Department of Transport and Main Roads

Guideline

Selection and design of cycle tracks

October 2019

Queensland Government

Translating and interpreting assistance

The Queensland Government is committed to providing accessible services to Queenslanders from all cultural and linguistic backgrounds. If you have difficulty understanding this publication and need a translator, please call the Translating and Interpreting Service (TIS National) on 13 14 50 and ask them to telephone the Queensland Department of Transport and Main Roads on 13 74 68.

Feedback

Please send your feedback regarding this document to: tmr.techdocs@tmr.qld.gov.au

Contents

Tables

Figures

2-way cycle track caters for all ages and abilities, Caloundra, Queensland

1 Introduction

1.1 Purpose

This document provides guidance on where and how to separate bicycle traffic from general traffic at intersections and mid-block locations on urban roads in new and retrofit situations. This will help achieve a direct, safe, comfortable and low-stress cycle network for the transport of people of all ages and abilities.

This document supplements information provided in the Austroads guides to Road Design and Traffic Management by providing in-depth guidance on bicycle facility selection, notably separated bicycle infrastructure such as cycle tracks. It also provides guidance on the design of separated cycle tracks mid-block and at intersections, including prioritising bicycle movement, based on best practice, research and lessons learnt in Queensland. It has been prepared to support the Department of Transport and Main Roads' (the department) *Cycling Infrastructure Policy* and to provide additional guidance to local government.

This is a guide only and engineering judgement will be necessary to ensure site-specific issues are dealt with appropriately. It is acknowledged that, in some situations, the recommended solutions presented in this document may need some innovative thinking to implement.

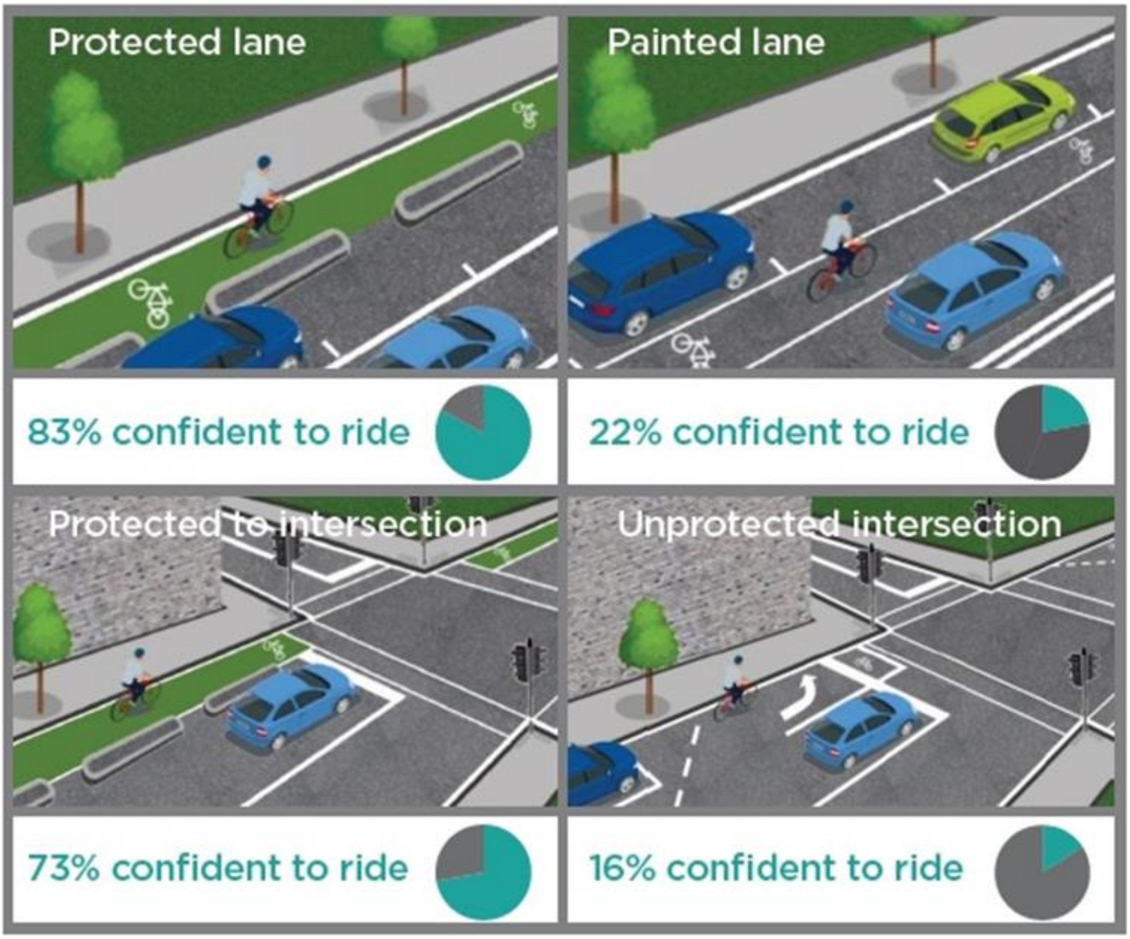
1.2 Rationale

The *Queensland Cycling Strategy 2017–2027* (QCS) aims to grow cycling participation for daily transport and for recreation by attracting new bicycle riders of all ages and abilities. Cycle tracks support the QCS by improving rider safety and the perception of safety which enable participation of new and cautious riders.

Providing cycle tracks and protected intersections instead of bicycle lanes increases the proportion of the community who may be confident to ride a bicycle in a road corridor.

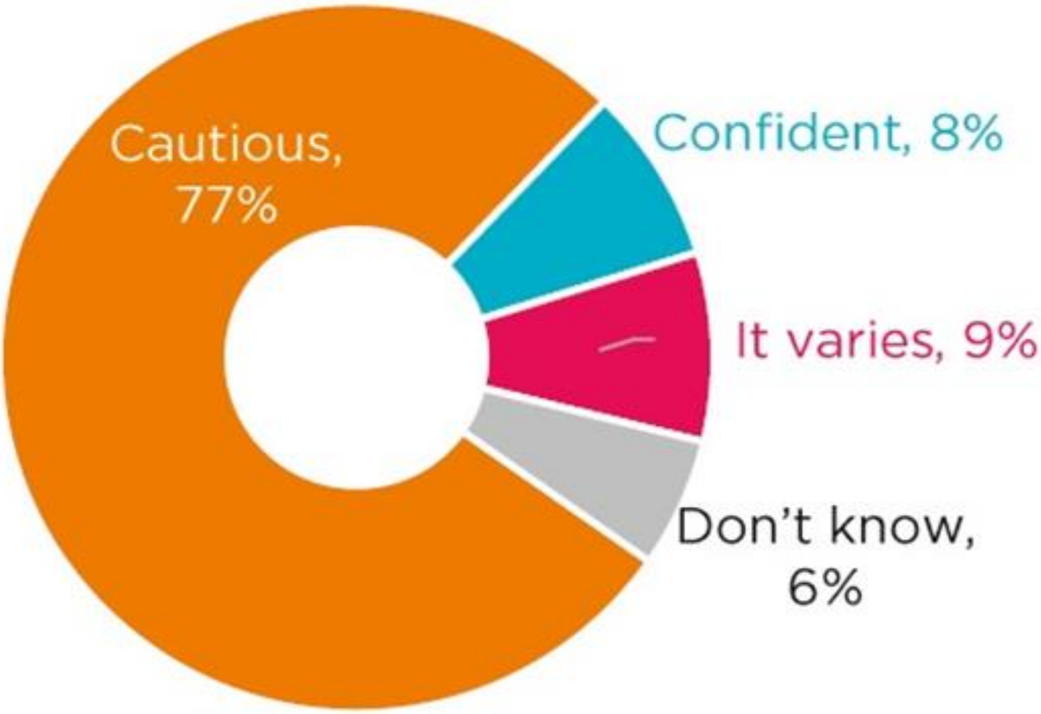
Recent research by City of Melbourne has confirmed that physically-separated cycle tracks enable confidence for new and cautious bicycle riders (Figure 1.2(A)). This work identified that cautious riders (including new riders) make up approximately 77% of the population (Figure 1.2(B)). In Australia, 69% of males and 74% of females state they would cycle more regularly if dedicated lanes and off-road routes were provided. Women are underrepresented in ridership in high-stress environments. Providing cycling infrastructure suitable for cautious bicycle riders is the key to growing cycling participation. To objectively measure this, level of traffic stress can be measured at network and project level (see Section 2.2).

Figure 1.2(A) – Confidence to ride for new and cautious riders



Source: City of Melbourne, 2017

Figure 1.2(B) – Cycling confidence



Source: City of Melbourne, 2017

The *National Road Safety Strategy 2011–2020* promotes the Safe System framework, as a systematic, proactive way to reduce road safety risk. The Safe System approach requires design, construction and maintenance of a road system so that forces on the human body generated in crashes are generally less than those resulting in fatal or debilitating injury. The Safe System acknowledges road users will continue to make mistakes and that mistakes should not result in death or serious injury.

The *National Road Safety Strategy* proposes two methods to improve bicycle rider safety and reduce exposure to risk:

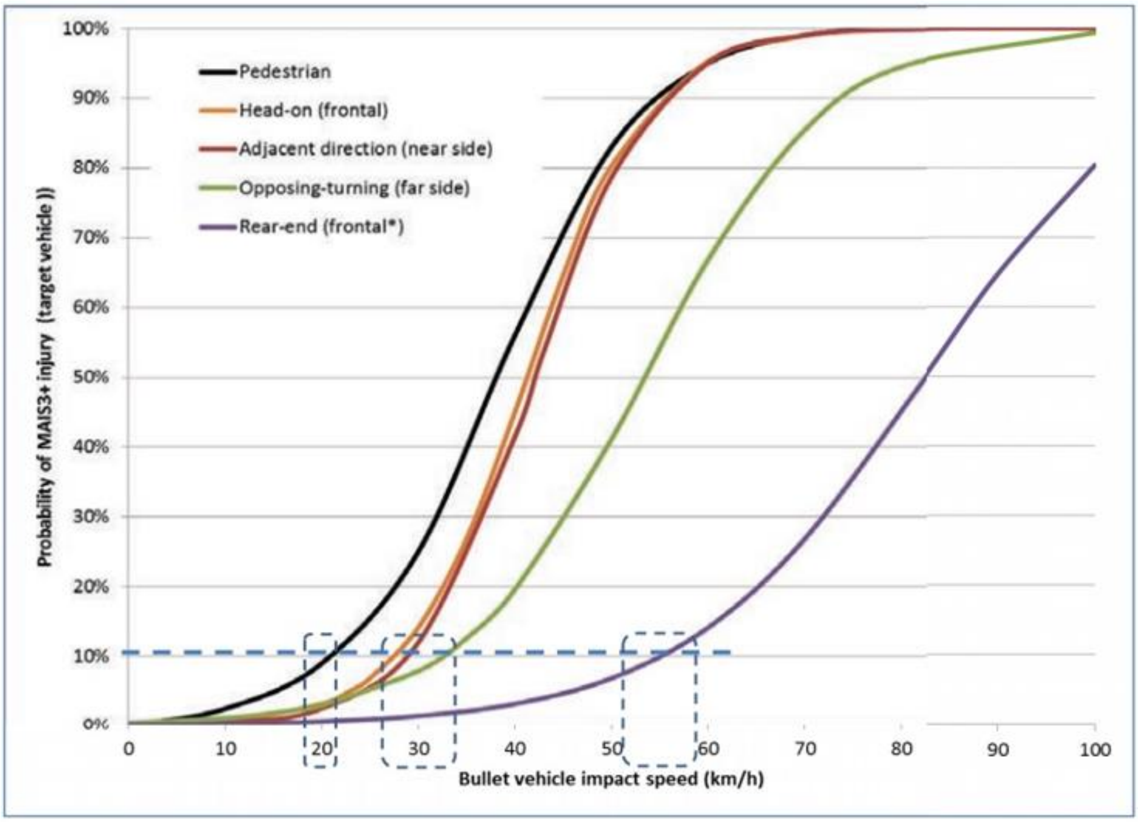
1. separation: prevent encounters between road users (conflict avoidance), and
2. highlight potential conflict zones: if encounters occur, design for safe speeds of motorised traffic, reducing incidence and severity of crashes (conflict presentation).

The department's *Road Safety Policy* supports the *National Road Safety Strategy* by stating that the department will implement Safe System principles, processes and practices that will deliver reductions in the number of fatal and serious injury crashes on Queensland roads. This will contribute to the Queensland Government's vision of zero road deaths and serious injuries. The *Road Safety Policy* also sets default safety standards that are considered best practice in the design and construction of safer road infrastructure. This includes minimum safety standards for intersections such as:

- pedestrian crossings to be provided on all approaches at signalised intersections – pedestrian crossing protection (delayed start to vehicle movements) is required
- unsignalised left-turn slip lanes should generally be avoided at intersections unless signalised with pedestrian protection, and
- new and upgraded signalised intersections must have protected right-turn lanes on the major road – filtered green arrows for right turns to be excluded unless justified through a risk assessment.

The pedestrian-vehicle crash curve in Figure 1.2(C) is also applicable to other vulnerable road users such as people riding bicycles or motorcycles. The Maximum Abbreviated Injury Scale (MAIS) is a measure of injury severity, MAIS3+ refers to a fatal or serious injury. Figure 1.2(C) indicates a lower probability of serious vulnerable user injury at lower collision speeds, particularly below 30 km/h. Road user separation, minimisation of number of conflict points, and greater management of road user movements can also be used to support Safe System outcomes.

Figure 1.2(C) – Probability of fatal or serious injury vs. vehicle impact speed



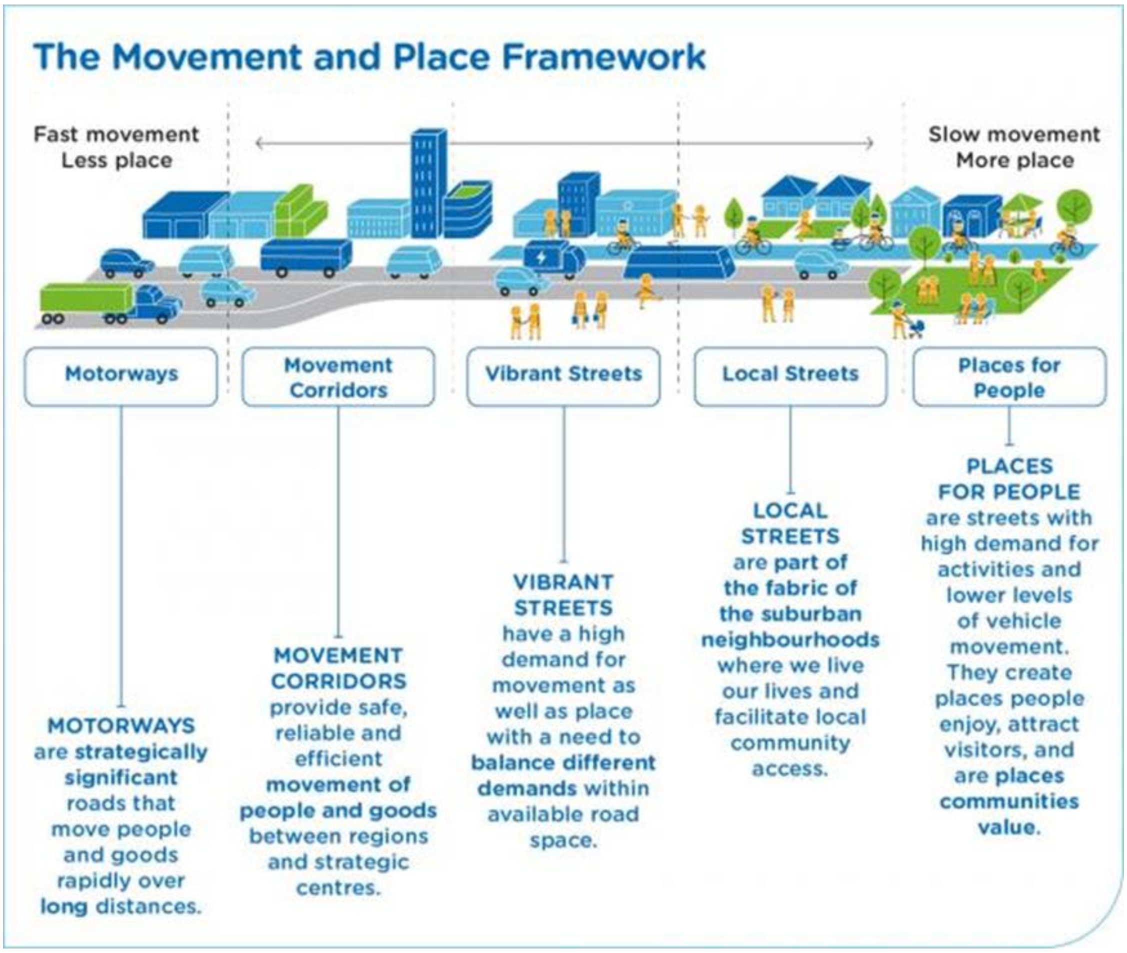
Source: Jurewicz, 2016[1]

The Movement and Place framework outlined in Austroads' *Guide to Traffic Management* Part 4 *Network Management* acknowledges that roads serve two primary roles for the users:

1. movement – facilitate the movement of people and goods, and
2. place – act as a place for people.

The adoption of Movement and Place principles to encourage more walking and bicycle riding is underpinned by recognising the importance of context-sensitive design. Designing for survivable traffic speeds in places for people and providing greater levels of separation where faster traffic movements are permitted (see Figure 1.2(D)).

Figure 1.2(D) – The Movement and Place Framework



Source: NSW Government, 2019[2]

Providing high-quality cycling infrastructure to increase the number of people riding bicycles will also act to mitigate the negative impacts of physical inactivity / sedentary lifestyle (and associated cost to the health system) amongst Queenslanders. The World Health Organisation (WHO) provides global recommendations on physical activity for health and outlines the type, intensity, frequency and duration of physical activity for optimal health benefits for youth, adults and older adults. The *Australian Physical Activity and Sedentary Behaviour Guidelines* recommend regular participation in physical activity for 150 minutes of moderate intensity physical activity each week for adults and 60 minutes each day for children.

There is evidence to suggest that effective human-centred design of the built environment can encourage physical activity in daily life by incorporating principles such as access to destinations, density, connectivity and mixed land uses. The Heart Foundation's *Healthy Active by Design* website (http://www.healthyactivebydesign.com.au) provides evidence, design features, case studies and resources to assist practitioners in focusing on modifying 'obesogenic environments' which are environments which encourage people to eat unhealthily and not do enough exercise. The evidence also extends to linking built environment features with movement networks, including high-quality cycling facilities such as cycle tracks, to contribute to increased rates of cycling and walking.

This document presents design guidance relating to bicycle infrastructure and intersection designs which separate bicycle riders from motorised traffic. Facilities such as these have been shown to improve safety, improve the perception of safety and increase the ridership of a wide cross-section of the community. These facilities align well with both crash reduction targets (outlined in the *Road Safety Strategy 2015–2021*) and cycling mode vision and growth targets (*Queensland Cycling Strategy 2017–2027*).

1.3 Terminology

Current Australian bicycle facility terminology includes bicycle lanes, shared paths and bicycle paths. Bicycle riders using bicycle lanes at intersections have priority, whereas cyclists using shared paths and bicycle paths generally do not have priority through intersections and driveways. This is contrary to the Austroads bicycle facility selection guiding principle of '*providing a high level of priority for cyclists across driveways and through intersections*'.

Current Austroads guidance includes an unclear array of terms referring to physically-separated bicycle-only facilities in the road corridor. These include: 'separated bicycle lanes', 'segregated bicycle lanes', 'protected bicycle lanes', 'separated protected bicycle lanes', 'kerb separated bicycle lanes', 'Copenhagen bicycle lanes', and 'protected two-way lanes'.

Internationally, in both European and North American countries, the term 'cycle track' is frequently used to describe a bicycle-only facility within the road corridor that has clear priority at intersections.

This document introduces the term 'cycle track' to describe a physically-separated bicycle-only facility in the urban road corridor that provides the combined benefits of a bicycle lane (priority at intersections) and a bicycle path (safety and comfort). The key features of cycle tracks are the priority crossing through unsignalised intersections and specialised controls at signals. These intersection features maintain the directness and level of service expected of a cycle track. Without these intersection features, the bicycle facility fails to achieve the level of directness and safety required for cycle track.

One-way cycle track: A one-way physically separated bicycle only facility with clear bicycle priority at intersections.

Two-way cycle track: A two-way physically separated bicycle only facility with clear bicycle priority at intersections.

These terms and others are listed in Appendix A.

1.4 How to read this document

The Austroads *Guide to Traffic Management* Part 4 Section 4.6.5 provides guidance for bicycle facility selection within urban road corridors. It outlines two guiding principles for bicycle facility selection within urban road corridors:

1. separating cyclists from motor vehicles
2. providing a high level of priority for cyclists across driveways and through intersections.

Austroads bicycle facility design guidelines do not provide clear guidance on physically separating bicycle traffic and only provide limited guidance for bicycle priority at signalised and unsignalised intersections and driveways. This guideline supports the two guiding principles of bicycle facility selection in these ways:

- Part 2 of this document discusses where to separate bicycle traffic from other traffic
- Part 3 shows how to separate bicycle traffic from motor vehicles at mid-block, and
- Part 4 discusses how to provide priority for bicycle traffic through intersections and at driveways.

Guidance has been provided for both greenfield and retrofit situations in this document. The appendices provide sample cross-sections for both situations. Drawing series titles refer to whether the drawings are for a greenfield site or retrofit situation. Drawing series A are one-way cycle tracks and series B are two-way cycle tracks.

The photos in this document show Australian facilities wherever possible. International photos are included where an equivalent Australian treatment is not yet available. Most international photos and diagrams in this document have been manipulated to depict the Australian context with traffic on the left.

2 Functional road hierarchy and bicycle facility type

Austroads *Guide to Road Design* Part 2 Section 2.4.1, which is adopted by the department's *Road Planning and Design Manual* Volume 3, sets out distinct road categories according to speed environment and volumes of road users in the urban functional road hierarchy. Where a bicycle route is located within the road corridor on urban roads, the decision of what bicycle facility type is appropriate for a certain location, depends on where the route sits in the road network hierarchy, the volume and speed of motorised vehicles, and space available.

The bicycle facility type selected must be clearly linked to the type of road in the road hierarchy. As differences in speeds and volumes increase, the separation of vulnerable road users must also increase. Consistency in design for each road category within the road hierarchy enhances clear priority at intersections, predictability, coherence, safety and comfort for all road users.

2.1 Bicycle facility selection

For a cycle network to be an effective and viable transport option, the bicycle facility types selected must be appropriate for the road type and be seamlessly linked along routes. The cycle network must be designed to meet the needs of bicycle riders for directness and safety rather than for recreation. Current Austroads guidance for bicycle facility selection highlights the need to separate bicycle riders from vehicles and provide priority for bicycle riders at conflict points.

For local roads in Queensland the general urban default speed limit is 50 km/h. An operating speed of 30 km/h in residential areas has been proven to save lives and save money[3]. The Queensland *Manual of Uniform Traffic Control Devices* (MUTCD) Part 4 permits 40 km/h and 30 km/h speed zones, particularly in locations where there is a high concentration of active transport users. Reduced speed limits, creating reduced speed differentials, are an important safety measure where bicycle riders are required to mix with motorised vehicles. Traffic calming measures may be required to support safer speed limits. Well-designed traffic calming is an implicit measure to support cycling safety[4].

Where larger differences in speeds exist, such as motorised vehicle speeds above 50 km/h, physical separation from motorised vehicles reduces risks for bicycle riders, creating a safer and more comfortable environment for all road users. Some experienced bicycle riders are comfortable mixing with motorised vehicles at high speeds; however, most people, especially less-experienced and traffic-intolerant bicycle riders, are most comfortable when physically separated from high-volume, high-speed motorised vehicles.

Table 2.1 guides the selection of bicycle facility type within urban road corridors, depending on road function and speed. Table 2.1 complements current Austroads guidance (*Guide to Traffic Management* Part 5 Figure 4.1) recommending physical separation at motor vehicle operating speeds of 50 km/h to accommodate new, traffic-intolerant bicycle riders. In retrofit situations, this table should be adapted to best accommodate site constraints while achieving the needs of bicycle riders for directness, safety, coherence, comfort and attractiveness (see Section 3.1). A level of traffic stress analysis, as discussed in Section 2.2, can further supplement this decision-making process.

Table 2.1 – Urban road bicycle facility selection depending on road function

<table>
<tr><th>Road function</th><th colspan="2">Vehicle operating speed (km/h)</th><th>Cycle tracks appropriate?</th><th>Explanation</th></tr>
<tr><td rowspan="2">Access function for example, local access street (with or without parking)</td><td colspan="2" rowspan="2">Up to 30 km/h</td><td>No</td><td>Mixed traffic is appropriate in low-speed environments, including cycle streets and advisory bicycle lanes*.
Cycle track with limited vehicle access may be appropriate (refer Section 3.2.4).</td></tr>
<tr><td rowspan="2">Maybe</td><td>Bicycle lanes or cycle tracks are preferred on a primary bicycle route.</td></tr>
<tr><td rowspan="3">Collector function for example, minor collector</td><td rowspan="2">Up to 50 km/h</td><td>No kerbside parking</td><td>Bicycle lanes with no parking or cycle tracks are suitable.</td></tr>
<tr><td>With kerbside parking</td><td>Yes</td><td>Cycle tracks preferred over bicycle lanes due to door zone conflicts (refer Section 3.4.1).</td></tr>
<tr><td colspan="2" rowspan="2">More than 50 km/h</td><td rowspan="2">Yes</td><td rowspan="2">High-quality parallel off-road separated or shared path or cycle tracks preferred over bicycle lanes due to high speed difference of ≤20 km/h or more.</td></tr>
<tr><td>Through traffic function for example, arterial road or trunk collector</td></tr>
<tr><td>Regional through traffic function for example, urban motorway</td><td colspan="2">More than 70 km/h</td><td>No</td><td>High-quality parallel off-road separated or shared path with grade separated, signalised or priority crossings at intersections is appropriate.</td></tr>
</table>

* Refer to Transport and Main Roads' *Supplement to Austroads Guide to Traffic Management Part 8 Local Area Traffic Management, Traffic and Road Use Management (TRUM) Manual* Volume 1 Part 8.

Bicycle facility selection should also consider the design principles of safety, directness, coherence, comfort and attractiveness to ensure the facility meets strategic performance objectives. Where bicycle volumes are high or expected to be high, or where the goal is to encourage cycling on a preferred route / principal cycle route, a higher-quality bicycle facility should be considered (refer Section 3.1).

2.2 Level of Traffic Stress methodology

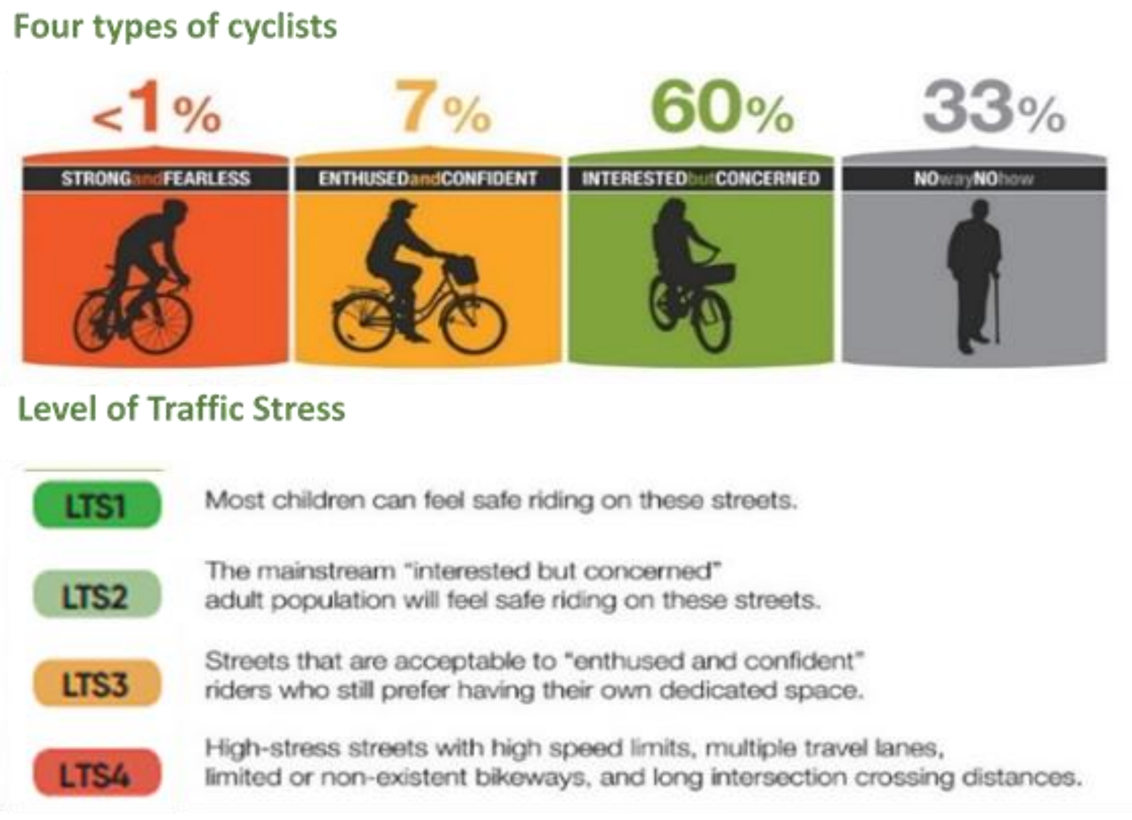
Undertaking a level of traffic stress (LTS) assessment for bicycle facilities can assist in guiding the selection of bicycle facility type. For the bicycle network to attract a wide range of users, including risk-averse riders, a low-stress cycle network is essential. Roger Geller introduced the concept of four types of cyclists, based on research undertaken in Portland USA. Figure 2.2 shows these four types and the typical proportion of the community that populates these categories. Similar surveys conducted in Queensland have found comparable proportions of the population.

For cycling to be a viable mode choice for more people, the 'interested but concerned' group is a key demographic. The key barrier for these users is a fear of mixing with motor vehicle traffic. The Geller 'type of cyclists' concept has been linked to LTS in a methodology developed by the Mineta Transportation Institute in the USA.

The aim of the LTS methodology is to achieve low stress connectivity between people's origins and destinations by enabling them to avoid links that exceed their tolerance for traffic stress without significant detour. There are four levels of traffic stress identified in the methodology, as shown in Figure 2.2. At a network level, the methodology assesses traffic stress based on characteristics such as traffic volumes, traffic speed, presence of kerbside car parking and driveways and overall directness of the route. At a project's mid-block and intersection level, more detailed assessment is needed.

The LTS methodology can assist practitioners to determine the most appropriate bicycle facility type to create a safe cycling environment for all users. LTS can also be assessed alongside complementary assessments for bicycle such as the iRAP Star Rating Scores (SWOV R-2014-14). Combining LTS and iRAP into a unified assessment tool is desirable but requires further development at this stage.

Figure 2.2 – Level of Traffic Stress categories



The LTS categorisation informs bicycle facility type selection and the drawings in Appendix B identify which LTS category is achieved for each scenario. Preliminary assessment indicates infrastructure achieving an LTS 1 rating would also achieve a 5-star iRAP 'Bicyclist' rating. A 5-star rating indicates the infrastructure-related contribution to risk of death or serious injury is extremely low.

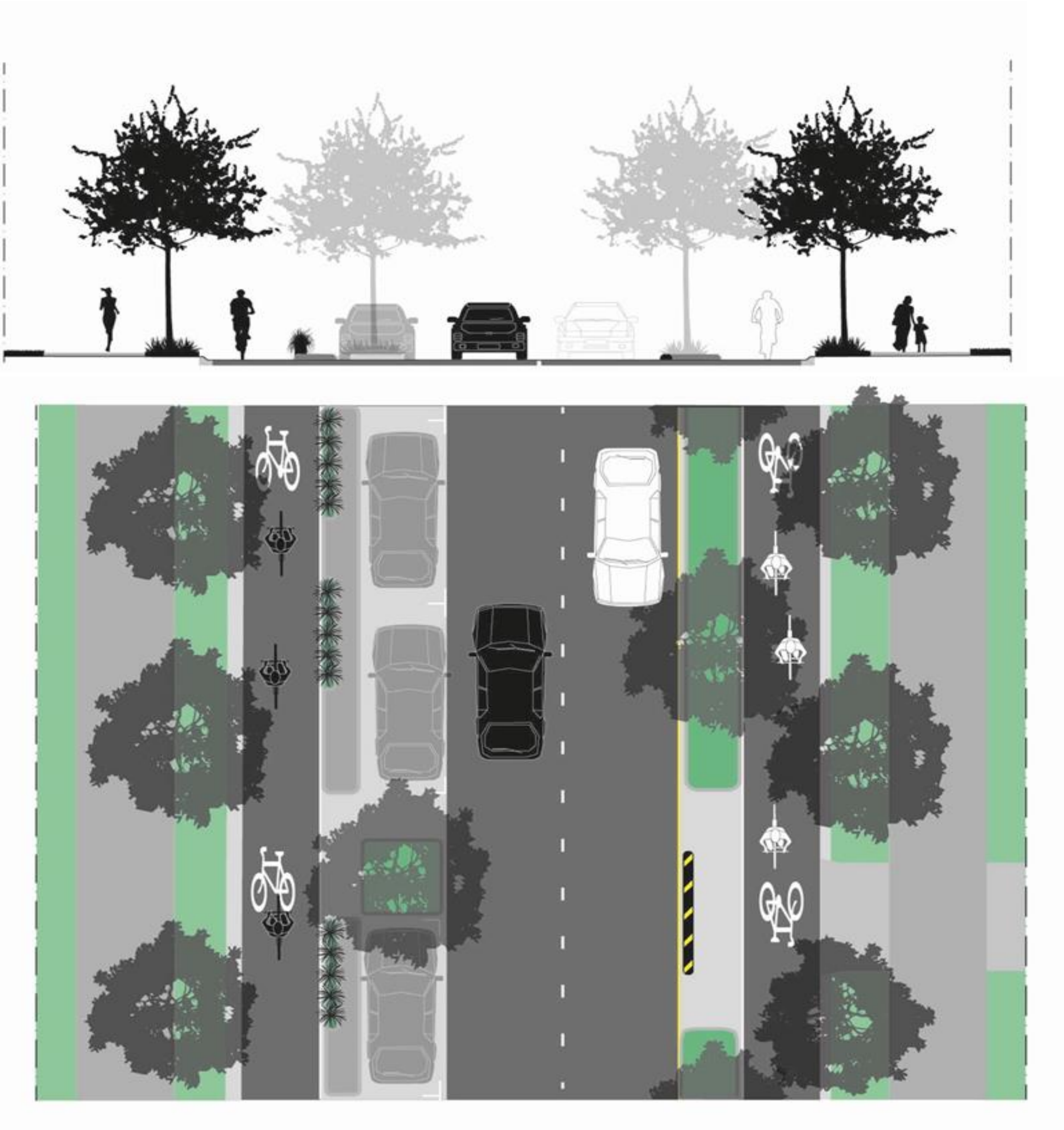
3 Mid-block bicycle facilities

This guidance should be read in conjunction with Austroads *Guide to Road Design* Part 3 Section 4.8. Guidance has been provided for both greenfield and retrofit situations, with drawings for various cross-sections included in Appendix B.

As vehicle speeds and traffic volumes increase, increasing separation between different road users is necessary for safety. Above an operating speed of 50 km/h, physical separation improves safety and willingness of less confident people to ride a bicycle. Figure 3 shows a road with 2.0 m one-way cycle tracks. The cycle track functions the same way as a bicycle lane but has a kerb on both sides, separating bicycle riders from both vehicles and from pedestrians.

To provide successfully for all ages and abilities of bicycle riders, all bicycle routes, including road crossings, ranging from local streets to along arterial roads must meet the needs of bicycle riders to be safe, direct, cohesive, comfortable and attractive.

Figure 3 – One-way cycle track example



Note: Refer Appendix B1.01 for more details

Overriding principles to guide cycle track design are found in Section 3.1.

This section provides guidance on physically separated mid-block bicycle facilities, specifically:

- one-way cycle track (both sides of the road), refer Section 3.2.1
- two-way cycle track (one side of the road), refer Section 3.2.2
- contra-flow one-way cycle track, refer Section 3.2.3
- service lanes, refer Section 3.2.4
- buffered bicycle lanes, refer Section 3.2.5, and
- cycle track cross-section options, refer Section 3.2.6.

Guidance on protected intersection design is then provided in Section 4.

3.1 Design principles

This section supplements existing guidance in Austroads *Guide to Road Design* Part 6A sections 3.1 and 4.2.1. To design cycling routes for transport, the infrastructure must meet the needs of all types of bicycle riders. There are five internationally-recognised requirements that must be balanced in the design of cycling infrastructure – directness, safety and perceived safety, comfort, attractiveness and coherence.

3.1.1 Directness

This can be measured by directness in time of travel (average speed) and directness in distance (trip length). Stops or loss of priority at crossings, delays at traffic signals, hills, detours, sharp corners, poor sight lines, shared paths (delayed by giving way to pedestrians) and rough surfaces, all affect directness. Because bicycles are human-powered, a direct route from A to B with optimal speed maintenance is essential in high-quality design.

Directness in time

Compared to motorised vehicles, once slowed or stopped, it takes a bicycle rider considerable time and effort to regain the required speed. Where bicycle riders are stopped or detoured, they will risk safety to save travel time. Any factor that slows down bicycle riders also influences directness in time and may reduce safety. The number of intersections where bicycle riders lose priority can be calculated as stopping frequency per kilometre, another indication of directness. This number should be as close to zero as possible.

Directness in distance

Directness can be calculated as the difference between the distance in a straight line and the shortest distance using the cycle network. A desirable maximum 'detour factor' of up to 1.4 should be used for a facility to still be seen as direct[5]. Cycling is attractive when the 'detour factor' of the cycle network is less than for motorised vehicles.

3.1.2 Safety and perceived safety

Safety of bicycle riders primarily depends on the amount of exposure to different masses and speeds of motorised vehicles. Perceived safety is equally important for less-confident, traffic-intolerant bicycle riders who feel especially vulnerable when mixing in the same space as fast-moving motorised vehicles. Where bicycle riders are provided exclusive space, cycling is perceived as safer and more people choose to ride[6]. To provide safety for all types of bicycle riders, conflicts with motorised vehicles should be avoided. Separation or clear priority should be highlighted with GIVE WAY lines and green surface treatment to reduce road user confusion and make roads and facilities self-explanatory.

Conflict avoidance

Generally, bicycle riders can safely mix with motorised vehicles up to 30 km/h; above this speed, cycle tracks separate bicycle riders to remove exposure and avoid conflicts. If it is not possible to separate motor vehicle and bicycle traffic, speed difference should be reduced. A road design that encourages a motor vehicle operating speed of up to 30 km/h achieves a comfortable mixing speed.

Conflict presentation

Where conflict points cannot be removed, reduce turning speeds and highlight clear priority to reduce severity of conflicts when they occur; for example, at intersections and driveways, this should be achieved by reducing turning speeds where motorised vehicles cross the path of bicycle riders and applying GIVE WAY lines and signs. By presenting these conflicts clearly, road users are made aware of risks and adapt behaviour.

Recognisable road hierarchy

Consistent design solutions make conflict situations more predictable, intuitive and comprehensible for all road users.

Other safety factors

Obstructions, poor surface quality, visibility of the road surface (especially at dusk and in the dark) and conflicts with other road or path users also affect safety.

3.1.3 Comfort

Reduce motorised vehicle threat

To design a bicycle facility that is comfortable for all ages and abilities to ride on, every effort must be made to reduce the threat caused to bicycle riders by motorised vehicles. Where the road is shared with motorised vehicles, posted speed should be reduced to achieve a comfortable mixing speed.

Maintain reasonable speed

An effective design aims to ensure bicycle riders can maintain their preferred speed comfortably. Obstructions that slow bicycle riders must be avoided, especially at intersections – ensure appropriate curve radii and width.

Smooth road surface

Asphalt is the preferred pavement type of cycle tracks and bicycle lanes. Surfaces for bicycle riders must be as smooth as, or smoother than, those acceptable for motorised vehicles. Asphalt cycle track at road level is recognised as part of the road network rather than the pathway network and is less likely to be used by people walking.

Any surface that is poorly maintained, collects debris, has joints causing vibrations or has obstacles, makes cycling a more complex task that requires more concentration and effort and reduces comfort. If the cycle track is rough or contains defects or other surface hazards, bicycle riders will choose to ride in the smoother traffic lane, potentially increasing conflict with motorised vehicle drivers. Rumble strips are also a hazard and should not be placed in or alongside the cycle track or bicycle lane.

This section should be read in conjunction with existing guidance in Austroads *Guide to Road Design* Part 6A Appendix C on path construction and maintenance.

Avoid sharp curves

Transport routes for people riding bicycles should be direct from A to B and bends should be avoided as much as possible.

Minimise steep grades

Multiple steep sections can reduce cycling comfort and may reduce the number of people who are likely to use the cycle route. Conflict points at the bottom of hills can impede rider momentum and significantly increase the required effort to climb the next hill.

Gradients near intersections should be minimised as much as possible (ideally less than a 5% downgrade on approach). Steeper gradients may reduce braking ability.

Protection from the elements

Like pedestrians, bicycle riders are exposed to sun, rain and wind and will seek shelter while riding. Bicycle riders can be protected from the elements with appropriate shade structures, vegetation or by buildings. Particular care must be taken to choose appropriate vegetation that will not cause a safety hazard or ongoing maintenance problem. Rounded fruits, seeds or slippery leaf litter can be problematic.

Trees alongside a cycle track can provide perceived safety, comfort and health benefits besides shade. Depending on the location of the tree, it can provide a visual and perceptual barrier between the cycle track and motor vehicles, and the cycle track and pedestrians. A preference study of users on tree locations undertaken in Boston by Lusk et al[7] indicated that low bushes between the cycle track and street / parked cars was most preferred, followed by trees in this location. Benefits noted by the respondents of vegetation in this location were a blocking of perception of traffic, reduced perception of pollution exposure and the user feeling cooler. Pedestrians, however, preferred the vegetation between the cycle track and footpath, particularly when the cycle track was at the same level as the footpath.

Shade trees, if feasible for the site, are preferred to address the Queensland weather.

3.1.4 Attractiveness

Attractiveness of a bicycle facility relates to both perceived safety and quality of infrastructure. The surroundings encountered when cycling range from attractive to intimidating and can encourage or discourage cycling along a route. Landscaping and surroundings can make a cycling route very attractive through an area that might have otherwise been avoided, while high fences, lack of casual surveillance and no lighting at night can result in perceived and actual loss of personal security.

A lack of bicycle infrastructure deters bicycle riders[8]. Bicycle infrastructure that is physically separated from motorised vehicles, direct and attractive is perceived to be safer and will attract all types of bicycle riders[9].

3.1.5 Coherence

Coherence is most relevant at the broader cycle network level. The cycle network should include an appropriate density of well-connected cycle routes linking all origins to all destinations, including public transport stations, without interruption. Cycle routes that suddenly stop are a major disincentive for cycling and may force bicycle riders into a dangerous situation. Bicycle riders should always be confident that there will be a high-quality cycling route to all destinations. Low density development and poorly connected streets reduce the coherence on the cycle network.

3.2 Mid-block cycle track design (one-way or two-way)

Physically-separated cycle track is recommended where the operating speed is 50 km/h or higher. Cycle track should have contrasting pavement of black asphalt to distinguish the cycle facility from the white concrete footpath. The cycle track separates bicycle riders from motor vehicles and pedestrians, resulting in significantly-lower injury risk for bicycle riders and increased ridership. Cycle tracks and separate footpaths are also preferred in locations where there are fewer than 30 pedestrians per hour, such as at activity centres, to reduce conflicts between these user types and maintain directness and comfort for people walking and cycling.

One-way cycle track (on each side of the road) is preferred over two-way cycle track, because more efficient traffic signal operations can be achieved, and the risk of crashes is higher at intersections where bicycle riders are travelling in both directions on one side of the road[10]. One-way cycle track also offers improved coherence, legibility and local access and should be installed where there is adequate space; refer Appendices B1.01 and B1.02 for details. Greenfield and retrofit situations are included, with series A referring to one-way cycle tracks and series B referring to two-way cycle tracks.

At mid-block, the location of the cycle track may place bicycle riders further from view of motorised vehicle drivers than a bicycle lane would. For this reason, the presence of bicycle riders should be highlighted at conflict points such as at intersections. Safe vehicle turning speeds and 70–90° observation angles for turning motor vehicle drivers maximise visibility of bicycle riders and reduce severity if conflicts do occur. Raised priority crossings and other safety improvements are recommended to highlight conflict points (refer Section 4).

