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Better streets, better cities

A guide to street design in urban India

December 2011

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Foreword

India is urbanising at a very rapid pace, and many of our cities are struggling to keep up with this pace. Urban streets play an important role in how this increasing number of people in our cities move about, interact, conduct business, etc. Hence, the design of streets is of utmost importance.

It gives me great pleasure to introduce *Better Streets, Better Cities: A guide to street design in urban India*. This guide for design of urban streets clearly articulates the concept of 'equitable allocation of road space.' This is also one of the key principles outlined in the National Urban Transport Policy. Well-designed and robustly constructed streets can significantly improve the quality of life of the urban citizenry. This guide provides a framework for understanding various elements of street design and a toolkit for well-designed streets. Implementing the recommendations mentioned here would not only improve the physical condition of streets, it would also lead to more sustainable cities.

I hope this finds frequent use amongst planners, engineers, architects, all of whom are engaged in the process of building, modifying, and maintaining our streets and our cities.

I. P. Gautam, Principal Secretary
Urban Development and Urban Housing Department
Government of Gujarat

September 2011

Preface

Streets occupy approximately 20 percent of the total land area in a typical city, and they are the most important and ubiquitous form of public space. Streets are the stage upon which the drama of urban life unfolds every day. And this is not a recent phenomenon—streets have played this role since the beginning of towns and cities.

But recently, streets have been reduced to a more restricted role of serving as conduits for the movement of automobiles. The situation is getting worse every day as the number of private vehicles grows exponentially. As a number of cities around the world have realized, this has undermined quality of life and the character of public spaces. There is an urgent need to look at streets as places where people walk, talk, cycle, shop, and perform the multitude of social functions that are critical to the health of cities.

Streets are also vital to the identity of cities. Broadway defines New York just as Market Street defines San Francisco. Chicago and Paris would be very different if Michigan Avenue and Champs–Élysées were primarily automobile-oriented roads. Similarly, what would Ahmedabad be without Manek Chowk, or Delhi without the Rajpath?

Streets in our cities should be representative of our lifestyle and culture. Their designs need to respond to the multitude of activities and functions that streets perform. Modern streets also carry a number of infrastructure services such as water, sewer, storm water, electrical, and telephone lines. The design of underground utilities needs to be coordinated with the surface layout and functioning of a street. Therefore, it is critical that streets are designed properly and in adequate detail.

This guide aims to facilitate the design of beautiful, safe, walkable, and liveable streets. The guide identifies the different functions of streets and emphasizes the need to design complete streets that provide space for all users. Through the street and intersection templates one can get a sense of how the different elements come together for different types and sizes of streets. Finally, there is an overview of the activities that are undertaken as a part of the overall process of street design.

This guide is intended for planners, urban designers, landscape architects, civil engineers, and, most importantly, government officials and citizens who are interested in improving the quality of urban environments and the character of streets in our cities. The guide is by no means the last word—if it helps frame the questions and show the direction in which the answers lie, then it will have done its job.

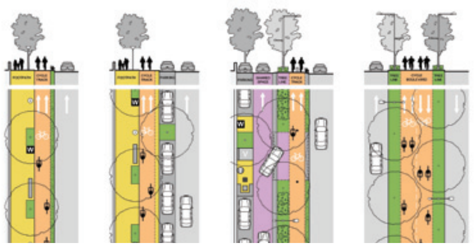
Bimal Patel, Environmental Planning Collaborative

Shreya Gadepalli, Institute for Transportation and Development Policy

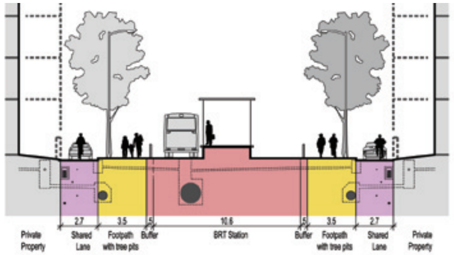
July 2011

Structure of the guide

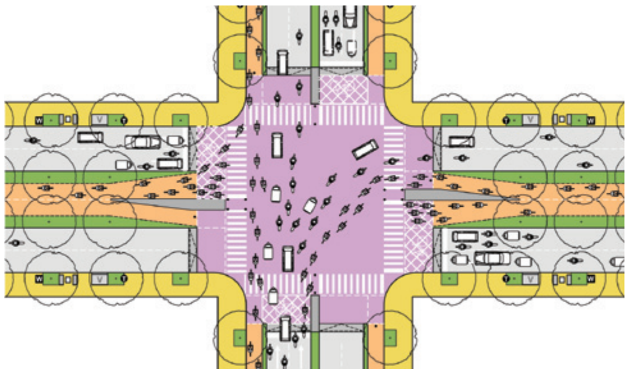
1 Introduction lays out our vision for better street design. It explains why streets need to be designed for all users, not just for motor vehicles.



2 Street design elements discusses sixteen elements that make up a street: footpaths, the carriageway, cycle tracks, service lanes, bus lanes, landscaping, utilities, and so on. For each element, we present principles that govern the placement and design of the element in relation to others, photos of good and bad practices, and various design options.



3 Street templates is a collection of street templates for typical road widths. For each width, we present a range of design solutions. The templates are based on the standards laid out in Chapter 2.



4 Intersection templates shows how the standard templates presented in Chapter 3 come together at intersections.

5 Design process explains our street design process, from the development of a vision through the completion of a final design, using the example of an urban intersection.

Contents

1

Introduction

Streets rank amongst the most valuable assets in any city. They not only ensure residents' mobility, allowing them to travel from one place to another, but also are a place for people to meet, interact, do business, and have fun. Streets make a city liveable. They foster social and economic bonds, bringing people together. Decisions about how to allocate and design street space have a tremendous impact on quality of life.

Indian cities struggle to reconcile the competing needs of mobility and liveability. As private motor vehicle ownership grows and governments attempt to accommodate the additional vehicles, it is becoming more and more difficult to retain adequate space for the social and economic activities that traditionally have taken place in our streets. Over time, streets have come to function less as social gathering spaces and market areas, and more as conduits for an ever-increasing volume of traffic.

Streets need room for all users.

One of the key problems of Indian streets is that they are designed from the centreline outwards, without taking the needs of all users into account. The median is marked and a carriageway constructed, and the undefined outer area is left for other purposes. After parking eats away a significant share of this area, pedestrians, trees, utilities, street vending, and social activities jostle for whatever space remains. It is no surprise that in most cases the leftover space is not sufficient to safely and comfortably accommodate these essential functions of the street.

Designs focus on improving private motor vehicle mobility by allocating more space to it—often at the expense of other functions of the street. However, the reality they create is different: pedestrian footpaths may vanish but the pedestrians do not, and the lack of proper pedestrian infrastructure forces people to walk on the carriageway. The same is true for cyclists, street vendors, and public transport. Eventually, everyone ends up sharing what is constructed as a motor vehicle carriageway, leading to a reduction in the amount of space that is usable by vehicles. The resulting arrangement is inconvenient, uncomfortable, and unsafe for everyone, including motor vehicle users. So, why not provide adequate space for all users in the first place?

Figure 1.1 If a street does not provide separate space for pedestrians, people will walk in the carriageway.

All streets that aim to maximise mobility also need separate slow zones. The slow space is for liveability—for people to walk, talk, and interact, for doing business, for children to play. The provision of an adequate slow zone makes it possible for the mobility zone of a street to provide for safe, relatively uninterrupted mobility at moderate speeds. The result is a safer and more pleasant street environment for everyone.

It should be noted that the motor vehicle capacity of urban streets is determined primarily by how quickly vehicles can clear intersections. Though constructing wide carriageways may allow for faster mid-block speeds, it does not enhance throughput, for intersections are the true bottlenecks. Widening the carriageway at the intersection, through additional queuing space, is a more effective way of increasing throughput.

Figure 1.2 A street with adequate space for walking and other activities is safer for pedestrians and allows for smoother motor vehicle movement.

Making streets more efficient, not simply widening them, can help solve our mobility problems.

The first question that often emerges when one talks about accommodating pedestrians, cyclists, and street vendors is, "Will that not reduce traffic movement?" Yet vehicle movement and mobility are not one and the same. Mobility is about getting people to where they want to go, efficiently, conveniently, and safely. Mobility can be provided through high quality, high capacity public transport, which does not necessarily mean moving large numbers of vehicles.

Figure 1.3 Wider roads, expressways, and flyovers bring temporary relief, but in the long run they only exacerbate a city's traffic problems.

Even if a road widening or flyover reduces congestion, the improvement is usually short-lived. The reason is simple: expanding the available road space initially increases speed and comfort and thereby encourages more people to travel in private motor vehicles. More and more users take to the route until the wider road returns to its original level of congestion—but with significantly more vehicles stuck in traffic.

A city government in turn may feel pressure to widen the road once again, but it is not possible to solve traffic jams by building larger and larger roads indefinitely. In fact, no city in the world has solved its mobility crisis by simply building more roads. On the contrary, some of the cities with the most elaborate road networks also have the worst congestion.

The only viable long-term solution for ensuring mobility is to build high quality facilities for public transport and non-motorised transport. These modes can carry large numbers of passengers without an exponential increase in road space requirements. For most Indian cities, the most viable option is bus rapid transit (BRT). A single BRT lane with articulated buses can carry 10,000 passengers per hour per direction. The same lane can carry little over 1,000 cars per hour—1,200 to 1,500 persons at typical occupancy rates—assuming that the lane receives one half of the signal time at intersections.

There are solutions to traffic congestion too. The key to reducing congestion is lowering the number of vehicles on streets rather than increasing street widths to accommodate an ever-growing number of vehicles. This can be done through various means, including parking fees, congestion charges, and other travel demand management tools as well as through traffic calming. At a larger scale, compact, walkable urban design is the key to reducing congestion by keeping trip lengths short.

Figure 1.4 A dedicated bus lane can carry many times as many passengers as a mixed traffic lane.

What makes up a complete street?

A complete street that caters to all users can take on a variety of forms, depending on factors such as the available right-of-way, traffic volumes, street-side activities, and adjacent land uses.

In general, smaller right-of-ways can function as slow shared spaces used by both pedestrians and vehicles. Street vending and social activities can also take place in the shared space. A narrow driving lane and other traffic calming elements help keep vehicle speeds low, so that vehicle movement remains compatible with the other uses.

A larger street can cater to walking and stationary activities as well as through movement, but it often makes sense to differentiate the slow, shared zone from the mobility zone to ensure comfort and safety for pedestrians and stationary users. The cycle track, though part of the mobility zone, is also segregated from motor vehicle traffic.

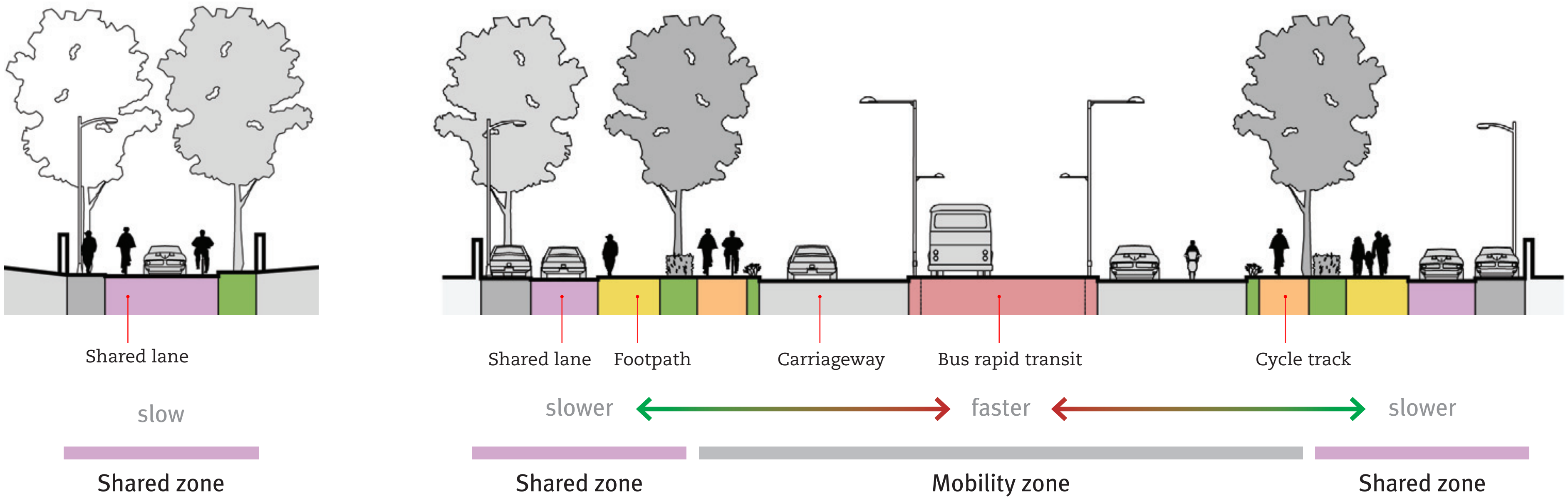


Figure 1.5 The 7.5 m street (left) is a shared space. The 42 m street (right) includes a slow-speed shared lane similar to the 7.5 m section, but it also provides separate spaces for mobility, including a cycle track, carriageway, and bus rapid transit lanes.

Principles for street design

The design approach outlined in this guide is guided by the following principles:

Safety

Streets must be safe for all users. This implies that every street needs to have a slow zone where pedestrians have priority. In smaller streets with a shared space format, the entire street becomes a slow zone for all users, including pedestrians, vendors, cycles, and cars.

Mobility

Larger roads can include a mobility zone for vehicle movement. This mobility zone—for private vehicles and public transport—is physically separated from the slow zone. The mobility zone may include a segregated cycle track if the speed differential between cyclists and motor vehicles is high. In addition, dedicated bus lanes can improve service quality for public transport users.

Pedestrian accessibility

All streets need to have continuous footpaths or safe shared space with minimal grade differences and adequate clear width for pedestrian through movement.

Liveability

Elements such as tree lines, landscaping, and furniture enhance a street's slow zone, creating space for relaxation, interaction, vending, and other activities.

Sensitivity to local context

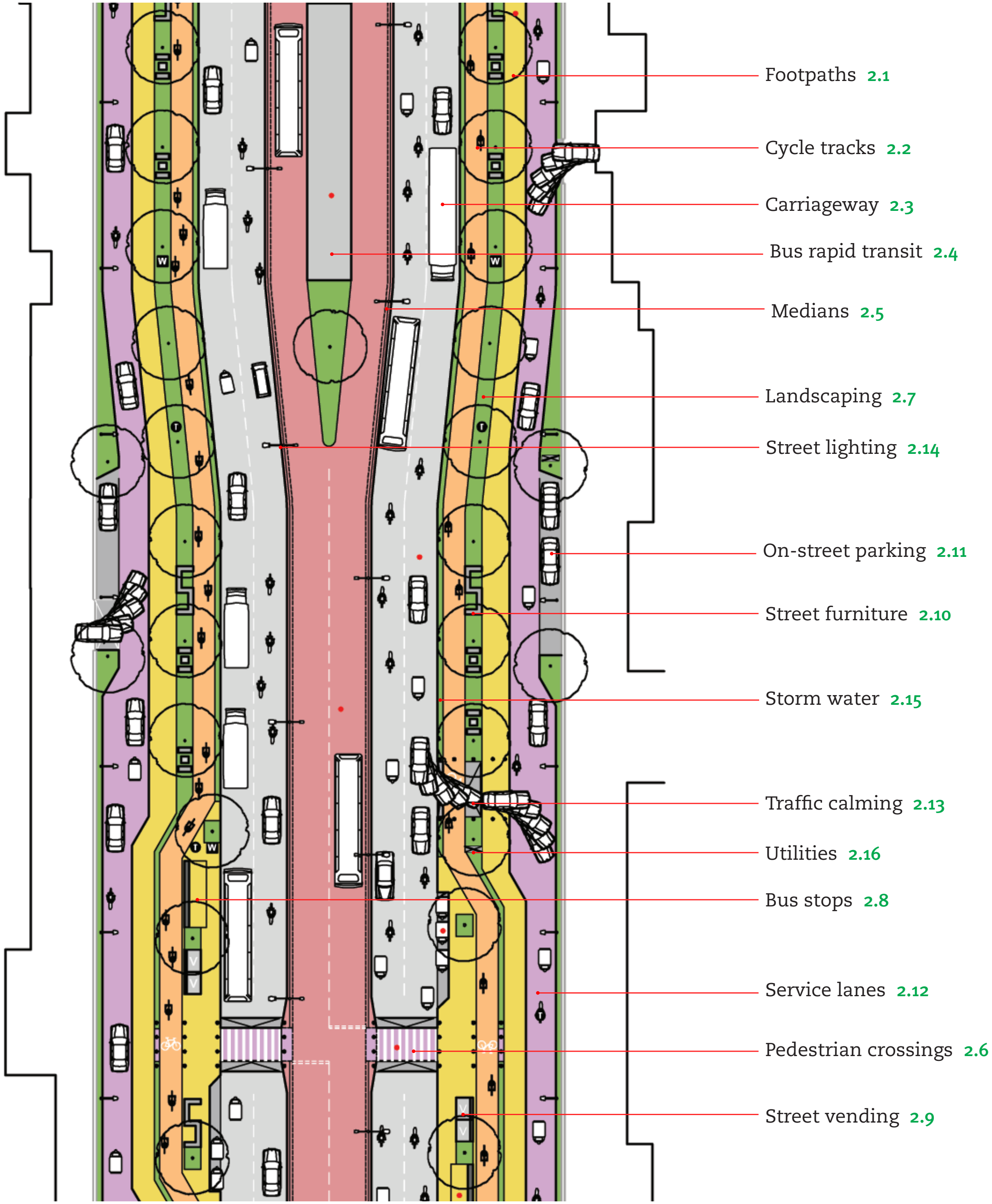
Street design should factor in local street activities, patterns of pedestrian movement, and nearby land uses.

Creative use of street space

For example, the width occupied by a parking lane can become multi-functional if it includes occasional bulb-outs for street vending or street furniture.

2

Street design elements



We define sixteen street design elements as the street components that accommodate or serve specific functions. For example, a footpath supports pedestrian movement, and street lights improve safety. The figure on the left shows all sixteen elements.

Street design elements demand detailed planning and need to be customised to fit the local context. Getting the elements in the right proportion and location is challenging because all elements interact with one another. For example, utility-oriented elements lie mainly underground, but when they surface in the form of utility boxes and manhole covers, they can impact the usability of elements such as footpaths and cycle tracks.

In this chapter, each street design element is briefly discussed in four subsections:

- What the element should achieve
- Its significance in the larger context
- Challenges to achieving its potential
- Design criteria and standards

2.1 Footpaths

Figure 2.1 This footpath is wide, continuous, and shaded. However, the continuous fencing towards the carriageway prevents free pedestrian movement.

✗ Figure 2.2 This recently constructed footpath does not accommodate obstacles in a way that would allow pedestrians to effectively use the footpath.

What good footpaths achieve

Good footpaths promote safe and comfortable pedestrian mobility. Together with other elements, such as furniture and landscaping, they constitute the primary public space of a city and are accessible to all users, regardless of age, gender, or special needs. Good footpaths are inviting spaces where people can meet, talk, sit, and eat.

Significance of footpaths

A significant proportion of trips, especially those below 2 km, are performed on foot. For example, the share of pedestrian trips in Ahmedabad is 38 percent.* Additionally, all public transport passengers and many private vehicle users start and end their trips as pedestrians on public streets. Hence accommodating pedestrians is an essential, if not the most important, task of transportation planning.

Footpaths are a critical elements of the streetscape unless traffic calming makes footpaths unnecessary. In smaller streets and service lanes, speed differentials may be small enough for pedestrians and motor vehicles to coexist in a pedestrian-priority space.

Challenges to better footpaths

Streets often are designed from the centreline outward, with priority given to motorised vehicles. Whatever space is left over after creating the carriageway and parking is designated as the footpath. The placement of utility boxes, trees, and light poles on the footpath leaves no clear space for pedestrian movement.

Even with an adequate width, a footpath may be difficult to use if it ends frequently at property access points. High curb heights and steps make footpaths difficult to use.

Poorly designed footpaths remain under-utilised and are easily encroached by parked vehicles and shops. In the absence of an adequately sized and usable footpath, the only clear space left for pedestrians is the carriageway.

Design criteria and standards

Comfort, continuity, and safety are the governing criteria for the design of pedestrian facilities. Footpaths should be provided on all streets, except on traffic calmed small streets

Footpaths should incorporate the following:

- A continuous unobstructed *minimum* width of 2 m
- No breaks or obstructions at property entrances and side streets
- Continuous shade through tree cover
- No railings or barriers that prevent sideways movement on and off the footpath
- Elevation over the carriageway (e.g. +150 mm) and adequate cross slope for storm water runoff. At the same time, the elevation should be low enough for pedestrians to step onto and off of the footpath easily
- Surmountable gratings over tree pits to increase the effective width of the footpath

* Centre for Environmental Planning and Technology, Comprehensive Mobility Plan and Bus Rapid Transit System Plan, Phase II (Ahmedabad: 2008) 4-5.

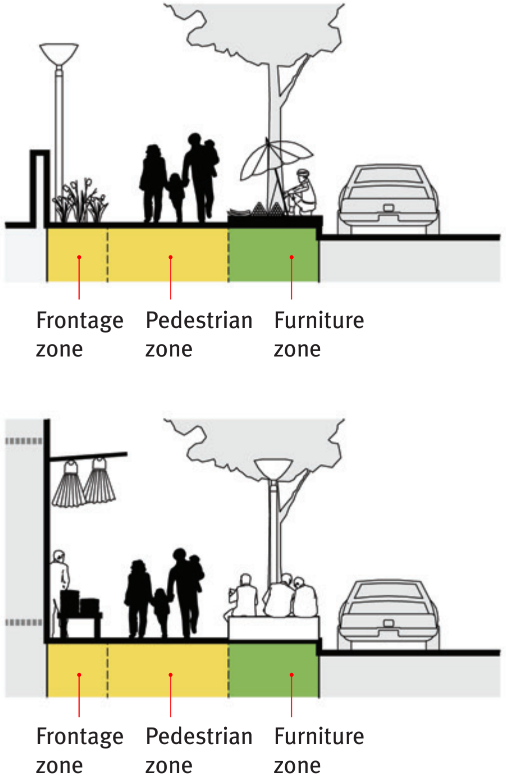


Figure 2.3 Footpaths have distinct zones that serve separate purposes:

- **Pedestrian zone**. This zone provides continuous space for walking and should be clear of any obstructions. It should be at least 2 m wide.
- **Frontage zone**. Provides a buffer between street-side activities and the pedestrian zone. Next to a compound wall, the frontage zone can become a plantation strip.
- **Furniture zone**. This is a space for landscaping, furniture, lights, bus stops, signs, and private property access ramps.

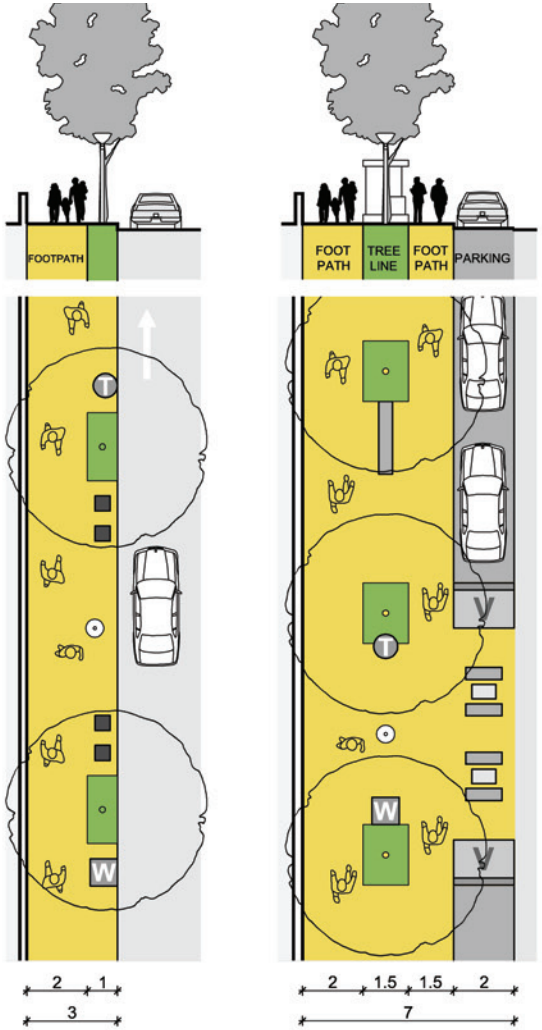


Figure 2.4 The smallest well functioning footpath/tree package has a width of 3 m, including a 2 m clear space and 1 m tree pits. Street furniture is positioned in line with the tree pits to maintain 2 m of clear space.

Wider footpaths can accommodate street vending and larger seating areas and are recommended in areas with large pedestrian volumes.

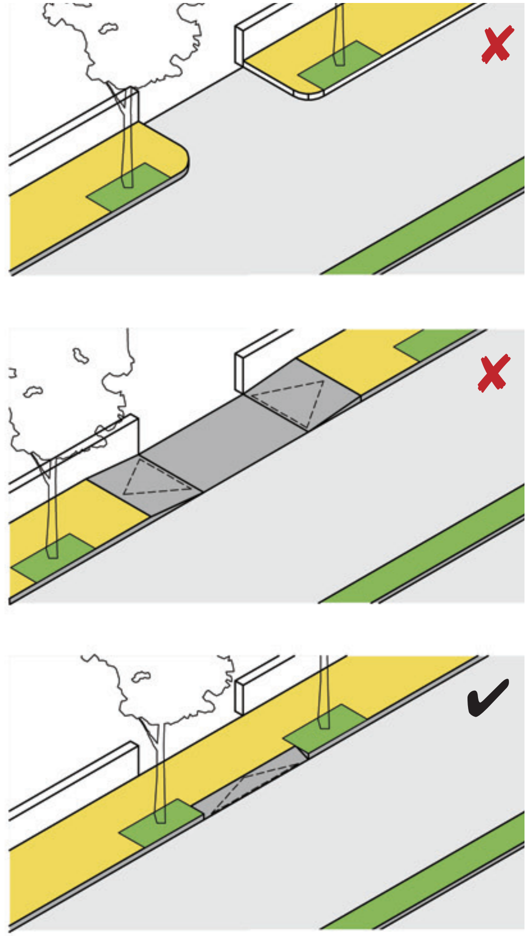


Figure 2.5 Where required to enable the access to private properties, vehicle ramps should be provided in the landscaping strip but not in the area of pedestrian through movement.

Ending the footpath with abrupt curbs or lowering the entire footpath to the level of the carriageway is unacceptable as property entrances may become waterlogged.

2.2 Cycle tracks

Figure 2.6 This cycle track is continuous and shaded. Curb heights are appropriate, and storm water drains into catch pits located in the landscaped buffer.

✘ Figure 2.7 This cycle track has four problems: (1) it is not continuous, (2) it collects water runoff and dirt because it is at the lowest point in the cross section, (3) it is not properly separated from the carriageway, and (4) the curbs and signpost reduce the usable width.

What good cycle tracks achieve

Good cycle tracks are continuous and provide for uninterrupted movement. They are physically separated from the main carriageway to ensure both comfort and safety, and are protected from encroachment by parked vehicles, pedestrians, and street vendors.

Significance of cycle tracks

The cycle is a core mode of urban transport. Cycles offer low-cost, pollution-free mobility and occupy only a fifth as much driving and parking space as automobiles.

Due to the lack of physical separation of motorised and non-motorised vehicles, cyclists face inconvenience and safety hazards from faster moving traffic. Therefore, the provision of safe and convenient infrastructure is essential to attract new users. Where motor vehicle lanes are saturated, cycling in a segregated track is often faster than using a private motor vehicle.

