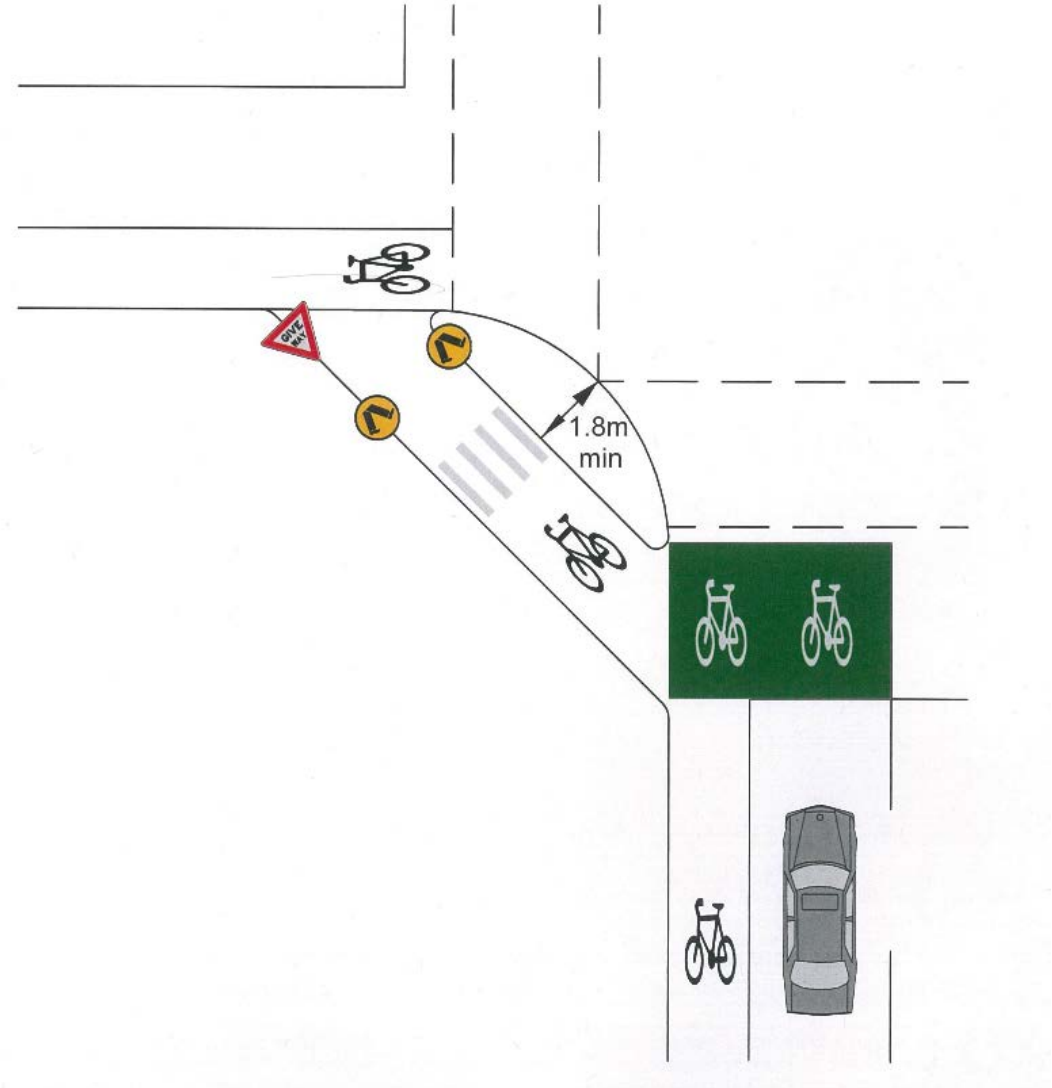
Left-turn bypass treatment

Left-turn access through signals may be provided for cyclists where a major bicycle route turns left through a signalised intersection as shown in Figure 5.8. This treatment has a bicycle lane in the intersecting road. Where there is no bicycle lane in the intersecting road the bypass should be designed as a free-flow arrangement where the bicycle lane is directed into an off-road path parallel to the intersecting road to join it with a protected transition (kerb extension).

Figure 5.8: Bicycle lane left-turn bypass at a signalised intersection



Source: Roads and Traffic Authority NSW (2005).

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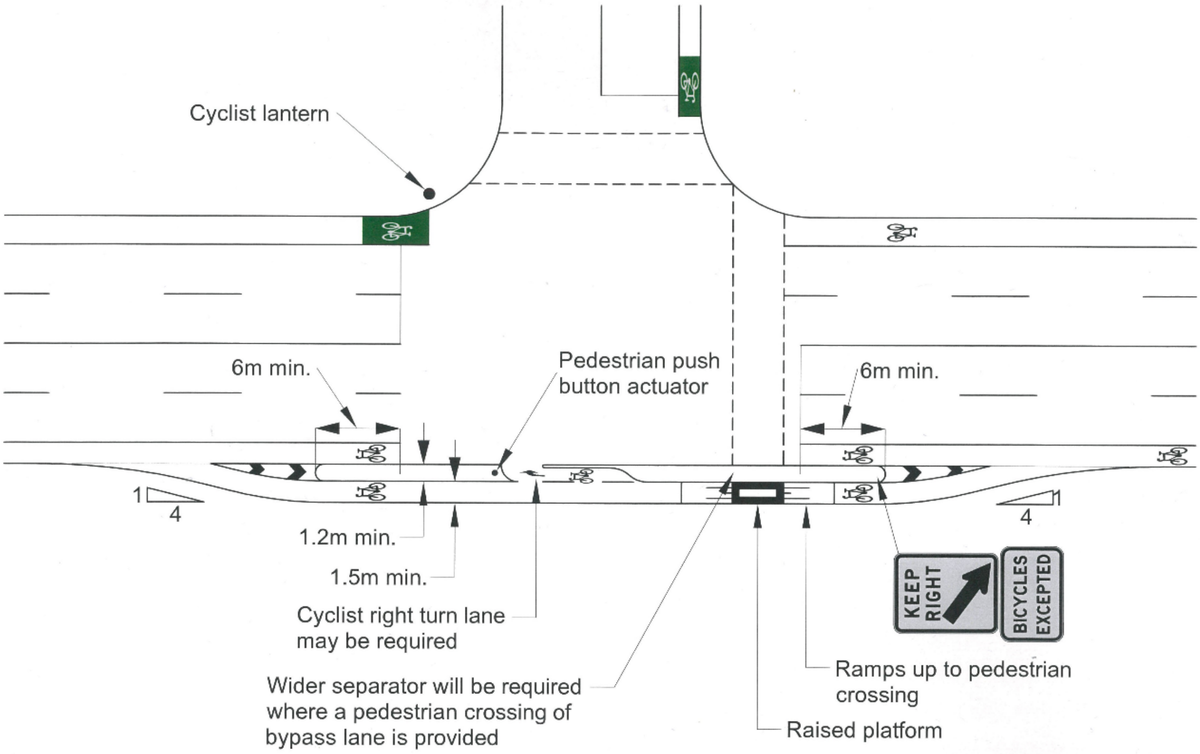
5.3.8 Bypass of a T-intersection

In order to limit the delay to cyclists at T-intersections, circumstances may permit the construction of a bypass of the intersection for cyclists opposite the discontinuing leg of an intersection, as shown in Figure 5.9. The bypass may be separated by channelisation as shown or a separated path treatment can be used where the bicycle path is raised and adjacent to the footpath. A disadvantage of the channelised treatment may be the accumulation of debris and the consequent maintenance. Use of the treatment is covered in AGRD04 (Austroads 2017a).

Figure 5.9: Cyclist bypass lane at a signalised T-intersection



5.3.9 Crossings at Signalised Intersections

General

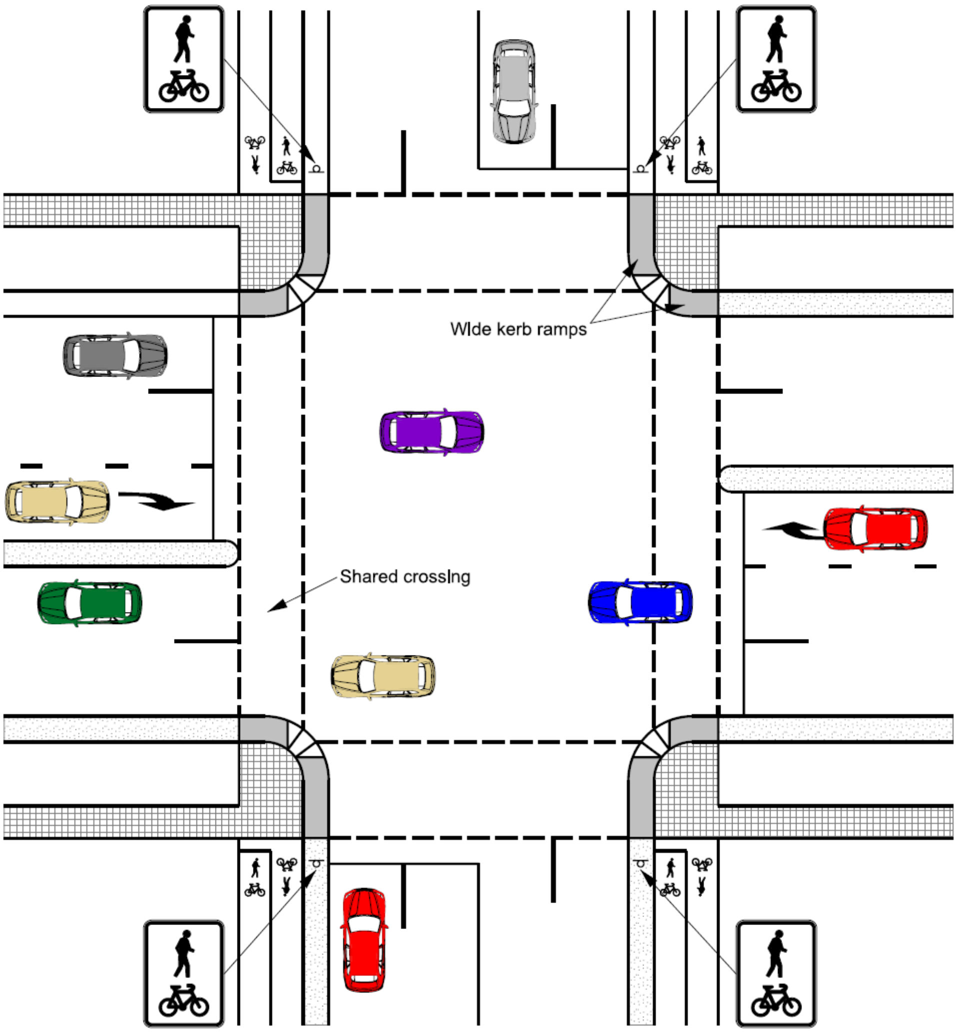
It is often necessary to integrate off-road bicycle facilities with other road user requirements at signalised intersections. The design should ensure that the movements of cyclists are managed and regulated to provide safer interaction of cyclists with pedestrians and motor vehicles.

The facility to be integrated may be a shared path, an exclusive bicycle path, or a separated path. Where a shared path passes through an intersection cyclists are expected to share the marked foot crossing with pedestrians. Where a bicycle path or a separated path is to be accommodated the cyclists and pedestrians will usually be separated on the crossing.

Separated path crossing

An example of a multilane road intersection with a shared path, is shown in Figure 5.10, and off-road bicycle paths, in Figure 5.11 in a constrained road reservation. In this case the various paths adjoin and cross parallel to the intersecting roads. For this type of treatment it is desirable to have separate detection and lanterns for cyclists and pedestrians (AGTM09 (Austroads 2014b)).

Figure 5.10: Shared path at a signalised intersection



Notes:

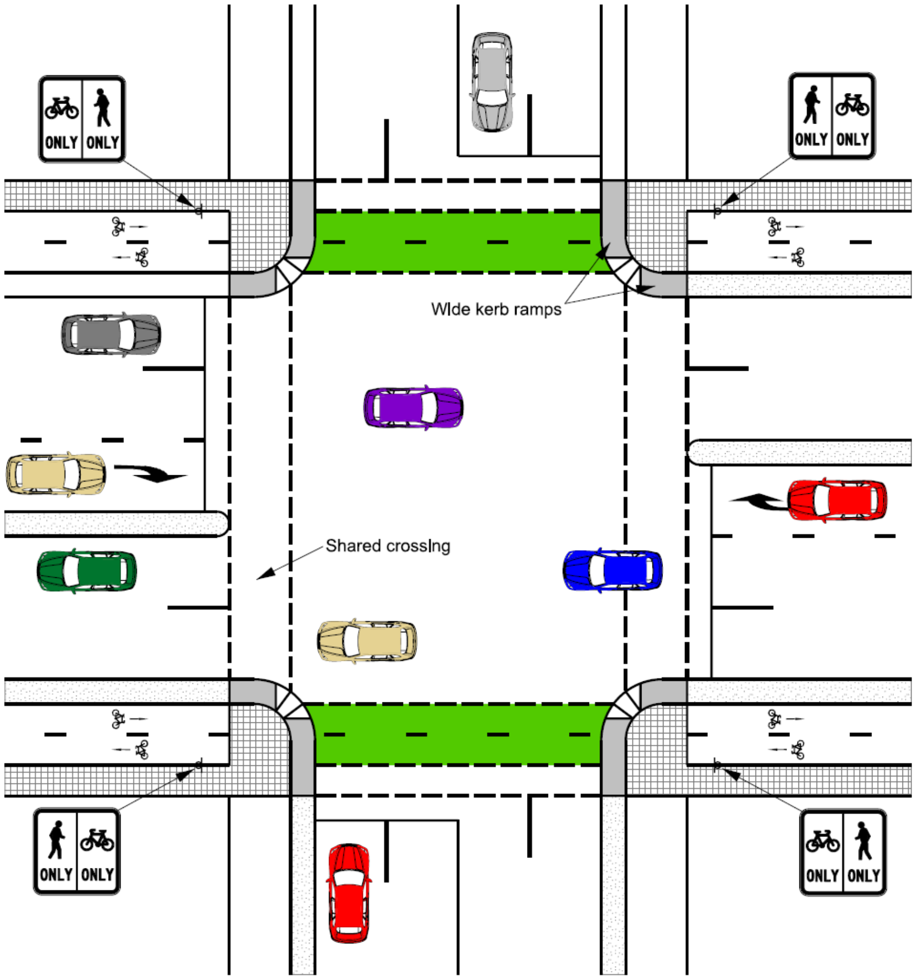
In-path or other remote detection is recommended for bicycle paths.

The width of the marked crossing for separated paths should match the width of the paths on the approach.

At intersections where the volume of cyclists and pedestrians is high it is advisable to provide contrasting surfaces to delineate the use and priority of movement.

Source: Roads and Traffic Authority (2005).

Figure 5.11: Two-way bicycle path at a signalised intersection



Notes:

In-path or other remote detection is recommended for bicycle paths.

The width of the marked crossing for separated paths should match the width of the paths on the approach.

At intersections where the volume of cyclists and pedestrians is high it is advisable to provide contrasting surfaces to delineate the use and priority of movement.

Source: Roads and Traffic Authority (2005).

Where off-road bicycle routes are required to pass through major intersections, signal control should be considered for left-turn slip lanes. The designer should aim to provide a similar level of service through the intersection for cyclists as for motor vehicles. Desirably the signal phasing and timing should enable cyclists to pass through the intersection in one stage. Where practicable pedestrian and cyclist crossings should be separated; however, where this is not possible cyclists will have to share the crossing with pedestrians.

It is important that:

- the design and markings are designed to minimise conflict between cyclists and pedestrians
- where appropriate, bicycle detection loops are provided
- where provided, bicycle activation buttons (similar to pedestrian buttons) are located in a convenient position close to the crossing approach or holding line
- adequate queuing and storage space is provided for cyclists
- additional width is allowed for cyclists starting up at the signals.

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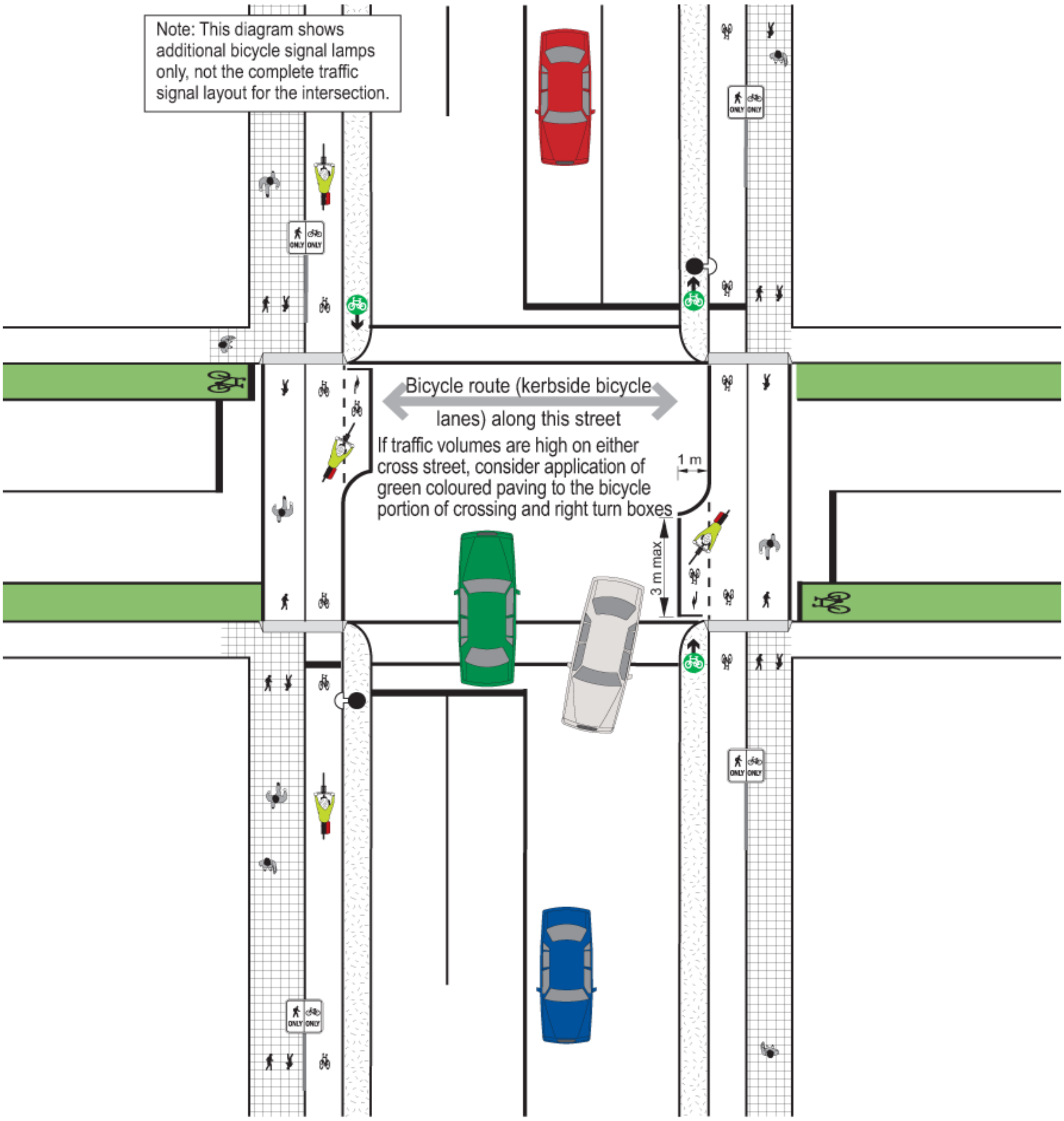
Right turns from off-road bicycle paths

The treatment shown in Figure 5.12 is similar to that used at large signalised intersections to assist bicycle hook turns between a separated path and a bicycle lane on the intersecting road. Up to four bicycles can be accommodated in this area while waiting for a green right-turn arrow. If the cyclist volume is high, green pavement surfacing should be considered on both the holding area and the bicycle crossing.

Figure 5.12: Right turn from an off-road bicycle path to an on-road bicycle lane



Source: Roads and Traffic Authority NSW (2005).

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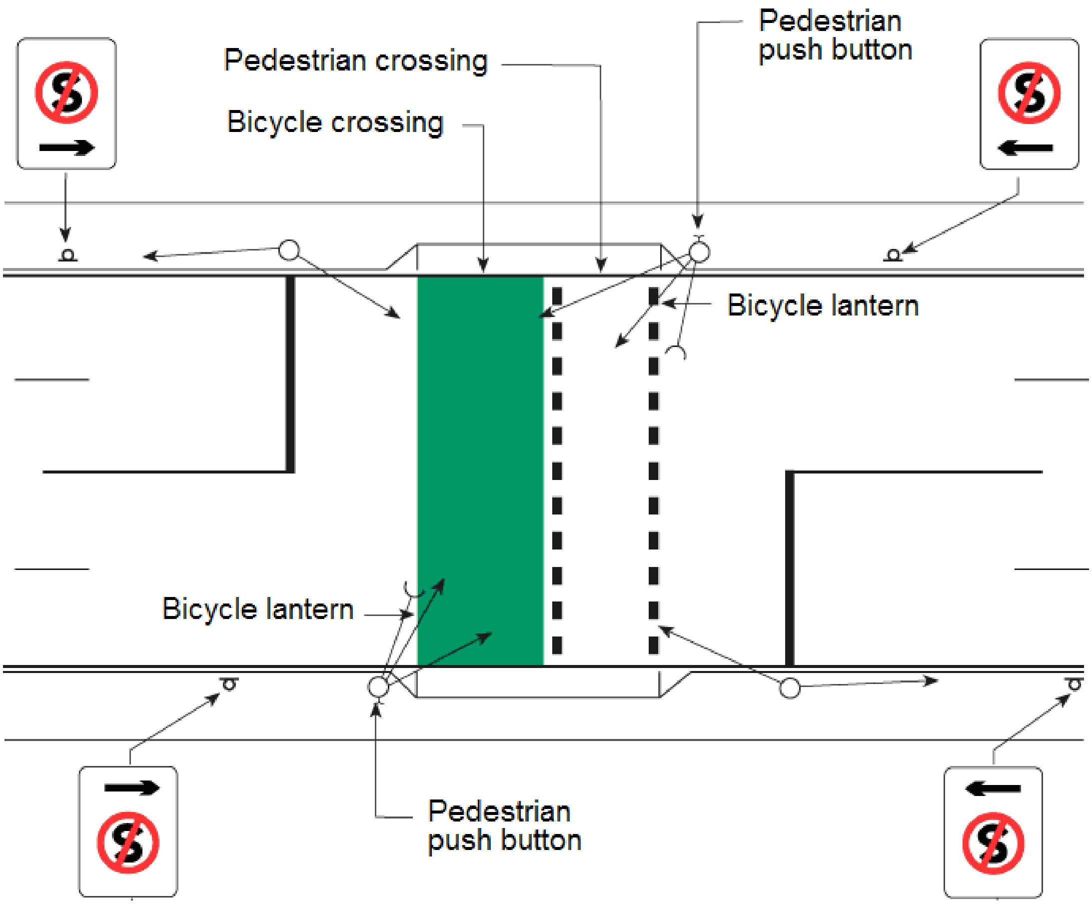
5.3.10 Signalised Mid-block Crossings

Road crossings for cyclists can be coordinated with signalised or unsignalised pedestrian crossings and school crossings. Cyclists are usually required by law to dismount at formal pedestrian crossings including school crossings. Where a bicycle route crosses a road at a signalised crossing care should be taken to ensure that activation buttons are located to avoid the need for cyclists to cross in front of oncoming path users and are within easy reach for a mounted cyclist. Induction loops can also be installed to facilitate detection.

Bicycle crossing lights (i.e. displaying bicycle symbols) should be provided where the crossing serves both pedestrians and cyclists provided jurisdictional traffic regulations permit this treatment. Where road rules permit, a green bicycle signal allows cyclists to ride across the crossing. Where pedestrian and cyclist demands are both heavy there is a tendency for pedestrians to move to the front and block the progress of cyclists using the crossing. In such cases consideration should be given to segregating cyclists and pedestrians as shown in Figure 5.13 (i.e. separate and well-delineated crosswalks for pedestrians and cyclists).

The appropriate type of crossing should be determined with reference to normal warrants for pedestrian crossings using the combined cyclist and pedestrian demand.

Figure 5.13: Signalised crossing with separate pedestrian and cyclist areas



Note: The intent of the green surfacing is to improve the discipline of cyclists and pedestrians in using their respective areas of the crossing. However, the delineation of the crossing, and hence the use of green surfacing, is a matter for the relevant road agency.

5.4 Unsignalised Road Intersections

5.4.1 General

This section covers treatments designed to assist cyclists to safely negotiate unsignalised intersections between two roads or between a road and a bicycle path or shared path. However, path terminal treatments are not included as they are discussed in Section 7.8 and Section 7 of AGRD06A (Austroads 2017c).

5.4.2 Basic and Channelised Intersections

Figure 5.14 and Figure 5.15 respectively illustrate the provision of bicycle lanes through basic and channelised intersection treatments for urban situations. Further information and examples on the integration of bicycle facilities into unsignalised intersections is provided in AGRD04 (Austroads 2017a). The most important requirements are that the bicycle lanes should be continuous through the intersection and be well delineated as a space for cyclists by appropriate placement of pavement logos, and use of a green surfacing where necessary (e.g. in complex treatments or high-risk situations).

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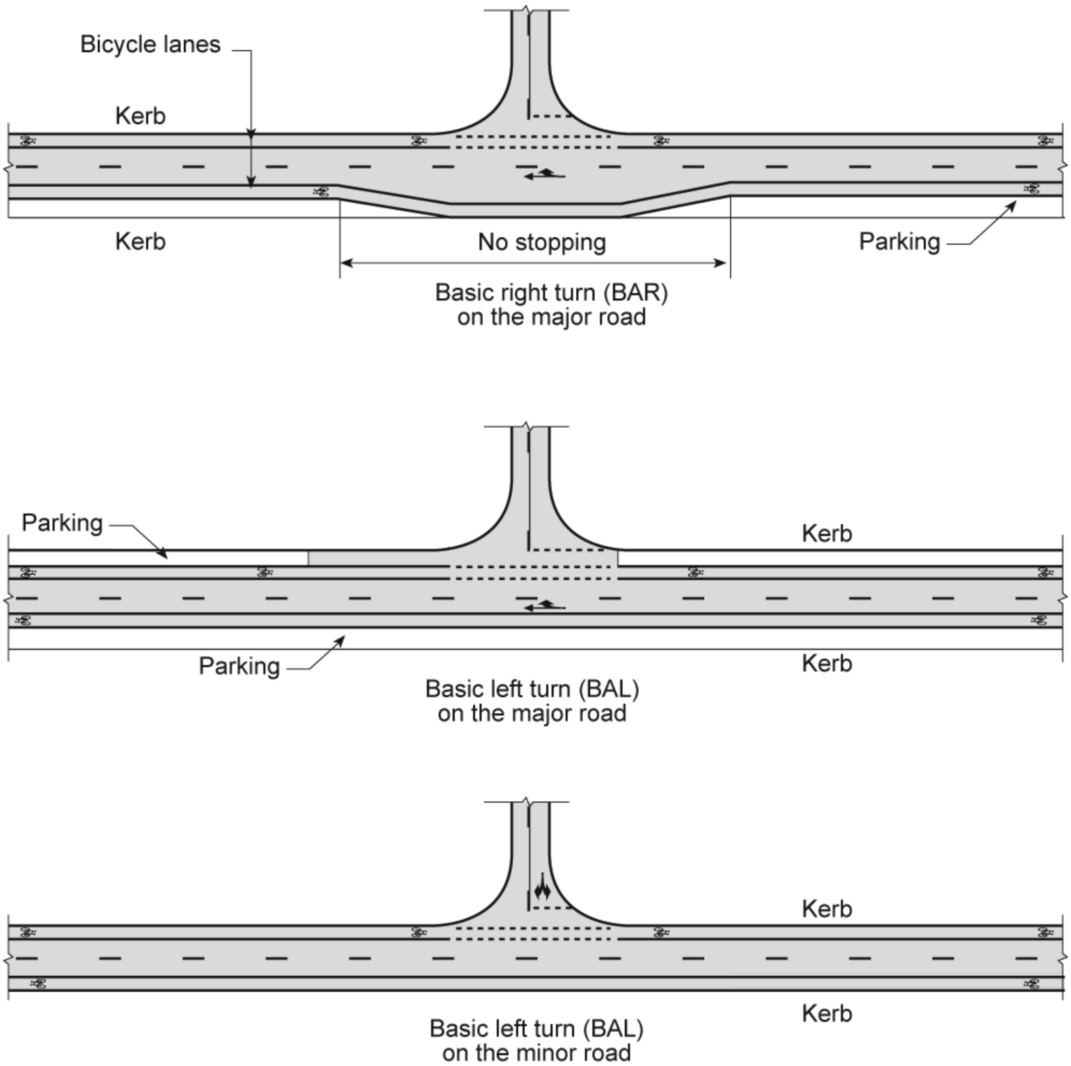
Figure 5.14: Urban basic (BA) intersection turn treatments



Note: Arrows indicate movements relevant to the turn type. They do not represent actual pavement markings.

Source: Queensland Department of Transport and Main Roads (2015a).

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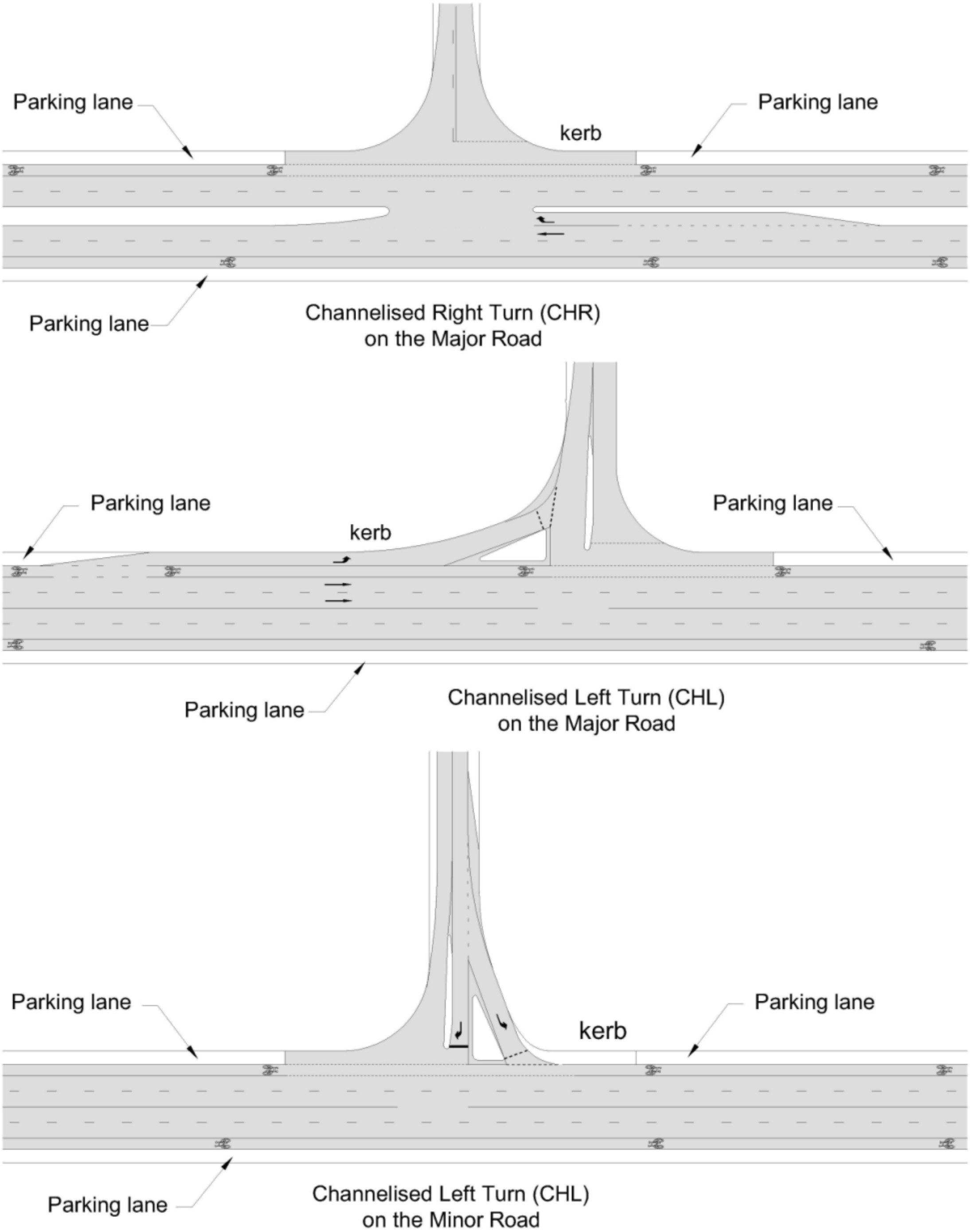
Figure 5.15: Urban channelised (CH) intersection turn treatments



Note: Arrows indicate movements relevant to the turn type. They do not represent actual pavement markings.
Source: Queensland Department of Transport and Main Roads (2006).

Bicycle lane treatments through intersections could also be considered at locations where cyclists would be at risk due to the geometric design requirements for motor vehicles. A short, marked bicycle lane through an intersection may provide safety advantages to cyclists provided that its termination point does not lead cyclists into an unsafe situation. Terminating at a sealed shoulder or in a wide kerbside lane would normally deliver adequate safety.

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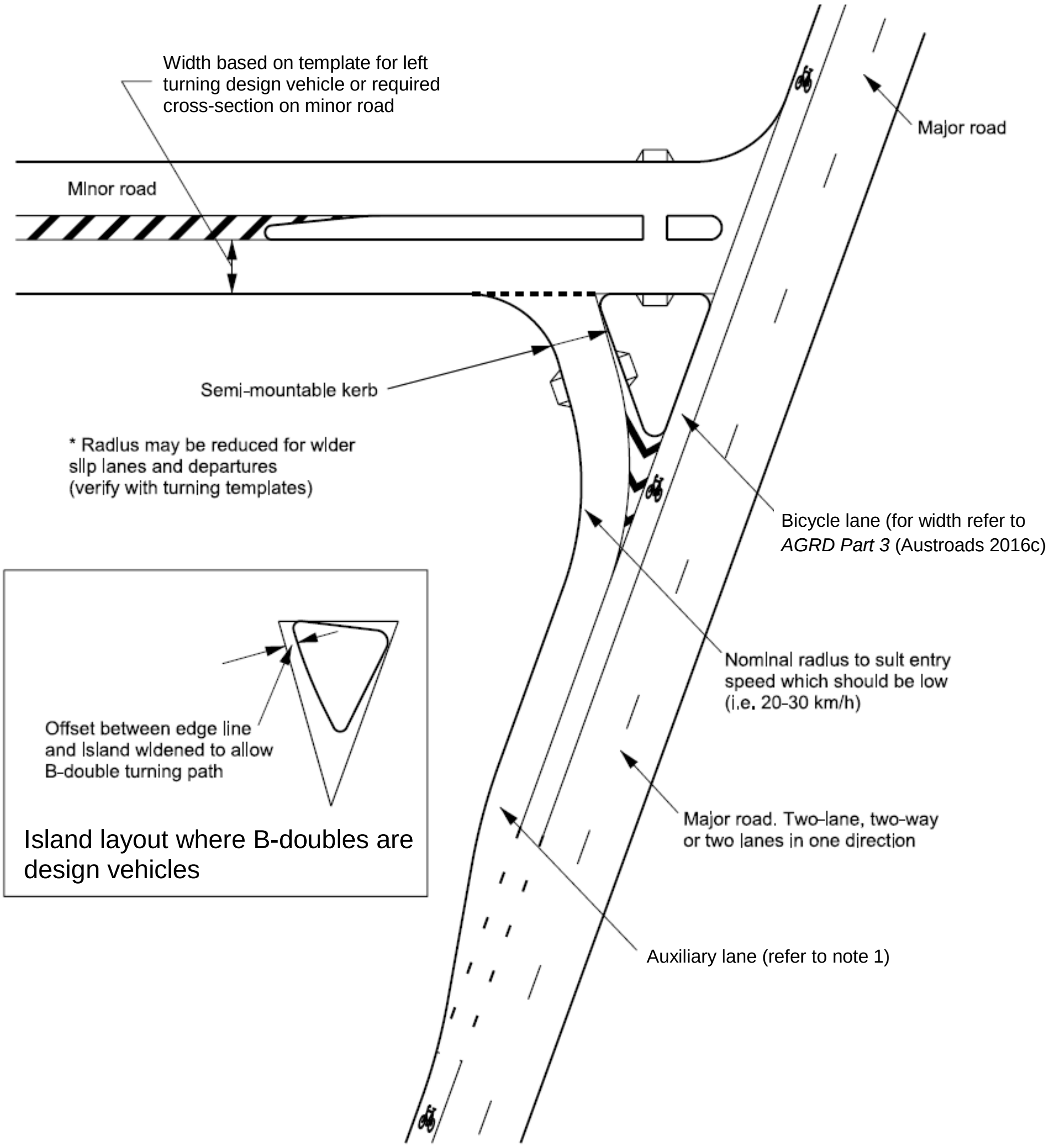
5.4.3 Channelised Left-turn Treatment

Figure 5.16 shows a bicycle lane passing through a channelised left-turn (CHL) treatment at an unsignalised intersection. The treatment may be provided to give cyclists priority through diverge areas and hence minimise conflict between cyclists and left-turning motor vehicles.

On priority cycling routes where there are long deceleration or acceleration tapers, large radius curves and high speeds, it is particularly desirable that a bicycle lane be marked through the diverge areas and merge areas. These treatments provide space for cyclists and also warn drivers of the possible presence of a cyclist.

Figure 5.16: Provision for cyclists at an unsignalised CHL treatment in a low-speed environment



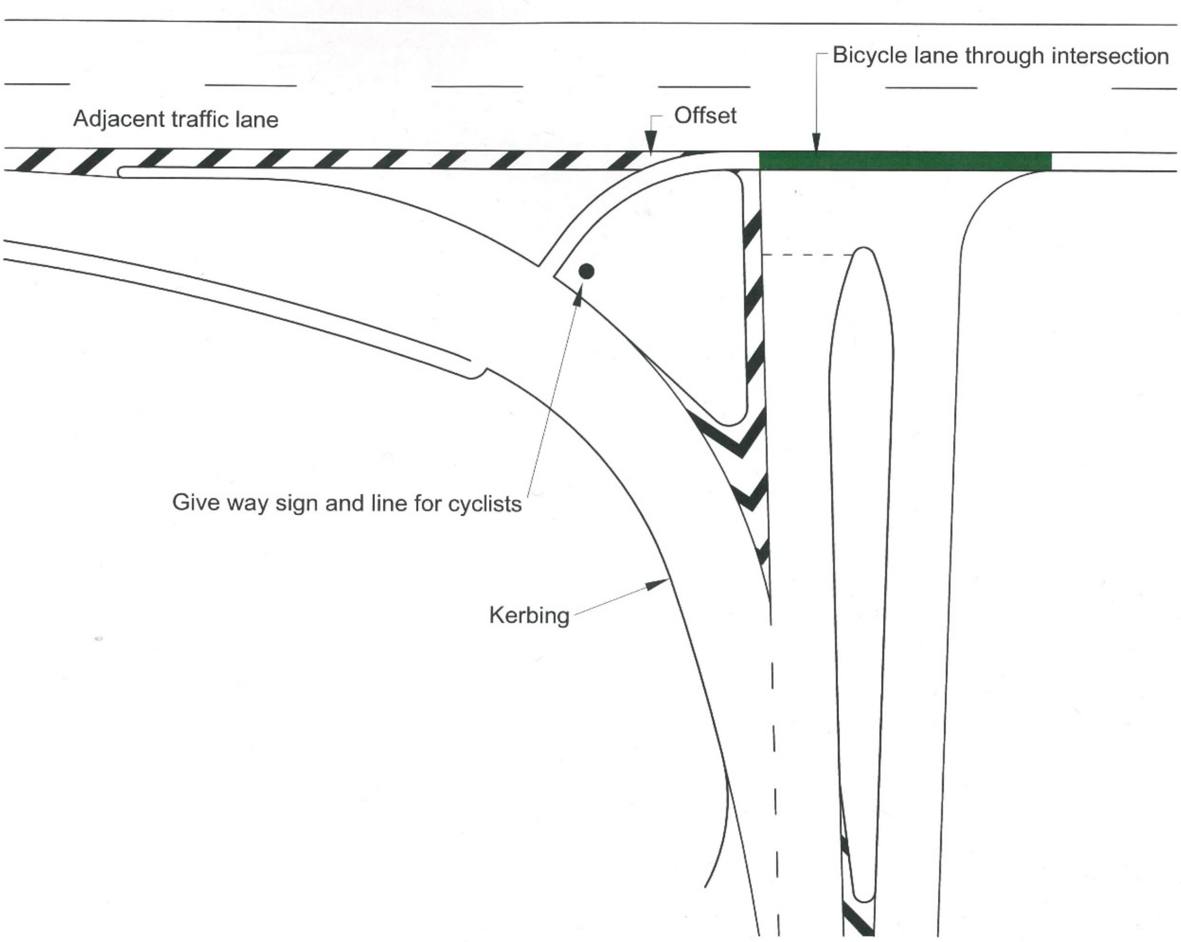
Notes:

- *Bicycle lanes on priority road must be continuous through unsignalised intersections and connect to bicycle facilities on the approach and departure.*
- *In cases where a bicycle route turns the corner bicycle lanes may be accommodated within the minor road and within the left-turn roadway.*
- *Green pavement surfacing may be used where high numbers of cyclists and motor vehicles interact. Where this is not the case normal surfacing, road markings and bicycle logos may be used to delineate the bicycle lane.*
- *A minimum width of 5.0 m is required in the left-turn slip lane to enable vehicles to pass a disabled vehicle by mounting the semi-mountable kerb. It is therefore necessary to have a solid surface immediately behind the kerbs.*

AGRD 04
S A.17

Figure 5.17 illustrates how a bicycle lane may be designed to provide a safer treatment for cyclists through a rural channelised free-flow left-turn island treatment. A similar treatment can be used for urban free-flow left-turn channelisations.