3.2.1 One-way cycle track (both sides of the road)

A one-way cycle track is the preferred form of cycle track and functions with the same priority at intersections as a bicycle lane. It is installed on both sides of the road and functions in the same direction as the adjacent traffic but is physically separated from vehicular traffic. The amount of physical separation depends on vehicle speed and volumes and can take the form of a median, kerb, verge or buffer planting.

A minimum cycle track width of 2.0 m is recommended (Table 3.2.1). In retrofits, an absolute minimum of 1.7 m may be used. Where bicycle traffic volume exceeds 150 / hour, and at steeper grades, a one-way cycle track should be wider. Cycle track that is 2.0 m wide allows comfortable overtaking and allows bicycle riders to ride side-by-side. Figures 3.2.1(A), 3.2.1(B) and 3.2.1(C) show good examples of one-way cycle track in Melbourne.

Table 3.2.1 – One-way cycle track dimensions (on each side of the road)

Peak hour volume (bicycle riders / hour)	Width (m)
0–150	2.0–2.5
150–500	2.5
>500	3.0

For further guidance refer to Transport and Main Roads' Supplement to Austroads Guide to Road Design, the Road Planning and Design Manual Volume 3 Part 6A Pedestrian and Cyclist Paths.

Figure 3.2.1(A) – One-way cycle track, Latrobe Street, Melbourne

Figure 3.2.1(B) – One-way cycle track with parking, with at-grade footpath at side road, Latrobe Street, Melbourne

Figure 3.2.1(C) – One-way cycle track under construction, Latrobe Street, Melbourne

Where on-street parking is permitted, or vehicle operating speeds are >60 km/h adjacent to the cycle track, a minimum 0.75 m separator is recommended (additional to cycle track width). Where no parking is provided adjacent to the cycle track, the buffer can be reduced to 0 m (physical separation is achieved with a 75–150 mm-high kerb) where dual kerb cycle track (see Section 3.2.6.1) is used and where vehicle operating speed is ≤60 km/h. Reducing the buffer to a vertical step (0 m) maximises the usable space in a constrained corridor. As vehicle speeds and volumes increase, physical separation of bicycle riders should also increase.

One-way cycle track on each side of the road is preferred over a two-way cycle track for improved safety and operations at intersections. One-way cycle tracks connect well with the surrounding non-cycle track facilities such as bicycle lanes, whereas two-way cycle tracks generally force one of the directions to cross the road, inducing delay and safety risks. Cycle tracks must have designated priority over side-streets and driveways to provide directness and safety for users and deter bicycle riders from using the adjacent traffic lanes. For information, refer to Section 4.2.

Vehicle parking must be prohibited on the cycle track. Where bicycle riders are observed travelling the wrong direction on one-way cycle track, directional arrows should be added.

3.2.1.1 Safety retrofit example bicycle / car parking lanes conversion

This section supplements Austroads *Guide to Road Design* Part 3 Section 4.8.10.

Where on-street parking is permitted along a road section which contains bicycle lanes, driver-side ‘dooring’ crash risk is introduced[11]. Less-experienced bicycle riders and car drivers may not be aware of this significant ‘dooring’ risk. This is compared in Figure 3.2.1.1(A). Often, riders feel pressured to hug the driver-side door zone. This high-stress situation is a deterrent to new bicycle riders as it can result in crashes of high severity that project a 'doored' rider into the adjacent traffic lane, while a rider falling prone into a traffic lane is exposed to a secondary impact of extreme high severity from a vehicle in the traffic lane. Reconfiguring the space to a one-way cycle track and using on-street parking to separate riders from moving vehicles reduces both the 'dooring' frequency potential (1.2 occupants per vehicle on average) and the high-severity secondary interaction with a moving vehicle[12]. A buffered bicycle lane may be an option if sufficient space is available (see Section 3.2.5).

The safest, most economical and space-efficient option is to eliminate driver side 'dooring' conflicts by removing parking on roads where bicycle lanes are required.

Other retrofit options are detailed in Appendix B1.

Figure 3.2.1.1(A) – Bicycle / car parking lane, Brisbane compared to one-way cycle track and parking, Assen, The Netherlands (both 4.0 m total width)

In retrofit circumstances, reduction in traffic lane width may also facilitate implementation of a bicycle infrastructure. Traffic lanes (>3.0 m) in urban areas encourage less safe motor vehicle speeds, longer crossing distances for people walking and less space for bicycle infrastructure or footpaths. Human behaviour is affected by the street environment. Narrower traffic lanes result in less aggressive driving and more reaction time to slow or stop a vehicle over a short distance[13].

Parking area delineation treatments such as cobblestones, porphyry stones or other surface treatments, along with landscaping between parking spaces, can also assist to narrow the road visually and promote a safer urban speed environment.

Figures 3.2.1.1(B) and 3.2.1.1(C) show examples of constrained kerbside cycle tracks adjacent to on-street parking at various widths.

Figure 3.2.1.1(B) – Two-way cycle track and parking, Sydney

Figure 3.2.1.1(C) – One-way cycle track and parking, Nijmegen, The Netherlands (5.0 m total width)

3.2.2 Two-way cycle track (one side of the road)

One-way cycle track on each side of the road is preferred over two-way cycle track because of reduced delay and improved safety and operations at intersections. The risk of crashes is slightly higher at intersections where bicycle riders are travelling in both directions on one side of the road. The complexity of two-way bicycle movement at an intersection can add additional time to a signalised intersection and affect its operation and capacity; however, two-way cycle track requires less overall space than one-way cycle track on each side of the road. Two-way cycle track on one side of the road is suitable:

- at school frontages (on school side, to reduce confusion at school gates and reduce need to cross road), see Figure 3.2.2(A)
- where there are long distances between intersections
- where attractions such as shops are located along only one side
- where very few or no accesses are located along one side of the road
- where the continuation of a two-way cycle track is the most coherent solution
- in greenfield developments, where future road duplication is required (enabling a two-way cycle track to be delivered with the first road stage), and/or
- where road corridor width is very constrained in a retrofit situation.

Figure 3.2.2(A) – Two-way cycle track mid-block in a new development, Aura, Caloundra

For a two-way cycle track, a width of 3.0 m is recommended, with a minimum width of 2.4 m at isolated locations. The recommended width based on the projected usage is shown in Table 3.2.2. Where there is on-street parking or vehicle speeds are above 60 km/h adjacent to the cycle track, a 1.0 m separator is recommended. As an absolute minimum, the separator between the two-way cycle track and parked vehicles or traffic can be reduced to 0.4 m (see Figure 3.2.2(B)). Where traffic speeds are higher (>60 km/h), a 1.0 m separator should be provided (regardless of the absence of on-street parking).

Figure 3.2.2(B) – 2.4 m-wide two-way cycle track College Street, Sydney

Arterial roads are often already on the future Principal Cycle Network, are usually the flattest and most direct routes, and are the best location for a cycle track. A two-way cycle track is especially effective where it follows the desire line and there are very few accesses on one side. For large urban arterial roads with few crossing opportunities, a two-way cycle track on each side of the road may be the best solution.

On an urban collector road with parking, a minimum 3.0 m-wide two-way cycle track is recommended (Table 3.2.2); however, there are some examples from Sydney, New South Wales where this width has been reduced further. Figure 3.2.2(C) shows an example in Bourke St, Sydney where traffic lanes have been reduced in width, centreline is removed, and parking width reduced to fit the two-way cycle track on one side and car parking on both sides.

Figure 3.2.2(C) – Two-way cycle track, Bourke Street, Sydney

Table 3.2.2 – Two-way cycle track dimensions

Peak hour Volume (bicycle riders / hour)	**Width (m)**
0–150	3.0 (min 2.4 m)
150–500	3.0
>500	4.0

For further guidance refer to Transport and Main Roads' Supplement to Austroads Guide to Road Design, the Road Planning and Design Manual Volume 3 Part 6A Section 2.2.3.

Figure 3.2.2(D) shows a good example of a major arterial road with no parking and a two-way cycle track separated by a median kerb.

Figure 3.2.2(D) – Two-way cycle track on major road, Annerley Road, Brisbane

Figure 3.2.2(E) – Two-way cycle track and parking, Sydney (4.7 m total width)

3.2.3 Contra-flow one-way cycle track

Austroads *Guide to Road Design* Part 3 Section 4.8.6 recommends contra-flow bicycle lanes where posted speed is ≤50 km/h. Where posted speed is >50 km/h, physical separation is recommended. A separated contra-flow bicycle lane is of most benefit where a direct route or logical shortcut is created (see Figure 3.2.3). Intersections and their approaches need continuity and clear continuity for the bicycle facility. See Section 4 for more details.

Figure 3.2.3 – Contra-flow one-way cycle track, Perth

Source Warren Solomon

Intersections and their approaches need particular consideration to ensure continuity and clear priority for the bicycle facility. See Table 3.2.3 for more details.

Table 3.2.3 – Contra-flow one-way cycle track dimensions

Peak hour Volume (bicycle riders / hour)	Width (m)
0–150	1.5–2.5
150–500	2.5–3.5
>500	3.5–4.0

3.2.4 Service lanes on arterial road for one-way local vehicle access mixed with bicycle traffic

Where property access is required for business or residents along an arterial road, a service lane (a single-lane service road) can be used to provide for cycling. Where vehicles access the service lane, it must be designed for an operating speed of ≤30 km/h. Narrow lane width (3.0 m) and other low-speed traffic calming treatments must be used to ensure speeds are homogenous and safe for mixing all road users.

As shown in figures 3.2.4(A) and 3.2.4(B), motor vehicle parking should be accessed in the service lane. Vehicle access to the service lane should be limited to between major intersections. Cycle tracks provide the link between service road terminals and major intersections.

This section should be read in conjunction with Austroads *Guide to Road Design* Part 3 Section 4.11.

Figure 3.2.4(A) – One-way cycle track with local vehicle access

Note: Refer Appendix B1.02 for more details including numbered note descriptions.

Figure 3.2.4(B) – One-way cycle track with local vehicle access, Rotterdam, Netherlands

3.2.5 Buffered bicycle lane

Where funding is not available for physically-separated cycle track designed in accordance with these guidelines, a buffered bicycle lane is a low-cost option. To separate bicycle riders from traffic, painted median and frangible bollards are installed as shown in Figure 3.2.5. Advantages and disadvantages of this facility type are:

- frangible bollards restrict car access but affect usable bicycle lane operating space
- existing kerb gives clear delineation from the footpath
- the existing drainage system is used, and
- regular maintenance is important to ensure the buffered bicycle lane does not collect debris and the physical separators remain in a safe state.

Section 7.1 *Bicycle lane separation devices* in Transport and Main Roads' Supplement to Austroads' *Guide to Traffic Management* Part 10 *Traffic and Road Use Management manual* Volume 1 provides further guidance on preferred treatments and design characteristics of bicycle lane separation devices.

Figure 3.2.5 – Buffered bicycle lane with clearway during peak hour and car parking in off-peak, Albert Street, Melbourne

3.2.6 Cycle track cross-section options (Appendix B1.04)

Cross-section options vary depending on access, constructability, drainage, maintenance, separation and utilities. Cross-section consistency along a route is highly desirable. Cross-section type may vary, especially in retrofit situations where high cost or non-negotiable constraints are more likely to govern project development.

In Australia, a cycle track at road level is generally preferred so that the cycle track is clearly part of the roadway environment, so existing kerb and channel can remain, reducing retrofit cost. A common Queensland width for urban roads is 12.4 m. Appendix B1.01A Section 12.4 shows one-way cycle tracks retrofitted into this common width with parking on one side.

Preference should be given to a separator kerb profile that is semi-mountable on the bicycle side with a barrier kerb on the motor vehicle side. Where separation is provided adjacent to moving traffic, the width should increase with higher traffic speeds. Careful consideration should be given to the surface finish of the separator. Any vegetation that is planted within the median should be low growing (below knee height <300 mm) and above head height (2.4 m) and require minimal maintenance.

3.2.6.1 Dual-kerb cycle track

A dual-kerb cycle track has kerbs on both sides of the physically-separated cycle track (that is, to road and to footpath) instead of a median separator.

The height of the kerb between the footpath and the cycle track needs to minimise trip hazards, especially when a change in pavement type is not obvious. At pedestrian desire lines, particularly at intersections, flush kerbs are recommended with obvious contrast distinction between the two facility types (for example, contrasting pavement materials or flush kerb non-slip divider strips).

For examples of dual-kerb cycle tracks, see figures 3.2.6.1(A) and 3.2.6.1(B). The key elements of a dual-kerb cross-section follow.

- It gives clear delineation from the footpath. Delineation with contrasting pavements should be considered, such as asphalt for the cycle track and concrete or coloured pavement for the footpath. Vegetation between the footpath and cycle track also improves delineation. These is particularly important where pedestrian desire lines exist across the cycle track, and aids useability for those with visibility impairments.
- It fits within a constrained cross-section.

- To form the cycle track, the existing kerb may be retained, and a new kerb provided, with the existing roadway covered in a layer of new asphalt between the existing kerb and the new kerb.
- Kerb heights of minimum 150 mm with a 1:8 slope (height: width) and smooth finish should be installed on the footpath side to minimise pedal strike and reduce trip hazards. The kerb height on the vehicle side should meet current standards (150 mm).
- Existing drainage is retained, with road run-off inlet pits placed in the new kerb and along the parking edge, and existing drainage pits adjusted to suit new levels / cross-falls to channel run-off to the existing road drainage pipes (see Figure 3.2.6.1(B)).
- The height of the existing kerb should be minimised to reduce the chance of bicycle pedal strike on the left (see Figure 3.2.6.1(A)).
- A 2–4% cross-fall is provided across the cycle track towards the kerb and channel. A dual-kerb cycle track cross-section is appropriate where there is inadequate space to accommodate a footpath-level cycle track cross-section with landscaping to separate bicycle riders from pedestrians on the footpath.

Figure 3.2.6.1(A) – Two-way cycle track, dual kerb profile, Sydney

Source: City of Sydney

Figure 3.2.6.1(B) – Dual kerb two-way cycle track with drainage pits at both kerbs, Bourke Street, Sydney

3.2.6.2 Median-separated cycle track

The alternative to a dual kerb cycle track is one which is physically separated by a median separator. The median separator is additional width to that required for the cycle track.

For examples of these types of cycle tracks, see figures 3.2.6.2(A), 3.2.6.2(B) and 3.2.6.2(C). The key elements of a median-separated cross-section follow.

- Existing kerb gives clear delineation from the footpath. Trees and poles along the kerb-line add to this delineation.
- To create the cycle track, a small median is constructed to separate the cycle track from traffic.
- Minimise kerb height to reduce chance of bicycle pedal strike.
- The existing drainage system is used. Gaps are carefully aligned to allow water to drain to existing pits along the retained kerb and channel.

- This median-separated cross-section may be the most cost-effective physical separation option if the existing drainage can be retained.
- Options exist to include planting within the median separator (refer figures 3.2.6.2(B) and 3.2.6.2(C)). Planting should be responsive to local conditions; consider ongoing maintenance and should either be low growing and/or, where space allows, have a canopy more than 2.4 m high for shade.

Figure 3.2.6.2(A) – Two-way cycle track, median separated profile, Woolloongabba, Brisbane

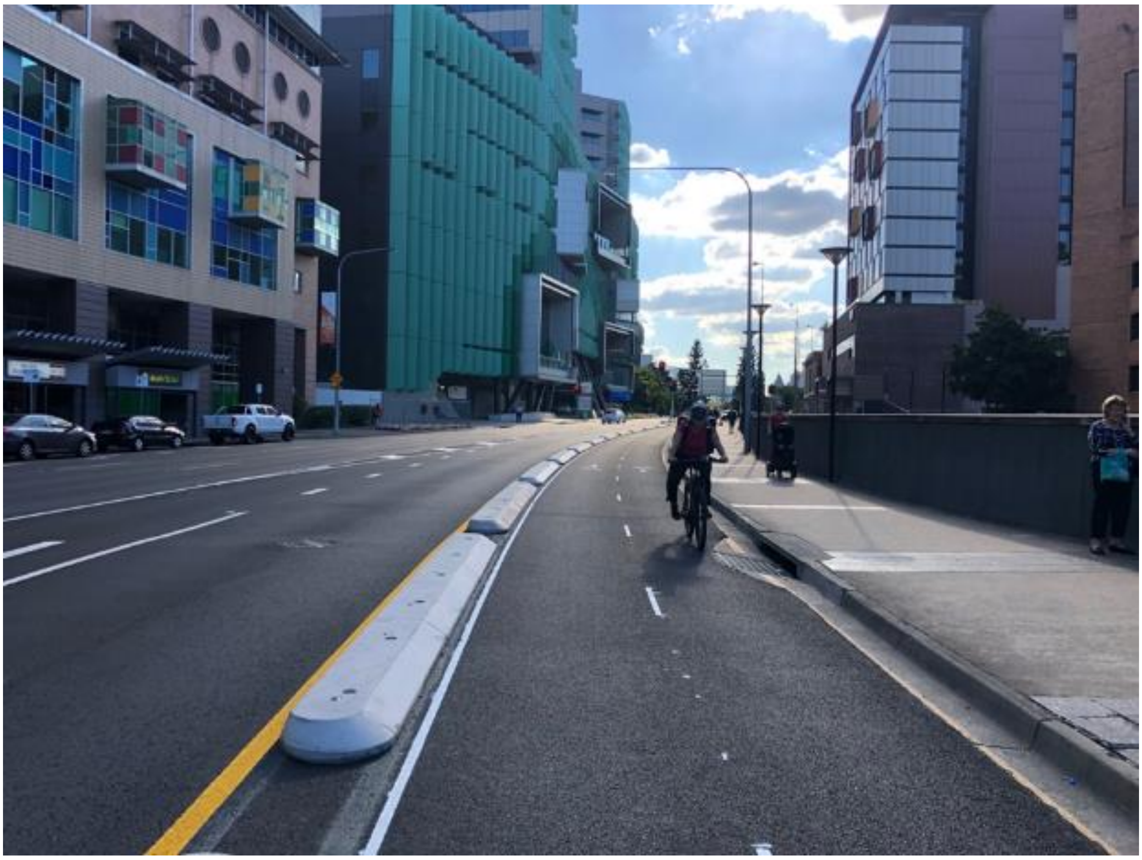


Figure 3.2.6.2(B) – Two-way cycle track, median separated profile, Sydney

Source: City of Sydney

Figure 3.2.6.2(C) – Two-way cycle track with planter separator, Auckland

Source: Google Maps

3.2.6.3 Cycle track at footpath level

Cycle track at footpath level can work well if appropriate delineation is achieved between space for pedestrians and space for bicycle riders such as a suitable landscaped separation. If there is no separation, pedestrians will most likely walk across the full width. Visual delineation such as white concrete footpath and black asphalt cycle track is essential.

For examples of cycle tracks at footpath level, see figures 3.2.6.3(A)–(D). The key elements of a footpath level cross section follow.

- A planting strip (minimum 0.5 m, depending on local conditions, plant selection and ability to maintain and water plants) is used to separate the cycle track from the footpath. If no planting strip is provided, pedestrian intrusion onto the cycle track may occur as there is no grade separation. Planting strips could be wider to cater for more substantial tree plantings for shade. Where planting is not feasible, a pavement strip using different or contrasting pavement types / colours could be considered.
- To create the cycle track, new kerb and channel is installed in the existing roadway. New asphalt is installed between new kerb and the existing kerb.
- The existing drainage line is retained, with road run-off inlet pits placed in the new kerb along the parking edge and along the edge of the cycle track to channel run-off to the existing road drainage pits.
- Paving between the cycle track and footpath is provided to allow egress between parked cars and footpath. Paving of cycle track is to be differentiated from the main footpath to reinforce separation (for example, black asphalt and white concrete).
- No kerb to the footpath side results in no chance of bicycle pedal strike.
- A footpath-level cross-section is only appropriate where there is adequate width within the footpath to accommodate the planting strip and also maintain sufficient footpath width to cater for pedestrian demand.
- A drain to the existing stormwater drainage system, alongside the planting strip, is required to channel run-off from both the cycle track and footpath to the existing road drainage pits.

Figure 3.2.6.3(A) – Two-way cycle track, one-step profile – planting separation and pavement contrast. Bourke Street, Sydney

Source: City of Sydney

Figure 3.2.6.3(B) – Two-way cycle track – planting separation, Aura, Caloundra

Figure 3.2.6.3(C) – Two-way cycle track, pavement delineation, Stanley Street, Woolloongabba

Figure 3.2.6.3(D) – Two-way cycle track at footpath level with drain alongside planting strip, Bourke Street, Sydney

3.3 Other considerations

The five principles listed in Section 3.1 apply to all aspects of design for bicycle riders. The following considerations are to be read in conjunction with existing Austroads guidance.

3.3.1 Assessing existing on-street parking demand

As part of any bicycle infrastructure improvement on the road network, assessment of car parking supply is an important consideration. Austroads *Guide to Traffic Management* Part 11 Section 3.2.2 outlines the correct process for setting parking supply based on actual demand. Surrounding walkable parking supply (both on-street and off-street) and future land uses should also be taken into account.

Reconsidering on-street car parking supply where appropriate can benefit bicycle riders. On-street car parking can affect LTS as 'dooring' risk can be a deterrent to new and existing bicycle riders. In retrofit situations, on-street car parking rationalisation can be an opportunity to provide more space for bicycle riders while also enabling safer and smoother motorised traffic flows.

3.3.2 Clearances to static objects

The functional path width of a bicycle facility does not include clearances to obstacles such as parked cars or other hazards. The recommended clearance widths to various hazards are shown in Table 3.3.2. All hazards should be considered, including beyond the kerb.

Where a cycle track or path is constrained by physical barriers, railings, crash barrier, fence and such on both sides, the clearance shown in Table 3.3.2 is recommended on each side of the cycle track or path. Refer to Austroads *Guide to Road Design* Part 6A Section 5.5 for further information on clearances.

Table 3.3.2 – Clearances to static objects

Feature	Minimum clearance	Desirable clearance
One-way cycle track with no car parking adjacent	0 m	1.0 m desirable for arterial roads
Parked cars adjacent to one-way cycle track	0 m	0.75 m desirable
Parked cars adjacent to two-way cycle track	0 m	0.40 m desirable
Bus stop, railing, crash barrier, poles, bollards, street tree, wall or fence	Refer to Austroads *Guide to Road Design* Part 6A Section 7.7	

Figure 3.3.2 – Two-way cycle track diverted around existing street tree, Bourke Street, Sydney

3.3.3 Bus stop treatments

Several conflicts may arise at bus stops, including those between bicycle riders, passengers waiting for the bus and passengers entering or alighting from bus services.

To provide access for pedestrians between the footpath and bus stop, clear crossing points across the cycle track can be provided at appropriate locations with adequate sight distance. Barrier or lean rail can be used within the bus stop area to guide pedestrians to designated crossing points. For specific guidance, refer to Transport and Main Roads *Public Transport Infrastructure Manual*. Figures 3.3.3(A) and 3.3.3(B) show a range of examples of constrained situations where bus stops are located in front or behind cycle tracks.

Figure 3.3.3(A) – Two-way cycle track behind bus stop, Bourke Street, Sydney

Figure 3.3.3(B) – One-way cycle track behind bus stop, Annerley Road, Brisbane

3.3.4 Pedestrian access

Access for pedestrians, particularly people with a mobility or vision impairment, is an important consideration in the separated cycle track design. Pedestrian desire lines, grade differences, visual contrast, tactile contrast and trip potential must be considered in the design of the treatment separating pedestrians and bicycles. This is particularly important at locations where high numbers of pedestrians are expected to cross the cycle track.

Clearly defining space for pedestrians is important to achieve appropriate use by pedestrians and bicycle riders. Separation between cycle tracks and footpaths can be provided via height difference of the kerb, differences in pavement type (for example, asphalt cycle track or concrete footpath), vegetation or pavement strips. Refer figures 3.3.4(A) and 3.3.4(B) for examples.

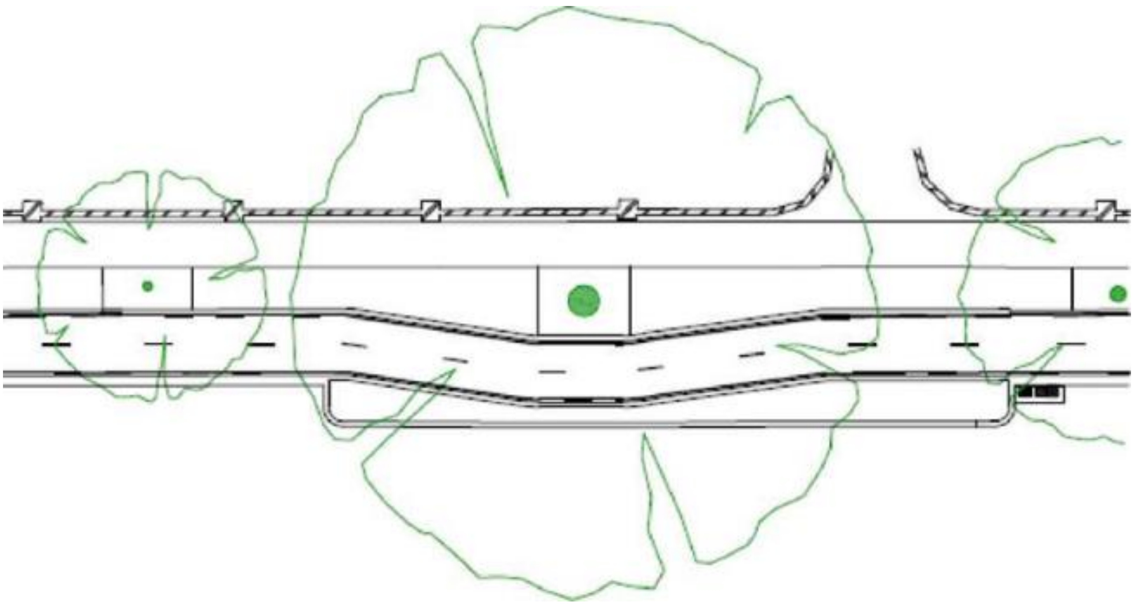
Figure 3.3.4(A) – Planting separation between cycle track and footpath, Brisbane Road, Mooloolaba

Figure 3.3.4(B) – Pavement difference between cycle track and footpath, Aura, Caloundra

3.3.5 Street trees

Retained street trees should be checked to ensure both appropriate horizontal and vertical clearance and sight lines are acceptable. In some cases, the alignment of the bicycle facility may need to be adjusted to avoid the street tree. A 1.0 m/s lateral shift would be appropriate (see figures 3.3.5(A) and 3.3.5(B)). Lighting should highlight the change in alignment.

Figure 3.3.5(A) – Treatment of a street tree



Trees alongside a cycle track can create visual and perceptual barriers between the cycle track and motor vehicles, and the cycle track and pedestrians. They also provide shade and shelter for pedestrians and bicycle riders.

Figure 3.3.5(B) – Two-way cycle track diverted to retain street tree, Bourke Street, Sydney

3.3.6 Detailed design

Detailed design issues for each site, including mid-block and at intersections, will vary. Existing standards and approaches on constructability, drainage / stormwater, maintenance, signage and utilities should be applied. Some drainage examples have been provided in this guide but ability to achieve these will vary for each site.

Ongoing maintenance of the cycle track should be considered during design; existing guidance in Austroads *Guide to Road Design* Part 6A Appendix C on path construction and maintenance and Transport and Main Roads Technical Note TN132 *Maintenance minimisation guidelines for walking and cycling facilities* should be referenced.

Drawings in Appendix B provide suggestions for garbage bins on cycle tracks if required. Garbage collection typically occurs one day a week, so its effect on the operation of the cycle track is minimal but important to include in design if possible.

4 Protected intersections

This section is to be read in conjunction with Austroads *Guide to Traffic Management* Part 6 Section 1.

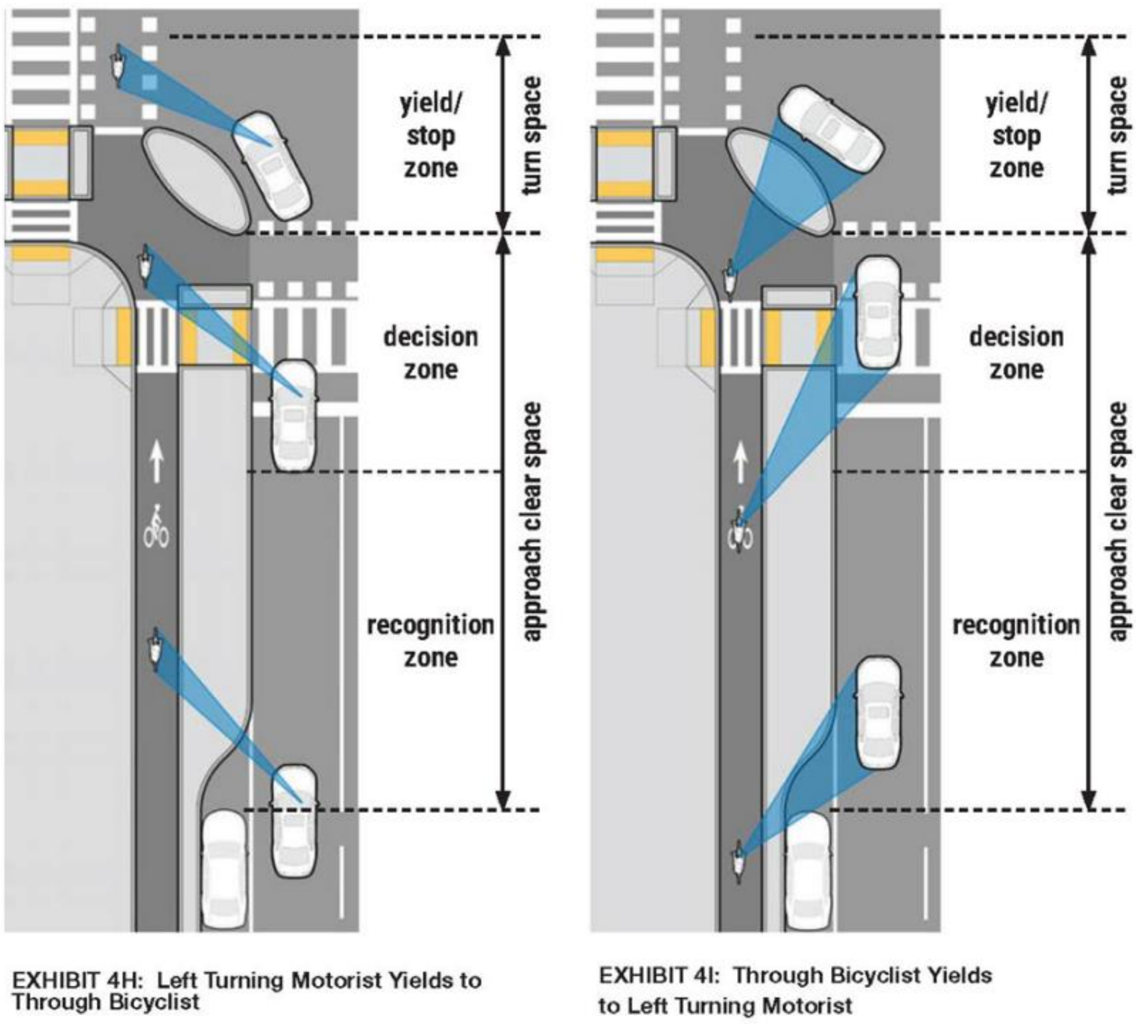
In new and retrofit situations, a protected intersection maximises physical separation of the bicycle facility throughout an intersection and minimises conflict area to where motorised vehicles are travelling below critical impact speeds while maximising motor vehicle driver visibility to bicycle traffic.

An overall aim of traffic management is to facilitate the operation of traffic on the roads with safety and efficiency, taking into account needs of all relevant road users. In the context of providing and managing intersection facilities, the Safe System approach aims to ensure that potential collisions are avoided and, if they occur, that the potential crash impact forces do not exceed human tolerances (that is, aiming to minimise the risk of fatal or serious injury). Human-centred design requires the relevant road authority to plan and design intersection facilities within these human tolerances.

Where motorised vehicles cross the path of people walking or cycling, high-severity conflicts can result, even if the relative speed is low; for example, when a person walking is hit by a motor vehicle travelling at 50 km/h, the fatality risk of a collision is twice as high as the risk at 40 km/h and more than five times higher than the risk of a motor vehicle travelling at 30 km/h. To reduce the severity of a crash when a person who is walking or cycling is hit by a motor vehicle, urban intersection design must result in 'survivable' impact speeds (<30 km/h)[14].

Satisfying these Safe System responsibilities at urban intersections with cycling facilities is achieved either by removing conflicts between motorised vehicles and bicycle riders or by locating the conflict so that it is below the survival range of impact speeds (refer Figure 1.2(C) in Section 1.2) and where visibility to bicycle traffic is best achieved (refer Figure 4).

Figure 4 – Safe visibility for conflicts at intersections



Source: Massachusetts Department of Transportation, 2015[15]

4.1 Intersection design that matches the functional road hierarchy

A self-explanatory functional road hierarchy results in clear expectations for all road users. Clear priority for the dominant road is required where it meets a lower-order road such as a local access road. At conflict locations, such as intersections where motor vehicles on a lower-order road cross bicycle traffic on the dominant continuing road, priority for bicycle traffic should be highlighted in the design with safety treatments such as raised priority crossings with GIVE WAY lines and signs to show clearly the continuing priority for cycle track and footpath users (see Section 4.3).

Primary Safe System intersection treatments for bicycle facilities on urban roads include:

- protected unsignalised intersections (refer Section 4.3)
- protected roundabout intersections (refer Section 4.4), and
- protected signalised intersections (slip lanes are not compatible, refer Section 4.5).

Protected intersection treatments achieve 'equitable speeds' (below critical impact speeds) at conflict points with motorised vehicles and maximise physical separation, including at approaches, bicycle storing areas and exits, while achieving the same level of directness as parallel general-purpose traffic lanes.

4.2 Intersection principles for bicycle traffic

To provide for bicycle riders at intersections, the key requirements are directness, safety and comfort. Table 4.2 gives explanations of the main requirements at intersections.

Table 4.2 – Summary of the main requirements for bicycle traffic at intersection

Main requirement	Important aspects	Explanation
Directness	Directness in time	Directness in time depends on delays, detours and maintaining design speed. Delays can be limited by minimising the chance of stopping and minimising waiting times. This includes using bicycle-friendly adjustment of signal phasings. Where a cycle route crosses a through road mid-block, a refuge can significantly reduce delay (where there is no time-separated facility such as a pedestrian zebra crossing). Often time delays on the bicycle infrastructure may result in riders continuing to use the traffic lanes.
	Directness in distance	Avoid obliging bicycle riders to make illogical movements at intersections or divert around intersections.
Safety	Risk of (serious) conflicts	The number of conflicts with motorised traffic is minimised. Where large speed differences are involved (vehicle speed >60 km/h), crossing traffic movements are time-separated by signals or grade-separated. For unsignalised crossings, speed differences are minimised, based on bicycle operating speed (varies, depending on gradients).
	Visibility	In built-up areas where speed is ≤60 km/h, the cycle track should be located within the motorists' field of vision (≤6 m from the main road) to locate the conflict point where vehicle speed is lowest when turning.

Main requirement	Important aspects	Explanation
	Smooth pavement	Asphalt pavement for the cycling facility meets requirements for evenness and smoothness.
	Clear expectations	Design principles and basic principles are applied in a uniform manner appropriate to the function of the intersecting roads.
	Lighting	Intersections, including approaches, are lit sufficiently.
Comfort	Smooth road surface	The asphalt paving is sufficiently smooth and ramp transitions are bicycle-friendly (1 in 20, undetectable smooth transition, no lip).
	Minimise delay	The risk of waiting (delays) is minimised.
	Clear passage	Curve radii take account of the design speed appropriate to the function concerned. Ongoing bicycle riders at intersections are not hindered by stationary bicycle riders or vehicles.
	Stress from motor vehicle traffic	Bicycle riders are not subjected to stressful conflicts from motorised traffic. In complex situations, the bicycle facility is separated physically.
	Weather nuisance	Nuisance due to wind, rain and sun is minimised; for example, shade structures at waiting areas.

4.3 Protected unsignalised intersections (Appendix B2.01A)

This section is to be read in conjunction with Austroads *Guide to Road Design* Part 4 Section 9.6 and Transport and Main Roads *Guideline: Raised priority crossings for pedestrian and cycle paths*. Throughout this section, LTS score is listed for examples. An example is shown in Figure 4.3(A).

Figure 4.3(A) – Protected unsignalised intersection with two-way cycle track and separate footpath with zebra pedestrian crossing, Aura, Caloundra (LTS1)

In new and retrofit situations, a protected unsignalised intersection maximises physical separation of the bicycle facility throughout an intersection and minimises the conflict area to where motorised vehicles are travelling below critical impact speeds while boosting motor vehicle driver visibility to bicycle traffic (refer Figure 1.2(C) in Section 1.2). Protected unsignalised intersections can be installed with continuing cycle track and separate footpath where there are >30 pedestrians per hour. Shared paths are appropriate where there are fewer than 30 pedestrians per hour.

In urban areas, where the aim is to attract new bicycle riders, the design of unsignalised intersections must highlight the continuing priority of bicycle traffic on the bicycle facility where vehicle traffic enters and exits side roads. Unsignalised intersections are designed:

- to be within critical impact speeds at conflicts for all road users
- to ensure that all road users are aware of the crossing and certain of the priority that applies
- so that the location and design of the crossing, and the priority applied, does not put people walking or cycling at risk of unsafe motor vehicle turning speeds, and
- to encourage safe and correct behaviour by motor vehicle drivers. This can be achieved using mountable apron areas at corners and raised priority crossings at unsignalised conflicts.

Where a through road with continuing bicycle facility intersects a minor terminating road, mandatory attributes are:

- entering vehicle turning speed is within critical impact speed (<30 km/h) at the conflict point with a person walking or cycling (horizontal or vertical deflection to ensure motor vehicle drivers can safely give way to continuing pedestrian and bicycle traffic), and
- clear GIVE WAY line marking and signs to give certainty of bicycle facility priority over road users entering or exiting the terminating side road.

Desirable attributes include:

- observation angle between 70° and 90° to the cycle track or shared path approach to their left for entering and exiting motor vehicle drivers
- approach sight distance to the crossing for motor vehicle traffic so the presence of the intersection is recognised in time to stop in a controlled and comfortable manner
- safe intersection sight distance from bicycle rider eye height on the continuing bicycle facility to observe a vehicle on the minor terminating road, and
- bicycle traffic design speed of typically 30 km/h to ensure speed maintenance for bicycle traffic – the intention of the design is not to slow down bicycle traffic.

Safety measures

A raised crossing with priority to the cycle track through a side road intersection, as illustrated in figures 4.3(B) and 4.3(C) is the most effective safety improvement for reducing crashes involving bicycle riders at these locations. Raised crossings have been shown to improve safety for all road users due to safer motor vehicle turning speed.

The following additional safety measures support raised crossings:

- highlight priority for bicycle riders and pedestrians with GIVE WAY lines and signs or with zebra pedestrian crossings

- tight turn geometry for vehicles entering and exiting the side road
- localised narrowing of the side road to shorten crossing distance to 5.5 m and allow entering vehicle turn path to use full width
- asphalt pavement for cycle track bordered by flush kerb, continued at constant level through the intersection
- concrete pavement for footpath continued at constant level through the intersection
- green coloured surface treatment in bicycle / vehicle conflict area, and
- mountable apron to accommodate design vehicle turn path.

Two-way cycle track or shared path priority crossings require more of these safety measures than at simpler, one-way cycle track or bicycle lane crossings.

Figure 4.3(B) – Example of two-way cycle track, 5 m buffer from the carriageway at raised priority crossings (LTS1)

Figure 4.3(C) – Example of two-way cycle track, 5 m buffer from the carriageway at raised priority crossings (different angle)

Section 8.1-1 in Transport and Main Roads' Supplement to Austroads *Guide to Traffic Management* Part 6 TRUM Volume 1 discusses pedestrian crossings (zebra) installed at side roads and recommends installing them on a raised crossing to enhance visibility and improve pedestrian safety when located on a pedestrian desire line. If a zebra crossing is not marked, the concrete footpath should continue through the intersection on the raised crossing. It is important to mark GIVE WAY lines on both sides and install GIVE WAY signs to show continuation of the road-related area and priority for pedestrians over vehicles entering and exiting the side road. This treatment effectively spans the road related area across the terminating minor road and provides visual and physical cues to support QRR 74. Examples are shown in Figure 4.3(D).

Figure 4.3(D) – Two examples of two-way cycle track, with 5 m buffer and raised priority crossing, continuing footpath example and zebra crossing example (LTS1)

Continued footpath and give-way lines

Zebra crossing

Buffer distance

The buffer distance between the continuing road and the continuing cycle track or shared path is often a consideration on priority crossings at side streets.

International research has shown that a buffer of 2–6 m is preferred in built-up areas[16]. This is a balance of:

- visibility (from the approaching motor vehicle driver to the approaching bicycle rider)
- directness (for the continuing bicycle traffic)
- 'stacking space' (space to store one normal vehicle exiting the terminating minor road without blocking the cycle track), and
- space available (in retrofit situations).

The need for a buffer distance could be minimised where through road drivers would expect delays in the kerbside lane due to frequent driveways or high-turnover, on-street parking. A larger buffer distance may be more necessary where through road drivers would not expect delays in the kerbside lane; for example, an access limited road (no driveways) where on-street parking is not permitted.

A 5 m buffer is recommended but not required where there are >50 vehicles per hour exiting the terminating minor road and where there is difficulty picking a gap when entering the continuing road such as where the flow is not interrupted by signals. If there is a <5 m buffer, exiting vehicles might block the cycle track while waiting for a gap. A priority crossing with a >5 m buffer locates bicycle traffic in a less visible location further from the continuing road.

Where the continuing road operating speed is ≥60 km/h, a 5–7 m buffer is recommended. A buffer >7 m is not recommended as visibility from driver to bicycle rider is reduced. More buffer space reduces the risk of vehicle-to-vehicle rear end (DCA 301) conflict from motor vehicles behind; however, this is a less severe crash than when a motor vehicle driver hits a person walking or cycling (refer Figure 1.2(C) in Section 1.2).

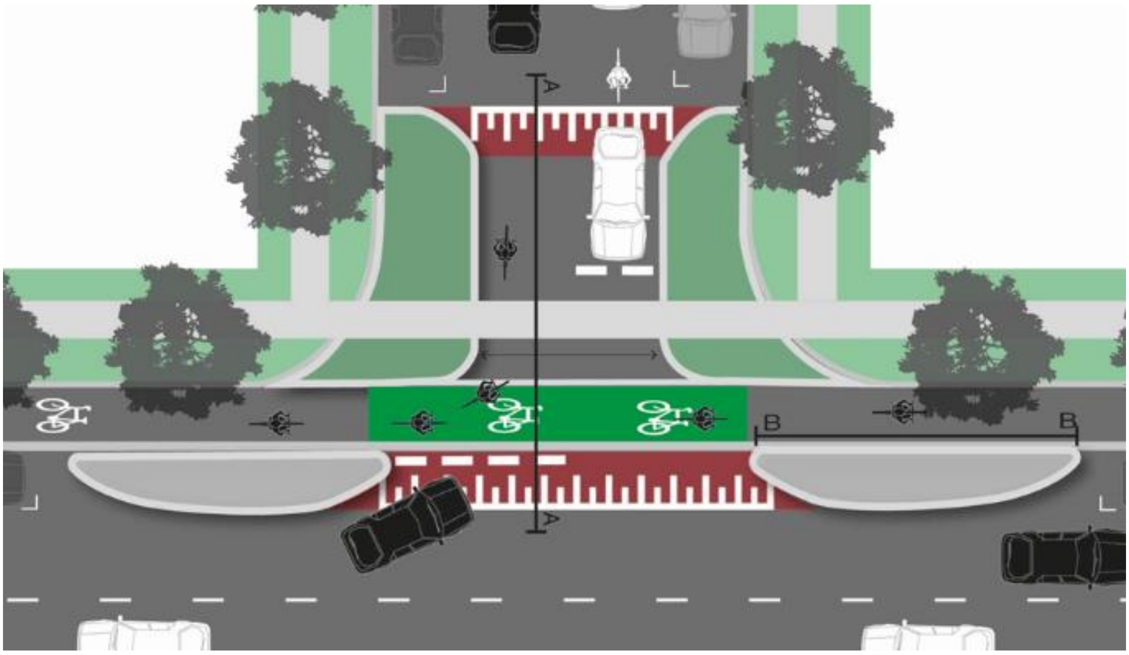
A consistent cycle track width is required on the approach to and through the intersection. Smooth curves for a design speed of 30 km/h or less are recommended on the bicycle facility as the intention is not to slow down bicycle riders. Pavement markings, including GIVE WAY line marking, are required through the intersection to designate priority for continuing bicycle traffic. It is desirable for the crossing to be raised to highlight the conflict point.