Challenges to better cycle tracks

There is significant resistance to creating dedicated cycling facilities, with the falling cycle mode share cited as an excuse. Even if mode shares are significant, cyclists are typically invisible in the planning process. Where they do exist, cycle tracks are often discontinuous and poorly constructed, leading to a self-fulfilling prophesy that cyclists do not use cycle tracks.

A lack of enforcement aggravates the situation further, as cycle tracks are easily taken over for activities such as parking and street vending or as a travel lane for motorised two-wheelers. Any cycle track that is easily accessible to cyclists is also accessible to motorised two-wheelers.

Design criteria and standards

Efficient cycle tracks are safe, convenient, continuous, and direct. On streets with high-speed traffic, cycle tracks can reduce conflicts between cycles and motor vehicles.

Cycle tracks in the median reduce conflicts with parking and street-side activities. However, street-side cycle tracks may be provided where encroachments due to parking or commercial activity are minimal, as may be the case if a service lane is available.

Cycle tracks should incorporate the following:

- A minimum width of 2 m for one-way movement and 3 m for two-way movement
- Continuity to allow for reasonable speeds
- A smooth surface material—asphalt or concrete. Paver blocks are to be avoided
- Manhole covers should be avoided and, if unavoidable, should be level with the surrounding surface
- Continuous shade through tree cover
- Elevation above the carriageway (e.g. +150 mm) that allows for storm water runoff
- A buffer of 0.5 m between the cycle track and parking areas or the carriageway
- At property access points, the cycle track remains at the same level and vehicle access is provided by a ramp in the buffer

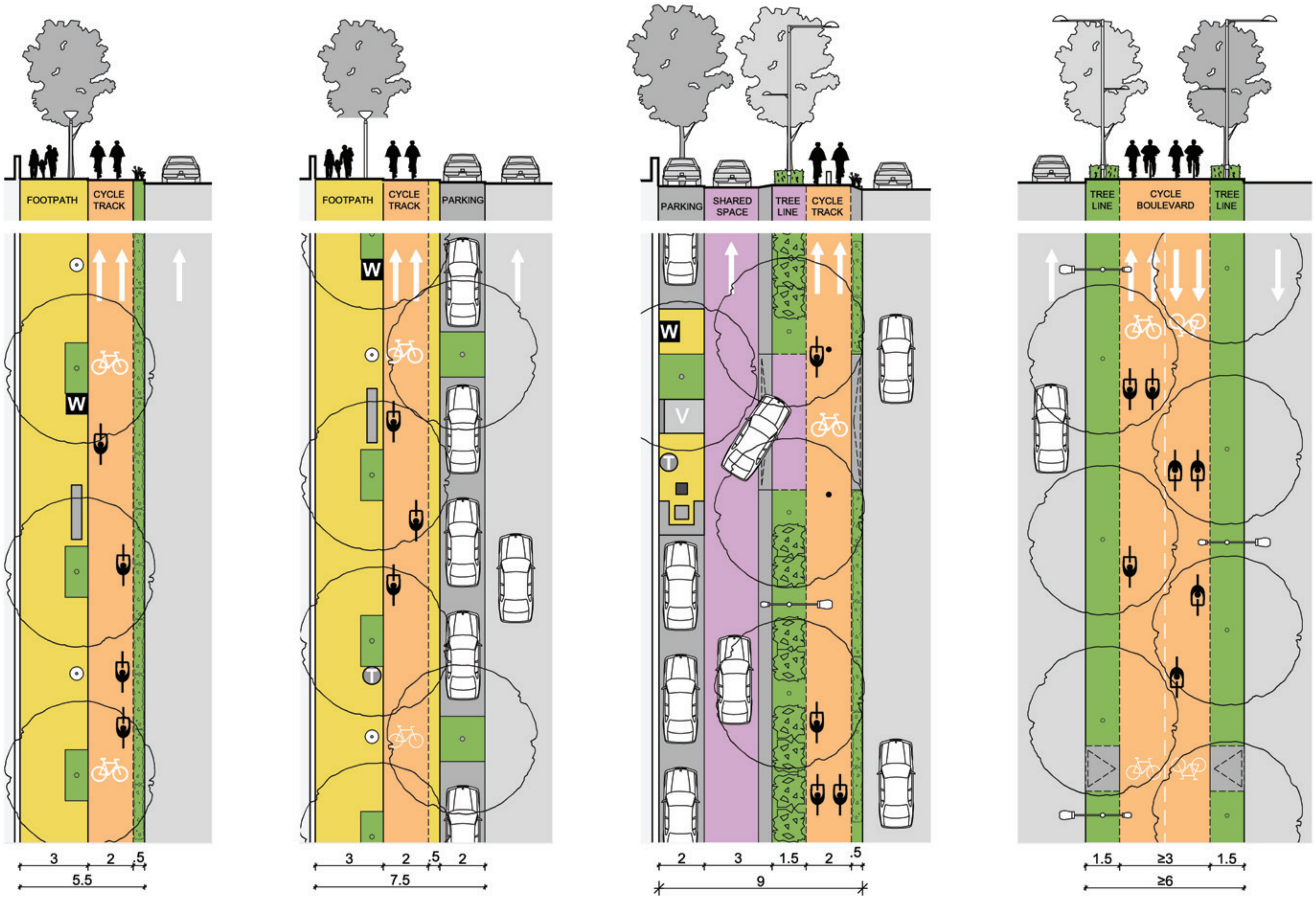


Figure 2.8 A clear width of 2 m is needed for one-way movement of cycles. To accommodate cycle rickshaws a minimum 2.5 m width is recommended, and to accommodate two-way movement, 3 m is recommended. A 0.5 m buffer is needed between a cycle track and motor vehicle or parking lanes. The buffer can accommodate ramps and storm water catch pits. The buffer should be paved if it is adjacent to a parking lane.

Median cycle tracks reduce conflicts with parking and property access. Frequent access points with ramps are essential. Turning movement conflicts at intersections can be mitigated through bicycle boxes and appropriate signal phasing.

2.3 Carriageway

Figure 2.9 A properly scaled carriageway keeps vehicle speeds low and prevents wrong-way driving.

✗ Figure 2.10 The wall-to-wall carriageway on this street in an educational area sends a signal to pedestrians that they are not welcome. Also, the excessive width of the carriageway encourages speeding and wrong-way driving. Footpaths, cycle tracks, or markets would be a better use of this excess carriageway space.

What good carriageways achieve

The primary purpose of a carriageway is vehicle mobility.

Significance of carriageways

A carriageway provides dedicated space for motorised vehicles separate from slow-speed modes, such as walking and cycling, and stationary activities. Carriageways are replaced by shared space in the case of narrow, traffic-calmed streets where motor vehicles, pedestrians, and cyclists coexist. A carriageway also can include segregated space for public transport.

Challenges to better carriageways

Since streets usually do not provide separate space for walking, cycling, and street vending, carriageways end up accommodating these very activities, compromising the motor vehicle throughput as well as safety and comfort for all users.

The width of a carriageway on a single linear stretch often varies in proportion to the width of the right-of-way. This leads to short spurts of speeding and intermediate bottlenecks and encourages wrong-direction driving without contributing to the primary function of vehicle mobility.

When carriageways become congested, they can no longer fulfil their role of providing for vehicle mobility. This can be addressed through road pricing and traffic demand management measures to reduce the number of vehicles on the street. This reduces congestion, thereby improving conditions for the remaining users.

Design criteria and standards

The carriageway should be designed for appropriate speeds suited to the street's role in the city's street network.

Carriageways should satisfy the following:

- Constant width, thereby ensuring the smooth flow of vehicles. The width should not increase on stretches where a wider right-of-way is temporarily available. Wider carriageway segments cause traffic jams where the width narrows again
- Clear boundaries defined through curbs and material differences
- Width defined by the function of the street rather than available right-of-way
- On major streets, a width of 6 m (two implied lanes) in order to accommodate large vehicles such as trucks and buses. Carriageways on urban streets should not be wider than 8.5 m (three implied lanes) per direction

Street space should be allocated to the carriageway after adequate usable space has been reserved for walking, cycling, trees, and street vending. Otherwise, such activities will spill over onto the carriageway. For a detailed discussion on carriageway widths, see the opposite page.

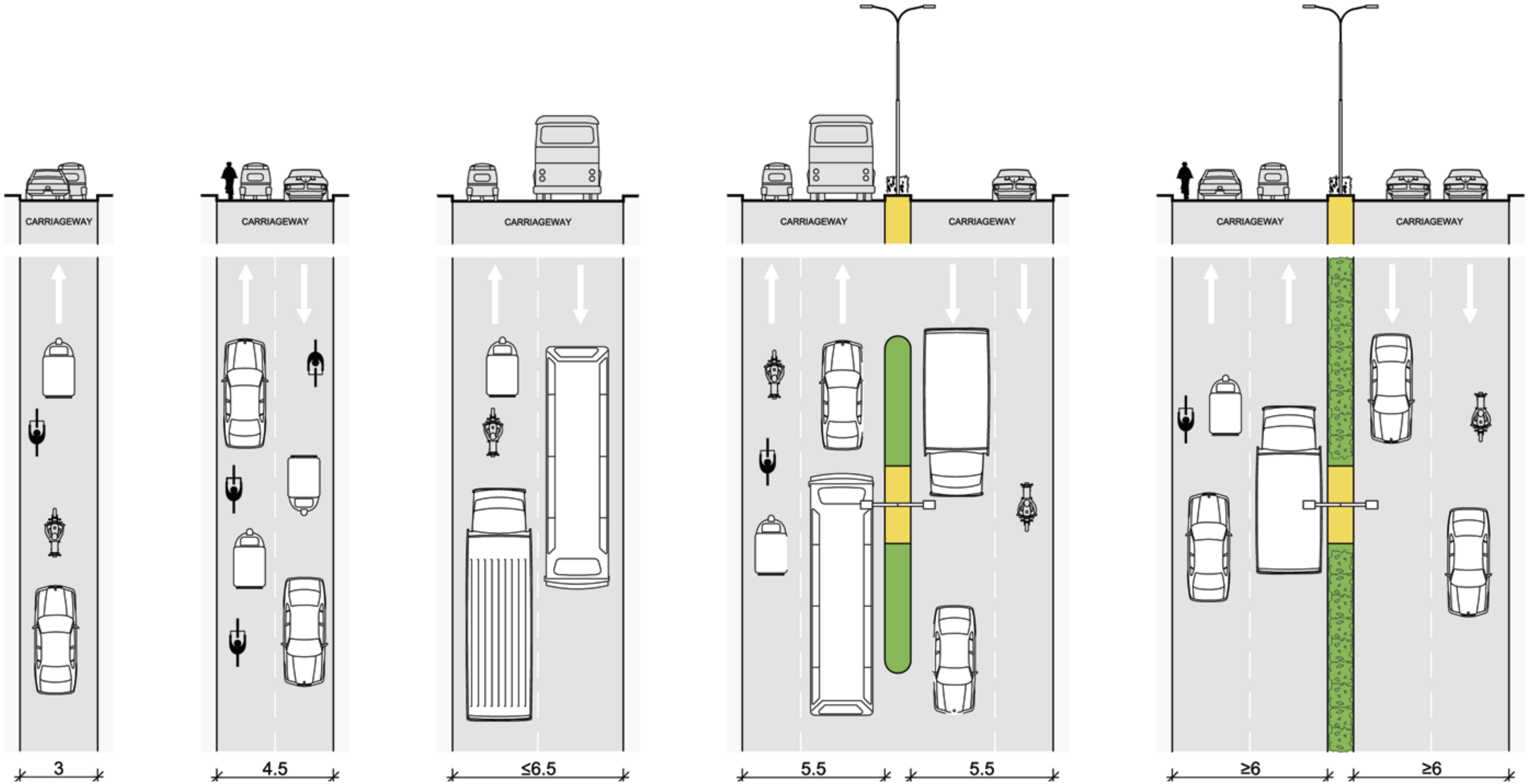


Figure 2.11 In a slow-speed local street (below 30 km/h), the optimum width for a carriageway is 3 m for one-way movement and 4.5 m for two-way movement.

In local streets that need to accommodate buses and trucks, the width of a two-way carriageway can vary between 6 and 6.5 m, depending on the volume of heavy vehicles.

In a collector street, the optimum width for the carriageway is 5.5 m per direction.

In arterial streets, the optimum widths for two and three implied lanes are 6 m and 8.5 m, respectively, in each direction. When considering carriageways wider than 6 m per direction, one should keep in mind that they easily lead to excessive speeds, wrong-way driving, and encroachments such as parking.

2.4 Bus rapid transit

Figure 2.12 This BRT station facilitates high quality service for passengers since it is located in the median and operates with level boarding. It also leaves sufficient queuing space at the intersection.

✘ Figure 2.13 BRT frees buses from traffic congestion so that they can provide prompt, reliable service. However, the width of this BRT station and its location directly at the intersection create unnecessary congestion, resulting in longer delays for bus riders and private vehicle users alike.

What good BRT achieves

Bus rapid transit (BRT) can offer high-capacity and high-quality public transport—similar to a metro rail but at a lower cost—by providing an exclusive right-of-way for BRT buses.

Significance of BRT

Urban growth and rising car ownership are causing severe road congestion. Longer travel times make existing bus transport less attractive, reducing public transport patronage and increasing private vehicle use. BRT can break this vicious cycle by maintaining competitive travel times and reliable scheduling in road-based public transport. BRT is the only financially viable option for providing high quality public transport service to a majority of urban residents in a short time span. BRT with median bus lanes also improves safety for cyclists by eliminating conflict points at bus stops.

Challenges to better BRT

The key challenge to implementing segregated bus lanes, especially in narrow roads carrying high volumes of private motorised traffic, is only political. Exemplary interventions in constrained widths are observed in Guayaquil, Quito, and Mexico City. Hence, we provide BRT templates for streets as narrow as 18 m in this guide.

Treating BRT only as a road infrastructure improvement leads to low capacity and poor system quality. Besides good physical design, successful implementation of BRT requires system management, operations planning, a dedicated BRT bus fleet with easy boarding and alighting, and sound placement of stations.

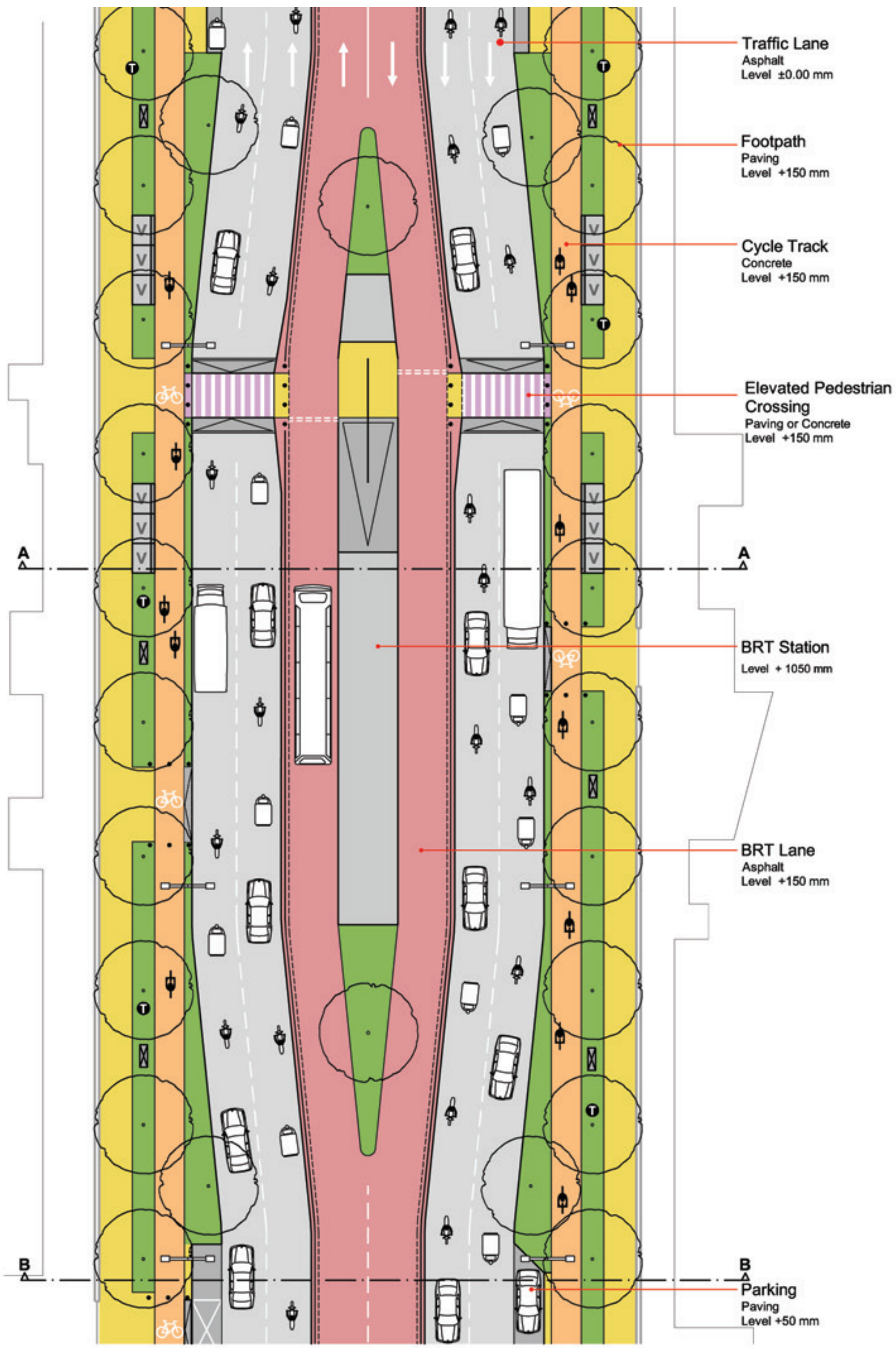
BRT can become a barrier to pedestrian and cyclist movement if at-grade crosswalks are not provided at reasonable intervals. Passengers may have trouble reaching bus stations unless pedestrian refuges and traffic calming measures improve pedestrian safety.

Finally, BRT requires steady enforcement to keep private vehicles from using BRT lanes or obstructing the path of BRT buses at intersections.

Design criteria and standards

BRT designs should satisfy the following:

- Exclusive bus lanes must be provided in the centre of the street except on small streets where mixed traffic runs as one-way on only one side of the street
- The width of a BRT lane is 3.3 m, plus buffer space next to mixed traffic
- At crossings, a 1 m pedestrian refuge between mixed traffic and a BRT lane is needed
- Centrally located BRT stations require 3 m (preferably 4 m) in the cross section. Larger widths may be required if demand is high
- Safe pedestrian access via crosswalks elevated to the level of the footpath (e.g. +150 mm)
- Stations should be placed 37 m or more off intersection stop lines to allow sufficient space for bus and mixed traffic queues
- To achieve capacities as high as those of metro systems, passing lanes, substations, and express services are required at BRT stations
- Cycle parking is needed at stations



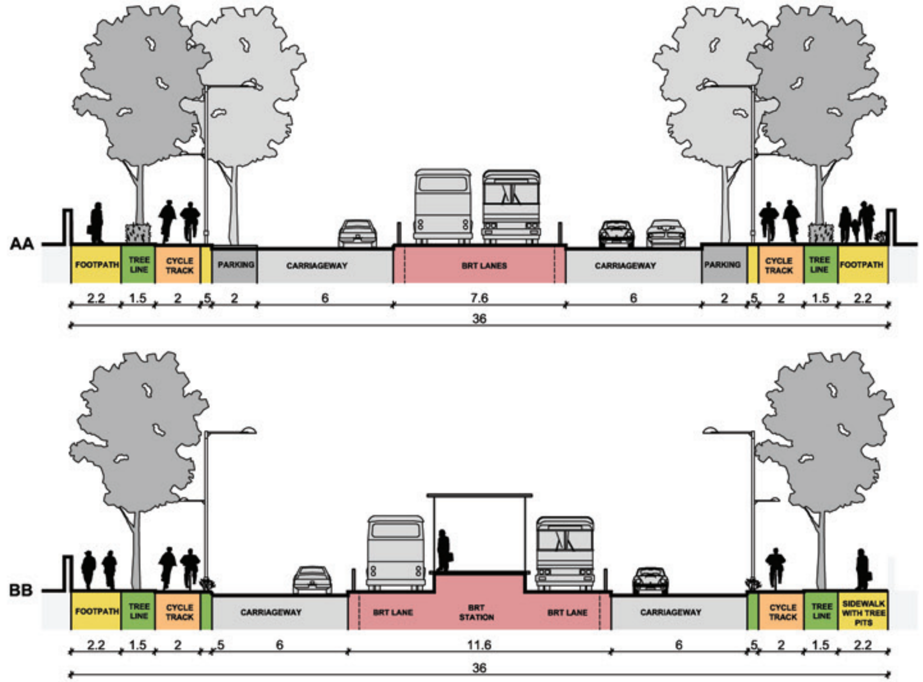
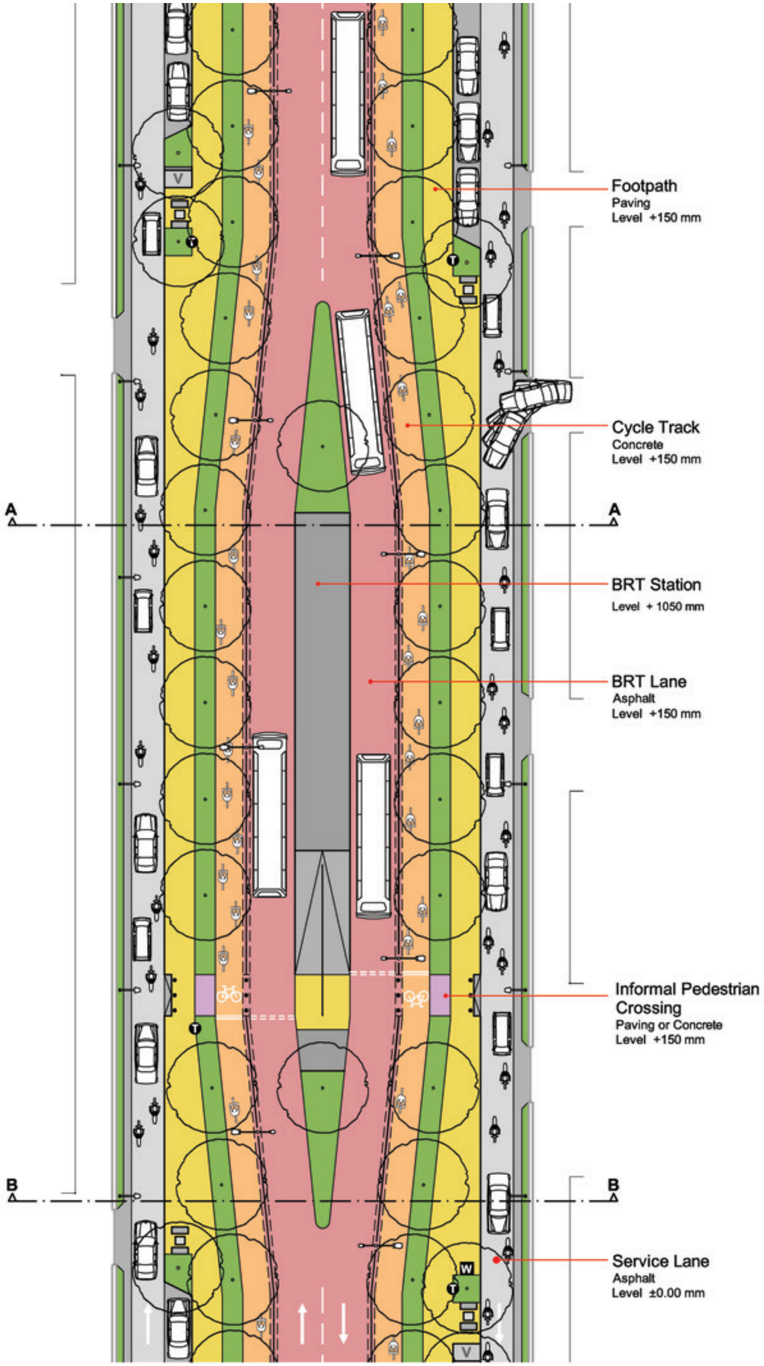


Figure 2.14 This typical BRT alignment on a 36 m street can already accommodate large passenger volumes of up to 6,000 passengers per hour per direction (pphpd) with 12 m buses. With articulated buses, a single-lane system can carry 10,000 pphpd.

The BRT lanes plus buffer normally occupy 7.6 m in the street cross section. At stations, the width increases to 11.6 m. The additional 4 m width needed for the station is gained by ending the on-street parking lanes.

Pedestrian access to the station is provided via a raised crosswalk (elevation +150 mm relative to the carriageway) to ensure safety.



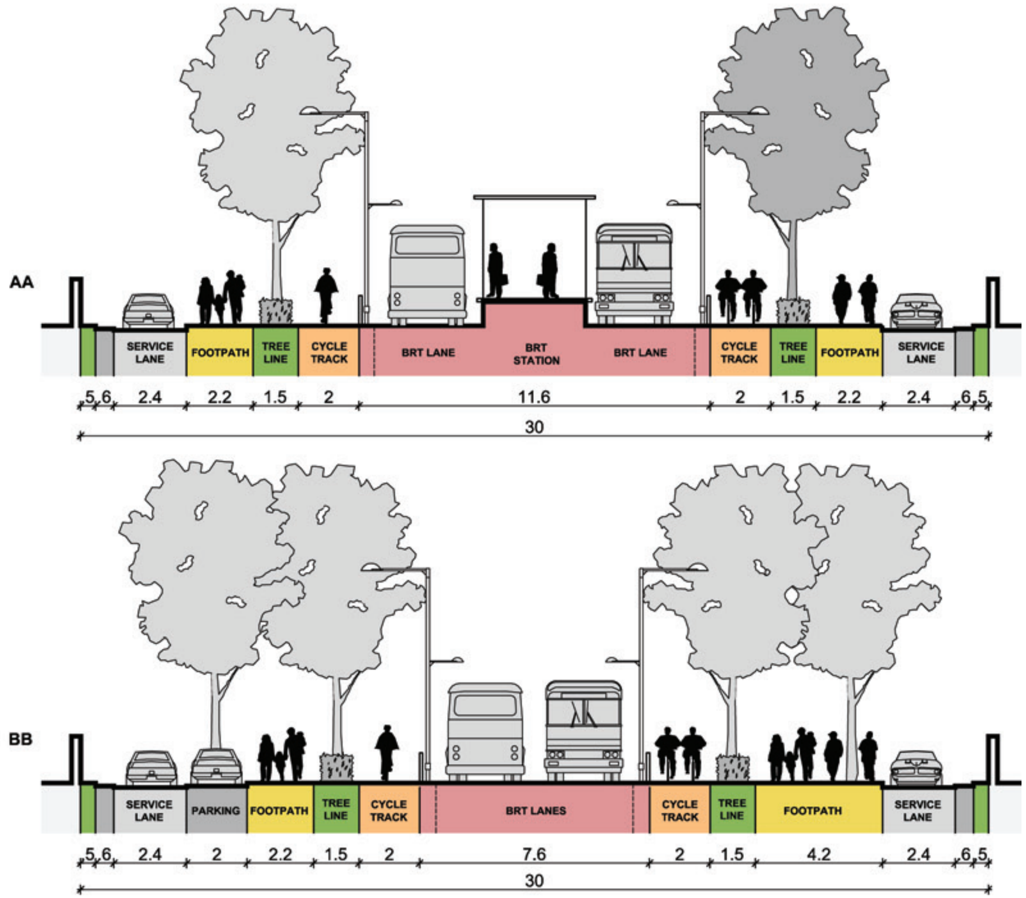


Figure 2.15 A 30 m right-of-way can accommodate BRT along with pedestrian footpaths, cycle tracks, on-street parking, and a local street carriageway. In order to accommodate the BRT station, the parking lanes are discontinued.