Figure 5.17: An example of provision for cyclists at rural free-flow left-turn treatments

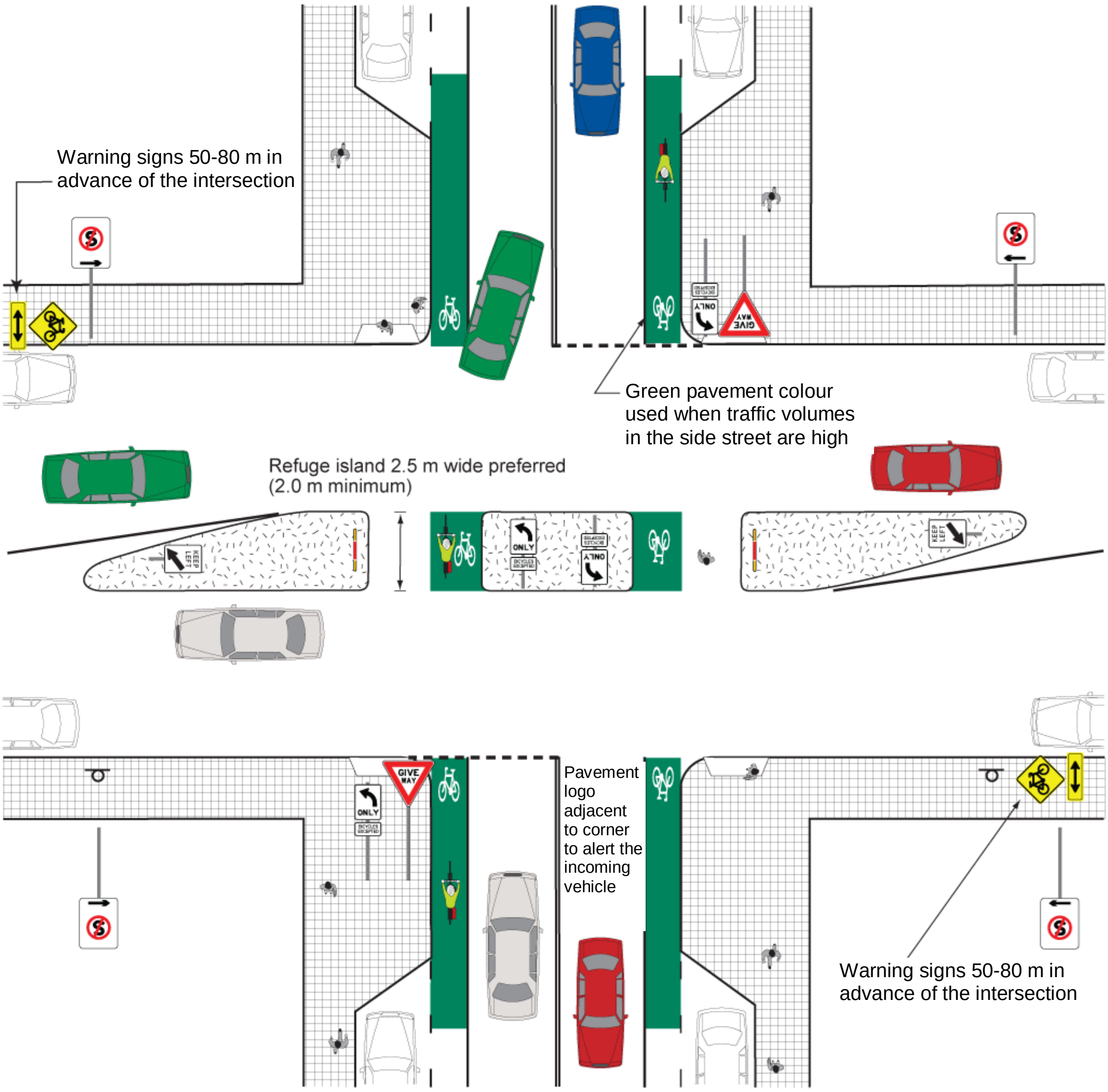


AGRD 04
S C.1.4

5.4.4 Refuge within an Unsignalised Intersection

A refuge may be placed within an intersection to accommodate the crossing movements of both pedestrians from footpaths and cyclists from bicycle lanes in the side roads while restricting motorists to a 'left-turn in/left-turn out' arrangement. Such a treatment is shown in Figure 5.18.

Figure 5.18: Refuge within an intersection for pedestrians and cyclists in bicycle lanes



Note
If the road being crossed by the bicycle route (horizontal road) is narrow and carries light traffic, the central refuge is not required. When a refuge is not used, straight-through movements are permissible for all vehicles

Note: If a road agency is concerned that illegal motor vehicle movements may occur through the pedestrian/cyclist slots in the refuge island, separate narrower slots may be provided for pedestrians and cyclists.

Source: Roads and Traffic Authority NSW (2005).

5.5 Roundabouts

5.5.1 Introduction

AGRD 04B S 5.3.1

Guidance on the use and design of roundabouts including bicycle treatments is provided in AGRD04B (Austroads 2015a) and in Section 4 of AGTM06 (Austroads 2013c). AGTM06 describes the different types of cyclists that need to be catered for at roundabouts and the associated traffic management considerations.

The treatments and/or traffic control measures needed to achieve an adequate level of safety for cyclists depend on:

- daily vehicle traffic volume and the peak-hour flows
- proportion of cyclists in the total traffic stream
- functional classification of the roads involved
- overall traffic management strategies for the location.

5.5.2 Safety Analysis of Roundabouts for Cyclists

AGRD 04B S 5.3.2

Designers should appreciate that, while roundabouts are safer than other types of intersections, roundabouts may not be as safe for cyclists as other road users (AGTM06). The selection of a roundabout for the intersection will often depend on the proportion of cyclists and other non-motorised road users expected to use the roundabout, along with other factors such as the functional classification of the roads involved and the overall traffic management strategy to be adopted.

It is also important to understand that the risk to cyclists and pedestrians depends on the type of roundabout. While a single-lane, low-speed urban roundabout may be satisfactory for pedestrians and cyclists, multilane roundabouts, or poorly designed single-lane roundabouts with inadequate entry curvature that promotes high entry speeds, are less safe for cyclists and pedestrians.

5.5.3 Designing Roundabouts for Cyclists

AGTM 06 S 4.4.2

Where circumstances require that a significant number of cyclists use a roundabout the approaches should be designed to cater for the lowest practicable approach speed. Consideration may also be given to adopting a European alignment (refer to Figure 7 of VicRoads 2005) for the approaches whereby traffic enters at an approach angle that is approximately perpendicular to the central island (i.e. minimal flare).

AGRD 04B S 5.3.3

Reducing the relative speed between entering and circulating vehicles, minimising the number of circulating lanes, and maximising the distance between approaches reduces the entering/circulating vehicle crash rates at roundabouts and should also minimise entering/circulating vehicle crashes involving cyclists. Therefore, the design concepts given in the Austroads *Guide to Road Design Part 4B: Roundabouts* (AGRD04B) (Austroads 2015a) to minimise entry speeds, should also minimise crashes involving cyclists.

The results of various studies indicate that a separated cycle path, located outside the circulating carriageway, is the safest design when there are high vehicle flows. On designated cycle routes that cater for commuter cyclists, consideration should be given to the provision of signalised intersections instead of roundabouts.

At small single-lane roundabouts on local streets, where the geometry encourages low approach speeds (e.g. 20 km/h), cyclists should be able to safely share the road with general traffic.

At larger single-lane or multilane roundabouts where speeds are higher, consideration should be given to separate treatments such as an off-road bicycle path around the roundabout with uncontrolled cyclist/pedestrian movement across each approach leg. There is some evidence to suggest that this is the safest design, at least where traffic flows are high.

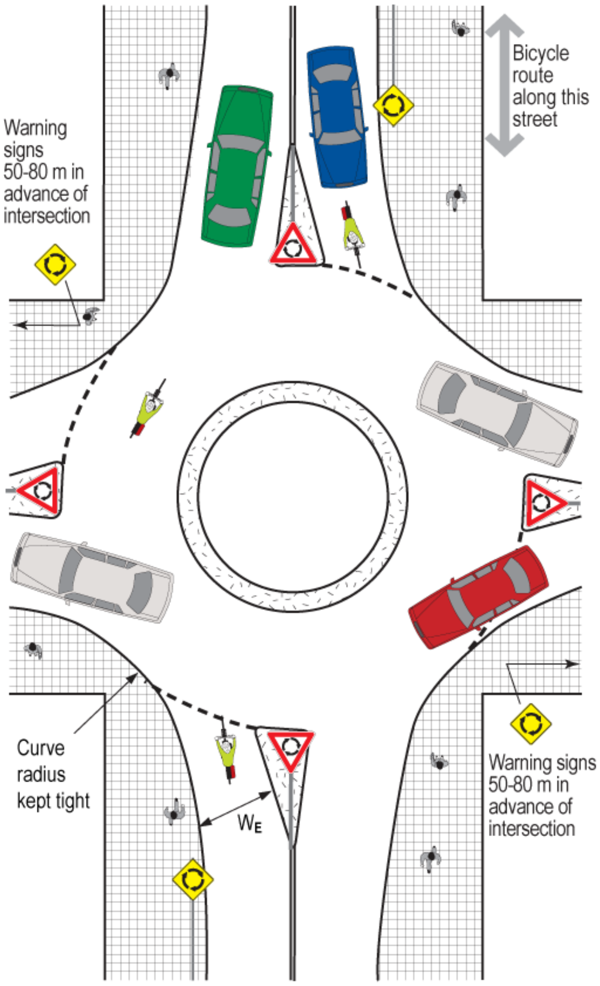
5.5.4 Roads with Shared Traffic

AGRD 04B S 5.3.4

Roads that have low traffic speeds (< 50 km/h) and relatively low volumes (< 3000 vpd) generally enable cyclists to safely share the road with other traffic.

Figure 5.19 shows an example of a low-volume single-lane roundabout which is based on cyclists occupying the approach lane. The approach-lane width should not exceed 3.0 m as wider lanes may encourage risky overtaking behaviour by motorists.

Figure 5.19: Bicycle route through a single-lane roundabout – no bicycle facility



Note: The width of the entry W_E should cater for the design vehicle (e.g. service vehicle or fire truck). However, it is preferable that W_E is less than 3.0 m so that drivers do not attempt to enter the roundabout alongside cyclists and 'squeeze' them into the kerb.

Source: Roads and Traffic Authority NSW (2005).

5.5.5 Multilane Roundabouts on Arterial Roads

AGRD 04B
S 5.3.5

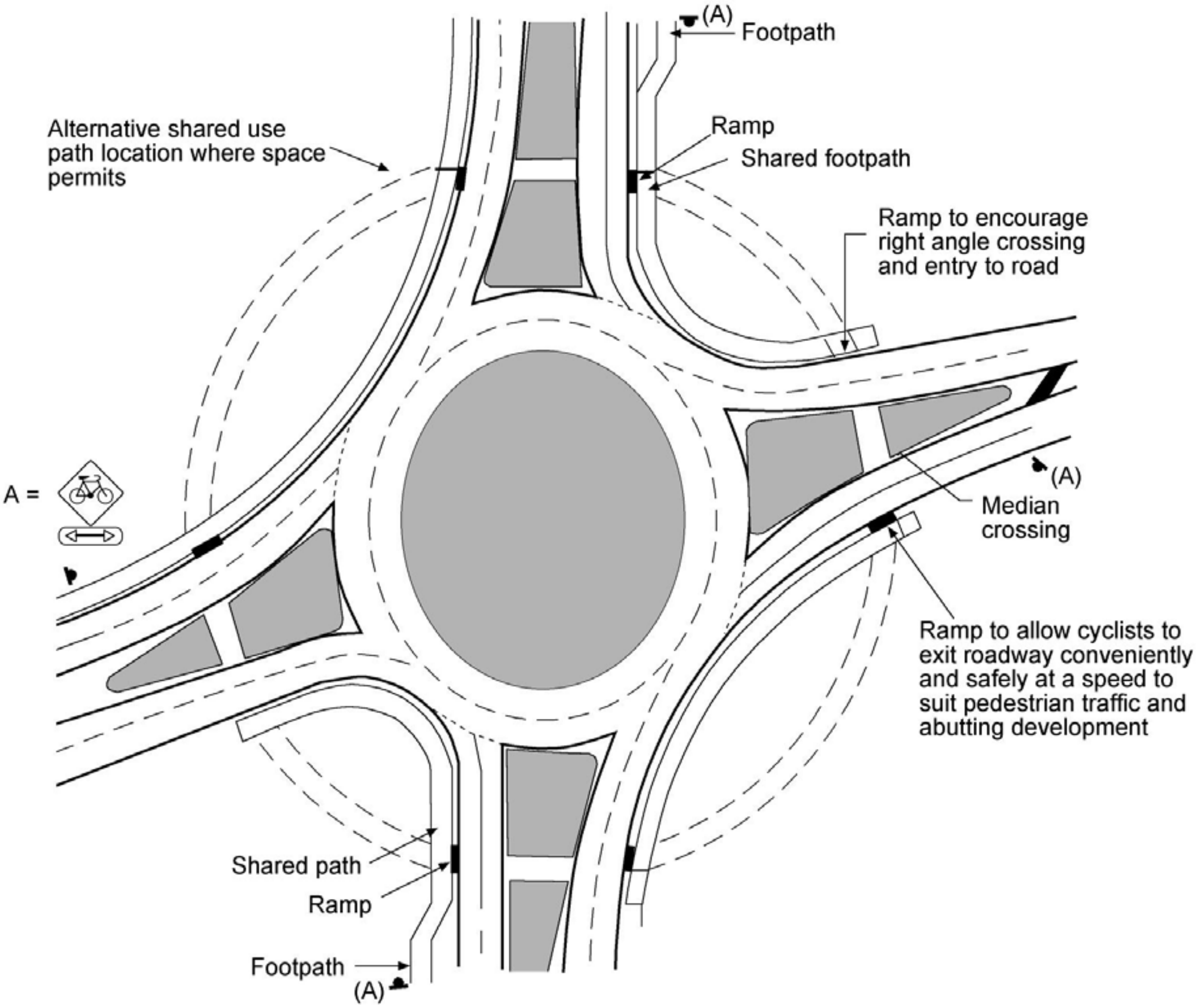
Multi-lane roundabouts usually carry high traffic volumes and have higher entry speeds than local street roundabouts and therefore create safety problems for cyclists. It is anticipated that only experienced cyclists will use this type of roundabout and whilst they may feel reasonably comfortable in selecting a gap and turning left and travelling straight through a multilane roundabout in the bicycle lane, they will generally find the right-turning manoeuvre challenging. Some cyclists will therefore bypass the right turn by using local streets, shared paths at the roundabout (where provided) or by undertaking a hook turn at the exit.

AGRD 04B
S 5.3.6

5.5.6 Bicycle Paths and Shared Paths at Roundabouts

Bicycle paths or shared paths may be provided adjacent to roundabouts to provide safer passage for inexperienced cyclists and pedestrians. An example of a treatment where there is a relatively small volume of pedestrians and cyclists is shown in Figure 5.20.

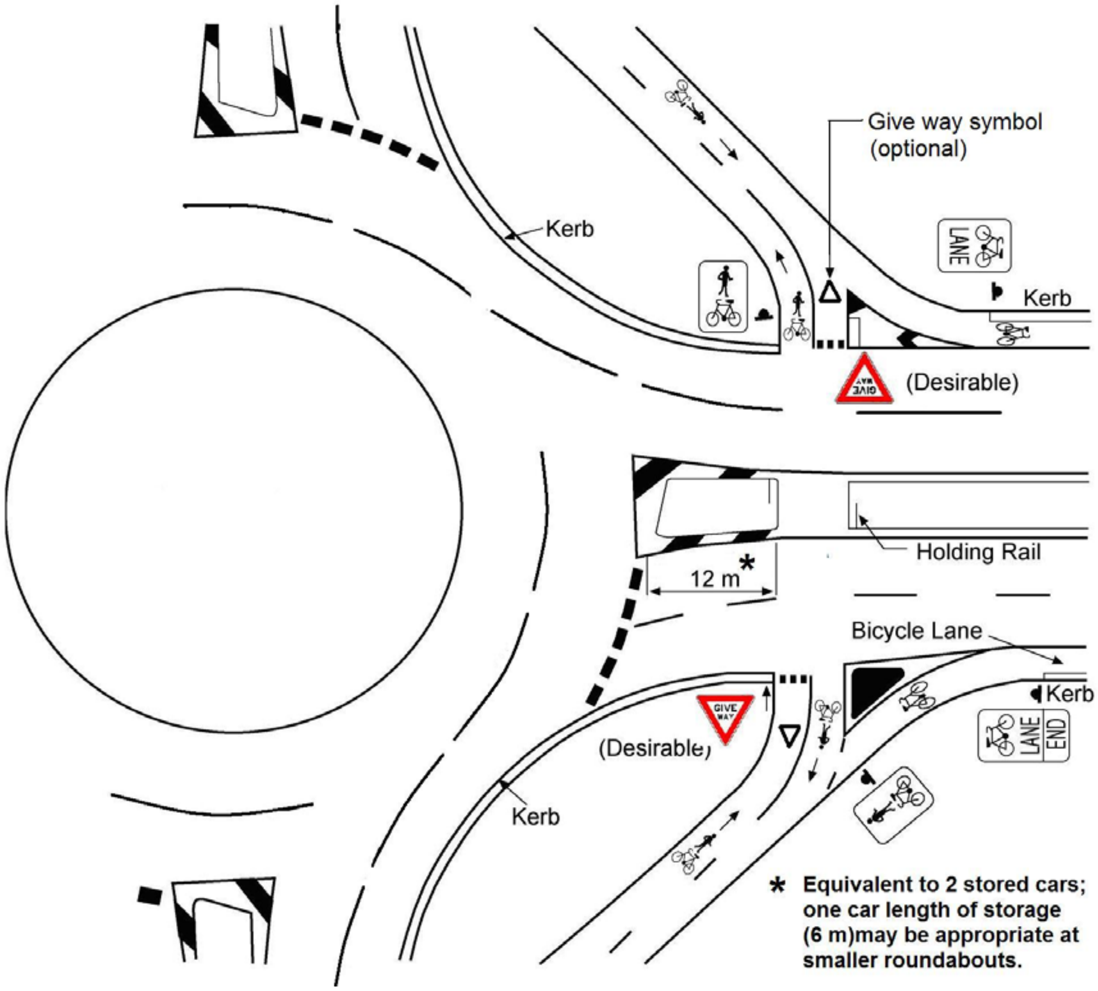
Figure 5.20: Path at a roundabout where cyclist and pedestrian volumes are low to moderate



Source: Queensland Department of Transport and Main Roads (2006).

Where a shared path is provided at a multilane roundabout and bicycle lanes exist on the approach, the crossing treatment shown in Figure 5.21 may be used. This treatment provides a crossing at road level as well as convenient connections between the bicycle lanes and the paths to encourage cyclists to use the shared path to negotiate the roundabout. It is also possible to modify this treatment so that the bicycle lane passes through the roundabout, thereby providing an option for cyclists to remain on the road or to utilise the shared path and road crossings. The treatment in Figure 5.21 also suggests that cyclists using the shared path crossings should be controlled by give-way signs.

Figure 5.21: Crossing detail for a shared path adjacent to a multilane roundabout



Source: VicRoads (2005).

5.5.7 Other Considerations

AGRD 04B S 5.3.7

Other situations where special consideration of cyclists is required to assist access and safety include the provision of a path to provide a bypass of three-legged roundabouts for cyclists travelling straight through the intersection.

To ensure that potential conflicts between cyclists and pedestrians are addressed, pedestrian movements must be considered where:

- it is proposed to construct separate perimeter paths around the outside of roundabouts
- shared-use paths exist around roundabouts.

5.6 Road Interchanges

5.6.1 General

AGTM 06 C 23

Issues and the general provisions for cyclists on freeways are covered in Section 4.7. This section provides some further information on options for dealing with cyclist movements at road interchanges (AGTM06, (Austroads 2013c)).

Where cyclists are permitted to travel on roads that have interchanges (freeways, motorways or arterial roads), they should be provided with safer and convenient facilities, such as wide shoulders that have smooth, clean surfaces suitable for cycling.

Cyclist access may be denied to freeways or motorways due to:

- the difficulties and safety risks associated with high-speed and high-volume traffic environments
- geometric features that are not conducive to safer cycling (e.g. narrow shoulders)
- use of shoulders for other purposes (e.g. public transport).

There is inherent danger associated with cyclists attempting to cross high-volume ramps at the nose (even if directed to use other routes), particularly two-lane exits.

It is important that the interchange design provides continuity of the bicycle route through the interchange and for safer and convenient movement of cyclists across ramps and the intersecting arterial road.

5.6.2 At-grade Treatment at Interchanges

AGRD 04C
S 14

At interchanges, the route to be provided for cyclists should be established and clearly signed. Cyclists should only be permitted to pass through interchanges via at-grade crossings of ramps where sufficient gaps exist in traffic flows to enable cyclists to cross the ramps. For additional guidance refer to Section 14 of the Austroads *Guide to Road Design Part 4C: Interchanges* (AGRD04C) (Austroads 2015b).

Where cyclists are permitted to pass through an interchange using at-grade crossings of ramps the desirable route should be clearly marked and signed as shown in Figure 5.22.

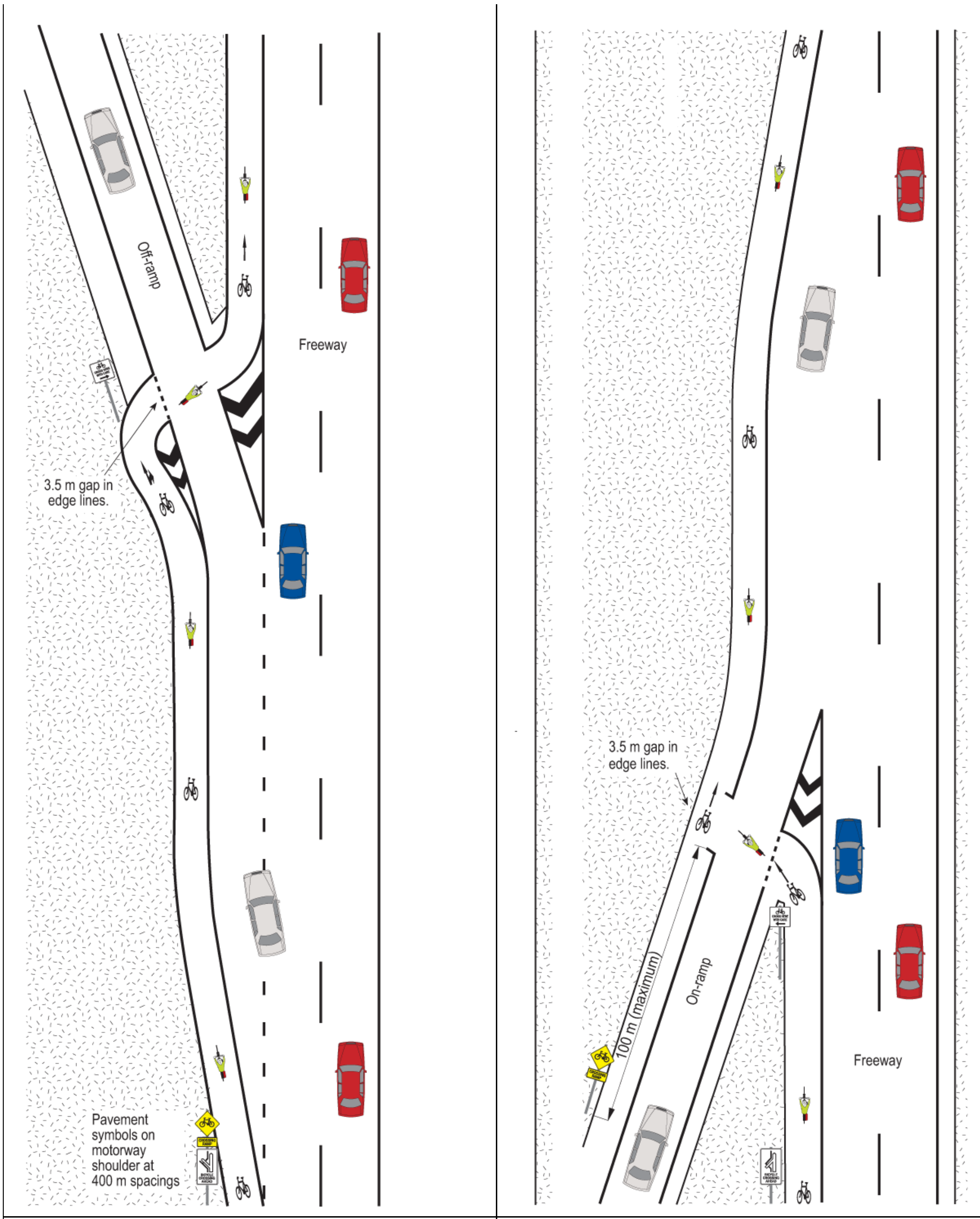
In order for cyclists to be able to cross a ramp at the nose, the volume and approach pattern of motor vehicles using the ramp must be such that adequate gaps occur in the traffic stream to enable a safer and convenient crossing of the ramp to be made by cyclists. This method requires a cyclist to turn from the shoulder/breakdown lane and cross the ramp at right-angles.

It is estimated that a cyclist requires a gap of seven seconds in order to cross the ramp (Ove Arup & Partners 1989). This gap was determined using the assumption that both the bicycle length and the car width are 2 m. Assuming that the speed of the bicycle is 5 km/h (1.4 metres per second), at the crossing it will take almost three seconds for the bicycle to pass in front of the motor vehicle. If it is further assumed that at least two seconds clearance is required after the passage of the first vehicle and also before passage of the second vehicle it follows that a minimum gap of seven seconds is required.

If the ramp is an off-ramp or the on-ramp is not controlled by traffic signals it may be reasonable to assume that vehicles using the ramp arrive at random and gap acceptance theory should be used to estimate the delay likely to be suffered by cyclists in crossing these ramps. If analysis indicates that the average delay to a cyclist is greater than 15 seconds (beyond which they are assumed to accept gaps of greater risk, i.e. less than seven seconds), then cyclists should be directed to use the exit ramp, cross the intersecting road at-grade, and re-enter the freeway via the on-ramp, or a grade separation of the ramp for cyclists should be evaluated. If an on-ramp is controlled by traffic signals then the ability of cyclists to cross the ramp must be evaluated in relation to the signal cycle and phasing and other traffic movements which may not be controlled by signals.

AGRD 04C
S 14.2.1

Figure 5.22: Typical at-grade treatment for cyclists at exit and entry ramps



(a) Exit ramp | (b) Entry ramp

Source: Roads and Traffic Authority NSW (2005).

AGRD 04C
S 14.2.2

5.6.3 Grade Separation of Ramps for Cyclists

Grade separation of cyclist movements across exit and entry ramps should be considered where large flows of cyclists use a freeway or a major path associated with a freeway. At such levels of flow it may be more appropriate to provide a high-speed exclusive bicycle path within the freeway reservation with grade separations at the minor roads. Even if cyclists continued to use the freeway shoulders it may be more viable and practical to require them to use the freeway ramps, and provide an underpass of the minor road, for example.

AGRD 04C
S 14.2.3

5.6.4 Alternative Routes

Where there are unacceptable risks for cyclists to use a freeway and there is insufficient space for a cycling facility, alternative routes providing a similar level of service should be defined and developed off the freeway. These routes may comprise:

- routes on the surface arterial road network or local street network
- a bicycle path or shared path within the freeway reservation with either at-grade crossings of the minor road at ramp terminals, or grade separation of the minor road (refer to AGRD06A (Austroads 2017c)).

Alternative routes should provide the highest practicable level of service for cyclists (e.g. minimise stops, most direct route, separation from motor vehicles etc.).

6. Provision for Cycling at Rail Crossings

6.1 General

Traffic management aspects and layout arrangements for pedestrian and bicycle crossings of railways are covered in AGTM06, AS 1742.7-2016 and the *Manual of traffic signs and markings (*MOTSAM, NZ Transport Agency 2010a and 2010b). Cross-references to the sections of Austroads Guides related to cyclists at rail crossings are shown in Table 6.1.

Table 6.1: Key cross-references related to cyclists at rail crossings

Series		Part	Section	Reference source
Section 6.2: Types of Rail Crossings				
AGTM	Guide to Traffic Management	6	Section 7.2	Austroads (2013c)
AGRD	Guide to Road Design	4	Section 10	Austroads (2017a)
Section 6.3: Key Requirements and Considerations				
AGTM	Guide to Traffic Management	6	Section 7.2	Austroads (2013c)
Section 6.4: Path Crossings				
AGTM	Guide to Traffic Management	6	Section 7.6	Austroads (2013c)

6.2 Types of Rail Crossings

AGTM 06 S 7.2

AGRD 04 S 10

Traffic control of at-grade rail crossings may be achieved through the use of passive or active traffic control devices. Paths may utilise at-grade level crossings or be grade separated.

Active protection (or active control) is the control of the movement of vehicular or pedestrian traffic across a railway crossing by devices such as flashing lights, gates or barriers (also half-arm barriers in NZ), or a combination of these, where the device is activated prior to and during the passage of a train through the crossing.

Passive protection (or passive control) is the control of the movement of vehicular or pedestrian traffic across a railway crossing by signs and devices, none of which are activated during the approach or passage of a train, and which relies on the road user, including pedestrians, detecting the approach or presence of a train by direct observation.

6.3 Key Requirements and Considerations

Key requirements are that the crossing should have a smooth and straight alignment, preferably at right angles to the rails, with a well-maintained interface between the path and rails, and the appropriate traffic control devices to warn, regulate, advise and control pedestrians (including people who have impairments) and cyclists.

AGTM 06
S 7.2

6.3.1 On-road Railway Level Crossings

Key considerations for different types of railway crossings are shown in Table 6.2.

Table 6.2: Considerations for pedestrians and cyclists at railway crossings

Type of railway crossing	Considerations for pedestrians and cyclists
Passive controlled at-grade crossings	• Provide signs to warn pedestrians and cyclists to look for trains; pavement markings to define footway and safer waiting position • Where cyclists are permitted to ride over the crossing, provide a cyclist warning sign on approaches to the crossing • Where cyclists are not permitted to ride over the crossing, provide 'cyclist dismount' signs on the approaches to the crossing • Ensure surface condition is adequate including flangeway gaps (within practicable limitations) • Where necessary (e.g. urban areas) provide pedestrian mazes or gated enclosures; where mazes are provided, people with visual or mobility impairments, or people pushing prams should be able to easily negotiate them • Requirements also apply to pedestrian crossings remote from vehicular crossings
Active controlled at-grade crossing	• Provide red symbolic standing pedestrian signals, audible alarms and signs to warn pedestrians and cyclists to look for trains. Also use pavement markings to define the footway and a safer waiting position • Where cyclists are permitted to ride over the crossing, provide a cyclist warning sign on approaches to the crossing • Where cyclists are not permitted to ride over the crossing, provide 'cyclist dismount' signs on the approaches to the crossing • Ensure surface condition is adequate including flangeway gaps (within practicable limitations) • Where necessary (e.g. urban areas) provide pedestrian mazes or gated pedestrian enclosures; where gated enclosures and mazes are provided, people with impairments or people pushing prams should be able to easily negotiate them • Requirements also apply to pedestrian crossings remote from vehicular crossings

Source: Austroads (2013c) Tables 7.1 and 7.2.

AGTM 06
S 7.6

6.4 Path Crossings

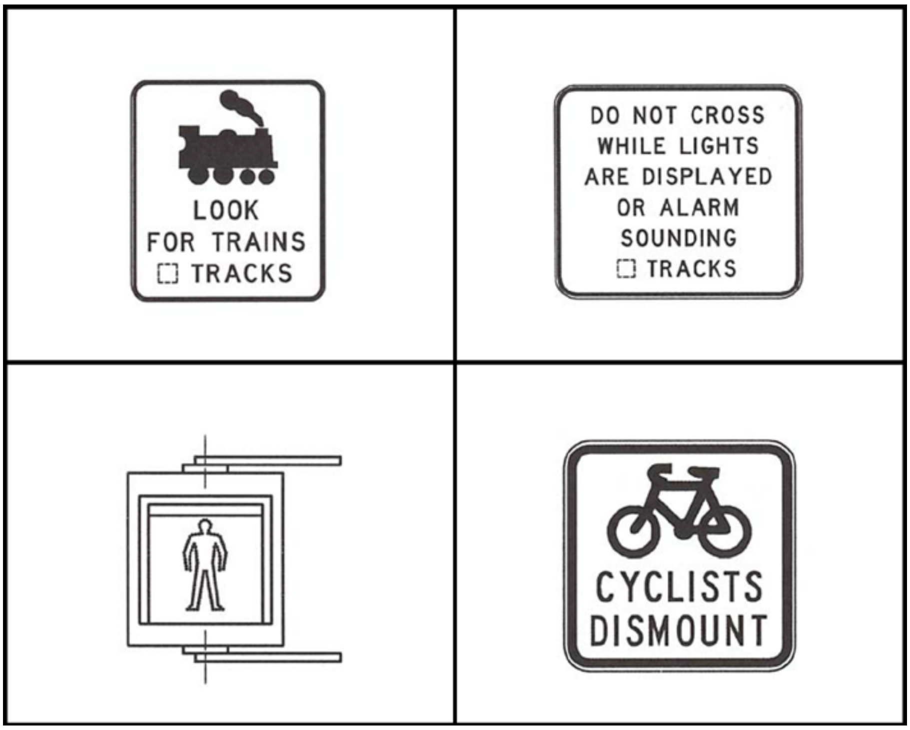
The type of path provided on a road approach to a rail level crossing is a matter for the relevant road agency. Key requirements are that the path crossing should have a smooth and straight alignment, preferably at right angles to the rails, with a well-maintained interface between the path and rails, and the appropriate traffic control devices to warn, regulate, and to advise and control cyclists. Railway crossings should comply with AS 1742.7-2016 or MOTSAM (NZ Transport Agency 2010a and 2010b).

AS 1742.7-2016:

- states that a 'cyclists dismount' sign shall be used at crossings that are primarily used by pedestrians i.e. that are not part of a shared path, but may be used by cyclists
  This requirement is intended to emphasise to cyclists that it is safer for both pedestrians and cyclists if they dismount and consequently they must not ride on the crossing.
- includes an informative appendix of typical examples of pedestrian facilities at rail level crossings
  The treatments include a minimum treatment, mazes, and gate enclosures. Treatments with passive and active control are illustrated. The 'cyclist dismount' sign is shown in Figure 6.1.
- does not provide warrants or guidelines to determine whether pedestrian or cyclist facilities are to be provided and, if so, which treatment is to be used.

Road and rail authorities should work together to develop warrants taking into account pedestrian and cyclist volumes, train movement patterns, whether active control is provided for vehicular traffic and any other relevant risk factors.

Figure 6.1: Examples of signs used at pedestrian and cyclist crossings of railways



6.4.1 Grade Separation for Paths

AGTM 06 S 7.6.3

In situations where a grade separation of a railway crossing forms part of a shared path, the structure must be designed to a standard that is adequate for combined use by cyclists and pedestrians, including wheelchair users and people pushing prams. In particular:

- Overpasses and underpasses should have an adequate width.
- Adequate vertical clearance is essential.
- Adequate sight distance must be available (particularly relevant to the entries and exits of underpasses).
- Higher railings, designed not to snag bicycle pedals, are required on overpasses.
- Suitable gradients must be provided.

7. Paths for Cycling

7.1 General

AGRD 06A
S 2

AGTM 05
S 3.4

The design of bicycle paths is comprehensively covered in AGRD06A (Austroads 2017c). Designers and practitioners are therefore referred to that Guide.

Commentary 1 of AGRD06A summarises the key objectives of the Australian and New Zealand cycling strategies and emphasises the important contribution cycling can make to the well-being and transportation of people.

From a traffic management perspective (AGTM05, (Austroads 2014a)) off-road bicycle facilities may be provided for the:

- safety of inexperienced, young and aged cyclists
- health and enjoyment of recreational cyclists
- convenience of commuter cyclists (e.g. high-speed exclusive bicycle path, shared path immediately adjacent to an arterial road to bypass a difficult section for cyclists).

Consequently paths may be provided for utility and commuter use, recreational use or a combination of these uses.

Cross-references to the guidance referred to in this section are summarised in Table 7.1.

Table 7.1: Key cross-references related to paths for cycling

Series		Part	Section	Reference source
Section 7.1: General				
AGRD	Guide to Road Design	6A	Section 2	Austroads (2017c)
AGTM	Guide to Traffic Management	5	Section 3.4	Austroads (2014a)
Section 7.2: Types of Path				
AGTM	Guide to Traffic Management	5	Section 3.4	Austroads (2014a)
Section 7.3: Choice of Appropriate Type of Path				
AGRD	Guide to Road Design	6A	Commentary 1.2.3	Austroads (2017c)
Section 7.4: Location of Paths for Cycling				
AGRD	Guide to Road Design	6A	Section 4.1	Austroads (2017c)
Section 7.5: Path Design Criteria for Bicycles				
AGRD	Guide to Road Design	6A	Section 5	Austroads (2017c)
AGRD	Guide to Road Design	5A	Section 5.6.2	Austroads (2013e)
Section 7.6: Path Crossings of Roads (also Sections 5.3.10 and 9.5)				
AGTM	Guide to Traffic Management	5	Section 3.4	Austroads (2014a)
AGRD	Guide to Road Design	6A	Section 8	Austroads (2017c)
AGTM	Guide to Traffic Management	6	Section 8	Austroads (2013d)
AGRD	Guide to Road Design	4	Section 9 and Appendix C.1	Austroads (2017a)

Series		Part	Section	Reference source
Section 7.7: Intersection of Paths with Paths				
AGRD	Guide to Road Design	6A	Section 6	Austroads (2017c)
AGTM	Guide to Traffic Management	6	Section 8.3	Austroads (2013c)
Section 7.8: Path Terminal Treatments				
AGRD	Guide to Road Design	6A	Section 7.5	Austroads (2017c)
Section 7.9: Fences and Road Safety Barriers (also Section 7.5.7)				
AGRD	Guide to Road Design	6	Section 6.5.2	Austroads (2010a)
AGRD	Guide to Road Design	6A	Section 5.5	Austroads (2017c)
Section 7.10: Road and Path Lighting				
AGRD	Guide to Road Design	6A	Section 5.11	Austroads (2017c)
AGRD	Guide to Road Design	6B	Section 4.2	Austroads (2015c)

7.2 Types of Path

AGTM 05 S 3.4

The types of path commonly used (AGTM05, Table 3.2 (Austroads 2014a)) are:

- shared paths that may be appropriate where
  - — demand exists for both a pedestrian path and a bicycle path but where the intensity of use is not expected to be sufficiently great to provide separate facilities
  - — an existing low-use path can be satisfactorily modified (e.g. by appropriate width and signage) to provide for cyclists
- bicycle paths that are set aside for cyclists and may be appropriate where
  - — there is a significant cycling demand and very few pedestrians desire to use the path or a separate pedestrian path is provided
  - — there is very limited motor vehicle access across the path
  - — it is possible to achieve an alignment that allows cyclists uninterrupted and safe travel at a relatively high constant speed (say 30 km/h)
  - — there is significant cycling demand and the path width is too narrow for shared use
- separated paths on which cyclists and pedestrians are required to use designated areas; separated paths
  - — are not common because they are justified only where there are large numbers of both pedestrians and cyclists desiring to use the path
  - — should not be used in busy shopping centres where large numbers of pedestrians are expected to cross the path
  - — may be one-way or two-way.