On the approach to an intersection, sharp curves, rumble strips and ramps should be avoided on the cycle track, as these can be a distraction from checking the movements of other road users. Also, T-intersections and offset T-intersections are preferred intersection types over four-way road intersections, due to reduced number of conflicts.

4.3.1 Retrofit protected unsignalised intersection

When retrofitting a one-way or two-way cycle track or shared path, the design of intersection is the same as discussed previously but often in a smaller space. The mandatory and desirable attributes are the same. How retrofits are achieved will vary; for example, Figure 4.3.1(A) shows a retrofitted raised priority crossing with a 2 m buffer from cycle track to parallel traffic lane. The asphalt cycle traffic is continued through the intersection with flush kerb running along the cycle track. Islands 10 m long are located either side of the intersection to prevent parking where visibility from vehicle drivers to bicycle traffic is required. A 1:6 ramp gradient is recommended to achieve effective vertical deflection; however, this may vary from 1:4–1:10, depending on hump height. Lower humps require steeper ramps.

Figure 4.3.1(A) – Retrofitted unsignalised protected intersection



Note: Refer Appendix B2.01A for more details

Figure 4.3.1(B) – Retrofitted protected unsignalised intersection with 2m buffer and flush kerb running both sides of the cycle track, part way through construction and finished, Nijmegen.

Source: Google Maps

Figure 4.3.1(C) shows a concept drawing of a retrofitted protected unsignalised intersection adjacent to a multiple lane road with operating speed >60 km/h. An added left-turn lane is shown to encourage deceleration prior to the intersection.

Figure 4.3.1(C) – Concept drawing of two-way cycle track with 6 m storage for exiting vehicles and 3 m buffer for vehicles entering from the added left-turn lane (LTS2)

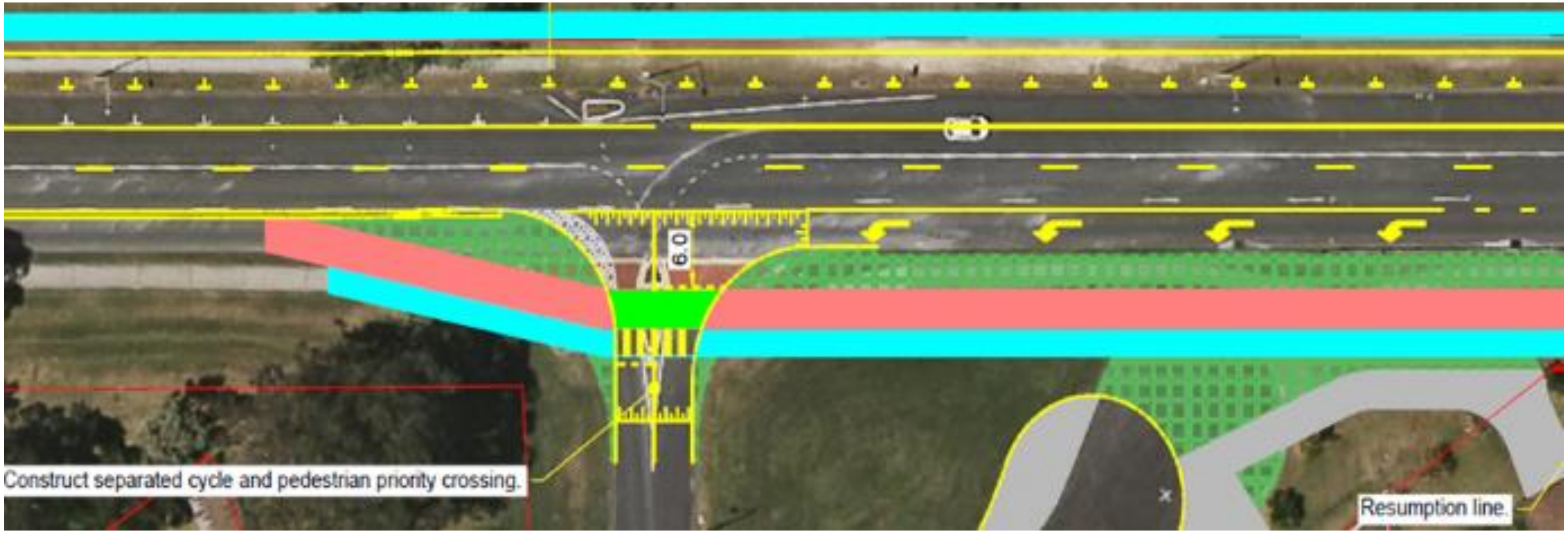


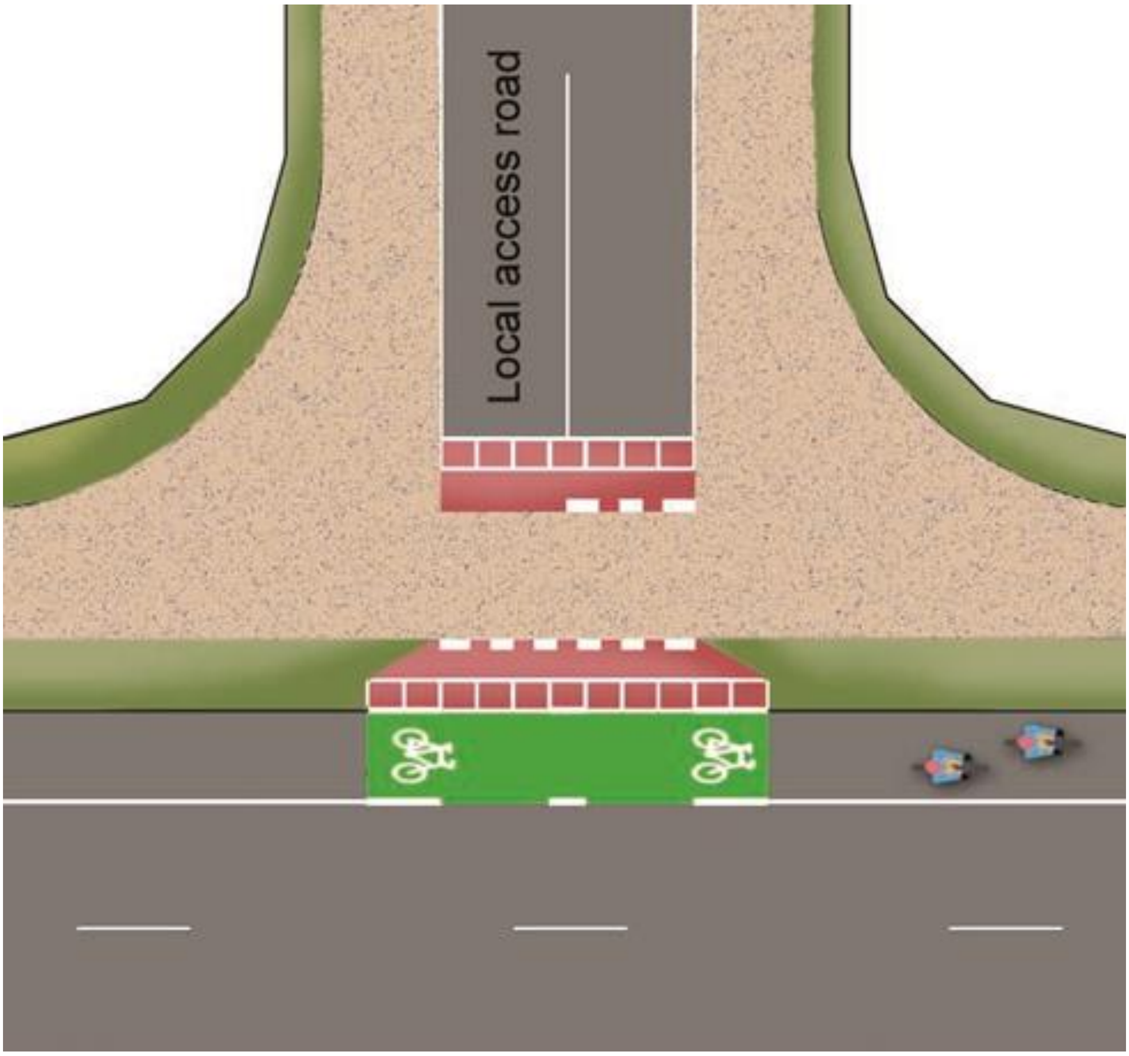
Figure 4.3.1(D) shows Quay Street in Auckland where low-cost, bolt-down, low-profile speed humps have been used instead of constructing a raised platform at the intersection. This treatment may be suitable in constrained situations; however, a lower LTS results for bicycle riders. A rounded profile hump with sufficient wet friction supply for motorcycle safety is recommended for this treatment.

Figure 4.3.1(D) – Low cost retrofit treatment side street Quay Street, Auckland (LTS2)

Source: Google Street View

This section supplements Austroads *Guide to Road Design* Part 4 Section 8.3.1. Figure 4.3.1(E) shows continuing footpaths and parallel bicycle lanes. This design creates a tighter turn into and out of the side road and a driveway-style steep crossover. When turning speed is lowered, drivers are more likely to give way, improving safety for bicycle riders, pedestrians and vehicle drivers. See Appendix B2.01 for details.

Figure 4.3.1(E) – Bicycle lane and at-grade footpath at side road (LTS2)



Note: Extract from Appendix B2.01

4.4 Protected roundabout intersections

This section is to be read in conjunction with Austroads *Guide to Road Design* Part 4B.

In new and retrofit situations, a protected roundabout intersection maximises physical separation of the bicycle facility throughout the roundabout and minimises conflict area to where motorised vehicles are travelling below critical impact speeds while boosting motor vehicle driver visibility to bicycle traffic. Protected roundabout intersections can be installed with continuing cycle track and separate footpath or with continuing shared path with priority crossings where there are <30 pedestrians per hour.

Throughout this section, LTS score is listed for examples.

This guidance discusses new and retrofit designs for carrying cycle tracks through roundabouts on urban roads safely. Retrofitting cycle tracks through existing roundabouts is a high value-for-money outcome that removes a significant barrier to people cycling.

In the past, the intent of Australian (tangential) roundabout design has included:

- maximising motor vehicle capacity
- maintaining motor vehicle speed, and

- allowing large vehicles to navigate the circulating space beside other vehicles for multiple lane roundabouts.

These design objectives have resulted in wide circulating space that encourages poor driving behaviour of 'straight-lining' with high vehicle speeds and consequently, a high rate of crashes involving bicycle riders.

Where cycle tracks cross roundabout entries and exits and conflicts between motor vehicles and bicycle riders occur, motor vehicle speed must be reduced to achieve a critical impact speed of 30 km/h. Radial roundabout design, small radius entry and exit curves, horizontal deflection and vertical deflection can all assist to achieve the necessary critical impact speed of 30 km/h.

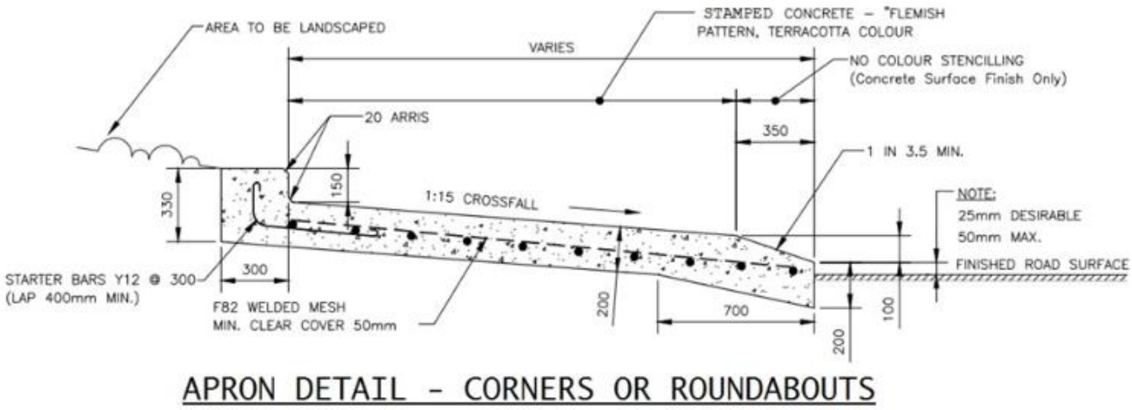
For appropriate speed control at a roundabout, radial design with entering and exiting motor vehicle angle at 90° for safer motor vehicle speeds should be used instead of tangential geometry (as shown in Figure 4.4(A)).

Figure 4.4(A) – Single-lane roundabout, motor vehicle entry and exit angle 90°, two-way cycle track with raised priority crossings and zebra crossings for pedestrian priority, Den Bosch, The Netherlands (LTS1)

Source: Google Street View

Horizontal deflection devices, such as kerb build-outs combined with centre island mountable apron and corner mountable apron, can be designed to cater safely for design vehicle turn paths while achieving critical impact speeds for normal-sized vehicles. The same apron cross-section used at roundabout centre island mountable aprons is used at corners of the roundabout. Figure 4.4(B) is an example of the preferred mountable area cross-section showing mountable kerb at the road level. Stamped concrete on the mountable apron is appropriate to discourage normal-sized vehicles tracking across the mountable apron area.

Figure 4.4(B) – Example apron detail for corners or roundabout centre island



Vertical deflection is useful for reducing speed and for highlighting a priority crossing in new and retrofit roundabouts. A platform device may be retrofitted to an existing roundabout that has inadequate horizontal deflection. Raised platforms across each leg of the roundabout influence both entry and exit speeds, achieving the critical impact speed of 20 km/h where motor vehicles conflict with vulnerable road users, and increase the chance of the motor vehicle giving way at a priority crossing. The raised platform at a priority crossing with parallel zebra pedestrian crossing gives all road users clear expectations of the priority for vulnerable road users.

4.4.1 Urban single-lane roundabouts (Appendices B3.01, B3.02 and B3.03)

This section should be read in conjunction with Transport and Main Roads Technical Note TN136 *Providing for Cyclists on Roundabouts*.

Single lane mixed-traffic roundabout with raised zebra crossings

Single lane mixed-traffic roundabouts with raised zebra crossings on all approaches can achieve a critical impact speed of 30 km/h where motor vehicles conflict with people walking and cycling or other vehicles. This is appropriate at lower-order intersections with <6000 vehicles per day. With the fewest conflict points, these can be the safest roundabout type if designed for 30 km/h approach, entry, circulating and exit speeds; however, they can be stressful for new riders, children and people with a disability if low vehicle speeds are not achieved. If designed without zebra crossings, the intersection does not provide for all road users.

Retrofitting a mixed traffic roundabout in place of a crossroads intersection can improve safety significantly for all road users. Zebra crossing should be installed on raised crossings across all approaches to provide for people walking, and to encourage safe entry and exit motor vehicle speeds; for an example, see Figure 4.4.1(A).

Figure 4.4.1(A) – Mixed single lane roundabout with zebra crossings on all approaches and mountable apron on centre island, Nelson Road, South Melbourne (LTS2)

Source: Nearmap

Protected roundabout intersections

A protected roundabout includes separated cycle tracks continuing with priority through the intersection; refer Figure 4.4.1(B). This is recommended at urban single lane roundabouts with 6000–20,000 vehicles per day.

Figure 4.4.1(B) – Protected roundabout intersection (LTS1)

Note: Extract from Appendix B3.02

Where separated cycle tracks continue through a roundabout on an urban cycle route, the design must include bicycle priority crossings at all legs. Bicycle priority crossings must be designed in conjunction with pedestrian crossings. In Queensland, it is recommended bicycle priority crossings be located on a raised platform road hump to further highlight the possible conflict area and achieve safe motor vehicle speeds. A 5 m buffer between the roundabout circulating lane and the continuing cycle track is recommended. This 5 m buffer can be difficult to achieve in retrofit situations. Clear GIVE WAY lines and signs are required to show priority for the continuing cycle track. Zebra crossings must be located parallel to the cycle track crossings. Refer Figure 4.4.1(C) for a retrofit example in Melbourne (curved cycle track geometry would be preferred).

Figure 4.4.1(C) – Retrofitted protected roundabout intersection with raised zebra and cycle track crossings, Moray Street / Dorcas Street, South Melbourne (LTS1)

Source: Nearmap

Retrofitting a protected roundabout intersection

Converting an existing roundabout intersection into a protected roundabout can have significant safety, operational and accessibility benefits. The aim is to achieve critical impact speeds at conflict points for normal vehicles while allowing for the turn path of design vehicles. Mountable areas can be designed to discourage normal vehicles while accommodating the design vehicle. Changes to entry and exit angles, mountable centre island apron and mountable corner aprons should be used. These measures contribute to achieving the critical impact speed of 30 km/h at conflict points. At this speed, motor vehicle drivers will have time to react and safely give way to a bicycle rider on the cycle track or a person walking across the zebra pedestrian crossing.

For a retrofitted protected roundabout intersection to function safely, it is essential that:

- deflection achieves motor vehicle critical impact speed of 30 km/h at conflicts with vulnerable road users, and
- GIVE WAY lines and zebra crossings are marked across motor vehicle entries and exits to show priority for continuing bicycle and pedestrian movements.

GIVE WAY lines and zebra crossings marked for continuity of the cycle track pedestrian crossing, across the motor vehicle entries and exits, are critical to achieve safe crossings for people who are cycling or walking.

A 5 m buffer between the roundabout circulating lane and the continuing cycle track is desirable but can be difficult to achieve when retrofitting cycle tracks at an existing roundabout.

Two-way cycle tracks at roundabouts

Two-way cycle tracks at roundabouts work well where bicycle traffic continues on a two-way cycle track or shared path on one side of a major road; however, two-way cycle tracks on roundabouts present an additional driving task for drivers of motor vehicles who may not check thoroughly to their left side where bicycle riders may be approaching from the anti-clockwise direction. Where two-way cycle tracks are constructed, radial roundabout design, conflicts located on raised priority crossings and two-way line marking to highlight two-way bicycle traffic is required. The ultimate safe solution is to grade separate bicycles from vehicles.

4.4.2 Urban multiple-lane roundabouts

Due to increased number of conflicts and increased speed difference on multiple-lane roundabouts, protected roundabout intersections with priority crossings are not recommended. With multiple-lane exits and entries, people walking, or cycling, are exposed to multiple threats and high speeds of motorised vehicles. Possible improvements to multiple-lane roundabouts include:

- change entries and exits to single lane (see Figure 4.4.2(A))
- underpasses or overpasses to remove conflicts with motorised vehicles (see figures 4.4.2(B) and 4.4.2(C)), and
- change to protected signalised intersection.

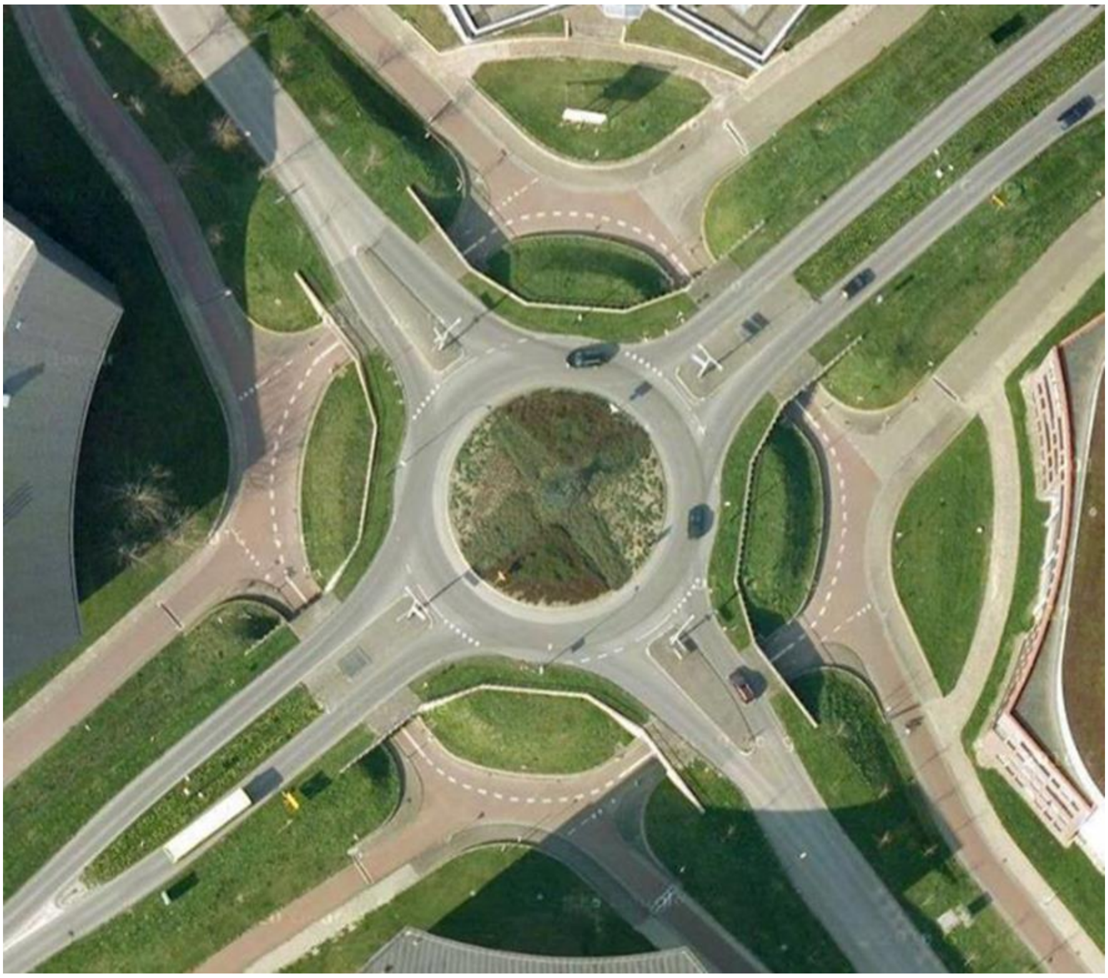
Multiple-lane roundabouts without a grade-separated alternative are a major barrier to both experienced and new bicycle riders and have a higher bicycle crash risk than single lane roundabouts[17]. A major risk is vehicle acceleration speed at two-lane exits. At two-lane exits, priority crossings for bicycle riders and pedestrians are not recommended[18]. Single-lane, lower-speed exits for multiple-lane roundabouts improve safety where pedestrians and bicycle riders cross. Figure 4.4.2(A) shows an example of multiple lane entries but with single-lane exits and bicycle priority crossings and pedestrian zebra crossings set back from the roundabout on raised platforms.

Figure 4.4.2(A) – Multiple lane roundabout with single lane priority crossings, Ultrecht (LTS1)

Source: Google Maps

New multiple-lane roundabouts with two-lane exits are not recommended for roads on the Principal Cycle Network, unless a direct and attractive grade-separated cycle track or shared path is provided. To improve bicycle safety at multiple-lane roundabouts, conversion to a single-lane protected roundabout intersection with separated cycle track and priority crossings is recommended. If this is not accepted, a signalised protected intersection with cycle tracks should be considered. Technical Note TN136 provides other potential treatment options.

Figure 4.4.2(B) – The ultimate safe solution: pedestrian and bicycle underpasses for grade-separation at a single-lane roundabout, Houten, Netherlands (LTS1)



Source: Google Maps

Figure 4.4.2(C) – Grade-separated roundabout, Houten, Netherlands (LTS1)

Source: Peter Berkeley

4.4.3 Rural multiple-lane roundabouts

Rural scenarios are outside the scope of this guidance. Technical Note TN136 should be referred to further details.

At multiple-lane roundabouts outside urban areas, a grade-separated path such as an underpass is recommended. Where the path is at-grade, priority should be assigned to road traffic and the roundabout should be adapted to achieve safer entry and exit speeds (see figures 4.4.3(A) and 4.4.3(B)). Refuges must be provided for people walking and cycling to undertake crossings in two stages. Comfort for bicycle riders waiting for a gap can be increased by providing foot rails and hand rails that are located on a flat area with good sight distance.

Figure 4.4.3(A) – Large multiple-lane roundabout with priority crossings for two-way cycle track crossing one lane at a time, on one leg only, Rotterdam, Netherlands (LTS2)

Source: Google Streetview

Figure 4.4.3(B) – Urban multiple lane roundabout, Rotterdam, Netherlands (LTS2)

Source: Google Maps

4.5 Protected signalised intersections

This section is to be read in conjunction with Austroads *Guide to Road Design* Part 4 Section 9.4. It discusses layout and signal feature information. Throughout this section, LTS score is listed for examples. Figure 4.5(A) shows an example of a protected signalised intersection.

Figure 4.5(A) – Protected signalised intersection with two-way cycle tracks. Aura, Caloundra

In new and retrofit situations, a protected signalised intersection maximises physical separation of the bicycle facility throughout an intersection and minimises conflict area to where motorised vehicles are travelling below critical impact speeds while boosting motor vehicle driver visibility to bicycle traffic.

Intersections present the greatest risk of conflict on most bicycle routes and should be the first improvement in a retrofit situation. On roads where vehicle operating speeds are >50 km/h, physically-separated bicycle facilities throughout the intersection improve safety and comfort for bicycle riders and other road users. The key conflict is with left-turning motor vehicles; refer Figure 1.2(C) in Section 1.2.

Table 4.5 compares the types of bicycle facilities at signalised intersections. A protected signalised intersection locates storing bicycle riders beside storing pedestrians, minimising the crossings distance and the area of conflict with motorised vehicles. This location also improves visibility from motor vehicle drivers to bicycle traffic before the conflict point by storing bicycle riders 10 m or more ahead of the motor vehicle STOP line.

An Advanced STOP Line locates bicycle riders beside motor vehicle traffic, with the STOP line slightly ahead of the motor vehicle STOP line. The bicycle storing area can be physically separated or separated by a pavement marked line. It is recommended that the Advanced STOP Line for bicycle traffic be located 4 m ahead of motor vehicle traffic; however, it is often marked less to fit without having to move loops and other line marking. This arrangement results in bicycle riders storing in a less visible location, especially for large vehicles.

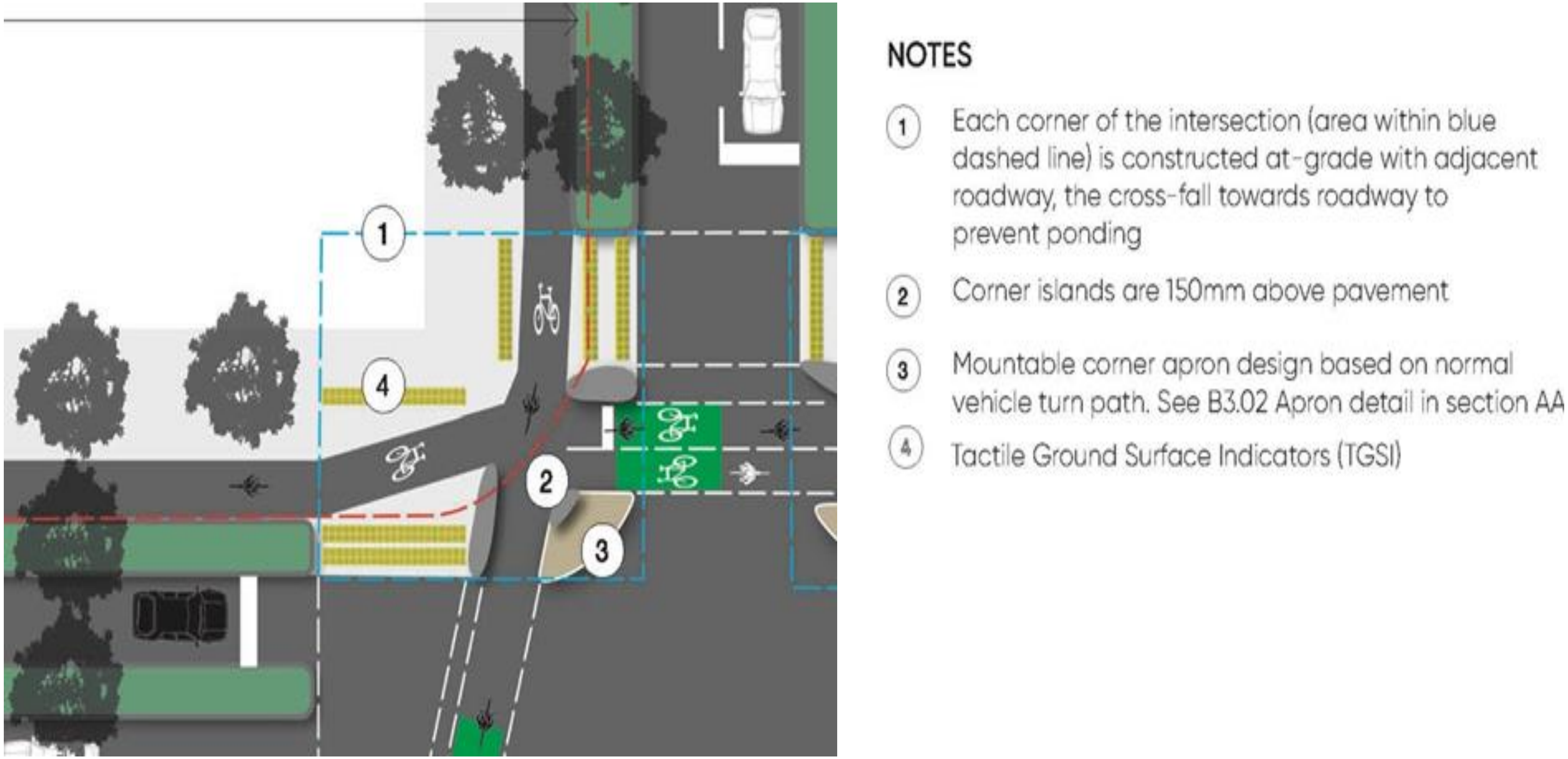
Table 4.5 – Signalised intersection bicycle facilities

Signalised intersection type	Level of Traffic Stress	Conflict with left-turning motor vehicle
Protected signalised intersection	LTS1, least stressful	Small conflict area, low motor vehicle speed due to corner island geometry and mountable corner apron, safe observation angle from motor vehicle driver to approaching bicycle traffic
Advanced STOP Line with physical separation	LTS1–LTS3	Small to medium conflict area, motor vehicle speed is not controlled by corner island but is not high speed, poor observation angle
Advanced STOP Line with bicycle lane to left of single traffic lane and bicycle box	LTS2–LTS4	Motor vehicles may track in the bicycle lane up to 50 m before the intersection, large conflict area, high speed difference, poor observation angle
Advanced STOP Line with bicycle lane to the right of motor vehicle left-turn lane	LTS3–LTS4	Approach conflict with motor vehicles turning left, high speed difference, poor observation angle
Mixed with motor vehicles	LTS3 or LTS4	Always conflicting with motor vehicles, bicycle riders must claim the lane, only appropriate for operating speed up to 30 km/h for most bicycle riders

Protected signalised intersections include (refer Figure 4.5(B)):

- layout features:
  - corner islands to protect storing bicycle riders from left-turning vehicle swept path and mountable corner apron areas when necessary to accommodate design vehicle swept path
  - distances between STOP line and crossing significantly improve visibility of people crossing to drivers of heavy vehicles and motor vehicles
  - asphalt bicycle storing area beside concrete pedestrian storing area at road level
  - clearly continuing bicycle crossing markings and green surface treatment to highlight the conflict area with left-turning motor vehicles that is separate from pedestrian crossing
  - concrete pedestrian storing area beside bicycle storing area at road level
  - clearly continuing black asphalt cycle track and storage areas and separate white concrete pedestrian footpaths and storage areas at same level, and
  - separate bicycle and pedestrian areas on approach to the intersection
- signal features:
  - three-aspect separate vehicle group signal phasing for bicycle movements or same timing as vehicle movements where the signal controller is at capacity, bicycle movements must not be run with pedestrian green times and clearance times
  - bicycle rider detection using loops, radar or other passive detection technology combined with call-up indicator light at the push button
  - approach detection of bicycle riders using loops, radar or other technology, and
  - bicycle rider push button with call-up indicator light on separate pole located within 200 mm of cycle track, and on flat area not on a ramp. Separate pole only required if cannot be co-located conveniently on existing pole (preferred).

Figure 4.5(B) – Protected signalised intersection layout and signal features



Note: Refer Appendix B4.02A for further information

These features are discussed in the following sections.

4.5.1 Layout features

Corner islands and mountable aprons to cater for design vehicles

Figure 4.5.1(A) shows the corner island with a mountable corner apron to accommodate the design vehicle.

To ensure safe turning speeds, corner protective islands should be used to increase safety for bicycle riders without losing space for other road users (see red highlighted areas in Figure 4.5.1(A)). Corner islands are, primarily, to ensure appropriate safe turning speed and secondly, to protect storing bicycle riders and pedestrians. A corner island can vary in size depending on the intersection as it is dimensioned to accommodate the left-turn path of the design vehicle.

The design vehicle is the largest vehicle that that needs to be catered for through an intersection. Designing for the swept path of the design vehicle at left turns can result in generous horizontal curves for normal vehicles, leading to unsafe turning speeds, high severity crash outcomes and reduced reaction time when a driver must give way to people walking or cycling through the intersection.

To accommodate the design vehicle while encouraging safe turning speed for normal vehicles, mountable corner aprons are installed in the same way they are commonly installed at roundabouts.

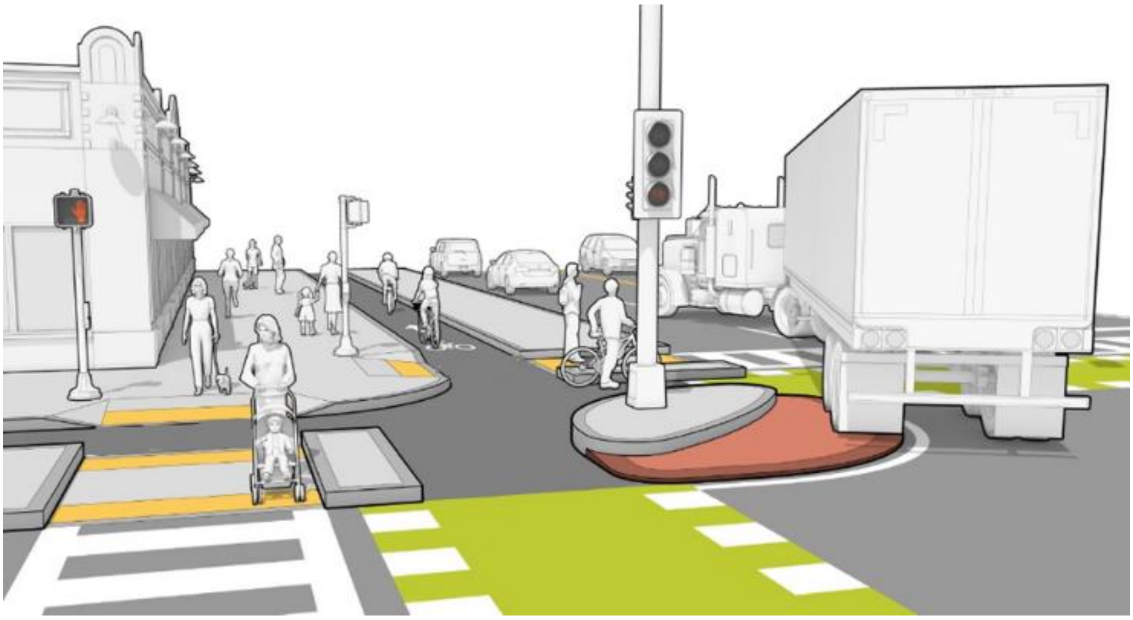
Design vehicles can be catered for in these ways at signalised protected intersections:

- providing mountable corner aprons that are unattractive to normal vehicles (see Figure 4.5.1(A) and refer Appendix B4 set of drawings)
- by designing for vehicles >7.5 m long to turn from an adjacent lane (refer Appendix B4.04) in accordance with *Queensland Road Rules* Section 28, and
- design vehicles turning into the furthest lane when entering a multiple-lane road.

A left turn from adjacent lane for vehicles >7.5 m long is not appropriate where:

- left turns are controlled independently from through movements, and
- heavy vehicle turning volume is >10 heavy vehicles per hour.

Figure 4.5.1(A) – Mountable truck apron example (LTS1)



Source: Massachusetts Department of Transportation, 2015[19]

Figure 4.5.1(B) – Protected signalised intersection with two-way cycle tracks, Caloundra (LTS1)

Asphalt bicycle storing area beside concrete pedestrian storing area at road level

Bicycle and pedestrian storing areas must be delineated clearly at protected signalised intersections. This is to maintain directness for each user and to avoid conflict. This is done by identifying the bicycle areas with black asphalt at road level and the pedestrian areas with white concrete. If concrete is used for both footpath and cycle track, pedestrians will use the whole area as footpath and the cycle track will be blocked and have conflicts – a poor outcome for people walking and cycling. Asphalt is a flexible pavement and will have a smoother finish. Asphalt for cycle track also looks more like part of the road compared to concrete.

Locating the bicycle storing area beside the pedestrian storing area creates a physical bicycle head start ahead of left-turning motor vehicle traffic at signalised intersections. Starting far in advance locates bicycle traffic in a very visible location for left-turning motor vehicle drivers. From this advanced storing location, bicycle riders arrive at the conflict point before left-turning motor vehicles. When moving off from stopped, the bicycle rider will usually clear the intersection before the left-turning motor vehicle arrives. An earlier signal for bicycle riders can also be referred to as a 'leading bicycle interval', similar to pedestrian protection which is mandatory on all of the department's urban intersection projects.

Clearly continuing bicycle crossing markings and green surface treatment

To highlight the conflict area with left-turning motor vehicles, green surface treatment may be used for the bicycle crossing, refer Figure 4.5.1(C). The bicycle crossing should be separate from the pedestrian crossing and have the same dashed edge lines.

Figure 4.5.1(C) – Continuing bicycle crossing with green surface treatment, Hamilton Northshore (LTS1)

Concrete pedestrian storing area beside bicycle storing area at road level

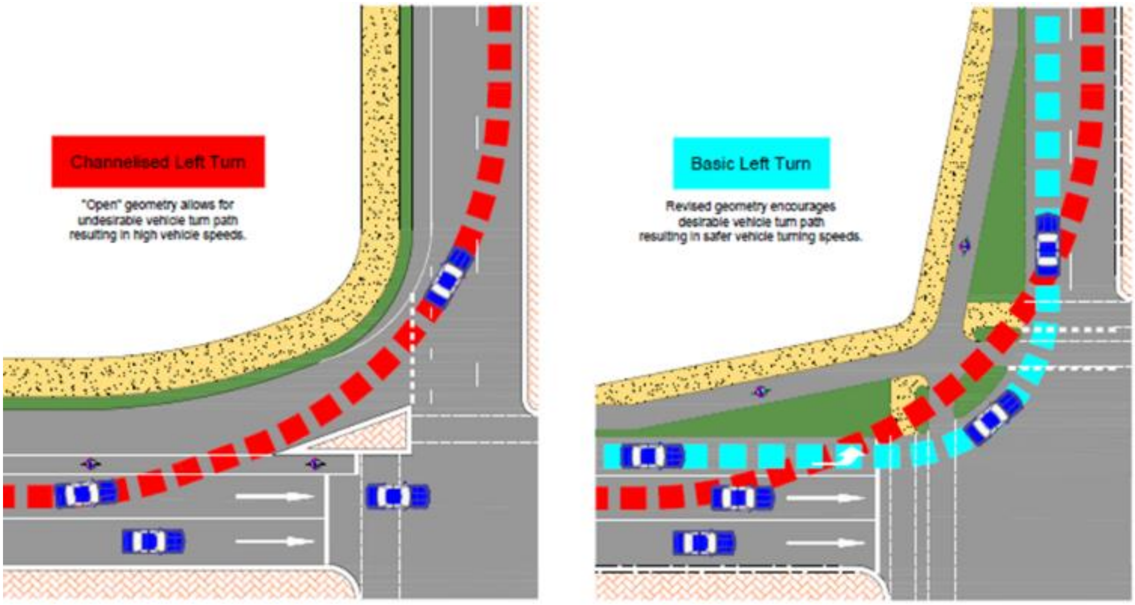
The area where pedestrians store while waiting is identified clearly with white concrete. Where people who are walking are to cross the cycle track, Tactile Ground Surface Indicators (TGSIs) are required to highlight the conflict.

Bicycle safety at left turns

Compared with a ‘stand-up’ left turn with cycle track, channelised left turns with a bicycle lane at the approach result in extended exposure for bicycle riders, increased vehicle speed at conflict point, rewards for poor driving practice and expanded area of pavement where conflict can occur. Taking into account extended exposure due to larger conflict area and higher speeds at conflict points, the current practice of bicycle lanes at channelised left turns that weave across a continuing bicycle lane present a safety risk that can be avoided with physical separation. The exposure also causes a barrier to cycling, due to unnecessary stress for bicycle riders, and does not provide for all ages and abilities of bicycle riders.

Figure 4.5.1(D) compares vehicle turn path for a channelised left turn (red) and for a left turn with cycle track (blue). The drawings also demonstrate that the land area used for this safety improvement treatment is similar or even less space than for a standard high-entry angle slip lane and bicycle lane with off-road shared path.

Figure 4.5.1(D) – Channelised (LTS4) versus basic left turn (LTS1): comparison of vehicle turn paths



Channelised left turn showing high speed vehicle travel path

Basic left turn showing low speed vehicle travel path

Highlight conflict at left turn slip lane

Where a conflict with bicycles is created, vehicle turning speed should be reduced to <30 km/h to achieve low speed difference at the conflict point; for example, where an existing shared path crosses at a slip lane, a raised 'wombat' crossing with GIVE WAY line marking and signs could be installed (see Figure 4.5.1(E)). This retrofit improves safety for all road users but does not achieve the directness equal to the parallel traffic lane required for the bicycle facility.

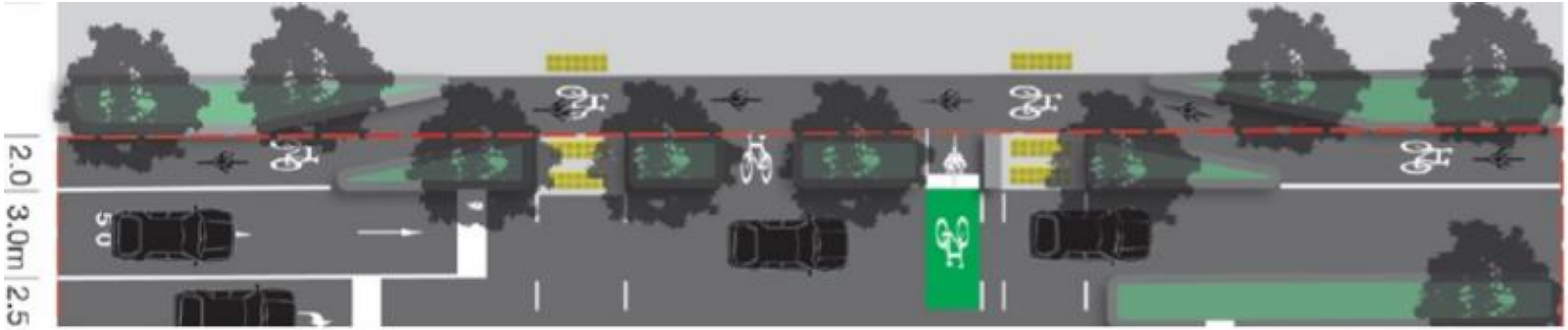
Figure 4.5.1(E) – Wombat crossing on left-turn slip lane, Entertainment Road, Oxenford

Source: Nearmap

Transition between bicycle lane and cycle track

At an intersection where a road with bicycle lane and a road with cycle track meet, the bicycle lane should transition to cycle track on the approach, as shown in Figure 4.5.1(F). This type of transition can be as simple as a splitter island beginning on the approach or could be a larger island with signal hardware and appropriate landscaping.

Figure 4.5.1(F) – Transition from bicycle lane to cycle track at road level



Note: Refer Appendix B4.01A.12.4

Remove all hazards near the intersections

Locating hazard such as barriers or trees to block the flow of bicycle traffic is not recommended. This will create unpredictable movements for people cycling and people walking and conflict between these road users as shown in Figure 4.5.1(G). To create predictable movements, cycle tracks and separated footpaths are required on the approach, storing areas, through and at the exit of the intersection.

Figure 4.5.1(G) – Hazard blocking the movement of people cycling and walking resulting in conflicts

Bicycle left turn bypass

As shown in Austroads *Guide to Road Design* Part 4 Section B.6 Figure B14.