Note that even narrower rights-of-way are capable of supporting BRT systems. Refer to the 18 m and 24 m templates in Chapter 4. In roads of 30 m or less, vehicle access to properties on both road edges can be provided by building service lanes on either side of the BRT lanes.

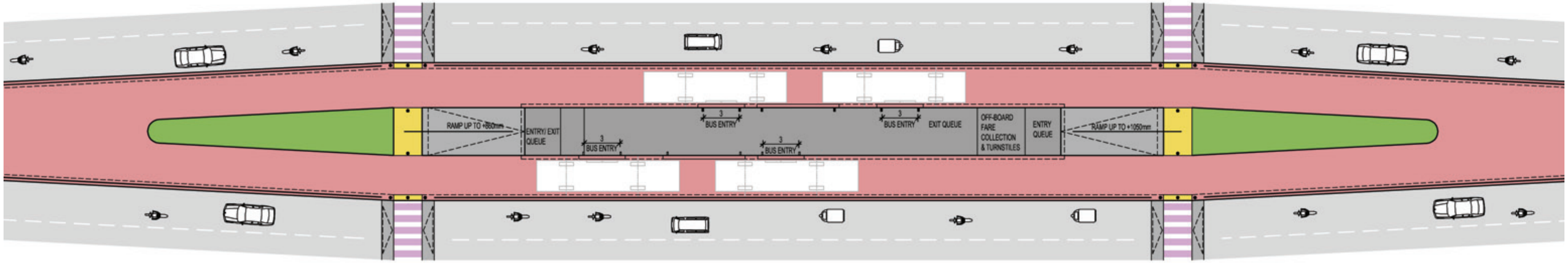
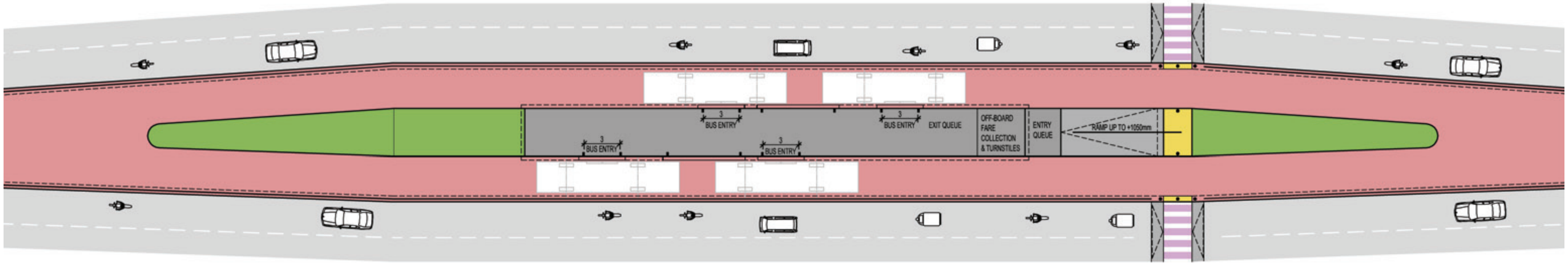
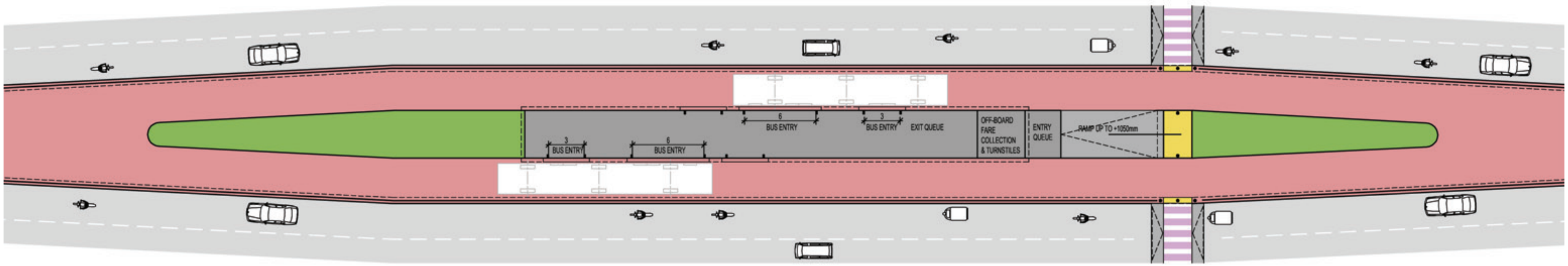
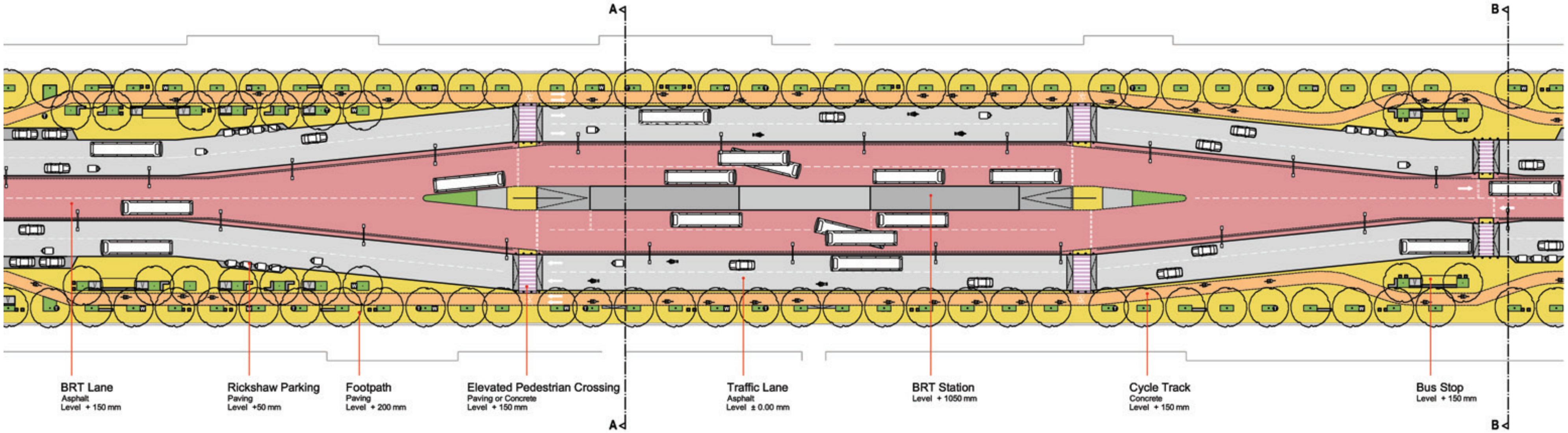


Figure 2.16 A typical BRT station (above) designed for 12 m buses requires sufficient length for passenger access ramps, ticket vending, turnstiles, boarding/alighting, and internal circulation. For stations with lower demand, a single entrance may be provided (below). The design provides two docking bays to increase system capacity.



Docking bays should be staggered to reduce friction between passengers boarding and alighting on opposite sides. Docking bays for 18m articulated buses (below) consist of two openings: a front opening of 3 m and a rear opening of 6 m.





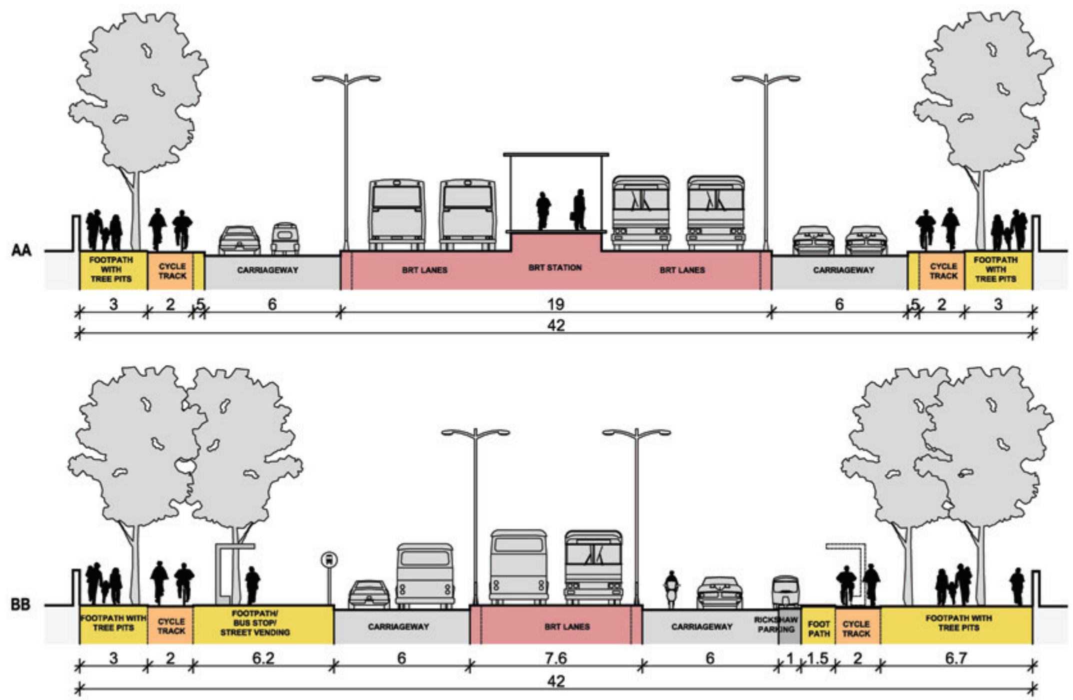
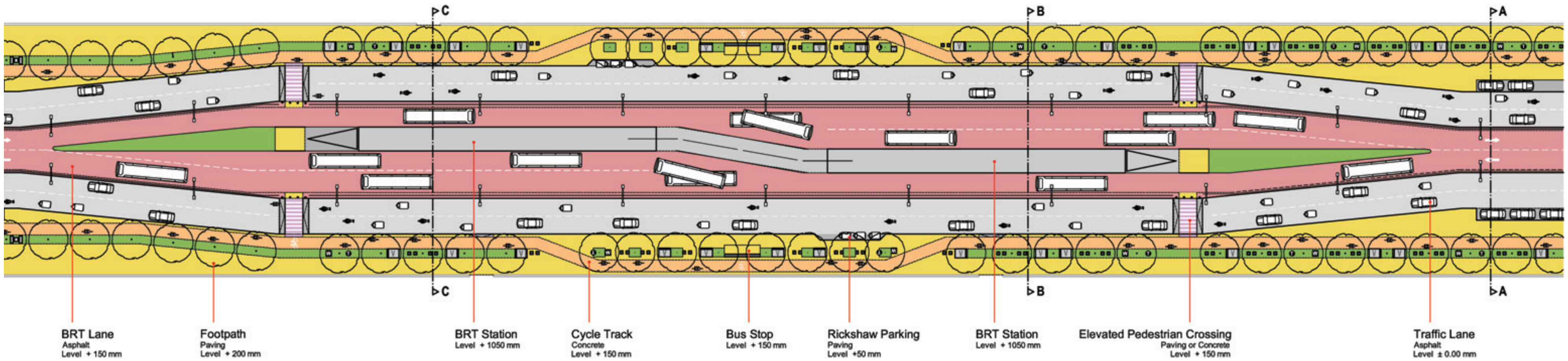


Figure 2.17 Passing lanes can increase the passenger capacity of a BRT system by allowing express buses to overtake local buses at certain stations. The Transmilenio BRT system in Bogotá, Colombia, carries 45,000 passengers per hour per direction through the use of passing lanes. Passing lanes also may be required if separate routes converge on a single corridor in a city centre context.

In this example, the station is comprised of two modules. Each module has one docking bay per direction, plus queueing space for one bus behind the docking bay. A 21 m gap for bus manoeuvring is provided between the modules. To allow for bus manoeuvring, the cumulative width of the stopping and passing lanes is at least 7 m.



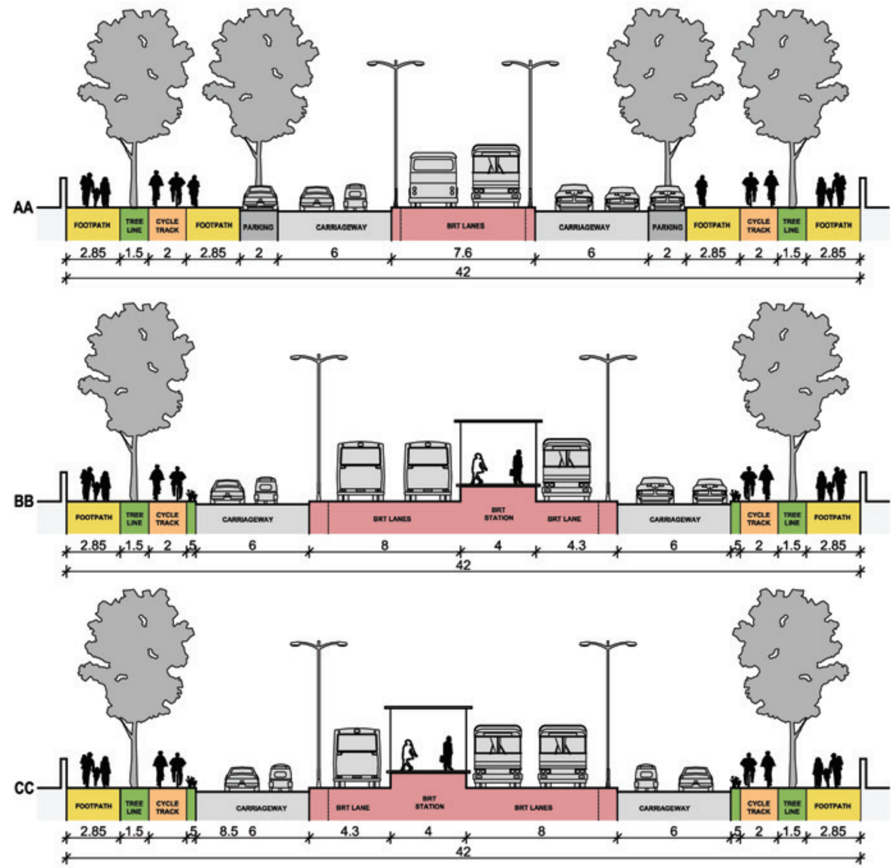


Figure 2.18 To accommodate passing lanes in a narrow profile—or to provide more space for other uses such as pedestrian and cyclist mobility and informal activities—separate offset platforms can be provided in each direction.

Compared to the design on the facing page, this design is able to fit in a narrower right-of-way or, as shown above, to maintain median tree lines and extra footpath width next to the station in a 42 m right-of-way. However, the design also requires a significantly longer stretch for accommodating the station.

2.5 Medians and pedestrian refuges

Figure 2.19 This opening in a median allows pedestrians to cross without climbing over the fence and waiting on the carriageway.

✘ Figure 2.20 This median fence is continuous, forcing pedestrians to climb over. There is no safe refuge, so pedestrians often stand in the carriageway while waiting for a break in the traffic.

What good medians achieve

A good median reduces conflict between opposite directions of traffic and acts as pedestrian refuge but has frequent enough breaks to discourage motor vehicle users from driving in the wrong direction.

Significance of medians

Medians can help streamline traffic and ensure safety on higher-speed streets where there is a risk of collisions involving right-turning traffic. In addition, they prevent speeding drivers from crossing into the opposing traffic lane.

Medians improve safety for pedestrians by functioning as refuge islands, which allow pedestrians to cross one direction of travel at a time. It is much easier to find an adequate gap in half the traffic flow rather than all of it.

Central medians can accommodate other elements such as landscaping, pedestrian and cycling boulevards, and parking.

Challenges to better medians

Medians that extend too far without any opportunities to cross, turn right, or make a U-turn make the other side inaccessible and unnecessarily increase the total distance travelled. They encourage vehicle movement on the wrong side, thereby compromising safety. Hence, the provision of breaks in a median at appropriate intervals is critical.

Sometimes, guardrails or high curbs are built to prevent pedestrians from crossing the street. However, they are surmounted anyway. If a median is not wide enough, pedestrians may spill over into the carriageway while waiting for traffic to clear (see Section 2.6 for more on pedestrian crossings).*

Design criteria and standards

Medians should satisfy the following:

- If the curb-to-curb carriageway width is 11 m or narrower, periodic pedestrian refuges can enhance safety
- On an artery where the curb-to-curb carriageway width is 12 m or wider, a continuous median surmountable by pedestrians (maximum elevation 150 mm) is advised
- In order for the median to function as a safe pedestrian refuge, a minimum width of 1 m should be provided. A cycle refuge should be 2 m wide
- Guardrails and high curbs are discouraged because they hinder pedestrian and cycle movements. They should be provided only on carriageways with a curb-to-curb width of 18 m or larger, with a break for pedestrian crossing every 50 m
- Adjacent to BRT lanes, longer stretches of guardrail can be provided, with breaks only at formal crossings (150–200 m)

* In special cases such as expressways that are uninterrupted for kilometres, medians should be completely unsurmountable rather than simply difficult to mount. However, creating expressways in urban environments is strongly discouraged.

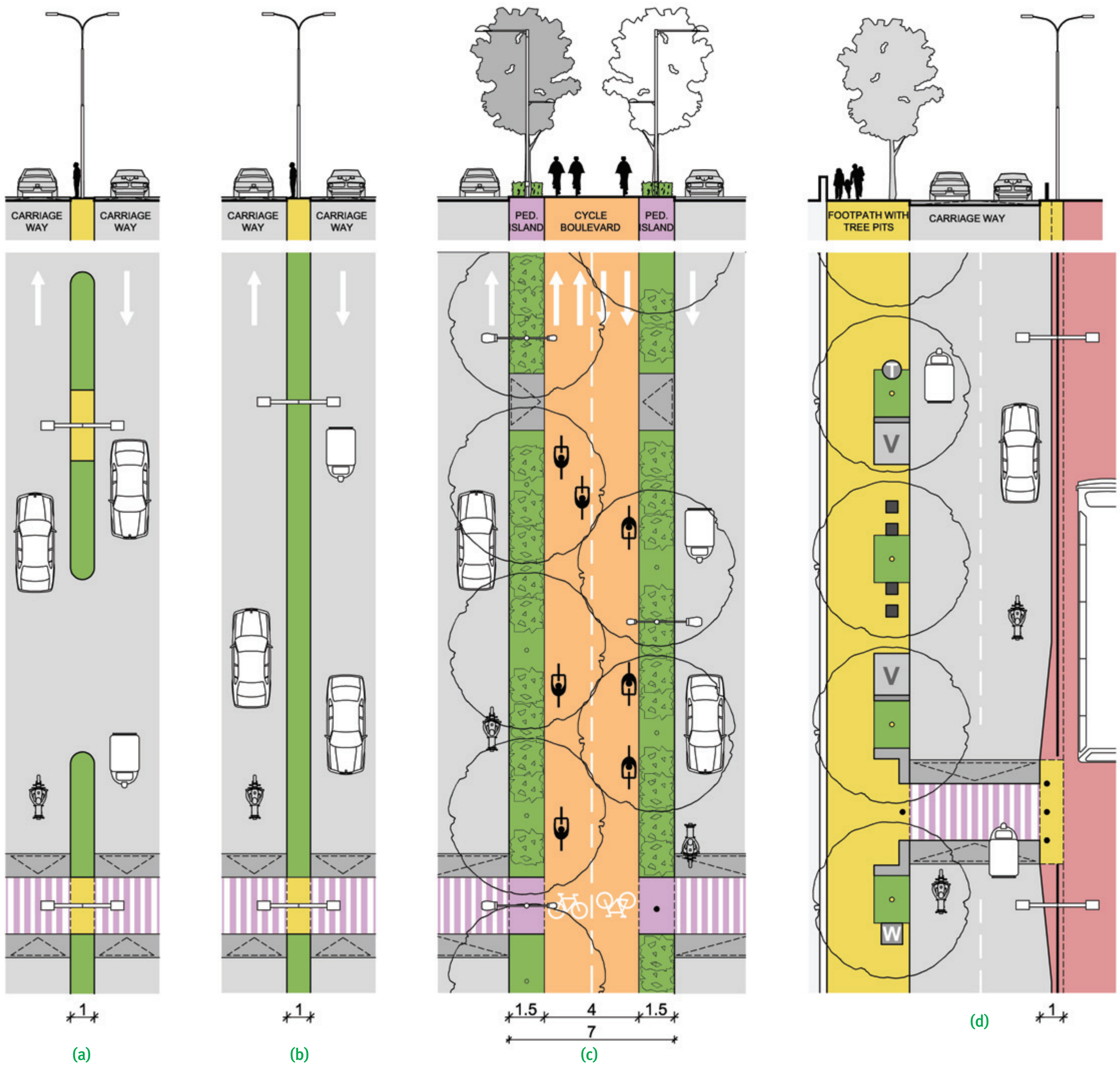


Figure 2.21 Medians can serve as pedestrian refuges if sufficiently wide (1 m or more).

(a) On a collector street, periodic median segments between formal crossings function as pedestrian refuge islands.

(b) On an artery with higher traffic volumes, a continuous landscaped median is provided. Periodic hardscaped sections function as pedestrian refuges.

(c) Median cycle boulevards reduce conflicts between cycles and motor vehicles and avoid encroachment by parked vehicles. To make the median accessible to cyclists starting or ending their trips, ramps should be provided in the landscaping buffer at regular intervals (of about 50 m).

(d) The buffer between a BRT lane and the carriageway is widened to 1 m in order to serve as a pedestrian refuge at formal crossings. Informal crossings are not provided in a BRT median, and formal crossings should be provided at more frequent intervals.

2.6 Pedestrian crossings

Figure 2.22 This painted crossing is completely ineffective. Since drivers do not observe painted road markings, the only means of ensuring pedestrian safety is physical treatment, perhaps assisted by enforcement.

Figure 2.23 This raised pedestrian crossing compels vehicle users to slow down. The height of the crossing is the same as that of the adjacent footpath, improving convenience for pedestrians.

What good pedestrian crossings achieve

Good pedestrian crossings allow pedestrians to cross busy streets safely and conveniently.

Significance of pedestrian crossings

When paired with traffic calming elements such as speed tables, they can improve safety and create a seamless connection between the two sides of a street.

Challenges to better pedestrian crossings

Many cities have sought to increase vehicle speeds by erecting barriers to prevent pedestrians from crossing. Pedestrians are forced to use overbridges or subways, which are inconvenient, potentially unsafe with regard to sexual assault and general crime, and often double as urinals. Even the benefits for motor vehicles may be dubious as high mid-block speeds do not necessarily translate into higher overall throughput.

Due to the difficulty and risks associated with the use of overbridges and subways, pedestrians continue to cross at ground level. In that case, pedestrians cross at random locations and do not benefit from the safety that crossing in groups at planned at-grade crossings can provide.

Measures that discourage walking induce more motorised trips, exacerbating traffic congestion. This tempts policymakers to build more high-speed roads that disrupt pedestrian movement even more. Properly designed pedestrian facilities can help break this vicious cycle.

When pedestrian crossings are provided, they are often indicated only by painted zebra markings. Since drivers in many cities do not follow painted markings, such crossings do not provide any safety benefit to pedestrians.

Design criteria and standards

The following design criteria apply:

- Except on expressways, pedestrian overbridges and subways are to be avoided
- Raised crosswalks should be elevated to the level of the adjacent footpath (150–200 mm above the road surface) with ramps for motor vehicles. The slope for vehicles should be at least 1:4
- Raised crosswalks should be located at all intersections (both signalised and uncontrolled) and at frequent intervals (e.g. every 150–200 m)
- Crosswalks should be as wide as the adjacent footpath and never narrower than 2 m
- Where fences are installed to prevent crossing, informal crossings in the form of breaks in the fencing should be provided wherever there is demand. The fence should be discontinued for at least 2 m in order to create a refuge island so that pedestrians do not spill over into the main carriageway. Given that opportunities for informal crossings should be given rather frequently, no treatment in the main carriageway should be given
- At formal and informal crossings, parking lanes should be converted to bulb-outs to reduce the crossing distance

For more information on the design of pedestrian crossings at intersections, see Chapter 4.

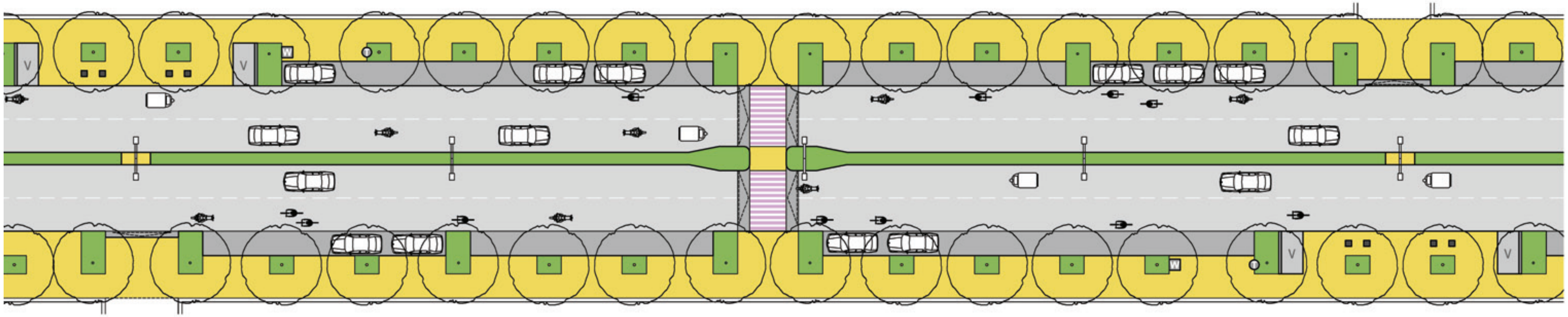
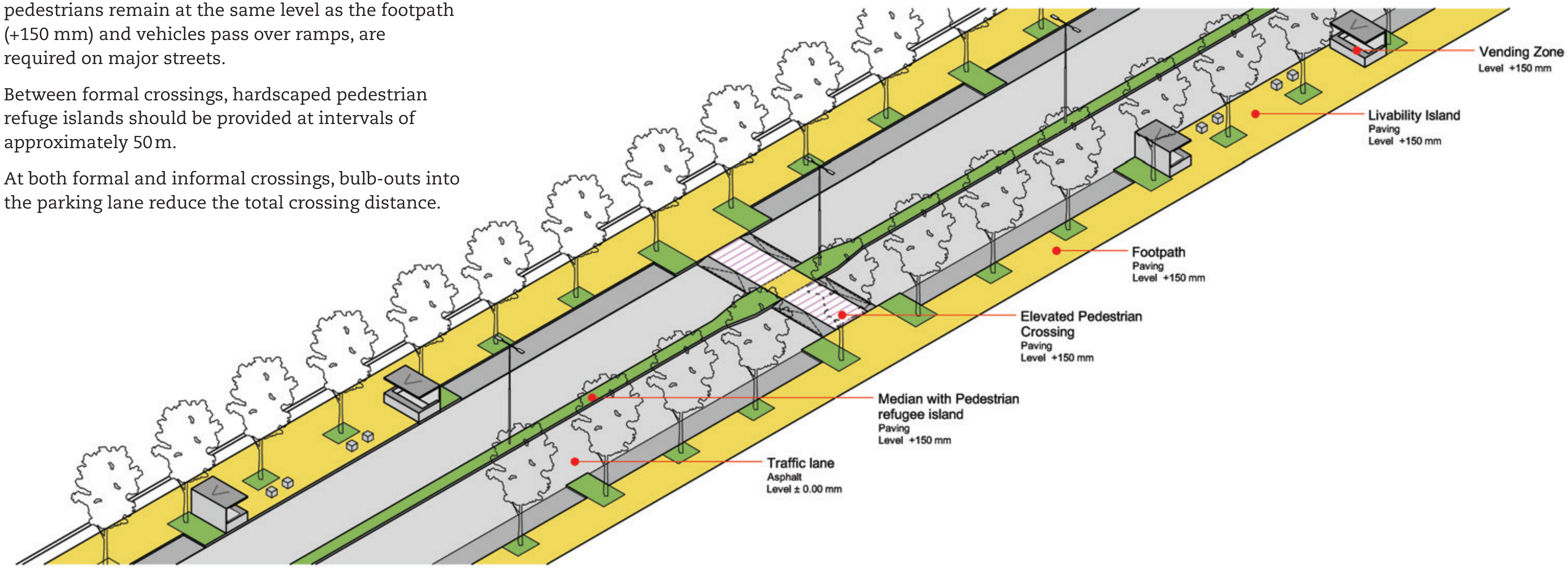


Figure 2.24 Formal pedestrian crossings, in which pedestrians remain at the same level as the footpath (+150 mm) and vehicles pass over ramps, are required on major streets.