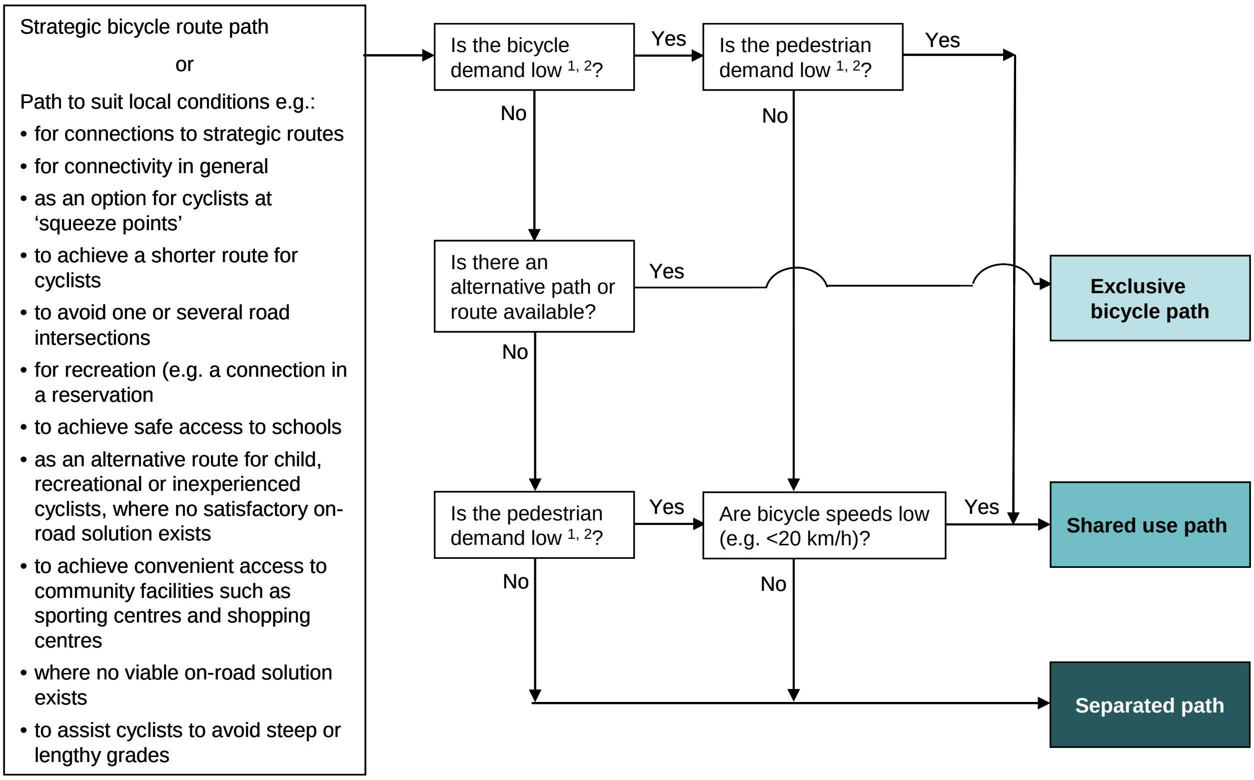
7.3 Choice of Appropriate Type of Path

AGRD 06A C1.2.3

The flow chart in Figure 7.1 is a basic guide to assist designers to choose an appropriate type of path. The flow chart only considers the primary factors needed to determine the type of treatment required. Prior to this chart being applied a decision will have been taken as to whether an on-road lane or an off-road path, or both, are required. Also, there may be other issues, constraints and practices that will have a bearing on the decision-making process.

The types of bicycle paths and their appropriate uses are discussed in Section 2 of AGRD06A (Austroads 2017c).

Figure 7.1: Guide to the choice of path treatment for cyclists



1 *The level of demand can be assessed generally on the basis of the peak periods of a typical day as follows:*

a. Low demand: Infrequent use of path (say less than 10 users per hour)

b. High demand: Regular use in both directions of travel (say more than 50 users per hour).

2 *These path volumes are suggested in order to limit the incidence of conflict between users, and are significantly lower than the capacity of the principal path types.*

AGRD 06A S 4.1

7.4 Location of Paths for Cycling

Paths may be located:

- in the reservations of major new or existing access-controlled arterial roads or freeways
- along river frontages
- on foreshores
- through parkland
- along railway reservations
- abutting bridges or across exclusive bridge facilities
- within the reservations of streets which have direct access to abutting property.

Commuter cyclists are likely to use paths only if the path offers a reasonably direct route or a useful connection between other links in the cycling network whereas recreational cyclists will generally accept indirect routes that provide an appropriate riding experience.

Guidance on factors that influence the detailed location of bicycle paths is provided in Section 4 of AGRD06A (Austroads 2017c).

7.5 Path Design Criteria for Bicycles

7.5.1 General

AGRD 06A S 7

Key design criteria and features for paths are provided in Section 5 of AGRD06A (Austroads 2017c). Table 7.2 lists design elements and features of paths along with reference to the relevant section in AGRD06A.

Table 7.2: Cross-references for key path design criteria

Element or feature	Relevant section of AGRD06A
Bicycle operating speed	Section 5.2
Horizontal alignment	Section 5.3
Width	Section 5.1.1 General Section 5.1.3 Bicycle paths Section 5.1.4 Shared paths Section 5.1.5 Separated paths
Vertical alignment	Section 5.4 Gradient Figure 5.7 Crest curves
Crossfall and drainage	Section 5.6
Clearances, batters and fences	Section 5.5
Sight distance	Section 5.7; Figure 5.16

The following sections provide a summary of the key design criteria shown in Table 7.2.

7.5.2 Bicycle Operating Speed

AGRD 06A S 5.2

Bicycle operating speeds on paths are influenced by a combination of human and other factors. It is important to recognise that under appropriate conditions many fit cyclists can maintain relatively high speeds. Speeds in excess of 35 km/h can be maintained on the flat whilst speeds of over 50 km/h can be attained on moderate gradients.

It is recommended that paths be designed for a speed of at least 30 km/h (Shepherd 1994) wherever possible and desirable given the purpose of the path, and in other cases for the anticipated operating speeds. However, it should be recognised that it may be necessary to adopt higher or lower design speeds in specific circumstances.

Where it is considered necessary to moderate the speeds of cyclists, such as at entry points and areas shared with pedestrians, physical treatments may be necessary to moderate cyclist speeds, refer to Section 5.2 of AGRD06A.

7.5.3 Horizontal Curvature

AGRD 06A S 5.3

Where a path location or alignment is not constrained by topography or other physical features, a generous alignment consisting of straights and large radius curves is desirable. Such an alignment will provide good sight lines that are essential for safety as well as a pleasant riding experience for cyclists.

While the anticipated type of use is a factor for consideration, the fact that a path is provided primarily for recreational use does not remove the need for a good alignment; nor should it encourage designers to provide tight curves to achieve what they consider to be a visually pleasing alignment. Many recreational cyclists travel at relatively high speeds and the radii of curves should be chosen to cater for the expected operating speed on the particular section of path. In addition, tight curves should not be provided to improve visual amenity because:

- Pedestrians and cyclists are likely to cut across the verge on the inside of the curve leading to unsightly bare patches, possible erosion and safety issues.
- There will be a subsequent requirement to treat the area on the inside of curves at additional cost in order to constrain cyclists and pedestrians to travel along the inadequate alignment.

The minimum horizontal radii shown in Table 7.3 should be used where a flat surface is used and it is not possible or desirable to provide superelevation. Table 7.4 shows the minimum radii that should be used in combination with superelevation.

When using Table 7.4 designers and practitioners should be aware that:

- The minimum radii used on shared paths should be no less than those shown in Table 7.4, corresponding to a superelevation of 2.5%.
- The values from Table 7.4 for a superelevation greater than or equal to 3% should only be used on exclusive bicycle paths.
- Curves should generally have positive superelevation so that they can be comfortably negotiated.
- Where practicable the minimum radius should not be used as tight curves can result in sight distance restrictions, a poor level of service and some cyclists choosing an informal alternative path to avoid the restriction.

Table 7.3: Minimum radii of horizontal curves without superelevation

Design speed (km/h)	Minimum radius (metres)
20	10
30	25
40	50
50	94

Note: Based on zero superelevation and friction factors of 0.31, 0.28, 0.25 and 0.21 for speeds of 20, 30, 40 and 50 km/h respectively.

Source: Austroads (2017c) Table 5.6.

Table 7.4: Minimum radii of horizontal curves that have superelevation

Speed (km/h)	Superelevation (%)				
	2	3	4	5	6
	Minimum radius (m)				
20	10	9	9	9	9
30	24	23	22	21	21
40	47	45	43	42	41
50	86	82	79	76	73

Notes:

Based on friction factors of 0.31, 0.28, 0.25 and 0.21 for speeds of 20, 30, 40 and 50 km/h respectively.

For intermediate values of superelevation the horizontal curve equation found in Guide to Road Design: Part 3: Geometric Design (Austroads 2016a) can be used.

Source: Austroads (2017c) Table 5.7.

7.5.4 Width

The width of paths is an important factor given construction costs and operational considerations. It can also have a significant bearing on the level of convenience and conflict between users and potentially on path safety.

The path width required depends on the envelope (i.e. space) occupied by pedestrians and/or cyclists using the path together with appropriate clearances. The clearances are required between path users travelling in the same direction or opposite directions, and also between path users and the edge of the path. Some allowance for the ability of cyclists to ride in a consistent wheel path (i.e. tracking of the bicycle within the envelope) is provided.

Bicycle paths

Table 7.5 shows desirable widths and acceptable ranges of width for bicycle paths (i.e. exclusive use). The upper limit of the acceptable range in the table should not discourage designers from providing a greater width where it is needed (e.g. very high demand that may also result in overtaking in both directions).

Table 7.5: Bicycle path widths

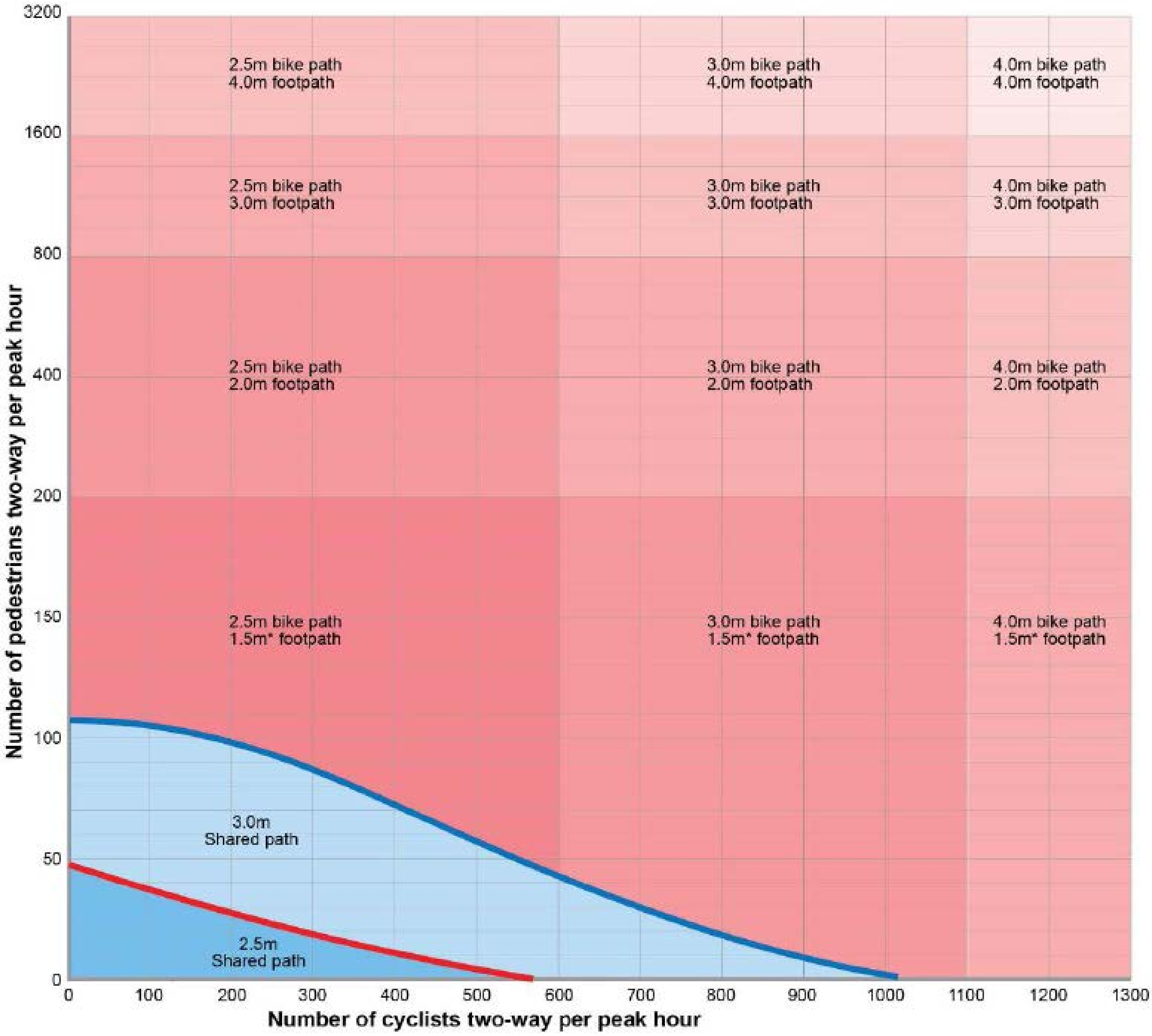
	Path width (m)	
	Local access path	Regional path
Desirable minimum width	2.5	3
Minimum width – typical maximum	2.5[(1)]–3[(2)]	2.5[(1)]–4[(2)]

1 *A lesser width should only to be adopted where cyclist volumes and operational speeds will remain low.*
2 *A greater width may be required where the number of cyclists is very high.*

Source: Austroads (2017c) Table 5.2.

When a bicycle path is primarily for high volumes and there is an emphasis on capacity, it is suggested that the path widths shown in Figure 7.2 and Figure 7.3 be used.

Figure 7.2: Path widths for a 50/50 directional split



** Indicates that the 1.5 m footpath width is the low use minimum only and is not appropriate at higher pedestrian volumes.*

Notes:

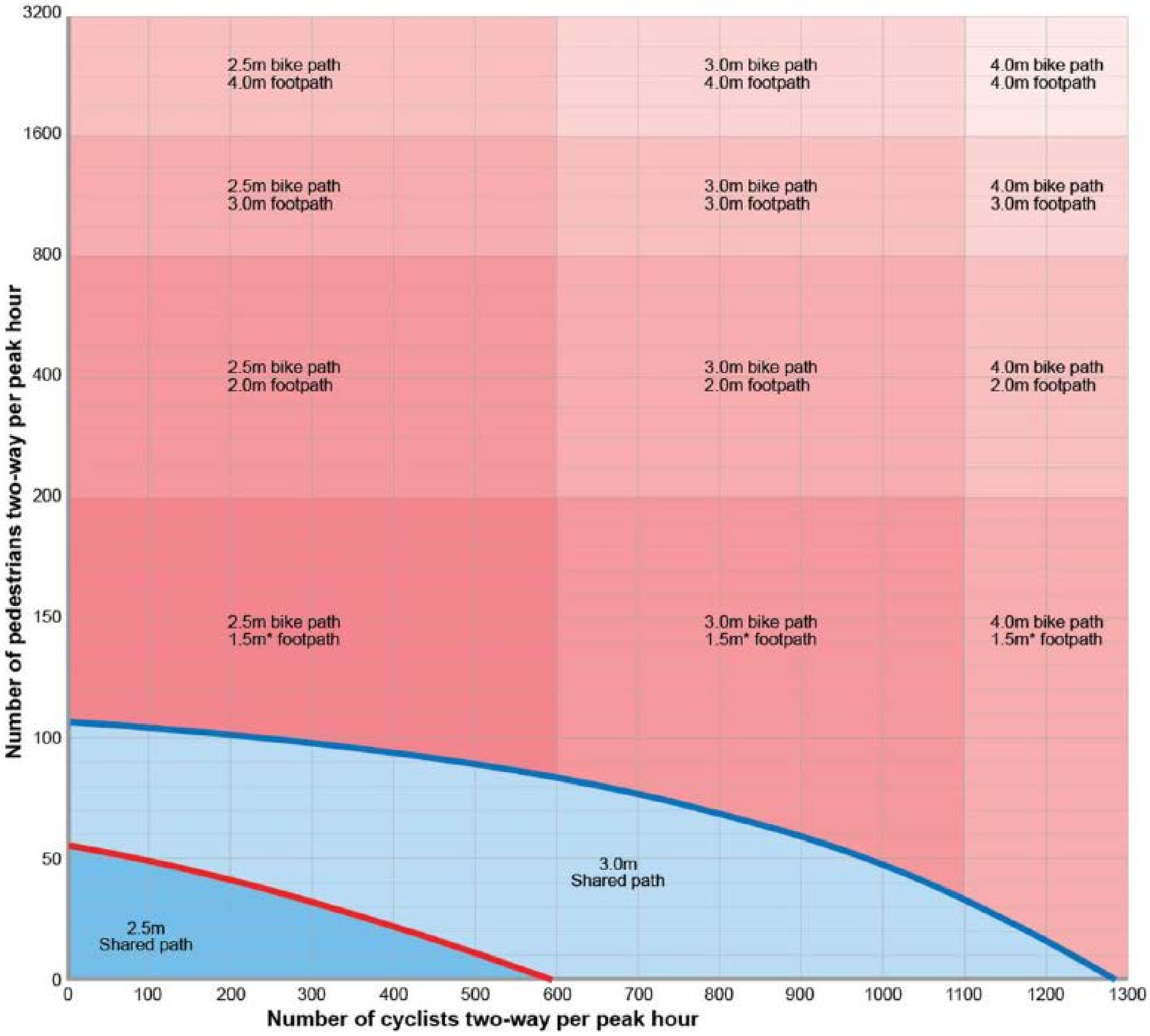
The chart is not to be used for pedestrian paths only.

A 50/50 directional split is typical for most recreational paths which have high use in both directions.

The directional split refers to the proportion of the total number of path users travelling in each direction, e.g. a 50/50 directional split means that 50% of the total volume of path users travel in each direction.

Source: Queensland Department of Transport and Main Roads (2015a).

Figure 7.3: Path widths for a 75/25 directional split



** Indicates that the 1.5 m footpath width is the low use minimum only and is not appropriate at higher pedestrian volumes.*

Notes:

This chart is not to be used for pedestrian paths only.

A 75/25 directional split (i.e. there is a greater volume of path users in one direction) is typical for most commuter paths which have high peak directional volumes.

The directional split refers to the proportion of the total number of path users travelling in each direction, e.g. a 75/25 directional split means that 75% of the total volume of path users travel in one direction and 25% travel in the opposite direction.

Source: Queensland Department of Transport and Main Roads (2015a).

AGRD 06A
S 5.1.4

Shared paths

Alternatively, where there is an emphasis on the capacity of the shared path, it is suggested that the path widths shown in Figure 7.2 and Figure 7.3 can be used.

Table 7.6 shows desirable widths and acceptable ranges of width for shared use paths. As for bicycle paths, the upper limit of the acceptable range in the table should not discourage designers from providing a greater width where it is needed (e.g. very high demand that may also result in overtaking in both directions).

Alternatively, where there is an emphasis on the capacity of the shared path, it is suggested that the path widths shown in Figure 7.2 and Figure 7.3 can be used.

Table 7.6: Shared path widths

	Path width (m)		
	Local access path	Regional path [3]	Recreational path
Desirable minimum width	2.5	3	3.5
Minimum width – typical maximum	2.5[1]–3[2]	2.5[1]–4[2]	3[1]–4[2]

1 *A lesser width should only to be adopted where cyclist volumes and operational speeds will remain low.*
2 *A greater width may be required where the numbers of cyclists and pedestrians are very high or there is a high probability of conflict between users (e.g. people walking dogs, roller bladers and skaters etc.).*
3 *May be part of a principal bicycle network in some jurisdictions.*

Source: Austroads (2017c) Table 5.3.

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Separated paths

Table 7.7 and Table 7.8 show desirable widths and acceptable ranges of width for two-way and one-way separated paths respectively. However, where it is appropriate (e.g. high traffic demand) designers may provide a greater width than the typical maximum shown in the tables.

Table 7.7: Separated two-way path widths

	Path width (m)		
	Bicycle path	Footpath	Total
Desirable minimum width	2.5	2	4.5
Minimum width – typical maximum	2–3	≥ 1.5	≥ 4.5

Source: Austroads (2017c) Table 5.4.

Table 7.8: Separated one-way path widths

	Path width (m)		
	Bicycle path	Footpath	Total
Desirable minimum width	1.5	1.5	3
Minimum width – typical maximum	1.2–2	≥ 1.2	≥ 3.4

A minimum width of 2 m is required where passing within the cyclists' path section occurs or where it is desirable that passing manoeuvres by cyclists occur outside of the pedestrian path section of the facility.

Source: Austroads (2017c) Table 5.5.

7.5.5 Vertical Alignment

AGRD 06A S 5.4

As a general principle longitudinal gradients on paths for cycling should be as flat as possible. The potential hazard for cyclists due to high speeds on steep downgrades is as important as the difficulty of riding up the grade when determining maximum gradients on two-way paths. (Section 5.4, AGRD06A (Austroads 2017c)).

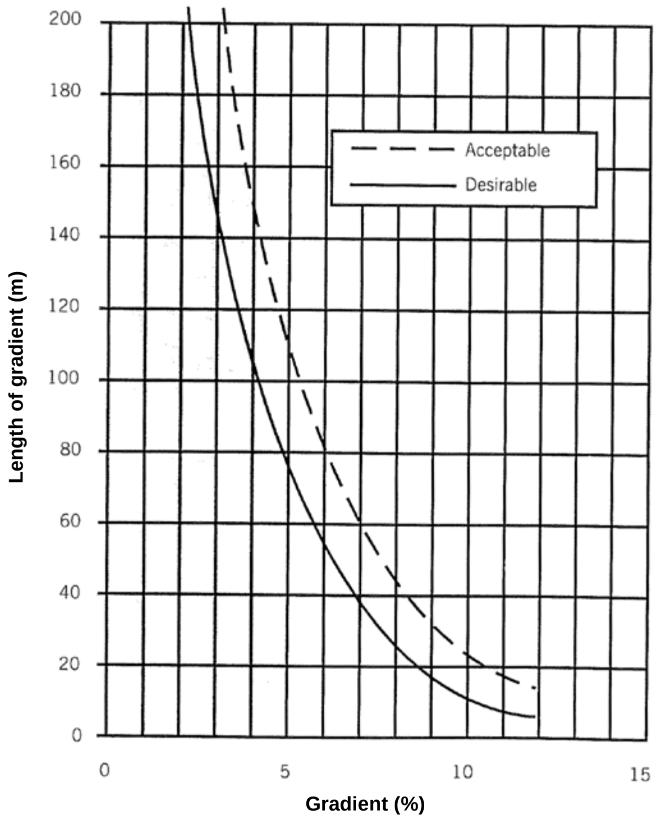
Ease of uphill travel

Steep grades must not be combined with sharp horizontal curvature (i.e. curves < 20 m radius). Figure 7.4 shows the maximum lengths of uphill gradient acceptable to cyclists. The figure is based on a review of the ease of uphill travel (Andrew O'Brien & Associates (1996), as cited in AGRD06A).

In using the figure designers should understand that:

- Above 3% the acceptable length reduces rapidly and it is considered this is the desirable maximum gradient for use on paths. However, in practice there are cases where it is not feasible to achieve a 3% maximum and the designer has no choice but to adopt a steeper gradient.
- In cases where 3% cannot be achieved consideration should be given to limiting gradient to a maximum of about 5% and providing short flatter sections (say 20 m long) at regular intervals to give cyclists travelling both uphill and downhill some relief from the gradient.

Figure 7.4: Desirable uphill gradients for ease of cycling



Notes:

Gradients and the associated length would normally be based on the distance between the tangent points for an isolated steep section. However, where there are consecutive grades of varying steepness (all uphill) or large radius vertical curves, these should be calculated based on the intersection points of the respective vertical curves.

In general, the 'acceptable' line in the figure would be satisfactory for paths with a high proportion of regular or physically fit cyclists, which in most instances would include commuter and sporting cyclists. Otherwise, the 'desirable' line in the figure is recommended.

Source: Based on a review by Andrew O'Brien & Associates (1996).

Safety and downhill travel on paths

Gradients steeper than 5% should not be provided unless it is unavoidable. It is most important that sharp horizontal curves or fixed objects do not exist near the bottom of hills, particularly where the approach gradient is steep (greater than 5%) and relatively straight. If a curve must be provided at the bottom of a steep grade then consideration should be given to providing additional path width, and a clear escape route or recovery area adjacent to the outside of the curve.

Many cases where gradients are in excess of 5% occur on the approaches to grade-separated facilities (e.g. underpasses) and in these situations the provision of widened paths or clear escape routes is not practicable. In these cases adequate sight distance should be provided together with appropriate delineation and warning signs.

There may be existing bicycle facilities that have gradients which require riding skills beyond inexperienced and young cyclists when they are riding down the grade. As a guide, a gradient greater than 10% over 50 m with horizontal curves or a gradient of 12% over 50 m on a straight path should be avoided.

Universal access

In some situations, the topography of the road or area where a path is to be located, may not allow path grades to meet the requirements of AS/NZS 1428.1-2009 to provide universal access. In these cases, the designer should, in Australia, refer to the Australian Human Rights Commission's *Advisory note on streetscape, public outdoor areas, fixtures, fittings and* furniture (Australian Human Rights Commission 2013).

7.5.6 Crossfall and Drainage Considerations

Crossfall

AGRD 06A
S 5.6

Water ponding on paths has a significant impact on the level of service provided to cyclists as spray leads to grit on both bicycle and rider. On straight sections crowning of the pavement is preferable as it results in less accumulation of debris. On sealed surfaces a crossfall of 2–4% should be adequate to effectively dispose of surface water whereas unsealed surfaces may require 5% to prevent puddles of water from developing.

Where paths are for shared use, the needs of other path users (e.g. impaired pedestrians) should be considered. In particular, AS/NZS 1428.4.1-2009 specifies that a path crossfall should not exceed 2.5% (1 in 40) to cater for people who have a disability.

Drainage

AGRD 05A
S 5.6.2

Paths for cycling should be constructed so that water does not pond on the surface and debris does not wash onto the path during heavy rain. The path should therefore have adequate crossfall and catch drains to collect water and prevent water and litter from flowing onto the path. Typical path cross-sections are illustrated in Figure 5.15 of AGRD06A (Austroads 2017c).

Major commuting and recreational paths should be designed for an equivalent flood immunity as that adopted for local roads unless suitable alternative routes can be easily accessed from the path. Major recreational paths that follow watercourses will have to satisfy the requirements of the responsible authority. In addition, for safety of path users, the water flow depth and velocity need to be assessed, refer to *Australian rainfall and runoff: revision project 10: appropriate safety criteria for people: stage 1 report*, (Engineers Australia 2010).

Cyclists have particular requirements with respect to drainage infrastructure. The following should be taken into consideration:

- Grated gully covers should be cyclist friendly (i.e. transverse bars, or other identified safe styles) for all locations other than where cyclist traffic is specifically prohibited such as freeways.
- Inlet pits within shoulders frequented by cyclists should not contain abrupt depressions of more than 10 mm. This has particular relevance to resurfacing works where inlet covers should be lifted to match the raised road surface levels.
- Side entry inlet covers should not protrude into abutting cycle paths.
- The channel components of kerb and channel should not be included as part of a defined cycle lane as the change in grade between the road crossfall and that of the channel can be destabilising for cyclists.

- Metallic covers on grated inlets pose a slip hazard when wet and they should not be placed within turn radii where cyclists or motorcyclists would reasonably be expected to travel.
- Pit lids should be designed to ensure the safety of cyclists. It is therefore important that pit lids are designed so that they do not constitute a hazard by trapping bicycle wheels (due to design of grates or their surrounds).

Guidance on crossfall and drainage for paths is provided in Section 5.6 of AGRD06A (Austroads 2017c). For further guidance on drainage matters, refer to the Austroads *Guide to Road Design Part 5: Drainage: General and Hydrology Considerations* (AGRD05, (Austroads 2013d)) and the Austroads *Guide to Road Design Part 5A: Drainage: Road Surface, Network, Basin and Subsurface* (AGRD05A, (Austroads 2013e)).

7.5.7 Clearances, Batters and Fences

AGRD 06A
S 5.5

Clearances

It is important for safer operation that adequate clearance is provided between bicycle operating spaces for cyclists traveling in opposite directions and between the cyclist operating spaces and potential hazards beside paths (e.g. fixed objects, vertical drops, steep batters).

The clearance between cyclist operating spaces varies according to the type of use and operating speeds as follows:

- On paths designed for commuting and major recreational activity a minimum lateral clearance of 1 m is required between opposing bicycle operating spaces because of the high relative speed which exists when cyclists approach one another from opposite directions at speeds of 30 km/h or more (i.e. closing speed of 60 km/h).
- On recreational paths where the speeds of cyclists are not likely to exceed 20 km/h a minimum lateral clearance of 0.4 m is necessary between opposing bicycle operating spaces.

The following guidelines should be applied for clearances between the cyclist operating spaces and potential hazards beside paths:

- Where both the areas beside the path and the path alignment are relatively flat a lateral clearance of at least 1 m (0.5 m absolute minimum) should be provided between the edge of any path for cycling and any obstacle, which if struck may result in cyclists losing control or being injured. However, on high-speed paths it is most desirable to have a clearance considerably greater than 1 m.
- Where it is considered that a hazard beside the path has attributes that could cause serious injury to cyclists (e.g. sharp surfaces such as the rear side of the posts and rails of steel W-beam road safety barrier), designers should assess the risk of cyclists losing control on the particular section of path, and consider either increasing the lateral clearance or shielding cyclists from the hazard. Depending on the situation a rub rail behind the posts or a cyclist fence near the edge of the path could be provided.
- Where a vertical drop or a steep batter exists or must be provided adjacent to the path the guidance under Batters and fences (below) should be applied.

AGRD 06B S 4.1.6

Batters and fences

The installation of a fence at the side of a path used by cyclists is desirable where:

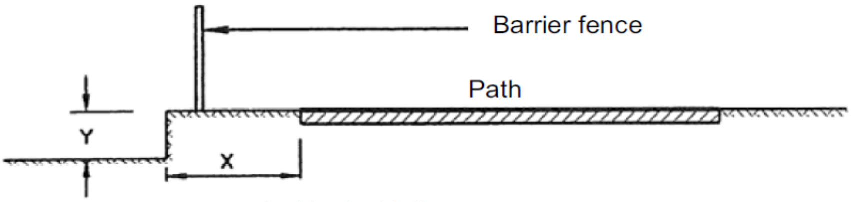
- there is a steep batter or large vertical drop located in close proximity to the path
- the path is adjacent to an arterial road and it is necessary to restrict cyclist access to the road
- a bridge or culvert exists on a path
- a hazard exists adjacent to a particular bicycle facility
- cyclists are likely to be ‘blazing a separate trail’ at an intersection between paths or around a path terminal.

The following types of fence should not be used in close proximity to bicycle lanes or paths. They should be located at least 1 m from the edge of bicycle facilities and preferably should be much further away:

- Treated pine log – these are often constructed with exposed ends and are invariably too low to be used adjacent to bicycle routes.
- Chain mesh – these may catch pedals, have exposed elements (e.g. bolts and nuts, loose wire) and in some instances have been responsible for spearing injuries.
- Post and wire – these have exposed elements.
- Irrespective of the type of fence used, the main requirement is that adequate clearance is provided between the edge of the path and the fence. Examples of cyclist fences on shared paths are shown in Section 4.1.6 of the Austroads *Guide to Road Design Part 6B: Roadside Environment* (AGRD06B, (Austroads 2015c)).

Figure 7.5 provides recommendations for the provision of a fence on a path in close proximity to a steep batter or vertical drop. Further guidance on clearances, batters and fences is provided in Section 5.5 of AGRD06A (Austroads 2017c).

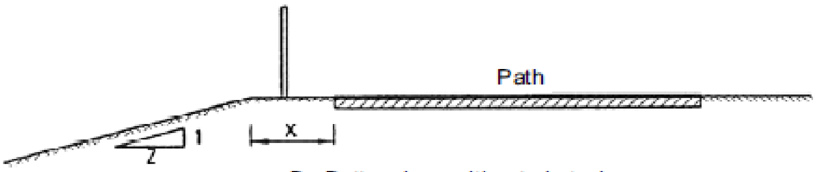
Figure 7.5: Requirement for fence barriers at batters and vertical drops



A. Vertical fall

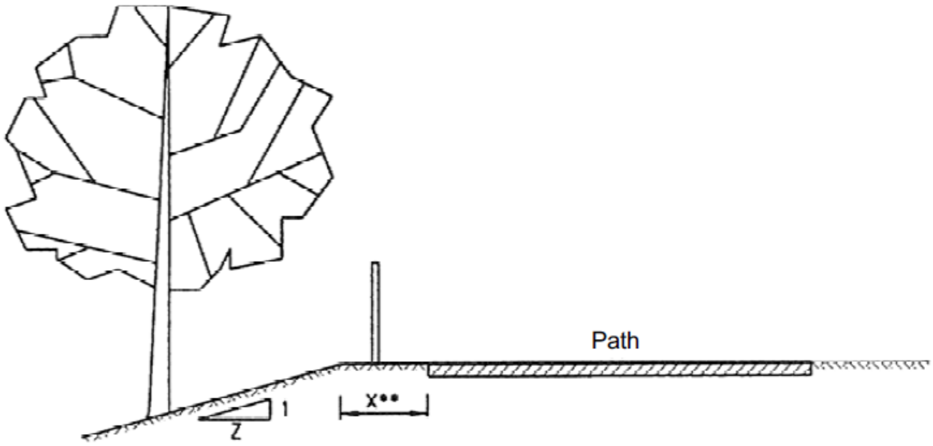
	X (metres)	Y (metres)
Fence not required*	<2	<0.25
Partial barrier fence required	<5	0.25 to 2
Full barrier fence required	<5	>2

* Batter off the surface where fall is within 1 m of path.



B. Batter slope without obstacles

	X (metres)	Z (metres)
Fence not required	<1 1 to 5	>8 >3
Partial barrier fence required	<5	1 to 3
Full barrier fence required	<5	<1



C. Batter slope with obstacles

	X (metres)	Z (metres)
Fence not required	<1 1 to 5	>8 >4
Partial barrier fence required	<5	3 to 4
Full barrier fence required	<5	<3

** Barrier fence required if obstacle within 1 m of path.

7.5.8 Sight Distance

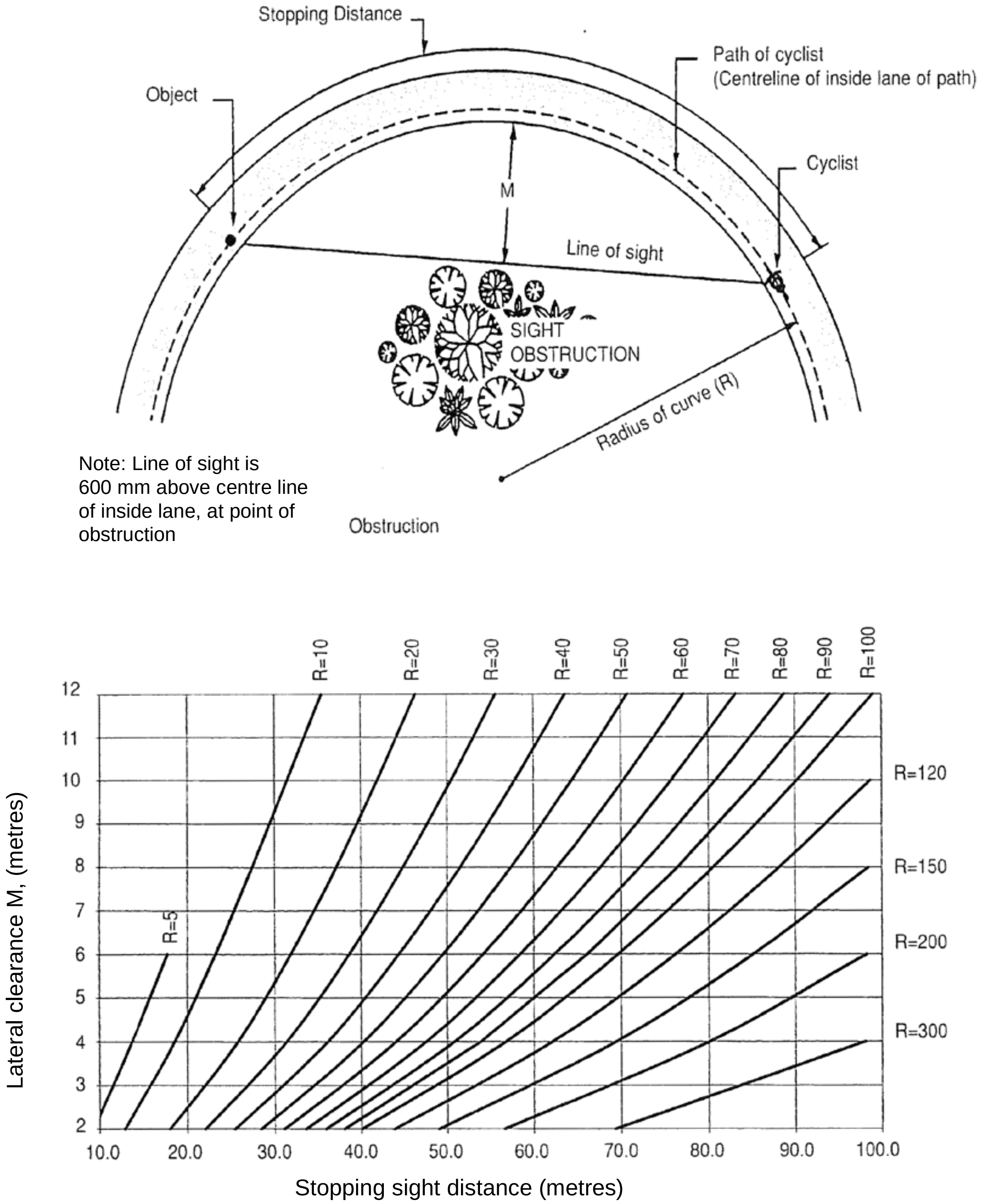
AGRD 06A S 5.7

Guidance on sight distance requirements is contained in Section 5.7 of AGRD06A (Austroads 2017c). For safer travel cyclists must be able to see across the inside of horizontal curves, under overhead obstructions in sag curves (e.g. where a path passes under a road) and over a vertical crest curve a sufficient distance to enable them to stop or take evasive action if necessary in order to avoid another cyclist, a pedestrian or an obstacle in their path.

Path sight distances can be drastically reduced by the growth of vegetation and hence the location and maintenance of vegetation are critical to safer path operation. Figure 7.6 illustrates the relationship between stopping sight distance, radius of the curve and the lateral clearance to significant visibility obstructions such as extensive vegetation or an earth embankment. Isolated features including trees do not necessarily constitute a significant obstruction if cyclists can see most of the curve beyond them.

It is essential that all two-way bicycle paths should be designed to provide a sight distance between opposing cyclists (i.e. as shown across a horizontal curve in Figure 7.6) at least equivalent to twice the design stopping sight distance determined using equation 1 in AGRD06A to ensure that cyclists who are overtaking can avoid a head-on collision.

Figure 7.6: Lateral clearances on horizontal curves



A vertical curve should join all changes of grade. Crest vertical curves must be of sufficient length to give the cyclist the stopping sight distance (Section 5.7, AGRD06A (Austroads 2017c)). Where practicable, sag curves should be the same length as equivalent crest curves to ensure comfort and an aesthetically pleasing path alignment.