Kerb, foot rails and holding rails

A 150 mm-high kerb beside the push button provides a comfortable storing position for bicycle riders waiting for the green signal, especially where the chance of stopping is high. A kerb is preferred, but a foot or holding rail can serve the same function by giving a place to put a foot or hand. Figure 4.5.1(H) shows a mid-block signalised crossing in Jindalee with hand and foot rails for waiting bicycle riders.

Figure 4.5.1(H) – Holding rails and foot rails for comfortable waiting at signalised crossing, Jindalee

4.5.2 Optimised signal phasing and other improvements

This section is to be read in conjunction with Austroads *Guide to Traffic Management* Part 9.

Three-aspect separate vehicle group signal phasing for bicycle movements

Three-aspect lanterns (Figure 4.5.2(A)) shall be used for bicycle traffic. Signal timings needed for bicycle riders are similar to motor vehicle timings. Bicycle riders travel about four times faster than pedestrians and can clear a crossing quite quickly, especially when already moving. If clearance time is set up for pedestrians where only bicycle riders cross, a lot of time is wasted.

Figure 4.5.2(A) – Three-aspect lanterns for bicycle traffic at low and high heights at nearside

Where an existing controller has extra capacity or is a next generation controller, bicycle movements shall have timings independent of people walking and motor vehicles. Where the controller is at capacity, the bicycle movements shall be the same as vehicle movements, while allowing sufficient time to clear long crossings. Bicycle movements shall not be run with the same timings as pedestrian signals.

Pedestrian crossing signals have short green times and long clearance times to suit a person walking at 1.2 m per second. With separate signal timing for people walking and people cycling, there is the opportunity to call up the bicycle movement without the pedestrian movement when no pedestrians are present. This saves time for all road users at the intersection.

Bicycle signal phasing separated from other road users can begin at the same time as 'pedestrian protection' where motor vehicle traffic begins a short time later; however, when the pedestrian green time is over, the bicycle green time continues for much longer, due to the shorter clearance time needed for bicycle traffic. Table 4.5.2(A) lists some phasing scheme options. Figures 4.5.2(B) to 4.5.2(E) show a phasing diagram and stripes to represent timings for each road user.

A small three-aspect lantern can be placed on the nearside at bicycle rider eye height, low on the pole for the bicycle rider at the front of the queue, as shown in Figure 4.5.2(F). A higher three-aspect lantern should be located for bicycle riders at the back of the queue. Where a far-side, three-aspect lantern is used, it must be located with motor vehicle lanterns or on a separate pole. Bicycle lanterns should not be located with pedestrian lanterns. Separating out the signal lanterns for these different road users avoids confusion and conflict.

Table 4.5.2(A)– Phasing scheme options with cycle tracks

Phasing scheme	Description	Pros	Cons
Bicycle phase with concurrent conflicting vehicle turns (Figure 4.5.2(B))	Bicycle phase run parallel with vehicle while vehicle left turns are permitted	Same green time as parallel vehicles Better bicycle rider compliance due to more green time	Not suitable with high volumes of turning motor vehicles Requires motor vehicles to give way when turning
Early start bicycle phase with concurrent conflicting vehicle turns (Figure 4.5.2(C))	Similar to 'pedestrian protection', bicycle traffic receives green a short time before motor vehicle traffic	Bicycle riders enter the intersection before motor vehicles Improved visibility for turning motor vehicles	Small decrease in motor vehicle green time Not suitable with high volumes of turning motor vehicles
Protected bicycle phase (Figure 4.5.2(D))	Bicycle phase that runs with parallel through vehicle phase Turning motor vehicles are before or after the through phase	Time separation of bicycle riders and turning motor vehicles Motor vehicles not required to give way to bicycle riders	Additional phase will increase cycle length An added turn lane is needed, and traffic capacity may be affected
Bicycle only phase (Figure 4.5.2(E))	Bicycle phase with all motor vehicle movements stopped May run with parallel pedestrian movements	Provides safest outcome with no conflicts between motor vehicles and people walking or cycling Can allow bicycle right turns across the intersection	Increases cycle length for all road users

Adapted from MassDot, 2015

Figure 4.5.2(B) – Bicycle phase with concurrent conflicting vehicle turns

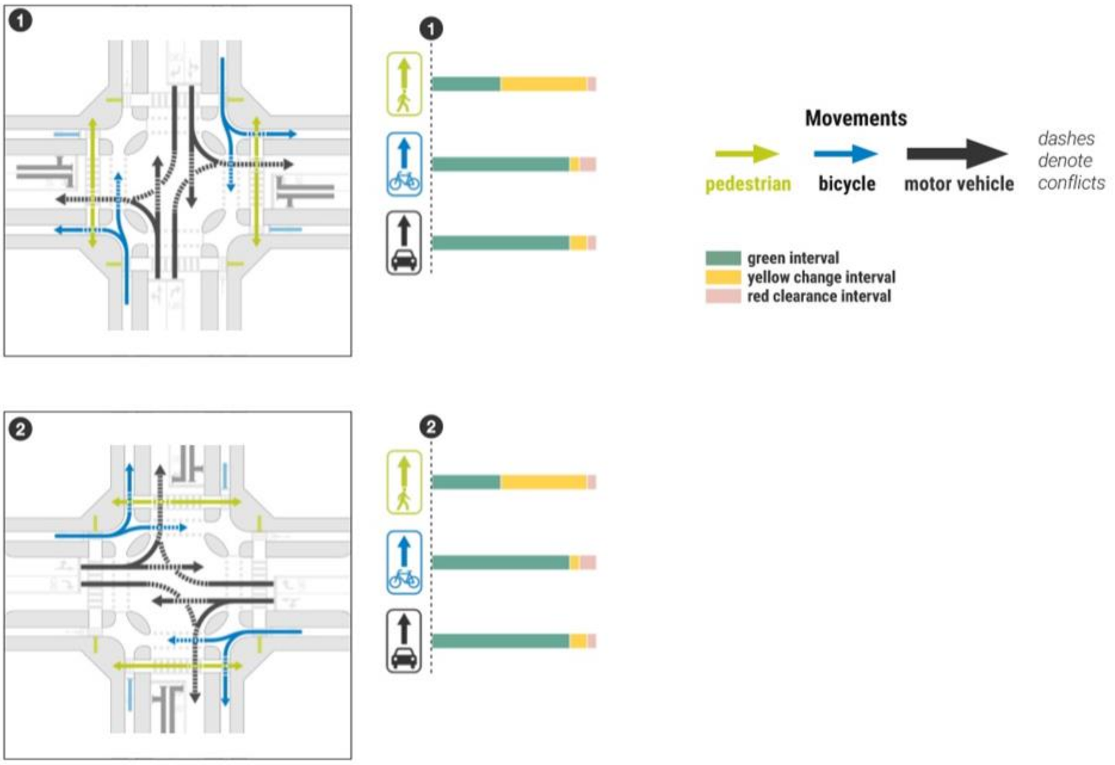


Figure 4.5.2(C) – Early start bicycle phase with concurrent conflicting vehicle turns

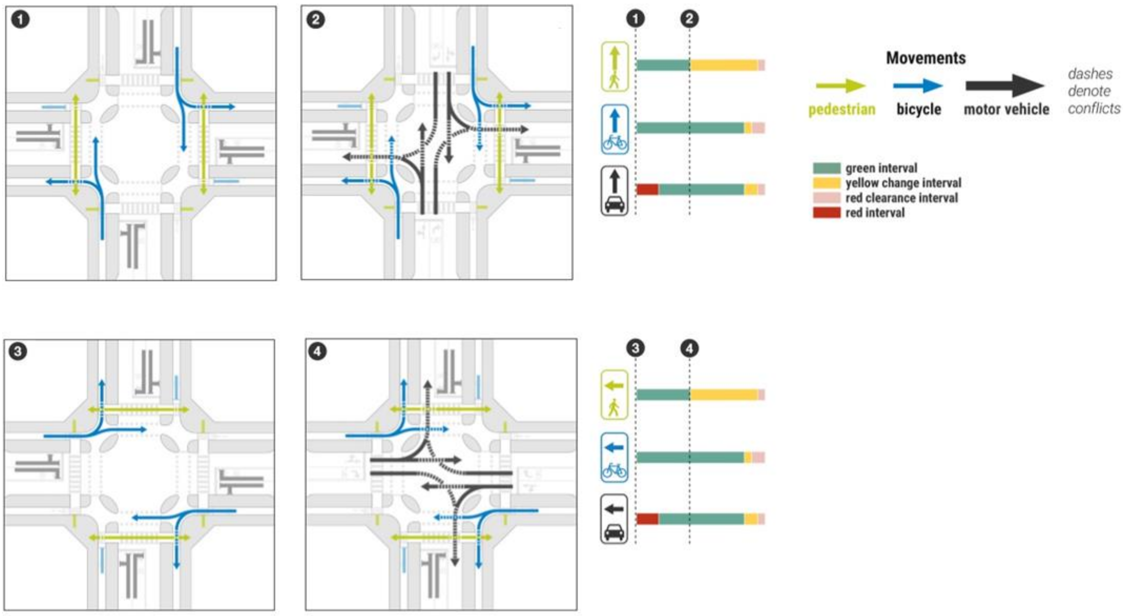


Figure 4.5.2(D) – Protected bicycle phase

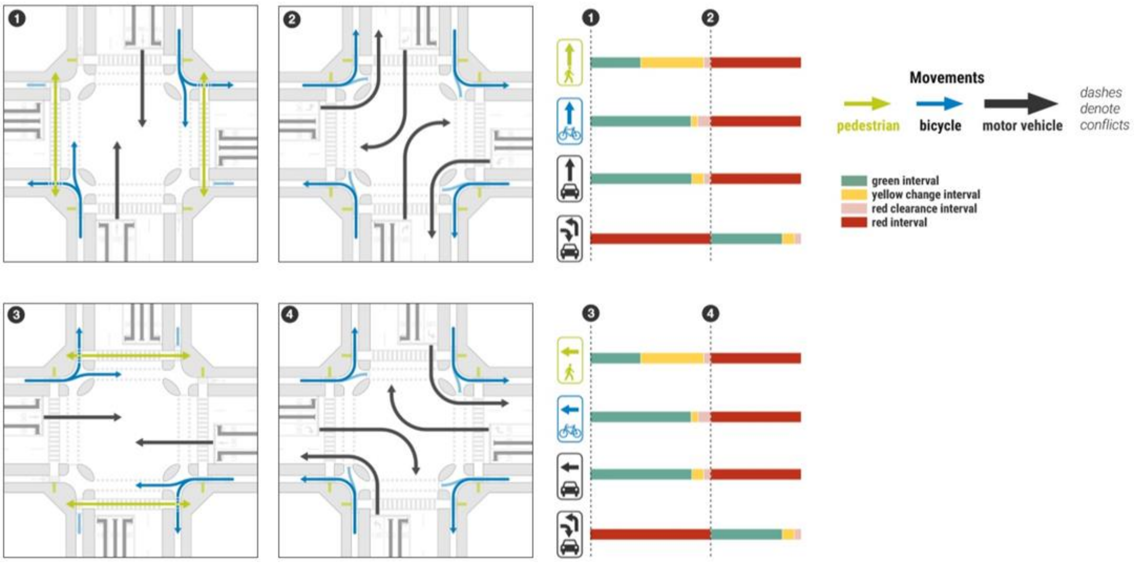
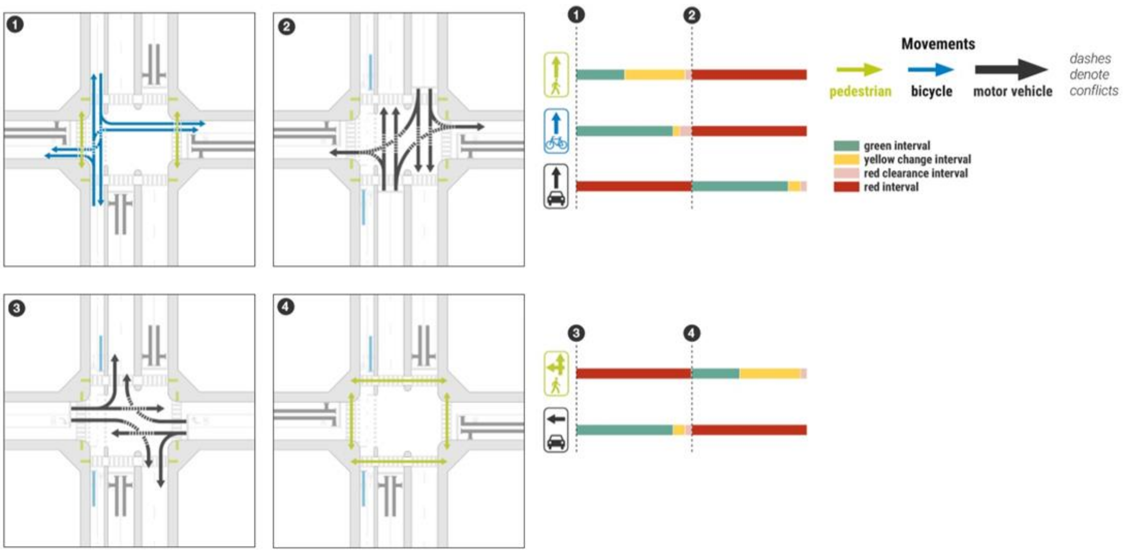


Figure 4.5.2(E) – Bicycle only phase



Bicycle rider detection using loops, radar or other passive detection technology combined with call-up indicator light at the push button

To improve intersection operational efficiency and improve comfort, passive detection combined with push button indicator light to show that the rider has been detected could be provided at protected signalised intersections. Passive detection refers to a loop, radar or other detection technology that identifies the rider at the storing area without the need to use the push button. The indicator light is located on the push button assembly.

Additional loops or non-invasive detectors can also cancel demand if a bicycle rider crosses early. This can save wasted time and improve efficiency for all road users. The design of the intersection must locate bicycle riders in a predictable location to ensure the detection loops will detect waiting bicycle riders effectively as shown in Figure 4.5.2(F).

Figure 4.5.2(F) – Three aspect lanterns and detection loops locations, Rotterdam, The Netherlands

The bicycle rider push button with indicator light should be located on a separate pole within 200 mm of cycle track, at the STOP line for bicycle traffic, outside of design vehicle swept path and on flat area not on a ramp, refer Figure 4.5.2(G).

Figure 4.5.2(G) – Push button conveniently located 200 mm from cycle track at signalised intersection with advanced stop line, Rotterdam

Approach detection of bicycle riders using loops, radar or other technology

Detection of bicycle traffic in advance of the intersection improves operational efficiency for all road users, refer Figure 4.5.2(H). Placing a bicycle detection loop in the bicycle lane or cycle track on the approach to signals can reduce dramatically the chance of having to stop for bicycle riders and reduce delay for other road users. This approach can be effective at most urban signalised intersections and dramatically improves efficiency.

Figure 4.5.2(H) – Example of advanced detection for bicycle traffic, Utrecht, The Netherlands

Time separate

It may be appropriate for low-volume motor vehicle left-turn arrow lanterns to dwell-on-red until triggered by turning vehicles. This also ensures low motor vehicle speeds through the turn. This will require a left-turn lane separate to the through lane.

Permit motor vehicle left turn conflicts

The conflict between a turning motor vehicle and a bicycle rider going straight can be permitted to reduce waiting times at most signalised intersections. Where this conflict is permitted, every effort must be made to show priority clearly for bicycles. This can be achieved through safe turning speeds, GIVE WAY lines and with supplementing green surface pavement treatment. A green turn arrow lantern must not be used when this movement conflicts with green for bicycles continuing straight. Thresholds for allowing the conflict between bicycle riders continuing straight and motorists turning are covered in Table 4.5.2(B).

Table 4.5.2(B) – Thresholds for time separating turning motor vehicles

Cycle track direction	Turning motor vehicles per hour across the cycle track			
	2-way road			1-way road
	Left turn	Right turn across one lane	Right turn across two or more lanes	Left or right turn
1-way	150	50	0	150
2-way	50	0	0	50

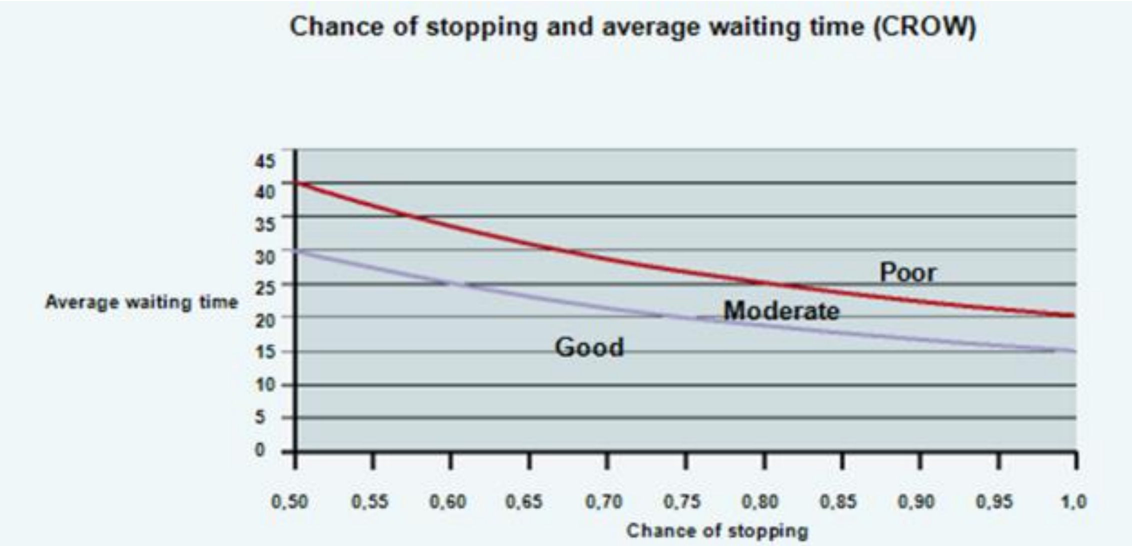
Chance of stopping and average waiting time

Two important criteria for achieving bicycle-friendly signalised intersection design are the chance of being stopped, and the average waiting time. Bicycle riders are affected greatly by loss of speed maintenance through stopping, delays when stopped and then the physical effort of getting back up to speed (loss of directness in time and discomfort). Where bicycle riders are stopped or detoured, they will take high safety risks in order to save travel time.

Energy use of stopping and starting just once is equal to cycling 100 to 200 metres[20].

In most cases, signals will delay bicycle riders more than crossing without signals. For this reason, signals should be avoided unless absolutely necessary; however, one advantage is the limit on maximum waiting time. Figure 4.5.2(I) shows the acceptable average waiting (not maximum waiting time) depending on chance of stopping.

Figure 4.5.2(I) – Relationship between chance of stopping and acceptable average waiting time at traffic light



Source: CROW, The Netherlands, 2007

Safe signal cycle time for bicycles

Appropriate overall cycle times are very important to achieve a bicycle-friendly intersection. Immediate improvements in flow of all road users can be achieved with shorter cycle times.

Cycle times longer than 90 seconds may cause unsafe levels of non-compliance from bicycle riders and are not recommended on bicycle routes. Shortening cycle times for all road users depends on clearance times. Intersections should be designed to be as compact as possible with short crossing distances for pedestrians and bicycle riders, so the overall cycle time will be quicker for all road users.

Separate bicycle and pedestrian movements

Figure 4.5.2(J) shows a mid-block crossing with separate bicycle and pedestrian movements.

Figure 4.5.2(J) – Separate bicycle phase with quick clearance time, Assen, The Netherlands

Two bicycle phases during a cycle

Two bicycle phases during a signal cycle may be used during wet weather with the use of a rain detector to ensure bicycle riders are not waiting in the rain. It is normal to have lower compliance from both people walking and cycle in wet weather. It may be applicable during peak times on primary bicycle routes.

Combining right-turning motorists and bicycle riders

Combine right-turning motorists with two-stage right-turning bicycle riders. The through movement should be first.

Green Wave for bicycle riders

Coordinate signals along a route to create a ‘green wave’ for bicycle riders at a comfortable pace; for example, 20 km/h.

All directions green for bicycle riders

Bicycle riders are highly-manoeuvrable vehicles and can navigate by each other at close passing distances. The all directions green shown in figures 4.5.2(K) and 4.5.2(L) is the same function as a scramble crossing for pedestrians. This function can also be combined with a scramble crossing for pedestrians, dependant on pedestrian volumes. Bicycle riders should be reminded to give way to pedestrians. In these examples, pedestrians do not have a scramble crossing. Pedestrians cross one approach at normal pedestrian crossings.

Figure 4.5.2(K) – All directions green for bicycle traffic at a large intersection, Groningen, The Netherlands

Figure 4.5.2(L) – All directions green for bicycle traffic at a smaller intersection, Assen, The Netherlands

Dwell on green for bicycle traffic

Where a higher-order road continues with priority past a lower-order road, the signals remain in ‘A phase’, with green for the busier road until a road user approaches from the minor road. The pedestrian and bicycle signals should also remain dwelling-on-green until a road user on the side road calls up the opposing movement, refer Figure 4.5.2(M). Where the higher-order road dwells-on-green, pedestrian and bicycle push buttons have no function; however, there should be indicator lights to show there is no need to push the button.

In most cases, road users continuing straight on and vehicle drivers turning left are permitted to run concurrently. Left-turning motor vehicle traffic at protected signalised intersections gives way to bicycle traffic continuing straight on. This is assisted by the improved visibility of bicycle riders due to the storing position further ahead and the observation angle at close to 90°.

Figure 4.5.2(M) – Dwell-on-green for bicycle traffic at signalised intersection, Rotterdam

4.6 Grade-separated intersections

Installing a tunnel or bridge completely removes the conflict between bicycle and motorised traffic. This measure is most appropriate on Principal Cycle Network routes, both in urban areas and outside the built-up area. Figures 4.6(A) and 4.6(B) are good examples of grade-separated, two-way cycle track with separated footpath.

Figure 4.6(A) – Pedestrian and bicycle underpass with rock walls, Nijmegen, Netherlands

Figure 4.6(B) – Pedestrian and bicycle underpass with artwork created by local primary school children, Nijmegen, Netherlands

4.7 *Other considerations*

4.7.1 Green surface treatment

For further information on coloured surface treatments, refer to Section 6.6-1 in Transport and Main Roads' Supplement to Austroads *Guide to Traffic Management* Part 10, TRUM Volume 1.

The use of green surface treatment at commercial and large residential driveways where there are a high number of vehicle movements and a heightened risk of conflict between bicycle riders and vehicles may be appropriate; however, due to the need to highlight the conflict area only and the high cost associated with its installation, the use of green surfacing should be limited to the immediate lengths of driveway and not on approach to them.

Avoiding the conflict at major commercial driveways such as service stations is recommended, instead of highlighting the conflict (Figure 4.7.1).

Figure 4.7.1 – Two-way cycle track and footpath on arterial road built behind the service station to avoid crossing conflicts, Rotterdam

Source Google maps

4.7.2 Industrial area driveways

Figures 4.7.2(A) to 4.7.2(C) show the appropriate treatment where a large commercial or industrial driveway crosses the cycle track. In some cases, such as the service station in Figure 4.7.1, the cycle track can avoid conflict with a large commercial entrance by going around.

Figure 4.7.2(A) – Three angles of a two-way cycle track crossing industrial area driveway, Rotterdam

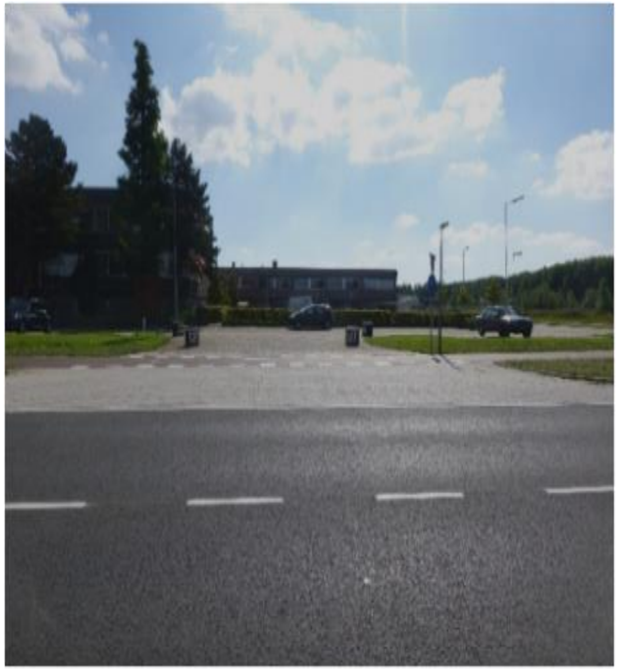


Figure 4.7.2(B) – Two-way cycle track crossing industrial area driveway, Rotterdam

Source Google maps

Figure 4.7.2(C) – Two-way cycle track crossing industrial area driveway, Rotterdam

Source Google street view

4.7.3 Residential driveways

Figure 4.7.3 show the appropriate treatment where a residential driveway crosses the cycle track. The treatment aims to emphasise that the priority movement is for the through bicycle movement.

Figure 4.7.3 – Two-way cycle track crossing residential driveway, Rotterdam

Appendices

Appendix A – Definitions

‘Bend-in’ Transition: A one-way cycle track transition to a bicycle lane at a road intersection, from a road related area to a road.

‘Bend-out’ Transition: A cycle track, shared path or bicycle path that bends away from the carriageway and continues at a side road intersection.

Bicycle facility: Any type of explicit bicycle infrastructure provision including bicycle path, bicycle lane, or cycle track.

Bicycle lane: An on-road special purpose lane for the exclusive use of bicycles.

Bicycle path: A dedicated two-way facility for bicycle riders that is considered a road-related area under the Queensland Road Rules.

Bicycle route: A route may comprise a number of different types of bicycle facilities or route signage to connect key origins and destinations.

Bikeway: A bicycle path or shared path most commonly located off-road for recreational use.

Cycle track, dual kerb: A physically-separated, bicycle-only facility with kerbs on both sides of cycle track (that is, to road and to footpath) instead of a median separator. Under the Road Rules, separated path rules apply to cycle tracks.

Cycle track, one-way: A one-way, physically-separated, bicycle-only facility with clear bicycle priority at intersections. Under the Road Rules, separated path rules apply to cycle tracks.

Cycle track, two-way: A two-way, physically-separated, bicycle-only facility with clear bicycle priority at intersections. Under the Road Rules, separated path rules apply to cycle tracks.

Intersection: Without altering the Queensland Road Rules definition, this guide also defines an intersection as the meeting between a cycle track at a road, path or driveway.

Off-road: A path located outside the road corridor, possibly through a park, reserve, easement, within a public transport corridor or other public or private land not open to motor vehicle traffic.

On-road: Where bicycles are operated in a general-purpose traffic lane, special purpose lane, auxiliary lane, a lane shared with parked cars or road shoulder.

QRR: Queensland Road Rules as defined by the Transport Operations (Road Use Management – Road Rules) Regulation 2009.

Road: As per the definition in Schedule 4 of the *Transport Operations (Road Use Management) Act 1995*.

Road-related area: As per Section 13 of the Transport Operations (Road Use Management – Road Rules) Regulation 2009.

Separator: An area that divides a bicycle facility or path from the footpath, nature strip or roadway.

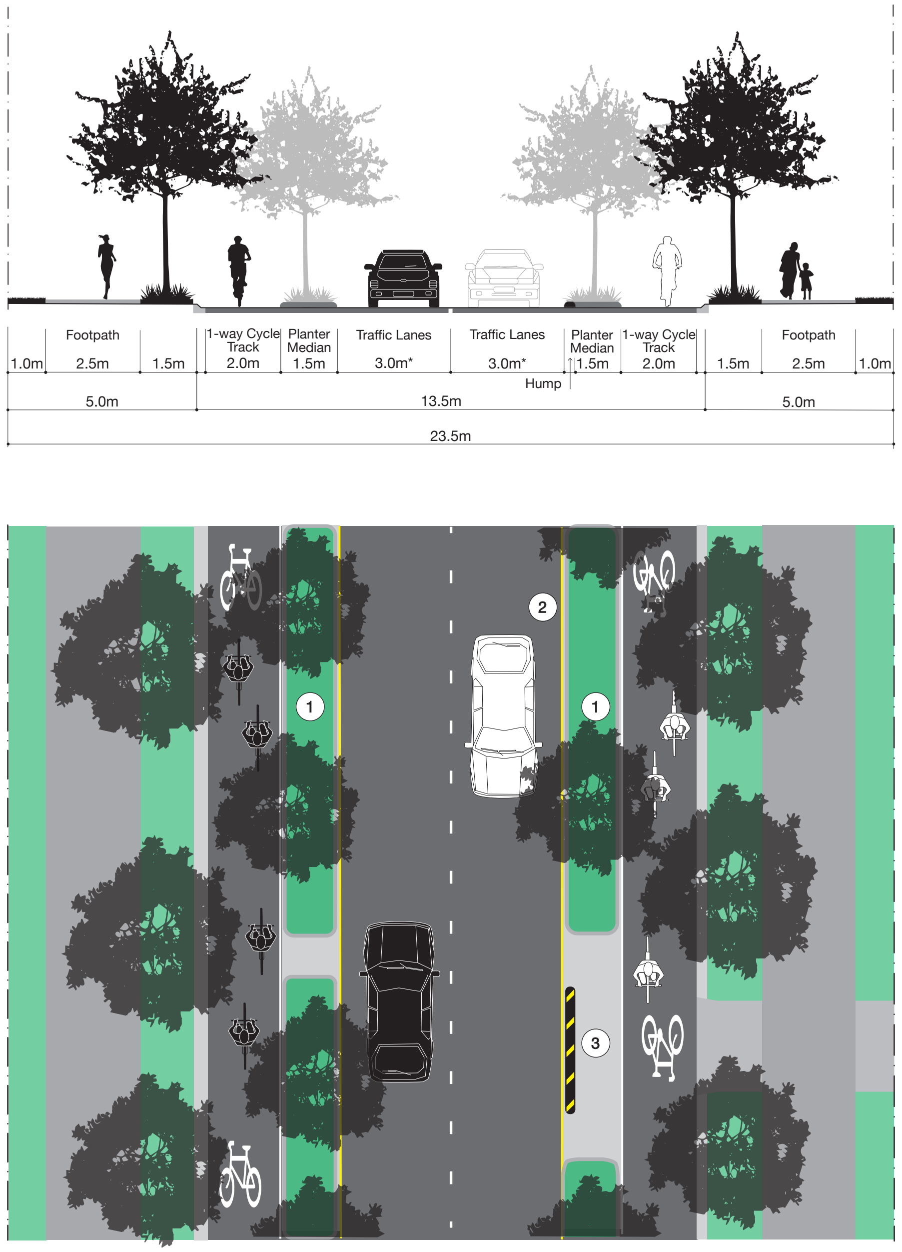
Shared path: A pedestrian and bicycle facility that gives pedestrians priority under the QRR.

‘Straight’: A cycle track, shared path or bicycle path that continues over a side road intersection.

Transition: A bicycle path connection, possibly a ramp, between road and road-related area (or vice versa), such as a Bend-in Transition.

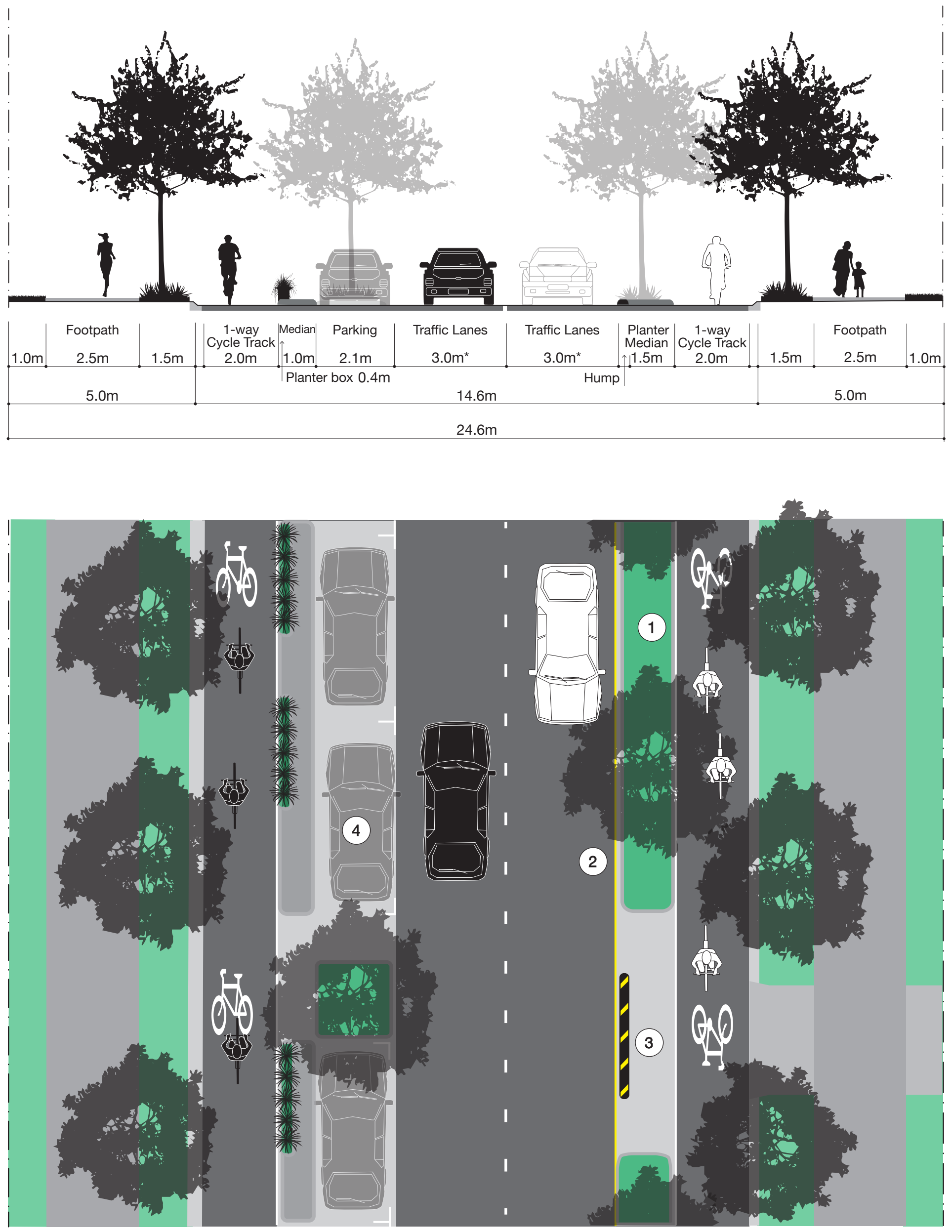
Veloway: An arterial standard bicycle path designed to cater for high bicycle volumes. Conflicts and delays eliminated through features such as grade separation at intersections with roads.

Appendix B – Drawings



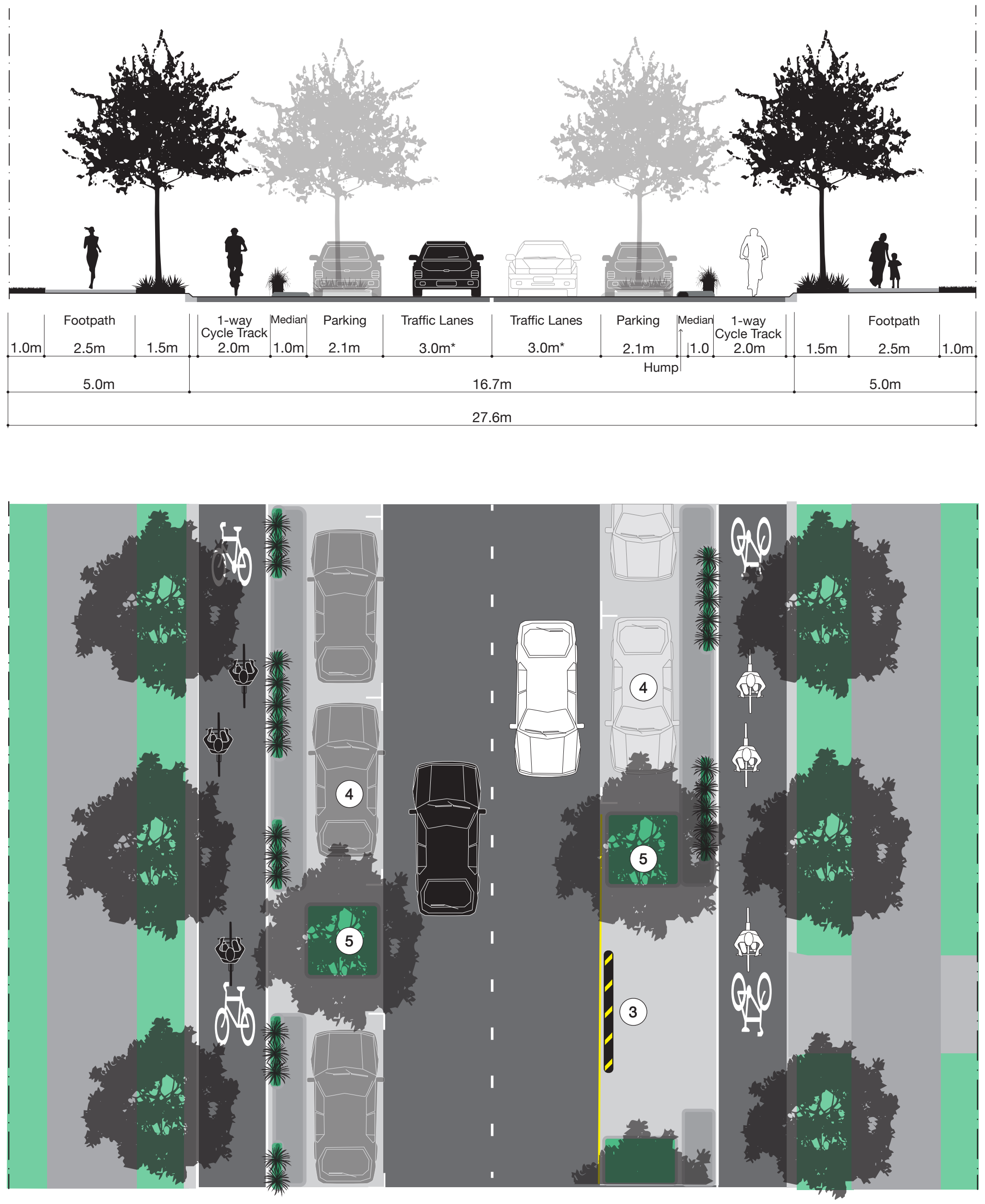
Two x 1-way separated cycle track
(preferred)

LTS1



Two x 1-way separated cycle track with parking one side
(preferred)

LTS1



Two x 1-way separated cycle track with parking both sides
(preferred)

LTS1

LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

- **LTS1** Feels safe for most children and adults. Separation except in low speed/low volume traffic.
- **LTS2** Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
- **LTS3** Adequate for confident experienced riders with recognised safety risks, or with poor directness.
- **LTS4** Uncomfortable for most people, significant safety risks.

NOTES

1. 1.5m wide median separator for shade trees and low landscaping
2. Yellow no stopping lines or "no parking signs"
3. Low profile speed hump in line with separators at driveways. Refer section 4.3.1 for further details
4. 2.1m indented parking
5. 2m x 2m planter box with trees and low landscaping

Council bins collected from median area if required

* Traffic lane width will vary depending on local demands

Refer to section 3.4 for further information

LEGEND

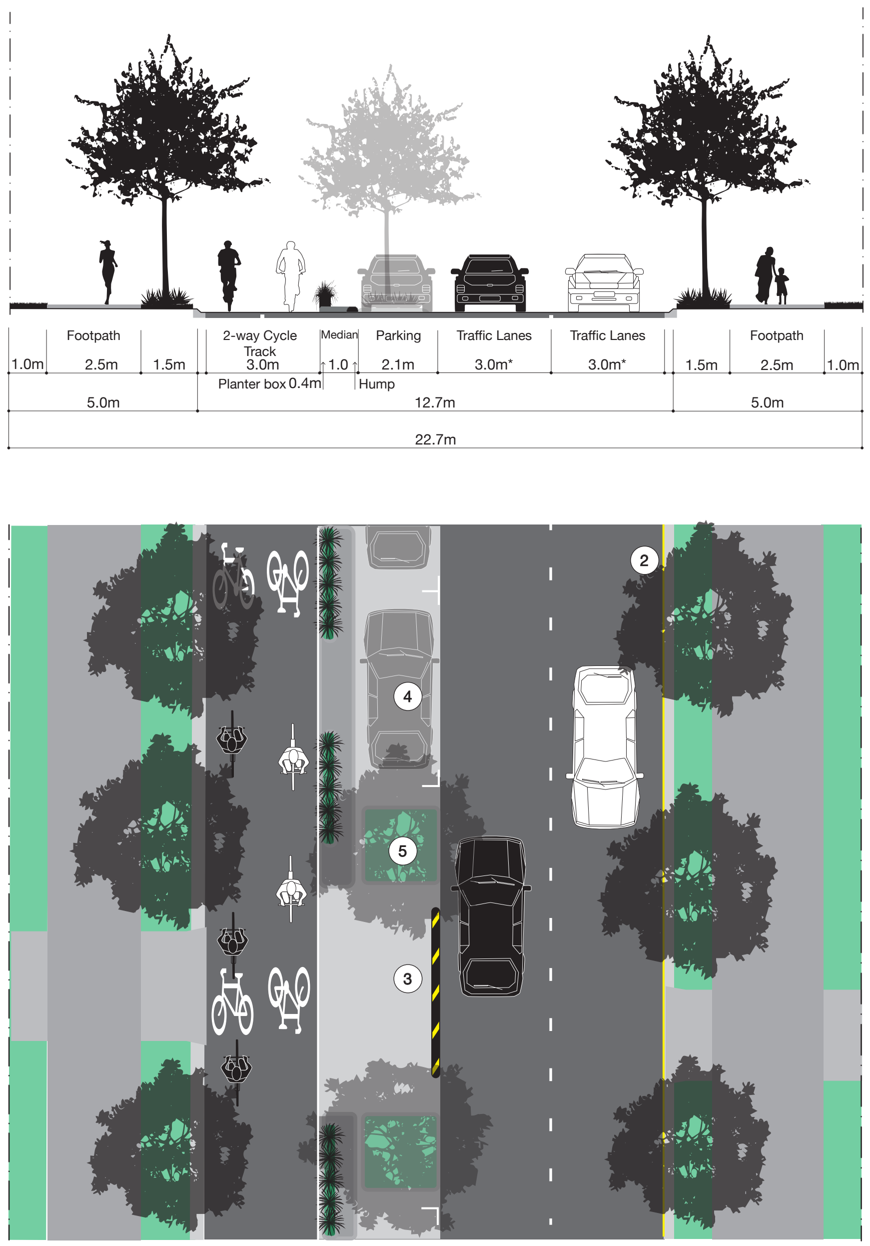
- Asphalt
- Concrete footpath
- Concrete median
- Concrete at road level
- Landscaping/grass
- Low profile speed hump

GREENFIELD 1-WAY CYCLE TRACKS ON COLLECTOR ROADS

FIGURE	B1.01A	VERSION	04	01
DATE	06/06/2019	SCALE	1:200 @ A3	

One x 2-way separated cycle track
(preferred)

LTS1



One x 2-way separated cycle track with parking one side
(preferred)

LTS1

One x 2-way separated cycle track with parking both sides
(preferred)

LTS1

LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

- **LTS1** Feels safe for most children and adults. Separation except in low speed/low volume traffic.
- **LTS2** Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
- **LTS3** Adequate for confident experienced riders with recognised safety risks, or with poor directness.
- **LTS4** Uncomfortable for most people, significant safety risks.