Between formal crossings, hardscaped pedestrian refuge islands should be provided at intervals of approximately 50 m.

At both formal and informal crossings, bulb-outs into the parking lane reduce the total crossing distance.



2.7 Landscaping

Figure 2.25 Landscaping, especially tree cover, can make the streetscape more beautiful and can improve comfort for pedestrians and cyclists.

Figure 2.26 Tree lines should be arranged so that shade falls on footpaths and cycle tracks. Landscaping buffers can enhance the psychological separation between the carriageway and the cycle track or footpath.

What good landscaping achieves

Landscaping improves the liveability of streets. It plays a functional role in providing shade to pedestrians, cyclists, vendors, and public transport passengers. It also enhances the aesthetic qualities of streets.

Significance of landscaping

Effective greening with street trees reduces the street temperature, making it comfortable for people to walk, cycle, or gather for social activities, even during summer afternoons. This is especially important in places with a humid climate or harsh daytime sun. On a larger scale, plants keep a city cool by reducing the urban heat island effect.

Trees also capture dust and remove glare. During storms, they reduce wind velocity. Additionally, trees can help reduce vehicle speeds by reducing the actual or the perceived width of a street.

Landscaping can beautify a street, providing an umbrella canopy and adding colours, fragrances, and textures. The potentially varied character of flora along a street can make it a more memorable space. A well-designed landscape promotes a sense of ownership among nearby residents or shop owners such that they contribute towards its upkeep. Finally, landscaping can incorporate fruit-bearing and medicinal or religious trees and shrubs.

Challenges to better landscaping

Good landscaping in cities with hot climates employs trees extensively to create shaded street environments. Unfortunately, greening of streets is often seen only as a beautification exercise, favouring low shrubs and flowers, which serve an aesthetic function but do little else to improve comfort for pedestrians and cyclists.

Trees are often avoided out of fear that drivers will run into them, or that they may disturb the carriageway, storm water pipes, and other utilities.

Design criteria and standards

Landscaping should satisfy the following:

- Appropriate distance between trees to provide continuous shade, depending on the individual trees' canopy size and shape. In dry climates where trees do not grow very fast, closer spacing is necessary
- Tree pits locations should be coordinated with the position of street lights
- Medium-height vegetation should be trimmed directly adjacent to formal crossings to improve the visibility of pedestrians and cyclists
- Trees with high branching structures are preferable
- Tree pits should have dimensions of at least 1.5 m by 1.5 m to accommodate roots at full maturity. On narrow sidewalks, the same surface area can be achieved with 1 m by 2.25 m tree pits. Hume pipes can lower the level at which roots spread out, thereby reducing damage to road surfaces and underground utilities

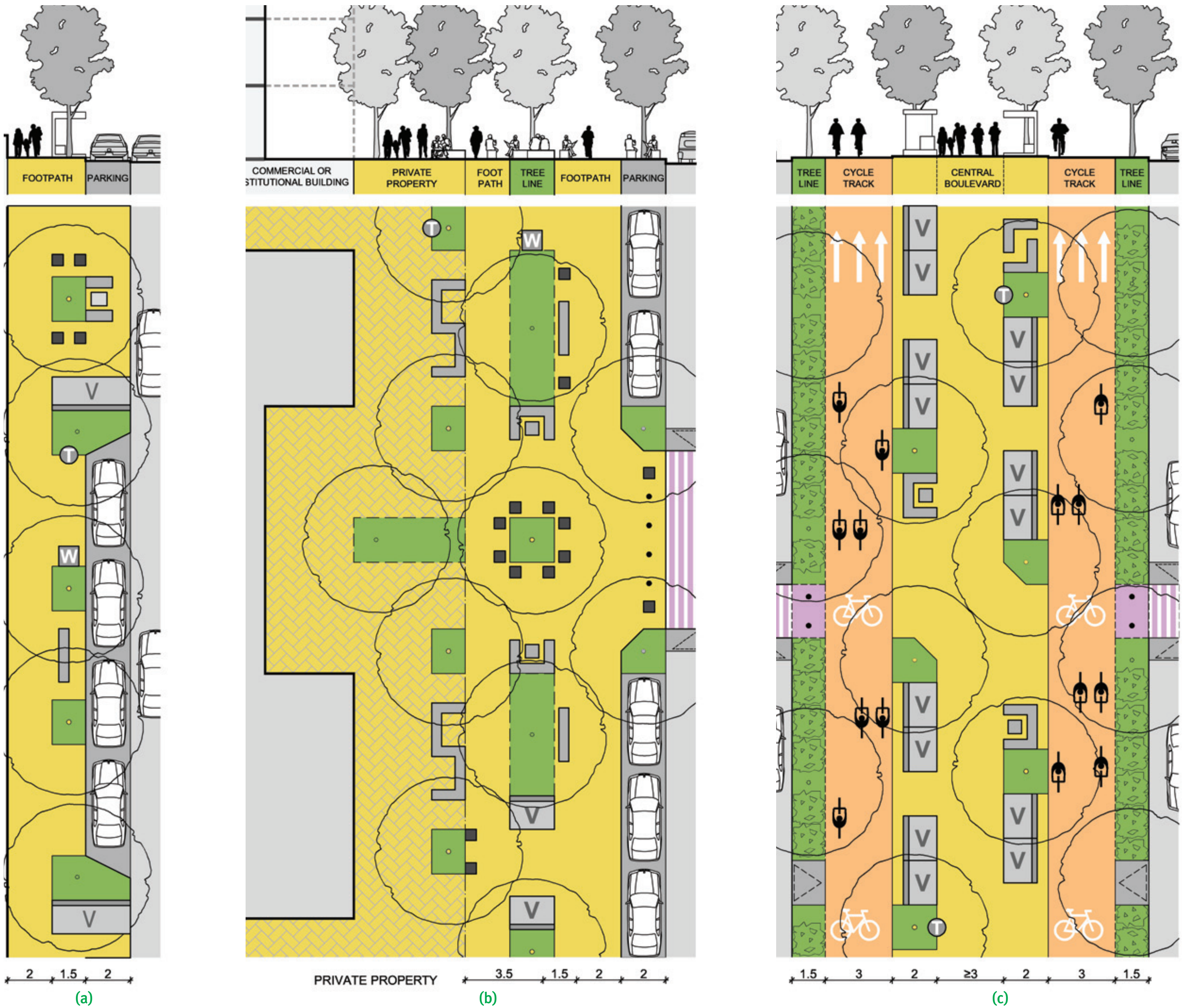


Figure 2.27 Landscaping treatments

(a) Every footpath should have a continuous tree line. Landscaping may extend into bulb-outs in the parking lane but a single tree line should be maintained in order to improve compatibility with underground utility lines. A continuous tree line is preferable to trees placed in the parking lane.

(b) Landscaping can enhance the character of market areas and commercial streets. The design of the public right-of-way can be coordinated with that of adjoining properties, creating large public spaces.

(c) A median pedestrian and cycle boulevard can incorporate four separate tree lines. The two exterior tree lines become landscaped buffers between the carriageway and cycle track, while the interior tree lines are great places for integrating other elements such as street furniture, amenities, and vending places.

2.8 Bus stops

Figure 2.28 This bus stop provides protection from the elements, is elevated above the carriageway, displays customer information, and has a clear identity.

✘ Figure 2.29 This bus stop is far from where buses actually stop, forcing riders to stand in the dirt and mud. In this way, it not only harasses passengers but also discourages other potential users by conveying a very negative image of the public transport system.

What good bus stops achieve

Good bus stops are easy to identify, provide safe and comfortable passenger waiting space, are conveniently located near street crossings, and do not obstruct pedestrian paths and cycle tracks.

Significance of bus stops

Bus stops are the interface between the street and a city's public transport system. They can help make the bus network usable and attractive to city residents. Since the time spent waiting at a bus stop is one of the more burdensome stages in a public transport trip, the passenger's experience at a bus stop has a significant effect on the overall perception of the service.

Challenges to good bus stops

Often bus stops are positioned against the far left edge of the right-of-way, assuming that buses will pull over into a "bus bay" or to the outer edge of the street. However, bus drivers generally stop in their original linear path so that passengers are forced to walk into the mixed carriageway to board the bus. Vehicles behind the bus sometimes attempt to pass on the left, causing a hazard for passengers.

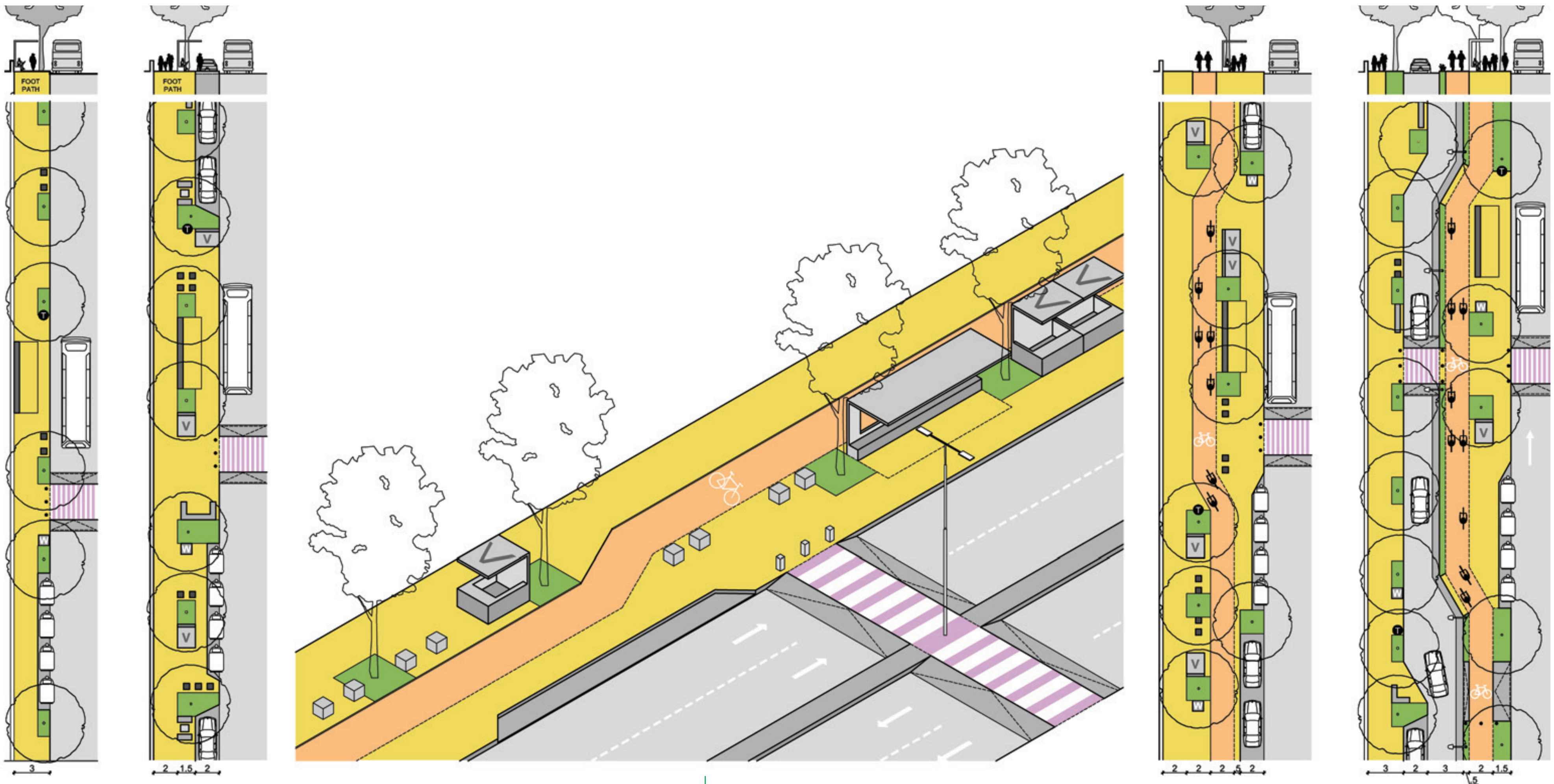
Additionally, if the bus stop is placed against the edge of the right-of-way, either the shelter itself or the waiting crowd may disturb longitudinal pedestrian and cycle movements.

Bus stops are often oriented such that waiting passengers need to stand at the lowest point in the street cross section. During the rainy season, these areas become flooded and muddy.

Design criteria and standards:

Bus stop placement should follow these criteria:

- Spacing in busy commercial districts is typically closer than in residential areas. Intervals between stops range from 200–400 m
- Stops should be located near cross streets and always provide for safe pedestrian crossings
- Bus bays are to be avoided. Bus stops should be placed adjacent to the bus' linear line of travel so that the bus does not need to pull over to the left. Ideally, a raised bus stop is integrated with the footpath and other raised elements so that passengers can reach the stop and board the bus directly from the footpath—without needing to step into the carriageway. If there is a parking lane between the footpath and carriageway, the bus stop can be located on a bulbout into the parking lane, giving pedestrians direct access to buses.
- Placement must allow for continuous footpaths and cycle tracks. This may imply diverting the footpath, cycle track, or service lane behind the stop
- Street vending space should be provided
- Dedicated cycle parking should be provided



(a) (b) (c) (d)

Figure 2.30 Bus stop placement for varying footpath widths.

(a) On a footpath of minimum 3 m width, the bus stop is located at the edge of the right-of-way.

(b) If at least 2 m of clear walking space can be provided between compound wall and bus stop, the stop and waiting area should be located near the carriageway. Where a parking lane is present, a bulbout in the parking lane can accommodate the bus stop.

(c) A cycle track should be routed around the back of a bus stop to reduce the chances of pedestrian encroachment. A 50 mm grade difference helps define the boundary between the cycle track and footpath. The bus stop is at the same level as the cycle track, but tree pits, vending stalls, and bollards help define the boundary of the passenger waiting area.

(d) At bus stops, service lanes are preferably discontinued. If this is not possible, service lanes can be offset (by ending the parking lane) to make room for a bus stop between the cycle track and carriageway.

2.9 Spaces for street vending

Figure 2.31 Informal activities enliven public spaces while providing a source of livelihood for vendors and inexpensive goods for customers.

Figure 2.32 Vendors may be more willing to participate in the upkeep of the spaces they use if municipal authorities provide formalised areas for street vending.

What street vending achieves

Well-planned spaces for street vending provide citizens with secure and dignified areas for the trade of goods and services.

Significance of street vending

Street vending offers convenient access to economical goods and services for a wide range of income groups, especially the poor. In India, street vendors constitute 2.5 percent of the urban population.* Assuming a household size of five and multiple income sources, over 10 percent of urban households likely depend on street vending.

Hence, it is important to provide improved and "formal" street vending areas, especially on major streets and near public transport nodes. Well located street vending reduces trip lengths by allowing people to shop on the way to other destinations. Spaces may be rented out to and managed by cooperatives. Formalizing street vending may be seen as a means of poverty alleviation—from point of view both of the vendor and of clients unable to afford more expensive goods and services in formal establishments.

Well-planned vending zones can make urban space more vibrant, promote social supervision, and improve public safety.

Challenges to better spaces for street vending

Existing street design fails to address street vending. Very few streets in India have spaces designated for vending. As a result, vendors end up using spaces intended for others such as footpaths or the carriageway. Where space is limited, conflicts among users lead to scepticism that vending is a legitimate activity in public streets. A common perception is that street vending makes a city look antiquated, dirty, and impoverished. Too often, street vendors play a cat-and-mouse game with the administration and police, which is costly and inefficient for both sides.

In reality, there is usually sufficient space for the formal and informal to coexist—as shown in the street templates (see Chapter 3). And there are numerous successful examples of formalised street vending around the world.

Design criteria and standards

The following criteria should be followed:

- Street vendors should be accommodated where there is demand for their goods and services—near major intersections, public transport stops, parks, and so on
- Supporting infrastructure, such as cooperatively managed water taps, electricity points, trash bins, and public toilets, should be provided
- Vending areas should be positioned so as to ensure the continuity of cycle tracks and footpaths

* Sharit Bhowmik, "Street Vendors in Asia: A Review," Economic and Political Weekly (May 28–June 4, 2005).

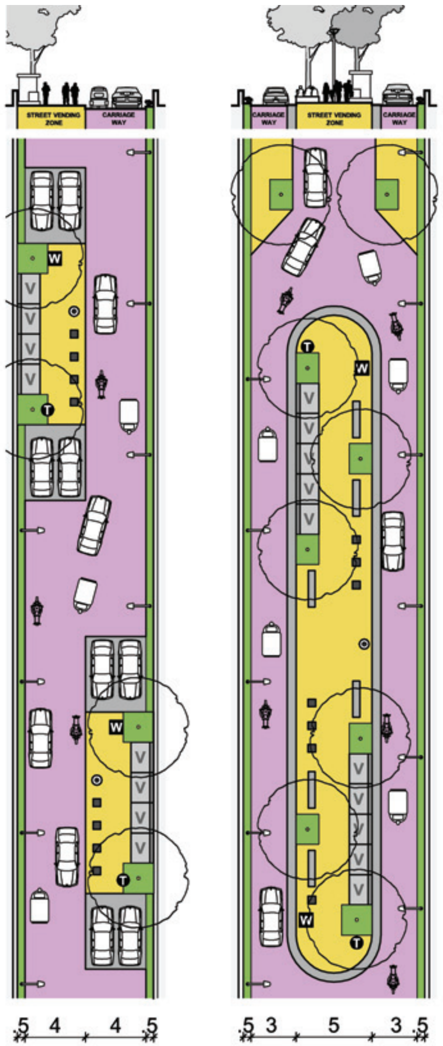
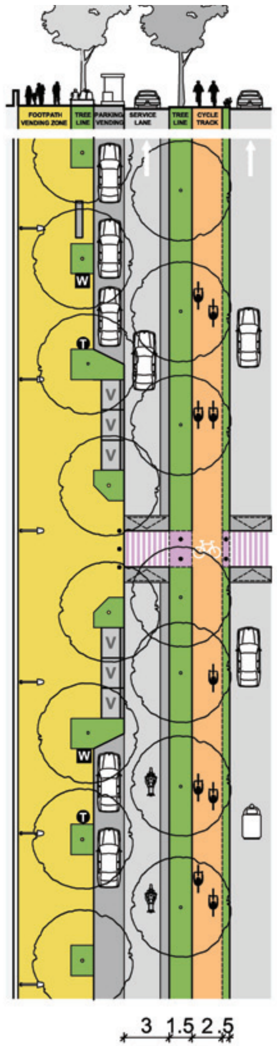
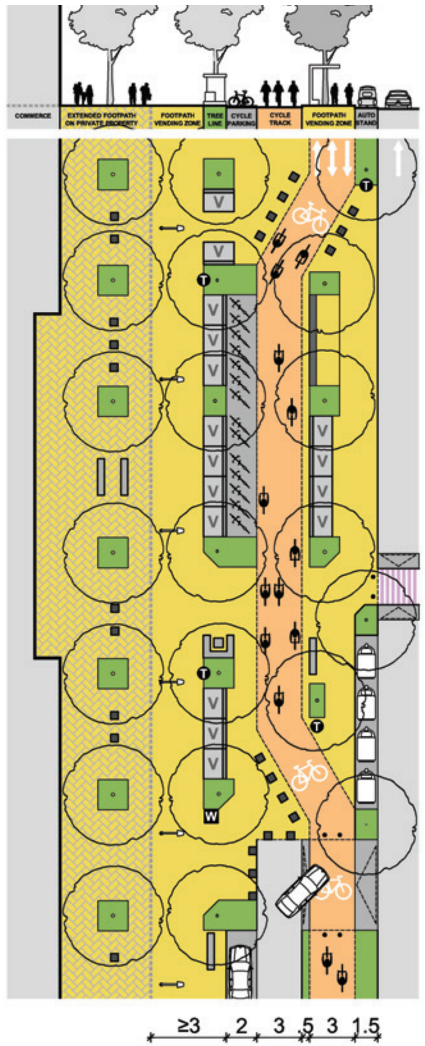


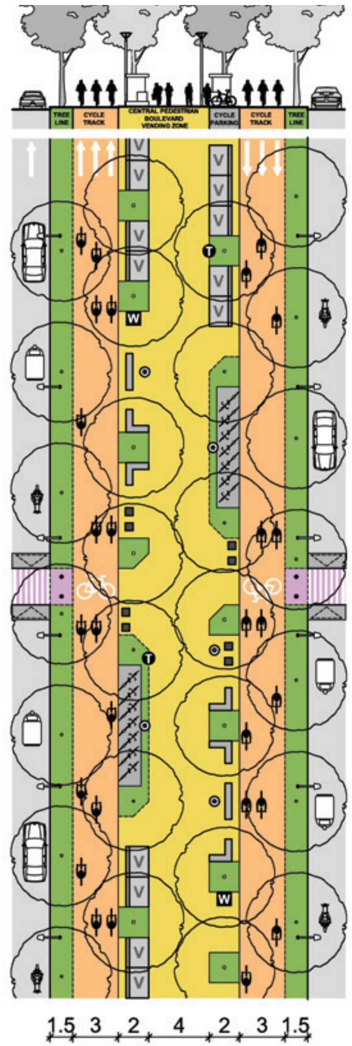
Figure 2.33 Pedestrian islands on meandering streets can accommodate street vendors at regular intervals.



Bulb-outs into the parking lane make room for street vending near a pedestrian crossing.



A service lane is interrupted at a bus stop, making room for a large vending area. This design option is preferred to a continuation of a stand-alone service lane, given that the parking lane must be suspended in any case to accommodate the bus stop.



A large central median accommodates a street market between cycle tracks. Ample seating is provided at regular intervals near the vending stalls.

A simple elevated concrete platform

A fully enclosed shelter

A platform doubling as lockable storage

A concrete platform plus roof, which doubles as a display platform

Figure 2.34 Street vending facilities can take on a number of forms, depending on the level of investment and formalisation.

2.10 Street furniture and amenities

Figure 2.35 Even inexpensive street furniture can facilitate a wide range of activities.

✗ Figure 2.36 Street furniture should be positioned so that it does not obstruct pedestrian and cyclist movements. This garbage can makes it impossible to continue walking on the footpath. If such obstacles are frequent, pedestrians will not use footpaths at all.

What good street furniture achieves

Street furniture provides people places to sit, rest, and interact with each other. Street furniture also includes services-related infrastructure, such as trash cans, street vending, toilets, and signage.

Significance of street furniture

Street furniture can help make a street an attractive place to spend time. When positioned on narrow shared streets, benches, tables, street vending spaces, and other furniture can also function as traffic calming elements.

Vending stands, tables, roofs, and water taps can support the formalization of street vending (see Section 2.10) and promote better sanitary conditions.

Finally, other street furniture, such as way-finding signs and bus stops, provides information.

Challenges to better street furniture

Poorly located street furniture occupies space rather than serving a useful purpose. Furniture and signposts placed in the middle of a footpath can reduce or eliminate the clear space available for walking.

Maintenance of street furniture elements is often inadequate. For example, broken benches are not repaired promptly or garbage bins overflow with rubbish because they are not emptied regularly. The installation of street furniture should be accompanied by a maintenance plan involving local partners.

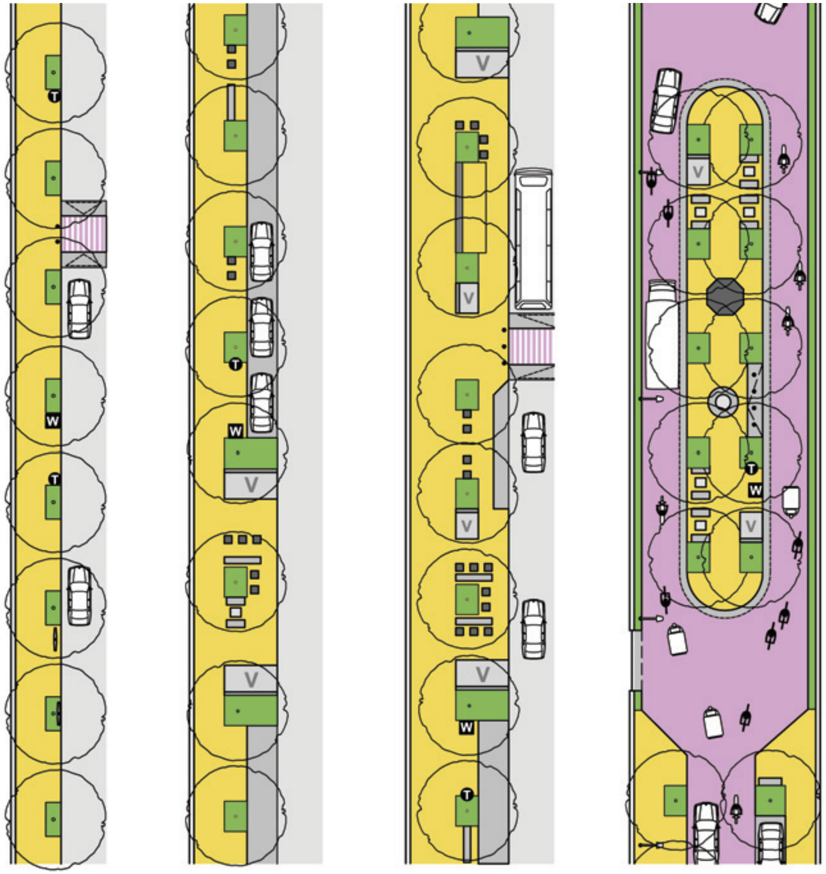
Design criteria and standards

Furniture and amenities should be located where they are likely to be used. Furniture is required in larger quantities in commercial hubs, market areas, crossroads, bus stops, railway stations, and public buildings.

Most street furniture, especially benches and tables, should be placed where it receives shade. Otherwise, it will become too hot to be used during the daytime.

Furniture should be located where it does not obstruct through movement. Bulbouts in parking lanes and street vending islands in shared streets are great places to install furniture. Similarly, a landscaping strip can be broken with street furniture on hardscaped spaces.

On streets with large numbers of pedestrians and commercial activity—especially eateries—trash bins should be provided at regular intervals (possibly every 20 m). On streets with lower pedestrian densities, trash bins can be provided according to adjacent land uses or street activity.



(a) (b) (c) (d)

Figure 2.37 Street furniture and other street design elements that are static (including utility boxes, street lighting, trees, parking, and liveability bulbouts), need to be aligned in order to leave adequate clear width for the movement of pedestrians, cyclists, and motor vehicles.