The minimum length of vertical curves for various changes of gradient and design speeds can be determined from Equation 2 in AGRD06A.

7.6 Path Crossings of Roads

7.6.1 General

AGTM 05 S 3.4

This section discusses cyclist crossing treatments of roads for situations where cyclists either have to yield to motor vehicles or have priority over motor vehicles.

One or more of the following facilities can assist cyclists in crossing roads:

- grade separation
- a signalised crossing with bicycle detection and lights
- median refuge
- road narrowing of excessively wide roads whilst also providing for cyclist needs along the road
- on-road lanes or off-road path connections to nearby traffic signals, to be supplemented with bicycle detection and lanterns
- a crossing that gives priority for cyclists in accordance with road rules.

7.6.2 Grade Separated Bicycle Path Crossing

General

AGTM 06 S 8.2.1

Grade separated crossings such as bicycle bridges, underpasses and overpasses may be provided to achieve a safer crossing of roads, rivers or railways. General guidance on the use of grade separations for use by pedestrians and cyclists is provided in Table 7.9.

Table 7.9: Benefits of treatments – grade separated facilities

Objectives and priority	Application	Treatment	Benefits and considerations[1]
To increase the safety of pedestrians and cyclists by eliminating physical conflict between them, and motorised traffic Removes priority considerations	Applicable at locations with: • high posted speed • high-volumes of motorised and crossing traffic • multiple lanes • cycle path continuity	Overpass, underpass	• May require high capital cost • Grade difference of an overpass is less preferred for impaired and aged persons, and cyclists • Underpass has problems with security, lighting and vandalism • Infrequent location may not cover desire lines causing increased journey distance, fencing may be required

1 *See Section 5 of AGTM08 (Austroads 2016c), AGRD04 (Austroads 2017a), AS 1742.9, AS 1742.10-2009, Land Transport New Zealand (2007) and NZ Transport Agency (2008).*

Source: Austroads (2013c) Table 8.3.

Although often provided as part of a shared path network grade separations may be provided as a safer alternative adjacent to narrow road bridges or through the fill behind a bridge abutment. In difficult terrain a structure may be used to continue a shared path along the bank of a river.

Culverts

AGRD 06A S 8.3

When using culverts as part of a path network, the following principles in the design and operation of the culvert and the approaches should be applied (based on de Groot 2007):

- Culvert length – keep the length of the culvert as short as possible to minimise the distance a path user is in the closed space.
- Visible entry – approaching path users are able to observe the path enters a culvert well before entering the culvert.

- Vegetation – at the entry and exit, vegetation is managed to ensure that it does not create any hiding places.
- Approach embankments – are not too steep, e.g. 1:1 embankment slope, to reduce the perception of being closed in, also assists with casual surveillance of the section of path.
- Culvert dimensions – a height to width ratio of 1:1.5 is preferable to reduce the perception of entering a narrow space.
- Drainage – the floor of the culvert drains quickly and is shaped to reduce the build-up of debris.
- Maintenance – the culvert size facilitates the maintenance operations to enable the culvert to be readily cleaned.

These principles also support crime prevention through environmental design principles, which assist in creating comfortable spaces for people to use.

Culverts for multi-use will require a clear distinction between wet and dry passageways. For cyclist movement the culverts should be designed for dry passage under a particular average recurrence interval (ARI) event. Typically, the pedestrian and cyclist path should be elevated above the water level for a chosen design storm, and in some cases may be protected by a flood wall to reduce the annual time of closure of the path. The size requirements for passage, as well as hydraulic requirements need to be considered and the culvert sized appropriately to meet both these requirements.

Use of existing culverts

The desirable vertical clearance within an underpass is 2.5 m. However, this height is problematic in that a standard height of 2.4 m has been used in many existing drainage culverts constructed with crown units and is adequate. In relation to severely constrained sites, culverts with a vertical clearance of only 2 m have been successfully utilised to accommodate paths for cycling under roads and this is considered to be acceptable when utilising existing structures.

The relative advantages and disadvantages of using a culvert with limited clearance rather than an at-grade crossing should be evaluated. If it is decided to use a culvert of limited height, signs should be installed to warn cyclists of the reduced headroom. Other steps should also be considered including some form of external (to the culvert) roof transition (from a height of 2.5 m to the height of the culvert roof) to negate the chance of a cyclist colliding with the abrupt low roof face of a culvert. Where a square corner cannot be avoided on the culvert ceiling at the entrance to the culvert some form of cushioning should be provided on the headwall to minimise injury to cyclists who may impact their head against it.

A drainage culvert should not cater for cyclist/pedestrian use unless it satisfies the recommendations in Section 7.6.2 of the Austroads *Guide to Road Design Part 6: Road Design, Safety and Barriers* (AGRD06, (Austroads 2010a)) for drainage, whilst providing adequate vertical clearance. Appropriate warning signs should be installed advising of alternative crossing points for use during higher water flows. A connecting path between the recreational path and the road is always provided to facilitate access to the path and is generally suitable for use as a bypass during high water flows. It is essential that good sight distance is provided to the culvert entrances so that cyclists have adequate warning and can see any debris, silt, etc. that may have built up around and in the culvert during and after these conditions.

If an underpass is used the alignment of the path on the approach should be designed such that users can see through the culvert. Vandal-proof lighting should also be provided in underpasses for shared paths.

Underpasses of roads should be constructed with minimal cover between the top of the underpass and the road. Whilst this may necessitate the relocation of services it has the advantage that shorter approach ramps can be used requiring less overall space. Also better opportunities for the provision of adequate sight lines may be possible in order to enhance personal security.

The gradients on approach ramps to shared path overpasses and underpasses should be in accordance with the requirements of AS/NZS 1428.4.1-2009, which are summarised in Section 7.5.5. Where the facility is an exclusive bicycle path a steeper gradient is permissible in accordance with Figure 7.4.

On existing structures that incorporate right angle landings in the alignment of the approach ramps, or where adequate sight distance cannot be provided, warning signs advising cyclists and other users of the hazards should be installed.

7.6.3 Signalised Bicycle Path Crossing

AGRD 04 S 9.4

It is often necessary to integrate off-road bicycle facilities with other road user requirements at signalised intersections. The design should ensure that the movements of cyclists are managed and regulated to provide adequate interaction of cyclists with pedestrians and motor vehicles.

The facility to be integrated may be a shared path, an exclusive bicycle path, or a separated path. Where a shared path passes through an intersection cyclists are expected to share the marked foot crossing with pedestrians. Where a bicycle path or a separated path is to be accommodated the cyclists and pedestrians will usually be separated on the crossing.

Signalised bicycle path crossings are further discussed in Section 5.3.10 and Appendix C2 of the Austroads *Guide to Road Design Part 4: Intersections and Crossings* (AGRD04) (Austroads 2017a).

7.6.4 Unsignalised Bicycle Path Crossing

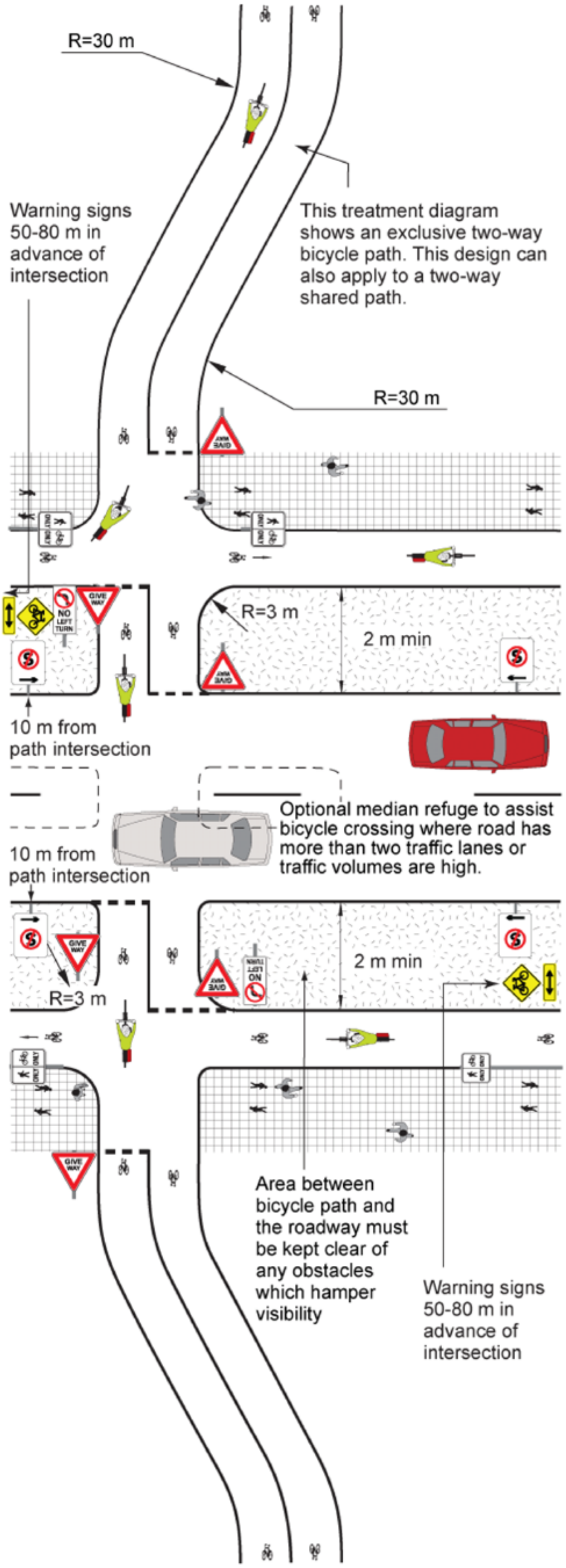
AGRD 04A Appendix C.1

Unsignalised crossings of two-lane two-way local streets or collector roads may require cyclists to give way to road traffic, and in low volume streets (< 3000 vpd) need not provide a refuge for cyclists in the middle of the road. In such situations the treatment provides for a straight crossing of the road using kerb ramps on both sides of the road with a suitable terminal treatment. A refuge in the centre of the road is desirable on busy roads (e.g. > 3000 vpd) so that cyclists can stage their crossing. Where important cycling routes intersect with low volume local roads it may be desirable for cyclists to have priority over motor traffic.

Median refuge

Figure 7.7 shows a treatment of a bicycle path where it intersects a low-volume street. This example includes separated paths in the verges of the street. Whilst separated paths are shown the treatment can be applied where footpaths or shared paths are provided within the street. Space is often not available to provide separated paths for pedestrians and cyclists within the verge of a road. However, the arrangement illustrates that it is particularly important to clearly define the priority that applies in order to reduce the likelihood of conflict between cyclists and pedestrians at the intersection between paths.

Figure 7.7: Bicycle path crossing of a two-way two-lane road and separated paths

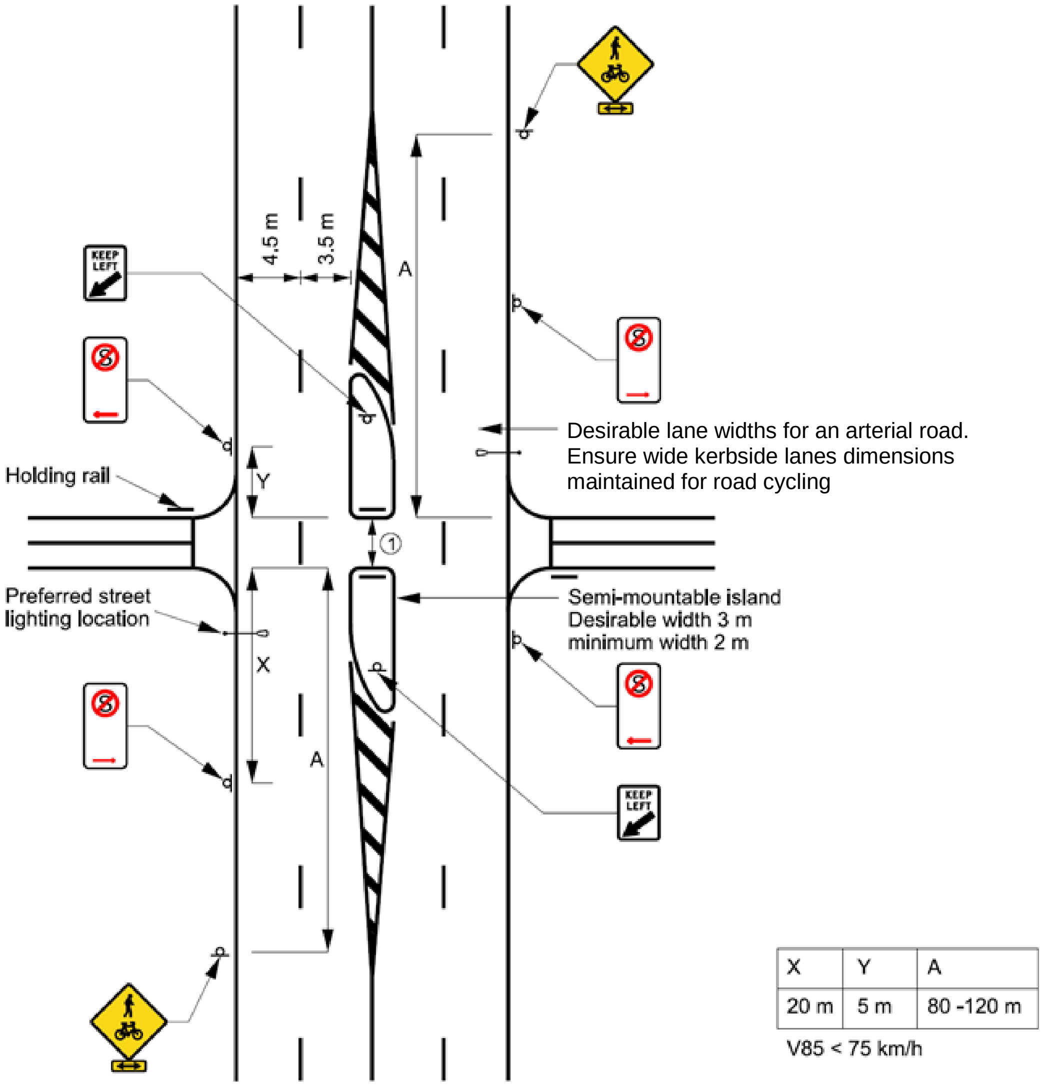


Source: Roads and Traffic Authority NSW (2005).

Refuges for path crossings away from intersections

Where an off-road path crosses a busy local street or an arterial road away from an intersection it may be necessary to provide facilities to aid cyclists to make a safer crossing. These facilities may be in the form of controlled crossings as discussed previously, or physical refuges. Physical refuges in the centre of the road are recommended to enable a staged crossing where volumes are greater than 3000 vpd. A typical refuge is shown in Figure 7.8 for a path crossing a two-way, four-lane road. Separate areas may be provided within the refuge for cyclists and pedestrians if sufficient space can be made available. Whilst the figure shows a shared path the treatment can be used for bicycle crossings.

Figure 7.8: Example of a cyclist and pedestrian refuge at a mid-block location



1 *Where required, tactile ground surface indicators should be provided on paths and ramps in accordance with AS/NZS 1428.4.1-2009 and jurisdictional guidelines.*

Source: Based on AS 1742.10-2009.

In order to accommodate a bicycle which is typically 1.75 m long, it is desirable that a refuge be at least 2 m wide. However, 1.8 m may suffice in tight situations. Where there are concentrated cyclist demands at certain periods of the day (e.g. secondary schools) a wider and longer storage area may be required within the refuge to provide additional space and separate areas for cyclists and pedestrians.

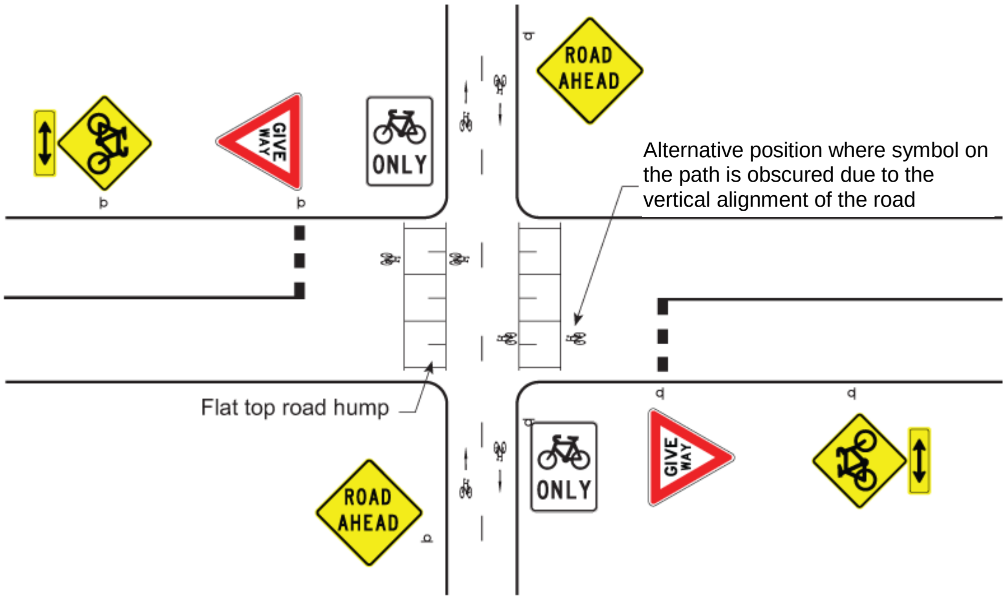
Refuges can be furnished with a holding rail to allow a stationary cyclist to remain mounted within the refuge area. Rails should be located clear of the gap although where the gap is wide (i.e. greater than 2 m) the rails can be located within the gap, on the left-hand side. Refuges should also be provided with adequate street lighting to enhance visibility of the island and cyclists using it at night.

Cyclist priority treatment at bicycle path crossings of low-volume streets

The occurrence of low-volume local streets frequently intersecting with paths that have a significant network role can result in a poor level of service for commuter cyclists, or an inferior riding experience for recreational cyclists.

Many local authorities invest considerable resources into local area traffic management schemes and into bicycle and pedestrian path networks. An opportunity often exists to improve the continuity of paths for cyclists and pedestrians while simultaneously providing a 'device' to control speeds in local streets. The preferred treatment is a path crossing that is raised with appropriate give-way sign or stop sign controls installed to regulate road traffic. A suggested treatment for a bicycle path is shown in Figure 7.9.

Figure 7.9: Cyclist priority treatment for use at a low-volume street crossing



Note: Pavement marking on flat top hump to be in accordance with AS 1742 - 2009, Figure 3.7.

There are legislative constraints on the use of the treatment in several jurisdictions and therefore some care needs to be taken before implementation to ensure any proposed treatment would conform to relevant requirements.

This treatment is generally appropriate where:

- it conforms to the details in Figure 7.9
- the speed environment is below the general urban speed limit, or where a local area traffic management scheme is proposed that would achieve suitable crossing conditions
- it is located in urban areas
- good visibility at the crossing point exists for both road and path users
- it is located away from intersections of roads
- the priority that would be assigned to the road is consistent with that elsewhere along the road, in the vicinity of the crossing

- not more than two lanes of traffic exist (both directions)
- the proportion of commercial traffic is low
- a warrant for a higher form of road crossing is not satisfied, such as a pedestrian actuated signal crossing, which should then be used as an alternative (AS 1742.10-2009 or relevant state regulations)
- a higher form of road crossing is not merited, such as a pedestrian actuated signal crossing, which should then be used as an alternative (AS 1742.10-2009 or relevant jurisdictional regulations).

Path crossings of side roads

AGRD 04 S 9.3.3

Paths which run parallel to busy roads often have to cross side roads which may be minor or important traffic routes and the intersection may be signalised or unsignalised. These crossings are covered in Section 9.3.3 of AGRD04 (Austroads 2017a).

Where a bicycle path or shared path is provided in the verge of a road, cyclists using the path will often have to cross intersecting side streets. These side street crossings should be designed:

- to ensure that motorists are aware of the existence of the crossing and the priority that applies
- so that the location and design of the crossing, and the priority adopted, does not put motorists at risk when turning from the major road
- to encourage safer and correct use by cyclists.

Where the path is located on one side of a road, kerb ramps should be provided opposite every side street to enable access for local users.

7.6.5 Path Approach Design Criteria

AGRD 04 S 9.3.2

The key requirements for the intersection between a path in a road reservation and a side road (Section 9.3.2, AGRD04) are:

- approach sight distance should be provided for drivers approaching the intersection from the side road
- drivers turning from the major road into the side street should have clear sight lines to cyclists using the path in both directions
- the speeds of cyclists using the path should be controlled on the path approaches to the intersection.

Sharp downgrades on path approaches to road crossings should be avoided where possible. Where the path alignment is straight on the approach to a road then the path should be as flat as possible. It is desirable that the longitudinal downgrade should be limited to 3% and should not exceed 5%.

Paths for cycling should be aligned to intersect roads at approximately 90°. Where the approach sight distance for cyclists is restricted, appropriate warning signs should be provided or measures taken to reduce the approach speed of cyclists.

7.6.6 Types of Crossings of Local Access Roads

AGRD 04 S 9.6.3

There are three types of treatment available for the design of path crossings of local access roads where:

- the path approach is bent-out (i.e. is deviated away from the major road)
- the approach is straight
- a one-way bicycle path is deviated to become an on-road bicycle lane.

These crossings are also covered in Section 9.3.3 of AGRD04 (Austroads 2017a). The first two types of treatment may be applied to bicycle paths or separated paths.

For cases involving two-way paths the priority can be allocated to the path or to drivers on the side road. Give-way signs and holding lines should be used to clearly define priority and regulate the movement of cyclists and motorists.

Bent-out treatment

Where there is sufficient space in the road reservation bicycle paths or separated paths can be bent away from the parallel road at its intersection with the side road. The principal reason for bending-out is to allow storage space for vehicles turning into the side road. Therefore, bending-out is only necessary where it is desired to give path users priority.

Figure 7.10 shows a bent-out treatment on a bicycle path which allows storage space for vehicles entering and leaving the side road. The minimum distance between the path and the parallel road is 6 m to allow for a car length and clearance. The desirable minimum distance is 15 m which allows for a single-unit bus/truck and clearance.

It is essential that the area between the bicycle path and parallel road be kept clear of obstructions to visibility as motorists will otherwise lose sight of cyclists and cyclists may perceive the bending-out as a major detour and look for short cuts.

The treatment may be suitable where:

- few large, heavy vehicles (e.g. semi-trailers) use the side road
- volumes on the side road are low
- the speed limit on the major road and side road is ≤ 60 km/h.

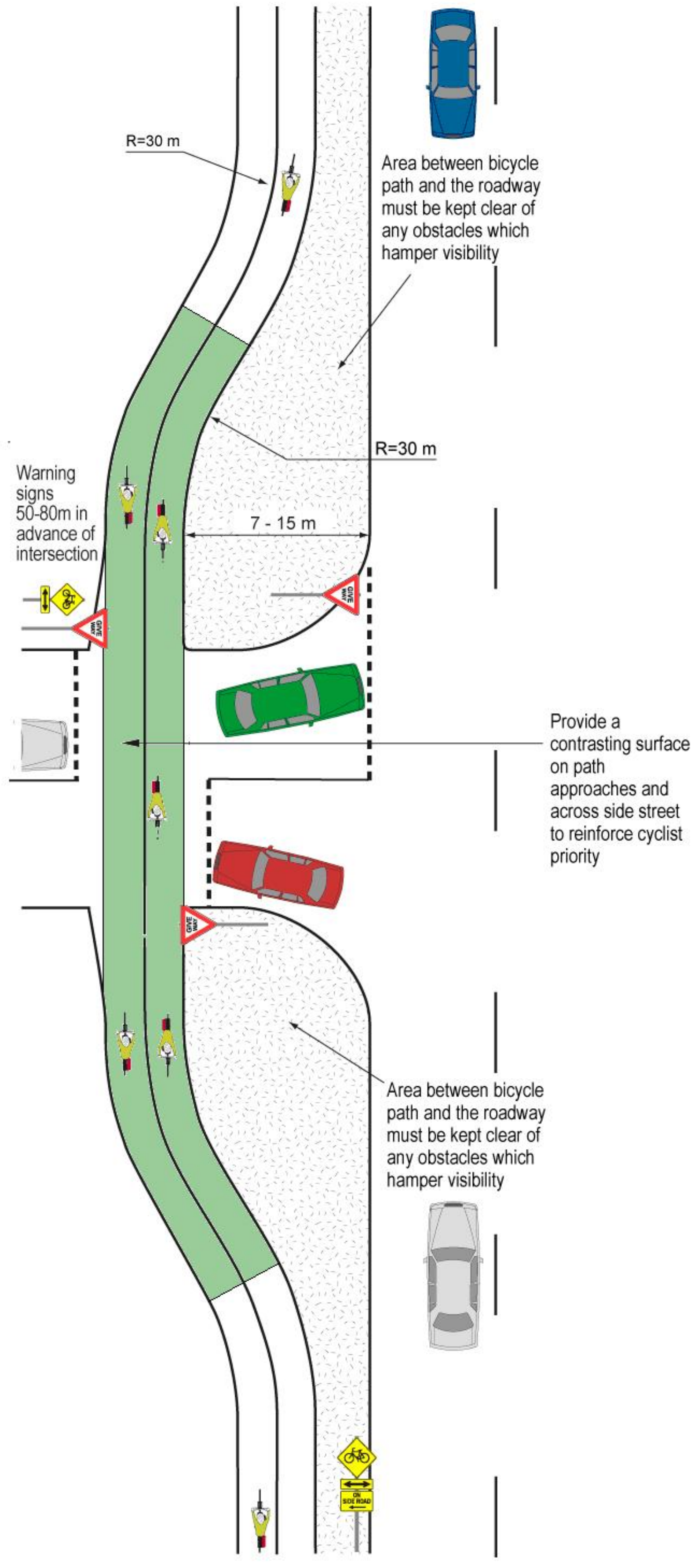
It is also desirable that:

- an auxiliary left-turn lane is provided on the major road to minimise the likelihood of turning vehicles queuing onto the major road
- the bicycle path or the bicycle section of a separated path is delineated by a contrasting surface across the side road
- where the treatment is applied to a separated path the pedestrian priority across the side road can be reinforced by installing a pedestrian crossing that complies with jurisdictional road rules and guidelines.

Bending-out should be achieved with smooth curves (e.g. 30 m) as the use of tight curves can introduce manoeuvres that require the cyclist’s attention at a point where their attention should be focused on the crossing and approaching vehicles.

In the past there has been a common misconception among practitioners that the purpose of bending-out is to reduce the speeds of approaching cyclists. Tight curves, rails and bollards should not be used as speed reduction devices at these locations and normal traffic management devices such as warning signs and regulatory signs should be used to control approach speeds and crossing priority.

Figure 7.10: Bicycle path crossing bent-out at side road



Source: Roads and Traffic Authority (2005).

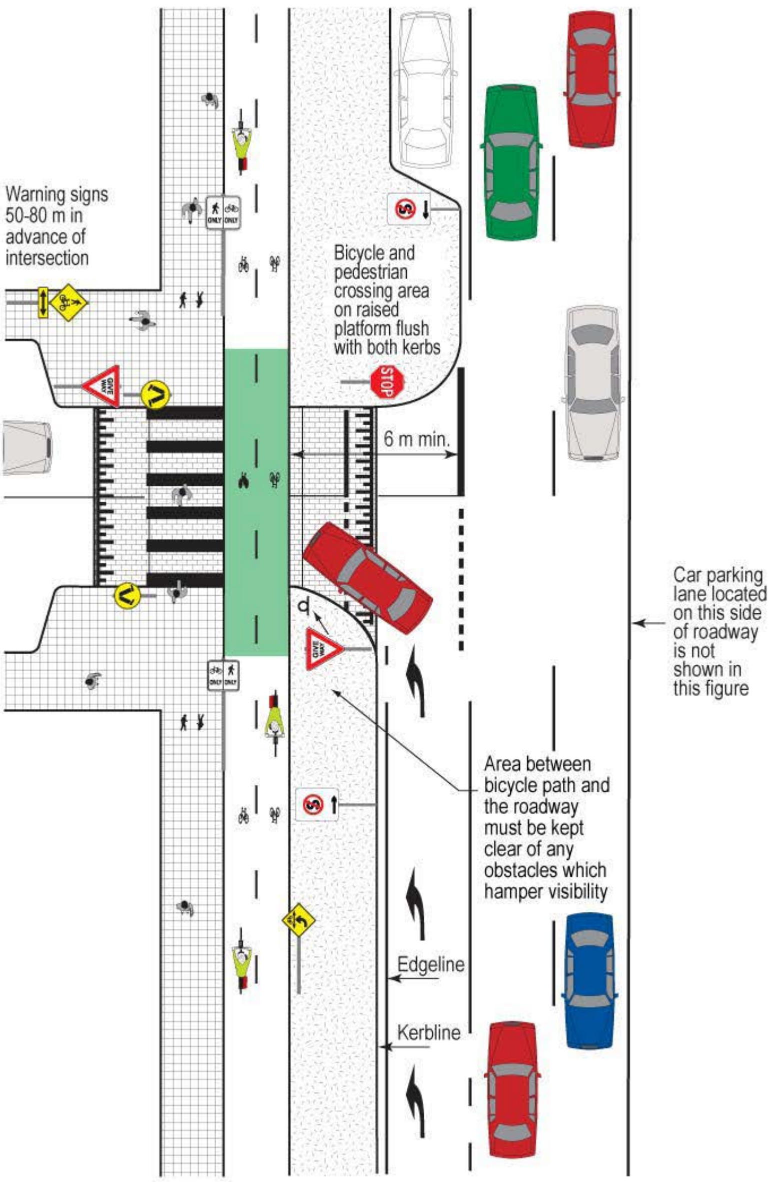
Straight crossings (not bent-out)

Figure 7.11 shows an option for a straight crossing on a separated two-way bicycle path. The treatment provides for both cyclists and pedestrians to have formal crossings of the side street controlled by pedestrian crossing signs and give-way signs respectively. To maintain better route continuity and rider comfort this treatment may be placed on a platform as shown in the figure.

The treatment is suitable where traffic volumes in side streets are low (e.g. residential streets). Where side streets have higher volumes a bent-in treatment may be appropriate. In instances where pedestrian and cyclist volumes are relatively low, priority will often be given to motor vehicles.

The main benefit of a straight crossing relatively close to the major road is that the path has a higher visibility for road users where space for a bent-out crossing is not available. It is important therefore that the path is placed close enough to the edge of the major road to maintain visibility although at least 6 m should be provided between the treatment and the major road in order to store a car clear of the crossing. This separation also enables a left-turn auxiliary lane to be provided.

Figure 7.11: Bicycle path crossing (not bent-out at side road)



Source: Roads and Traffic Authority (2005).

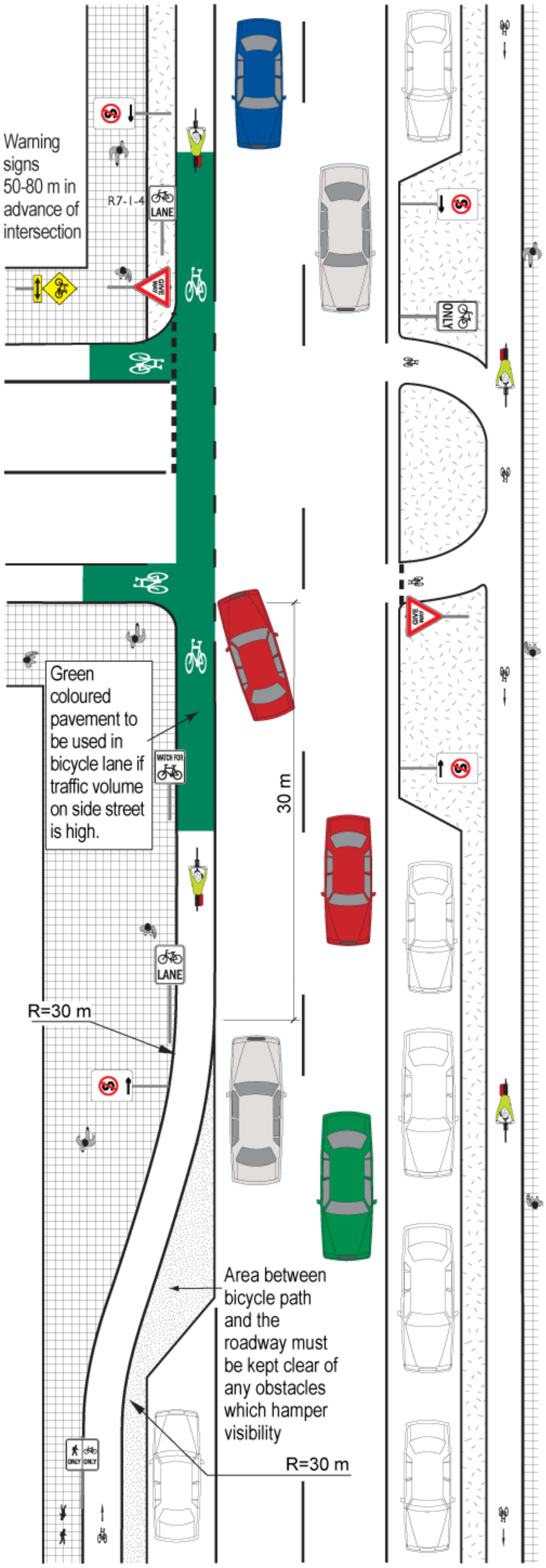
Bent-in treatment

This treatment provides for a one-way bicycle path to transition into an on-road bicycle lane, thereby enabling cyclists to have priority across the side street. It should not be used for two-way paths because of the head-on conflict that would arise between cyclists and motor vehicles. This treatment is shown in Figure 7.12.

The bent-in treatment has the advantage of providing greater visibility of cyclists for drivers at the intersection and should enable drivers to better anticipate the movement of cyclists. It also easily provides for cyclist priority at the intersection and for the transition from path to on-road lane to be physically protected. These treatments are suitable only for experienced cyclists who have the skill and maturity to safely enter and ride in traffic. They are not suitable for paths used by children riding to schools.

If a pedestrian crossing is provided in the side street it should be located at least a vehicle storage length from the side-street holding line.

Figure 7.12: One-way bicycle path crossing (bent-in side road)



Source: Roads and Traffic Authority (2005).

7.7 Intersections of Paths with Paths

7.7.1 Considerations

AGTM 06 S 8.3

Intersections between paths, bicycle paths or shared paths can be relatively basic but do require the same consideration of factors as those applied to road intersections. Some specific considerations are:

- appropriate sight distance, gradients, adjacent areas are clear of hazards
- speed control and priority allocation where volumes are elevated
- cross-intersections which allow high-speed conflicts should not be provided
- provision of holding rails where cyclists may have to stop at intersections with roadways.

Key conflict issues between pedestrians and cyclists on shared paths and footpaths are identified and described in the report *Pedestrian-cyclist conflict minimisation on shared paths and footpaths* (Austroads 2006b), and guidance on key conflict minimisation strategies and options are presented. Summary information on these conflicts is provided in AGRD06A (Austroads 2017c).

For further guidance on intersections of paths with paths, refer to Section 6 of AGRD06A and AS1742.9-2000.

7.7.2 Design of Intersections of Paths with Paths

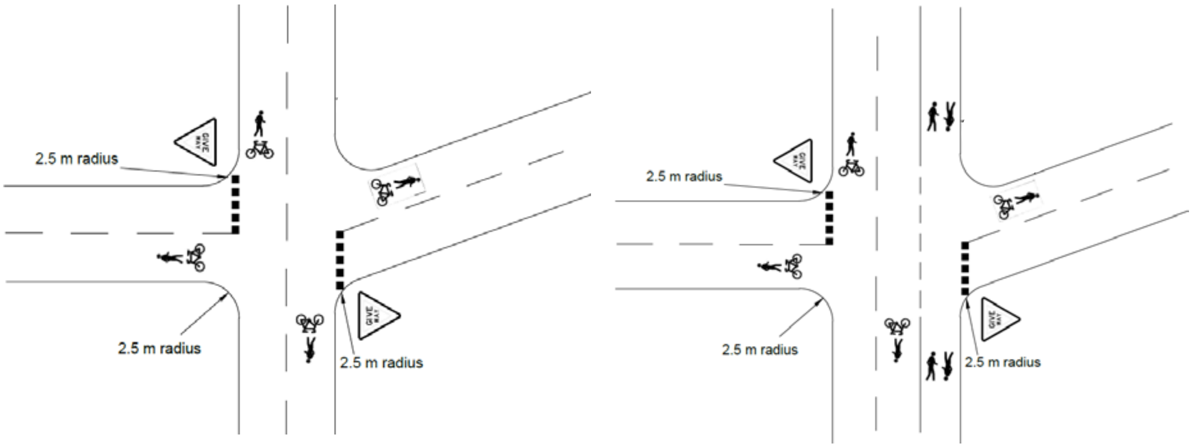
AGRD 06A S 6.4

According to AGRD06A factors that should be considered in relation to intersections where bicycles are permitted are that:

- Pavement markings should include centre lines and give-way holding lines.
- Pavement splays in the corners should have a minimum radius of 2.5 m. The path intersection should also assist a cyclist undertaking a turn on a radius of ≥ 5 m to maintain their upright position through the turn.
- T-junctions, at busy locations, should be widened to allow for through cyclists to pass a turning cyclist as the extra space reduces the number and intensity of conflicts. Where hold rails are used in the side path the width should cater for turning cyclist envelopes plus an additional lean allowance.
- The area around path intersections should be kept clear of hazardous obstacles, such as log barriers, to provide cyclists with a recovery zone. However, it should be noted that landscaping is useful in deterring cyclists who may attempt to travel the shortest path between path junctions or at sharp curves, which, if it occurs, inevitably results in maintenance problems. Any landscaping should be soft and of low height.
- Care should also be exercised in the location of intersections on paths adjacent to watercourses so that water holes and steep embankments do not present a hazard to cyclists. The treatment at the sides of paths should provide a forgiving environment in terms of cyclist safety.

The treatment at the intersections of shared paths, establishing priority is shown in Figure 7.13 and Figure 7.14.

Figure 7.13: Intersection of shared paths



(a) Shared path with a shared path (b) Shared path with a separated path

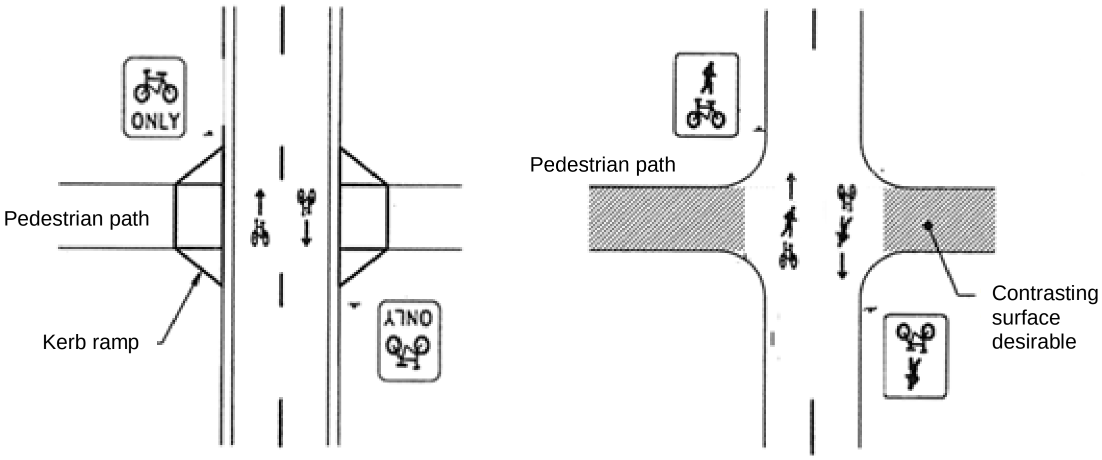
Note: Give way signs are optional and should only be used where there is a demonstrated need.

Figure 7.14: Example of a shared path intersection

Source: City of Adelaide (n.d.).

Figure 7.15 and Figure 7.16 show four arrangements where a bicycle path or shared path intersects with a pedestrian path and priority is reinforced through delineation and traffic control devices. Figure 7.15 illustrates cases where cyclists have priority and demonstrates how pedestrian ramps can be provided (Figure 7.15a) or a contrasting surface material (Figure 7.15b) on the pedestrian path can be used to provide an interface between the paths.