NOTES

1. 2m wide median separator for shade trees and low landscaping
2. Yellow no stopping lines or "no parking signs"
3. Low profile speed hump in line with separators at driveways. Refer section 4.3.1 for further details
4. 2.1m indented parking
5. 2m x 2m planter box with trees and low landscaping

Council bins collected from median area if required

* Traffic lane width will vary depending on local demands

Refer to section 3.4 for further information

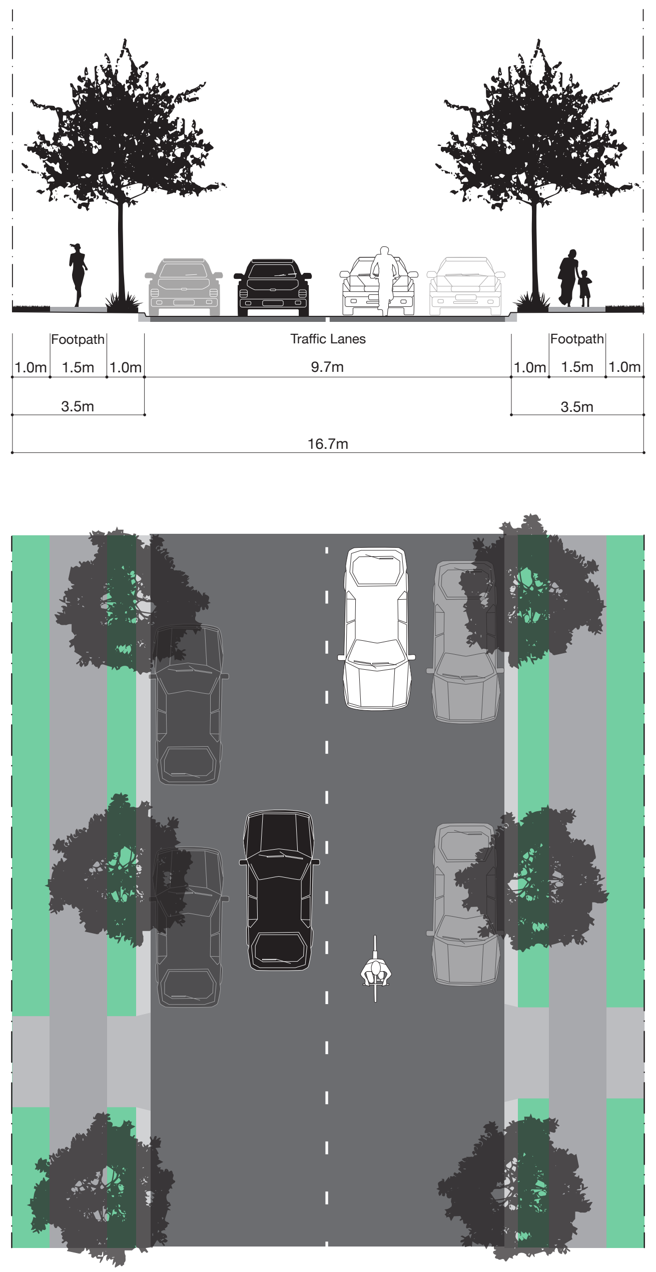
LEGEND

- Asphalt
- Concrete footpath
- Concrete median
- Concrete at road level
- Landscaping/grass
- Low profile speed hump

0 1m 2m 5m 10m

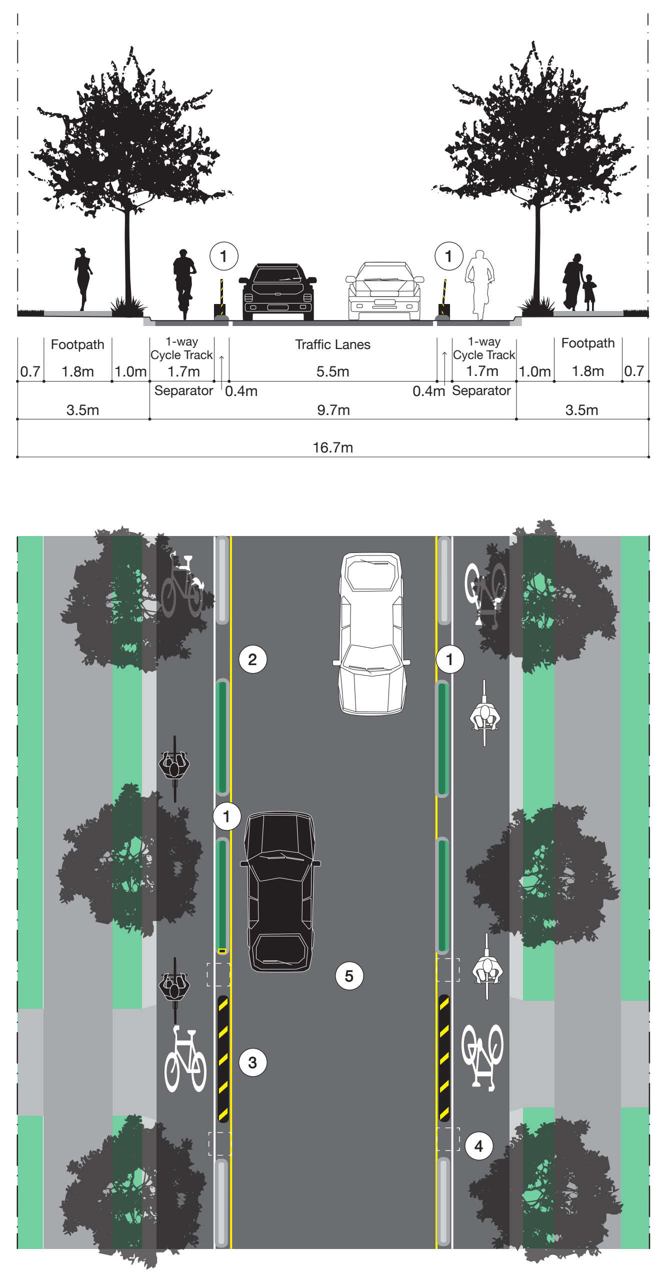
GREENFIELD 2-WAY CYCLE TRACKS ON COLLECTOR ROADS

FIGURE	B1.01B	VERSION	04	02
DATE	06/06/2019	SCALE	1:200 @ A3	



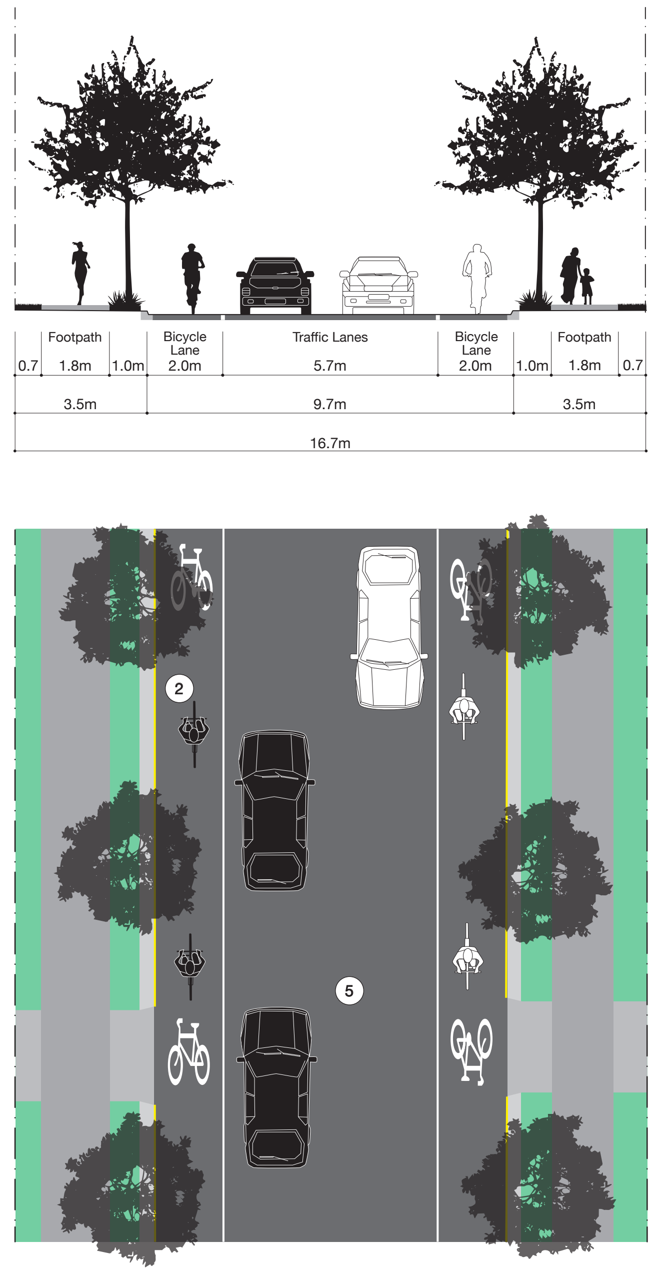
Exisiting

LTS4



Two x 1-way separated cycle track (preferred)

LTS1



Two x 2m bicycle lanes (Risk of vehicles parking in bicycle lanes)

LTS2

Lorem ipsum

LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

- **LTS1** Feels safe for most children and adults. Separation except in low speed/low volume traffic.
- **LTS2** Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
- **LTS3** Adequate for confident experienced riders with recognised safety risks, or with poor directness.
- **LTS4** Uncomfortable for most people, significant safety risks.

NOTES

1. Median separator with guide posts. Planter boxes with guide posts on leading planter box optional. Note that these separator boxes should not be used beside on-street parking, use wider separator
2. Yellow no stopping lines or "no parking signs"
3. Low profile speed hump in line with separators at driveways. Refer section 4.3.1 for further details
4. Council bin collection areas could be designated where medians are less than 600mm wide and may overlap in cycle track retrofit situations
5. No centreline

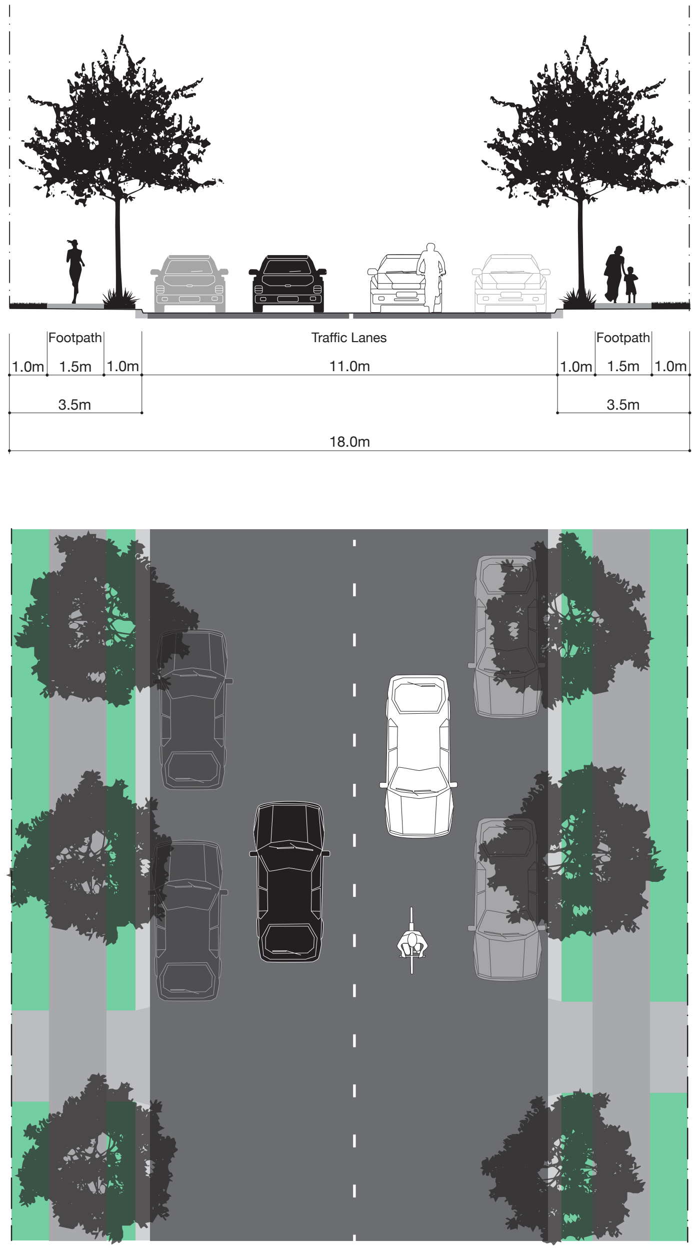
Refer to section 3.4 for further information

LEGEND

- Asphalt
- Concrete footpath
- Concrete median
- Concrete at road level
- Landscaping/grass
- Low profile speed hump

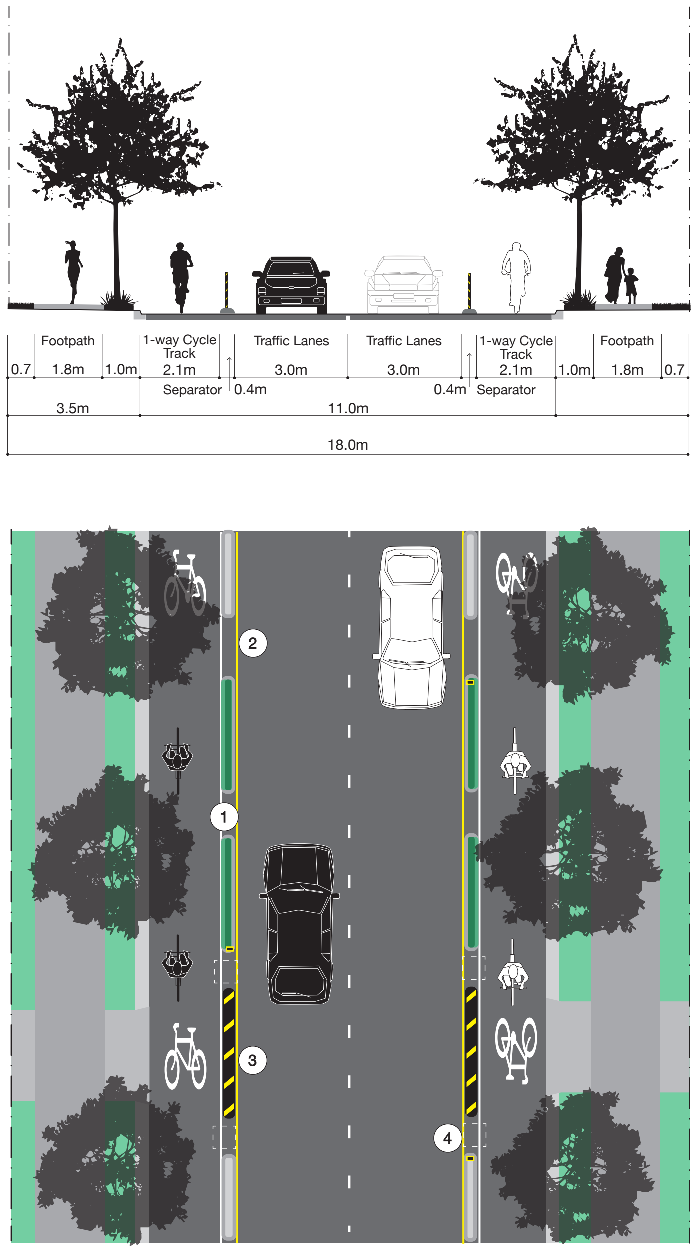
EXAMPLE RETROFIT 1-WAY CYCLE TRACKS ON 9.7 ROADS

FIGURE	B1.01A.9.7	VERSION	02	03
DATE	06/06/2019	SCALE	1:200 @ A3	



Exisiting

LTS4



Two x 1-way separated cycle track (preferred)

LTS1

LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

LTS1	Feels safe for most children and adults. Separation except in low speed/low volume traffic.
LTS2	Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
LTS3	Adequate for confident experienced riders with recognised safety risks, or with poor directness.
LTS4	Uncomfortable for most people, significant safety risks.

NOTES

1. Median separator with guide posts. Planter boxes with guide posts on leading planter box optional. Note that these separator boxes should not be used beside on-street parking, use wider separator
2. Yellow no stopping lines or "no parking signs"
3. Low profile speed hump in line with separators at driveways. Refer section 4.3.1 for further details
4. Council bin collection areas could be designated where medians are less than 600mm wide and may overlap in cycle track retrofit situations

Refer to section 3.4 for further information

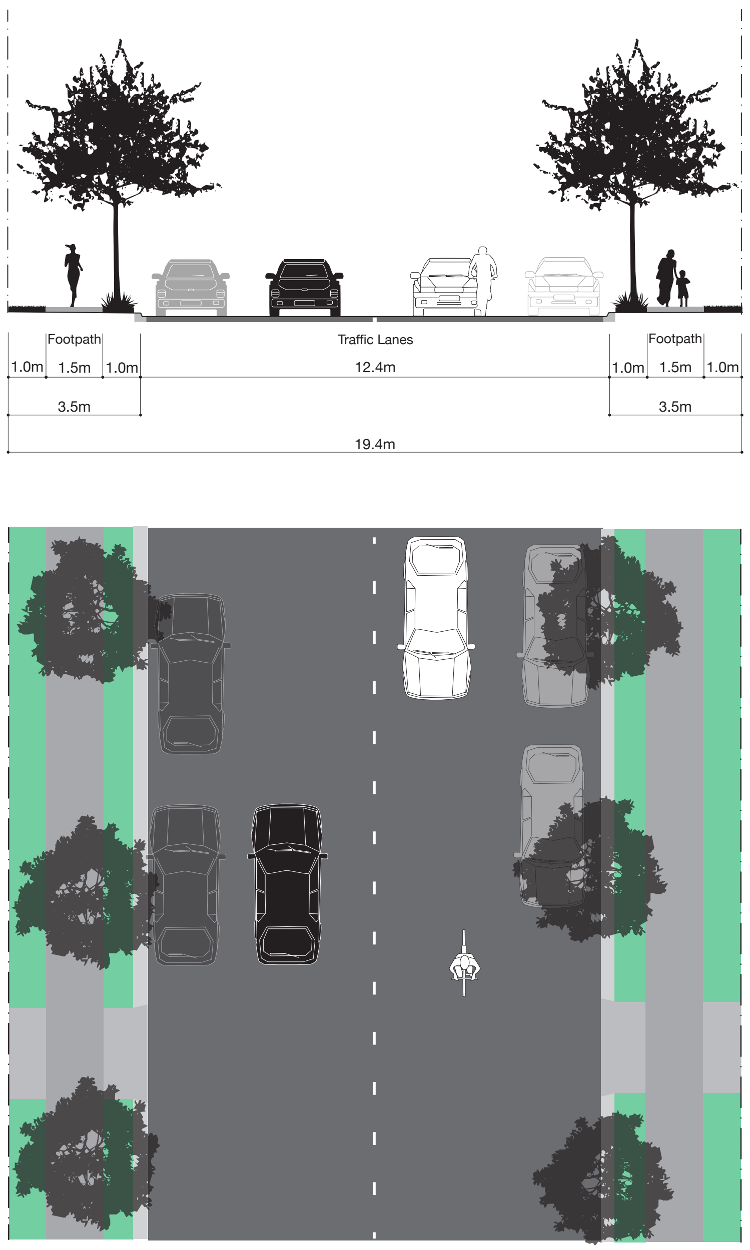
LEGEND

- Asphalt
- Concrete footpath
- Concrete median
- Concrete at road level
- Landscaping/grass
- Low profile speed hump

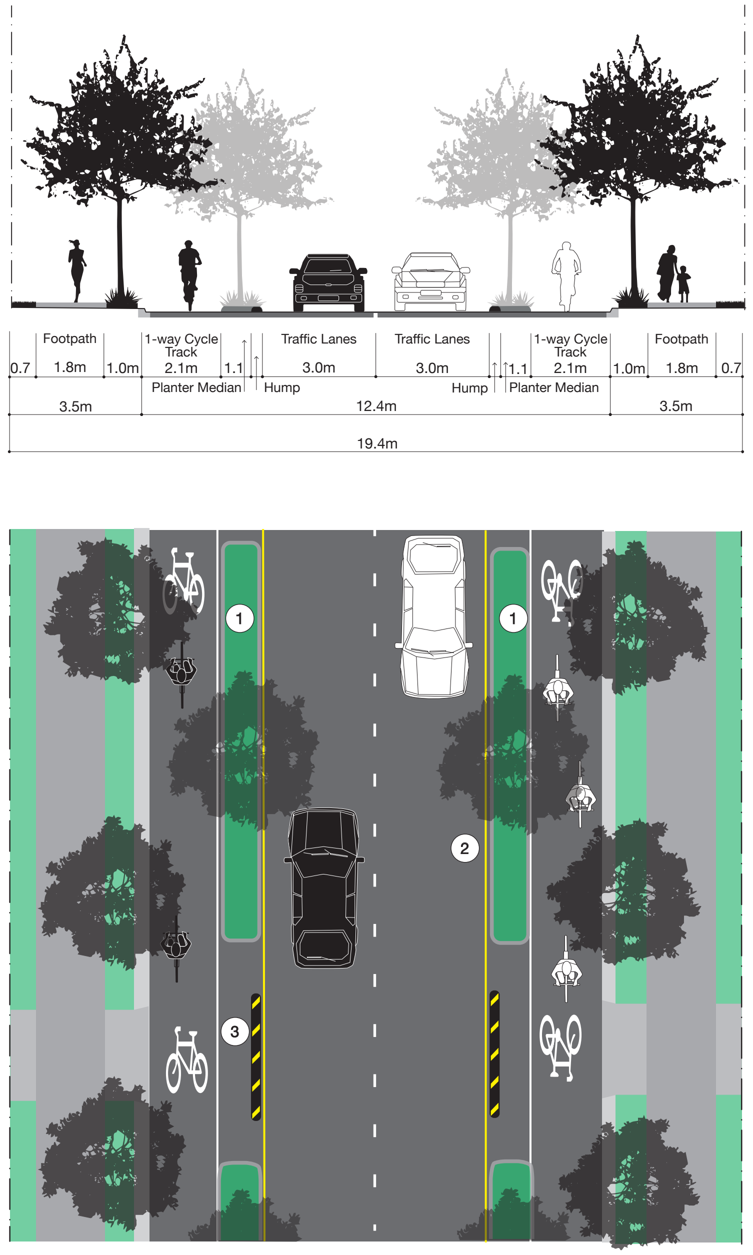
0 1m 2m 5m 10m

EXAMPLE RETROFIT 1-WAY CYCLE TRACKS ON 11m COLLECTOR ROAD

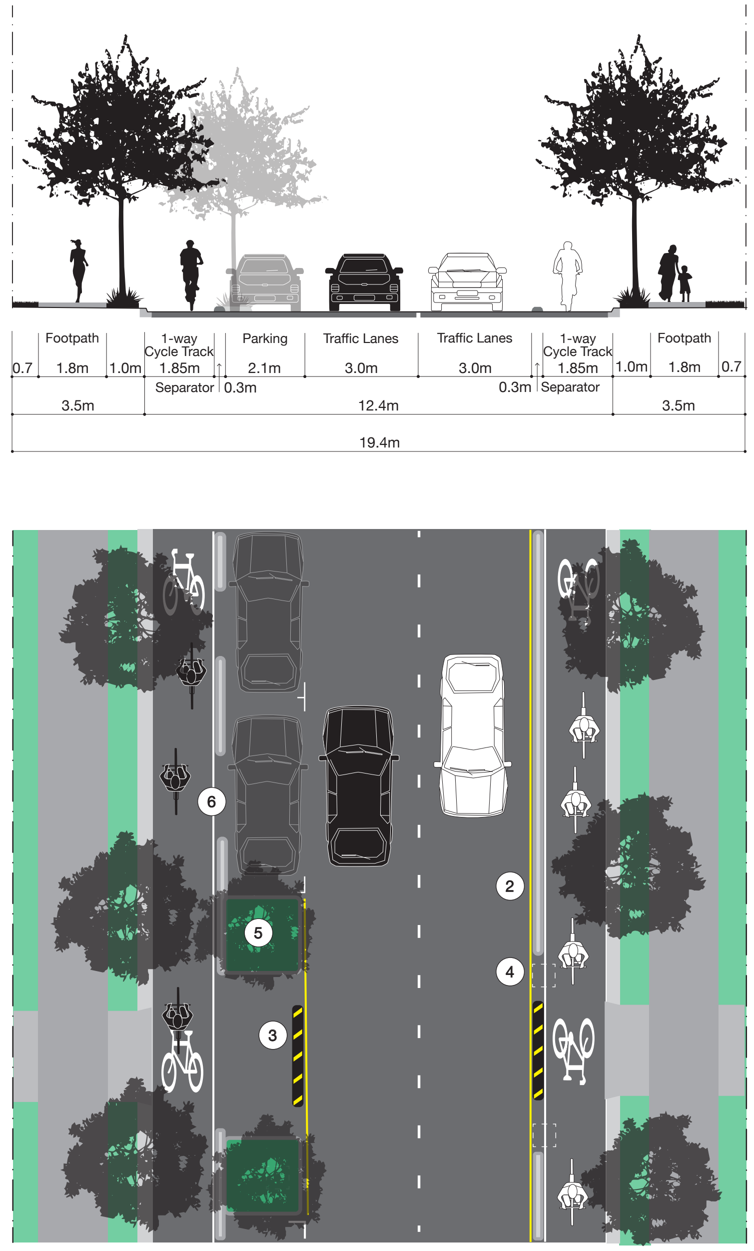
FIGURE	B1.01A.11.0	VERSION	02	04
DATE	06/06/2019	SCALE	1:200 @ A3	



Exisiting LTS4



Two x 1-way separated cycle track (preferred) LTS1



Two x 1-way separated cycle track (narrow with car parking) LTS1

LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

- **LTS1** Feels safe for most children and adults. Separation except in low speed/low volume traffic.
- **LTS2** Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
- **LTS3** Adequate for confident experienced riders with recognised safety risks, or with poor directness.
- **LTS4** Uncomfortable for most people, significant safety risks.

NOTES

1. 1.1m wide median separator for shade trees and low landscaping
2. Yellow no stopping lines or "no parking signs"
3. Low profile speed hump in line with separators at driveways. Refer section 4.3.1 for further details
4. Council bin collection areas could be designated where medians are less than 600mm wide and may overlap in cycle track retrofit situations
5. 2m x 2m planter box with trees and low landscaping
6. Locate gaps in narrow separator where car doors open

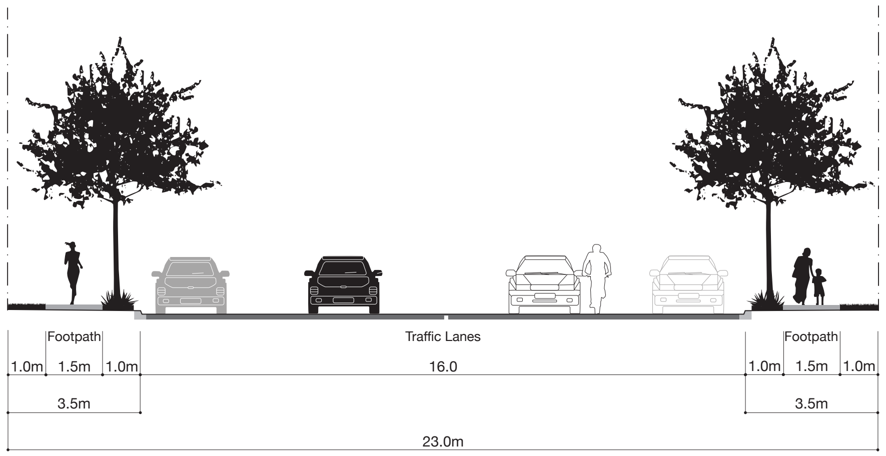
Refer to section 3.4 for further information

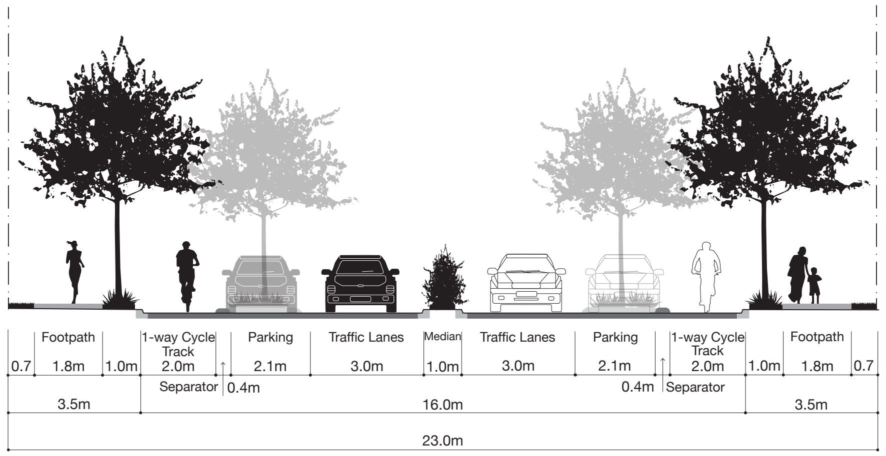
LEGEND

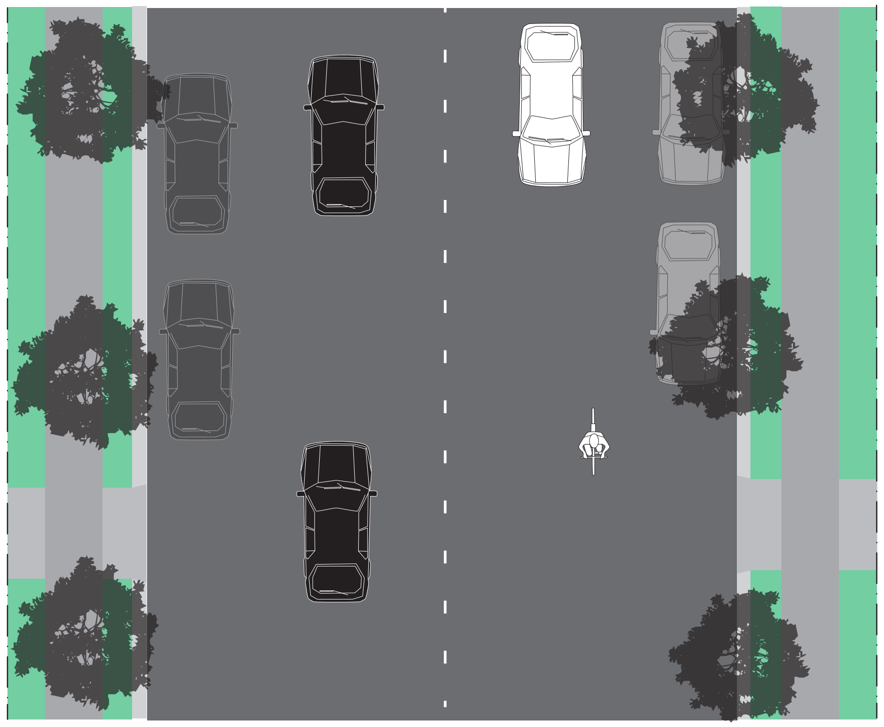
- Asphalt
- Concrete footpath
- Concrete median
- Concrete at road level
- Landscaping/grass
- Low profile speed hump

EXAMPLE RETROFIT 1-WAY CYCLE TRACKS ON 12.4m COLLECTOR ROADS

FIGURE	B1.01A.12.4	VERSION	02	05
DATE	06/06/2019	SCALE	1:200 @ A3	

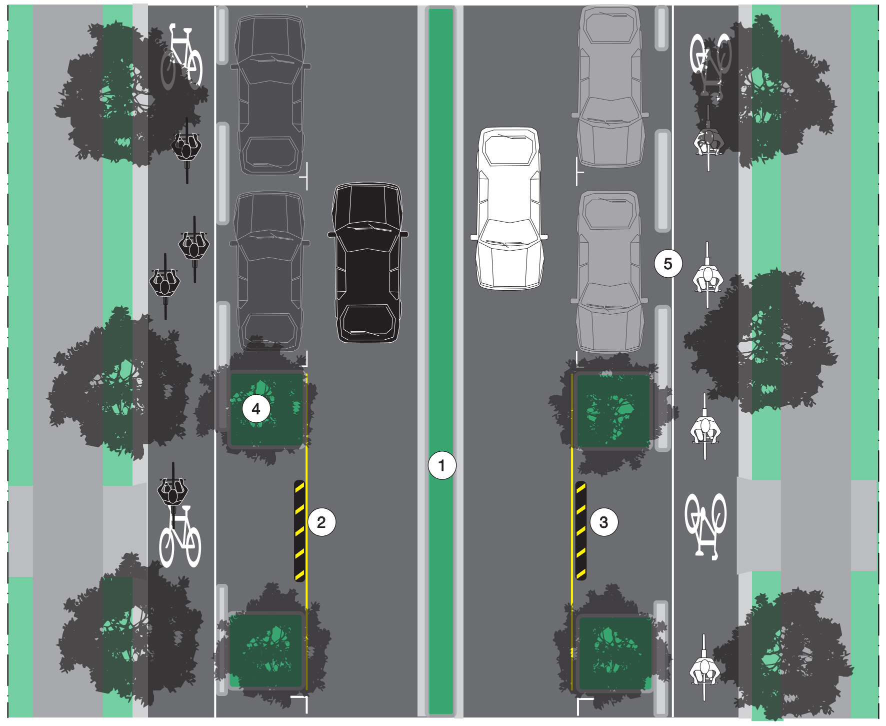






Exisiting

LTS4



Two x 1-way separated cycle track
(narrow with car parking)

LTS1

LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

- **LTS1** Feels safe for most children and adults. Separation except in low speed/low volume traffic.
- **LTS2** Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
- **LTS3** Adequate for confident experienced riders with recognised safety risks, or with poor directness.
- **LTS4** Uncomfortable for most people, significant safety risks.

NOTES

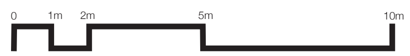
1. 1.0m wide median. Separator shrubs or low landscaping options
2. Yellow no stopping lines or "no parking signs"
3. Low profile speed hump in line with separators at driveways. Refer section 4.3.1 for further details
4. 2m x 2m planter box with trees and low landscaping
5. Locate gaps in narrow separator where car doors open

Council bins collected from median area if required

Refer to section 3.4 for further information.

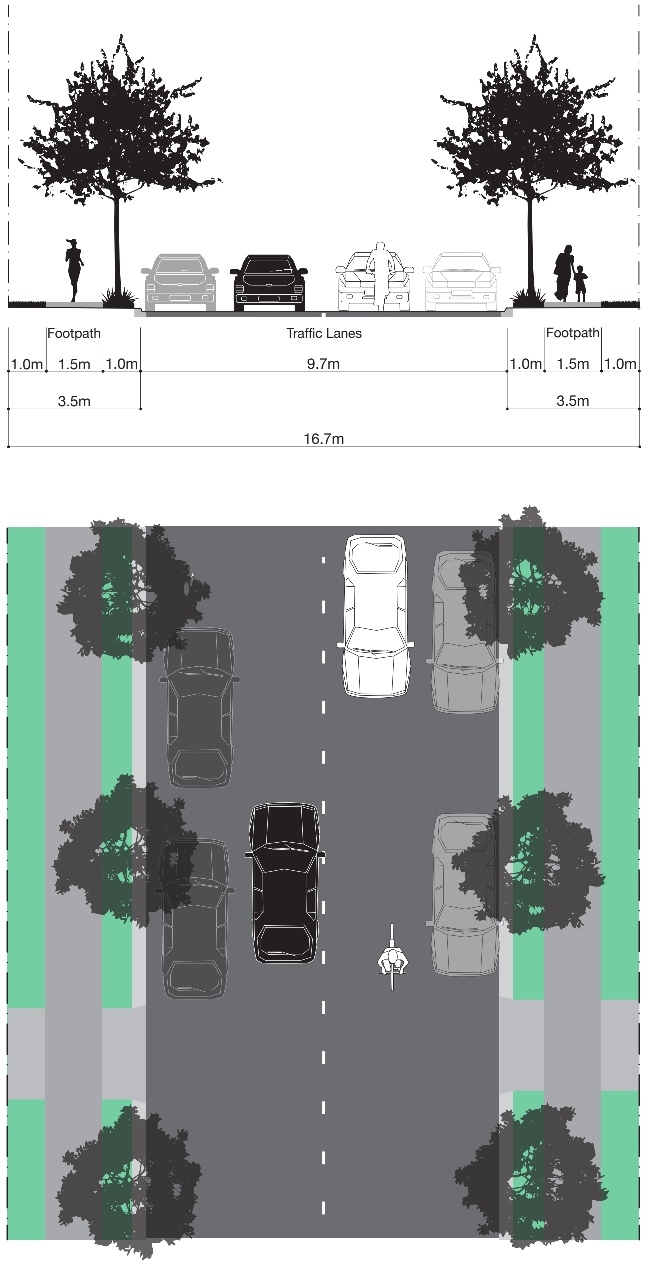
LEGEND

- Asphalt
- Concrete footpath
- Concrete median
- Concrete at road level
- Landscaping/grass
- Low profile speed hump



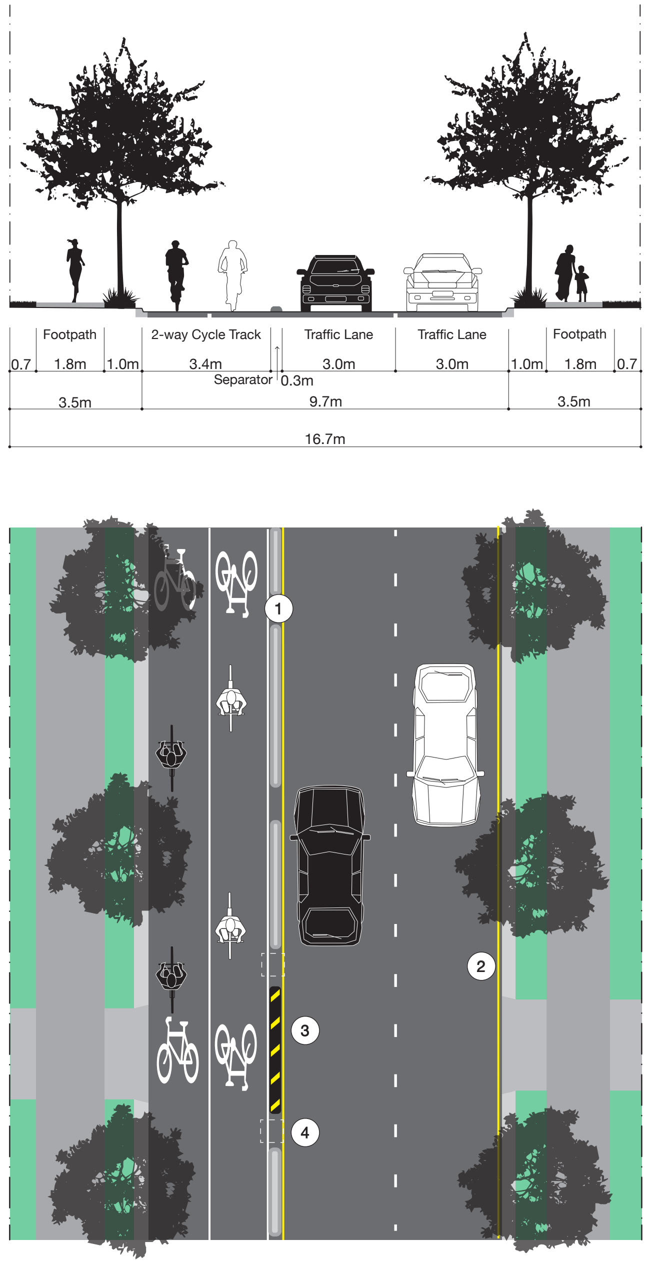
EXAMPLE RETROFIT 1-WAY CYCLE TRACKS ON 16.0m COLLECTOR ROADS

FIGURE	B1.01A.16.0	VERSION	02	06
DATE	06/06/2019	SCALE	1:200 @ A3	



Exisiting

LTS4



Two x 2-way separated cycle track (preferred)

LTS1

LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

- **LTS1** Feels safe for most children and adults. Separation except in low speed/low volume traffic.
- **LTS2** Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
- **LTS3** Adequate for confident experienced riders with recognised safety risks, or with poor directness.
- **LTS4** Uncomfortable for most people, significant safety risks.

NOTES

1. 300mm median separator
2. Yellow no stopping lines or "no parking signs"
3. Low profile speed hump in line with separators at driveways. Refer section 4.3.1 for further details
4. Council bin collection areas could be designated where medians are less than 600mm wide and may overlap in cycle track retrofit situations

Refer to section 3.4 for further information.

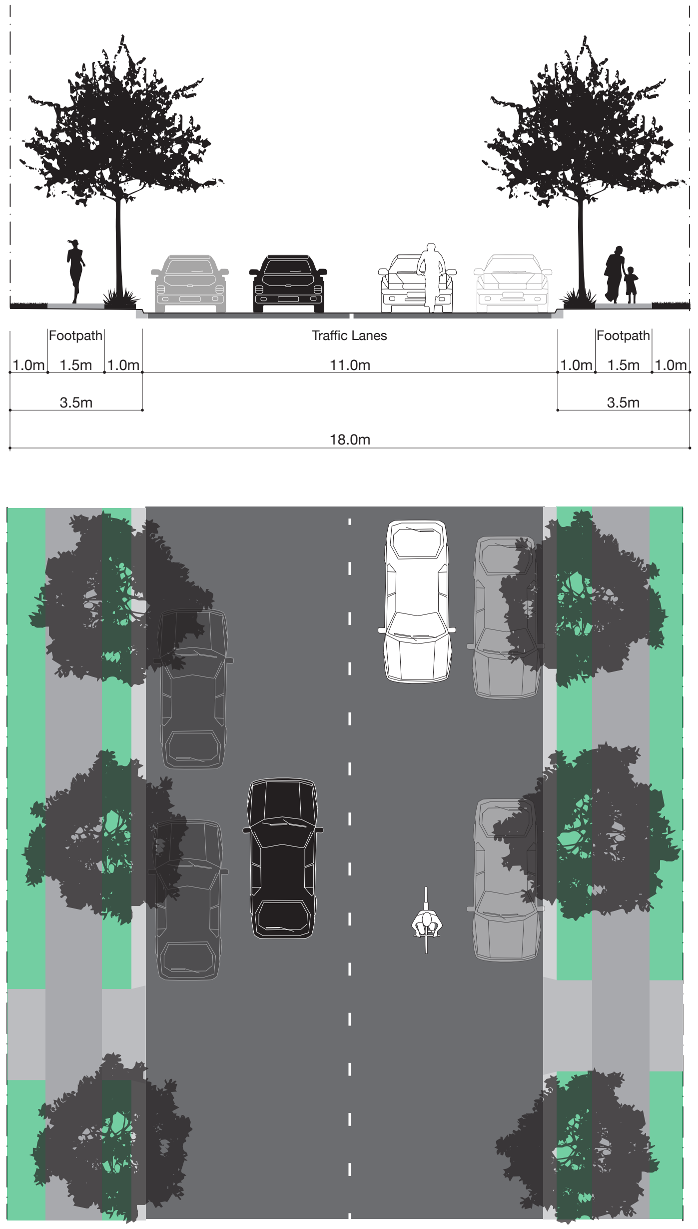
LEGEND

- Asphalt
- Concrete footpath
- Concrete median
- Concrete at road level
- Landscaping/grass
- Low profile speed hump

0 1m 2m 5m 10m

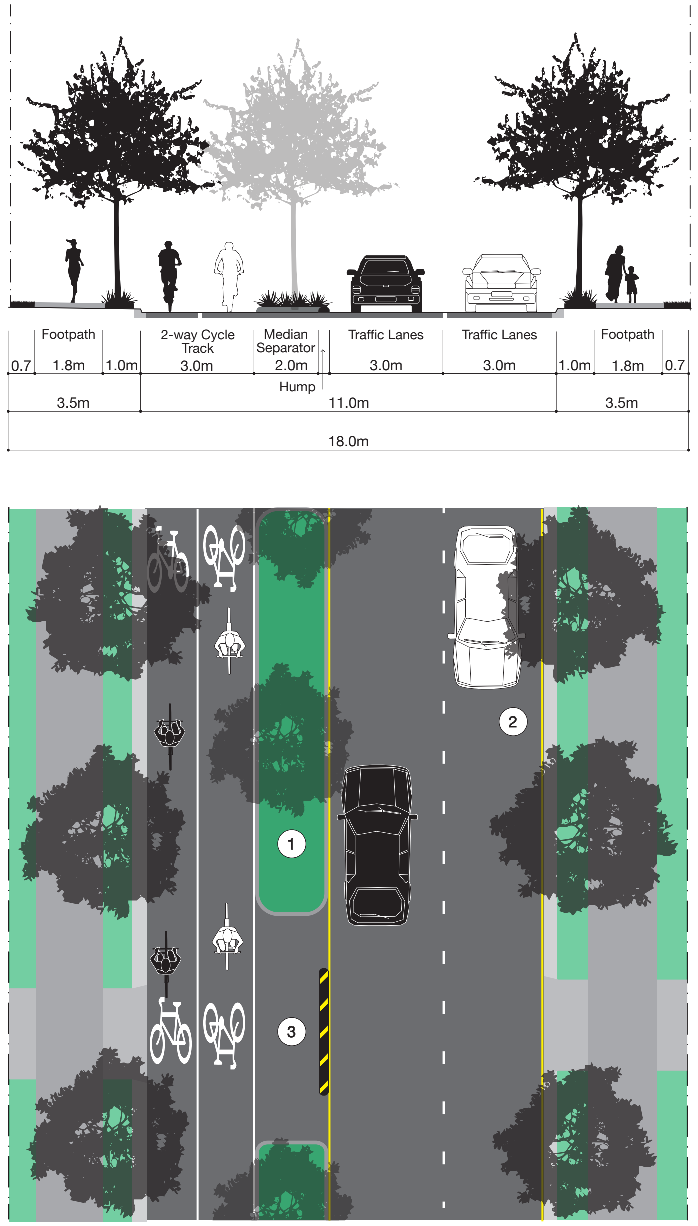
EXAMPLE RETROFIT 2-WAY CYCLE TRACKS ON 9.7m COLLECTOR ROADS

FIGURE	B1.01B.9.7	VERSION	02	07
DATE	06/06/2019	SCALE	1:200 @ A3	



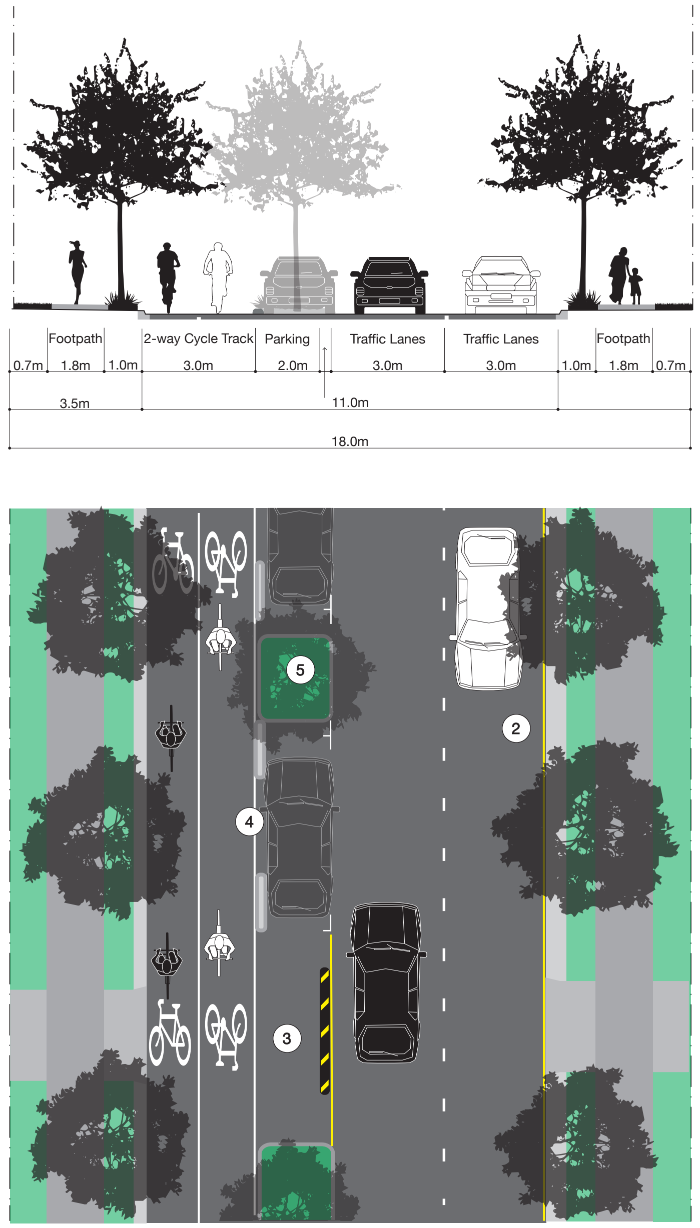
Exisiting

LTS4



One x two-way separated cycle track (preferred)

LTS1



One x two-way separated cycle track (wth narrow car parking)

LTS1

LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

- **LTS1** Feels safe for most children and adults. Separation except in low speed/low volume traffic.
- **LTS2** Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
- **LTS3** Adequate for confident experienced riders with recognised safety risks, or with poor directness.
- **LTS4** Uncomfortable for most people, significant safety risks.