(a) On a 3 m wide footpath, furniture and amenities should be provided sparingly and in the tree line to maintain a minimum 2 m clear space for walking.

(b) Bulb-outs in a parking lane can accommodate street furniture and amenities without compromising pedestrian mobility.

(c) A parking or service lane discontinued in the vicinity of a bus stop provides space for street vending and furniture.

(d) On a shared street, furniture can be placed on islands that double as traffic calming elements.

Figure 2.38 Best and worst practice in street furniture placement.

✔ These benches are shaded by trees in the adjoining park and leave a large free space for walking.

✘ The placement of this sign post discourages pedestrians from using the footpath.

✔ A tree pit doubles as a bench. Located in the parking lane, the bench leaves enough clear space for pedestrians.

✘ Several benches close the entire width of the footpath to pedestrian through movement.

✔ Vending and furniture at the edges of the footpath leave space for pedestrian movement.

✘ Benches and a sign post completely block the footpath, so pedestrians walk in the carriageway.

2.11 On-street parking

Figure 2.39 This street provides semi-formal parking areas that are accessed from a service lane. The design facilitates the collection of parking fees by delineating parking and no-parking zones and reduces the number of conflict points on the main carriageway.

✘ Figure 2.40 When pedestrians encounter haphazardly parked vehicles, they generally walk next to moving vehicles because this part of the street offers the most direct route.

What on-street parking achieves

On-street parking is clearly designated, managed, charged, and restricted in volume, enabling access to nearby properties without disturbing the flow of motor vehicles, pedestrians, and cyclists.

Significance of on-street parking

On-street parking is seen as being favourable to local business, even though successful business districts without on-street parking can be found around the world.

Free on-street parking subsidises private vehicles. This subsidy is undesirable because it increases private motorised traffic—with all of its negative side effects, including congestion, air pollution, and reduced safety for pedestrians and cyclists.

Hence, on-street parking should be restricted, and whatever parking is available should be charged, not only to counter the mode shift to private vehicles, but also to serve as significant source of funds for the improvement of public space, public transport, and non-motorised transport.

Challenges to better on-street parking

On-street parking areas generally are not designated formally. Instead, parking accumulates organically near points of attraction. On streets with high vehicle volumes, parking may cause delays, especially for buses, and may pose a safety hazard.

Where footpaths are not provided, haphazard parking can create difficult conditions for pedestrians, who are forced to weave their way through the parking area or walk on the right-hand edge of the parked vehicles, in moving traffic. When footpaths and cycle tracks are provided, they often become parking lots for cars and two-wheelers unless physical barriers or law enforcement prevent such encroachment.

The lack of adequate parking fees gives the impression to users that parking is a deemed right. Instead, on-street parking should be treated as a premium service. A high charge encourages short duration parking, thereby allowing multiple users to access the same spot. It also promotes the use of off-street parking.

Design criteria and standards

In contrast to mobility-oriented elements such as carriageways, cycle tracks, or footpaths, parking involves fewer design constraints as it does not require continuous linear space.

Parking should satisfy the following:

- Parking areas should be allotted after providing ample space for pedestrians, cyclists, trees, and street vending
- Tree pits can be integrated in a parking stretch to provide shade. Otherwise, shaded street elements, such as footpaths, may be encroached by parked vehicles
- Near intersections, parking lanes can be discontinued to reduce conflict and to give additional vehicle queueing space
- Dedicated cycle parking should be provided at public transport stops and stations and in commercial districts

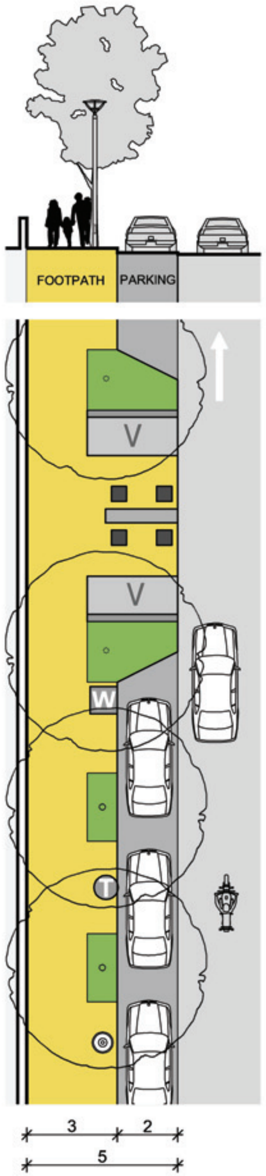
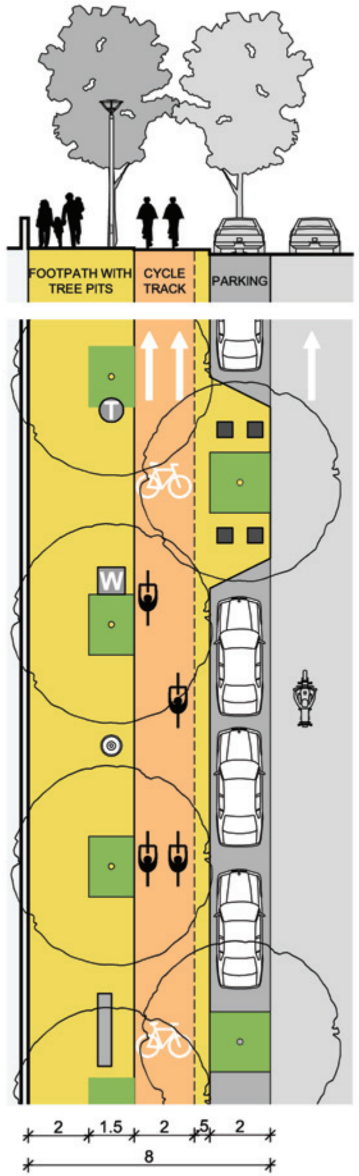
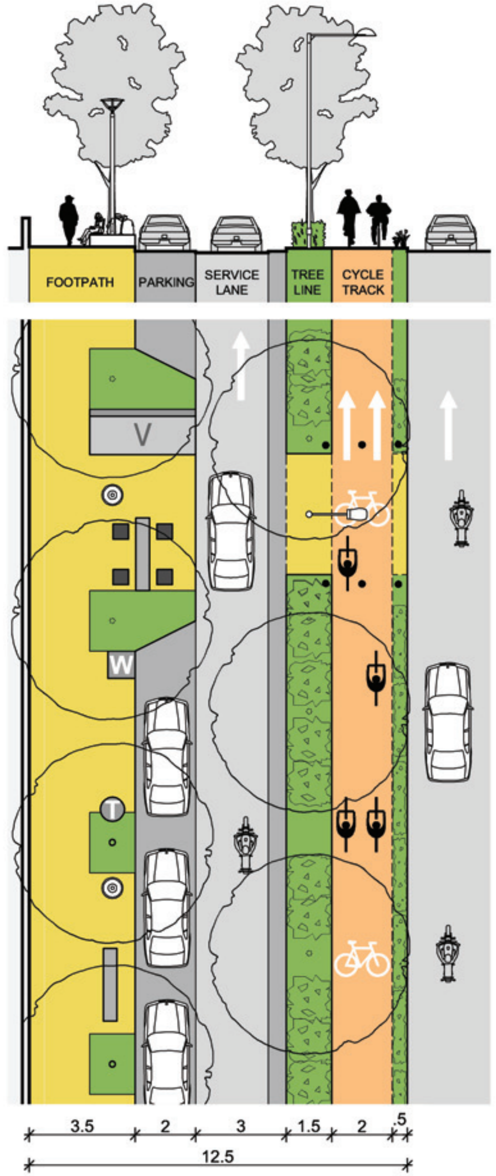


Figure 2.41 Bulbouts between parking areas provide space for street furniture and vending.



Cycle tracks next to parking lanes require a 0.5 m buffer so that car doors do not open over the cycle track.



In service lanes, parking should be located on the left side so that passengers do not spill over on the cycle track when they exit a vehicle.

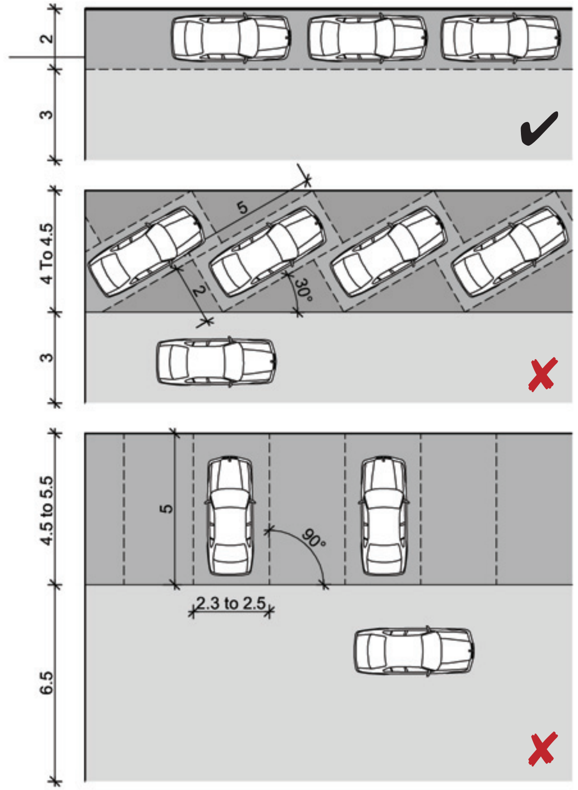


Figure 2.42 Parallel parking for cars is the most efficient parking layout in terms of the number of vehicles relative to the area occupied. The same parking lane can be used as perpendicular parking for two-wheelers.

Table 2.1 Space requirement for various parking layouts. Note that these dimensions differ from values used for larger cars in Europe and the U.S.

Angle (°)	0	30	45	60	90
Manoeuvring space width (m)	3.0	3.0	4.5	5.0	7.0
Parking space width (m)	2.0	2.3	2.5	2.5	2.5
Space per car (sq m)	25	33	33	30	30

2.12 Service lanes

Figure 2.44 The narrow width of this service lane keeps vehicle speeds low and makes it a good shared space. While pedestrians have priority, vehicles can enter the service lane to access on-street parking and adjacent properties.

✘ Figure 2.45 This wide service lane does not function as a safe pedestrian space because it permits vehicles to travel at very high speeds.

What good service lanes achieve

Service lanes improve safety and throughput by segregating property access points and parking from the main carriageway. They also reduce interruptions in cycle tracks and can also serve as pedestrian-priority shared spaces.

Significance of service lanes

Service lanes can increase the mobility function of the main carriageway while also maintaining liveability for non-motorised road users. With reduced speeds because of traffic calming, service lanes can function as slow shared spaces. Paradoxically, the presence of slow-moving vehicles ensures a clear walking space without encroachments by stationary activities.

Service lanes also increase the usability of cycle tracks by reducing the number of interruptions for property access.

Challenges to better service lanes

Service lanes that are too wide encourage fast driving, thus defeating one of the primary roles of service lanes: to provide safe pedestrian space. In particular, it is difficult to maintain priority for pedestrians on service lanes that are wide enough for two-way car movements. In addition, wide service lanes invite encroachment by shops, parked vehicles, or street vendors.

Design criteria and standards

The need for a service lane is determined by the frequency of property access points. If such property access points would interrupt the footpath and cycle track at frequent intervals (more than once every 15 m), a service lane may be warranted.

The position of the footpath relative to a service lane is determined by the character of the private property edge. If the street is lined by boundary walls or setbacks used for vehicle parking, the parking lane should be located at the edge of the right-of-way and the footpath on the carriageway side of the service lane. Such a design is also appropriate if activities on adjacent properties spill over into the public right-of-way.

In residential areas where there is a porous boundary between the street and private properties, the footpath can be placed on the property side. Likewise, in retail areas where there are no setbacks and buildings open directly onto the street, the footpath should be located at the edge of the right-of-way.

Additionally, service lanes should satisfy the following:

- A service lane should be between 2.7 and 3 m wide, with a 2.4 m wide core driveway and the remaining space elevated slightly (e.g. 50 mm). The narrow core driveway discourages fast driving. The elevated area should be next to the adjacent pedestrian footpath or landscaping elements rather than be combined with the parking
- Access into and out of a service lane should be provided via a ramped crossing over the footpath and cycle track, which continue at their original levels

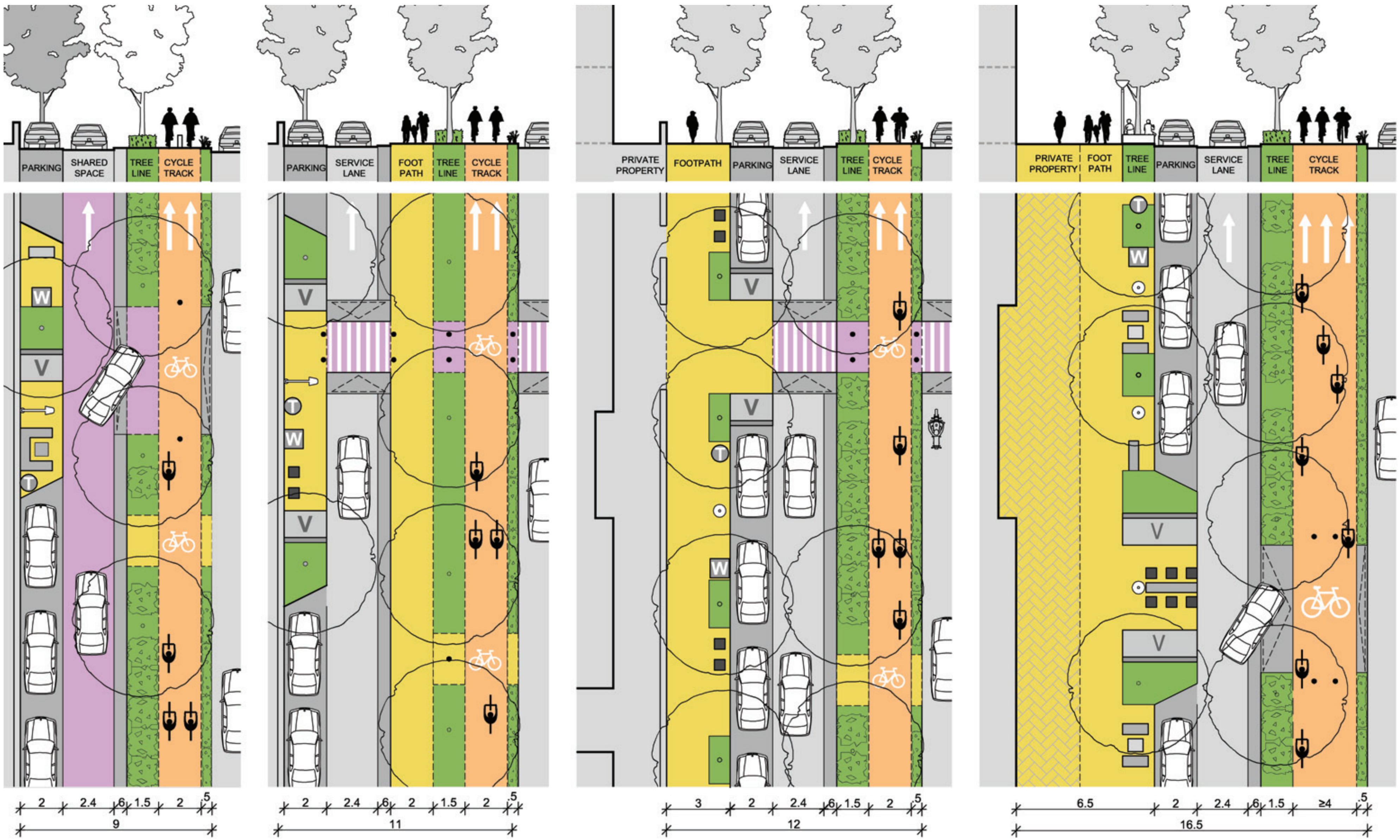


Figure 2.46 If no footpath is provided, parking should be in line with existing trees and/or utility boxes, which are usually on the outer edge.

When boundary walls inhibit interaction between private and public spaces, the footpath should be located between the service lane and the cycle track/carriageway.

Adjacent to plots with semi-permeable boundary walls, the footpath should be located on the outer edge so that it can promote liveability and interaction between public and private open spaces.

Adjacent to active commercial edges, the footpath should be located on the outer edge, where it can combine with private building plazas to create larger pedestrian spaces.

2.13 Traffic calming elements

Figure 2.47 This left-turn pocket is raised and textured, helping to reduce car speeds and improving safety for cyclists who must merge with the left-turning cars if they wish to continue straight through the intersection.

Figure 2.48 This stone block in an alley shuts out cars and trucks and slows other vehicles by narrowing the space through which they can pass.

What good traffic calming achieves

Well-designed traffic calming elements ensure pedestrian and vehicle safety by reducing at least the speed—and potentially also the volume—of motor vehicles.

Significance of traffic calming

The increased use of private vehicles necessitates traffic calming to ensure that streets remain safe for pedestrians and cyclists. Traffic calming elements are particularly important in places where large numbers of children are present, such as schools, parks, and residential areas.

Given the high rates of noncompliance with painted zebra crossings and even traffic lights, the most effective way to increase the safety of non-motorised users is to slow down motorised traffic forcibly through physical measures such as speed humps, raised speed tables, and bollards.

Challenges to traffic calming

Traffic-calming elements are often implemented on smaller residential streets where speeds are already relatively low. On arterial streets, traffic calming is rejected on the grounds that it hinders traffic flow. A more balanced approach is necessary, especially for arterial streets that also accommodate large volumes of pedestrians.

Some traffic calming elements, such as speed bumps and speed tables, are easy to implement, but others, including roundabouts and textured pavements, are difficult to construct and may appear expensive. However, traffic calming can provide major benefits at a nominal expense compared to the overall cost of road infrastructure. Roundabouts have the benefit of improving both safety and traffic flow.

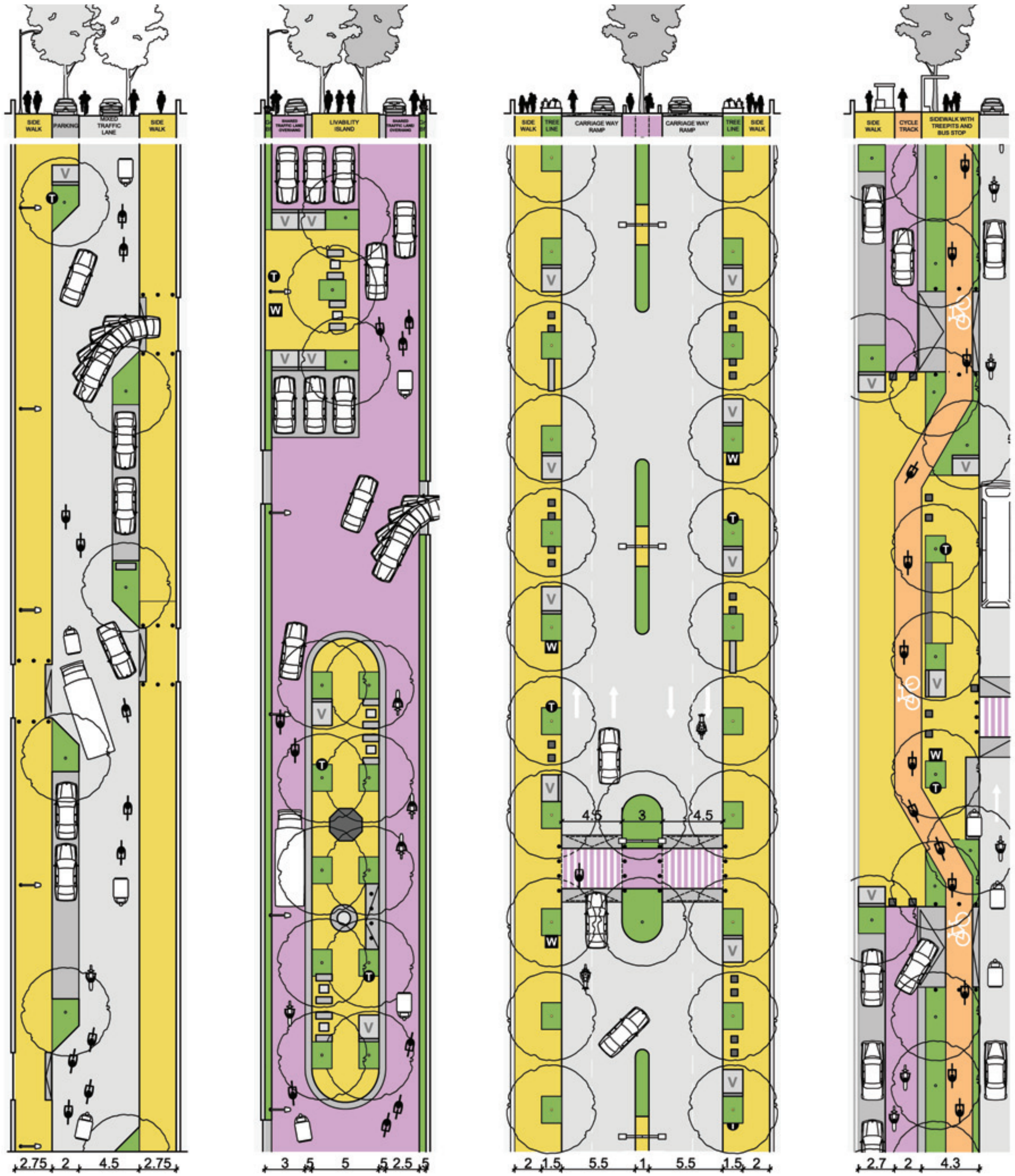
Design criteria and standards

Traffic calming slows down vehicles through one of the following mechanisms: vertical displacement, horizontal displacement, real or perceived narrowing of the carriageway, material/colour changes that signal conflict points, or the complete closure of a street. Traffic calming can take different forms depending on the context, and is most effective where two or more mechanisms are combined. Typical forms of traffic calming include speed humps and raised pedestrian crossings (see section 2.6), both of which rely on vertical displacement to reduce vehicle speeds.

Criteria for selecting appropriate elements are:

- No restriction of pedestrian and cycle connectivity
- Traffic and pedestrian volumes
- Frequency and types of accidents
- Road and carriageway width or intersection size
- Traffic mode to be calmed. For example, a street might be closed to cars but left open for cyclists and pedestrians

Severe speed bumps are uncomfortable for cyclists, rickshaws, and animal-driven carts.



(a) (b) (c) (d)

Figure 2.49 Traffic calming options.

(a) The parking lane alternates between the two sides of this 12 m street, preventing vehicles from speeding. The alternating obstacles are known as chicanes.

(b) In this shared space design, vehicles need to navigate around pedestrian islands of varying shapes, sizes, and locations within the right-of-way. The islands provide space for street vending, socialising, and other activities.

(c) In order to improve safety at the formal pedestrian crossing, the median has been widened to 3 m. The narrower carriageway induces vehicle users to slow down before they reach the crossing. The crossing itself, raised to +150 mm, serves as an additional traffic calming element.

(d) Wherever access requirements of private properties permit, service lanes may be discontinued to create street vending and bus stop zones.

2.14 Street lighting

Figure 2.50 Good street lighting improves personal safety and reduces the risk of collisions. This street has sodium vapour lamps above the carriageway and metal halide lamps above the pedestrian footpath to ensure that the yellow tactile strip is visible to the visually impaired.

What good street lighting achieves

Well-designed street lighting enables motor vehicle drivers, cyclists, and pedestrians to move safely and comfortably by reducing the risk of traffic accidents and improving personal safety.

Significance of street lighting

Pedestrians, cyclists, rickshaws, and even some motorised vehicles do not have lights and depend on street lighting, not only to see but also to be seen.

From a traffic safety standpoint, street lighting is especially important in potential conflict points, such as intersections, driveways, and public transport stops. Additionally, lighting helps road users avoid potholes and missing drain covers.

Finally, from a personal safety standpoint, street lighting is essential for mitigating the pedestrian's sense of isolation and reducing the risk of theft and sexual assault. Thus, improved lighting is particularly important in isolated spaces such as under- and overpasses and walkways next to parks or blank façades.

Challenges to good street lighting

Sufficient street lighting is rare, and even where it exists, infrequent maintenance reduces its effectiveness. Lighting systems need regular upkeep in the form of electrical maintenance, bulb replacement, and dust cleaning in order to remain effective.

Design criteria and standards

The following criteria should be considered:

- Additional lighting should be provided at conflict points
- The placement of street lighting should be coordinated with other street elements so that trees or advertisement hoardings do not impede proper illumination
- The spacing between two light poles should be approximately three times the height of the fixture, as indicated in the table below
- Poles should be no higher than 12 m. Especially in residential areas, they should be significantly lower than 12 m to reduce undesirable illumination of private properties

Table 2.2 Light pole height and spacing options

Street type	Pole height (m)	Spacing (m)
Footpath or cycle track (< 5 m width)	4.5–6	12–16
Local street (< 9 m width)	8–10	25–27
Arterial or collector (> 9 m width)	10–12	30–33

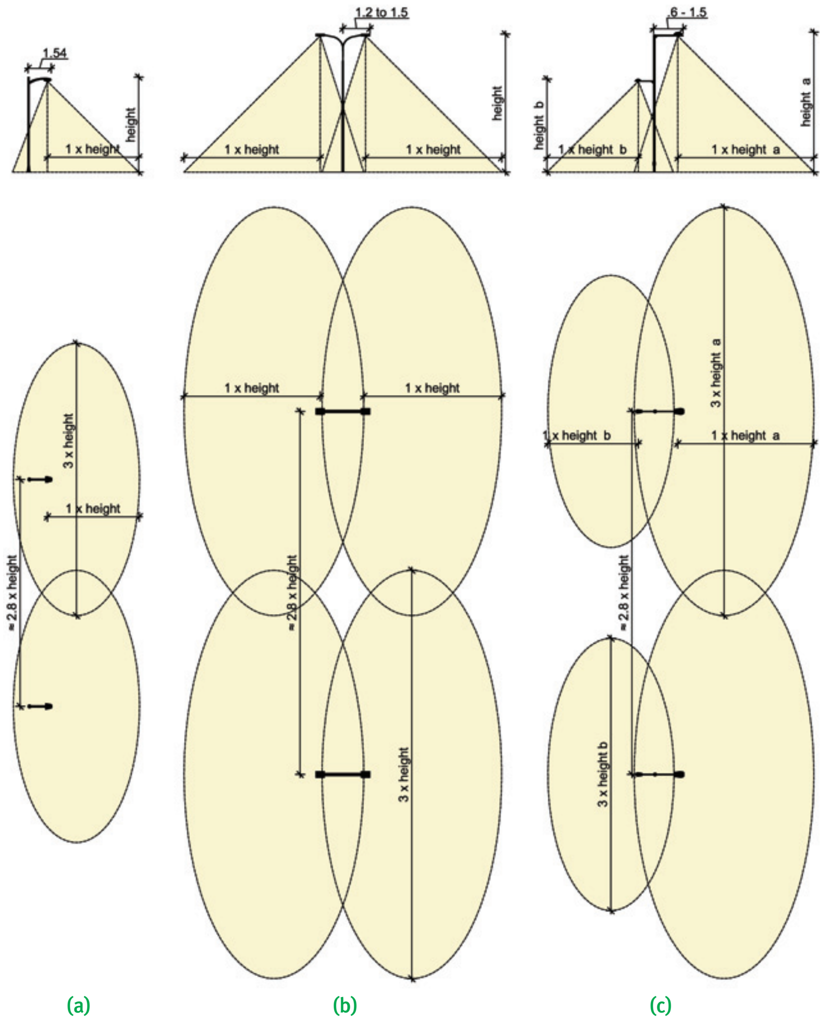


Figure 2.51 Street lights typically illuminate an elliptical area. As a rule of thumb, the longitudinal dimension is equivalent to three times the pole height, and horizontal dimension is slightly longer than the pole height.