Figure 7.15: Intersection of bicycle path and pedestrian path where cyclists have priority

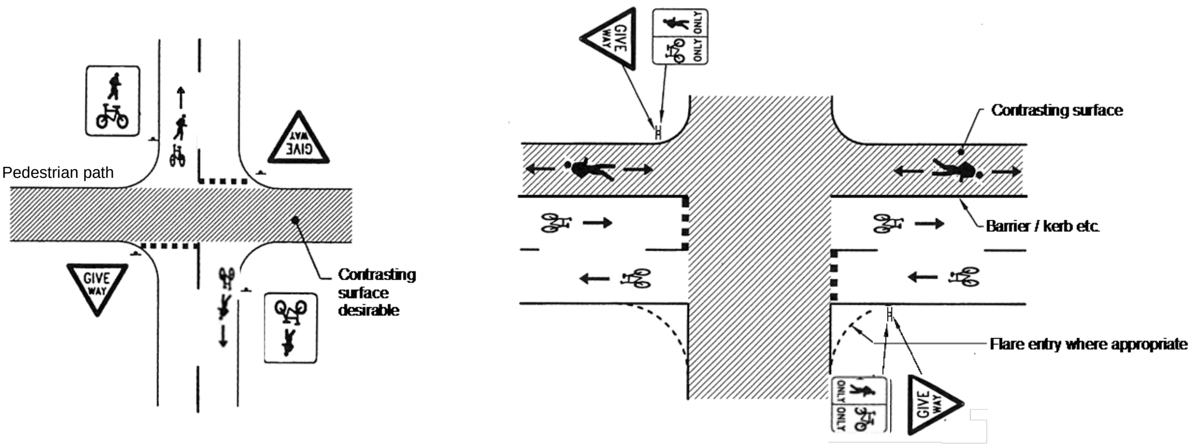


(a) Bicycle path and pedestrian path

(b) Shared path and pedestrian path

Figure 7.16 shows cases where pedestrians have priority at an intersection with a shared path (Figure 7.16a) and a separated path (Figure 7.16b) and shows the use of give-way signs to control cyclists and contrasting surfaces to emphasise that pedestrians have priority.

Figure 7.16: Intersection of a shared path and separated path where pedestrians have priority



(a) Shared path and pedestrian path

(b) Separated path and pedestrian path

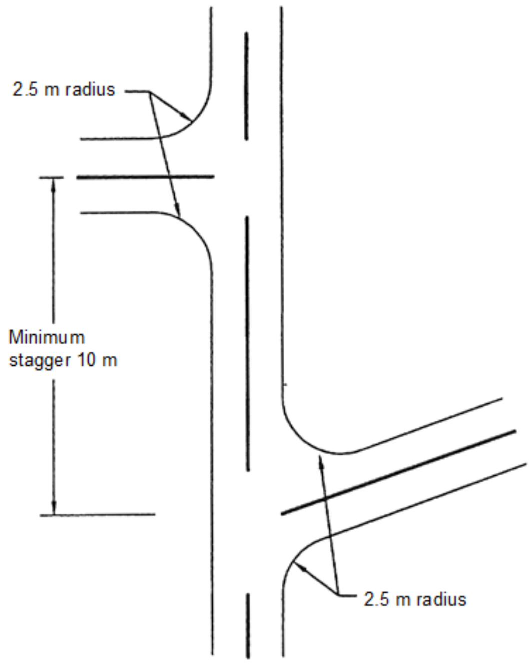
Note: Give way signs are optional and should only be used where there is a demonstrated need.

7.7.3 Special Treatments for Intersections of Paths with Paths

AGRD 06A S 6.5

At locations where there is a proven record of conflict or where there are other specific safety challenges such as short sight distances, the use of cross-intersections between intersecting bicycle paths or shared paths may not be appropriate. At these intersections, a staggered T arrangement should be adopted to prevent high crossing speeds as shown in Figure 7.17.

Figure 7.17: Example of a staggered T-intersection



Note: Consider provision of holding rails on side of paths where main path volumes are high.

7.8 Path Terminal Treatments

AGRD 06A S 7.5

A path terminal treatment may be required where a shared path or bicycle path intersects with a road, e.g. when a path crosses a road from a road reservation or parkland. Path terminal treatments are provided to restrict illegal access by drivers of motor vehicles to road reserves and parkland to prevent damage to path structures (such as lightweight bridges) that have been designed only for bicycle and pedestrian use. Guidance on the use and design of path terminal treatments is provided in Section 7.5 of AGRD06A (Austroads 2017c).

These devices can be hazardous to cyclists and they generally should not be installed unless:

- unauthorised motor vehicle access may result in damage to path structures
- there is clear evidence of unauthorised and undesirable motor vehicle access
- the device is effective at excluding such vehicles and not readily circumvented.

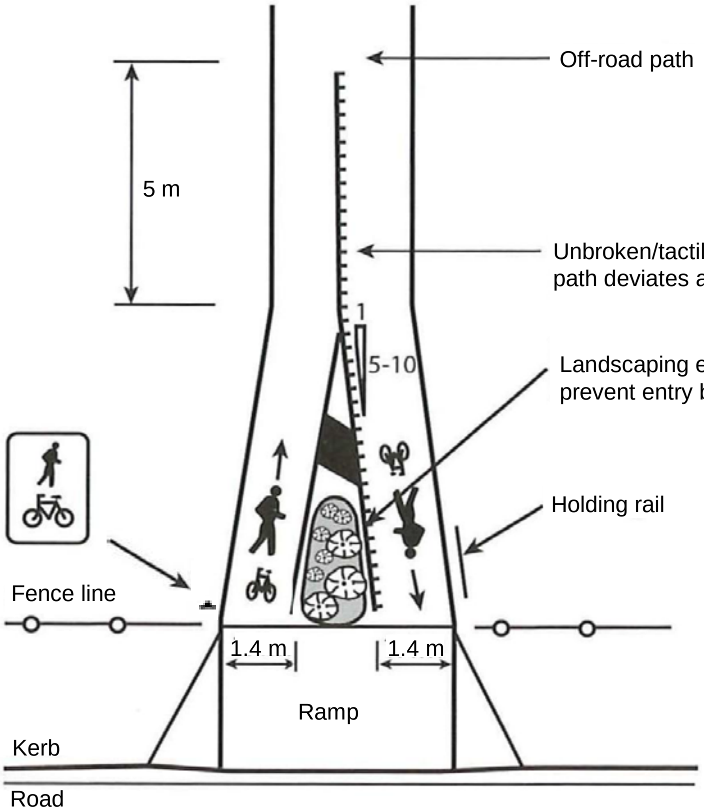
Where installed, terminal treatments should be designed and installed in such a way that they serve their intended purpose and do not cause an unacceptable hazard to cyclists. Cyclists must be able to:

- negotiate path entrances with ease
- concentrate on other traffic, pedestrians, pavements and ramps
- not be distracted by overly restrictive barriers.

It should be noted that not every jurisdiction permits the use of physical barriers to slow or advise cyclists of an approaching road. Physical barriers may be a hazard to other road users and any treatment should have a risk assessment undertaken.

The preferred terminal treatment to restrict access and warn cyclists to slow down is shown in Figure 7.18. This treatment is the bicycle path equivalent of providing a median island at a road intersection with similar benefits with respect to warning cyclists and channelising traffic movements. It provides sufficient guidance to cyclists that they are approaching a road and does not place an obstacle (such as a bollard) in the path of cyclists. AGRD06A (Austroads 2017c) provides examples and guidelines for the design of the treatments that include bollards or staggered fences (refer to Figure 7.19 and Figure 7.20).

Figure 7.18: Separate entry and exit terminal



Source: VicRoads (2005).

Figure 7.19: Example of a bollard treatment

Source: Roads and Traffic Authority (2005).

Figure 7.20: Example of a bollard treatment with lighting

Note: The light and fitting should be located outside of the clear height requirements, refer to Section 5.5.1 of Austroads (2017c).

Source: Queensland Department of Transport and Main Roads (n.d.).

7.9 Fences and Road Safety Barriers

7.9.1 Fences

AGRD 06A
S 5.5

The need for fences in relation to batters adjacent to paths and required clearances is summarised in Section 7.5.7 and discussed in Section 5.5 of AGRD06A (Austroads 2017c). A fence may be required to prevent errant cyclists from running off the path into a hazardous area adjacent to the path.

7.9.2 Road Safety Barriers

AGRD 06
S 6.5.2

Guidance on the use of road safety barrier systems for locations where there are pedestrians and cyclists is provided in AGRD06 (Austroads 2010a).

Cyclists and pedestrians may require a barrier to prevent them inadvertently running onto a traffic lane from an adjacent path. In cases where there is no need to protect path users from errant vehicles, or errant vehicles from roadside hazards, a fence of a suitable height for cyclists will be adequate.

Where there is a need to provide a safety barrier between a path and road traffic it is important that the rear of the safety barrier is not a hazard for pedestrians and cyclists. Designers should ensure that:

- adequate clearance is provided between the rear of the safety barrier and the path (refer to AGRD06A (Austroads 2017c))
- no sharp edges, burrs or other potential hazards (e.g. protruding bolts) exist
- where sufficient clearance cannot be provided, cyclists are protected from ‘snagging’ on posts by the provision of suitably designed rub rails or other appropriate means
- where sufficient clearance cannot be achieved, consideration is given to the need to increase the height of the barrier either to prevent errant cyclists from falling over the barrier and into a traffic lane or to discourage pedestrians from climbing over the barrier to cross the road at an unsafe location.

Designers should ensure that any extension to the height of a barrier would not be detrimental to its performance under vehicle impact or result in components being hazardous to motorists or path users in the event of a crash with the barrier (e.g. horizontal rails spearing vehicles).

Where sufficient space is available a frangible pedestrian fence may be installed behind the road safety barrier at a distance that would accommodate the likely deflection of the barrier under impact by an errant vehicle. Adequate clearance is also required between pedestrian fences and bicycle paths and shared paths. In situations where space is restricted, it may be necessary to consider provision of a higher rigid barrier.

Where pedestrian facilities are incorporated behind a road safety barrier system, the desirable minimum height of the barrier is 1200 mm above the surface of the footway. Where provision for cyclists is required, the desirable minimum height above the surface of the path should be 1400 mm.

Access through barriers

Preferred practice is to avoid providing breaks in a safety barrier. However, it may be necessary to consider breaks at locations such as intersections, points of access to property, sites where pedestrians cross the road, and access points in medians. Where breaks are necessary safe end treatments must be provided.

Bridges and overpasses

AS (/NZ) 5100: 2017 Series provides information on barriers for bicycle and pedestrian bridges and for some design elements for bicycle/pedestrian paths as they relate to bridges.

Temporary barriers and roadworks

During roadwork activities, consideration needs to be given to providing bicycle and/or pedestrian access through the works. Other times where provision of temporary barriers may be required include during special events where there is a need to control vehicle and pedestrian movements.

7.10 Lighting

AGRD 06B
S 4.2.8

Effective lighting is an important influence on travel on paths for cycling after sunset. As lighting involves significant capital and operating costs, its provision needs to be carefully considered. While many bicycles may be equipped with modern lighting, it is generally inadequate to illuminate the pavement so that cyclists, travelling at a 'reasonable' speed, are able to avoid potholes and other hazards.

The provision of lighting does not remove the need for providing a separation (centre) line.

The provision of lighting on paths for cycling depends on the nature of the facility and its expected use at night. In general, lighting of bicycle facilities may be categorised as follows:

- Paths for cycling associated with promenades or some other centre of night-time activity. These are typically by the seaside, a river bank or in a city centre where a high standard of lighting is desirable to create an attractive environment.
- Paths for cycling used predominantly for commuting by workers or students. Because it becomes dark relatively early in many Australian and New Zealand cities, commuter cyclists have no alternative but to ride during dusk, dawn or hours of darkness. Lighting of these paths may be justified if there is significant usage at night. Conversely, the lack of lighting may adversely affect the use of the path at night.
- Recreational paths, many of which are used primarily during daylight hours. The cost of lighting is generally not justified. Designers should, however, consider whether a proposed path is likely to attract enough night-time use to warrant lighting, at least at locations of increased hazard.

AS/NZS 1158 provides standards for the lighting of urban roads and other public thoroughfares including shared paths. The United Kingdom and Europe, where bicycle usage may be higher than in Australia or North America, tend to provide higher levels of lighting as indicated in British Standard BS 5489-1:2013 and it may be appropriate to adopt this higher standard.

Roads which have roadway lighting to the Category V standard of AS/NZS 1158.1.1-2005 will provide sufficiently for on-road bicycle facilities and will have enough surrounding illumination to provide adequate lighting of shared footpaths or bicycle paths located within 3 m to 5 m of the kerb and on the road side of the lighting poles.

The level of horizontal illumination needs to be sufficient for cyclists to easily follow the path, avoid potholes and obstacles, and to read surface markings (a minimum lighting level of 5 lux is required). An adequate level of vertical illumination should also make vertical surfaces such as fences, walls, kerbs, trees and shrubs visible. The overall level of lighting should enable cyclists to see other cyclists, read signs and also enable motorists to see cyclists where the path intersects a road or runs close to a road.

In the absence of significant experience in Australia and New Zealand on lighting levels for paths for cycling, Table 7.10 provides suggested lighting levels which should achieve the above objectives. The lighting levels provided accord with the American and Canadian guides. The levels suggested in the North American guides for tunnels, however, are considered to be excessive and the lighting levels shown in Table 7.10 are therefore based on experience with pedestrian underpasses in Victoria.

The levels listed in the table are for new installations. AS/NZS 1158.1.1-2005 provides guidance on the appropriate maintenance factor to apply to the values in Table 7.10.

Table 7.10: Minimum cycling path illumination levels

Facility	Minimum average horizontal levels (lux)	Average vertical levels (lux)
Path for cycling	5	5
Cycle/pedestrian tunnel < 10 m long	10	10
> 10 m long	20	20

Source: Austroads (2015c) Table 4.5.

Where continuous lighting along a path is difficult to justify, it may be appropriate to light only the locations of increased hazard such as:

- intersections with other paths or roads
- sharp horizontal and vertical curves, and steep grades
- ramps to structures and at the portals of tunnels and subways
- where clearance to obstructions is minimal
- where pedestrian numbers are high
- locations which have special security problems
- special facilities such as stairs and bicycle parking.

Where it is proposed to continuously light a highly utilised path to the levels given in Table 7.10, special attention should be given to the above-listed locations of increased number of hazards to ensure that they are lit to above the average levels given in the table.

Higher illumination levels are generally desirable in pedestrian/cycle tunnels or underpasses to enhance cyclists' personal security. It is also desirable to eliminate the temporary loss of sight experienced when riding from a bright into a relatively dark environment. For this reason it is usual to adopt a higher level of lighting in long tunnels during daylight hours and reduce the level at night when the contrast is less.

Vandalism can be a problem, particularly along paths in isolated areas and this should be taken into account in considering the provision of lighting and in the choice of luminaires. If lighting cannot be provided on a path, provision of a separation line and retro-reflective signs and markers will result in improved guidance for cyclists.

AGRD 06A S 5.11

Bicycle path lighting is also covered in Section 5.11 of AGRD06A (Austroads 2017c). Where paths are heavily used during periods of darkness (i.e. dawn, dusk and at night) consideration should be given to the provision of path lighting. The decision to provide lighting is a matter for the relevant agency. If it is decided to light a path the lighting should be designed in accordance with relevant standards, which include:

- AS/NZS 1158.1.1:2005: Lighting for Roads and Public Spaces: Vehicular Traffic (Category V) lighting: Performance and Design Requirements
- AS/NZS 1158.1.2:2010: Lighting for Roads and Public Spaces: Vehicular Traffic (Category V) lighting: Guide to Design, Installation, Operation and Maintenance
- AS/NZS 1158.3.1:2005: Lighting for Roads and Public Spaces: Pedestrian Area (Category P) Lighting: Performance and Design Requirements.

Designers should also refer to the relevant jurisdiction for the local lighting requirements.

8. Cycling Provision at Structures

8.1 General

AGRD 06A S 8

The design of structures is very important to cyclists. Road bridges are often narrower than the road on the approaches thus creating a squeeze point for cyclists. Because of the high relative cost of new bridges there is an understandable tendency for designers to be as economical as possible in the widths provided for the various users. It is important, however, that road managers look for ways to better cater for cyclists at all existing structures and that designers and planners ensure that cyclists are adequately provided for in the design of all new structures.

Guidance on the provision of facilities for cyclists at structures is covered in Section 8 of AGRD06A (Austroads 2017c).

Table 8.1: Key cross-references related to cyclist provision at structures

Series		Part	Section	Reference Source
Section 8.1: General				
AGRD	Guide to Road Design	6A	Section 8	Austroads (2017c)
Section 8.2: Bridges and Underpasses				
AGRD	Guide to Road Design	6A	Section 8	Austroads (2017c)
AGBT	Guide to Bridge Technology	General	General	Austroads Guides
Section 8.3: Road Tunnels				
AGRT	Guide to Road Tunnels	General	General	Austroads Guides

The structures may cross rivers, railway lines or busy roads. They may be overpasses or underpasses that cater for motor traffic, small bridges or underpasses specifically for cyclists and pedestrians, large drainage culverts which also accommodate cyclists or a bicycle structure attached to a road bridge.

8.2 Bridges and Underpasses

AGRD 06A S 8.1

The primary requirements of cyclists using bridges and underpasses are that designers should provide:

- adequate path width and/or bicycle lane width and horizontal clearances to objects (e.g. walls, safety barriers, kerbs, fences, poles, street furniture etc.)
- adequate vertical clearance, particularly in underpasses
- good sight lines into and through structures
- a smooth surface that is not slippery under any conditions including the surface of expansion joints
- adequate turning radii at changes of direction on pedestrian/cyclist overpasses and underpasses
- adequate drainage infrastructure, particularly at each end of underpasses.

AGBT

For additional guidance on bridges and accommodating the needs of cyclists, practitioners are referred to the *Guide to Bridge Technology*.

AGRT

8.3 Road Tunnels

Provision for cyclists in long road tunnels is problematic because of the very high cost of providing space, particularly treatments that provide a safer and healthy cycling environment. Nevertheless, the needs of cyclists should be considered as part of the planning and design of tunnels and if a satisfactory facility cannot be provided within the tunnel the availability or provision of a suitable alternative route should be investigated.

For further information on cyclist considerations at road tunnels, practitioners are referred to the *Guide to Road Tunnels*.

9. Traffic Control and Communication Devices

9.1 General

Traffic control and communication devices include all signs, traffic signals, pavement markings, traffic islands, or other devices installed with the approval of a road agency having the necessary jurisdiction, to regulate and guide cyclist, motor vehicle and other road user traffic. For additional guidance on the use of these devices, refer to AGTM10 (Austroads 2016d).

Cross-references to the guidance discussed in this section are shown in Table 9.1. Note that traffic control devices used at rail crossings are discussed separately in Section 6.

Table 9.1: Key cross-references related to traffic control and communication devices

Series		Part	Section	Reference source
Section 9.2: Signs (also Section 2.4.5)				
AGTM	Guide to Traffic Management	4	Section 3.6.3	Austroads (2016b)
AGTM	Guide to Traffic Management	10	Section 3.6	Austroads (2016d)
Section 9.3: Pavement Markings				
AGTM	Guide to Traffic Management	10	Section 6.3.8	Austroads (2016d)
Section 9.4: Pavement Surface Colour				
AGTM	Guide to Traffic Management	10	Section 6.6	Austroads (2016d)
Section 9.5: Cyclists at Traffic Signals (also Sections 5.3 and 7.6.3)				
AGTM	Guide to Traffic Management	10	Sections 8.1.4, 8.3.7 and 8.5.5	Austroads (2016d)
AGTM	Guide to Traffic Management	9	Sections 7.6.11 and 7.9 Appendix H.6	Austroads (2014b)

9.2 Signs

AGTM 04 S 3.6.3

Signing of bicycle facilities provides the information to assist all road users to move safely and conveniently on the road and bicycle network. The three main categories of signs and their functions are to:

- regulate and advise the type of facility within the context of the overall road system, e.g. whether a facility is shared with pedestrians or for the exclusive use of cyclists
- warn users of identifiable potential hazards within the riding environment
- guide users around the network.

Bicycle routes should be signposted to indicate destinations and, if required, the distance to them. Uniformity of design and application of signs is desirable to avoid confusion and potential hazardous situations, applicable particularly for cyclists travelling away from their local area. Practitioners should also refer to AS 1742.2-2009 which provides information on general signage and AS 1742.9-2000 as it provides details of facilities including signage specifically for bicycles.

The Australian Bicycle Council website (Appendix B, Australian Bicycle Council 2014) provides examples of a number of bicycle signing schemes.

AGTM 10
S 3.6

9.2.1 Route Planning and Directional and Wayfinding Signage for Cyclists

The active transport and recreational needs of communities are efficiently served by the development of regional and local networks of interconnected cycling routes linking major trip origins to destinations. The planning of these networks is undertaken by government agencies and local governments as part of regional and municipal bicycle plans.

Directional signs provide wayfinding and informational guidance for cyclists across these bicycle networks.

When developing wayfinding signage for bicycles, road designers, engineers and transport planners should aim to provide high quality, professional and consistent directional signs. Ideally these should be consistent with bicycle wayfinding signage in cycle networks across Australian and New Zealand cities and towns to enable riders to use the networks to their full potential and make quick and accurate route choices.

When developing bicycle wayfinding signage consideration needs to be given to:

- focal point mapping, destinations and decision points that are signposted
- route hierarchy and the types of signs appropriate for each type of route in the cycle network
- facility naming, route numbering and branding
- location and mounting of signs
- special sign situations such as marked detour routes, tourist destinations and routes through
- complex intersections
- other users of the road network and their signage requirements in order to avoid signage overload and signage confusion.

Appendix E provides further guidance on bicycle wayfinding including signage design, cycle route types, developing a directional sign plan, signing complex intersections, sign installation, sign maintenance and alternative sign design. Further detailed guidance is provided in Appendix B of Austroads (2015g). Practitioners should also refer to AS 1742.2-2009 which provides information on general signage and AS 1742.9-2000 as it provides details of facilities including signage specifically for bicycles.

9.3 Pavement Markings

In addition to signs, the safety and effectiveness of bicycle facilities is dependent on the provision of appropriate and high-quality delineation including pavement markings.

Pavement markings are necessary for all on-road facilities and also for major bicycle paths, shared paths and separated paths.

9.3.1 Roads

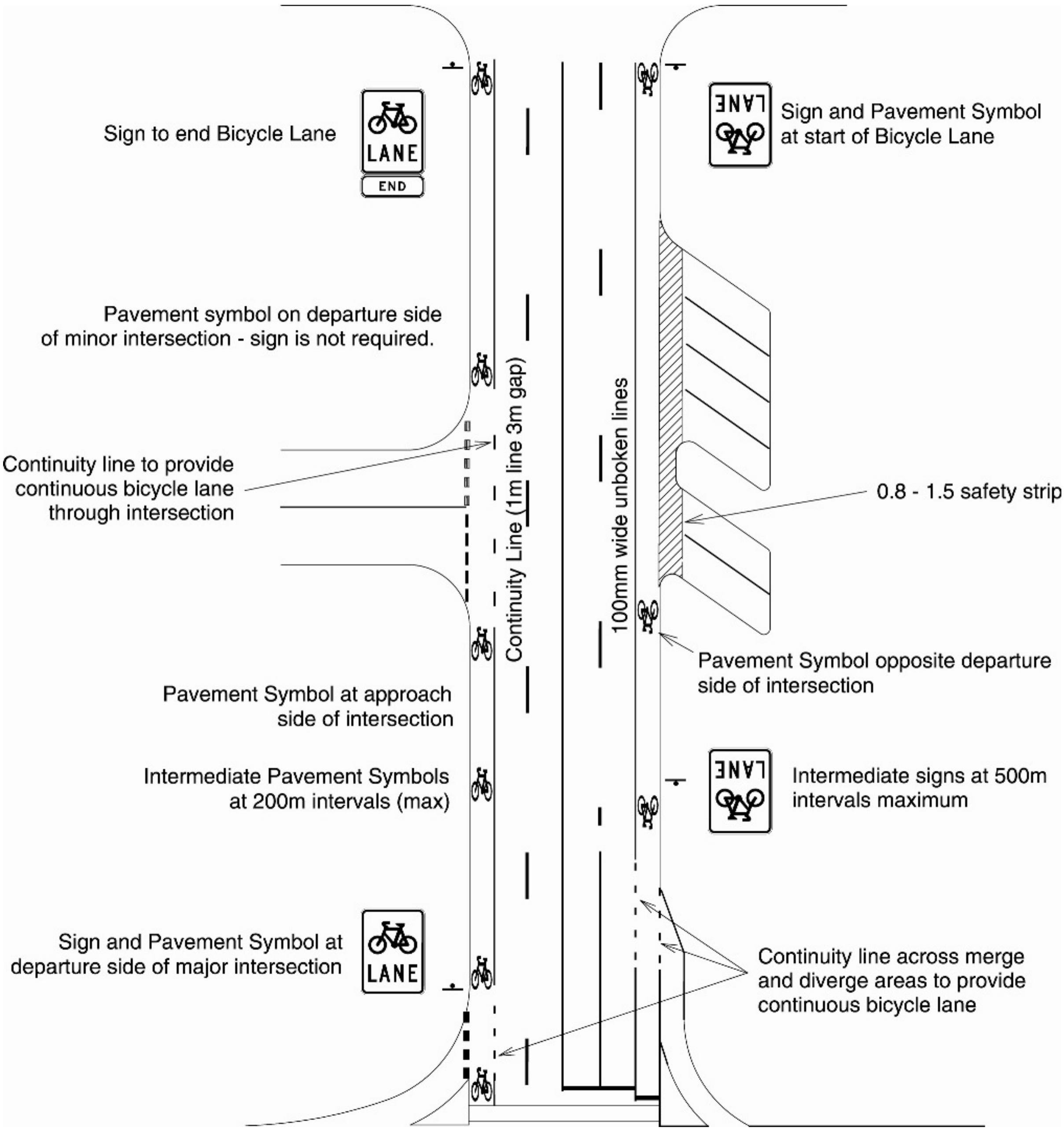
AGTM 10
S 6.3.8

Bicycle lanes are generally separated from general traffic by a 100 mm wide continuous white line. In areas where bicycles and motor vehicles cross or intersect, continuity lines are used to define the bicycle lane. Figure 9.1 provides an illustration of a bicycle lane treatment for a road that shows the marking treatment through an unsignalised intersection, on the approach to a signalised intersection including a ‘head-start’ treatment, and adjacent to angle parking.

9.3.2 Paths

Separation lines on shared paths and bicycle paths should be marked in accordance with AS 1742.9-2000.

Figure 9.1: Example of bicycle lane markings



Source: VicRoads (2001).

9.4 Pavement Surface Colour

AGTM 10 S 6.6

Bicycle lanes may be enhanced by using green coloured pavement surfaces in order to provide easier recognition by motorists and to improve compliance. The surfacing is relatively expensive, and guidelines for its use vary among jurisdictions.

An example of a bicycle lane with a green coloured surface treatment is shown in Figure 4.2.

Some road agencies are choosing to provide coloured surfacing throughout the entire area of some bicycle lanes in order to provide enhanced recognition by motorists and to improve compliance.

The use of green surfacing for bicycle lanes by some authorities may be limited to areas where cyclists experience considerable stress, such as:

- where the paths of motor vehicles and bicycles cross or weave, typically on the approaches and departures of intersections at the tapers to left-turn lanes and added lanes (diverge and merge areas)
- within particularly complex intersections, or very wide intersections, where enhanced delineation of the bicycle lane is essential.

Practitioners are also referred to Austroads (2011), which found that coloured cycle lanes, of good width leading from the transition to the advance limit lines of signalised intersections improve bicyclist perceptions of safety to a greater extent than the improvement in actual crash risk observed. As such facilities improve cyclists' perceptions and encourage more to ride.

9.5 Cyclists at Traffic Signals

9.5.1 Traffic Signal Displays for Cyclists

AGTM 10 S 8.1.4 AGTM 09 Appendix H

Traffic signal displays for cyclists are discussed in Section 8.1.4 of AGTM10 (Austroads 2016d) and Appendix H.6 of AGTM09 (Austroads 2014b).

Where regulations permit, bicycle aspects can be used in a similar way to pedestrian aspects to control cyclists crossing the road, or in a similar way to vehicle aspects to control on-road cyclists at an intersection. The symbol for bicycle aspects is shown in Figure 9.2.

Figure 9.2: Bicycle signal aspect

Two aspects, red and green, are used for road crossings (except in New Zealand). Three aspects – red, yellow and green – are used at road intersections with exclusive bicycle lanes, or at intersections of a road and at bicycle path. Under the *Australian Road Rules* (National Transport Commission 2012) traffic signals relating to cycling movements are called bicycle crossing lights.

AGTM 10 S 8.3.7

The basic sequence for bicycle displays with a two-aspect arrangement is steady red to green to flashing red to steady red. The sequence for bicycle displays with a three-aspect management is green to yellow to red to green.

When bicycle signals are not provided at signalised intersections, bicycles on the roadway are controlled by the vehicle signals

Two-aspect bicycle crossing lights used at mid-block signalised crossings or intersection signalised crossings are connected to the same signal group in the controller that drives the two-aspect pedestrian signal faces. In this case, the pedestrian 'walk' and 'clearance' times apply to the bicycles as well.

Three-aspect bicycle crossing lights can also be used at signalised intersections. In this case:

- For bicycle movements parallel with a main road and crossing narrow minor roads, the bicycle crossing lights are connected to the adjacent vehicle signal group, and introduced with the green display for vehicles and terminated with the vehicle movement.
- For bicycle movements across a main road, and for those parallel with a main road and crossing wide minor roads, the bicycle crossing lights are driven by a separate signal group with green, yellow and red times that reflect a bicycle speed of 20 km/h.

The following measures can be adopted in order to allow for slower speeds of cyclists compared with vehicle speeds:

- Adjusting the yellow time for the bicycle movement to warn cyclists to stop before other traffic in the same phase, i.e. increase the intergreen time only for the cyclists (effectively providing an early cut-off). Since this reduces the bicycle green time, it should be ensured that the combined green plus intergreen time is sufficient for a cyclist accelerating from rest at the stop line to clear the controlled area.
- Allowing the cyclists to move off before the vehicle traffic (late start). This is appropriate where the bicycle lane does not continue through the intersection and bicycles have to merge with other traffic.

Where bicycles use on-road facilities, it is recommended that, at intersections, a stop line for bicycles is placed 2 m downstream of the normal stop line so that left-turning motor vehicle drivers, in particular bus and truck drivers, will be aware of bicycles waiting for a green signal. If vehicles cannot turn left, there is no need for this treatment.

9.5.2 Bicycle Detection

AGTM 09
S 7.6.11

Bicycle detection at signals is covered in Section 7.6.11 of AGTM09 (Austroads 2014b).

When separate bicycle lanes are provided and bicycle detection is required, loop detectors with very sensitive loop arrangements spanning the whole width of the bicycle lane are necessary.

Where bicycle traffic shares lanes with other vehicles, it is not always possible to detect bicycles due to their small electromagnetic footprint. It might be appropriate in such cases to install other devices such as push buttons to assist bicycle riders to lodge a demand, or pavement markings to indicate the most bicycle-sensitive area of the detection zone or, where bicycle volumes are low, do nothing.

AGTM 09 S7.9

9.5.3 Treatments for Cyclists at Traffic Signals

Treatments for cyclists at traffic signals are outlined in Table 9.2.

Table 9.2: Signal timing and phasing treatments for cyclists

Traffic signal treatment	Comments
Late start for vehicles (early start/leading interval for cyclists)	Bicycle phase is started prior to parallel vehicle phases An early start positions cyclists where they are more likely to be noticed by motorists when a parallel vehicle phase begins May assist where cyclists are required to merge downstream of an intersection (e.g. bicycle lane does not continue through intersection) Most effective where cyclists are able to pass queued vehicles (e.g. locations with bicycle lane or wide kerb side lane) May be implemented in conjunction with an early start for pedestrians depending on the specific layout, signal displays and operation of a signalised intersection May be considered with an early start for buses in some situations, such as where cyclists share bus priority lanes (i.e. to reduce conflict between cyclists queued in front of buses during an early start for buses)
Extended clearance interval	The intergreen time (e.g. yellow time) for a bicycle movement may be longer than for other traffic (i.e. early cut-off of cyclist movement) A cyclist may travel slower than other vehicles and may not have sufficient time to safely clear an intersection (e.g. wide intersection or rising gradient) Can be implemented without creating additional delays for other road users As this reduces the bicycle green time, it should be ensured that the combined green plus intergreen time is sufficient for a cyclist accelerating from rest at the stop line to clear the controlled area Requires bicycle display aspects at traffic signals May result in poor compliance and a lack of respect for the bicycle signal aspect, as displaying a green vehicle signal aspect and red bicycle signal aspect may present a conflicting message to cyclists
Signal coordination	In some situations, traffic signals coordination may be provided for the benefit of cyclists (refer to Section 7.7 of AGTM09) May be considered in specific situations such as on bicycle routes with high cyclist volumes, several closely spaced signals and a strong tidal flow
Scramble phase	Allows all cyclist movements, including diagonal movements, to operate simultaneously within the marked limits of a crossing while eliminating vehicle conflicts Should only be installed where there is demonstrated need for cyclists to cross diagonally May be less appropriate for cyclists (than pedestrians) as cyclists may not easily filter without clearly defined pathways Scramble crossing phases should operate full time Needs to consider the delay impact for road users

Source: Austroads (2014b) Table 7.7.

AGRD 06A
S 12
App. B

10. Construction and Maintenance Considerations at Cycling Facilities

10.1 General

If bicycle paths or on-road facilities are not adequately constructed and maintained, cyclists are not likely to use them, or may swerve in order to avoid surface irregularities thus creating a hazardous situation. The importance of maintenance in relation to cyclist safety, Section 12 and Appendix B of AGRD06A (Austroads 2017c) provide information on construction and maintenance considerations. Key Austroads guidance related to construction and maintenance considerations for cycling facilities is summarised in Table 10.1

Table 10.1: Key cross-references related to construction and maintenance

Series		Part	Section	Reference source
Section 10.1: General				
AGRD	Guide to Road Design	6A	Section 9 Appendix B	Austroads (2017c)
Section 10.2: Pavements for Cycling (also Section 3.3 and Appendix F4)				
AGRD	Guide to Road Design	6A	Section 9.1	Austroads (2017c)
AGPT	Guide to Pavement Technology	General	General	Austroads Guides
Section 10.3: Maintaining Cycling Facilities (also Appendices F, G and H)				
AGRT	Guide to Road Design	6A	Section 9.2	Austroads (2017c)
AGAM	Guide to Asset Management	General	General	Austroads Guides
AGPD	Guide to Project Delivery	General	General	Austroads Guides

10.2 Pavements for Cycling

AGRD 06A
S 9.1

Smooth, debris-free surfaces are a fundamental requirement for riding bicycles in safety on paths and roads. As cyclists can ride at speeds up to 50 km/h on downhill grades, a rough surface or pothole can cause a cyclist to fall, leave the path or road and crash or come into conflict with other path or road users. On uphill grades on roads, the speed differential between cyclists and motor traffic is greater and hence cyclists are exposed to potential conflict with motor traffic for a relatively long time as they manoeuvre around poor surfacing.

Most bicycles have no suspension or shock absorbers and many bicycles have relatively thin tyres inflated to high pressures. Consequently, when a cyclist hits a pothole at speed it is uncomfortable, difficult to maintain control and potentially hazardous for the cyclist.

AGPT

Surface irregularities which are not noticeable in a motor vehicle can make cycling unpleasant and slow down the travel speed considerably. In order to gain an appreciation of the problems faced by cyclists with respect to maintenance it is suggested that road maintenance supervisors should ride a bicycle over sections of paths and roads used by cyclists. This enables a more detailed examination of the surface to be made including problems that are easily missed from a patrol motor vehicle. Further guidance on pavements for cycling is provided in Appendix F and the *Guide to Pavement Technology*.

10.3 Maintaining Cycling Facilities

A substantial capital investment is often made in providing cycling facilities and jurisdictions and road agencies should have an effective management regime to define responsibilities and to ensure that these facilities are adequately maintained.

Reference should be made to Appendix F regarding construction and maintenance considerations for cyclists including:

- maintenance requirements
- provision for cyclists at work sites
- pavements and surfacing
- quality systems.

10.3.1 Bicycle Safety Audits

AGRD 06A S 9.2

An important aspect of quality systems is bicycle safety audits. Bicycle safety audits are as important as safety audits that relate to other road users and should also comply with guidelines presented in the Austroads *Guide to Road Safety Part 6: Road Safety Audit* (AGRS06) (Austroads 2009c).

Bicycle safety audits should be applied to both on-road and off-road facilities, existing and proposed facilities, and all stages of the development of proposals from feasibility studies to pre-opening of the facility. An example of a bicycle safety checklist is provided in Appendix G. Such lists should be used in conjunction with Austroads lists that relate to road design, transportation and traffic in general. An example of a bicycle safety audit is provided in Appendix H.

10.3.2 Further Guidance

AGAM

Asset management plays a key role in managing and maintaining cycling facilities. For further guidance on this topic, practitioners are referred to the *Guide to Asset Management.*

AGPD

Practitioners are also referred to the *Guide to Project Delivery* for further guidance on project delivery in relation to the asset function and strategic planning process.

11. Bicycle Parking and End-of-trip Facilities

11.1 General

It is important that adequate facilities are provided at common destinations of bicycle trips. The facilities that are necessary include showers, lockers to store clothing and cycling equipment, and convenient and secure bicycle parking facilities.

AGTM11 (Austroads 2017) is the primary cross-reference for this section. Table 11.1 summarises key Austroads guidance related to cyclist parking and end-of-trip facilities.

Table 11.1: Key cross-references related to bicycle parking and end-of-trip facilities

Series		Part	Section	Reference source
Section 11.2: Bicycle Parking (also Appendix I)				
AGTM	Guide to Traffic Management	11	Section 7.15.5 Commentary 2.3 and 9	Austroads (2017d)
AGTM	Guide to Traffic Management	4	Section 3.6.3	Austroads (2016b)
Section 11.3: On-street Bicycle Parking				
AGTM	Guide to Traffic Management	11	Section 8.9.5	Austroads (2017d)
Section 11.4: Types of Parking Devices				
AGTM	Guide to Traffic Management	11	Commentary 9	Austroads (2017d)
Section 11.5: Signs and Markings Showing Location and Purpose of Parking Facilities				
AGTM	Guide to Traffic Management	11	Commentary 9	Austroads (2017d)
Section 11.6: Showers, Lockers and Security				
AGTM	Guide to Traffic Management	4	Section 3.6.3	Austroads (2016b)
AGTM	Guide to Traffic Management	7	Section 3.8.4	Austroads (2015e)
AGTM	Guide to Traffic Management	11	Commentary 9	Austroads (2017d)

11.2 Bicycle Parking

11.2.1 General

AGTM 11
S 7.15.5
C 2.3

AGTM 04
S 3.6.3

Bicycle parking requirements are discussed in AGTM11 (Austroads 2017d), some of which are presented in this section.

Parking for cyclists falls into four categories:

- all-day parking at trip destinations (e.g. for employees and students)
- all-day/part-day parking at public transport stations or interchanges
- short-term parking at shopping centres, offices and other institutions
- overnight parking at residences and other accommodation.

Each category and site will have different requirements. AGTM11 provides comprehensive information on parking and includes guidance on bicycle parking facilities. However, bicycle parking facilities should also be designed in accordance with AGTM11, AS 2890.3-2015 and Transit New Zealand (2007) as appropriate.

Planning codes and policies in various jurisdictions may contain certain mandatory requirements for bicycle parking and other end-of-trip facilities such as showers and lockers in new developments. These facilities may also be installed as a result of the outcomes of local strategic bicycle plans, urban planning strategies or based on specific needs (Section 7.15.5, AGTM11).

An indication of the levels of bicycle parking needed for various land uses is shown in Commentary 2.3 of AGTM11 and Appendix I.

When considering the provision of new or modified car parking arrangements, practitioners should also consider the needs for additional facilities for cycling as well as the methods to minimise the impact of car parking on existing or future cycling use. This would normally include consideration of any strategic bicycle plan for the affected road(s) and, where practicable, ensuring good visibility for drivers including designing the layout of parking areas in such a way so as to reduce the chance of car doors being opened into the path of oncoming cyclists.