NOTES

1. 2m wide median separator for shade trees and low landscaping
2. Yellow no stopping lines or "no parking signs"
3. Low profile speed hump in line with separators at driveways. Refer section 4.3.1 for further details
4. Locate gaps in narrow separator where car doors open
5. 2m x 2m planter box with trees and low landscaping

Council bins collected from median area if required

Refer to section 3.4 for further information

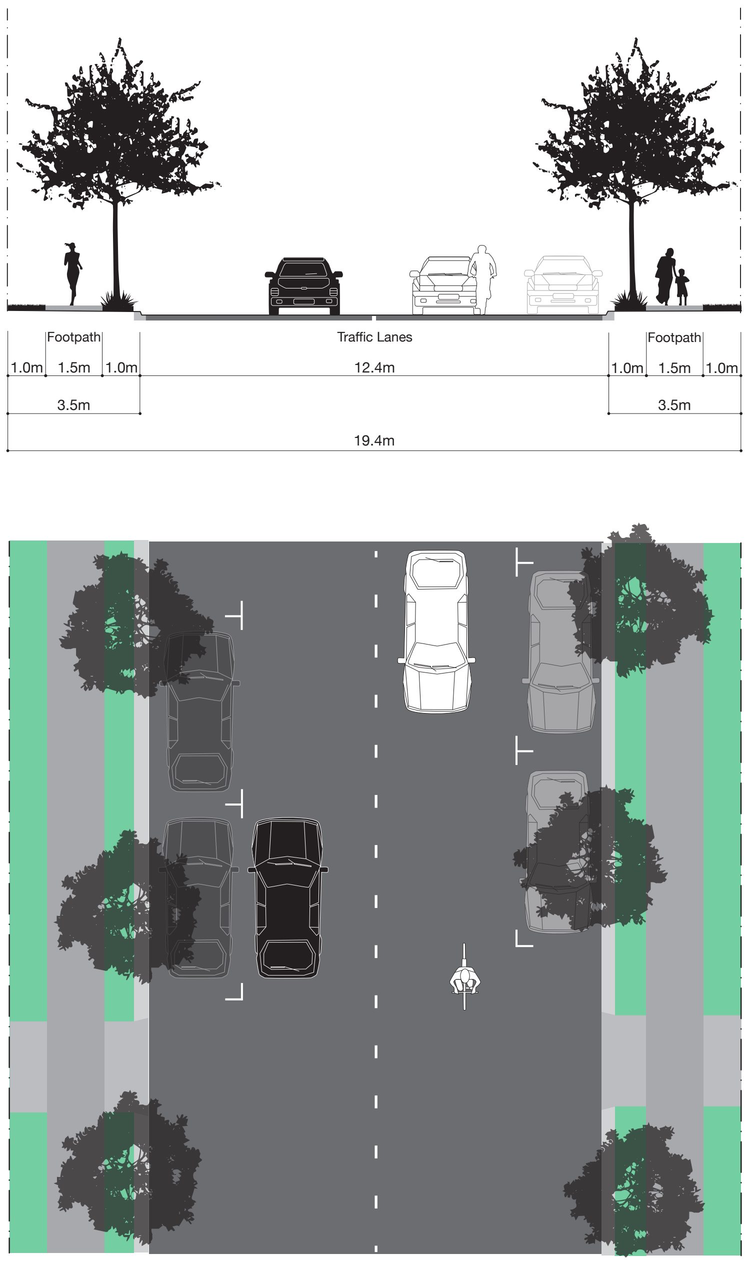
LEGEND

- Asphalt
- Concrete footpath
- Concrete median
- Concrete at road level
- Landscaping/grass
- Low profile speed hump

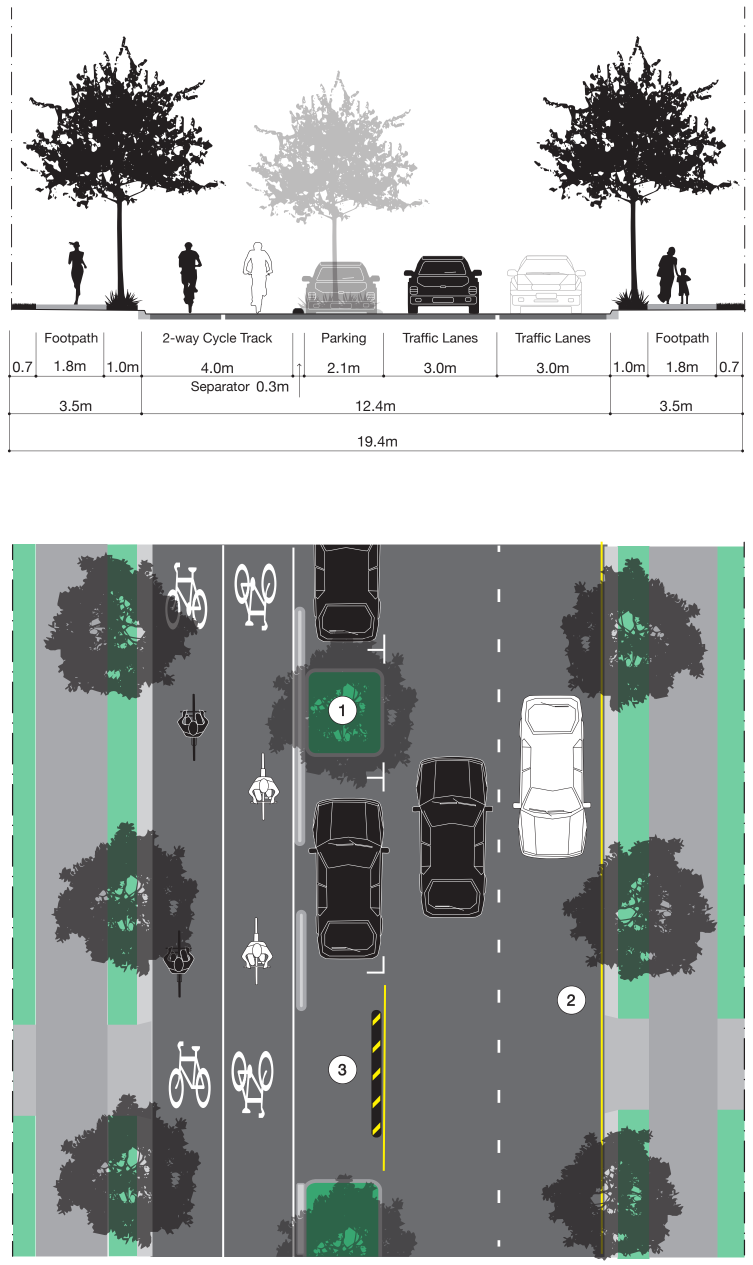
0 1m 2m 5m 10m

EXAMPLE RETROFIT 2-WAY CYCLE TRACKS ON 11.0m COLLECTOR ROADS

FIGURE	B1.01B.11.0	VERSION	02	08
DATE	06/06/2019	SCALE	1:200 @ A3	



Exisiting LTS4



One x 2 way separated cycle track (preferred) LTS1

LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

- **LTS1** Feels safe for most children and adults. Separation except in low speed/low volume traffic.
- **LTS2** Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
- **LTS3** Adequate for confident experienced riders with recognised safety risks, or with poor directness.
- **LTS4** Uncomfortable for most people, significant safety risks.

NOTES

1. 2m wide median separator for shade trees and low landscaping
2. Yellow no stopping lines or "no parking signs"
3. Low profile speed hump in line with separators at driveways. Refer section 4.3.1 for further details

Council bins collected from median area if required

Refer to section 3.4 for further information

LEGEND

- Asphalt
- Concrete footpath
- Concrete median
- Concrete at road level
- Landscaping/grass
- Low profile speed hump

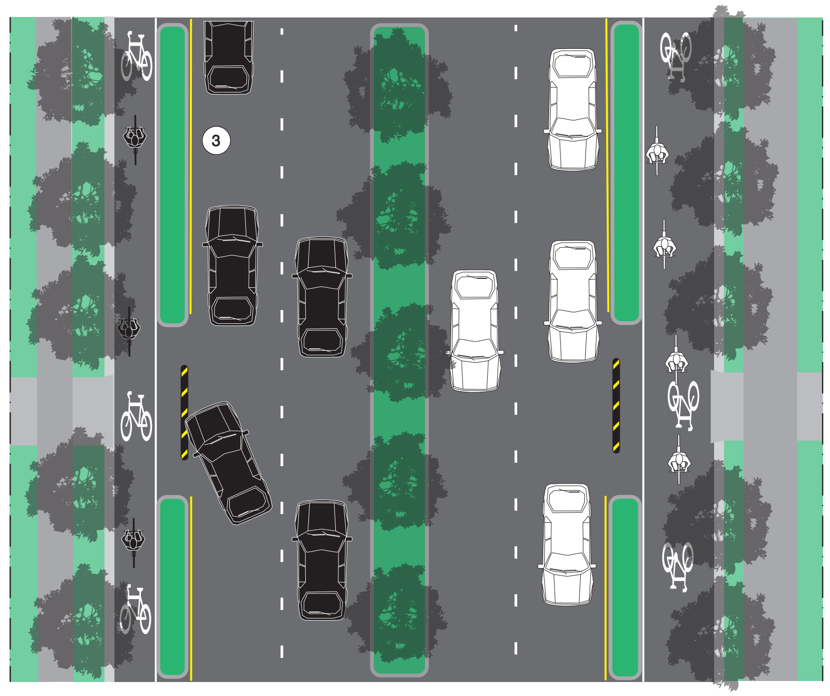
0 1m 2m 5m 10m

EXAMPLE RETROFIT 2-WAY CYCLE TRACKS ON 12.4m COLLECTOR ROADS

FIGURE	B1.01B.12.4	VERSION	02	09
DATE	06/06/2019	SCALE	1:200 @ A3	

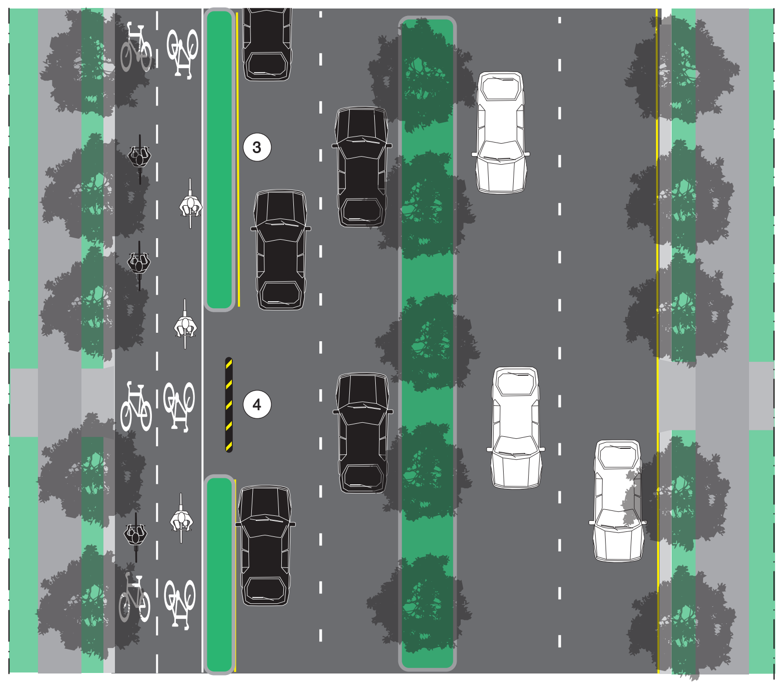
FOUR LANE DIVIDED ARTERIAL WITH SERVICE LANE AND PARKING BOTH SIDES
(41 m kerb to kerb)

LTS1



1-WAY CYCLE TRACKS ON ARTERIAL ROAD
Not to scale

LTS1



2-WAY CYCLE TRACK ON ARTERIAL ROAD
Not to scale

LTS1

LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

- **LTS1** Feels safe for most children and adults. Separation except in low speed/low volume traffic.
- **LTS2** Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
- **LTS3** Adequate for confident experienced riders with recognised safety risks, or with poor directness.
- **LTS4** Uncomfortable for most people, significant safety risks.

NOTES

1. Service lane to be designed in accordance with Queensland Cycle Street requirements (TRUM Vol 1 Part 8)
2. One way service roads with 2.5m indented parking and landscaping including mountable kerb along service road
3. Yellow no stopping lines or "no parking signs"
4. Low profile speed hump in line with separators at driveways. Refer section 4.3.1 for further details

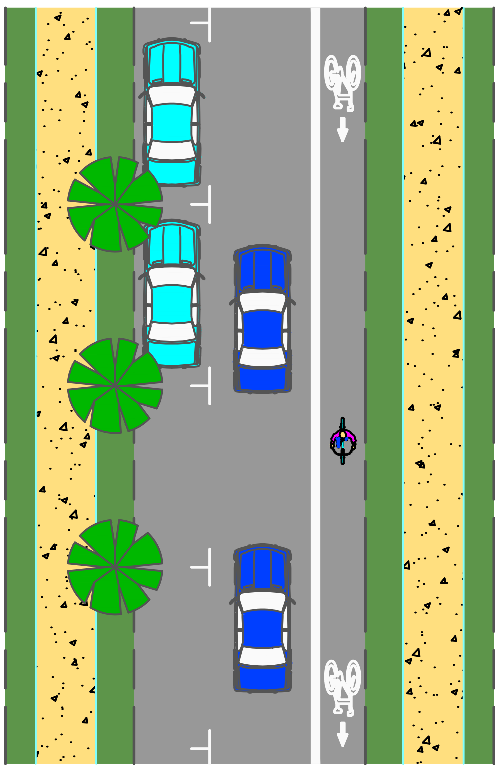
Refer to section 3.4 for further information.

LEGEND

- Asphalt
- Concrete footpath
- Concrete median
- Concrete at road level
- Landscaping/grass
- Low profile speed hump

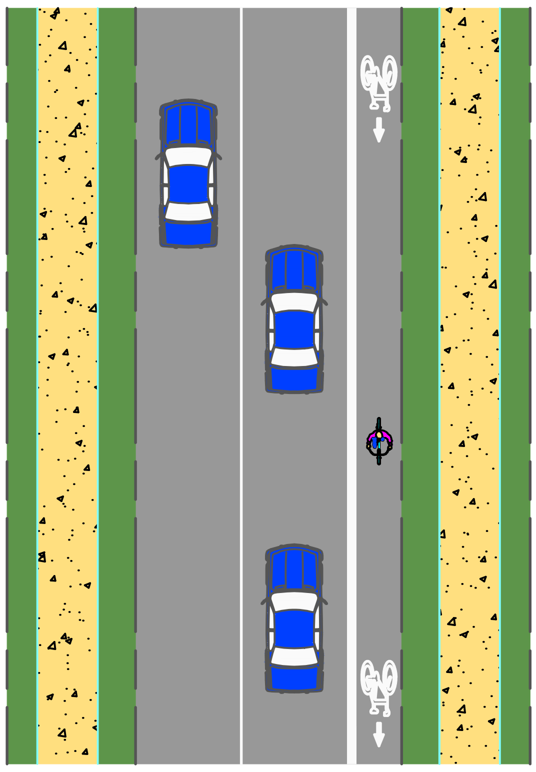
GREENFIELD CYCLE TRACKS ON ARTERIAL ROADS

FIGURE	B1.02	VERSION	04
DATE	06/06/2019	SCALE	1:200 @ A3



Contra-flow bicycle lane with linemarking only on right hand side of the road (preferred)

LTS3



Contra-flow bicycle lane with minor separation on right hand side of the road

LTS3

Notes:

- Refer Section 3.2.3 for further information.

Legend

Footpath (concrete)

Turf buffer strip

Level of Traffic Stress (LTS) Classification

LTS1 Feels safe for most children and adults. Separation except in low speed/low volume traffic.

LTS2 Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.

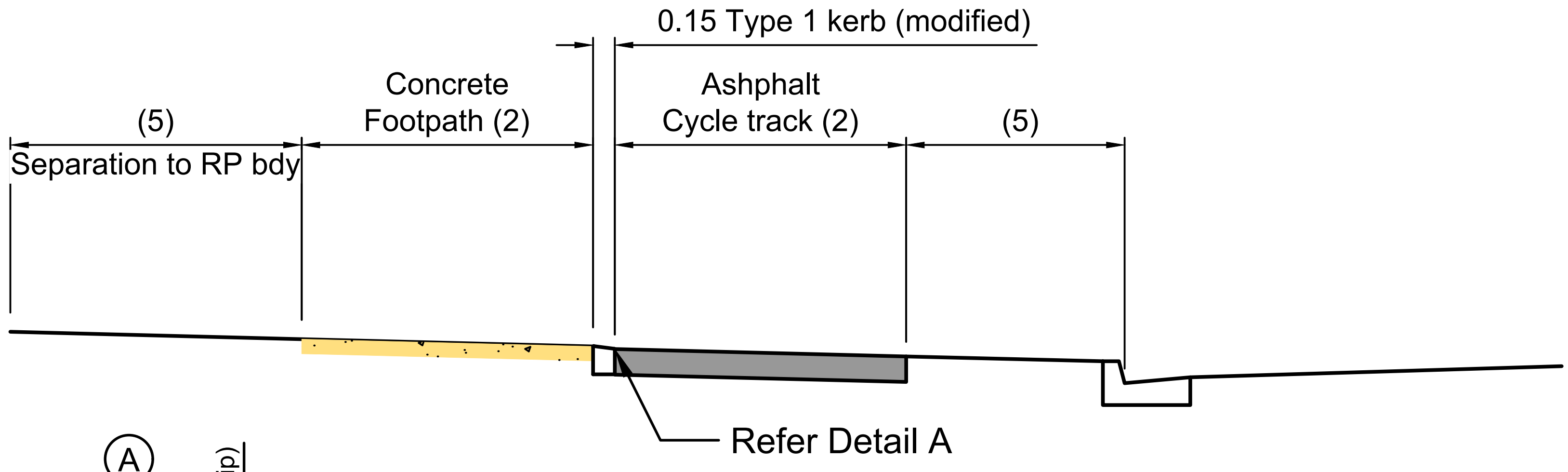
LTS3 Adequate for confident experienced riders with recognised safety risks. or with poor directness.

LTS4 Uncomfortable for most people, significant safety risks.

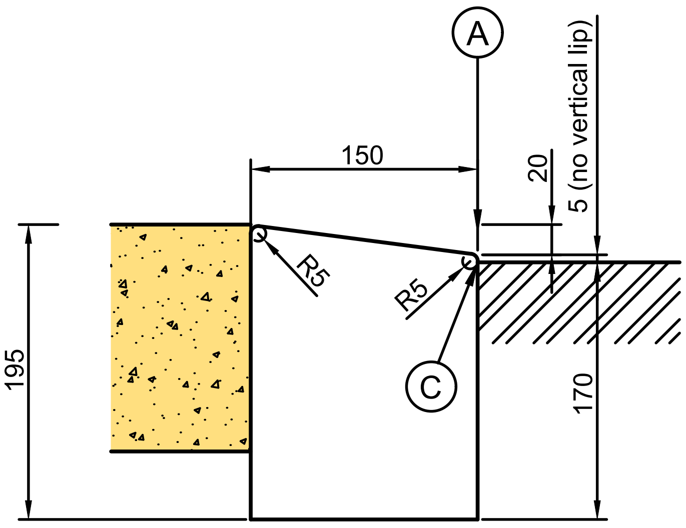
D:\Documents\ACCLARO\TMR Drawings\Revised June 2019\Figure B1.03 Rev 03.dwg

CONTRA-FLOW CYCLE TRACKS ON 1-WAY ROAD EXAMPLES

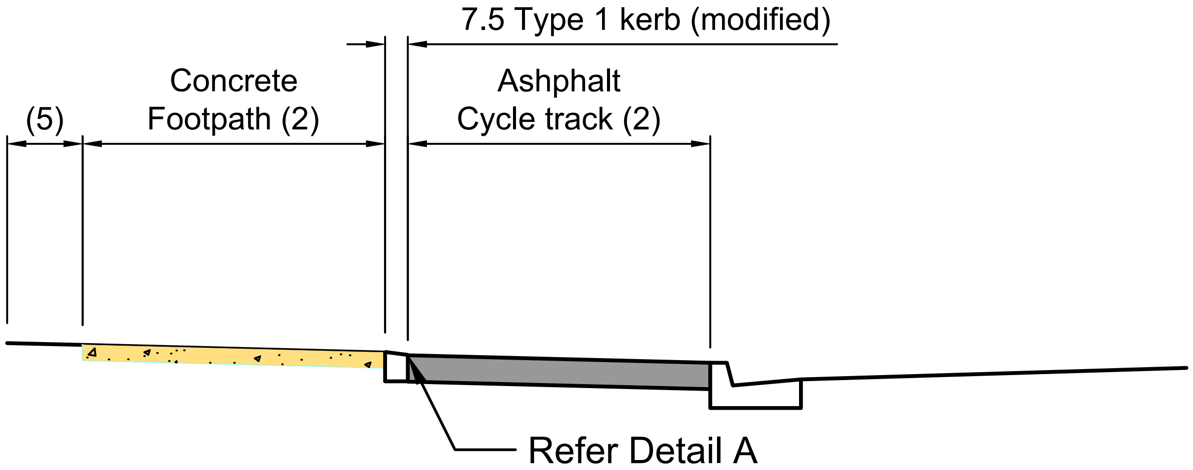
FIGURE B1.03 | 03



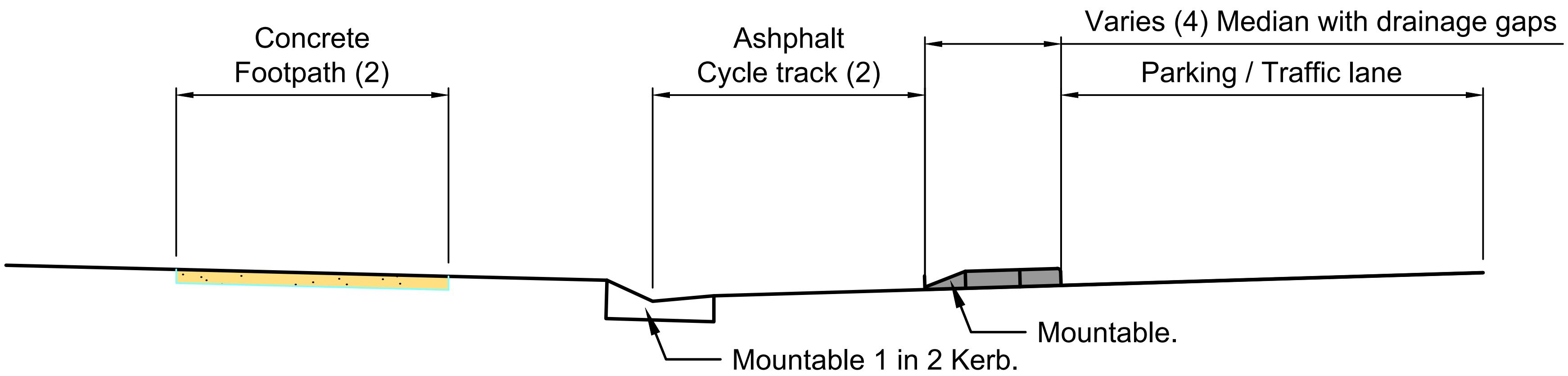
Dual kerb cycle track



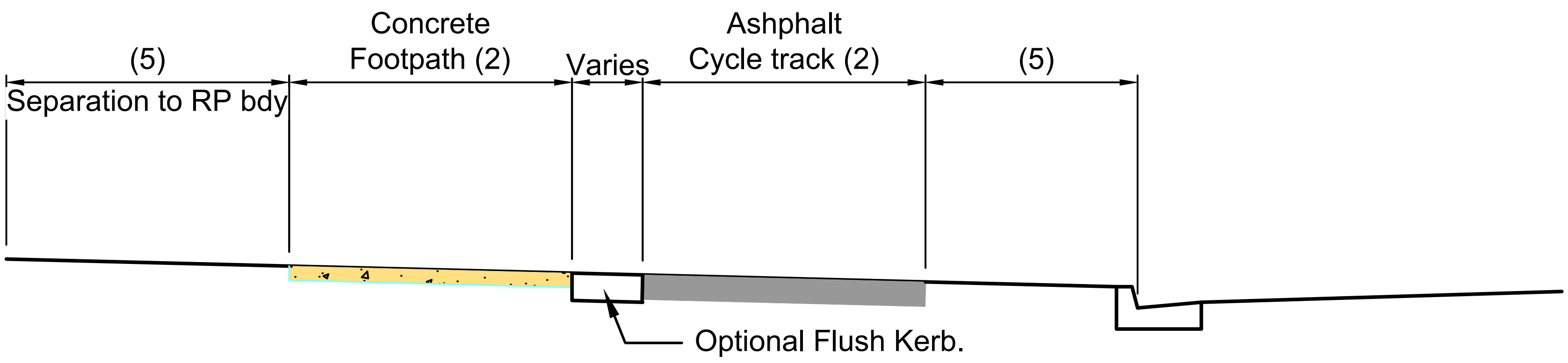
Detail A:
Mountable Kerb
Modified version of
TMR Standard Drawing
1033 Kerb Type 1



Dual kerb cycle track (constrained corridors with no parking or residential frontage)



Median separated cycle track (Preferred)



Footpath level cycle track

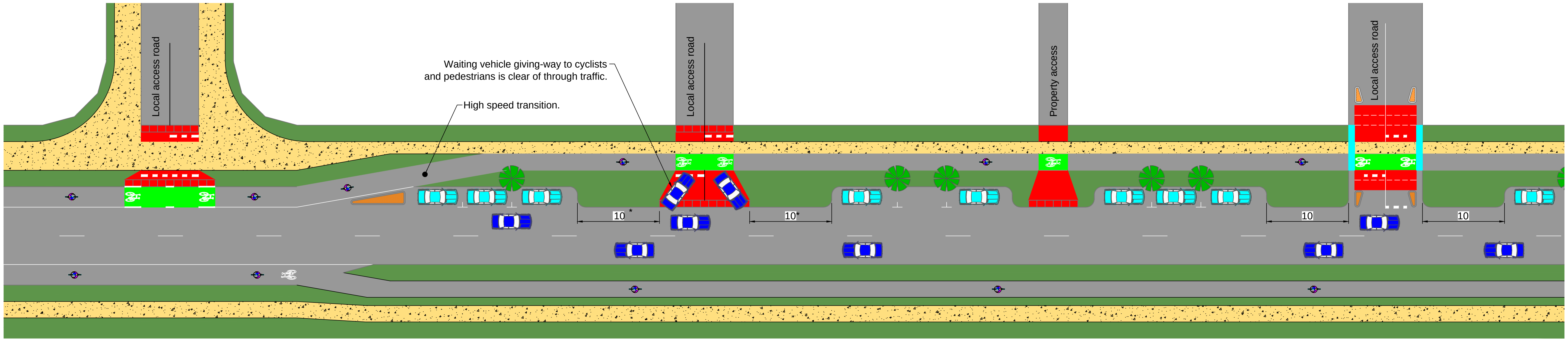
Notes:

1. Refer Section 3.4.4 for further information.
2. One-way cycle track refer Table 2. Two-way cycle track refer Table 3.
3. 1.5m allows for:
- 0.6m clearance from the bus / traffic lane to power poles, street lights, road furniture;
- 0.5m clearance from the cycle track to power poles, street lights, road furniture; and
- Storage for wheelie bins.
4. 0.4 minimum
- Clearance for parked cars to open doors; Refer B1.01 A12.4 and B1.01 B12.4 for location of gaps where car doors open.
- Space for passengers to exit parked cars; and
- Storage for wheelie bins. Designate "Bin Zone" where separator is <600mm, show with dashed line. Refer B1.01 A.11.0 Note 4
- See Fig B1.05 for retrofit planter separator.
5. Refer to Austroads for required widths.
6. Consider pedestrian desire lines and adjust kerb as required.

C:\Users\user\AppData\Local\Temp\AcPublish_8096\Figure B1.04 Rev 04.dwg

CYCLE TRACK CROSS SECTIONS

FIGURE B1.04	04

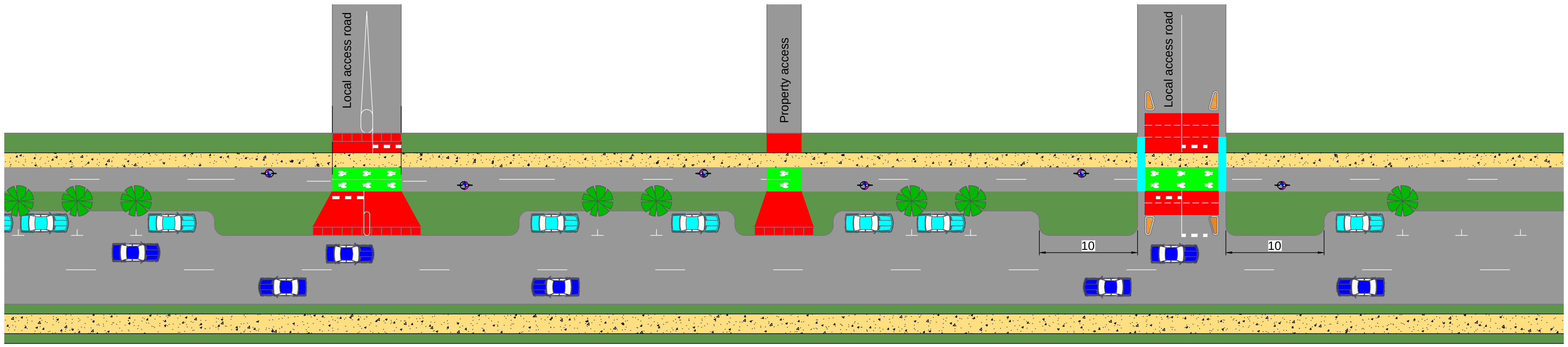


Bicycle lane and footpath

One-way cycle track and footpath

One-way cycle track and footpath
at Property Access

One-way cycle track and footpath
with drainage grate
(Refer Figure B2.03 for Road Hump Details)



Two-way cycle track and footpath

Two-way cycle track and footpath
at Property Access

Two-way cycle track and footpath
with drainage grate
(Refer Figure B2.03 for Road Hump Details)

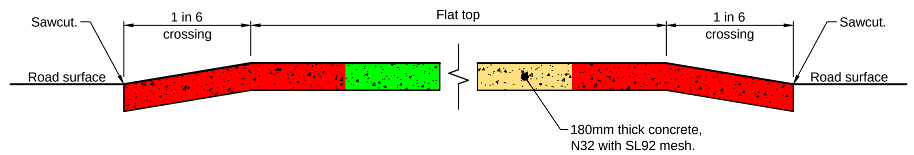
Notes:
- Refer Section 4.3 for further information.

* review to meet required sight distance for specifci site

Purpose
- Design with clear priority and no confusion for any road user with use of Give Way signs and linemarking.

Function
- Urban area intersection of collector and local access road / property access.

Considerations
- Safe design outcome, safe speed at conflict points resulting in lower severity crashes, clear priority.
- Direct and attractive for bicycle traffic and pedestrians.
- Both the cycle track and footpath should be continued at grade across the local access road and property access to clearly delineate priority, maintain cyclist comfort, and improve constructability and maintenance.
- Cycle track to be constructed in smooth AC.
- Footpath to be constructed in contrasting surface to cycle track.



Ramped vehicular crossing profile

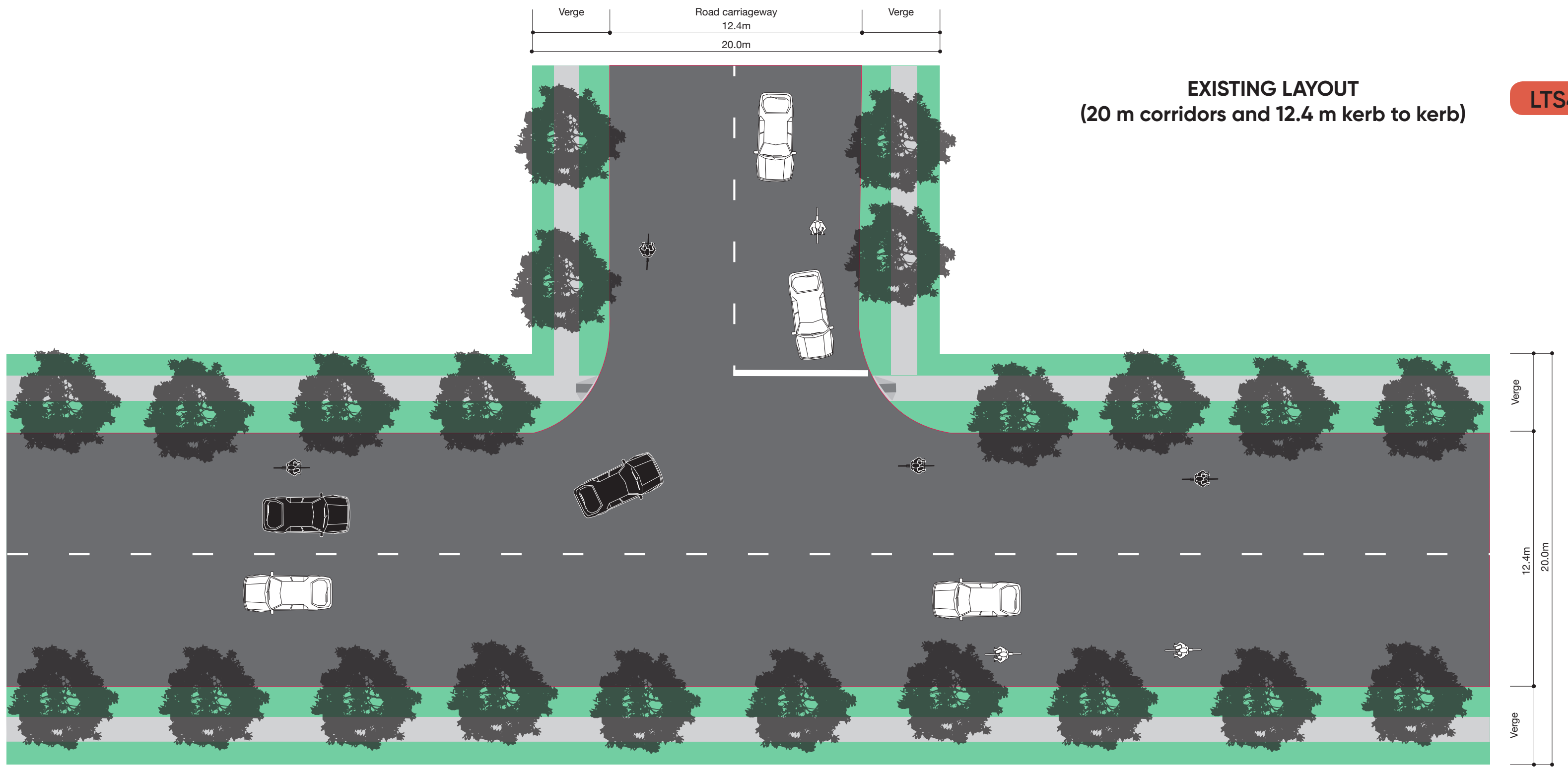
Legend
- Cycle track (AC)
- Footpath
- Turf
- Cycle crossing, green
- Raised platform, red
- 1 in 6 Ramped vehicular crossing (Entrance width determined by design vehicle)

PRIORITY CROSSINGS AT SIDE ROADS

FIGURE B2.01	04

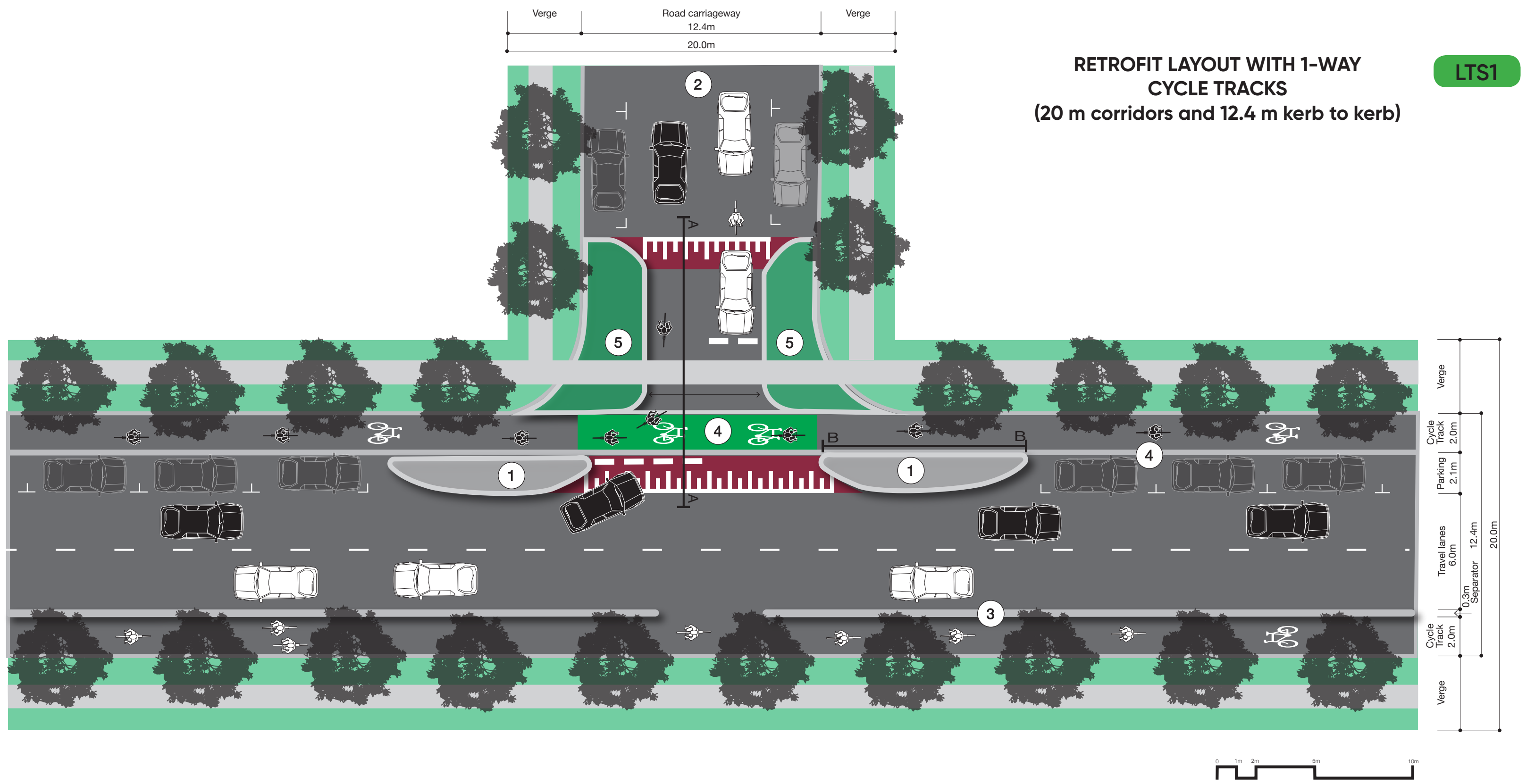
EXISTING LAYOUT
(20 m corridors and 12.4 m kerb to kerb)

LTS4



RETROFIT LAYOUT WITH 1-WAY CYCLE TRACKS
(20 m corridors and 12.4 m kerb to kerb)

LTS1



LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

- **LTS1** Feels safe for most children and adults. Separation except in low speed/low volume traffic.
- **LTS2** Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
- **LTS3** Adequate for confident experienced riders with recognised safety risks, or with poor directness.
- **LTS4** Uncomfortable for most people, significant safety risks.