(a) A single row of light posts is generally sufficient for streets up to 12 m wide.

(b) On wider streets, dual lights can be mounted on a single central post.

(c) If a central post is insufficient or cannot be accommodated, multiple rows of posts can support lights at different levels.

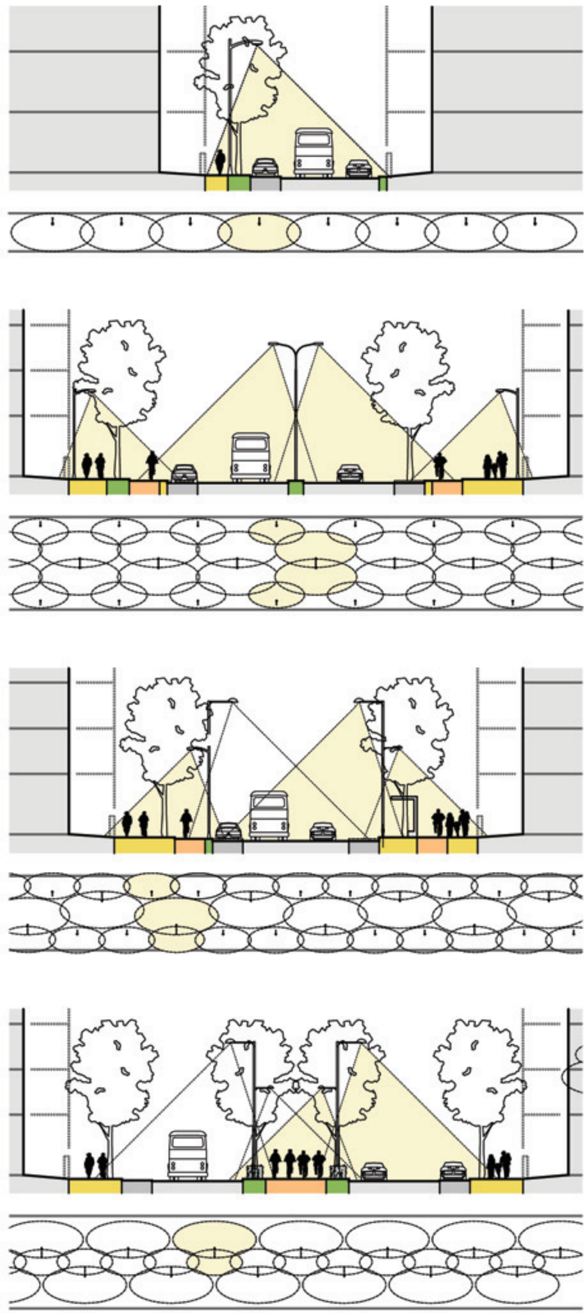


Figure 2.52 These sections indicate how lights can be oriented to accommodate varying street widths and light post locations.

2.15 Storm water drainage

Figure 2.53 This design lets water fall into a catch pit in the buffer and then into pipes under a cycle track. The level of the drain is below that of the cycle track.

✗ Figure 2.54 The joint between the drain cover and the surface of a cycle track is substandard and the placement of the drain in the cycle track means that cyclists ride through the deepest water in the cross section.

What good storm water drainage achieves

Adequate and efficient storm water drainage prevents water logging and erosion.

Significance of storm water drainage

Under-investment in storm water drainage results in major longitudinal storm water flows, which can erode the street surface. Deteriorated surfaces may cause accidents and thus imply costs beyond direct maintenance expenses. In flooded areas, pedestrians and cyclists are forced to make their way through uncomfortable and potentially dangerous terrain hidden under the water's surface. After the water drains away, the remaining mud and debris act as a deterrent to walking and cycling.

Challenges to better storm water drainage

The design of many streets places pedestrians and cyclists at the lowest point in the cross section, forcing them to wade through water and mud during the rainy season.

Drains are often placed in an ad-hoc manner and are not levelled with the surrounding road surface.

Design criteria and standards

Drainage facilities should meet the following criteria:

- Catch pits should be located at regular intervals, depending on their size and the catchment area, and at the lowest point of the street cross section
- The lowest point in the cross section should occur on the carriageway. Cycle tracks, footpaths, bus stops, and street vending areas should be at a higher level
- Drain surfaces should be at grade with the surrounding street surface unless provided in landscaped areas
- More environmentally benign approaches such as landscaped swales improve groundwater recharge, reduce storm water runoff, and improve the overall liveability of a street. Swales range in size from tree pits and landscaping strips to large low-lying neighbourhood parks. Swales are most appropriate on wide rights-of-way with large areas of unused space, but not in constrained environments where they take away space from pedestrians, cyclists, and street vendors
- The number of storm water lines in the cross-section should be minimised to keep construction and maintenance costs low. For example, an equal number of catch pits can be accommodated on two instead of four lines if they are placed strategically
- Gratings should be designed so that they do not catch cycle wheels

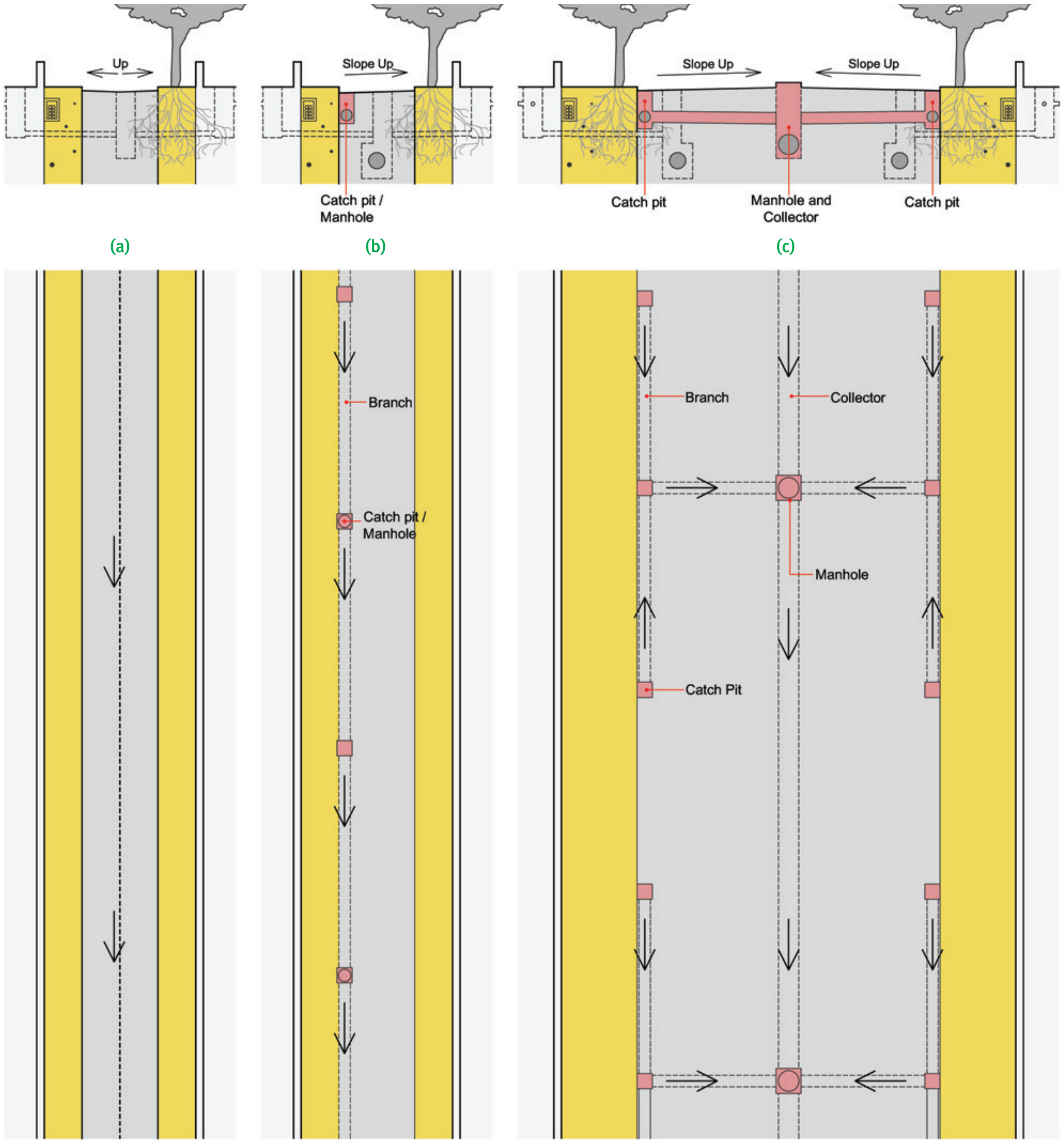
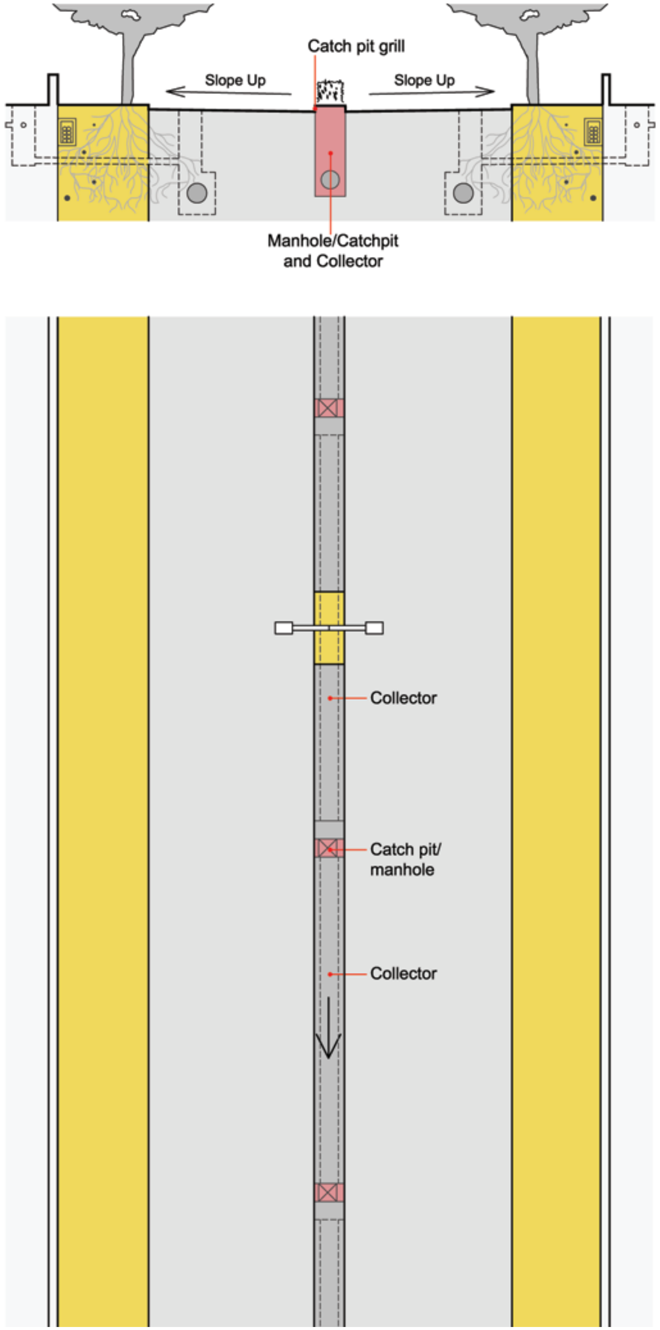


Figure 2.55 Storm water drainage arrangements.

(a) On a narrow and short street, underground piping is usually unnecessary. Instead, storm water can be carried off directly on the carriageway. The lowest elevation is at the centre of the street in order to maintain drier areas for pedestrians.

(b) A simple drainage design has a single row of catch pits connected to an underground pipe.

(c) On wider streets, a hierarchy of storm water pipes may be desirable, primarily to reduce the number of manholes in the driving zone. In this example, water drains to the outer edges of the carriageway, where it falls into catch pits. Periodically (every third or fifth pit) the catch pit lines are connected to a single trunk pipe that runs under the centre of the road. Manholes for the centrally located collector may be limited to these connections.



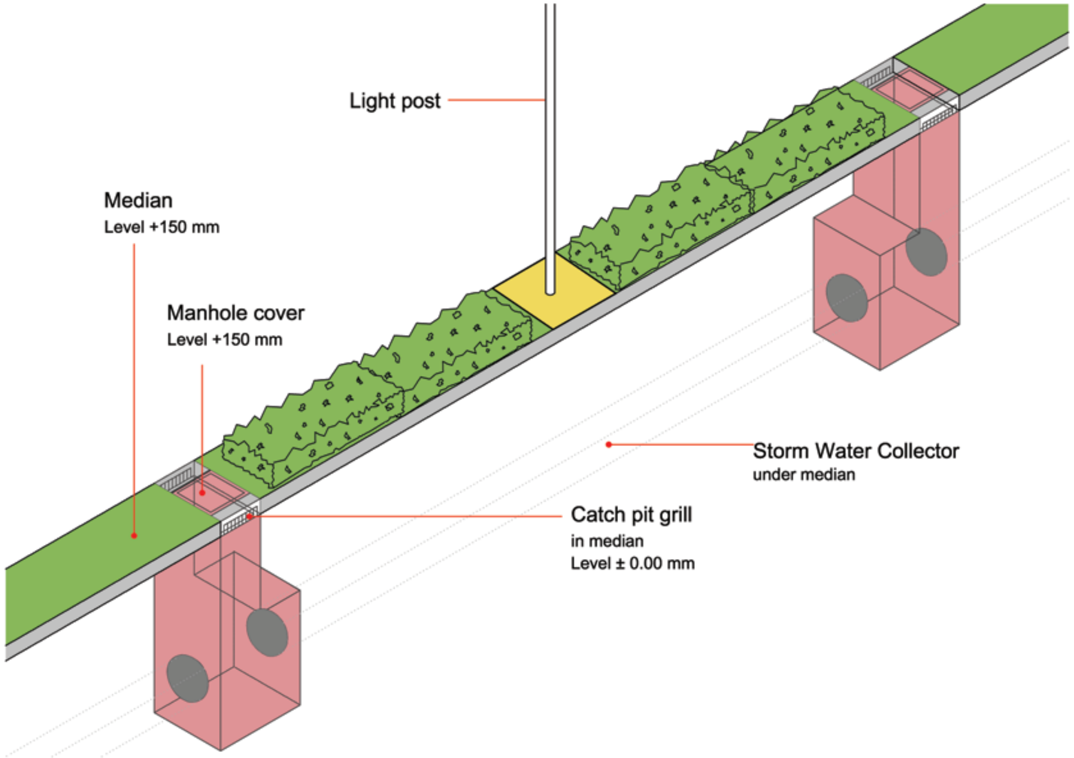
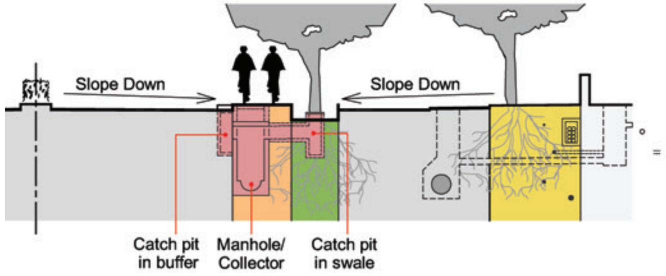
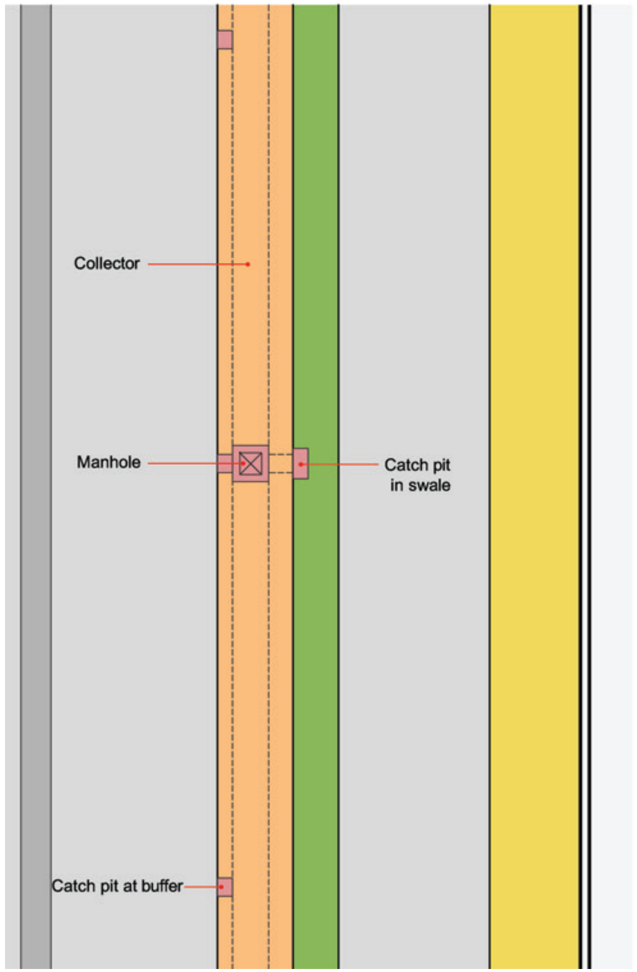


Figure 2.56 Storm water drainage infrastructure can be integrated with medians to reduce construction and maintenance costs.

In this design, the lowest elevation is at the *centre* of the cross section. Water drains through vertical grates into catch pits located under pedestrian refuge islands.

This design is cost effective for three reasons: (1) a single longitudinal pipe, connecting the catch pits under the centre of the road, is sufficient to drain the entire road section; (2) manholes and catch pits are integrated, reducing the complexity of the design; and (3) the catch pits and manholes, located in the median, are well protected from heavy traffic and are less likely to need replacement.





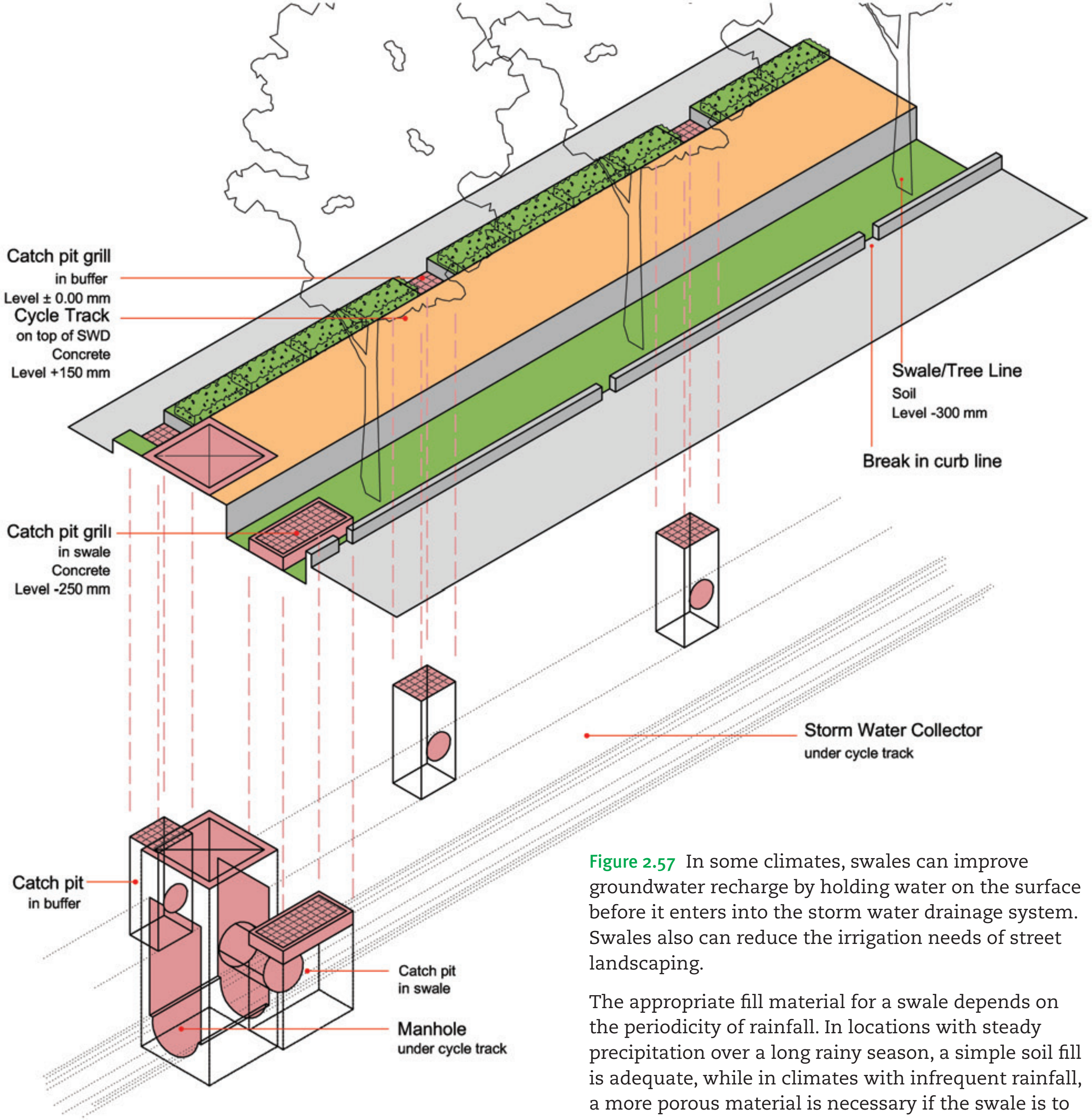


Figure 2.57 In some climates, swales can improve groundwater recharge by holding water on the surface before it enters into the storm water drainage system. Swales also can reduce the irrigation needs of street landscaping.

The appropriate fill material for a swale depends on the periodicity of rainfall. In locations with steady precipitation over a long rainy season, a simple soil fill is adequate, while in climates with infrequent rainfall, a more porous material is necessary if the swale is to contribute meaningfully to groundwater recharge.

2.16 Other underground utilities

Figure 2.58 Utility boxes on footpaths should be oriented parallel to the street in order to maximise the free space available for pedestrian movement.

Figure 2.59 Utility boxes can be accommodated on easements at the edge of private properties, leaving the footpath free of obstructions.

What good utilities achieve

The placement of above- and below-ground utilities at the appropriate location in the right-of-way ensures unconstrained movement as well as easy access for maintenance.

Significance of utilities

Streets are the conduits for major services, including electricity, water, sewage, communication, and gas. The physical infrastructure may occur in form of pipelines, telephone and fibre optic cables, ducts, and poles. Some utilities, such as telecommunications cables, require frequent access for expansion and maintenance.

Challenges to better road utilities

Utilities are generally placed at the edge of the right-of-way, but this is often the location of the pedestrian path. In this case, the underground utilities can create obstacles to the use of pedestrian facilities: either through above-ground access boxes located within the movement zone or through differential settlement of the footpath after the ground is opened for maintenance.

In fast-growing urban areas, the provision of underground utilities is a major challenge. Therefore, proper planning and mapping of utilities is an essential city management priority.

Design criteria and standards

Utilities should meet the following criteria:

- Underground utilities are ideally placed below the parking area or service lane, if present, which can be dug up easily without causing major inconvenience. Where this is not possible, underground utilities can be placed at the outer edge of the right-of-way.
- The ideal approach for reducing conflicts with pedestrian movements is to place utility boxes in easements just off the right-of-way. Where this is not possible, utility boxes should be placed within parking or landscaping areas. If it is absolutely necessary to locate utilities in the footpath, a space of at least 2 m should be maintained for the through movement of pedestrians. Utility boxes should never constrain the width of a cycle track
- Though it is possible to accommodate underground utilities even below a tree line, this may lead to the destruction of the trees and a deterioration in liveability if the utilities need to be uncovered. In order to minimise disruptions, utilities should be installed with proper maintenance infrastructure. For example, telecommunication lines should be placed in a duct that can be accessed at frequent service points, and empty pipes should be laid before planting trees in order to accommodate additional infrastructure

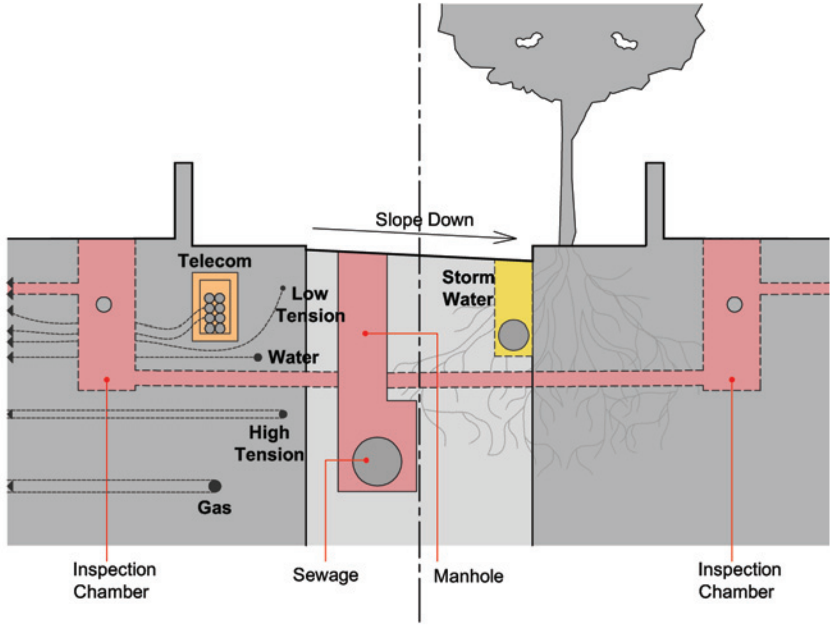


Figure 2.61 The placement of underground utilities should be coordinated with the location of street trees so that the trees are not disturbed if utilities are dug up for maintenance or replacement. Telecommunications, fresh water, and electricity lines generally can be accommodated within a 1.5–2 m wide area at the edge of the right-of-way. Sewage and storm water lines are usually placed closer to the centre of the cross section.

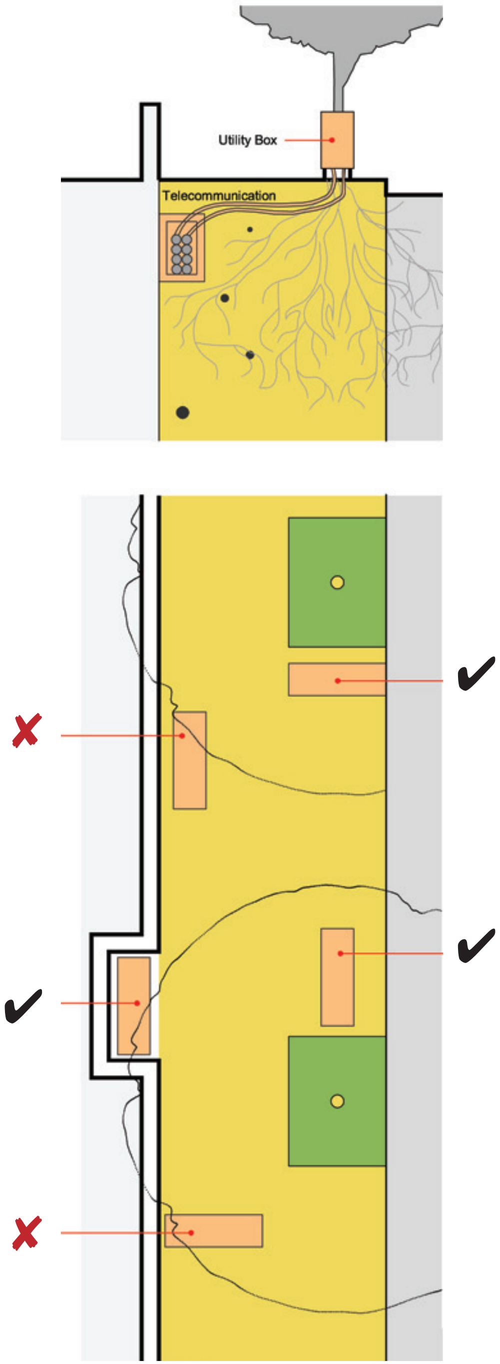


Figure 2.60 Access boxes for underground utilities should not constrain the space needed for through movement. If it is not possible to place utility boxes on private easements, the ideal location is in line with tree pits, to avoid conflicts with pedestrian movements.