11.2.2 General Requirements for Devices

AGTM 11 S 7.15.5

In general every bicycle parking facility should satisfy the following requirements:

- be safe for all users of the designated space, securely fixed and conveniently located for users
- accommodate and support a standard bicycle with sufficient space so as to minimise damage while parked and during movement into or out of the parking space
- do not obstruct or hinder pedestrian access ways, loading zones, public help access points, fire hydrants, fire escapes, areas adjacent to accessible car parking as required by AS/NZS 2890.6-2009, and the like
- include a minimum of 20% of ground level (horizontal) bicycle parking devices in any bicycle parking facility
- enable wheels and frame to be locked to the device without damaging the bicycle
- be placed in view of staff, customers and passers-by or covered by CCTV cameras
- be located outside pedestrian movement paths, segregated where possible and possibly allowing extra footpath width in anticipation of cycles chained to poles
- be easily accessible from the road
- be arranged so that parking entries and exits will not damage adjacent vehicles
- be protected from manoeuvring motor vehicles and opening car doors
- be as close as possible to the cyclist’s ultimate destination
- be well lit by appropriate new or existing lighting
- be protected from the weather
- be attractive and designed to blend in with the surrounding environment
- be appropriately signed
- be well-maintained and kept free from graffiti: It should be noted that recurring maintenance costs should receive as much consideration in budgeting as the initial construction and installation costs
- have a convenient kerb ramp should be provided near bicycle parking facilities.

Monitoring of demand/use should be carried out regularly in order to determine the effectiveness of the end-of-trip facility.

11.3 On-street Bicycle Parking

AGTM 11
S 8.9.5

Bicycle parking along a street is generally provided in the form of bicycle rails (Section 11.4). These facilities should be located parallel to the kerb or footway unless a footpath extension is provided, and on both sides of the road where demand warrants it. Bicycle parking facilities should be located as follows (Section 8.9.5, AGTM11 (Austroads 2017d)):

- clear of driveway and building entrances/exits
- clear of pedestrian footpaths where they adjoin the property/building line
- clear of high volume pedestrian movements
- clear of opening car doors
- clear of attachments for blinds or awnings
- clear of access covers set in the pavement
- clear of other street furniture, loading zones, public transport stops and pedestrian crossings
- with a minimum clearance between a parked bicycle and the edge of a motor vehicle traffic lane, parking lane or roadway of 500 mm
- with a minimum clearance from a disabled access car parking space of 1600 mm where the parking space is parallel to bicycle parking or 2400 mm for other orientations in accordance with AS/NZS 2890.6-2009
- with a minimum clearance for passage of pedestrians between a parked bicycle and any other obstruction on a walkway or footpath of 1800 mm (greater clearance will be needed at high pedestrian volumes).

The minimum clearance in the above cases should be the clearance to any part of a bicycle when attached to the parking device in the intended manner.

When considering the provision of new or modified car parking arrangements, practitioners should also consider the needs for additional facilities for cycling as well as the methods to minimise the impact of car parking on existing or future cycling use. This would normally include consideration of any strategic bicycle plan for the affected road(s), and, where practicable, ensuring good visibility for drivers including designing the layout of parking areas in such a way so as to reduce the chance of car doors being opened into the path of oncoming cyclists.

11.4 Types of Parking Devices

General

AGTM 11 C 9.2

Bicycle parking facilities are classified by security level as shown in Table 11.2.

Table 11.2: Classification of bicycle parking facilities

Class	Security level	Description	Duration of parking	Main user type
1	High	Fully enclosed individual locker	All day and night	Bike-and-ride commuters at railway and bus stations
2	Medium	Lockable enclosure, shelter or compound fitted with class 3 facilities where cyclist is responsible for locking their bicycle within the communal enclosure	All day	Regular employees, students, regular bike-and-ride commuters
3	Low	Bicycle rails or racks to which both the bicycle frame and wheels can be locked	Short to medium term	Shoppers, visitors, employees of workplaces where security supervision of the facility is provided

Source: Austroads (2017d) Table C9 1, Commentary 9.

Bicycle lockers

As shown in Figure 11.1 bicycle lockers offer the highest level of bicycle security currently available. They also have the added advantage that helmets and other gear can be securely stored along with the bicycle. Bicycle lockers restrict access to one user and are most effective in public places where there is a high risk of theft or vandalism. They are most commonly located at railway stations and bus terminals to encourage the use of multi-modal travel, as well as at apartments, residential complexes, and university residences. They should be situated in a well-lit area, and fabricated from corrosion-resistant materials if close to the sea.

It is important that the use of lockers is managed by an appropriate authority such as the managers of a shopping centre, major building, or railway station. They can either be rented to a single user for a period of time, or casual users can obtain a lock and key from the facility manager. It is also possible to manage lockers automatically with electronic access control similar to that used by some airport luggage lockers.

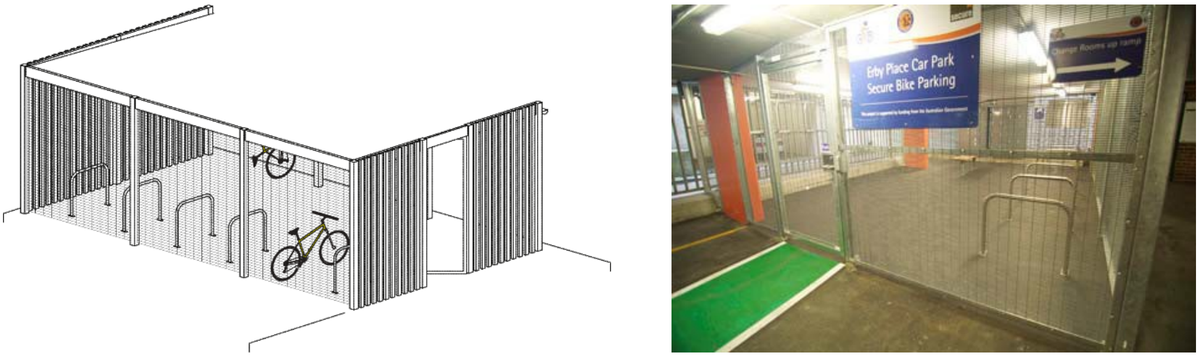
Figure 11.1: Example of bicycle lockers location at a bus terminal in Canberra

Bicycle enclosures

Bicycle enclosures offer a medium level of security in that while the owner can lock the bicycle within the enclosure, other users also have access to the enclosure. These are usually located at railway stations, public transport terminals, workplaces, universities/TAFE colleges, schools, apartments/residential complexes and university residences. Enclosures can be a room, a compound, or a purpose-built area containing groups of bicycle parking rails, and fitted with a roof for increased security and weather protection. Public lighting is desirable where they are located in a public place and used after dark.

Enclosures should be lockable to prevent unauthorised access. If restricted keys are used, unauthorised copying will be prevented. Electronic access control may also be suitable particularly if the building already has such a system. It is important to ensure that a nominated person is responsible for managing access issues and distributing keys or access cards to the enclosure. If a higher level of security is required, it may be possible to install a surveillance camera to monitor the door to the enclosure. Examples of bicycle enclosures are shown in Figure 11.2. Additional guidance can also be found in the Austroads *Research Report – Bicycle Parking Facilities: Guidelines for Design and Installation* (Austroads 2016f).

Figure 11.2: Examples of cage facilities



Where space is limited, an enclosure designed for vertical bicycle storage may be provided.

Bicycle parking rails

The parking rail is amongst the most versatile methods of bicycle parking currently available in that it is:

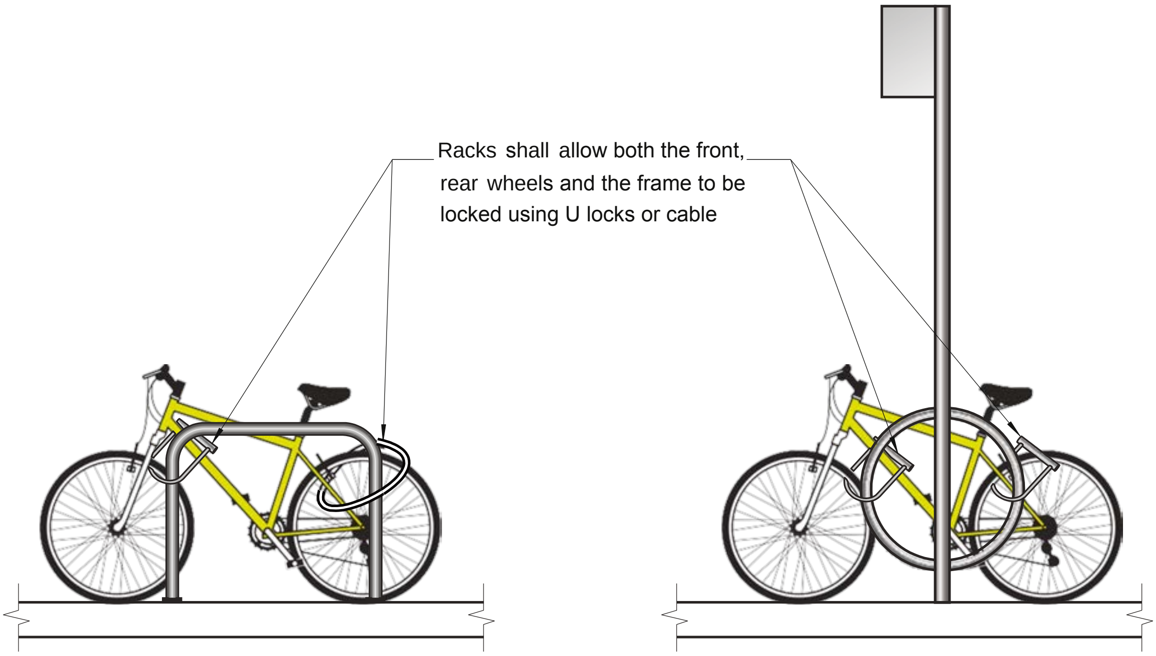
- inexpensive to install and maintain
- easily fabricated
- able to be located close to cyclist destinations
- suited to short and medium-term parking.

Parking rails are usually located at shopping centres/markets, business districts, recreational centres/swimming pools, libraries and universities/TAFE colleges. They should be located in well-lit areas in public view, where they will not impede the opening of doors on parked cars, and where they can also be easily seen by motorists. Where possible they should be situated near buildings that have on-site security or if a high level of security is required, it may be possible to install a surveillance camera to monitor the rails.

Parking rails as shown in Figure 11.3 may come in a number of shapes and sizes and can be as ornate as the site requires as long as the rail:

- supports the entire bicycle
- is of a shape that allows the cyclist to lock the front wheel and frame, top bar and back wheel and frame to the rail
- is manufactured from smooth steel tubing of a diameter that a u-lock can easily fit around (usually 50 mm) and is vandal resistant
- has base plates welded to the bottom of each leg so that they can be bolted to a concrete surface or long enough so they can be set in concrete footings.

Figure 11.3: Examples of bicycle parking rails



Note: Signposting or physical devices may be required to discourage or prevent access to the area by motorcycles.

Source: AS 2890.3-2015.

Parking rails can be arranged to best fit the available space. Each parking rail can accommodate two bicycles, one on each side of the rail. They can also be installed in clusters or groups to meet the parking demand. Bicycle racks may also incorporate plastic coated chains which can be secured by padlock.

The traditional 'toaster rack' style bicycle stands holding only one wheel have been around for a long time, as shown in Figure 11.4. They do not, however, meet the requirements of AS 2890.3-2015 as they do not allow the frame and wheels to be locked to the rack, and can therefore damage the wheels. They should be replaced progressively giving priority to those where the security risk is greatest.

Figure 11.4: An example of toaster rack style bicycle stand

11.4.1 Location of Bicycle Parking Facilities

AGTM 11 C 9

Bicycle parking facilities should be provided in small clusters within 100 m of common commuting and recreational destinations of bicycle trips such as schools, shopping centres, railway stations, bus terminals/interchanges, work places, sports grounds, etc.

It should be noted that if parking facilities are not conveniently located, cyclists will ignore them and continue the disorderly practice of securing bicycles to nearby railings, posts, seats, parking meters, trees etc. In particular, short-term bicycle parking needs to be convenient if it is to be effective.

11.5 Signs and Markings Showing Location and Purpose of Parking Facilities

AGTM 11 C 9.3

Information signs (Figure 11.5) and pavement markings should be provided to direct cyclists to parking facilities and indicate the purpose of the facility in order to encourage their use. Lockers and other facilities must also display instructions for use.

Figure 11.5: Examples of wayfinding and position signage

Signs should be provided in accordance with AS 2890.3-2015, consisting of a standard bicycle pavement symbol with an additional panel below. The message on the lower panel should normally read Bicycle lockers, Parking enclosure, Parking rails or Parking. Another message may be required in special circumstances.

It is also recommended that bicycle rails have a small bicycle pavement symbol painted on the pavement beneath to clarify the purpose of the rails or have the words ‘Bicycle Parking’ stencilled on the rail. This is usually applicable to ornate rails that may be mistaken for street art.

11.6 Showers, Lockers and Security

In order to make bicycle trips in excess of five kilometres attractive to people it is necessary that clean, functional, secure showers and changing facilities be provided in the workplace. There is limited information on these facilities in the Austroads Guides; however, the need for them is recognised in several Guides.

AGTM 07 S 3.8.4

Section 3.8.4 of AGTM07 (Austroads 2015e) provides guidance for traffic management in activity centres and indicates that at workplaces where all-day bicycle parking is used on a regular basis, could be expected to be combined with end-of-trip facilities such as showers, lockers etc. Demand for such parking is more likely to justify grouping of racks, often within areas where there is controlled access, such as in basement car parks, CCTV and casual monitoring by security staff. Individual bicycle lockers may be appropriate.

AGTM 04 S 3.6.3

Section 3.6.3 of AGTM04 (Austroads 2016b) indicates that all-day parking should provide a high level of security to prevent others from tampering with the bicycle, or stealing the bicycle or parts of it. Long-term parking therefore involves the provision of personal bicycle lockers, cages, or compounds ideally not more than 100 m from the destination. Cages and compounds should not only have a locked gate but also provide for the frame and both wheels to be locked to a rail within the enclosure.

AGTM 11 C 9

AGTM11 (Austroads 2017d) provides considerable reference to lockers in combination with bicycle parking facilities that is summarised in Section 11.4.

11.7 End-of-trip Facilities

Increasing numbers of office tenants are using the bicycle as their preferred mode of transport. Bicycle parking and end-of-trip facilities are one of the key drivers of demand in Australia's CBD property markets and are key to attracting employees. Examples of end-of-trip facilities are shown in Figure 11.6 where some end-of-trip facilities include:

- secure access with free Wi-Fi access
- showers with male and female amenities
- accessible W/C amenity and shower
- complimentary towel service
- hair dryers and straighteners with refresh stations
- ironing stations, garment air drying units and airing cupboards, and free shoe shine
- change rooms with ironing facilities hair dryers and a hair straightener, a fresh towel service and a same day dry cleaning service
- swipe-card lockers offered on both a casual and permanent basis
- communal bicycle tools including a repair stand and electric air compression bicycle pump with quarterly bicycle tune-ups and repairs.

Figure 11.6: Bike storage and secure clothes lockers, shoe shine and air pump

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Appendix A Bicycle Network Evaluation Example

A.1 General

The Austroads *Guide to Project Evaluation Part 8: Examples* provides guidance on how evaluation should be carried out. For additional guidance, practitioners are also referred to the *National Guidelines for Transport System Management in Australia* (Australian Transport Council 2006). The Australian Bicycle Council website (Appendix B, Australian Bicycle Council 2014) also provides a number of examples of the evaluation of cycling.

AGPE 08 S 3.10

This example is taken from Section 3.10 of AGPE08 (Austroads 2006a) and is a direct adaptation from a Perth bicycle network evaluation project (Ker 2004). The program that is the subject of evaluation in this example consists of the following components of the Perth bicycle network to be funded over five years:

- principal shared paths – $37.35 million
- train station precinct projects – $1.6 million
- local bicycle routes – $15 million (including $7.5 million local government)
- cycling infrastructure grants – $15 million (including $5 million local government)
- regional recreational paths – $8 million (including $4 million local government).

Cycling is an environmentally-friendly mode of transport for a number of trips for which it can be a good substitute for car use. Cycling generates no significant negative externalities, especially when bicycle infrastructure that minimises conflict with motor vehicles is available.

A cycling benefits assessment framework that was developed by the Perth project (Ker 2004) to evaluate the effects of cycling substituting for car travel is summarised below. The methodology used describes the following steps:

- estimate benefits for each cycle-km generated (i.e. new) and diverted (from other routes) as shown in Table A 1
- estimate usage of new facility and convert to cycle-km, taking care to relate to existing trend (e.g. if cycle use is generally increasing, then some part of the facility usage would have been expected even without the facility) and distinguishing between new trips and diverted trips
- estimate capital and maintenance costs of the new facility
- discount values to base year to calculate net worth of project.

Table A 1 shows the values used to calculate the benefit per kilometre of car travel transferred to bicycle.

As shown in Table A 1 the direct financial benefits to the user (i.e. the person who previously travelled by car) are equivalent to 19.7 cents per kilometre. These are based only on the savings in variable running costs for a car. Some households might decide that they are then able to do without a second car, in which case there would be additional fixed-cost savings (vehicle registration, depreciation, interest on capital), but no account has been taken of this possibility, as in these circumstances it would be likely that other changes in travel behaviour would be made and a simple benefit-cost evaluation would be of limited use. This benefit is only offset to a small extent (3.6 cents/km) by the cost of owning and operating a bicycle (Table A 1).

The socio-economic benefits are calculated to be substantially higher than the individual's financial benefits, and are greater in the peak than the off-peak traffic period. Within this overall value, there is only one negative (other than the cost of owning and operating a bicycle) and that is the increase in cyclist road trauma, but this is more than offset by the health and fitness benefits.

Table A 1: Benefit values per kilometre reduction in car travel (2004 prices)

Item of benefit	Value (cents/km)	
	Peak	Off-peak
Financial benefit to individual		
Private vehicle operating costs	19.7	19.7
Cycle user cost (increase)	(3.6)	(3.6)
Socio-economic benefits		
Private vehicle operating costs (net of tax)(1)	12.9	12.9
Cycling user cost	(3.3)	(3.3)
Road trauma (increased cycling)	(14.6)	(14.6)
Road trauma (cycling diverted to PSPs)(2)	14.6	14.6
Road trauma (reduced car use)	5.2	5.2
Road traffic congestion	15.8	3.2
Air pollution costs to community	3.6	2.7
Greenhouse gas emissions	1.2	1.2
Improved health and fitness due to exercise	17.2–34.4	17.2–34.4
Traffic noise(1)	3.6	0.7
Water pollution(1)	2.4	2.4
Social impacts(1)	Not quantified	Not quantified
TOTAL per new cycle trip-km	61.2	44.8
TOTAL per existing cycle trip diverted to PSP	14.6	14.6

1 *Based on current traffic conditions. All studies indicate that traffic volume will increase relative to road capacity and hence congestion, vehicle operating costs, exhaust emissions and associated impacts will increase. In the case of exhaust emissions and greenhouse gas emissions, technological improvements (e.g. use of cleaner fuels) may offset this to some extent.*

2 *PSP denotes Principal Shared Path.*

Source: Austroads (2006a) Table 3.2.

A.2 Impact of Cycle Use

Counts of cyclist numbers across Perth have been undertaken annually since 1998. Counts at all sites showed an 84% (13% per year) increase between 1999 and 2004. This demonstrates the effectiveness of the Perth Bicycle Network, along with other initiatives, in increasing cycle use in key areas. Screenline counts in the East Perth/Highgate area indicate that the opening of the Principal Shared Paths (PSP) along the railway between Maylands and East Perth resulted in substantial increases in cycle trips from 2002 to 2004. The net trip generation of the PSP has been around 600 trips per weekday (3000 per week), with around 100 trips per day (500 per week) gaining the benefit of a substantially safer cycling environment by transferring from other routes to the PSP. The net trip generation of the PSP has been around 207 000 per year, with around 35 000 gaining the benefit of a substantially safer cycling environment by transferring from other routes to the PSP.

A.3 Benefit-cost Evaluation

A conventional benefit-cost analysis framework was then applied to the PSP component of Stage 3 of the Perth Bicycle Network. For evaluation purposes, it was assumed that:

- Each km of PSP constructed will generate and attract cycle trips at the same rate as the Maylands-East Perth PSP (which was 2.9 km).
- Trip lengths will be substantially longer than the average cycle trip length of 2.25 km, as this figure includes a high proportion of purely local trips not served by PSPs. It was assumed that the average cycle trip length is 6.1 km, in line with the average length of cycle trips generated by TravelSmart Individualised Marketing in Perth.

The results of this conventional project evaluation demonstrate a net present value (NPV) of $75.6 million and a benefit-cost ratio of 3.3 for this project. These results have been obtained using a discount rate of 7% per annum over a 25 year project horizon, with no residual value assumed for the PSPs. The evaluation includes appropriate allowance for the maintenance costs of the PSPs under the WA Main Roads term network maintenance contracts.

A.3.1 Other Factors Affecting Level of Benefits

In addition to the level of cycle usage as identified above, the following factors will affect the benefits achieved by the PSP program:

- Level of path usage by pedestrians. Whilst walking trips are generally substantially shorter than cycle trips, the PSPs will attract walking activity. They are adjacent to rail lines and train stations, thus serving walk access to public transport, and also serve a number of activity centres (schools, shops, employment) along the way. These benefits will be additional to those estimated above.
- Concentrated promotion of new PSPs. Previous PSPs have not been given strong marketing in the area they serve. The proposed Stage 3 PSPs will be given concentrated marketing to potential users in the area. This will increase the levels of use beyond those observed for previous PSPs and, hence, those used as the basis of this evaluation.
- The extent to which cycle trips replace trips other than car driver. The evaluation has been based on all new cycle trips being converted from car driver trips (i.e. each cycle trip means one less car on the road). In practice, there may be some substitution from other modes, although this is least likely for walk (as walk trips are short) and public transport (as the main ‘competition’ is with rail (for which trips are longer than average, so more likely to be beyond typical cycling distance – in 1986 (the most recent travel survey data available for Perth) only 14% of train trips were less than 5 km and 30% less than 10 km).
- That leaves car passenger trips, a proportion of which (including driving children to and from school and other activities) are undertaken solely for the benefit of the passenger and involve two car trips (there and back) for each passenger trip. For those previous car passenger trips where the driver still has to travel, this evaluation will overstate the benefits of the substitute cycle trip, as the car will still be on the road for the same amount of time. However, for those where the driver no longer has to travel, the evaluation will understate the benefits by a factor of two, as two car trips are removed for each cycle trip.
- Given that car occupancy rates in Perth are low (around 1.2, on average) and around 40% of car passenger trips are for education (mainly school) purposes, the net impact of substitution for car passenger, rather than car driver trips is likely to be small.

Overall, it is likely that the factors indicating that the evaluation will underestimate benefits, including the pre-existing declining trend in cycle usage, will outweigh any factors leading to overestimation.

A.4 An Overview of this Bicycle Example

The PSP component of the proposed Stage 3 of the Perth Bicycle Network has been demonstrated to generate user and community benefits in excess of the costs of building the facilities. A benefit-cost evaluation, using conventional transport project assessment methodology has calculated a project NPV of $75.6 million and a BCR of 3.3.

This is likely to be a conservative value as it takes no account of the additional usage likely to be generated by the extension of an incomplete network of facilities, including some missing links that will greatly enhance the range of destinations it serves.

Other components of the investment proposal are for much lower-cost facilities, including local bicycle routes and other local, rather than regional, bicycle facilities. The general increase in cyclist numbers at sites surveyed since 1998–99, especially those on local bicycle routes, is sufficient to justify the investment, given the substantially lower cost of these facilities.

Regional recreation paths, in particular, will also generate substantial levels of recreational walking activity, which has been acknowledged to be highly beneficial in relation to health outcomes.

Public sector proposals are increasingly required to be assessed against the triple bottom line criteria of economic, environmental and social impacts. The Perth Bicycle Network proposal demonstrates a positive impact on:

- financial/economic outcomes, primarily through savings in car operating costs and congestion costs
- the environmental bottom line, through reductions in air pollution, water pollution and greenhouse gas emissions
- the social bottom line, through improvements in health and fitness that more than offset any net increase in road trauma.

Appendix B Australian Bicycle Council Website

The Australian Bicycle Council website (www.bicylecouncil.com.au) is an information hub for Australian practitioners in both the public sector and private sector. It is designed to provide high quality information to planners, engineers, academics and advocates on bicycle-related issues.

The site contains Australian Bicycle Council publications such as the National Cycling Strategy and National Cycling Participation Survey as well as policy, guidance, research and case studies on a variety of topics such as:

- cycling education
- encouragement and promotion
- bicycle equipment
- evaluation and monitoring
- infrastructure and design
- rules and enforcement
- planning and policy.

The site is administered by the Australian Bicycle Council with the operational support of Austroads.

AGTM 03 Appendix E

Appendix C Bicycle Survey Methods

C.1 General

Bicycle survey methods are discussed in AGTM03 (Austroads 2013b), particularly Appendix E, from which the following information is sourced.

C.2 Manual Bicycle Counts

Manual counts consist of an observer recording the flow of cyclists past a certain point for the required time period. The most common method of collecting volume data is by manual counts of the flow of cyclists at a particular point in the traffic system. In the simplest form, the observer manually records the number of cyclists for the time period. The demands of data collection can be reduced by using mechanical, electrical or computerised tally counters.

Manual cyclist counts rely on good planning and skilled observers to ensure accurate and useful results. The number of observers will depend on the general level of traffic activity and the data-recording task. For example, if classification of cyclists (by demographic and/or direction of travel) is necessary, more observers will be required. Observation sites need to be chosen so that they provide a good view of the area but also provide protection from the weather and inquisitive people.

C.3 Questionnaire Surveys

Questionnaire surveys can provide useful information on route choice, origin-destination information, characteristics of cyclists, crash history and the adequacy of bicycling facilities. Questionnaires can be mail-back, self-administered or interviewer-administered. The mail-back questionnaire is useful when the respondent has little time to answer the questions. The response to such surveys, however, can be quite low (30%) and unless information on the characteristics of the non-respondents is known, the results could be misleading. Simple, readily understandable questions will provide the highest response rate. Self-administered questionnaires are completed by cyclists (or pedestrians) at the location where they are handed out. For this technique to be successful the respondent must be captive and not pushed for time. As with the mail-back survey, the questions must be simple and easily understood. The on-site interview involves an interviewer asking the cyclist (or pedestrian) a series of questions, and recording the answers. Again, the respondent must not be pressed for time and the questions asked should be kept to a minimum. The advantages of this technique are an increased response rate and the ability to further explain difficult questions.

Another form of questionnaire is the household or workplace survey. These types of surveys can be used to collect considerable information on trip purpose, route and origin-destination and socioeconomic characteristics. Household surveys are expensive to undertake, particularly on a random sample of the population because cycling is a relatively rare activity.

An important factor to keep in mind when preparing questionnaires is the use of appropriate definitions. For example, one problem area is the definition of a trip. A trip can be defined as a one-way movement of a person or vehicle between two points for a specific purpose.

C.4 Bicycle Detection

Inductive loop detectors are commonly used to detect vehicles but can also be used to detect bicycles. The loops, which are buried just below the surface of the road or cycle way record metallic objects passing over due to a change in the inductance. Bicycles have a lower metal content than vehicles. Bicycle inductive loop detectors therefore need to be more sensitive to produce acceptable results.

Piezo-detectors can also be used to detect bicycles. Piezo materials change electrical characteristics when subjected to mechanical deformation caused by pressure. The deformation can cause a change in resistance (piezo-resistive) or the generation of a charge (piezoelectric). The piezo-resistive sensor can detect a bicycle at low to zero speeds, whilst the piezoelectric sensor is not effective at very low speeds.

As with the detection of pedestrians, microwave, infra-red, ultrasonic and laser detection methods can also be used to detect bicycles. Again, these types of sensors may not provide the required accuracy due to difficulties in distinguishing between closely spaced bicycles.

C.5 Video

Video recordings can be analysed to determine bicycle flow rates, speeds and headways. The time stamp of the video including the frame number allows an accurate time recording. A technique by Khan and Raksuntorn (2001) automatically determines bicycle-flow data and could greatly simplify the study of bicycle-flow characteristics. The technique estimates bicycle location data by transforming screen coordinates of video frames to ground or roadway coordinates. The process is called rectification and enables automatic recognition of location and hence speed and acceleration data.

Further research is needed in this important area and imaging technologies are expected to continue to improve.

C.6 Travel Time and Delay Studies

Travel time and delay information can be collected via a number of methods including questionnaires, video with time-stamp facilities and tagging.

In a tagging survey, cyclists entering a study area are given a card showing the time of arrival, classification and entry point. This information is updated as they pass other tagging points. The cards are collected and stamped with appropriate time and location information at the exit points. The method can yield a large amount of data on trip patterns and travel times. For detailed route information the cards need to be marked at a number of locations. The delay involved in this marking could well influence the travel time measures. Cards may also be lost or discarded.

Delay information is also of interest to traffic professionals. The delay of cyclists can either be a delay determined at a point in the traffic system or the delay over a route. The route delay can be determined by subtracting the unimpeded travel time along a route from the observed travel time measured in the study. The unimpeded travel time is the average travel time for a sample of unimpeded cyclists. Point delay can be determined by observing the number of cyclists stopping and measuring the length of time they are stopped. In situations where there is a large queue and the delay at different points in time is required, it may be necessary to employ a large number of observers or use techniques that do not involve detailed observation of individual movements. Appendix C of AGTM03 (Austroads 2013b) provides further details on travel time and delay surveys, some of which can apply in bicycle studies.

C.7 Behaviour and Conflict Studies

The illegal use of traffic signals and other facilities and incidence of queue jumping could influence the effectiveness of a facility. Information on the proportion of cyclists not observing regulations and making illegal manoeuvres can be collected using manual observation of the system. Video recording may also help. The unusual nature of the movements recorded, however, precludes most automatic methods of data collection.

C.8 Data Analysis and Results

The Australian Bicycle Council (2000) released a set of guidelines on the reporting of cycling data, which was an initiative under the national cycling strategy (Austroads 2005). The guidelines provide a framework for the reporting of comparable state and territory data, so that relevant comparisons could be made. The development of the guidelines allowed the measurement of progress towards a goal of increased cycling participation. The guidelines cover the reporting of bicycle ownership, infrastructure, usage, demographics and safety.

The Council recommended that data be obtained from existing data sources such as those from Australian Bureau of Statistics (2012) population census and household travel surveys of capital cities. Surveys should also be undertaken in stages to collect the appropriate data, which included the following in the first stage:

- bicycle ownership per capita
- bicycle network coverage (urban)
- cycling mode share
- cycling trip purposes
- proportion of population cycling
- cyclists age and gender
- cyclist injury rates – hospital reported
- cyclist crash rates – police reported.

C.9 Future Development

The development of new technologies has already automated a number of tasks in bicycle studies, as was described above. In the near future, advancements to existing technologies and the development of new techniques should see a further simplification of study techniques by decreasing the manual component even more. These include:

- Global positioning system (GPS) – GPS receivers and loggers can currently be installed in vehicles to record route, speed and travel time information. Hand-held units could provide similar information about cyclists (Stopher 2011).
- Geographic information system (GIS) – in all the questionnaire and interview techniques discussed above there is an opportunity to ask respondents to mark their routes on a map of the locality. These routes can be entered into a GIS and the frequency of trips along a particular route can then be easily determined (Richardson, Ampt & Meyburg 1995).
- Video – further development of video capture and data processing technology should enable accurate automatic recording of bicycle flow, speed, congestion, route and origin-destination data.
- Smart card – non-contact smart card technology already exists for payment of public transport fares (Luk & Yang 2001). This technology could be adapted to provide data on bicycle flows, in a study similar to the tagging survey described in Appendix C.6.

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Appendix D Human Powered Vehicles

Although the bicycle is the standard vehicle for the design of facilities, the use of tandem bicycles, tricycles and other 'pedal powered vehicles' may be popular in some areas and an allowance for these vehicles may be appropriate in the design of some facilities (refer to AGRD06A, Austroads (2017c).

There is limited information available on the needs, and operating characteristics of these vehicles, and in particular on their performance from the perspective of road and path design, or in relation to traffic management and safety. Therefore designers should make their own assessment of the required measures that need to be taken, accounting for the local use of these vehicles.

The aspects listed in Table D 1 may be relevant.

Table D 1: Human powered vehicle (HPV) – facility design considerations

Issue	Details
Sight distance	Consider low cyclist eye height (as low as 0.7 m above riding surface in some instances)
Braking performance	Due to factors such as the low centre of gravity and braking system, braking performance of a recumbent tricycle can be significantly more effective than a standard bicycle. Conversely, tandem bicycles may have a lesser performance
Median or refuge width	Additional length of some HPVs may necessitate special consideration
Turning paths	Refer to Table D 2
Width (of road and path facilities)	Use vehicle design envelope equal to difference in inner and outer turning path radii, plus 0.3 m (0.4 m for tandem). If greater than bicycle design envelope width then increase path or road treatments accordingly
Path terminals	Give due allowance for lesser turning capabilities and in particular avoid chicanes
Speed	May be relatively high for tandem bicycles. May be lower for elderly cyclists, or cyclists with a disability
Gradients	Path gradients may have to be flatter for elderly cyclists, or cyclists with a disability
Education	Make available relevant advice e.g. conspicuity for low vehicles

Source: Austroads (2017c) Table C2 1.

The following example vehicle dimensions may be helpful as a guide.

Table D 2: HPV dimensions

	Overall vehicle width (m)	Inner turning path radius (m)	Outer turning path radius (m)	Length (m)
Recumbent touring tricycle (Greenspeed)	0.9	1.4	2.3	1.95
Tandem recumbent touring tricycle (Greenspeed)	1	3.1	4.1	3.5
Tandem bicycle (Cannondale)	0.56	1.85	2.55	2.45
Bicycle with two wheel trailer (Coolstop)	0.82	0.7	1.85	2.67
Bicycle with BOB trailer (i.e. Beast of Burden)	0.56	0.9	1.6	2.8
Bicycle with hitch-bike (Thorogood)	0.56	1.7	2.55	1.7

Source: Austroads (2017c) Table C2 2.

Appendix E Route Planning and Directional and Wayfinding Signage for Cyclists

E.1 Introduction

The active transport and recreational needs of communities are efficiently served by the development of regional and local networks of interconnected cycling routes linking major trip origins to destinations. The planning of these networks is undertaken by government agencies and local governments as part of regional and municipal bicycle plans.

Directional signs provide wayfinding and informational guidance for cyclists across these cycle networks. These guidelines deal only with directional signs for cycling routes (both on- and off-road) within a cycling network. They do not cover the many other aspects of cycling network signs and markings, such as regulatory and warning signs, linemarking, regulatory pavement symbols and behaviour signs for which there are separate guidelines (Table E 1).

Table E 1: Reference documents for cycle network signs

Contents	References
Regulatory, warning, advisory and directional signs. Linemarking and pavement symbols	Australian Standard AS 1742.2-2009: Manual of Uniform Traffic Control Devices: Traffic control devices for general use NZ Traffic Control Devices Manual – Part 2: Direction, Service and General Guide Signs (NZ Transport Agency 2011)
Design, layout and dimensioning of individual directional signs	Australian Standard AS 1743-2001 Road Signs - Specifications
Detailed directional sign planning, installation guidance and resources	Bicycle Wayfinding – Publication no AP-R492-15 – Austroads (2015g) A Guide to Signing Cycle Networks (Queensland Department of Transport and Main Roads 2009) (available for download from the TMR website: www.tmr.qld.gov.au) Main Roads Western Australia guidance on Bicycle Directional Signs outlined in three parts • Part A: Policy Statement • Part B: Application and Approval Guidelines, • Part C: Technical Guidelines

Source: Austroads (2016d) Table A 1.

These guidelines are designed to assist road designers, engineers and transport planners to provide high quality, professional and consistent directional signs for cycle networks across Australian and New Zealand cities and towns. Directional signs enable riders to use cycle networks to their full potential and make quick and accurate route choices.

The guidelines provide guidance and advice on the following issues:

- planning a directional sign system (focal point mapping, destination and decision points)
- route hierarchy and the types of signs appropriate for each type of route in the cycle network
- facility naming, route numbering and route branding
- location and mounting of signs
- special sign situations such as marked detour routes, tourist destinations and routes through complex intersections.

The purpose of the signs is to provide wayfinding and directional assistance for cyclists using routes which comprise a wide range of facilities, some of which may be shared with motorists or pedestrians. Directional signs have no regulatory purpose or intent and do not imply an use by cyclists of paths shared with pedestrians or streets shared with drivers. In practice, care should always be taken to ensure that directional signs are fully supported by regulatory signs relevant to the street/path facilities that comprise the cycle route.

In the interests of uniformity, local governments and private sector large-scale landowners are encouraged to apply these guidelines when installing directional signs for cycling route facilities on streets, roads and paths under their control. To assist cycle network providers with the implementation of the guidelines, the Queensland Department of Transport and Main Roads resource manual, *A Guide to Signing Cycle Networks* (Queensland Department of Transport and Main Roads 2009), is recommended. This publication contains additional information and advice on the practical aspects and processes involved in the installation of cycle network directional sign systems.

E.1.1 Application of the Guidelines

The guidelines (Table E 1) are intended to supplement guidance on directional signs for cycling networks described in Section 5 of Australian Standard AS 1742.9: Bicycle Facilities, Australian Standard AS 1743-2001 Road Signs – Specifications and the NZ Traffic Control Devices Manual Part 2: Direction, Service and General Guide Signs (TCDM-2) (NZ Transport Agency 2011). In each jurisdiction, additional guideline supplements may apply and practitioners should consult them to determine the most appropriate sign implementation.

E.1.2 Signing Routes With and Without Cycle Infrastructure

Cyclists are legally defined as vehicles and can use public roads unless specifically prohibited for operational safety reasons (e.g. urban motorways). The lack of cycling infrastructure along a route, such as cycle lane markings, regulatory and warning signs and bicycle pavement symbols, does not necessarily mean that the route is unsuitable for cycling.

It is noted that cyclists have differing levels of competency and sensitivity to traffic. Experienced cyclists will often prefer unmarked wide kerb side traffic lanes to marked cycling/car parking lanes due to their close proximity to opening car doors. Others (such as children, new adult riders and the elderly) may prefer to avoid trafficked roads altogether and ride off-road.

Fitting a route with a system of directional signs provides all cyclists with important wayfinding information which helps them to more effectively use their bicycles for a wide range of local and regional trips. Without these signs it is difficult for them to take full advantage of the road system and to use their bicycles as an efficient means of transport.

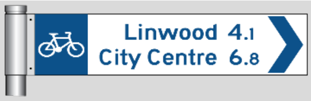
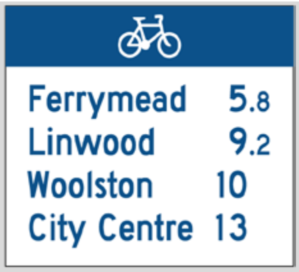
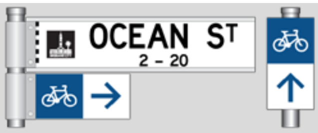
On routes where off-road cycling facilities are provided, the needs of on-road cyclists are always considered. This may often mean the installation of additional signs at junctions or turning points to address the separate cycling travel paths of each user group.

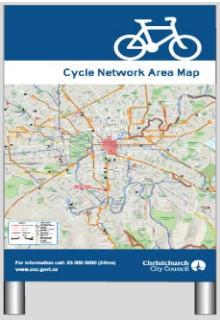
E.2 Sign Designs

There are eight types of cycle directional signs and a set of directional pavement indicators used on cycle networks. Each route type has its own family of signs consisting of some or all of these sign types. Pavement markings can be used on all route types for wayfinding guidance.

The various types of bicycle wayfinding signs as detailed in Austroads (2015g) are outlined in Table E 2. Included is the type, description and example of each of these sign types.