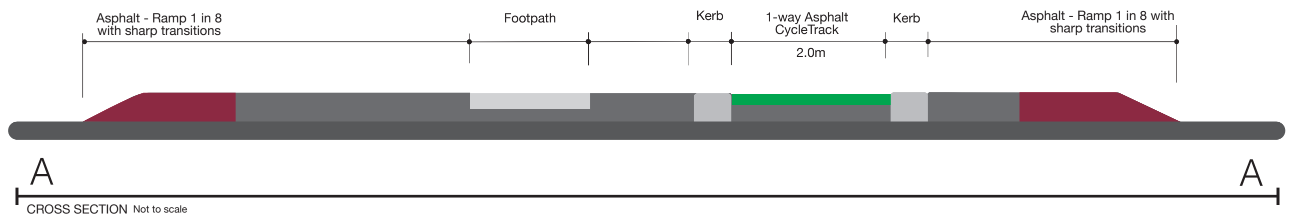
NOTES

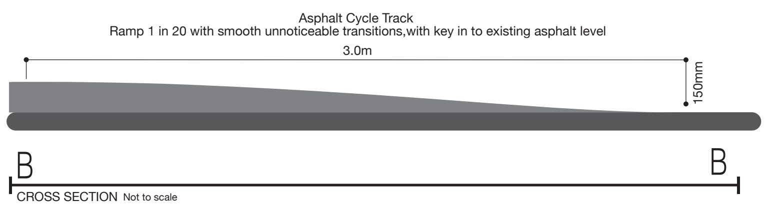
1. 2.1m wide x 10m long median separator with no landscaping
2. Local access street 5.5m width
3. Median separator or painted bike lane with yellow no stopping line with 400mm planter box option
4. Continuing kerb parallel to cycle track
5. Water Sensitive Urban Design (WSUD) opportunity

Refer to section 4.3 for further information

LEGEND

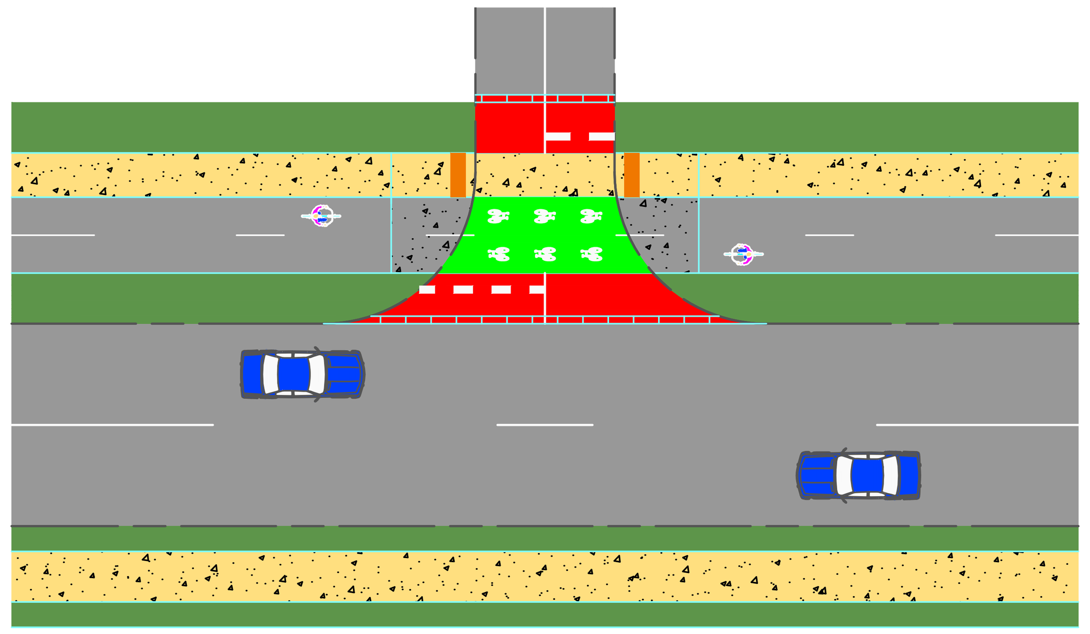
- Asphalt
- Footpath
- Concrete median
- Concrete at road level
- Landscaping/grass





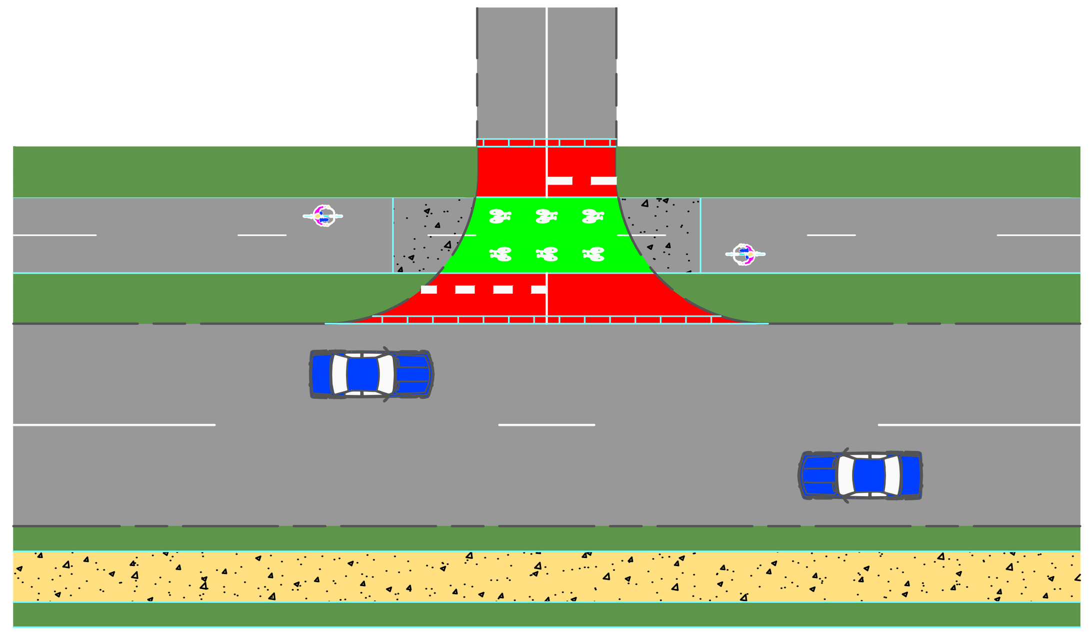
EXAMPLE RETROFIT COLLECTOR ROAD 1-WAY CYCLE TRACK CONTINUING AT LOCAL STREET INTERSECTIONS

FIGURE	B2.01A	VERSION	02	15
DATE	06/06/2019	SCALE	1:350 @ A3	

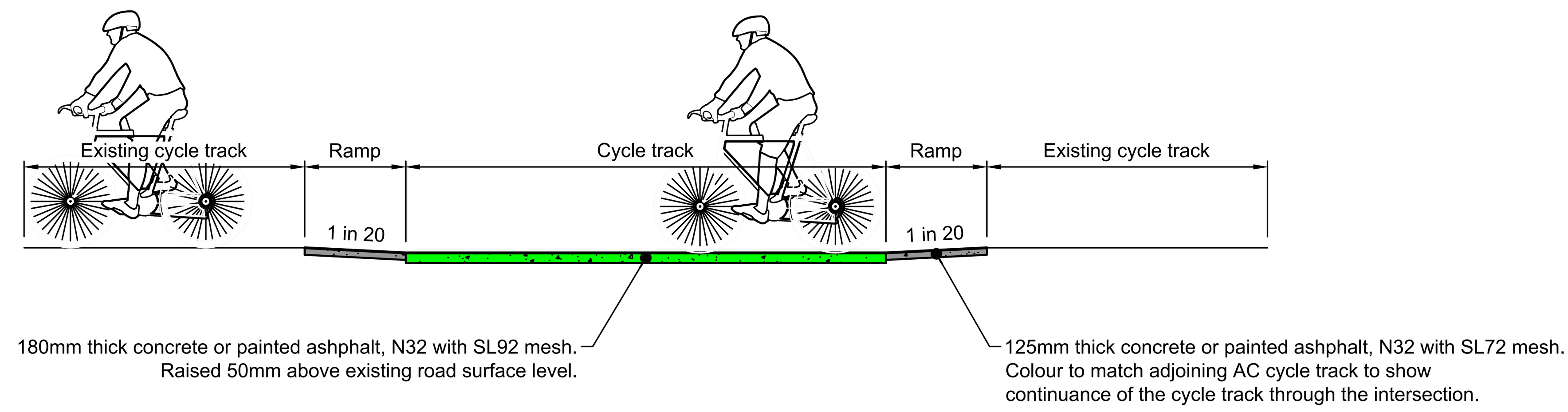


Two-way cycle track and footpath at side road

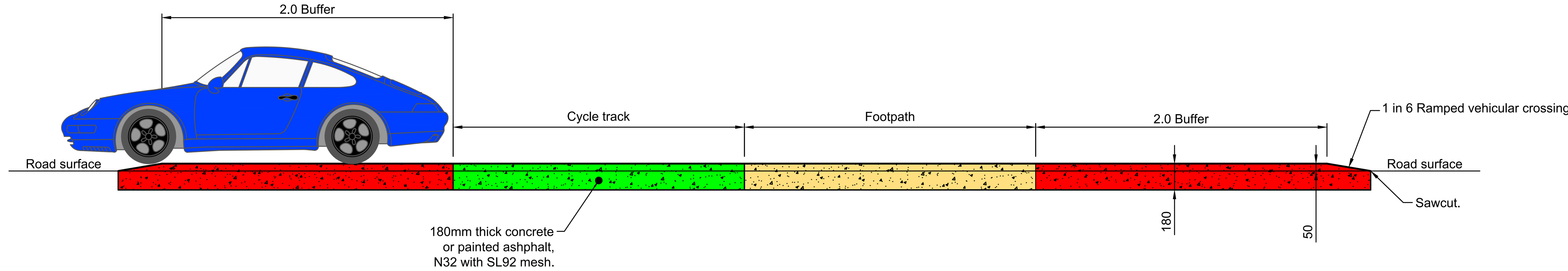
(Refer below for details)



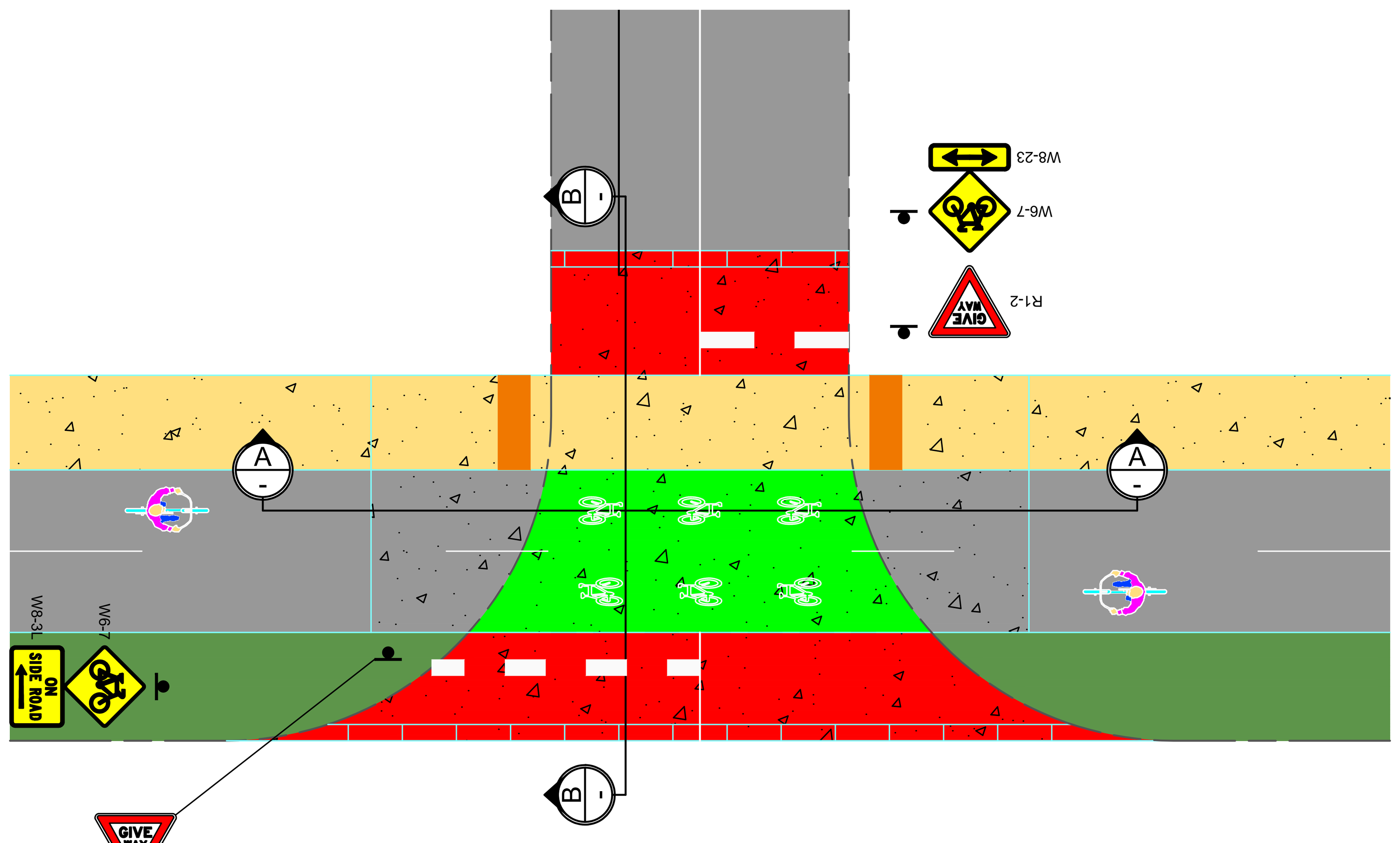
Two-way cycle track at side road



Section A-A: Cycle track profile



Section B-B: Road hump profile



Two-way cycle track and footpath crossing details

Notes:

- Refer Section 4.3 for further information.

Legend

- Cycle track (AC)
- Footpath / shared path
- Tactile Ground Surface Indicator
- Turf
- Cycle crossing, green
- Raised platform, red
- 1 in 6 Ramped vehicular crossing

RETROFIT CONCRETE PRIORITY CROSSINGS AT SIDE ROADS

FIGURE B2.02 | 04

C:\Users\user\AppData\Local\Temp\AcPublish_13848\Figure B2.02 Rev 04.dwg

Purpose
- Achieve homogeneous speeds for all road users (<30kmh).
- Design with clear priority and no confusion for any road user.

Function
- Urban area intersection of Collector Road and Local Access "mixed-use" street.

Considerations
- Safe design outcome, fewer conflict points than regular give-way intersection, safe speed at conflict points resulting in lower severity crashes, clear priority.
- Relatively high capacity.
- Direct and attractive for bicycle traffic.
- Two-way bicycle facility at roundabouts is not recommended due to crashes caused by cyclists approaching from unexpected direction.
- Design vehicles (8.8m service vehicle) must negotiate at low speeds (<30kmh) driving over the centre island apron.

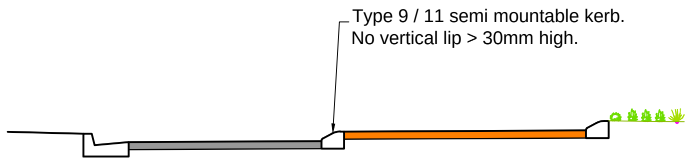
Notes:
1. "Mixed-use" suitable for low volume, low speed, local streets only.
2. Cycle track and footpath to be at road level, i.e. no kerb ramps.
3. Refer Figure B3.02 for all other details.
4. Refer Section 4.4 for further information.

Legend

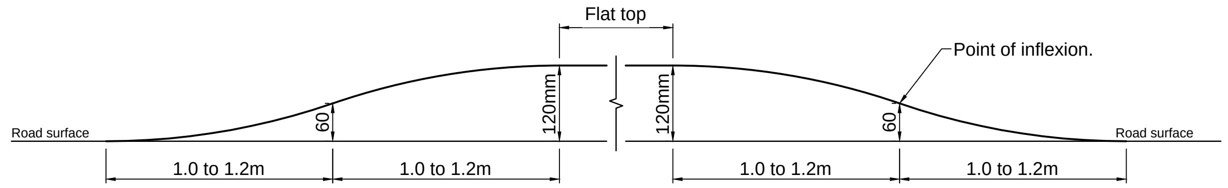
Grey	Cycle track (Ashphalt)
Sand	Footpath (concrete)
Dark green	Turf
Bright green	Green pavement treatment
Hatched	Median
Orange	Apron / encroachment area
Red	Raised platform / threshold treatment

ONE-WAY CYCLE TRACK AT SINGLE LANE ROUNDABOUT
WITH TRANSITIONS AND LOCAL ACCESS OPTION

FIGURE B3.01 | 03

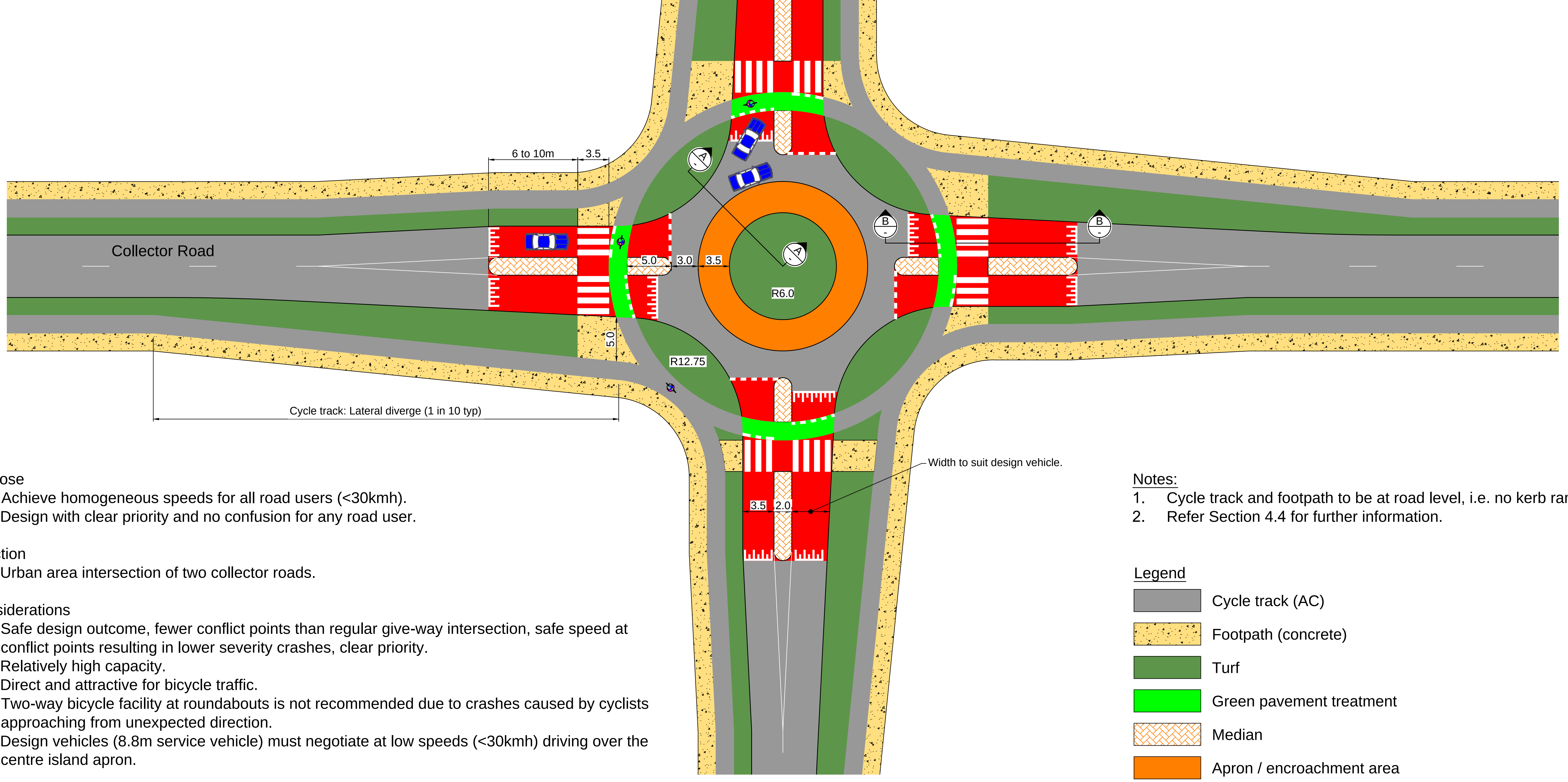


Section A-A: Apron profile



Section B-B: Sinusoidal raised platform profile

Not to scale



Purpose

- Achieve homogeneous speeds for all road users (<30kmh).
- Design with clear priority and no confusion for any road user.

Function

- Urban area intersection of two collector roads.

Considerations

- Safe design outcome, fewer conflict points than regular give-way intersection, safe speed at conflict points resulting in lower severity crashes, clear priority.
- Relatively high capacity.
- Direct and attractive for bicycle traffic.
- Two-way bicycle facility at roundabouts is not recommended due to crashes caused by cyclists approaching from unexpected direction.
- Design vehicles (8.8m service vehicle) must negotiate at low speeds (<30kmh) driving over the centre island apron.

Notes:

1. Cycle track and footpath to be at road level, i.e. no kerb ramps.
2. Refer Section 4.4 for further information.

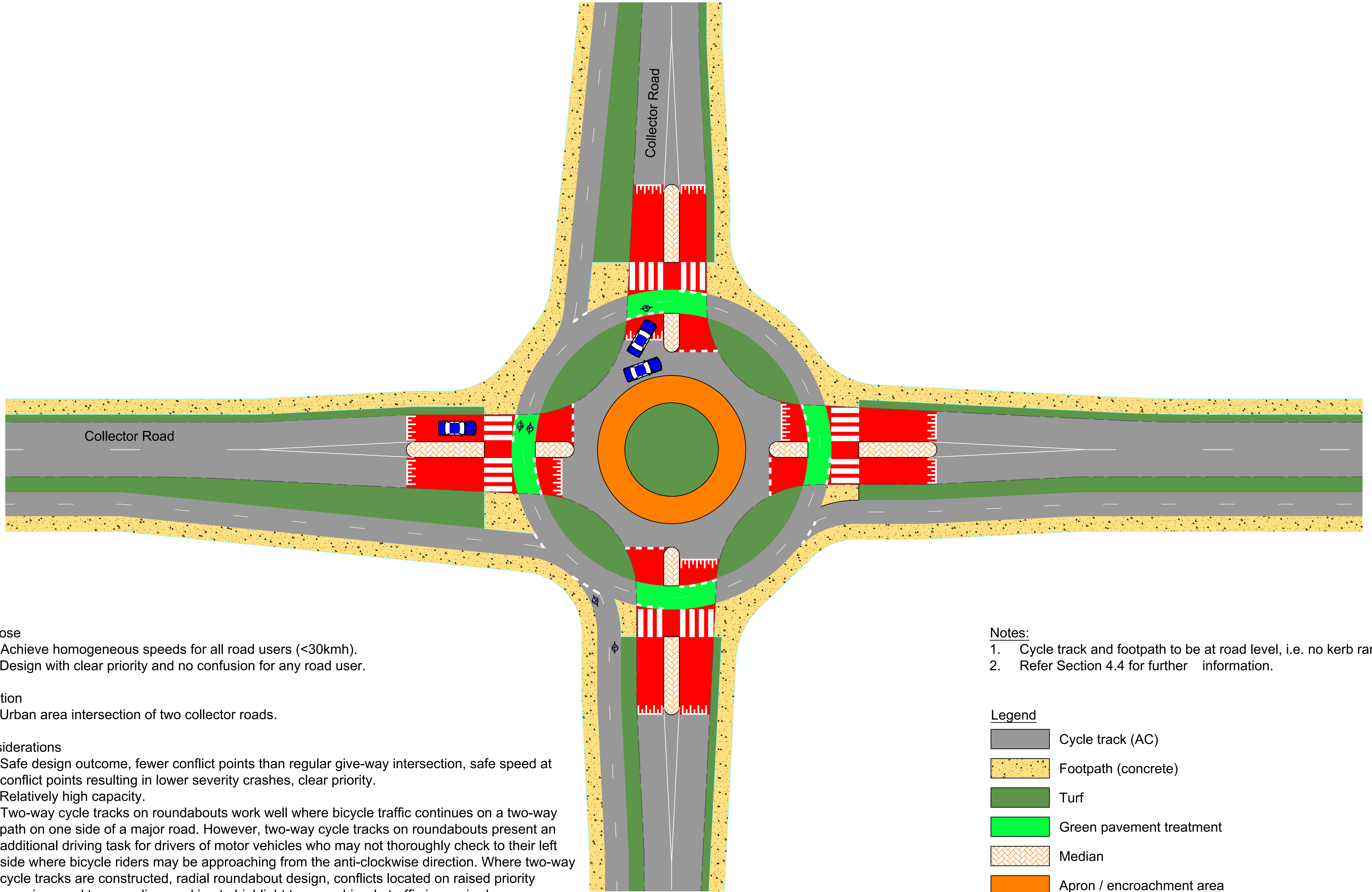
Legend

- Cycle track (AC)
- Footpath (concrete)
- Turf
- Green pavement treatment
- Median
- Apron / encroachment area
- Raised platform / threshold treatment

ONE-WAY CYCLE TRACK AT SINGLE LANE ROUNDABOUT
AT COLLECTOR ROADS

FIGURE B3.02 | A

G:\WHRF-Projects\Cycleways\Separated Cycleways Drawings\October 2014\Figure B3.02 Rev 02.dwg



Purpose
- Achieve homogeneous speeds for all road users (<30kmh).
- Design with clear priority and no confusion for any road user.

Function
- Urban area intersection of two collector roads.

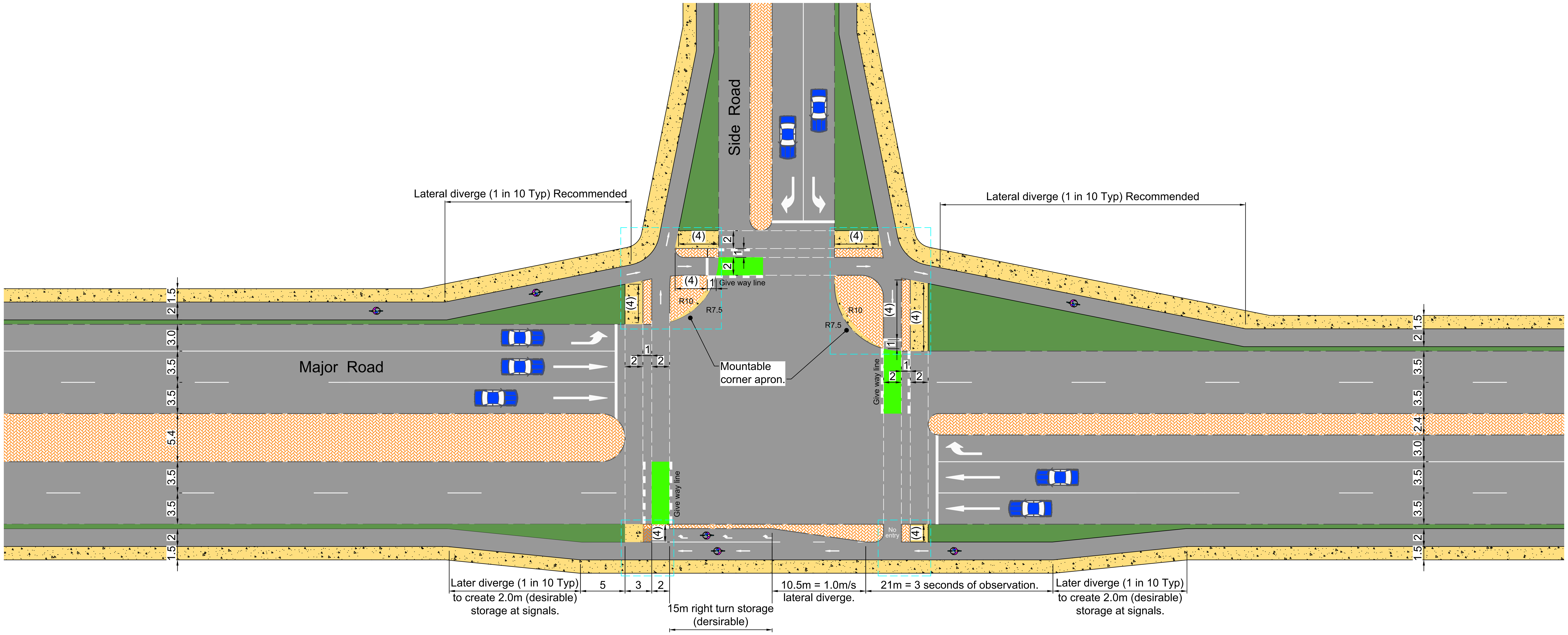
Considerations
- Safe design outcome, fewer conflict points than regular give-way intersection, safe speed at conflict points resulting in lower severity crashes, clear priority.
- Relatively high capacity.
- Two-way cycle tracks on roundabouts work well where bicycle traffic continues on a two-way path on one side of a major road. However, two-way cycle tracks on roundabouts present an additional driving task for drivers of motor vehicles who may not thoroughly check to their left side where bicycle riders may be approaching from the anti-clockwise direction. Where two-way cycle tracks are constructed, radial roundabout design, conflicts located on raised priority crossings and two-way line-marking to highlight two-way bicycle traffic is required.
- Direct and attractive for bicycle traffic.
- Design vehicles (8.8m service vehicle) must negotiate at low speeds (<30kmh) driving over the centre island apron.

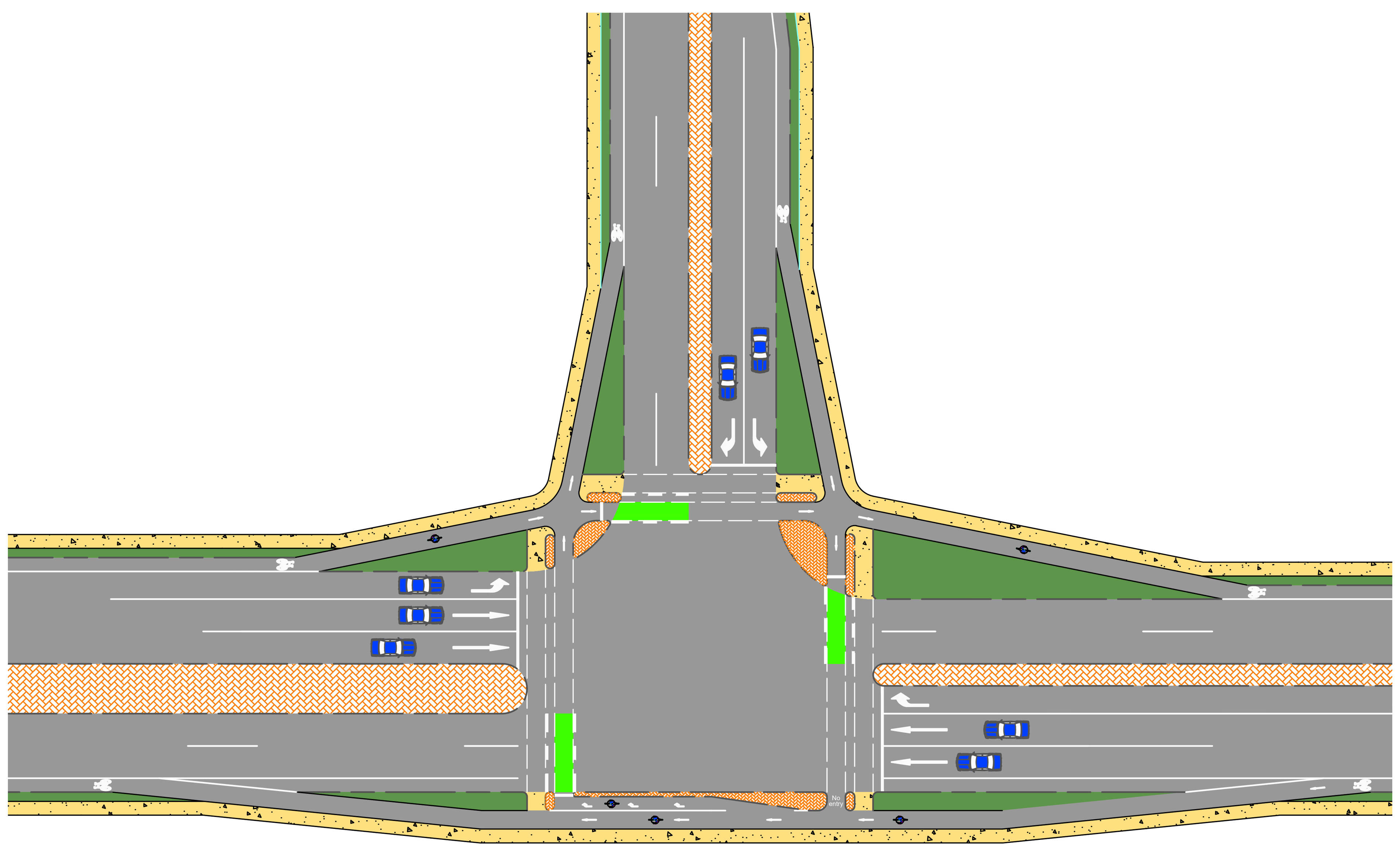
Notes:
1. Cycle track and footpath to be at road level, i.e. no kerb ramps.
2. Refer Section 4.4 for further information.

Legend
- Cycle track (AC)
- Footpath (concrete)
- Turf
- Green pavement treatment
- Median
- Apron / encroachment area
- Raised platform / threshold treatment

TWO-WAY CYCLE TRACK AT SINGLE LANE ROUNDABOUT
AT COLLECTOR ROADS

FIGURE B3.03 | 03





Bicycle lane transition to cycle track

Purpose

- Design with clear priority and no confusion for any road user.

Function

- Urban area intersection of arterial or collector roads.

Considerations

- Safe design outcome, fewer conflict points than regular give-way intersection, safe speed at conflict points resulting in lower severity crashes, clear priority.
- Direct and attractive for bicycle traffic.
- Cycle track at intersection can transition from / to on-road bicycle lane if required as shown.
- Signal phasing (including advanced detection) to ensure safety and priority for cyclists.
- Each corner of the intersection (area within blue dashed line) is constructed at-grade with adjacent roadway, the cross-fall towards roadway to prevent ponding.

Notes:

1. No filtering of turning movements across two-way cycle tracks.
2. Cycle track and footpath to be at road level, i.e. no kerb ramps.
3. Refer Section 4.5 for further information.
4. Refer to Austroads for required width.

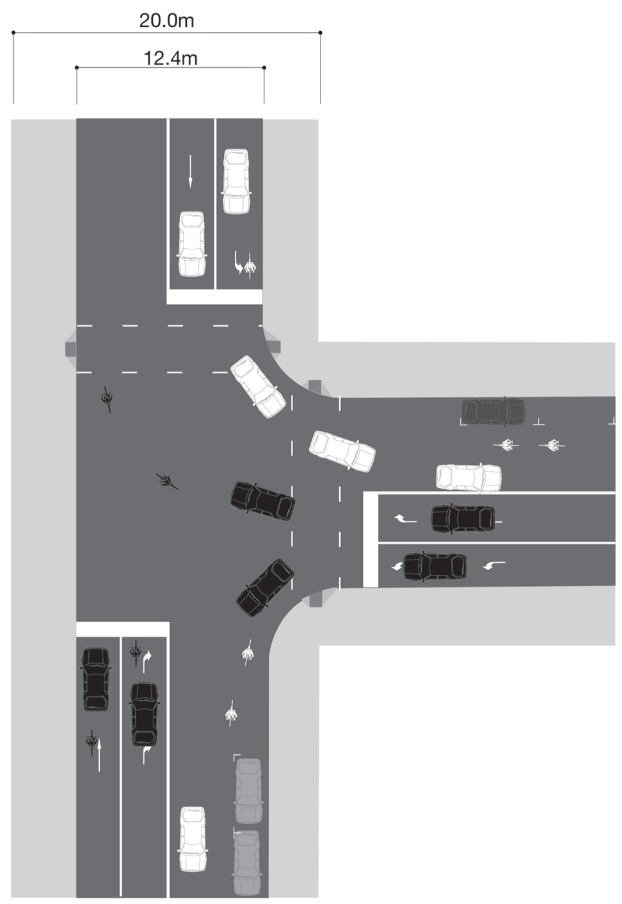
Legend

- Cycle track (Ashphalt)
- Footpath (concrete)
- Green pavement teatment
- Turf
- Median / Traffic island
- Mountable corner apron (concrete)

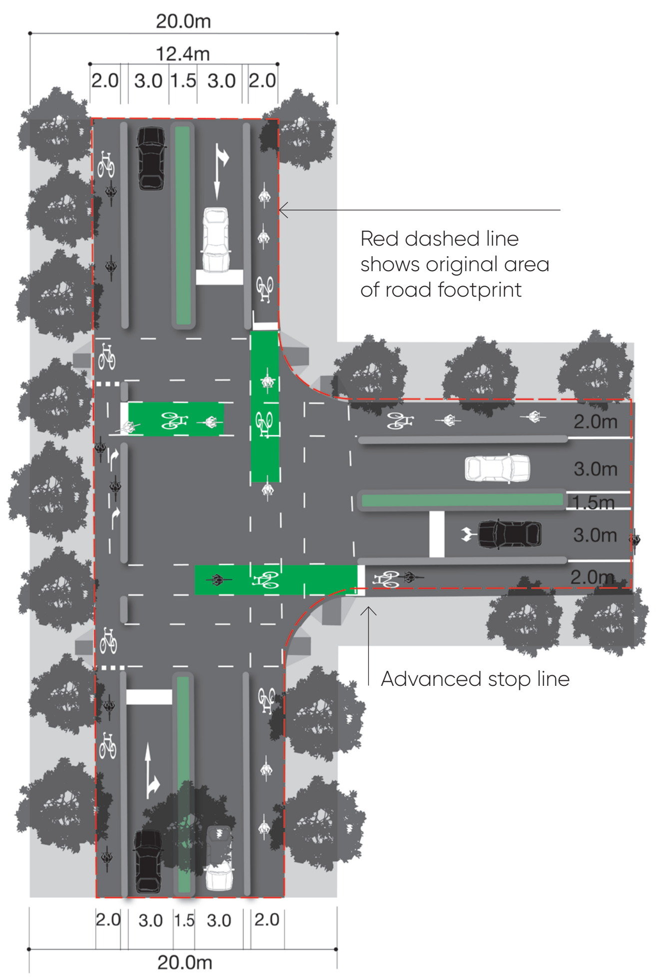
ONE-WAY CYCLE TRACK AT SIGNALISED T-INTERSECTION

FIGURE B4.01 | 04

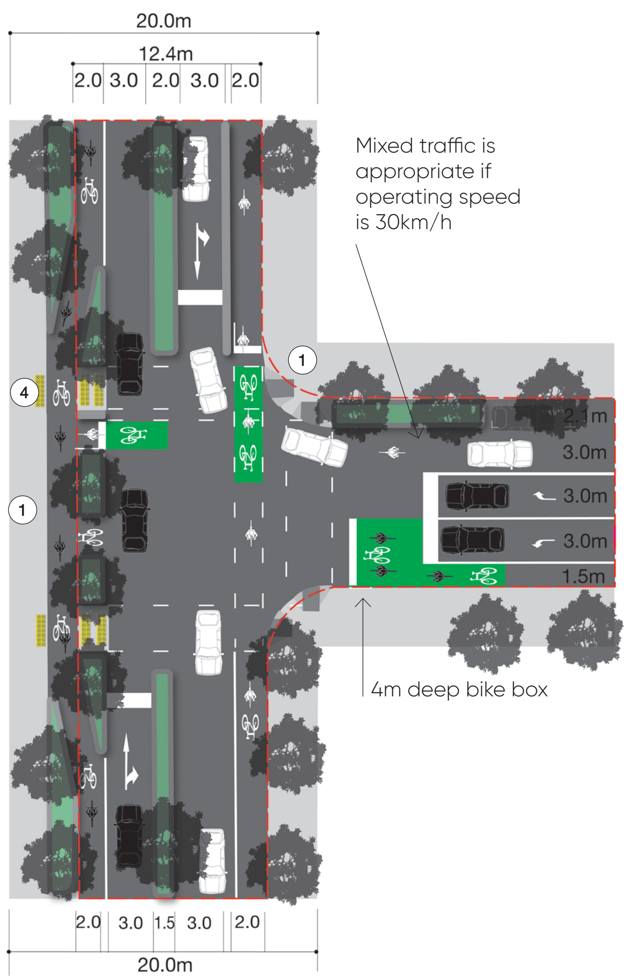
C:\Users\user\AppData\Local\Temp\AcPublish_20268\Figure B4.01 & B4.04 Rev 04.dwg



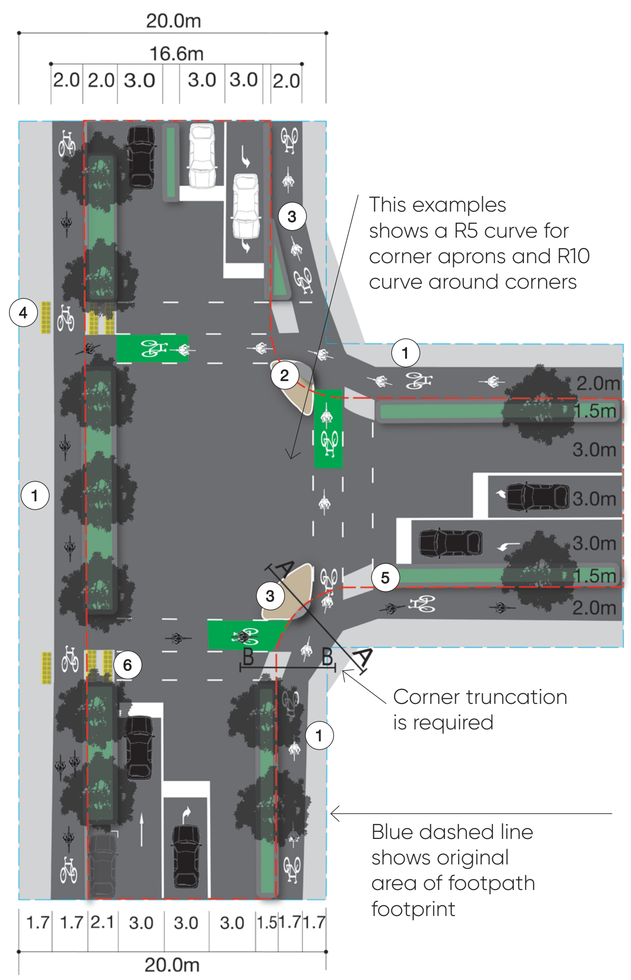
EXISTING LAYOUT
(20 m corridors and 12.4 m kerb to kerb) LTS4



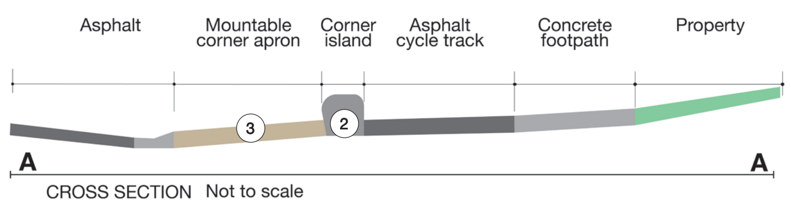
RETROFIT ADVANCE STOP LINES AND CYCLE TRACK ON APPROACHES
(no kerb changes) LTS2

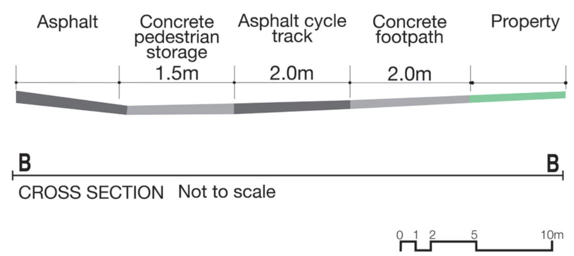


RETROFIT PARTIAL PROTECTED INTERSECTION
(some kerb changes, bike box on minor road) LTS2



RETROFIT PROTECTED INTERSECTION
(kerb changes and corner truncation) LTS1





LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

- **LTS1** Feels safe for most children and adults. Separation except in low speed/low volume traffic.
- **LTS2** Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
- **LTS3** Adequate for confident experienced riders with recognised safety risks, or with poor directness.
- **LTS4** Uncomfortable for most people, significant safety risks.