If there is no way to avoid placing a utility box in the pedestrian movement zone, then it is essential to orient the box parallel to the street. Placing the box perpendicular to the street, where it stands directly in the way of pedestrians, is unacceptable.

3

Street templates

In this section we provide a collection of street templates to show how the elements presented in Chapter 2 can be combined to provide varying degrees of liveability and mobility. Each template contains a ground plan at a scale of 1:500 and a cross section at a scale of 1:250. If the template's cross section changes, such as in case of a meandering street (see template 9b) or a BRT corridor (see template 18BRT), we provide more than one cross section.

In the following pages we group the templates under thematic headers based on four features:

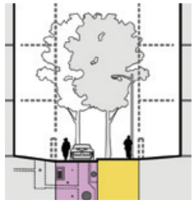
- Pedestrian mobility and access
- Cyclist mobility
- Parking and property access
- Private vehicle mobility

The templates are then shown in order of increasing street width: 6, 7.5, 9, 12, 18, 24, 30, 36, and 42 m. Finally, we present BRT templates for street widths ranging from 18 to 42 m. Each template can be adjusted for a slightly wider right-of-way by increasing the width of any element except the carriageway and parking lanes.

Small streets with shared space

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility

Small streets prioritise pedestrians by reducing motor vehicle speeds. Islands provide space for street vending and socializing while also serving as traffic calming elements. Parking, islands, and other elements in alternating locations prevent vehicles from speeding. Since speeds remain low, cyclists can safely travel in mixed traffic.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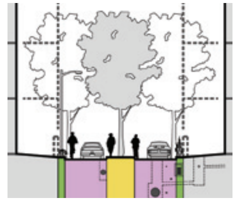
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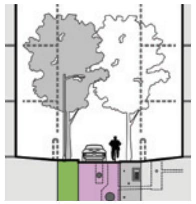
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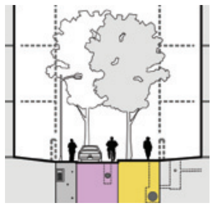
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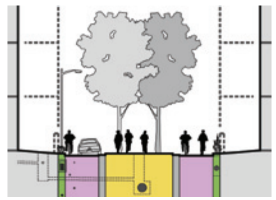
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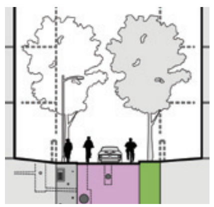
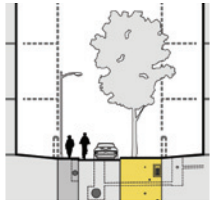

7.5c

Small streets with footpaths

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility

Small streets that handle high volumes of motor vehicle traffic or have large numbers of trucks and buses may function better with segregated footpaths.



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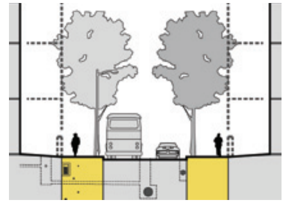

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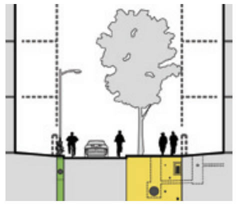

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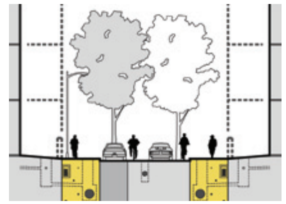

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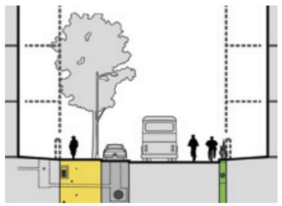

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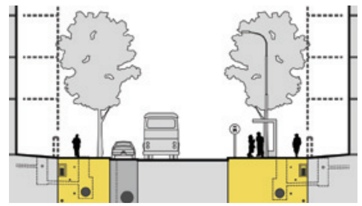
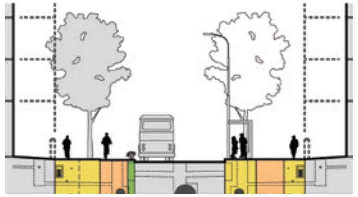


18c

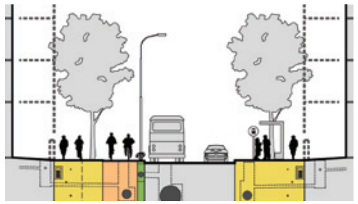
Small streets with cycle tracks

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility

Cycle tracks become viable with street widths of 18 m and above. If there are heavy volumes of cyclists or motor vehicles, it may make sense to segregate these modes. To address space constraints in an 18 m section, a single two-way cycle track can be provided on one side of the street.



18a

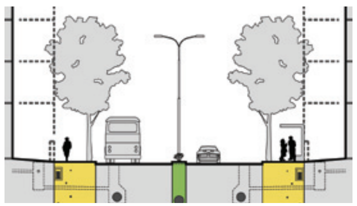


18b

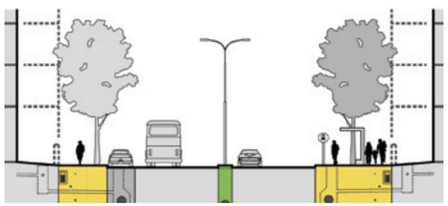
Divided carriageways without cycle tracks

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	**Mixed traffic**	Cyclist mobility
Service lane	**No service lane**		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility

These templates offer generous space for motor vehicle mobility but do not have cycle tracks. They may be acceptable if nearby streets already provide safe cycle facilities.



18d

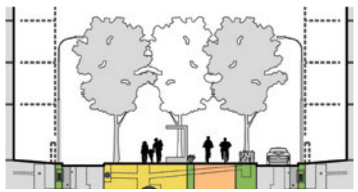


24c

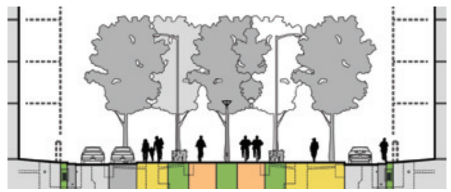
Forest streets

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	**No carriageway**	Private vehicle mobility

These templates prioritise pedestrians, creating safe spaces for children to play and for street vendors to conduct business. They can serve as key non-motorised transport links in a city's street network. The service lane allows for property access but is not meant to function as a conduit for through traffic.



18e

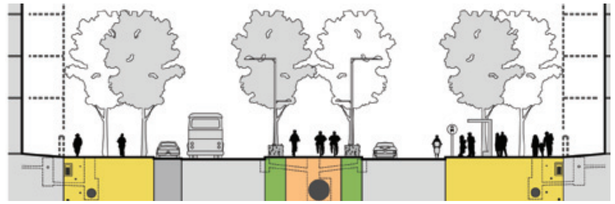


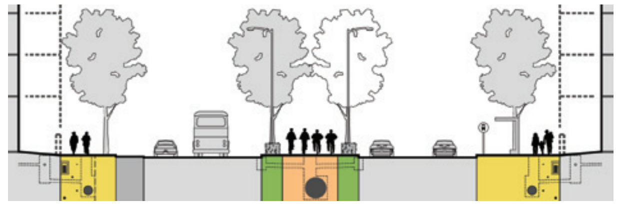
24e

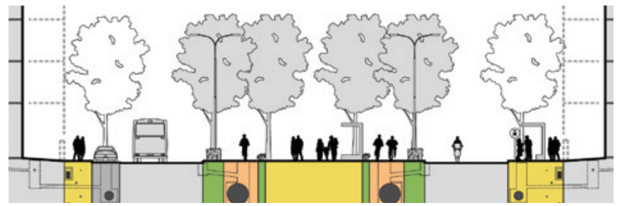
Large streets with median cycle tracks

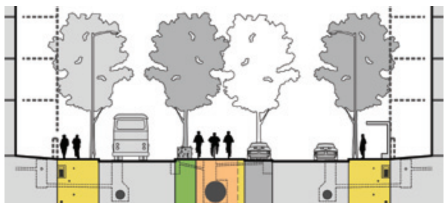
Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility

Median cycle tracks reduce the possibility of encroachment by parked vehicles. Proper signal phasing and geometric design are necessary to ensure that conflicts are mitigated at junctions. Trees should be planted in the median to shade the cycle track.


36a

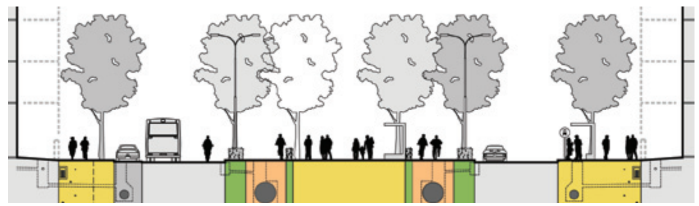

36d


36e


24a


42a

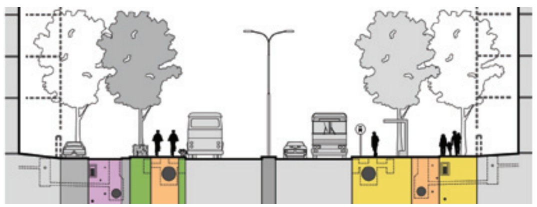

30a


42d

Large streets with service lanes

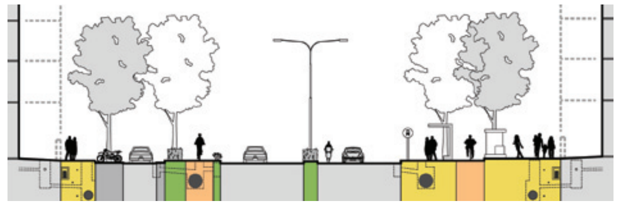
Footpath	**Shared space**		Pedestrian mobility and access
Median track	**Side track**	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility

In these templates, on-street parking and private properties are accessed from a service lane, resulting in smoother traffic flow and fewer interruptions in the cycle track. Where extra width is available, a dedicated footpath can be created at a higher level than the service lane. The service lane should not be widened as this results in higher vehicle speeds.

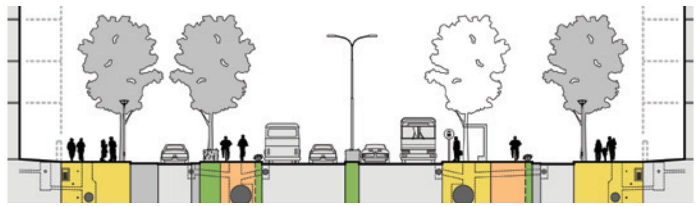


30c

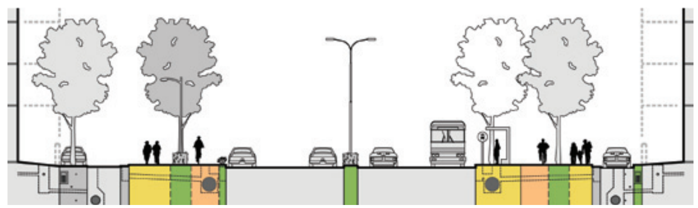
Footpath	Shared space		Pedestrian mobility and access
Median track	**Side track**	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility



36c



42b



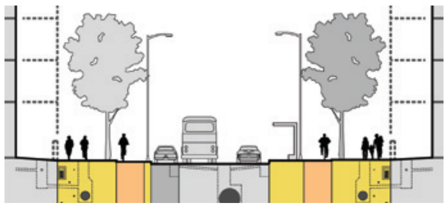
42c

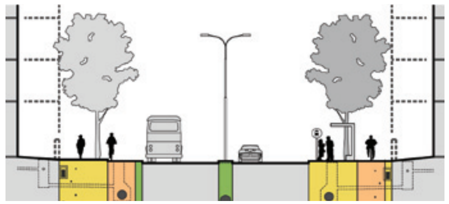
Large streets with side cycle tracks

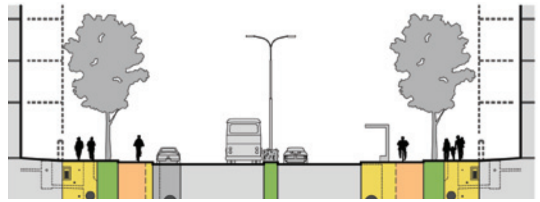
Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility

Side cycle tracks need to be designed to ensure continuity. At property access points, the cycle track and footpath should stay at the same level. Vehicle access can be provided via a ramp in the cycle track buffer. The cycle track passes behind bus stops to prevent conflicts between cyclists and waiting bus passengers. Trees are positioned to shade both the footpath and cycle track.


24d


24b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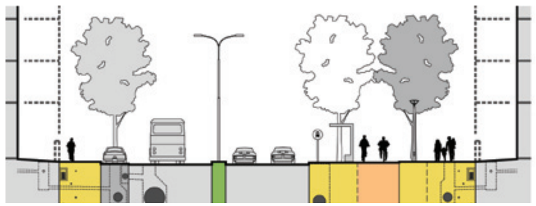

30d


36b

Streets with bus rapid transit

Footpath | Shared space — Pedestrian mobility and access

Median track | Side track | Mixed traffic — Cyclist mobility

Service lane | No service lane — Parking and property access

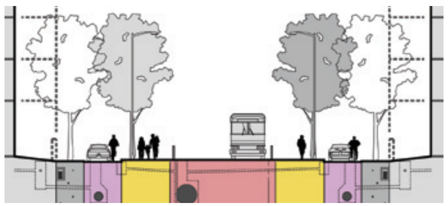
Divided carriageway | Undivided carriageway | No carriageway — Private vehicle mobility

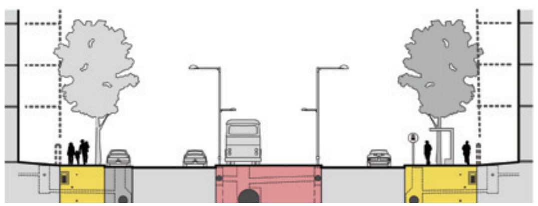
The BRT sections have various combinations of elements.

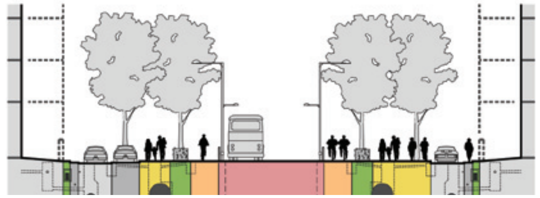
BRT can be implemented on streets of any width starting at 18 m. One-way systems can be built on narrower streets.

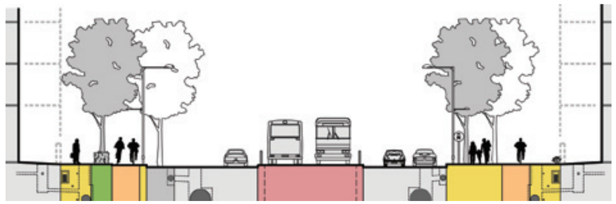
BRT requires a wider cross section at stations. On streets with on-street parking, the extra 4 m needed for the station can be gained by temporarily discontinuing the parking lane. The footpath should not be narrowed. Raised speed tables should be provided at stations to allow pedestrians to cross the carriageway safely.

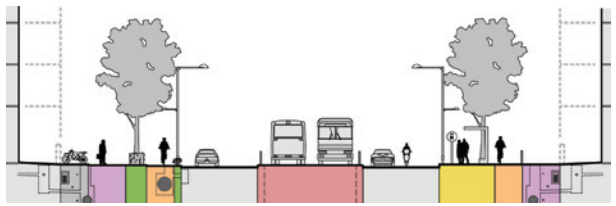

18BRT

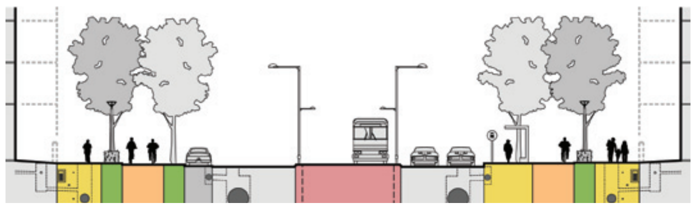

24BRT

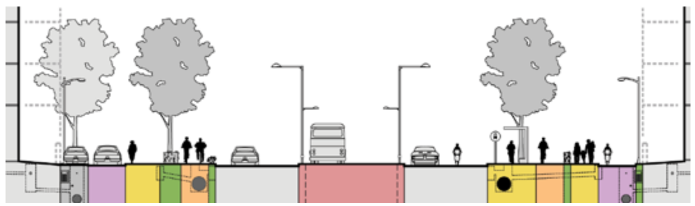

30BRT a


30BRT b


36BRT a


36BRT b

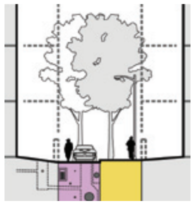

42BRT a


42BRT b

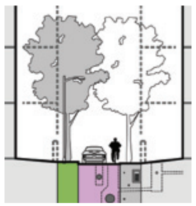
6 m templates

Small streets with shared space

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility



6a

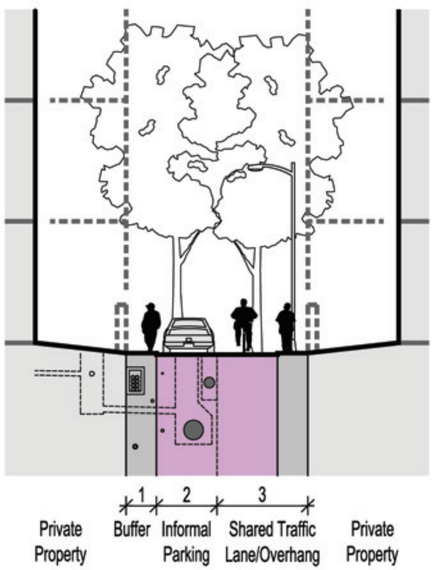


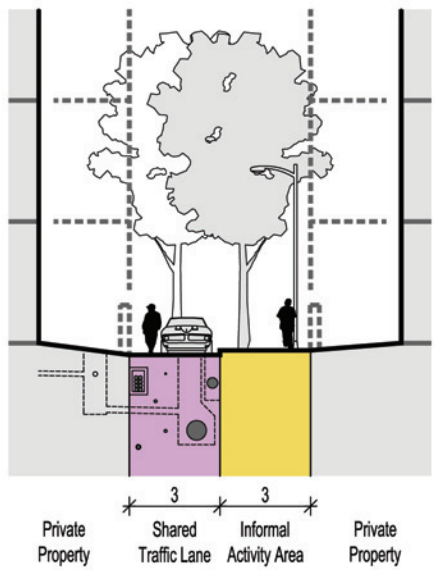
6b

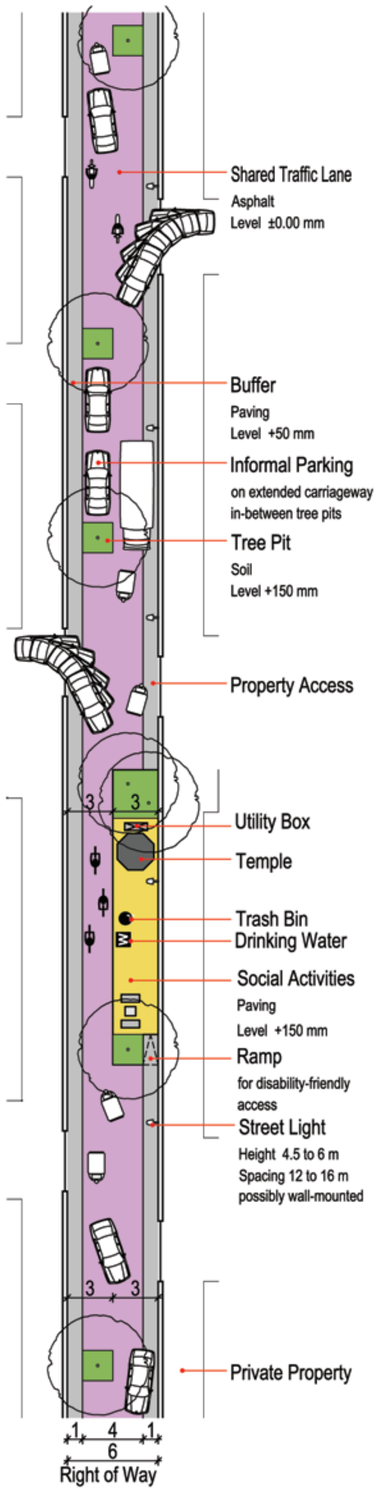
6a

Small streets with shared space

Footpath		**Shared space**	Pedestrian mobility and access
Median track	Side track	**Mixed traffic**	Cyclist mobility
Service lane		**No service lane**	Parking and property access
Divided carriageway	Undivided carriageway	**No carriageway**	Private vehicle mobility



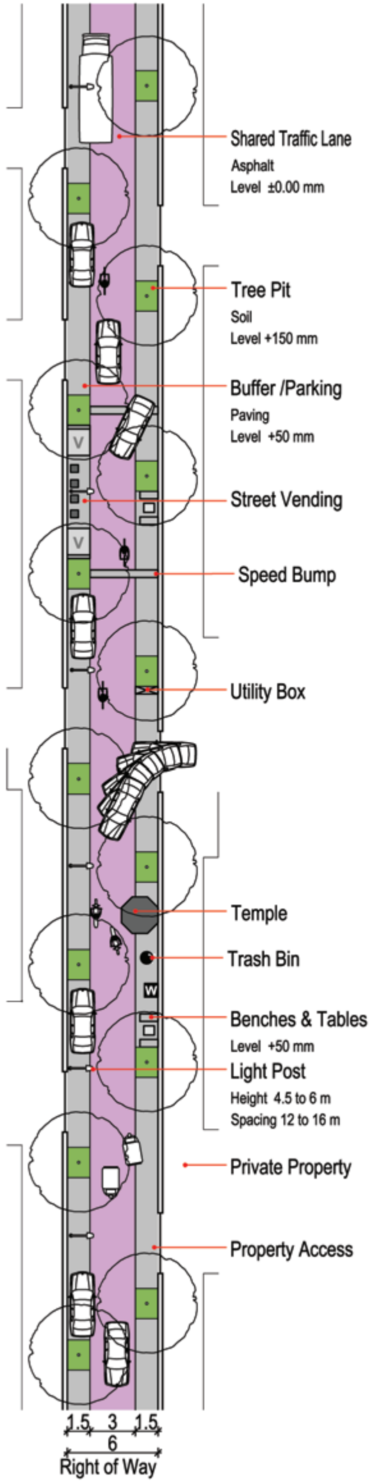


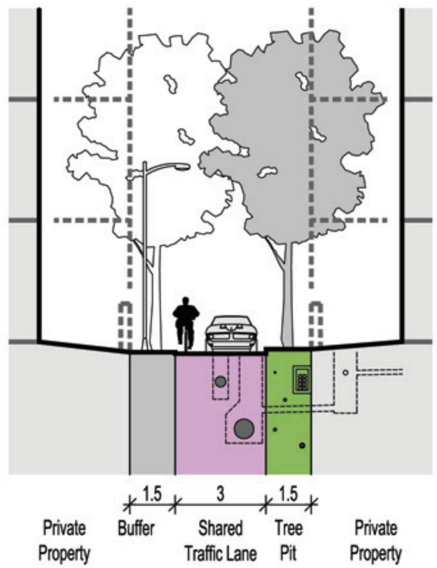


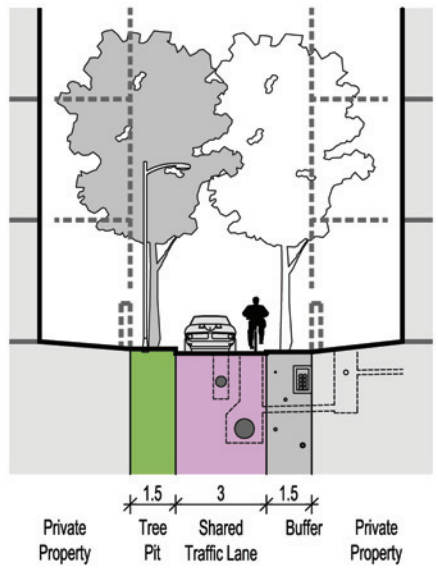
6b

Small streets with shared space

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway

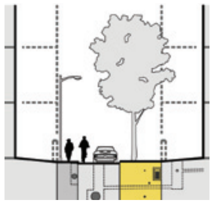




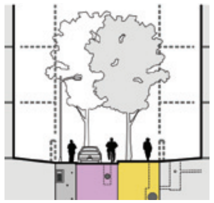


7.5 m templates

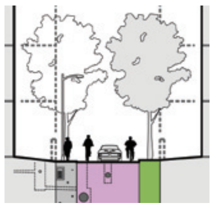
Small streets with footpaths	Small streets with shared space	
Footpath / Shared space	Footpath / **Shared space**	Pedestrian mobility and access
Median track / Side track / **Mixed traffic**	Median track / Side track / **Mixed traffic**	Cyclist mobility
Service lane / **No service lane**	Service lane / **No service lane**	Parking and property access
Divided carriageway / **Undivided carriageway** / No carriageway	Divided carriageway / Undivided carriageway / **No carriageway**	Private vehicle mobility