Table E 2: Bicycle wayfinding sign types

Bicycle wayfinding sign type	Description	Example
Fingerboards	Fingerboards are double-sided direction signs used at intersections and route turnings to show the way to destinations further along the route. When fingerboards are located at junctions with other routes they also show distances to the destinations shown on the sign. Fingerboards are used to mark all route types	
Direction indication signs	Direction indication signs are used in place of fingerboards where that type of sign cannot be used due to siting/mounting or legibility issues. Direction indication signs can show destinations only (at turning points) or destinations and distances (at junctions with other routes). Direction indication signs are used on veloways and primary routes	
Advance direction signs	Advance direction signs are used to indicate the destination choices in advance of a route junction. They are used on veloways and primary routes at junctions with other veloways or primary routes. They can be used on veloways or primary routes at junctions with local or tourist/recreational routes if those routes are of importance and connect to a major trip attractor relevant to cycle traffic on the primary route	
Reassurance direction signs	Reassurance direction signs are used following route junctions on veloways and important primary routes to reassure cyclists that they are following the correct route. These signs also indicate the distances to multiple destinations on the route being followed. They are usually only used on high-speed, limited-access veloways but can be used on important primary routes if reassurance is needed due to complex navigational situations	
Location signs	Location signs are used at underpasses or bridges over a cycle route to identify cross streets/roads which are not otherwise signed due to the remoteness of the site. Location signs can be used on all types of route	
Facilities/services signs	Facilities/services signs are simple one-line fingerboards used to indicate nearby facilities and services easily accessible from a route. These signs can be used on all types of route	
Route markers	Route markers are simple direction arrow signs used to indicate route turns in place of other types of directional signs. Route markers are used on local and tourist/recreational routes to indicate route turnings in between junctions with fingerboards. They are not used on veloways and primary routes. Direction indication or fingerboards should be used on these routes	

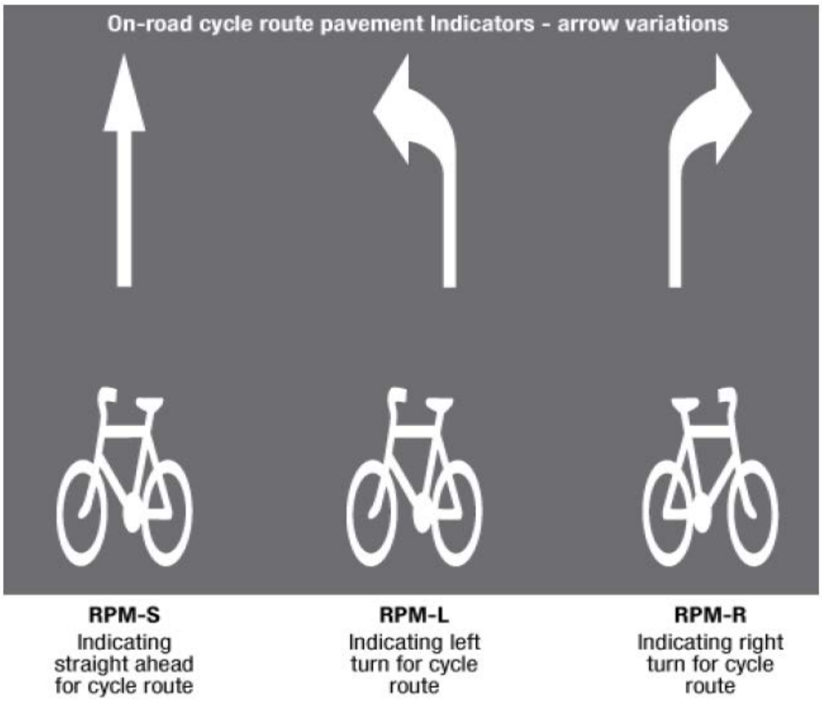
Bicycle wayfinding sign type	Description	Example
Map signs	Map signs are used on veloways and primary routes to provide additional wayfinding information to cyclists such as other routes and destinations within an area covered by a network map	
Project signs	Project signs are used on cycle facilities to provide information about new/changed cycleway and shared path infrastructure projects. Project signs are usually installed following the announcement of a project and can remain in position for up to two years after completion to highlight the public investment in the new infrastructure Project signs should meet the following objectives: • communication of critical project information • identification of the funding authority • delivery date Project signs may additionally list the following: • future planned infrastructure details • funding scheme (if applicable) • cycle network infrastructure funding agency additional involvement	

Source: Austroads (2016d) Table A 2.

E.3 Directional Pavement Markings

Route directional pavement markings (Figure E 1) indicate on-road route turns to warn cyclists of on- to off-road transitions which may be difficult to see from a distance or at speed. Directional pavement markings are a useful aid to navigation and provide an important supporting role to signs. The pavement markings can be used on all types of route as an aid to navigation.

Figure E 1: Directional pavement marking example



E.4 Cycle Route Types

Cycle networks consist of five distinct route types: veloways, primary, local, tourist/recreational and long-term detours. Each route type (Table E 3) uses a different combination of sign types appropriate to the needs of the route within the overall network hierarchy. Design details for each sign type, including sign variations and recommended usage, are provided in Austroads (2015g).

Table E 3: Cycle routes and the sign types used on each route type

	Route types				
Sign types	**Veloway**	**Primary**	**Local**	**Tourist/ recreational**	**Long-term detours**
Route type description	High-speed, limited-access routes usually paralleling major arterial roads or motorways	The main arterial routes of urban cycle transport networks	Shorter routes connecting primary routes to local destinations	Off-road, shared path and tourist/recreational routes	Long-term detour routes for veloways, primary or tourist/recreational routes
Fingerboards	Yes, at junctions with other routes and where the route changes direction	Yes, at junctions with other routes and where the route changes direction	Yes, integrated with street signs	Yes	Yes
Direction indication signs	Yes, at junctions with other routes and where the route changes direction	Yes, at junctions with other routes and where the route changes direction	No, use markers instead	No, use markers instead	Yes

Route types					
Sign types	**Veloway**	**Primary**	**Local**	**Tourist/ recreational**	**Long-term detours**
Advance direction signs	Yes, before route junctions with veloways or primary routes	Yes, before route junctions	No, use markers instead	No, use markers instead	No
Reassurance signs with distances	Yes, after route junctions with other veloways or primary routes	Only on lengthy remote routes for reassurance	No, use markers instead	No, use markers instead	No
Route markers	No, use direction indication signs	No, use direction indication signs	Yes	Yes	No, use direction indication signs
Route numbering	Yes	Yes	No	Yes	Yes, if route replaced by detour is already numbered
Route branding	Yes	Yes	No	Yes	No
Street signs	Yes, if none exist	Yes, if none exist	Yes, if none exist	Yes, if none exist	Yes, if none exist

Source: Austroads (2016d) Table A 3.

E.5 Developing a Directional Sign Plan

The methodology recommended in these guidelines for planning and implementing cycling sign projects is similar to other transport systems such as highway and arterial road signs. A key requirement is that routes are planned and signed within the context of the surrounding regional cycle network. This planning enables routes to be fully signed indicating the full range of destinations available across a region rather than within a narrow corridor.

The following steps for developing a directional sign plan are outlined in the following sections (Austroads 2016d):

- Document the current (and planned) cycle routes (Appendix E.5.1).
- Create (or update) the focal point map for the region (Appendix E.5.2).
- Document any facilities which will need to be named on signs (Appendix E.5.3).
- Document any route numbering which will be required on signs (Appendix E.5.4).
- Document any route branding which will be required on signs (Appendix E.5.5).
- Conduct a pre-sign, risk assessment survey (Appendix E.5.6).
- Document all junctions with other routes (Appendix E.5.7).
- Prepare a sign schedule covering the route (Appendix E.5.8).
- Prepare a sign artwork files for the sign manufacturer (Appendix E.5.9).

E.5.1 Identify Cycle Routes

When considering cycling routes for sign projects, it is essential to differentiate between cycle routes and cycling facilities. Cycle routes are continuous connections which facilitate travel within an area served by the cycling network. Each cycling route can consist of many types of cycling facilities from on-road lanes and separated off-road cycleways within the road corridor to low-traffic volume local streets with little or no linemarking or explicit cycling facilities.

The lack of defined regulatory cycling facilities and engineering treatments such as bicycle lanes and paths should not prevent the installation of directional signs along a designated route providing that the usual road safety and traffic management practices are followed. A cycle route only has to be assessed as legally rideable for it to be considered for signing.

The planning phase for signing cycle networks and their component routes is only concerned with cycle routes. The type and existence of cycling facilities is a key consideration in the implementation phase of a sign project, as the precise siting of any directional signs should be directly influenced by the facilities.

The first stage in developing a sign plan for a route or routes is to identify all interconnecting cycle routes and the destination names (focal points) used on these routes which should be included on signs. For example, at a junction of two primary routes, the advance direction signs on each approach will list the next focal point for the route being followed and those for each intersecting route. At route junctions, fingerboards for other intersecting routes are usually installed at a later stage when the full sequence of signs for those routes are being installed.

E.5.2 Create a Focal Point Map

When planning and designing directional signs for cycling routes utilising a network approach, designers first need to determine the destination and decision points (route junctions) for each route within the network. These details can then be used for single or multiple-route sign projects. The key tool for the coordinated development of directional sign systems for cycling is the focal point map for a region.

A focal point map is a planning document used by the cycle network’s manager to establish the destinations which appear on directional signs for the network. A key aim is to achieve rigid consistency in the use of named destinations so that a coherent system of signs can be developed to enable direct and unambiguous navigation around the cycle network. Only those destinations appearing on the focal point map are used on cycle network signs.

This map is usually maintained by a government authority responsible for the regional cycle network. This could be a centrally located council working in consultation with the road agency and neighbouring councils. As cycle networks are more urban-oriented than the main road network, they may use different focal points to highway/arterial road focal point maps within the same area or region.

The following guidelines apply to focal point mapping methodology for cycle networks. Further details can be found in Austroads (2015g):

- Focal points are significant destinations within a region where routes join, cross or terminate. They are indicated in the focal point map by a solid disc symbol. At complex junctions where routes overlap or cross, small red arrows are sometimes used on the map to clarify the paths for each route. For an urban cycle network, it is recommended that focal points be spaced at approximately 5 km.
- Terminal destinations are focal points where routes terminate. This may lie beyond any junction with another route or where a route terminates by joining another route at a T-junction etc.
- Sub-destinations are important intermediate centres along a route. To keep sign content compact, only one sub-destination is listed with the next focal point destination until the sub-destination is reached.
- In areas where a focal point is needed but is not immediately apparent, the focal point map designer consults with stakeholders to determine the most appropriate destination name to include on route direction signs.

City centre focal points are used in large and complex metropolitan CBDs where many routes converge but do not intersect neatly at a single junction. A city centre focal point is usually defined as a small area encompassing all route junctions with a compact geographical area. Primary routes leading to the city centre are considered to have reached it when they are at the defined boundary even though this may be a distance from the actual geographical centre of the city. The destination wording (used for the particular city centre) should continue to be used on signs between the boundary edge and the geographical centre. It is usual practice to list any destinations on the opposite side of the city centre which that route may connect with and continue onto. This practice further assists with route-finding within a complex area.

E.5.3 Identify any Named Facilities

Veloways, primary and tourist/recreational cycle routes may occasionally use all, or sections of, path facilities which have been named by a local council or government agency. The use of cycle facility names on cycle route signs should be kept to a minimum as it can place heavy demands on available sign space often increasing the physical size of signs and does not necessarily improve wayfinding.

Veloway and primary route signs can include facility name indication as follows:

- Facility name indication is limited to the start and finish of the named facility or at junctions where other primary routes enter the facility.
- The length of a facility name sign or integrated facility name box should not exceed the length of the associated route sign. Lengthy facility names are abbreviated or the facility name shown using the more condensed AS 1744-2015 Series C typeface.
- On veloways and major primary routes, the names of significant intersecting streets/roads (route exit points) may be shown on signs using a similar layout.

E.5.4 Identify any Numbered Routes

In densely populated cities where there are far more route options than in smaller centres, route numbering may make it considerably easier for users to navigate their way around the cycle network. Route numbering may also be appropriate on longer-distance (inter-city) routes as numbered routes can extend across an entire metropolitan or city area.

Adoption of a system of cycle route numbering is sanctioned by the appropriate authorities responsible for the cycle network within a city, region or state. Planning and maintenance of the cycle route numbering system is the additional responsibility of an inter-governmental group or agency/jurisdiction which maintains the focal point map for the cycle network within that city/region. If route numbering is sanctioned, the numbering system is applied consistently on all network directional signs within the region.

There are three levels of numbered routes recommended:

- Alpha-numeric numbered routes (white letter/number on a blue background). These are usually higher-speed, limited-access veloway routes or ‘cycling super highways’ offering the highest quality level of service and access to urban centres for cyclists. This type of route uses an alpha-numeric code comprising the letter V (for veloway) followed by the route number in the series. The use of this type of route numbering is limited to a small number cycle routes within a capital city or between cities within a densely populated region (such as the V1 in Southeast Queensland which links Brisbane to the Gold Coast using the M1and M3 Motorway corridors).
- Two-digit numbered routes (white numbers on a green background). These routes are the core primary routes for the metropolitan cycling network providing continuous cycle travel between major urban centres.
- Three-digit numbered routes (white numbers on a dark brown background). These routes are major urban or rural tourist/recreational facilities providing a continuous route throughout the region. Examples of this type of route are: lengthy and continuous urban recreational routes, rural rail trails, urban on-road training routes, and long distance rural routes on and off roads.

Veloway, primary and tourist/recreational route signs can include route numbering indication as follows:

- Route numbering can be used on signs and markers.
- Route numbers can be associated with a single destination, a group of destinations or a route.
- Route numbering and route branding are separate systems with potentially overlapping segments.

Examples of route numbering signs are shown in Austroads (2015g).

E.5.5 Identify any Branded Routes

Longer tourist/recreational routes are being developed in many Australian and New Zealand communities. Part of the implementation of these routes, which may often pass through a number of local government areas, is the application of a common branding and promotional identity which often encompasses design elements such as a branding logo, specialist wayfinding and facilities sign designs.

Veloway, primary and tourist/recreational route signs can include route branding indication as follows:

- Logos are the preferred method of branding. Logos use a simplified design and are instantly recognisable.
- Cycle route branding can be integrated into sign designs or installed as a separate sign above or below fingerboards. When an external route branding sign is used with a fingerboard for the same route, the branding sign is mounted above the fingerboard. If an external route branding sign is installed with a fingerboard for an overlapping primary or tourist/recreational route, the external branding sign is fixed below the fingerboard.
- Route numbering always takes precedence over route branding.
- Route branding and route numbering are separate systems with potentially overlapping segments. When branding logos are used on the same destination line as route numbers, the route number indicator is positioned next to the destination name.

Examples of branded routes are shown in Austroads (2015g).

E.5.6 Conduct a Pre-sign Risk Assessment

Prior to the installation of directional signs on a cycle route it is recommended that a physical risk assessment of the route is made. This assessment will study the route to determine if it can be legally cycled. The condition of existing cycle facilities on and off road, intersections/crossing points and any critical safety issues will be noted. Where major deficiencies occur in the permanent infrastructure (one-way streets preventing two-way cycle access, off-road sections where cycling is not permitted, continuous medians preventing route turns etc.) remedial action will be recommended and carried out prior to sign installation.

The type and extent of remedial work will usually depend on the structure of the road environment and the availability of any bicycle-specific treatments and infrastructure. Recommendations for pre-sign risk-assessment procedures are provided in the Queensland Department of Transport and Main Roads publication *A Guide to Signing Cycle Networks* (Queensland Department of Transport and Main Roads 2009) (search title on the TMR website www.tmr.qld.gov.au).

E.5.7 Design Sign Layouts For Route Junctions

Figure E 2, Figure E 3, Figure E 4 and Figure E 5 show recommended intersection sign layouts for the four route types: veloways, primary, local and tourist/recreational routes. The examples show usage of various bicycle wayfinding signage referred to in the previous sections. Due to the complexity of intersections it may often be advisable to use a graphical presentation for advance direction signs.

Figure E 2: Typical intersection sign layout for veloways

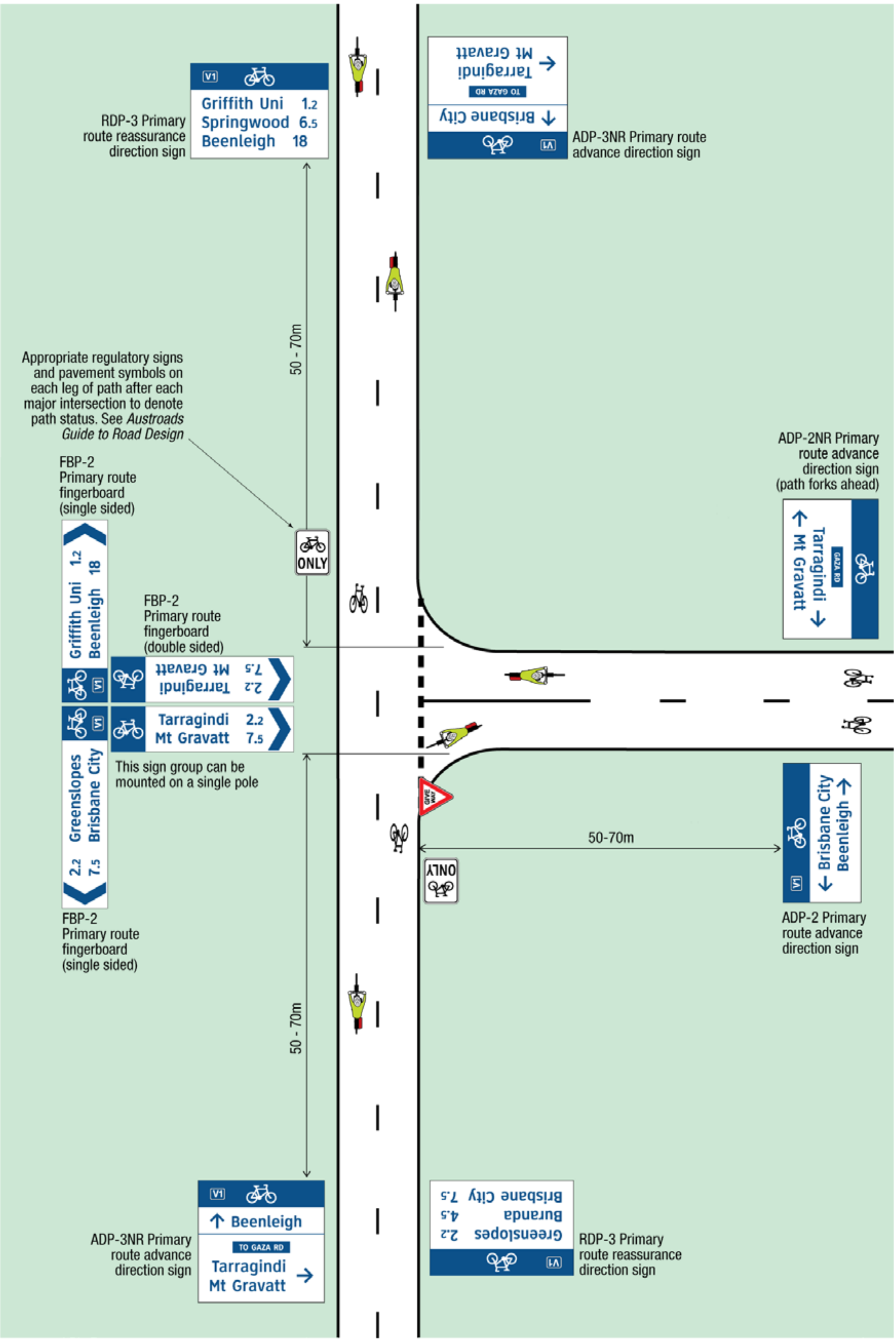


Figure E 3: Typical intersection sign layout for primary cycle routes

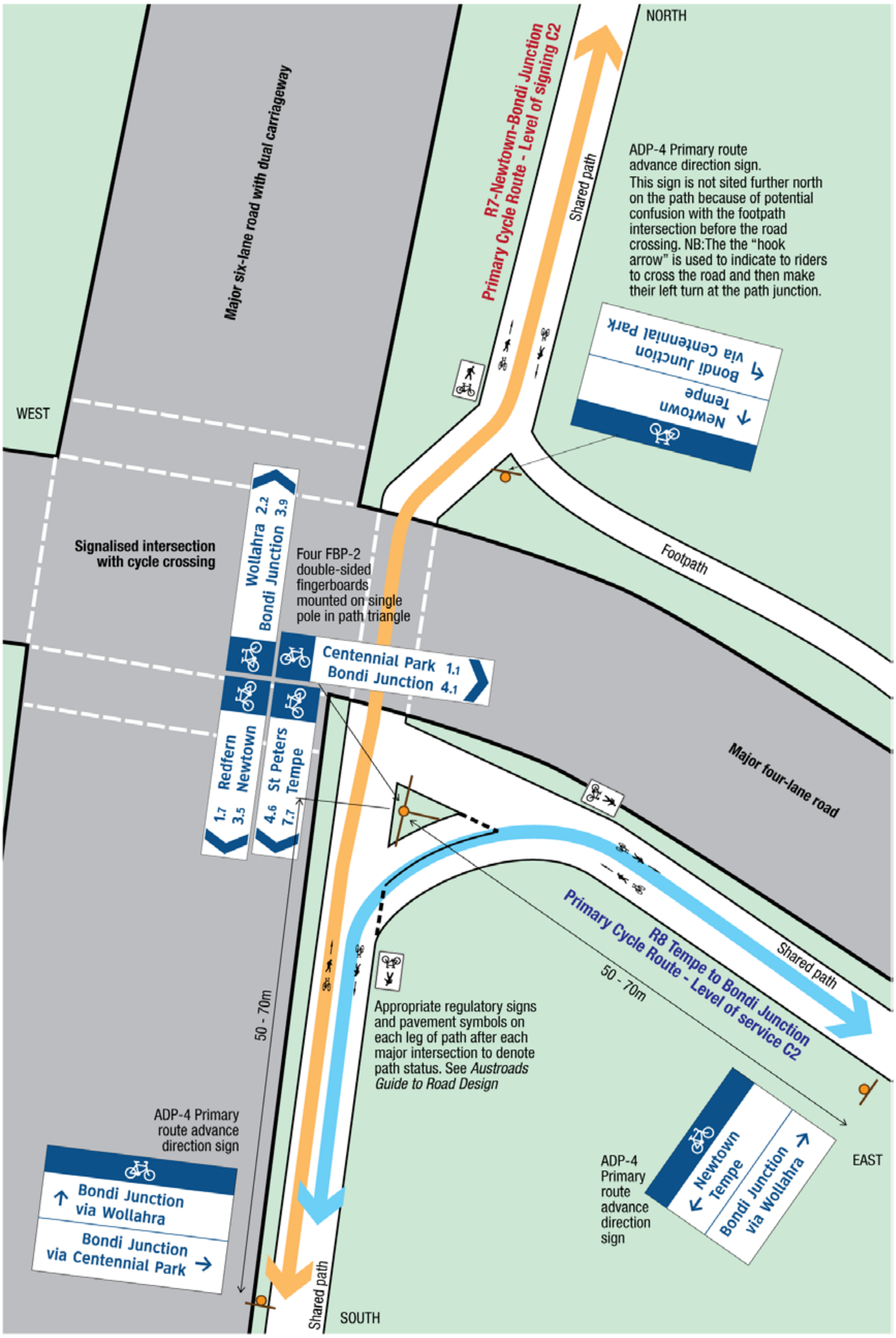


Figure E 4: Typical intersection sign layout for local cycle routes

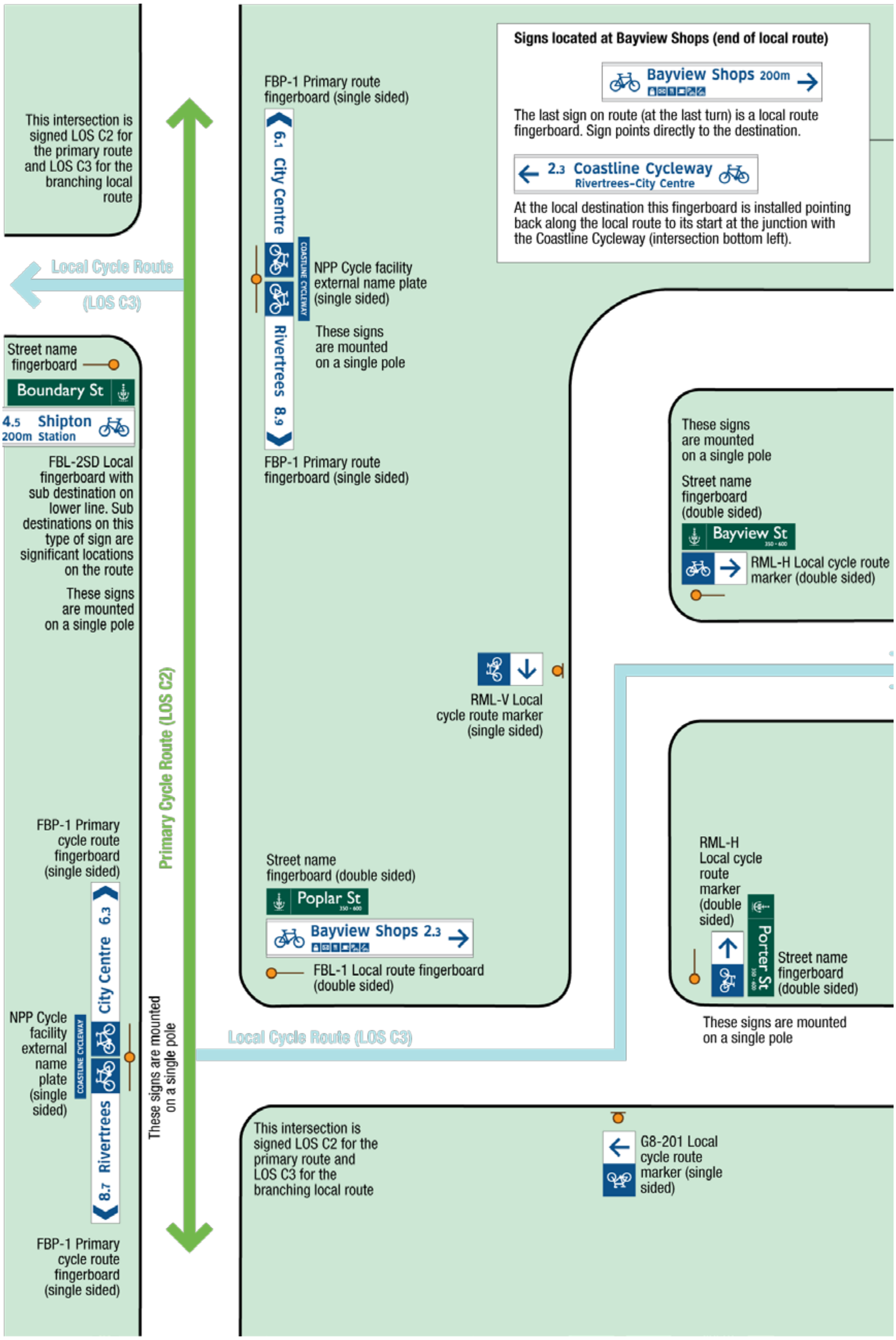
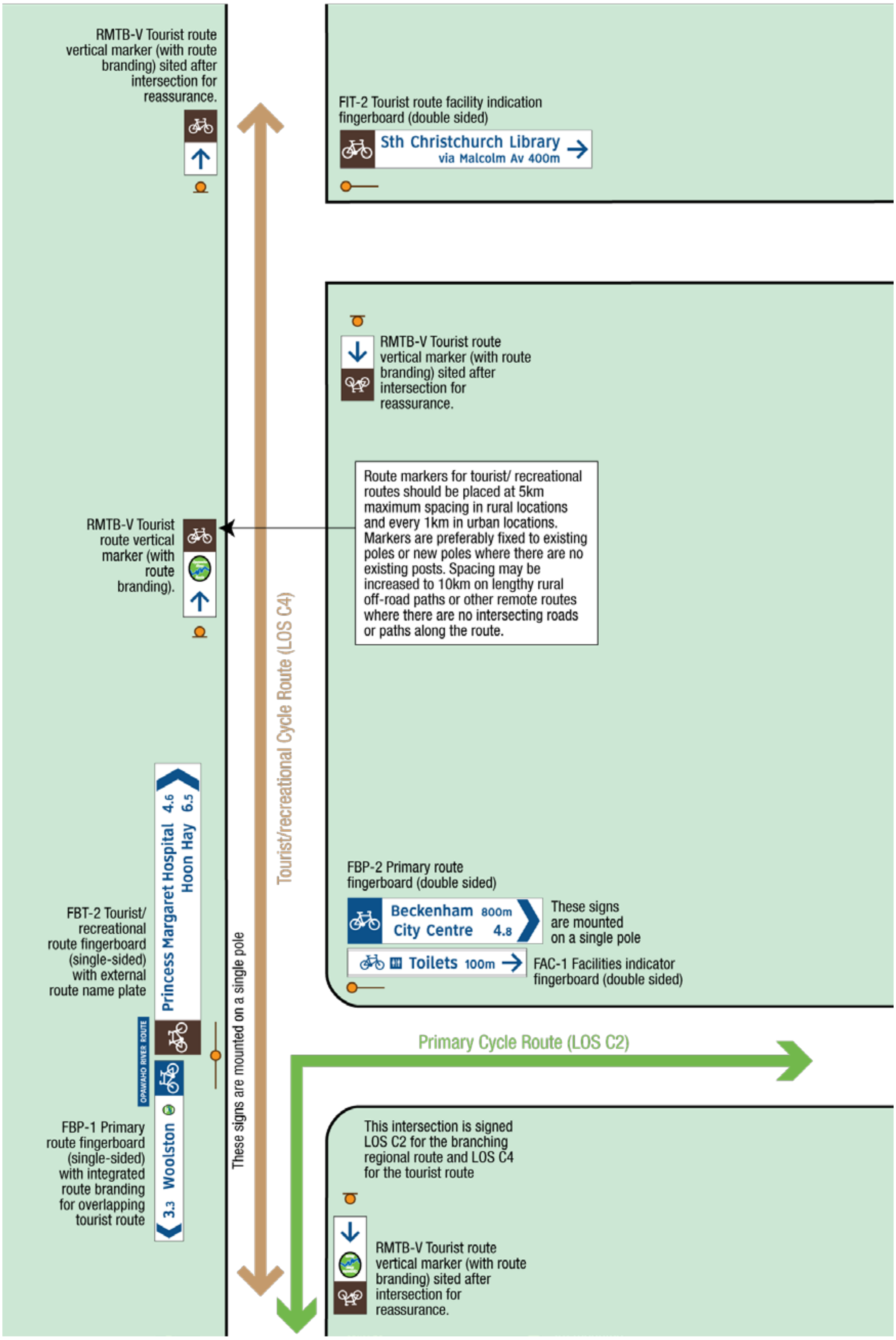


Figure E 5: Typical intersection sign layout for tourist/recreational cycle routes



E.5.8 Create Sign Schedules

A sign schedule (detailing the location, type and lettering) is the key reference document used to specify the content and location of all signs in the project. Typical details included in a sign schedule are:

- Contents for all signs in the project (including destinations, distances and direction arrows). To determine which destinations to show on advance direction signs for intersecting routes, refer to the focal point map which lists all destinations applicable for each route.
- Precise location of each sign. It is recommended that marked-up site photos, detailed site maps or diagrams be appended to the sign schedule to ensure an accurate communication with the sign installer for each sign's particular siting requirements.
- Mounting details/requirements (new pole, existing poles, modifications to existing, fixing type etc.).
- New signs found necessary by the site assessment – missing regulatory signs, services and facilities signs, signs indicating connecting paths to the street system, additional signs at junctions for separate on- or off-road facilities and street name signs at junctions and route turns.
- Redundant signs to be removed.
- Additional works required to fully install the signs (minor tree pruning and branch removal where vegetation obscures signs when installed).

E.5.9 Prepare Sign Artwork for Manufacture

The completed route sign schedule can then be used to manufacture the signs. The first stage of this process is to transfer the information in the sign schedule into electronic artwork for each sign. This work is usually undertaken 'in-house' by the sign manufacturer or by an external graphic artist.

It is recommended that the sign project designer/planner recheck all electronic sign layouts for accuracy prior to sign fabrication. Sign layouts should conform to the sign layout templates in AS 1743-2001.

E.6 Signing Complex Intersections

Often it is not possible to indicate a simple path through a road intersection due to the size and location of the roads through the junction and the complexity of the intersection layout. This is particularly an issue when routes transition between on- and off-road facilities at large multilane, signalised intersections. Appendix B of Austroads (2015g) provides examples of how to provide bicycle wayfinding through a complex intersection.

E.7 Sign Installation

The manufactured signs can be installed according to the sign schedules and detailed siting instructions provided by the sign system planner/designer. Additional advice and recommendations on sign installation issues are provided below.

E.7.1 Sign Mounting and Clearances

Signs are mounted in full view of cyclists using the cycle route, and located so that they provide clear unambiguous directions at critical turning points or junctions. Care is needed to place signs where they can be clearly seen by cyclists and in a location where their message is not compromised or overwhelmed by proximity to other road signs or structures.

Cycle network signs should be sited so that they do not diminish the effectiveness of, or conflict with, existing road signs and create ambiguity for other road users.

Cycle network signs, like highway signs, are a discrete system designed to guide cyclists through often complex road environments. Cycle route signs are not included with, or mounted on, main/arterial road directional signs or sign supports. Cycle route directional messages are not included or integrated into main/arterial road signs.

Sign clutter should be minimised by utilising existing sign poles and street poles where this does not compromise the effectiveness of the direction sign or the host sign. Mounting on existing power poles is permissible provided that the council or road agency has an arrangement with the power utility to sanction this. In urban environments some councils permit the co-use of parking sign poles as a clutter reduction measure.

Signs should be mounted at a clearance height of 2.5 m and preferably no higher than 4 m. Sign supports need a minimum of 0.5 m clearance from the cycleway or roadway. Do not mount signs so that they overhang the roadway or interfere with turning vehicles.

Where there is a risk that signs could be rotated by either wind or vandalism, use anti-rotational fittings or fixing screws can be used. This is particularly important on fingerboard signs which indicate travel direction at intersections.

Map and information display signs need to be mounted with sufficient horizontal clearance (1.5 m minimum, 2 m preferred) to permit cyclists and other path users to comfortably view the sign and still provide clearance to other street/path users.

Route markers for tourist/recreational routes on rural routes are placed at 5 km maximum spacing and generally located on existing sign posts or new route marker posts where there are no existing sign posts. Spacing may be increased to 10 km along off-road paths or other remote routes where there are limited or no intersecting roads/paths along the route. In urban environments, markers should be placed on continuous or branded recreational routes at 1 km intervals increasing to 2 km where there are no intermediate junctions.

E.7.2 Sight Distances and Sign Visibility

At cycle route junctions/decision points, directional signs need to be positioned so that cyclists can safely read the signs and comfortably follow their chosen route. Stopping distance and the sight distance to the intersection are also important in hilly conditions.

When placing advance direction signs it is essential to take into account all local variables such as slope and sight distances. Signs should be located to provide adequate warning of a change of direction depending on the site. Table B.9 in Austroads (2015g) lists recommended mounting distances for advance direction signs.

If two signs indicating separate directions cannot be mounted on the same pole on one corner of an intersection due to site conditions, separate mounting of the signs should be considered. This also applies to mounting signs on existing sign or power poles (where an agreement exists between the road/street/path owning authority and the power supply company) provided that such mounting offers superior sight lines and visibility for the sign(s).

E.7.3 Sign Legibility and Lighting

Direction signs need to be easily readable in either day or night conditions. Signs located in a normal urban environment usually have adequate ambient lighting. If possible, signs should be located under, or adjacent to, overhead lighting.

E.7.4 Sign Stack Mounting Order

At major junctions it is important to place fingerboards in a logical vertical order so that cyclists can easily follow the signs for a particular route. Generally, fingerboard pairs for a continuous route through a junction are placed together in the vertical sign stack. Ideally fingerboard pairs for the same route are mounted at the same level but this may not be possible due to mounting system limitations. Always consider sign visibility from different approaches for large sign installations when multiple routes pass through junctions.

E.7.5 Integration with Existing Path Signs

Many local governments are implementing wayfinding sign systems to assist people using shared paths and urban greenways. Many of these paths have been developed with unique signs and branding. Cycle network signs installed as an overlay on existing paths (with existing signs) require careful sign placement to ensure the needs of path users and the cycle network are fully accommodated.

Cycle network signs should be kept to a minimum at locations as follows:

- entry to the path where the primary route joins
- path-branching intersections of other primary and local routes
- exit from the path of the primary route.

Existing path signs should provide the necessary destinations, distances, directions to facilities, cross-street/access-path naming and map signs. Off-road paths and path junctions are signed the same as on-road routes. Where no existing path sign system is in place, normal cycle network signs are applied throughout the path.

E.7.6 Post-installation Check and Review

Following installation, the location and sign contents are finally checked on site by the sign system planner/designer. All signs need to point in the right direction and be easily visible to cyclists riding the route. Signs wrongly installed or containing inaccurate information need to be documented and supplied to the sign installer for rectification.

E.8 Sign Maintenance

Cycle network direction signs can be installed during the implementation phase of a cycleway project or retrofitted as part of a longer-term program for high quality wayfinding and directional sign systems across a cycle network.

The maintenance of cycle route direction signs is usually the responsibility of the government agency, local government or private landowner that owns or operates the road, street or path. It is important that ongoing sign maintenance responsibilities be assigned and carried out, particularly where joint funding and partnership arrangements have installed the signs and infrastructure. Any ongoing maintenance of cycle network infrastructure needs to include the maintenance of the sign system.

E.8.1 Sign Defect Reporting Systems

Asset managers/owners are increasingly interested in accurate reporting systems which allow them to more efficiently maintain infrastructure such as cycling network directional signs.

Internet-based infrastructure defect reporting systems are currently used by a number of Australian and New Zealand councils and government agencies. It is important that these systems be accessible to the cyclists who regularly use the network to ensure prompt reporting of missing or damaged signs. This type of reporting system is recommended as it encourages network users to report faults which may otherwise take much longer to detect under the asset authority's regular maintenance inspections.

It is essential that asset items relating to cycling signs be added to existing internet-based defect reporting systems as soon as directional signs are installed so that users may make an accurate selection from the reportable faults listed on the system.

E.9 Alternative Sign Design Options

Alternative sign design options include providing travel time and shared route markings. Detailed guidance on these markings is outlined in Appendix B of Austroads (2015g).

AGRD 06A
Appendix C

Appendix F Construction and Maintenance

F.1 General

Careful location, design and construction of paths for cycling can reduce future maintenance requirements. Careful attention to drainage, the location of vegetation and the type of vegetation planted can assist in minimising maintenance. A large amount of maintenance can be prevented if debris is not washed onto paths, and if appropriate plant species are selected so they do not cause pavement damage and trimming of overhead branches is not required.

The path alignment and cross-section should be designed to minimise the amount of debris, which can wash onto the path surface. Paths adjacent to watercourses should be located so that the likelihood of inundation and the resulting slippery surface is reduced.

Bushes that will not grow tall enough to obstruct sight distance should be planted on the inside of curves. Trees should be chosen and planted away from the edge of paths so as to minimise the likelihood of roots causing deformation and cracking of the path surface.

Paths for bicycles should be included in asset management programs in a similar manner to roads, to ensure a safe and useable riding surface and also to avoid the increasing cost of maintenance or reconstruction as a result of the asset degradation.

It is essential for effective maintenance operations that all aspects of the design allow for ease of access for all necessary maintenance plant (i.e. truck, backhoe, and mowers), not only to the path but abutting reservations that do not have alternate access. As the construction may not be performed by the agency performing the maintenance, consultation should be undertaken throughout the design process in order to determine maintenance requirements.

F.2 Path Maintenance Requirements

Regular maintenance activities on paths should include:

- filling of cracks (Figure F 1)
- trimming or removal of grass so that it does not intrude into the path
- sweeping of paths to remove debris such as broken glass and fine gravel (including that arising from construction and maintenance activities such as crack sealing)
- re-painting of pavement markings
- cleaning of signs
- trimming of trees and shrubs to maintain safe clearances and sight distances.

Figure F 1: Asphalt paths requiring maintenance

(a)

(b)

F.3 Pavements

F.3.1 Pavements for Bicycle Paths

The pavement of paths for cycling must be designed and constructed to a standard that ensures a satisfactory level of service for cyclists throughout the life of the facility.

The maintenance activities discussed previously require the use of a truck and other substantial machinery. If paths are not designed to carry the live loads imparted by this equipment then pavements will suffer structural damage, which will affect use of the facility, and be expensive to repair. All paths should therefore be designed to withstand at least a fully laden small truck.

Most paths should have a hard weatherproof surface. Primarily they can be constructed as a flexible pavement of crushed rock surfaced with asphalt or a bituminous seal, or as a rigid concrete pavement.