NOTES

1. This section is constructed at-grade with adjacent roadway, the cross-fall towards roadway to prevent ponding
2. Corner islands are 150mm above pavement
3. Mountable corner apron design based on normal vehicle turn path. See B3.02 Apron detail in section AA
4. Tactile Ground Surface Indicators (TGSI)
5. TGSI can be staggered to fit small storage areas, refer AS1428.4.1
6. Where pedestrian storage is space is less than 2100mm, locate a 600mm deep strip of warning TGSIs 300mm back from road on concrete at road level

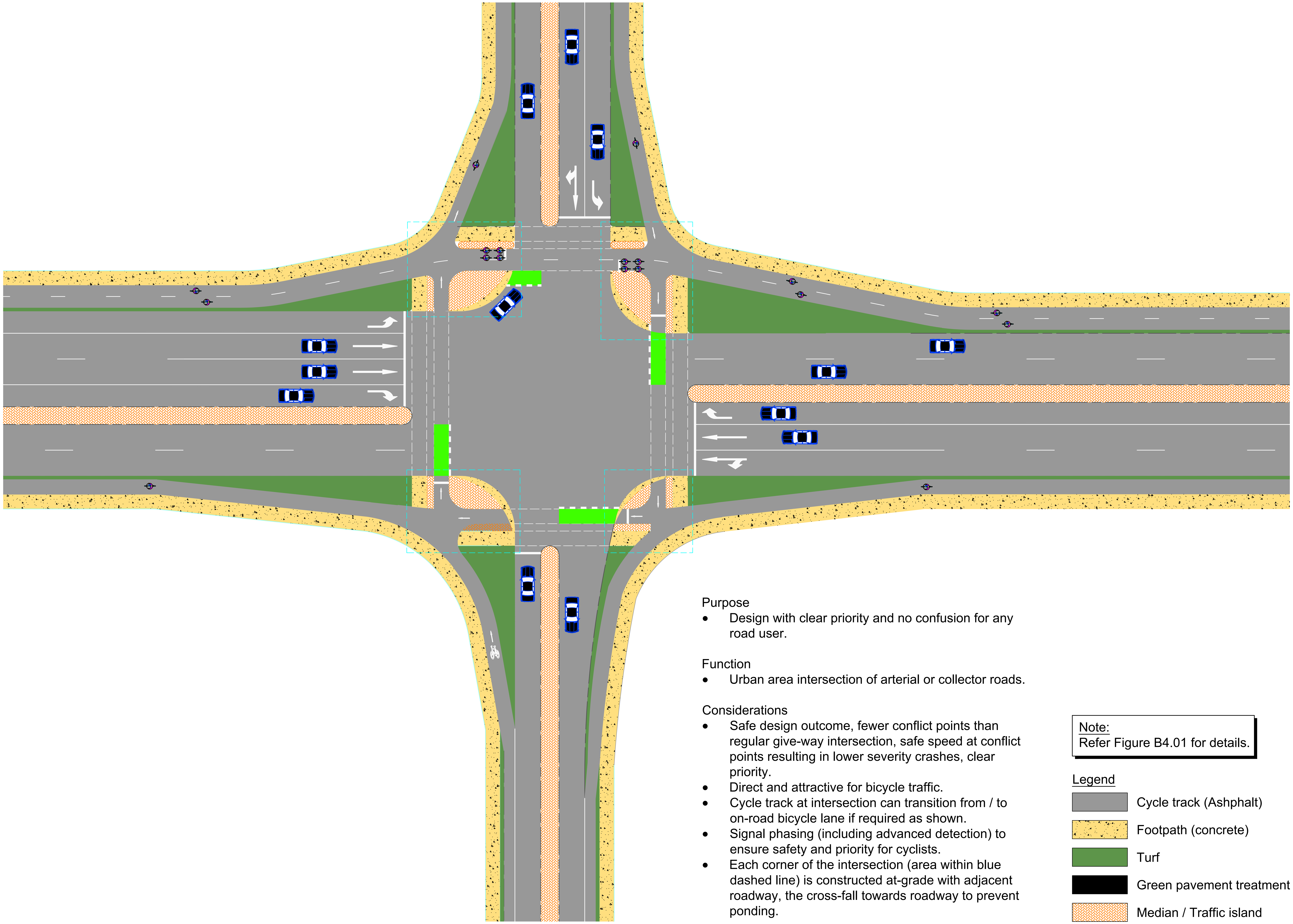
Refer to section 4.5 for further information.

LEGEND

- Asphalt
- Footpath
- Concrete median
- Concrete at road level
- Landscaping/grass

EXAMPLE RETROFIT OPTIONS FOR SIGNALISED INTERSECTIONS

FIGURE	B4.01A	VERSION	02	26
DATE	06/06/2019	SCALE	1:500 @ A3	



Purpose
- Design with clear priority and no confusion for any road user.

Function
- Urban area intersection of arterial or collector roads.

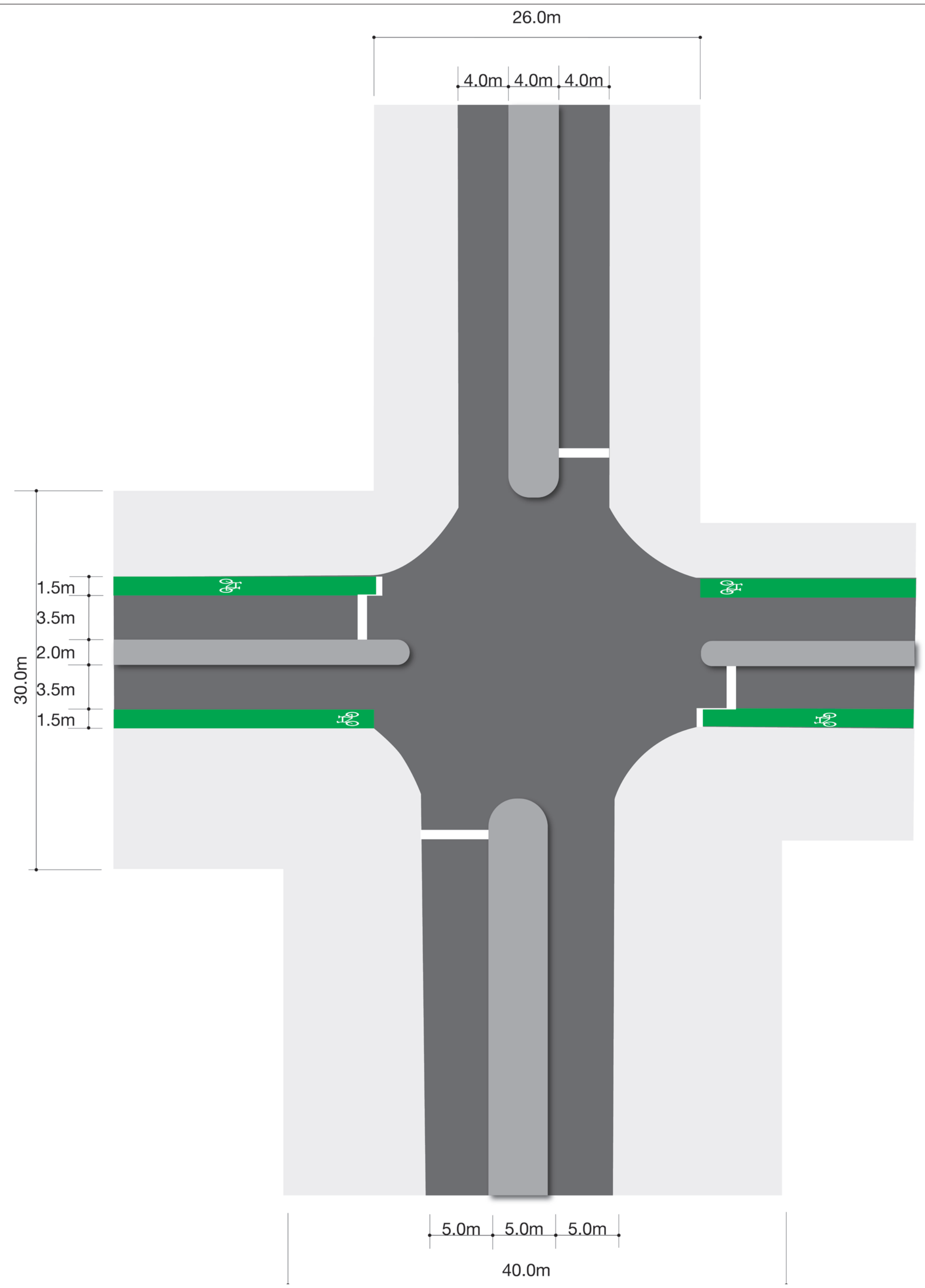
Considerations
- Safe design outcome, fewer conflict points than regular give-way intersection, safe speed at conflict points resulting in lower severity crashes, clear priority.
- Direct and attractive for bicycle traffic.
- Cycle track at intersection can transition from / to on-road bicycle lane if required as shown.
- Signal phasing (including advanced detection) to ensure safety and priority for cyclists.
- Each corner of the intersection (area within blue dashed line) is constructed at-grade with adjacent roadway, the cross-fall towards roadway to prevent ponding.

Note:
Refer Figure B4.01 for details.

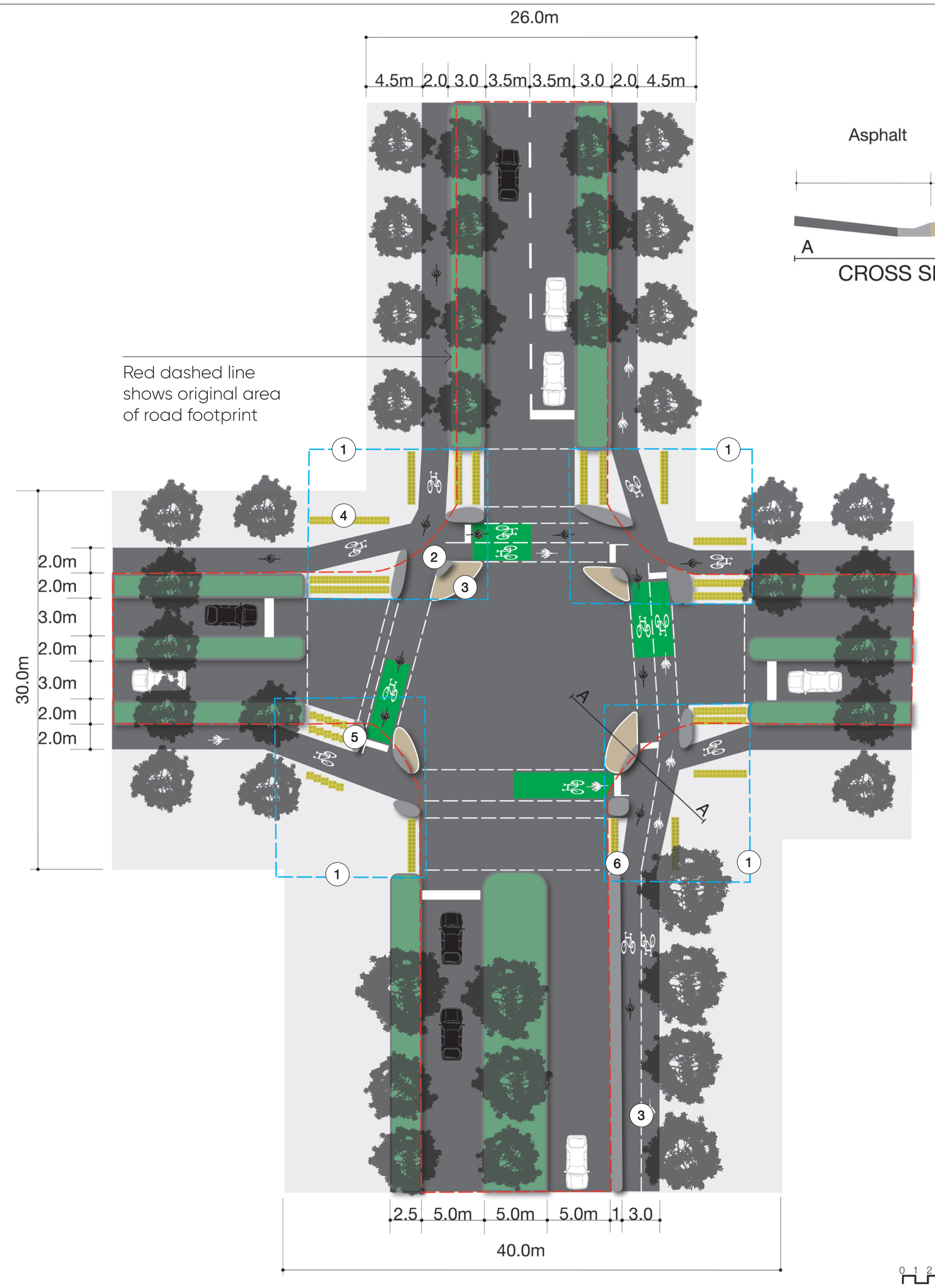
Legend
- Cycle track (Ashphalt)
- Footpath (concrete)
- Turf
- Green pavement treatment
- Median / Traffic island
- Mountable Corner Apron (concrete)

SIGNALISED 4-WAY INTERSECTION WITH
ONE-WAY AND TWO-WAY CYCLE TRACKS

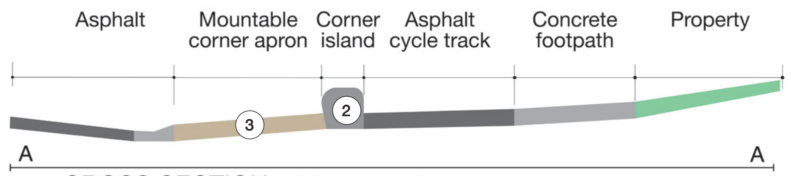
FIGURE B4.02 | 04



EXISTING SIGNALISED INTERSECTION LTS4



RETROFIT SIGNALISED INTERSECTION LTS1



CROSS SECTION Not to scale

LEVEL OF TRAFFIC STRESS (LTS) CLASSIFICATION

- **LTS1** Feels safe for most children and adults. Separation except in low speed/low volume traffic.
- **LTS2** Feels safe for most adults. Continuing bicycle space separated at high speed/high volume traffic.
- **LTS3** Adequate for confident experienced riders with recognised safety risks, or with poor directness.
- **LTS4** Uncomfortable for most people, significant safety risks.

NOTES

1. Each corner of the intersection (area within blue dashed line) is constructed at-grade with adjacent roadway, the cross-fall towards roadway to prevent ponding
2. Corner islands are 150mm above pavement
3. Mountable corner apron design based on normal vehicle turn path. See B3.02 Apron detail in section AA
4. Tactile Ground Surface Indicators (TGSI)
5. TGSI can be staggered to fit small storage areas, refer AS1428.4.1
6. Where pedestrian storage is space is less than 2100mm, locate a 600mm deep strip of warning TGSIs 300mm back from road on concrete at road level

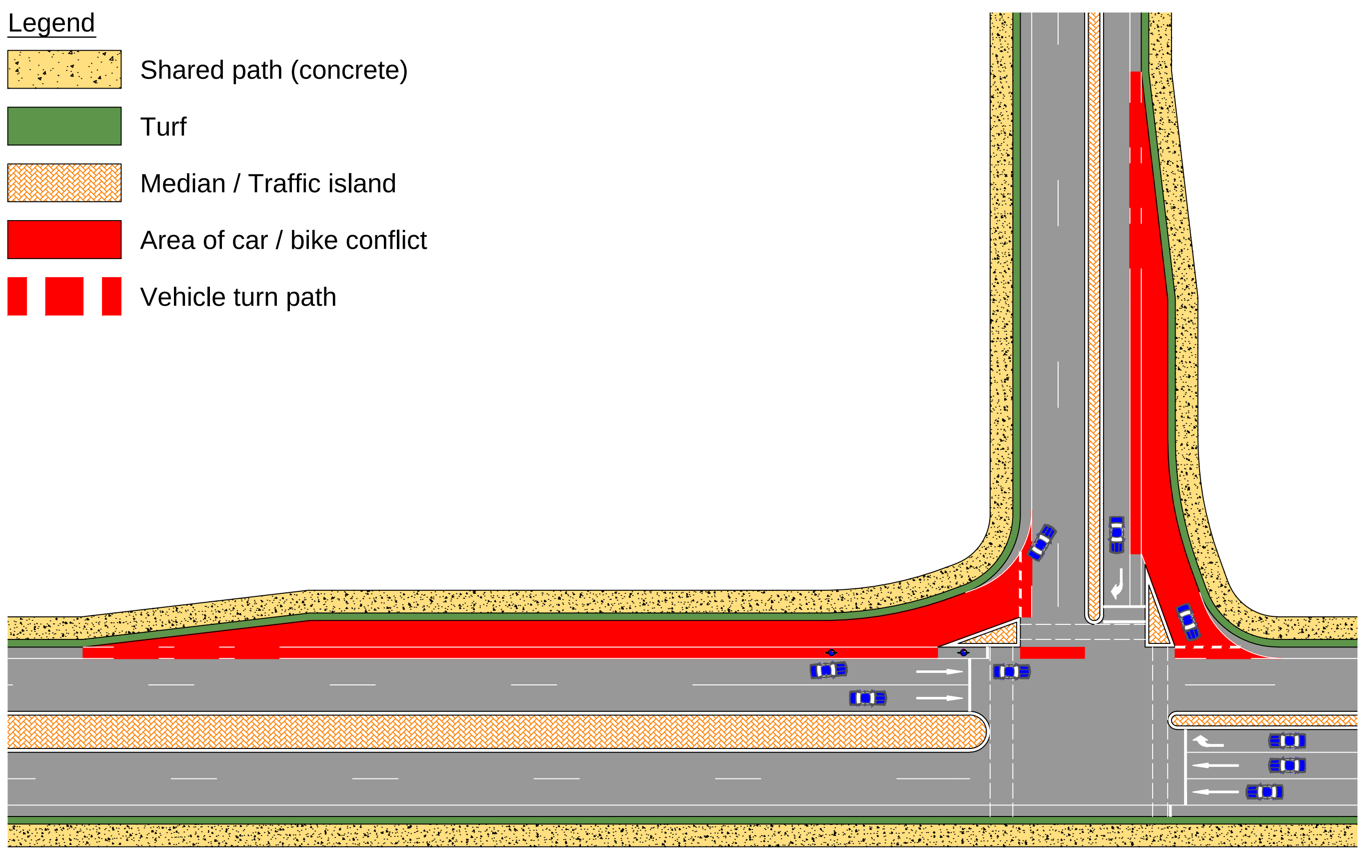
Refer to section 4.5 for further information

LEGEND

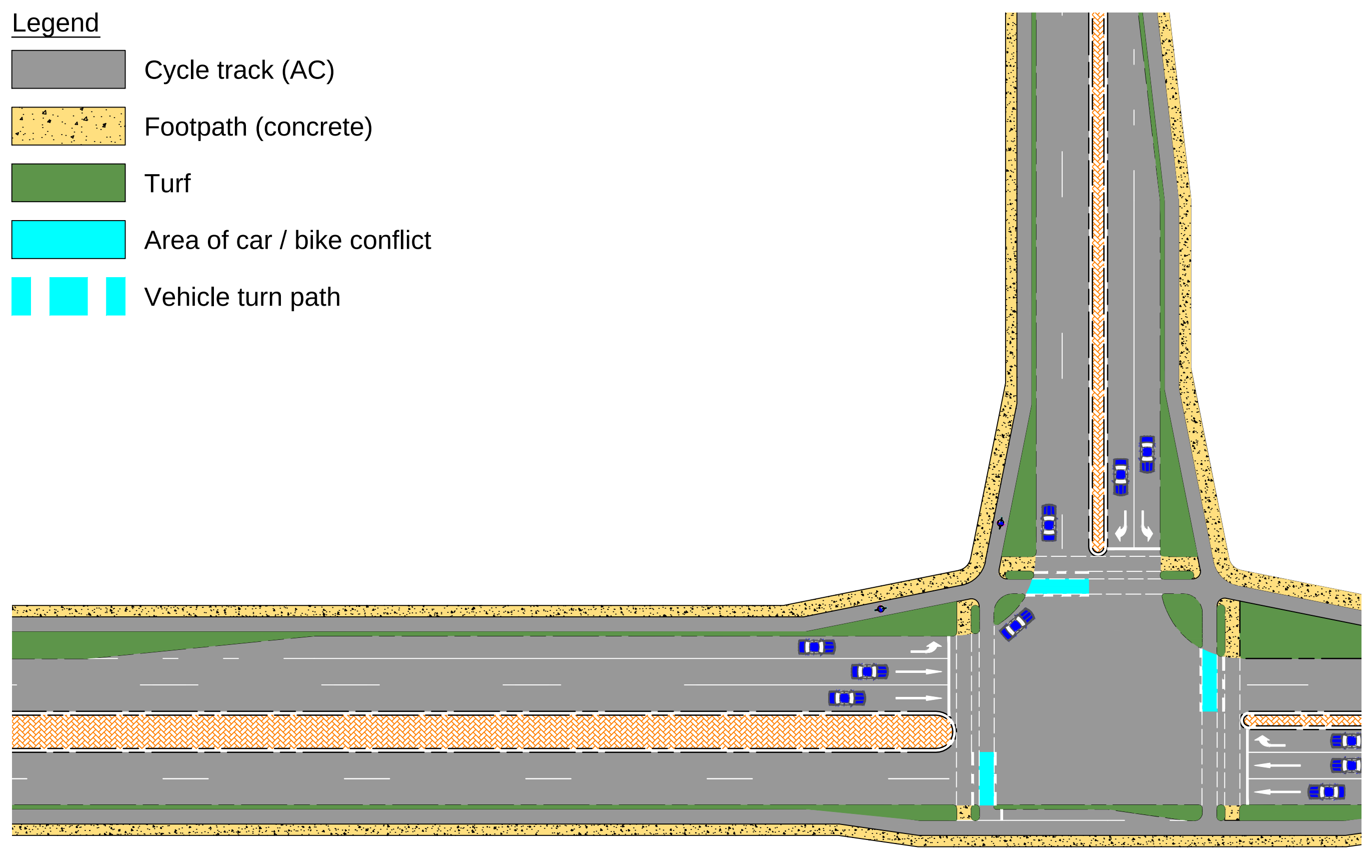
- Asphalt
- Footpath
- Concrete median
- Concrete at road level
- Landscaping/grass

EXAMPLE RETROFIT OF CYCLE TRACK AT A SIGNALISED INTERSECTION

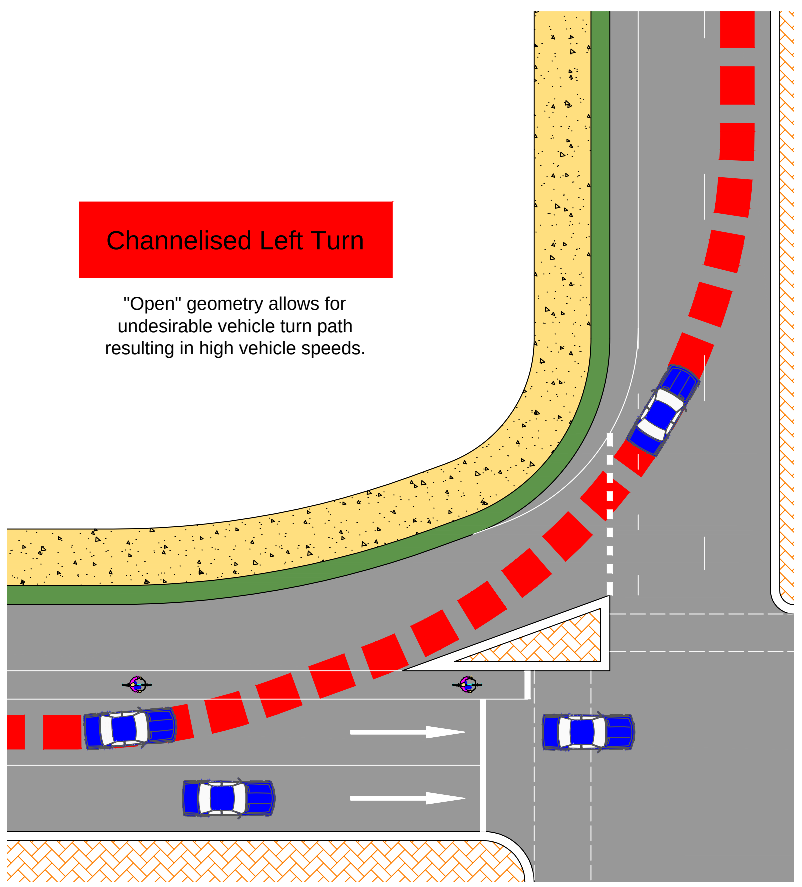
FIGURE	B4.02A	VERSION	02	23
DATE	06/06/2019	SCALE	1:500 @ A3	



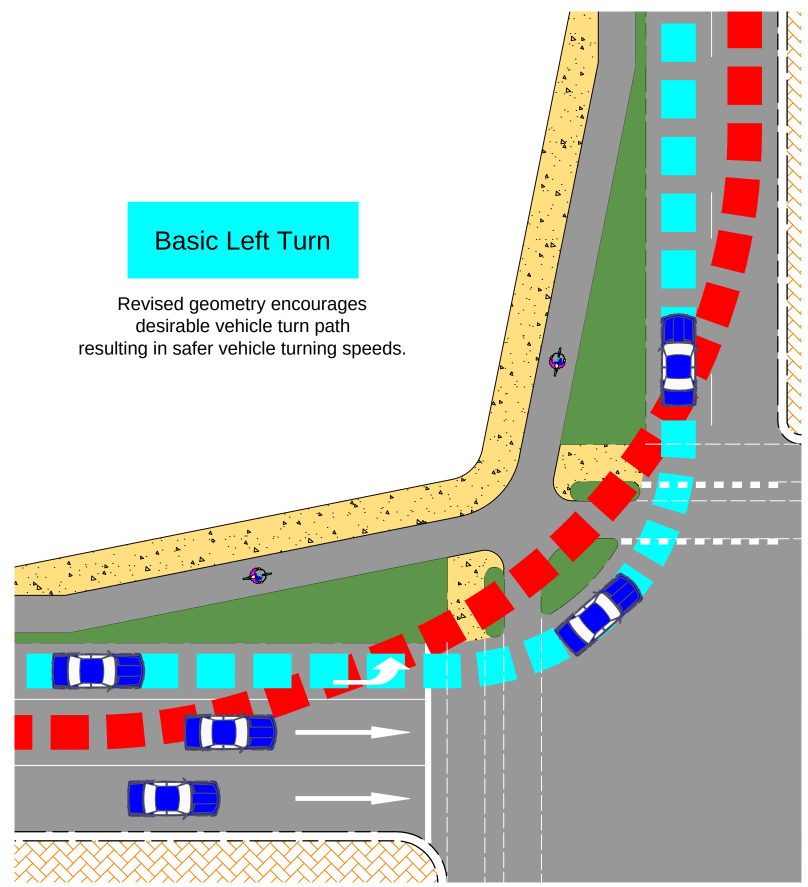
Channelised left turn with bike lanes and shared path showing car / bike conflict areas



Basic left turn with cycle track and footpath showing car / bike conflict areas



Channelised left turn showing high speed vehicle travel path

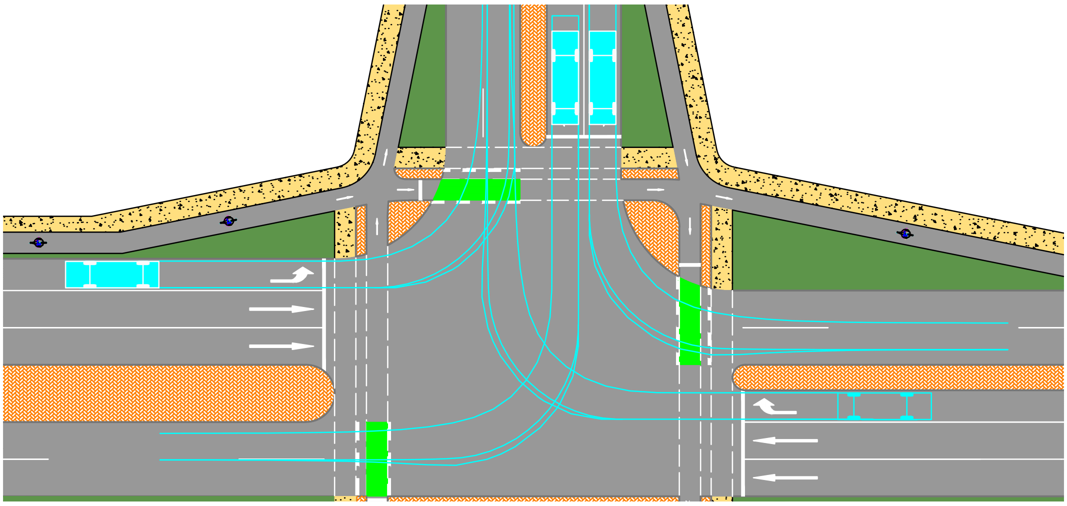


Basic left turn showing low speed vehicle travel path

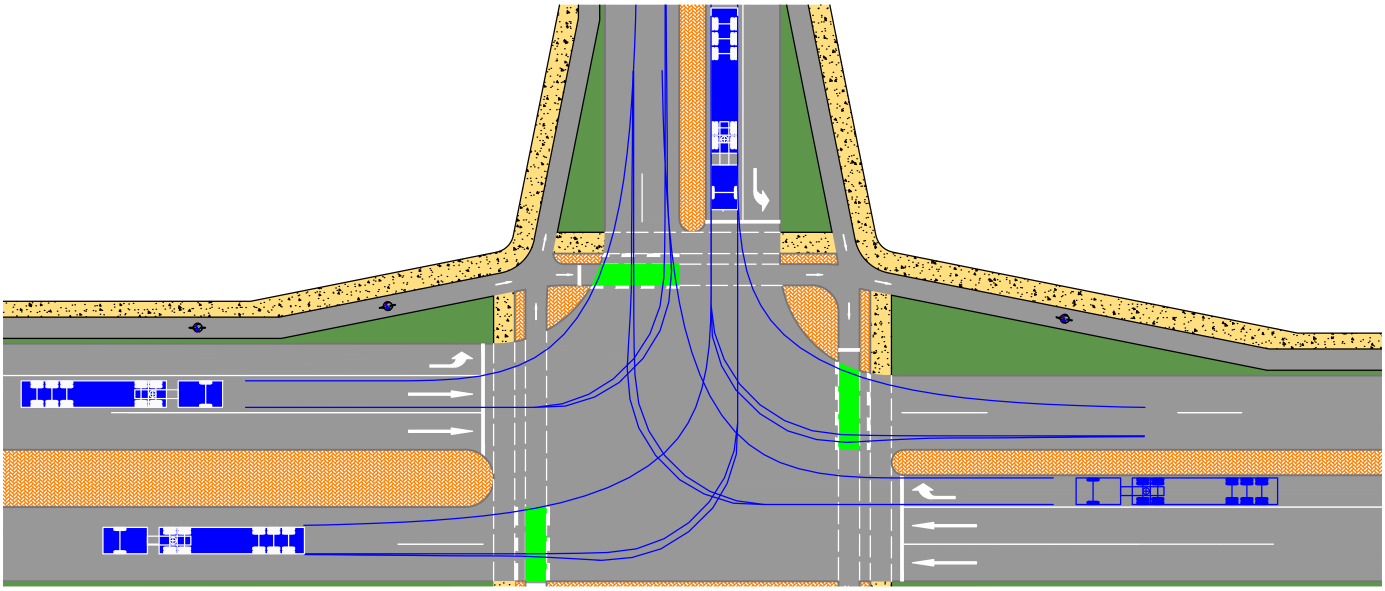
CHANNELISED VERSUS BASIC LEFT TURN:
COMPARISON OF CAR / BIKE CONFLICT AREAS AND VEHICLE TURN PATHS

FIGURE B4.03 | 03

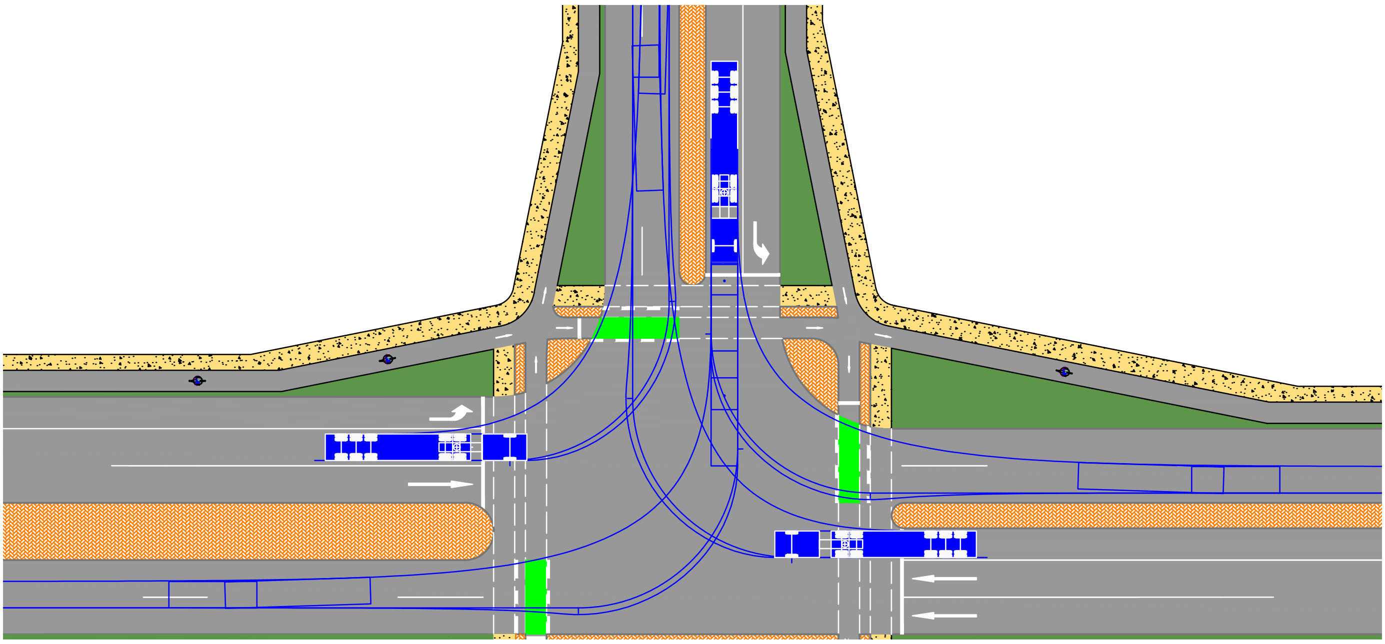
G:\WHRF-Projects\Cycleways\Separated Cycleways Drawings\February 2015\Figure B4.03 Rev 03.dwg



Turning movements: Service vehicle (R12.5m)



Turning movements: 19m semi (R12.5m)

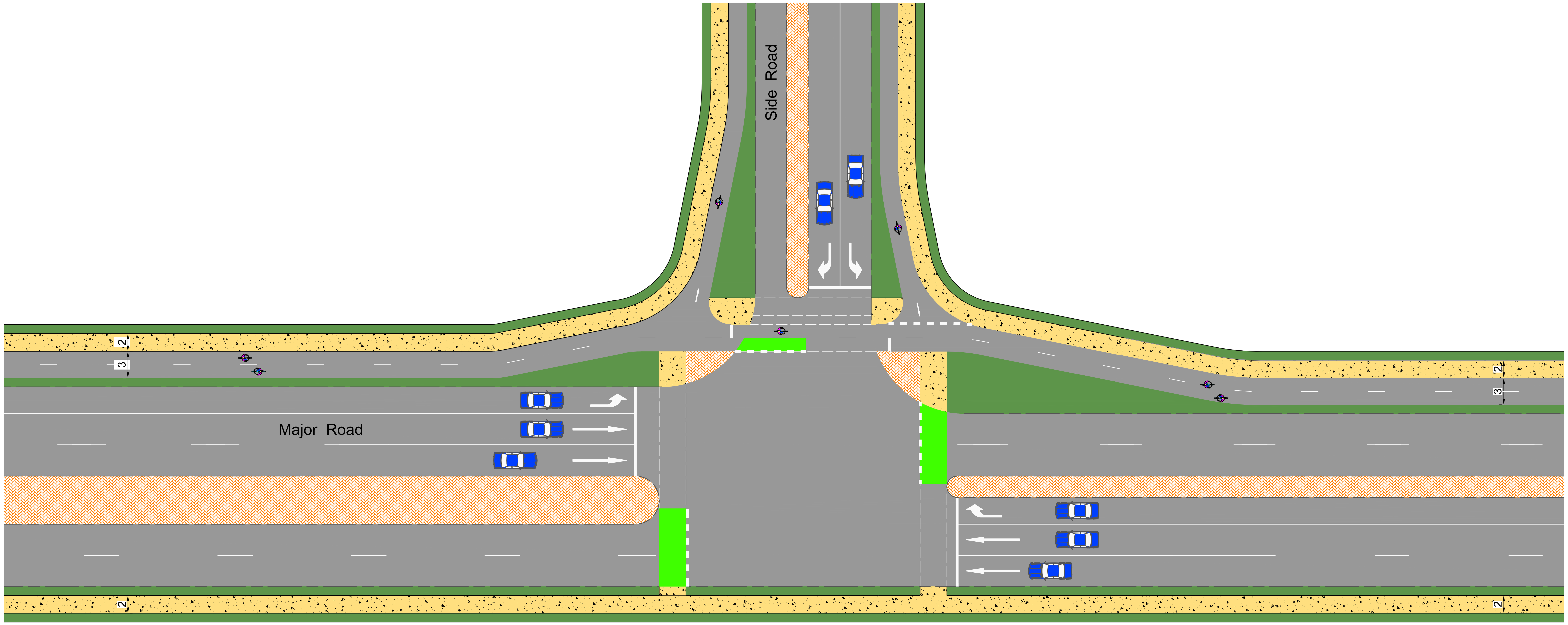


Turning movements: 19m semi (R15m)

TURNING MOVEMENTS FOR SERVICE VEHICLE AND 19m SEMI
AT SIGNALISED T-INTERSECTION WITH ONE-WAY CYCLE TRACK

FIGURE B4.04 | 03

G:\WHRF-Projects\Cycleways\Separated Cycleways Drawings\February 2015\Figure B4.01 & B4.04 Rev 03.dwg



Notes:

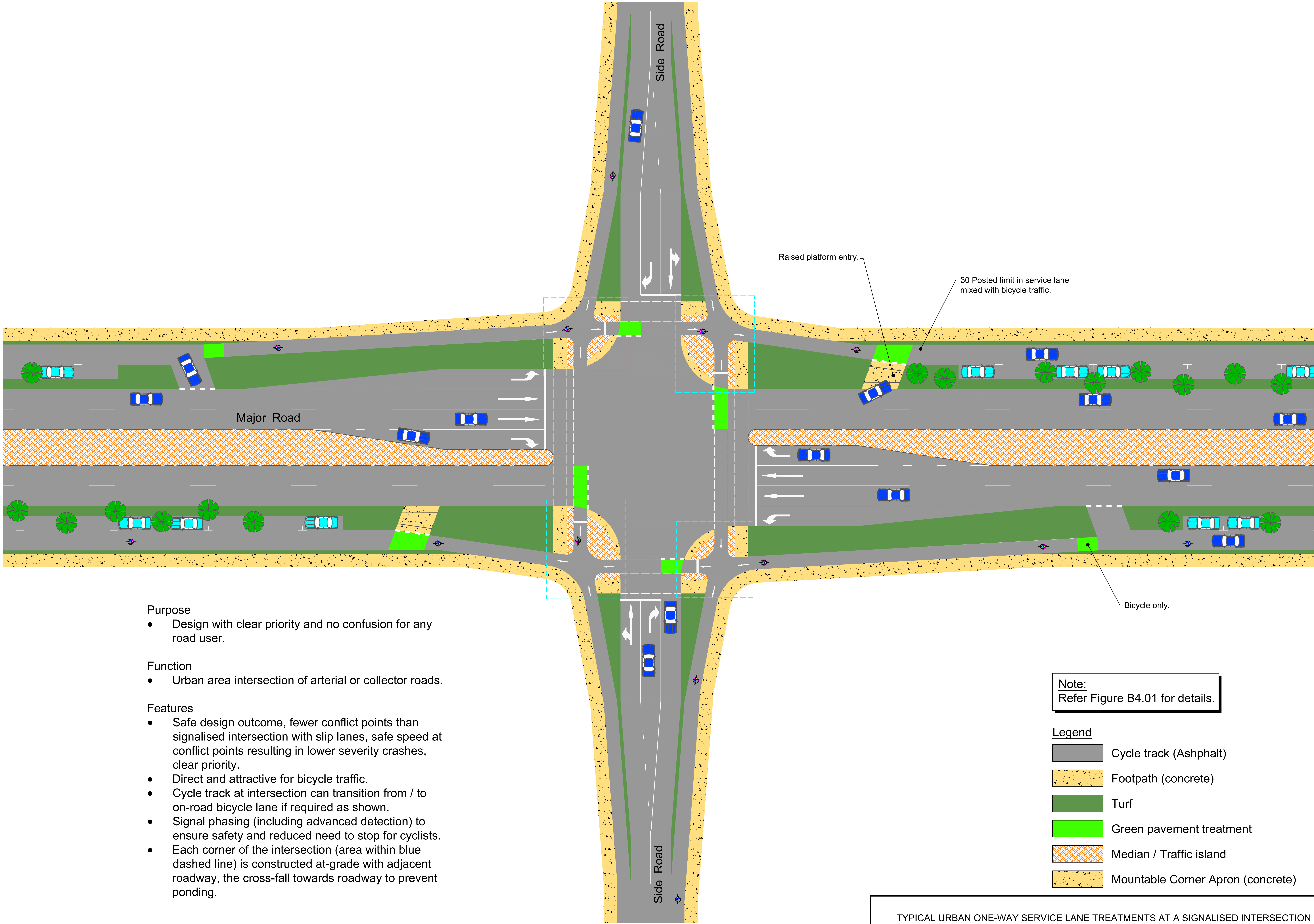
1. No filtering of turning movements across two-way cycle tracks.
2. Cycle track and footpath to transition to road level at the intersection i.e. no kerb ramps.
3. Refer Section 4.5 for further information.

Legend

- Cycle track (AC)
- Footpath (concrete)
- Turf
- Median / Traffic island

SIGNALISED T-INTERSECTION
TWO-WAY CYCLE TRACK ON THE CROSSING SIDE OF THE MAJOR ROAD
ONE-WAY CYCLE TRACKS ON BOTH SIDES OF THE SIDE ROAD

FIGURE B4.05 | 03



Purpose
- Design with clear priority and no confusion for any road user.

Function
- Urban area intersection of arterial or collector roads.

Features
- Safe design outcome, fewer conflict points than signalised intersection with slip lanes, safe speed at conflict points resulting in lower severity crashes, clear priority.
- Direct and attractive for bicycle traffic.
- Cycle track at intersection can transition from / to on-road bicycle lane if required as shown.
- Signal phasing (including advanced detection) to ensure safety and reduced need to stop for cyclists.
- Each corner of the intersection (area within blue dashed line) is constructed at-grade with adjacent roadway, the cross-fall towards roadway to prevent ponding.

Note:
Refer Figure B4.01 for details.

Legend
- Cycle track (Ashphalt)
- Footpath (concrete)
- Turf
- Green pavement treatment
- Median / Traffic island
- Mountable Corner Apron (concrete)

TYPICAL URBAN ONE-WAY SERVICE LANE TREATMENTS AT A SIGNALISED INTERSECTION

FIGURE B4.06 | 01

References

[1] Jurewicz, C., Sobhani, A., Woolley, J., Dutschke, J., and Corben, B. (2016). *Exploration of vehicle impact speed–injury severity relationships for application in safer road design*. Transportation research procedia, 14, 4247–4256.
[2] New South Wales Government. (2019). Sydney City Centre Access 2018. Retrieved from https://access2018.mysydneycbd.nsw.gov.au/map
[3] Institute for Road Safety Research (SWOV). (2010) SWOV Fact Sheet, *Zones 30 – urban residential areas*. The Netherlands.
[4] Dirk Dufour, Ligtermoet & Partners. (2010) *Giving Cycling a Push*: *Presto Cycling Policy Guide, Infrastructure.* The Netherlands.
[5] Dirk Dufour, Ligtermoet & Partners. (2010) *Giving Cycling a Push*: *Presto Cycling Policy Guide, Infrastructure.* The Netherlands.
[6] Robinson D. (2005) *Safety in numbers in Australia: more walkers and bicyclists, safer walking and bicycling*. Health Promotional Journal of Australia.
[7] Lusk, A. C., da Silva Filho, D. F., & Dobbert, L. (2018). *Pedestrian and cyclist preferences for tree locations by sidewalks and cycle tracks and associated benefits: Worldwide implications from a study in Boston, MA*. Cities. doi: https://doi.org/10.1016/j.cities.2018.06.024
[8] Bauman, A et al. (2008) *Cycling: getting Australia moving – barriers, facilitators and interventions to get more Australians physically active through cycling.* 31st Australasian Transport Research Forum.
[9] Robinson D. (2005) *Safety in numbers in Australia: more walkers and bicyclists, safer walking and bicycling*. Health Promotional Journal of Australia.
[10] Institute for Road Safety Research (SWOV). (2010). *SWOV Fact Sheet*: *Bicycle facilities on distributor roads*. The Netherlands.
[11] Munro, C. (2012) *Bicycle rider collisions with car doors.* Prepared for Road Safety Action Group Inner Melbourne.
[12] Austroads. (2014) *Assessment of the effectiveness of on-road bicycle lanes at roundabouts in Australia and New Zealand.*
[13] Karim, DM. (2015) *Narrower Lanes, Safer Streets.* Canadian Institute of Transportation Engineers Conference.
[14] Rosen, E. and Sander, U. (2009) *Pedestrian fatality risk as a function of car impact speed.* Accident, Analysis and Prevention, Sweden.
[15] Massachusetts Department of Transportation. (2015) *Separated Bike Lane Planning and Design Guide*, Boston.
[16] Voorham. (2010) *Safety of Left Turning Cyclists.*
[17] Rosen, E and Sander, U. (2009) *Pedestrian fatality risk as a function of car impact speed.* Accident, Analysis and Prevention. Sweden.
[18] CROW. (2007) *Design Manual for Bicycle Traffic*. The Netherlands.
[19] Massachusetts Department of Transportation. (2015) *Separated Bike Lane Planning and Design Guide.* Boston.
[20] Zeegers, T of Fietsersbond. Quoted in Hendricks, R. (2010) *Twice green almost always feasible.* The Netherlands.