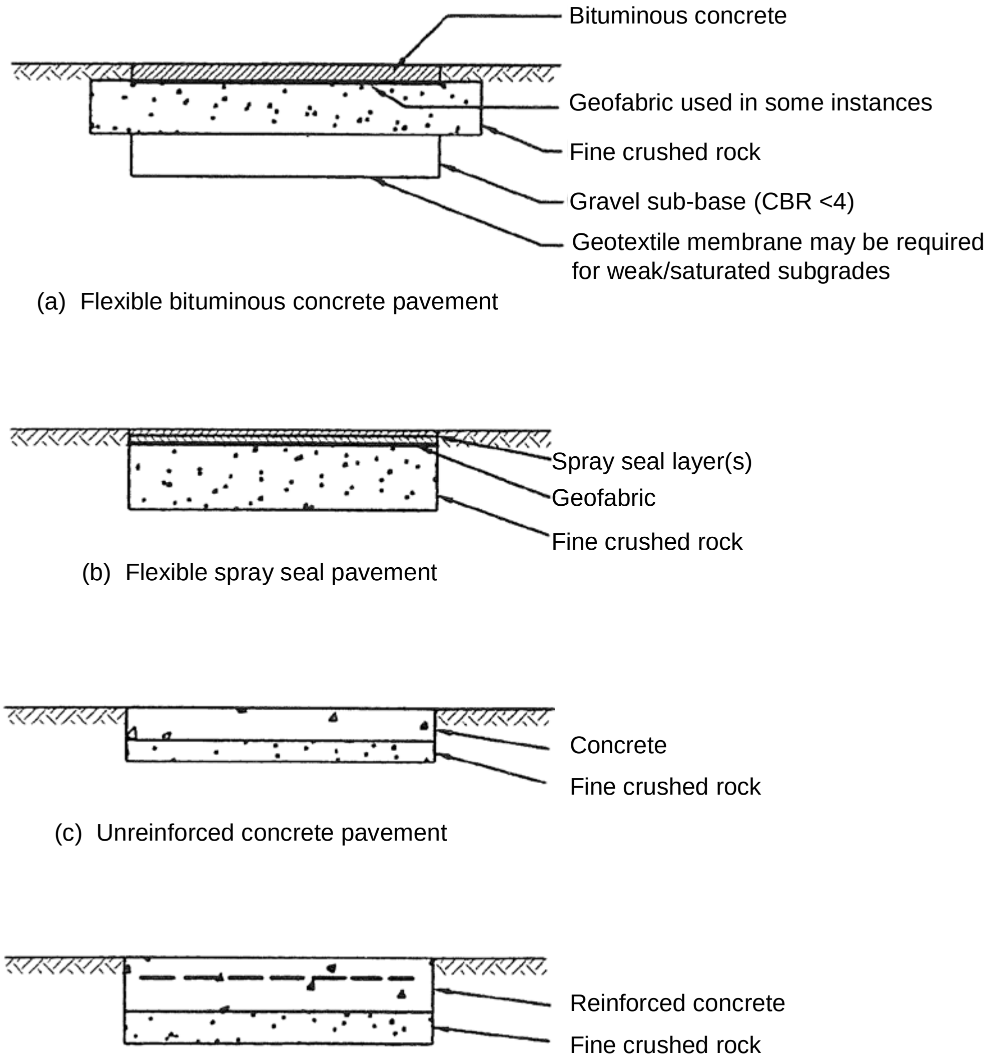
It is important that the sub-grades of both flexible and rigid pavements are compacted to a satisfactory standard and soft areas are treated. It may be necessary in some cases to assess sub-grade conditions along the line of the proposed path.

Typical cross-sections of flexible and rigid pavements are shown in Figure F 2. Individual road agencies will have a preference for particular types of pavement based on experience using local materials that should result in economical pavements. Appropriate pavement design advice should be sought in every instance.

Where paths are located on river banks and likely to become inundated they should be constructed of concrete to provide greater resistance to scour by flood water.

Coloured pavement surfaces are used in some instances (refer to the Austroads *Guide to Traffic Management: Part 10: Traffic Control and Communication Devices* (Austroads 2016d)).

Figure F 2: Typical pavements for paths



(a) Flexible bituminous concrete pavement

(b) Flexible spray seal pavement

(c) Unreinforced concrete pavement

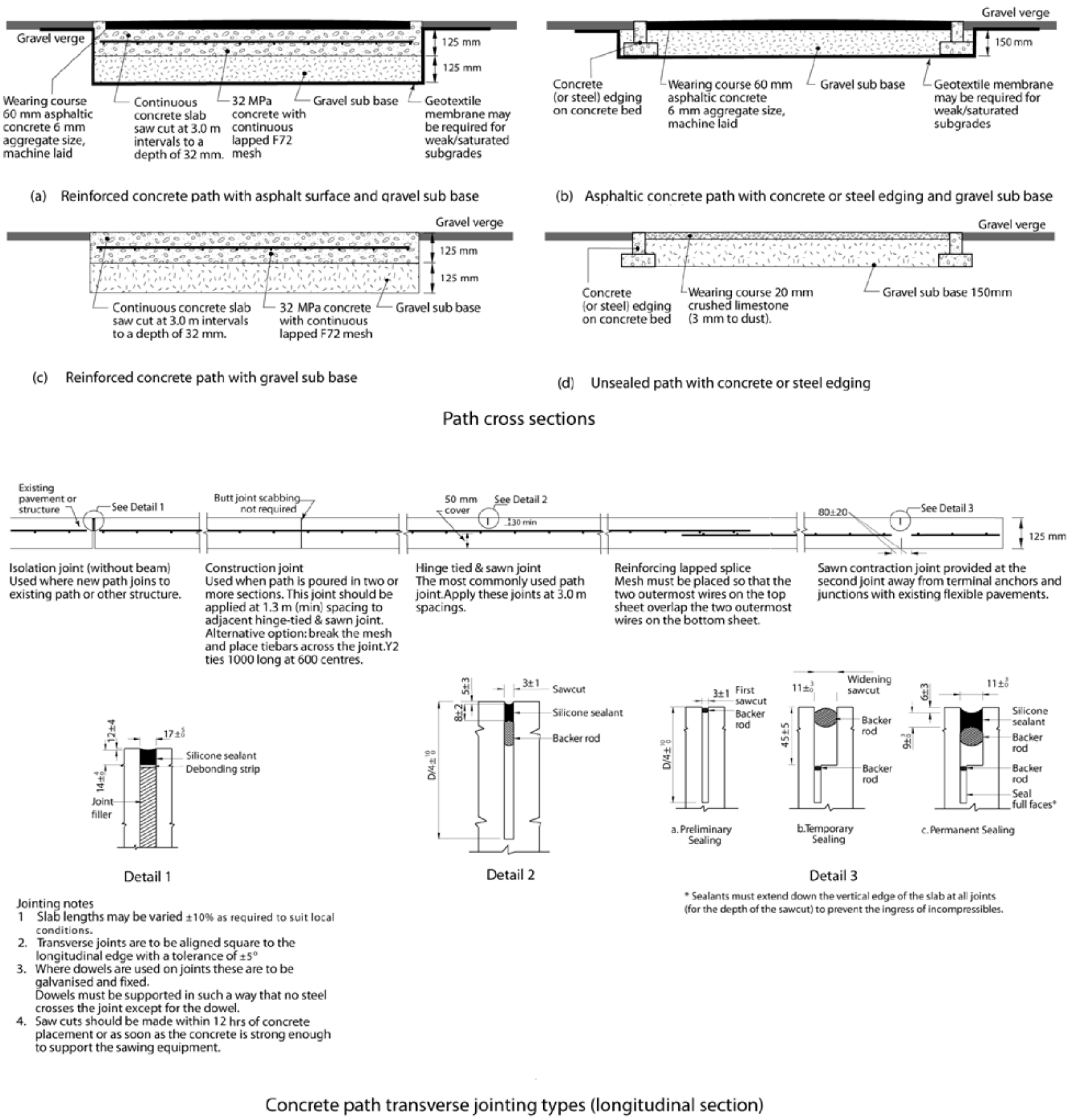
(d) Reinforced concrete pavement

Some road agencies have detailed specifications for the construction of bicycle path and shared path pavements. Figure F 3 shows examples of different pavement types and transverse joint types for concrete pavements.

Skid resistance

The surface of a path needs to provide a skid resistant surface to minimise the occurrence of cyclists and pedestrians slipping or uncontrolled skidding on the path. As a guide information on the performance of various types of path surfaces is available in *Development of a performance based specification for a major bicycle facility* (Cairney & King 2003).

Figure F 3: Examples of bicycle path pavements



Source: Roads and Traffic Authority (2005).

F.3.2 Bituminous Surface Pavements

Flexible pavements have in the past been favoured in some jurisdictions because they are usually cheaper to construct than concrete and have in general provided superior riding qualities.

Asphalt mixes should be similar to those used for lightly trafficked streets. For a path a 5 mm aggregate size is commonly used. The asphalt aggregate size should not exceed 10 mm nominal size and when a sprayed seal is used, the aggregate size should not exceed 7 mm as larger aggregates may result in an unacceptably rough surface.

More information on asphalt surfaces is contained in *A Guide to Asphalt for Lightly Trafficked Streets*, (Australian Asphalt Pavement Association 1990) available at <http://www.aapa.asn.au/technology-and-publications/advisory-notes>.

Due to the high pressure in many bicycle tyres it is desirable that sprayed sealed surfaces have a stone size less than 14 mm in order to provide a comfortable ride for cyclists.

F.3.3 Concrete Pavements

The use of concrete paths can be beneficial on the basis of whole-of-life costs, but only where appropriate construction methods are employed. In general, concrete paths have a longer life and are relatively unaffected by:

- inundation and should therefore be preferred for paths close to watercourses
- the deleterious effects of vegetation either at cracks or along the path edges
- low levels of maintenance
- the absence of motor traffic (important to the condition of bituminous pavements)
- poor sub-grade conditions in some instances
- occasional heavy traffic (in the case of reinforced paths).

Concrete paths should be of sufficient strength to resist cracking and differential vertical movement. A skid-resistant surface finish should be provided by transverse brooming of the wet concrete. Similar attention should be given to the smoothness of path sections both at joints and in between.

The development of concrete path construction techniques and products has resulted in significant improvements in rider comfort. It is critical that such techniques (Cement and Concrete Association of Australia 2004) are employed. They include:

- preformed or saw-cut contraction joints
  As a consequence bull floating, trowelling and broom finishing can be extended right up to the joints resulting in a considerably improved riding surface. In particular, wet formed contraction joints made using a grooving tool, should be avoided. The sealing of contraction joints may be important to minimise the ingress of dirt and to limit weed growth amongst other benefits.
- the use of extended bull floats (up to 4 m wide) to avoid long wave corrugations that affect cyclists travelling at speed
- narrower and fewer joints.

It is sometimes perceived that the contrast between the colour of lines and concrete surfaces is insufficient. Conversely, concrete paths are thought to offer a higher standard of delineation for cycling in dark conditions. As for other path surface types, it is important that pavement markings are maintained on concrete paths to a high standard.

F.3.4 Unsealed Paths

Consideration may be given to the provision of a stabilised unsealed surface as the first stage of development where:

- it is necessary to reduce construction costs
- the path is unlikely to flood to the extent that excessive damage to an unsealed path or excessive maintenance costs will result
- the volume of cyclists initially using the path is expected to be low
- flat gradients exist (e.g. less than 3%)
- costs need to be reduced
- the environmental amenity of an area will be reduced by a sealed path.

The second stage would be the provision of an asphalt, or bituminous surface, or possibly a concrete surface.

Care should be taken in the selection of the (unsealed) surface material to ensure that the riding surface is smooth and well bound, as cyclists will not be attracted to a path that has a poor surface. Well graded river gravels are most suitable. Materials that result in loose surfacing should not be used under any circumstances. Good drainage is also an important factor in the success of gravel paths.

F.3.5 Timber Surfaces

Gaps between longitudinal planks in timber decks can trap bicycle wheels and cause serious injuries to cyclists. Consideration should therefore be given to remedial treatment of existing timber bridges such as through an asphalt overlay of the outer 1 m sections of deck to provide a smooth, safe ride for cyclists. At the very least warning signs should be provided on the approaches to bridges that have longitudinal gaps in the deck.

On new timber bridges the planks should be placed perpendicular to the direction of travel of cyclists. In constructing and maintaining bridges it is important to ensure that the deck joints at abutments and piers provide a smooth and hence safe passage for cyclists.

Drainage should not be a problem when one considers the number of gaps in the decks of timber bridges. However, individual planks have the potential to warp and collect small, localised pools of water. Timber surfaces can be slippery in wet or shady conditions. Where these circumstances are common the application of a non-slip finish is also desirable, regardless of the alignment of planks.

F.3.6 Life Cycle Costing

When selecting a pavement for a path, consideration should be given to the costs, the initial capital cost, annual maintenance costs and renewal costs so that the constructing agency is able to determine a pavement with the knowledge of the financial, initial and future requirements for the path. An example of a life cycle costing for path surfaces is shown in Table F 1.

Table F 1: Example of life cycle costs

Material	Construction cost(1) ($)	Annual maintenance cost(2) ($)	Life cycle cost ($)
Decomposed granite	105 000	27 000	391 000
Asphalt	120 000	3000	152 000
Concrete	195 000	1500	210 000
Boardwalk	1 200 000	2000	1 221 000

1 *Assumes a 20 year period.*
2 *Assumes regular rain and flooding, requiring 30% replacement of surface annually.*

Note:

The construction costs and annual maintenance costs are indicative only for the nominated section of path and have been provided to show the development of the life cycle costs. For other paths, these costs should be determined using jurisdiction information.

Source: Austroads (2017c) Table C 1 and Roads and Traffic Authority (2005).

F.4 Provision at Works

F.4.1 General

When construction and maintenance work is carried out involving trenching or other construction work across roads and paths, access for cyclists and pedestrians should be maintained to a satisfactory quality to avoid the use of alternative routes which may be hazardous or inconvenient.

Construction and maintenance works should be undertaken in such a way that these activities do not place cyclists and pedestrians at risk during the works period. This is particularly important, for instance, where a sealed shoulder is closed for maintenance on freeways or other high speed roads where cyclists may be permitted.

F.4.2 Signing and Delineation at Work Sites on or Adjacent to Paths

The signing and delineation of construction and maintenance works on roads and paths should be performed in accordance with AS 1742.3-2009 and any relevant local codes of practice and regulations. In general, provision for works on paths should be made in accordance with the principles of these standards.

A principal objective of providing for cyclists and pedestrians adjacent to works site, the surface should be maintained in a clean and smooth state.

Figure F 4, Figure F 5 and Figure F 6 highlight the desired level of provision required in the vicinity of works, depending on the circumstances. The actual provisions to be made are dependent on the conditions that exist, including:

- presence of a traffic controller
- existing level of bicycle use, and also of pedestrian use in the case of shared path diversions
- available opportunities to provide for cyclists
- road or path alignment
- traffic speeds and volumes
- duration of work
- surface material and condition
- environmental impacts.

Provision for cyclists on roads should be made in the following circumstances:

- where bicycle lanes exist
- arterial roads
- collector roads, with an AADT in excess of 3000 vehicles per day
- strategic and other significant bicycle routes.

Safety barriers should be provided where required by AS 1742.3-2009, and are generally appropriate where cyclists or pedestrians are detoured onto roads. Temporary (lower) speed limits may also be appropriate in this circumstance.

Figure F 4 provides guidance where adequate provision for cyclists is not possible on a road, access along a path in the area of the roadside verge may be appropriate. Provided adequate separation from the work area can be maintained, it is generally acceptable to initiate and terminate the roadside verge bicycle access within the road lane transition zones either side of the work area.

For paths, reference should be made to Section 7 and Section 3 for guidance relating to paths located away from road reserves where temporary roadside verge access is required. The controls highlighted in these sections are applicable to temporary paths.

Containment fences should be provided in accordance with the requirements of AS 1742.3-2009, and otherwise as required by the Austroads *Guide to Road Design: Part 6B: Roadside Environment* (Austroads 2015c). These may be appropriate to separate pedestrians and cyclists where a pedestrian path is to be used for access by cyclists, and where:

- significant pedestrian or bicycle volumes exist
- safety issues may arise due to the unexpected use of a pedestrian path by cyclists.

Examples of provisions for paths located adjacent to roads and in reserves are shown in Figure F 5 and Figure F 6.

Temporary paths should be sealed. Whilst dependent on circumstances, such as bicycle volumes, safety and the extent of inconvenience to cyclists, this may be unnecessary where:

- the works are carried out over a short period (e.g. less than two or three weeks duration)
- the temporary path surface is firm, smooth and free of thorns
- the works are carried out during dry weather conditions
- path traffic is minimal.

However, it is very desirable that temporary paths are sealed and delineated where works are carried out over longer periods. Separated paths should be suitably delineated regardless of the period of construction.

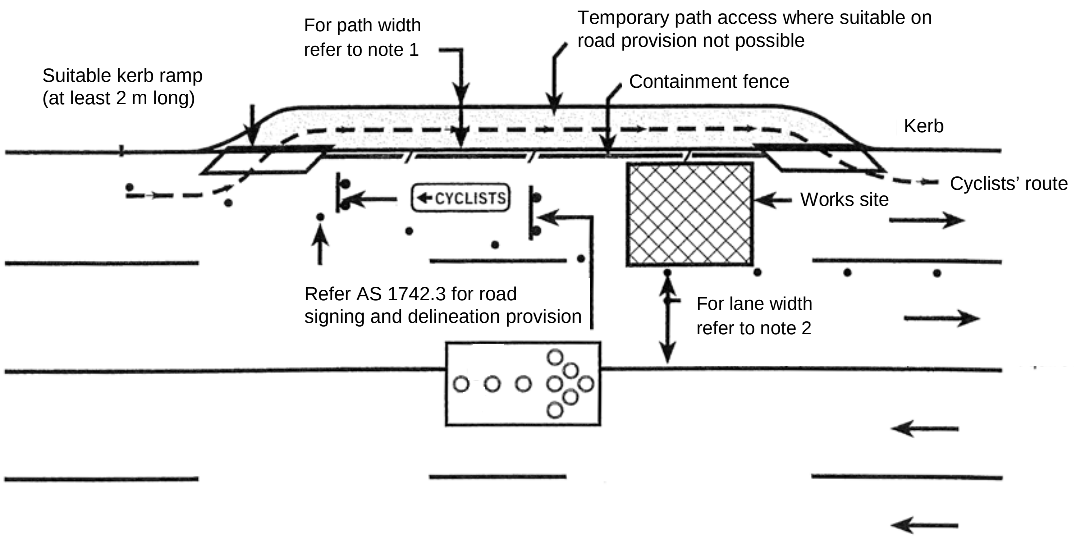
Where works on paths are carried out for a period exceeding one day, the works should be made sufficiently visible for night-time path travel, so that path users are able to observe conditions under low ambient light conditions including temporary access paths, and take appropriate action. In addition, as a general principle, lighting on temporary access paths should not be less than the existing level on the original path.

Specific consideration may need to be given to the intersections of paths and roads. The measures taken to protect traffic should be balanced with consideration to all of the potential users and movements at such locations.

Where containment fences are used, to avoid catching the pedals of cyclists the fence should be set back from paths by at least 0.3 m and fine weave mesh should be used to prevent bicycle handlebars or pedals from catching on the fence.

Surface tolerances for bicycle riding surfaces are provided in Section 5.10 of AGRD06A (Austroads 2017c). Where steel road plates are used to cover excavated or damaged pavement surfaces, appropriate steps should be taken to ensure that any steps and grooves are within the permissible tolerances.

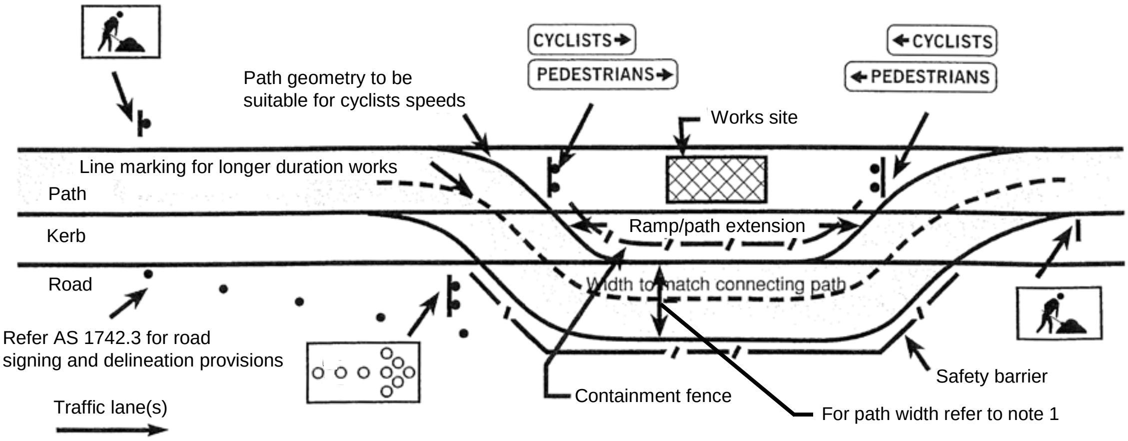
Figure F 4: Works on roads – exclusive bicycle path diversion



1 For path width refer to Section 5.1.3 AGRD6A (Austroads 2017c).
2 For lane width refer to AGRD03 (Austroads 2016a).

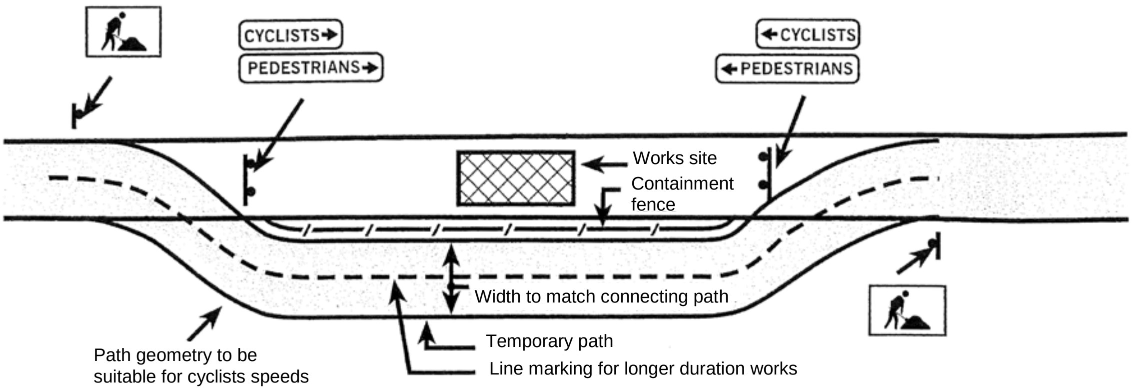
Source: Austroads (2017c) Figure C.5.

Figure F 5: Works on paths adjacent roads – shared path diversion



1 *For path width refer to Section 5.1.4 AGRD6A (Austroads 2017c).*

Figure F 6: Works on paths – shared path diversion



Source: Austroads (2017c) Figure C.7.

Appendix G Bicycle Safety Audit Checklist

G.1 Introduction

The implementation of a system of auditing of the infrastructure, which includes cycling facilities, either integrated with a similar process for roads, or otherwise, is recognised as the most appropriate means of undertaking these assessments.

In accordance with the Austroads road safety audit process (Austroads 2009c), it is appropriate that audits of bicycle routes and other facilities are conducted at various stages from planning through to construction, and in relation to existing infrastructure.

The lists of items in the sections below represent the possible contents of a checklist to assist the identification of relevant safety issues or concerns associated with bicycle facilities. It is unlikely that they include all of the issues that are of relevance or concern to cyclists, particularly given the wide variation in construction and design practice, and the conditions that exist.

It is therefore essential that personnel conducting audits of bicycle facilities are experienced in and knowledgeable about the provision of bicycle facilities.

Individual items provided in the lists may be applicable during several audit stages or may only relate to existing infrastructure.

Where existing infrastructure is to be audited, it is important that to some degree the audit is performed on a bicycle and on foot. The type of bicycle used should be representative of the most common type in the region of the audit, but should not have a suspension system or tyres wider than 32 mm.

Similarly, it is important that safety audit personnel ride at speeds typical of most users – which may be in excess of 25 km/h. Riding at slower speeds may not reveal potential problems such as geometric limitations or pavement surface defects.

Appendix G.2 is generally applicable to roads, paths and intersections. The requirements that relate mainly to either paths or roads are provided in Appendix G.9 and Section Appendix G.10 respectively.

In so far as roads are concerned, it is assumed that general road safety auditing processes exist, and hence the lists below represent additional considerations for bicycles.

G.2 General Requirements for Roads and Paths

- Are the designated crossing points and routes appropriate and acceptable to meet the required cyclist volumes?
- Are the characteristic bicycle use patterns accommodated (i.e. categories of cyclists, volumes, times of travel)?
- Do the proposals account for surrounding bicycle network deficiencies and opportunities?
- Do consistent and suitable provisions exist for the respective categories of cyclists anticipated along the route, or can they be achieved; for instance, is a path required for children and inexperienced cyclists?
- Are grade separated or controlled crossings required?
- Are traffic calming or local area traffic management measures required? (refer to the Austroads *Guide to Traffic Management: Part 8: Local Area Traffic Management*) (Austroads 2016c).
- Are the requirements of local codes of practice met?

G.3 Alignment and Cross-section

- Does the cross-section of the lane/path facility safely accommodate the anticipated cyclists?
- Are stopping sight distances adequate for all traffic, accounting for paths, roads, driveways, railways etc.?
- Are sight lines applicable to the operation of cyclists obscured by obstacles such as signs, trees, pedestrian fences and parked cars?
- Is the horizontal and vertical alignment suitable? If not, are warning signs installed?
- Are there any sections of riding surface which may cause confusion for users, e.g.
  - Is alignment of the riding surface clearly defined, particularly at unexpected bends or for dark conditions?
  - Have disused pavement sections been removed or treated?
- Is sufficient route information or guidance provided?
- Does the design avoid or minimise the need for cyclists to slow or stop?
- Do hazardous conditions (e.g. concealed intersecting paths, curves) exist at the bottom of steep gradients?

G.4 Signs, Delineation and Lighting

- Are all necessary pavement markings provided?
- Are there any redundant pavement markings? Have redundant pavement markings been properly removed?
- Are all necessary regulatory, warning and direction signs provided and located appropriately? Are they conspicuous and clear in their intent? Are they at a safe distance/height with respect to the riding surface?
- Are signs in good condition and of an appropriate standard?
- Are there any redundant signs?
- Are fixed objects close to or on the path (trees, fences, holding rails, etc.) treated to ensure visibility at night (e.g. painted white and fitted with reflectors or reflective tape)?
- Are pavement markings clearly visible and effective for all likely conditions (e.g. day, night, rain, fog, rising or setting sun, oncoming headlights, light coloured pavement surface, poor lighting)?
- Are user movements obvious or delineated through intersections?
- Is public lighting of facilities required? Is the lighting design satisfactory, particularly at tunnels, underpasses and areas of high pedestrian activity? Is it operating satisfactorily?
- Are raised pavement markers recessed flush with the surface or located outside of the paths of travel of cyclists, or outside of bicycle lanes?
- Are thermoplastic markings chamfered?

G.5 Riding Surface

- Is the riding surface suitable for cycling?
- Are the riding surface and edges smooth and free of defects (e.g. grooves, ruts or steps) which could affect the stability of cyclists or cause wheel damage?
- Is the pavement design/construction of a satisfactory standard?
- Can utility service covers, grates, drainage pits etc. be safely negotiated by cyclists?

- Are smooth and flat gutters/channels provided at stormwater drainage pit inlets?
- Is the riding surface free of loose materials (e.g. sand, gravel, broken glass, concrete spills)?
- Is there suitable protection to prevent sand or other debris from depositing on the riding surface?
- Does the riding surface have adequate skid resistance, particularly at curves, intersections, bridge expansion joints and railway crossings?
- Is the riding surface generally free of areas where ponding or flow of water may occur?
- Is special protection required to prevent cyclists from running off the riding surface?

G.6 Vegetation, Maintenance and Construction

- Is suitable access for cycling available during maintenance and construction activities? (Appendix F).
- Are all locations free of construction or maintenance equipment?
- In the absence of an appropriate and regular maintenance program
  - Is there a possibility of the encroachment of grasses into bituminous riding surfaces (e.g. kikuyu) or similar circumstances that could result in poor edge conditions or pavement degradation?
  - Do thorn bearing grasses (e.g. caltrop) exist, or are they likely to be introduced adjacent to the riding surface?
  - Are channels, kerb slots or similar treatments over which cyclists ride, located under deciduous trees etc., or otherwise likely to experience a build-up of debris due to poor drainage conditions?
- Will crack sealing processes or the application of spray seals result in the presence of loose/granular material/sand on the riding surface?
- Does landscaping allow adequate clearances, sight distance etc., and will these be maintained given mature plant growth?
- Could personal security of path users be adversely affected due to the position of bushes and other landscape features?
- Is landscaping required as a wind break?
- Will the positioning of trees and the species used contribute to the degradation of the pavement (e.g. through undermining or moisture variation)?

G.7 Traffic Signals

- Are separate pedestrian and/or bicycle phases provided where necessary?
- Do traffic signals operate correctly? Are signal displays located appropriately for all users?
- Does the design of the signals prevent conflicting motor vehicle movements during crossing phases for pedestrians and cyclists?
- Where a permanent demand for individual phases does not exist, have suitable detection facilities been provided for cyclists? Are these operating satisfactorily?
- Are inductive detector loops provided for bicycle users, are they located appropriately, of a suitable design and do they operate correctly for bicycles in the various stopping positions?
- If push-button actuators have been provided, are they located to allow convenient and legal operation from the normal stopping position (e.g. on the left of riding surface or kerb ramp, behind stop line)? Do they operate correctly?
- Are phasing and phase times acceptable? Are suitable warning signs or guidance for cyclists installed where intersection crossing times are insufficient?

G.8 Physical Objects

- Are fences, safety barrier or other objects located within 1 m of the path(s) of cyclists
  - — free of sharp edges, exposed elements or corners so as to minimise the risk of injury to cyclists in the event of the feature/object being struck by a bicycle?
  - — designed to minimise the potential for bicycle handle bars or pedals to become caught in the feature should an errant bicycle collide with it?
- If there are any obstructions located adjacent to the paths of cyclists, are they adequately delineated?
- Are clearances to the operating space of cyclists acceptable?

G.9 Paths

This section should be read in conjunction with Section G.2.

G.9.1 General

- Are automatic reticulation systems timed to avoid periods of significant path use? Do sprinklers spray away from the path (rather than across it)?
- Do irrigation hoses need to be placed across path surfaces?
- Are provisions for car parking in the vicinity of the path satisfactory in relation to the operation and safety of path users?
- Are there any potential problems of conflict between the various path users (e.g. pedestrians and cyclists)?
- Is the path subject to flooding? If so, are warning signs provided and located appropriately?

G.9.2 Alignment and Cross-section

- Where a path is located adjacent to a road, is there sufficient separation and/or protection from the carriageway?
- Are adequate overtaking opportunities provided?
- Is the path width, at structures or otherwise, adequate for the likely usage levels of pedestrians and cyclists?
- Is the geometric alignment and gradient satisfactory?
- Is the design speed appropriate?
- Is path crossfall suitable for the anticipated path users?
- Is the crossfall steep enough to adequately drain the path and prevent ponding on the surface, while being flat enough to be comfortable for pedestrians?

G.9.3 Intersections

- If justified, is path priority assigned to path users at road crossings?
- At intersections with busy roads, are appropriate facilities provided, e.g. traffic signals, underpass, overpass or median refuge, to allow path users to safely cross? Are the intersection controls satisfactory?
- Is the location of road/path or path/path intersections satisfactory and obvious with respect to horizontal and vertical alignment?
- Is the presence of intersections obvious to road/path users?
- Is a refuge required at road crossings? Would it adversely affect (e.g. squeeze) cyclists travelling along the road?

- In relation to path entry controls
  - Are terminal devices required? If so, does the device design meet the requirements of this guide?
  - If central holding rails or bollards exist, is there a legitimate reason why they are needed, and if so is there sufficient pavement width either side?
- Are kerb ramps adequate and suitable for all users (width, slope, flush surface)? Are turning radii adequate?
- Are holding rails provided? Are they positioned so as to not unduly interfere with access for cyclists and other users (consider tandem bicycles, bicycles with trailers etc.)?
- Are the controls associated with path/path intersections satisfactory?

G.10 Roads

Whilst this Part relates to paths it is often the case that road and path treatments interface therefore this section contains some information relating to roads that may impact on path users.

G.10.1 General

- Are bicycle lanes required?
- Are bicycle lane widths or the left traffic lane widths adequate to accommodate cyclists?
- Can sufficient space be obtained? Are there any squeeze points for cyclists?
- Does the construction of the lane facility conform to this Part and other relevant standards?
- Are special provisions required along curving roads?
- Are road markings for cyclists suitable and adequate, and do they meet relevant standards?
- On controlled access roads, is a path for experienced riders required within the reservation?
- Are local area traffic management treatments appropriate for bicycles?
- Are drainage pit covers flush with the surface or are there level differences that could be hazardous to cyclists and pedestrians?
- Is the positioning of bicycle pavement symbols potentially hazardous to motorcyclists?
- Are sealed shoulders at least as smooth as traffic lanes?

G.10.2 Intersections

- Are the intersection treatments appropriate?
- Are there any common cyclist movements (legal or otherwise) that differ from typical traffic movements? Are these likely to be anticipated by other traffic? Can these movements be made safely and if not what remedial measures are required?
- Are ‘head start’ storage areas required due to conflicting manoeuvres of bicycles and other traffic, or due to high cyclist volumes?
- Are special provisions for cyclists required at roundabouts?
- Are there continuity lines marked where appropriate?
- Are grated drainage pits that are potentially hazardous to cyclists and pedestrians located within the road/path intersection or within the turning path of cyclists (i.e. radii in the corners of the intersection)?
- Are grated pits on paths or in close proximity to paths properly designed so that they cannot trap bicycle wheels?

Appendix H Example of Bicycle Safety Audit

H.1 Background

The following example is taken from Section 7.7 of AGRS06 (Austroads 2009c). Shared bicycle/pedestrian paths have been developed beside a major road. A project to convert the major road to full freeway standard has involved modifications to bicycle facilities. The audit took place at the pre-opening stage of the freeway conversion project. Auditing the bicycle facilities was specifically required as part of the audit of the whole project.

H.2 Paths on the North/East Side

On the south side of Toorak Road there is poor sight distance between the link path from Toorak Road and the main path to the north (under the bridge). The acute angle of connection of these two paths makes movements between them very difficult.

Recommendation 1: Consider options for improving safety at the junction of the paths, such as provision of signs to warn cyclists/pedestrians of the junction. Consider relocation and realignment of the two paths about 5–10 m further from Toorak Road. (Important).

At a number of locations there are posts and ends of rails at the edge of the path that are a hazard to any errant cyclist.

Recommendation 2: Review the design and location of all posts and rails beside the path and shield or modify those in exposed locations. (Important).

The Keep Left markings at bends along the path include a left-angled arrow above the words. Northbound, just south of Toorak Road, the arrow gives a misleading message about alignment of the path and whether cyclists/pedestrians should use the link path to Toorak Road, which is on the right.

Recommendation 3: Remove the left pavement arrow from the Keep Left messages, or locate it across the centreline.

At Toorak Road, the shared path crosses the road at pedestrian signals. At this point the path beside the road is too narrow and is overgrown (Figure H 1).

Recommendation 4: Widen the path beside Toorak Road.

Figure H 1: The path to pedestrian signals is narrow and overgrown

H.3 Paths on the South/West Side

The shared path west of Burke Road (adjacent to Carroll Crescent) has a broken surface near the Gardiner railway station.

Recommendation 5: Repair and maintain surface of the shared path. (Important).

There is loose gravel on the shared path under the Tooronga Road bridge that is a safety hazard for cyclists.

Recommendation 6: **Remove the loose gravel from the shared path. Seal the path. (Important).**

There is no footpath across the railway line where the shared path reaches Toorak Road (Figure H 2).

Recommendation 7: Provide a footpath across the railway line on the south side of Toorak Road. Link it to the paths on each side. (Important).

Figure H 2: The link path from Toorak Road joins at an acute angle, with restricted sight distance

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C 2.3

Appendix I Bicycle Parking Provision Rates

Table I 1 gives an indication of the levels of bicycle parking needed to be provided for various land uses. These bicycle parking provision rates may be used to provide guidance if local standards or data are not available. It should be noted that the application of these types of provision rates needs to be undertaken with caution as local circumstances may often render them inappropriate.

Table I 1: Bicycle parking provision

Land use	Employee/resident parking spaces	Class	Visitor/shopper parking spaces	Class
Amusement parlour		1 or 2	2 plus 1 per 50 m^2 gfa	3
Apartment house	1 per 4 habitable rooms	1	1 per 16 habitable rooms	3
Art gallery	1 per 1500 m^2 gfa	2	2 plus 1 per 1500 m^2 gfa	3
Bank	1 per 200 m^2 gfa	2	2	3
Café	1 per 25 m^2 gfa	2	2	3
Community centre	1 per 1500 m^2 gfa	2	2 plus 1 per 1500 m^2 gfa	3
Consulting rooms	1 per 8 practitioners	2	1 per 4 practitioners	3
Drive-in shopping centre	1 per 300 m^2 sales floor	1	1 per 500 m^2 sales floor	3
Flat	1 per 3 flats	1	1 per 12 flats	3
General hospital	1 per 15 beds	1	1 per 30 beds	3
General industry	1 per 150 m^2 gfa	1 or 2	–	3
Health centre	1 per 400 m^2 gfa	1or 2	1 per 200 m^2 gfa	3
Hotel	1 per 25 m^2 bar floor area 1 per 100 m^2 lounge beer garden	1 1	1 per 25 m^2 bar floor area 1 per 100 m^2 lounge beer garden	3
Indoor recreation facility	1 per 4 employees	1 or 2	1 per 200 m^2 gfa	3
Library	1 per 500 m^2 gfa	1 or 2	4 plus 2 per 200 m^2 gfa	3
Light industry	1 per 1000 m^2 gfa	1 or 2	–	3
Major sports ground	1 per 1500 spectator places	1	1 per 250 spectator places	3
Market	–	2	1 per 10 stalls	3
Motel	1 per 40 rooms	1	-	3
Museum	1 per 1500 m^2 gfa	1	2 plus 1 per 1500 m^2 gfa	3
Nursing home	1 per 7 beds	1	1 per 60 beds	3
Office	1 per 200 m^2 gfa	1 or 2	1 per 750 m^2 over 1000 m^2	3
Place of assembly	–	2	–	3
Public hall	–	1 or 2	–	3
Residential building	1 per 4 lodging rooms	2	1 per 16 lodging rooms	3
Restaurant	1 per 100 m^2 public area	1 or 2	2	3
Retail show room	1 per 750 m^2 sales floor	1	1 per 1000 m^2 sales floor	3
School	1 per 5 pupils over year 4	2	–	3
Service industry	1 per 800 m^2 gfa	1	–	3
Service premises	1 per 200 m^2 gfa	1	–	3
Shop	1 per 300 m^2 gfa	1	1 per 500 m^2 over 1000 m^2	3
Swimming pool	-	1 or 2	2 per 20 m^2 of pool area	3

Land use	Employee/resident parking spaces	Class	Visitor/shopper parking spaces	Class
Take-away	1 per 100 m^2 gfa	1	1 per 50 m^2 gfa	3
University/Inst. of Tech	1 per 100p/t students 2 per 100f/t students	1 or 2 2	– –	3

Notes:

1. Refer to Table 11.2 for Class definitions.

2. '– ' indicates that No Parking demand information is available and therefore planners should make their own assessment of the required bicycle parking provisions on an individual project basis.

3. GFA – Gross Floor Area.

4. It is sometimes appropriate to make available 50% of the level of provision recommended in the table at the initial installation stage, however, space should be set aside to allow 100% provision in the event that the full demand for bicycle parking is installed.

Source: Austroads (2017d) Table C2 6, Commentary 2.

Cycling Aspects of Austroads Guides delivers, in one document, information about the planning, design and traffic management of cycling facilities. The content is sourced from Austroads Guides, primarily the Guide to Road Design, the Guide to Traffic Management and the Guide to Road Safety.

The publication is intended as a guide for engineers, planners and designers involved in the planning, design, construction and management of cycling facilities. Throughout the document practitioners are referred to relevant Austroads Guides for additional information.

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