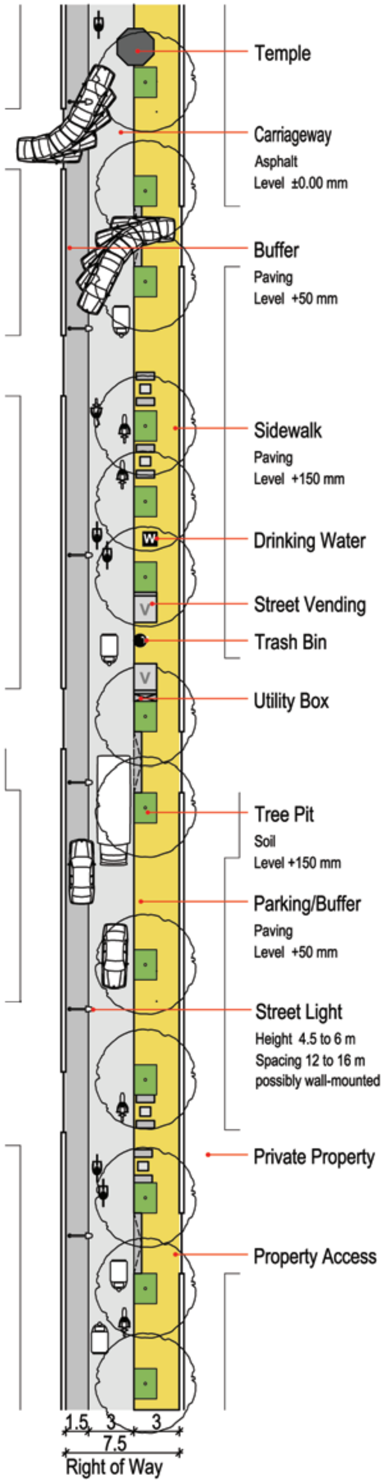
7.5a



7.5b



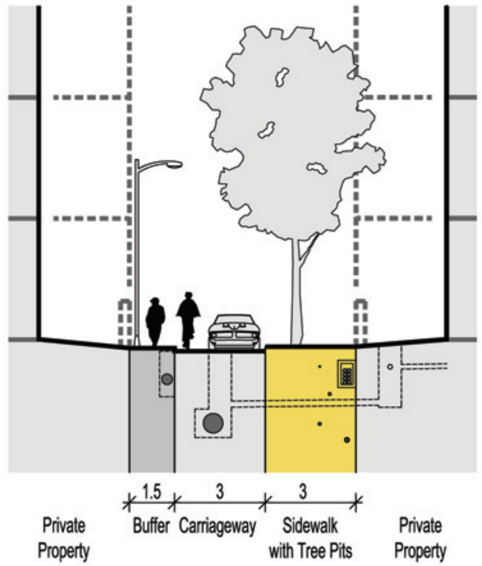
7.5c



7.5a

Small streets with footpaths

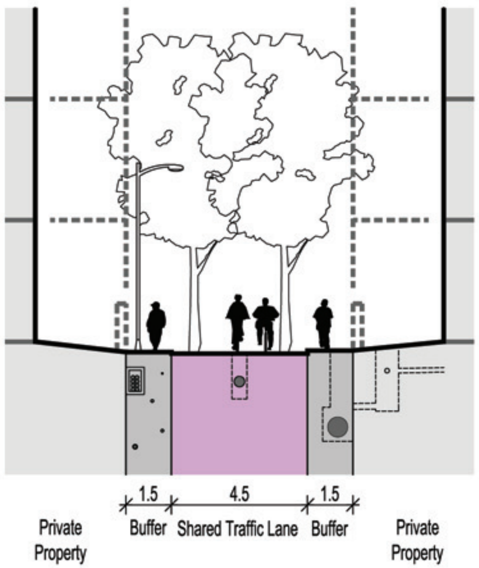
Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	Median track	Side track	**Mixed traffic**
Parking and property access	Service lane	**No service lane**	
Private vehicle mobility	Divided carriageway	**Undivided carriageway**	No carriageway

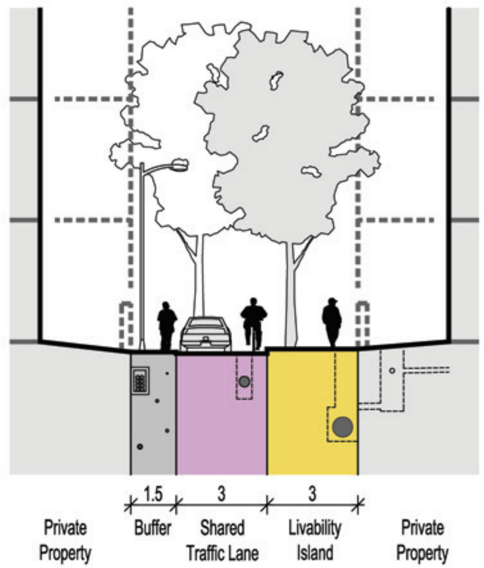


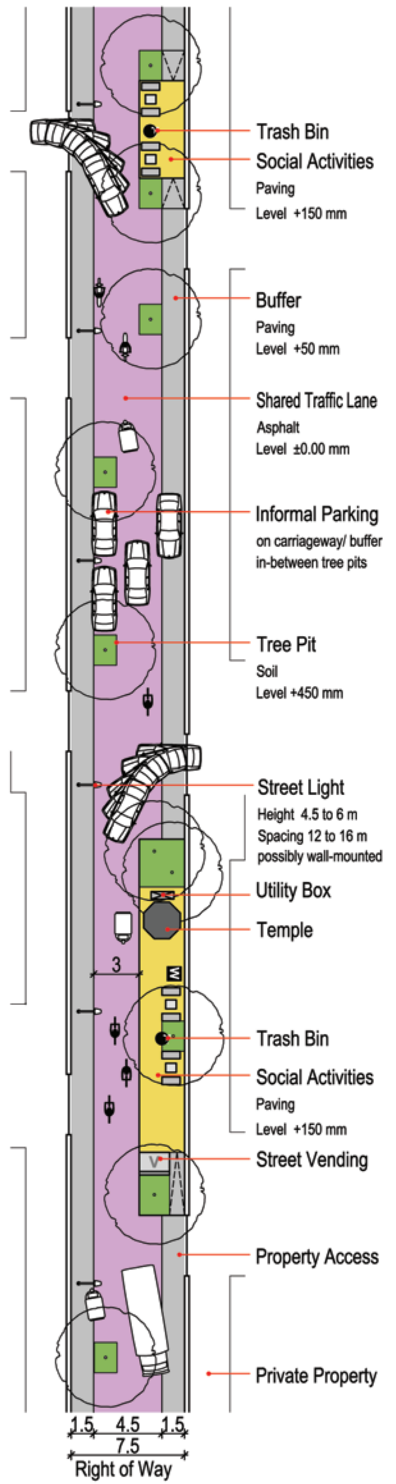
7.5b

Small streets with shared space

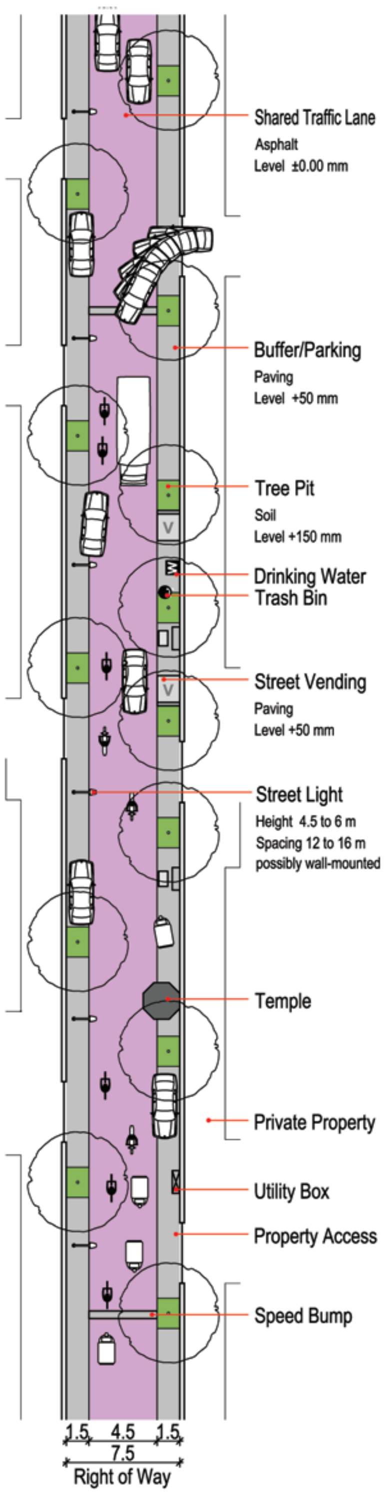
Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility





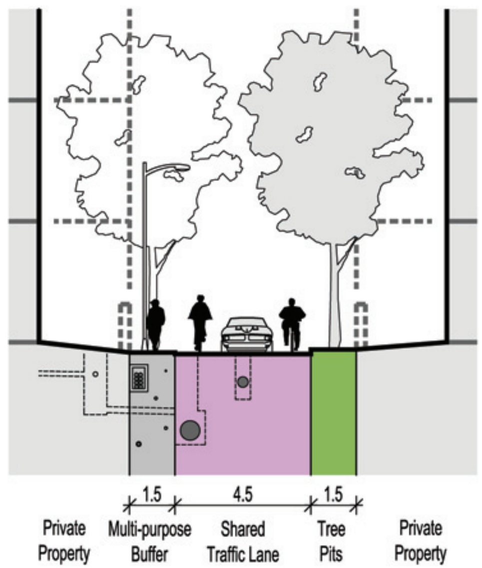


7.5C



Small streets with shared space

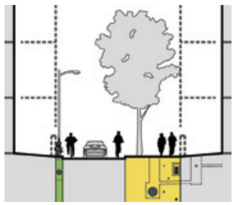
Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway



9 m templates

Small streets with footpaths

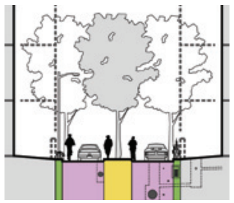
Footpath	Shared space	
Median track	Side track	Mixed traffic
Service lane	No service lane	
Divided carriageway	Undivided carriageway	No carriageway



9a

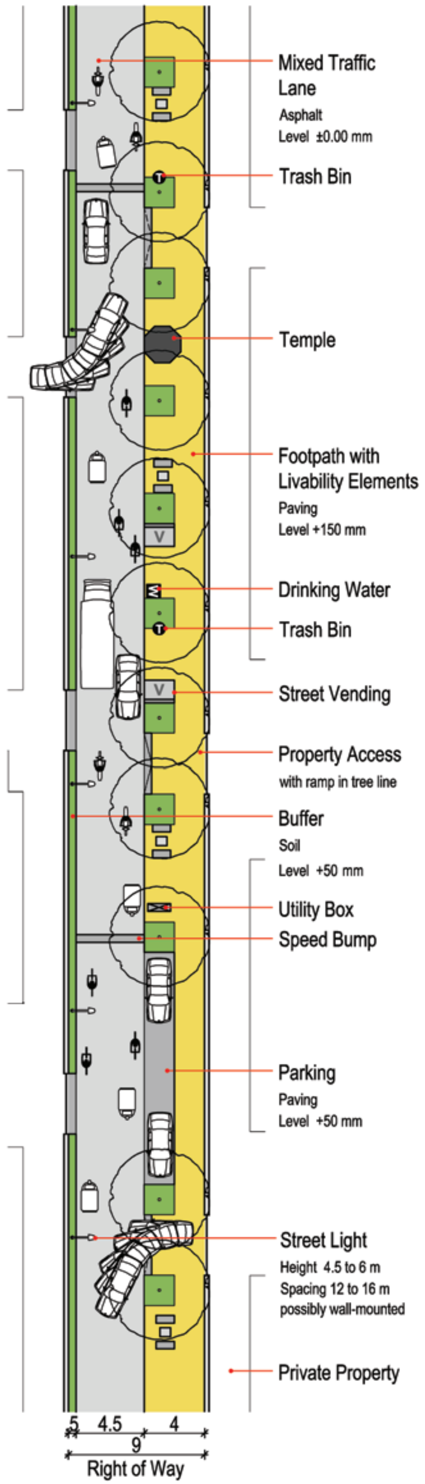
Small streets with shared space

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility



9b

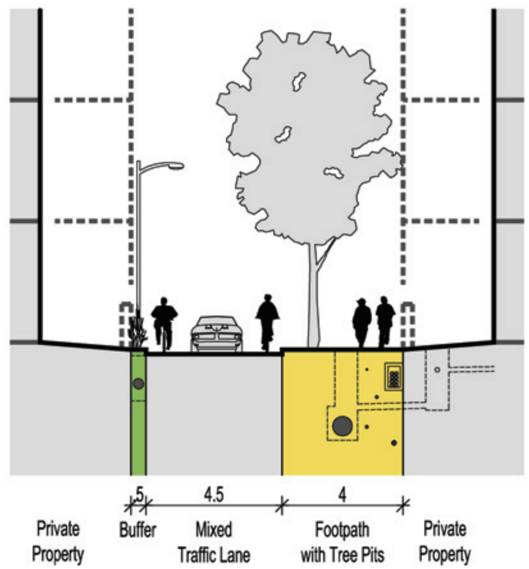
9c



9a

Small streets with footpaths

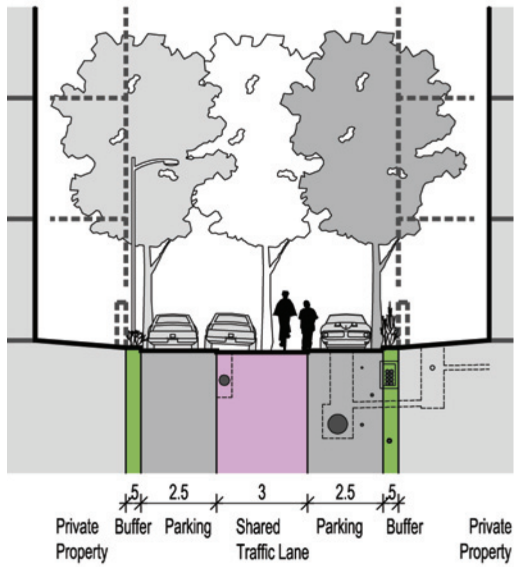
Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	Median track	Side track	**Mixed traffic**
Parking and property access	Service lane	**No service lane**	
Private vehicle mobility	Divided carriageway	**Undivided carriageway**	No carriageway

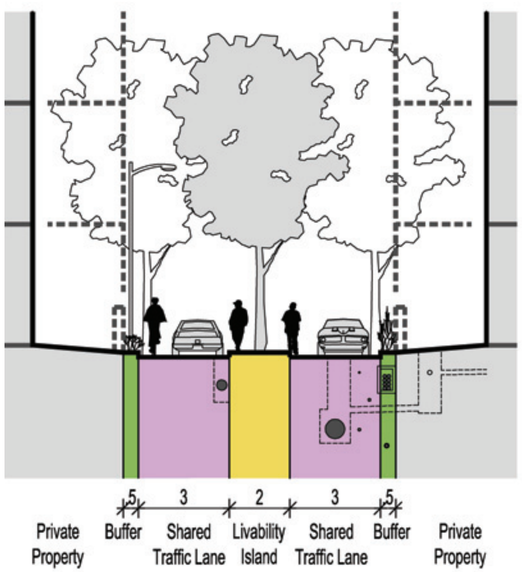


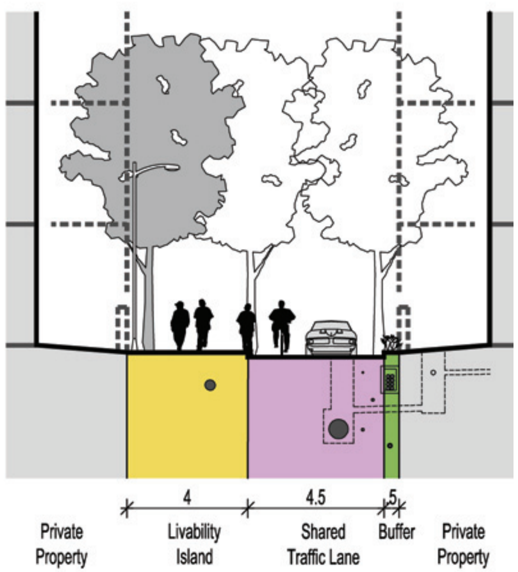
9b

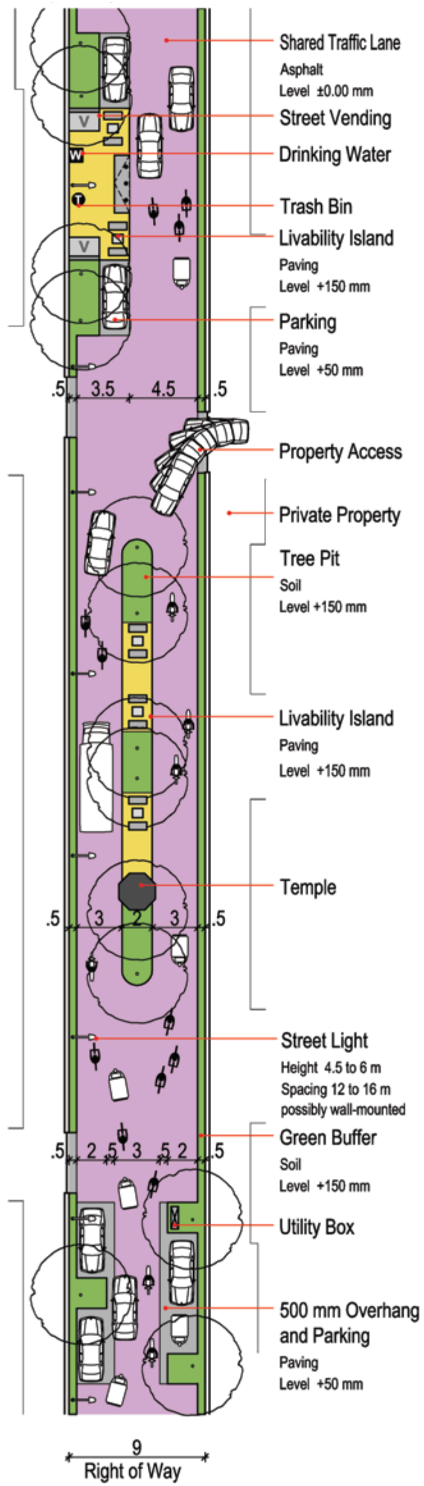
Small streets with shared space

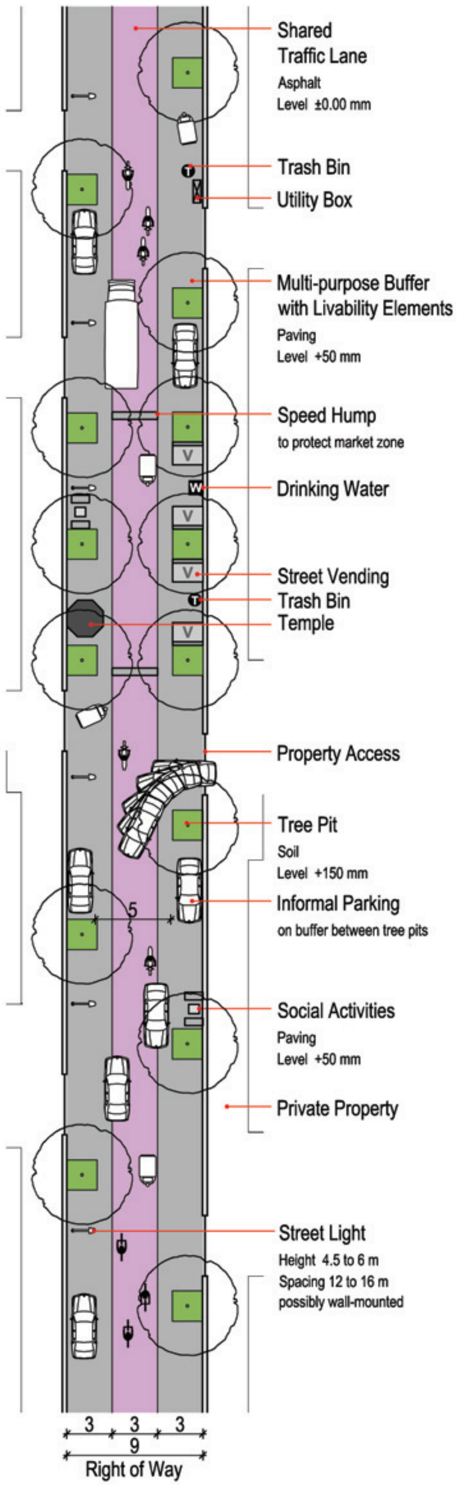
Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility







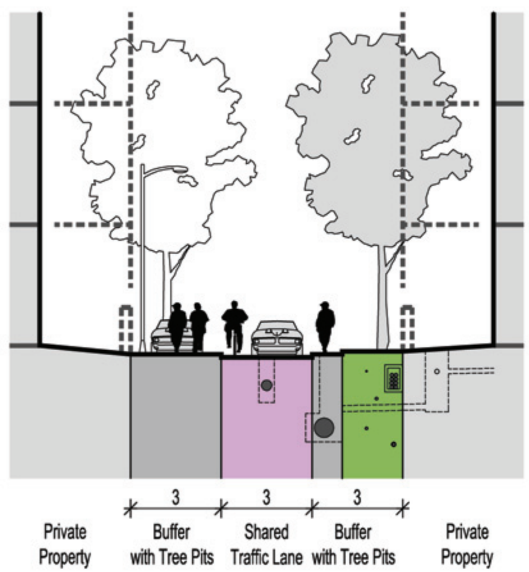




9C

Small streets with shared space

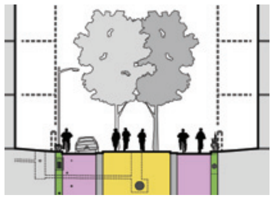
Pedestrian mobility and access	Footpath	**Shared space**	
Cyclist mobility	Median track	Side track	**Mixed traffic**
Parking and property access	Service lane	**No service lane**	
Private vehicle mobility	Divided carriageway	Undivided carriageway	**No carriageway**



12 m templates

Small streets with shared space

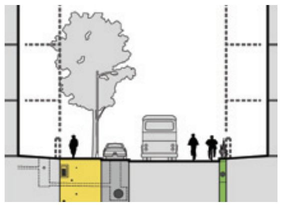
Footpath	**Shared space**		Pedestrian mobility and access
Median track	Side track	**Mixed traffic**	Cyclist mobility
Service lane	**No service lane**		Parking and property access
Divided carriageway	Undivided carriageway	**No carriageway**	Private vehicle mobility



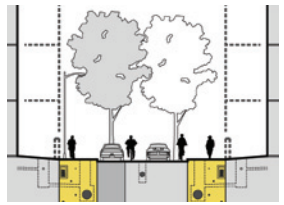
12a

Small streets with footpaths

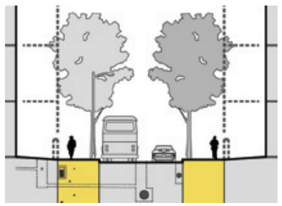
Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	**Mixed traffic**	Cyclist mobility
Service lane	**No service lane**		Parking and property access
Divided carriageway	**Undivided carriageway**	No carriageway	Private vehicle mobility



12b



12d

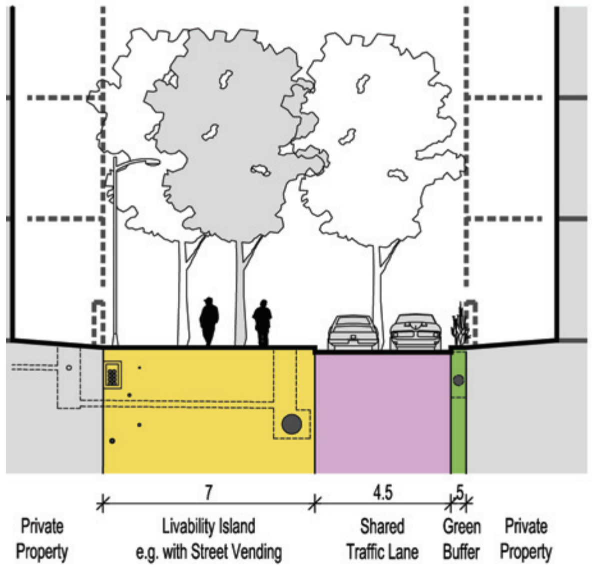


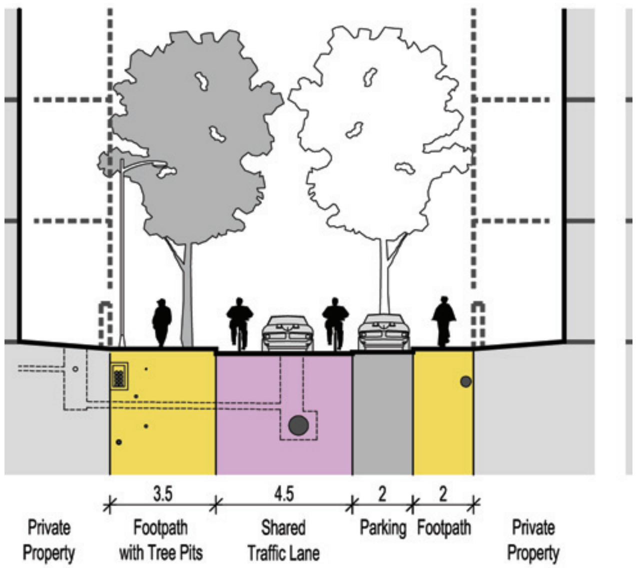
12c

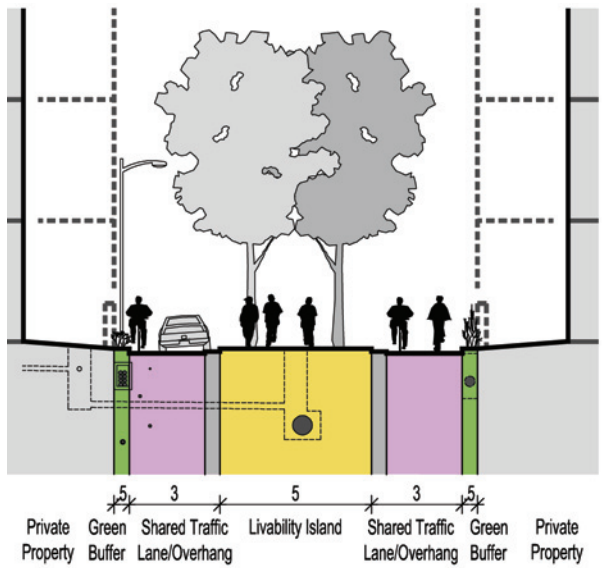
12a

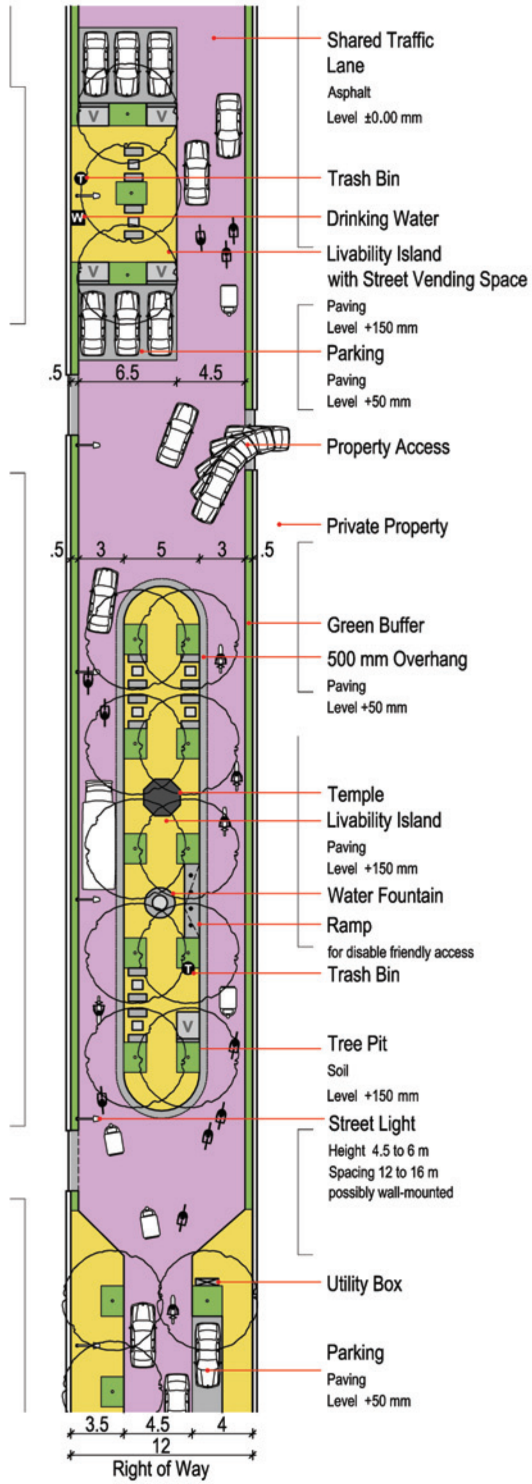
Small streets with shared space

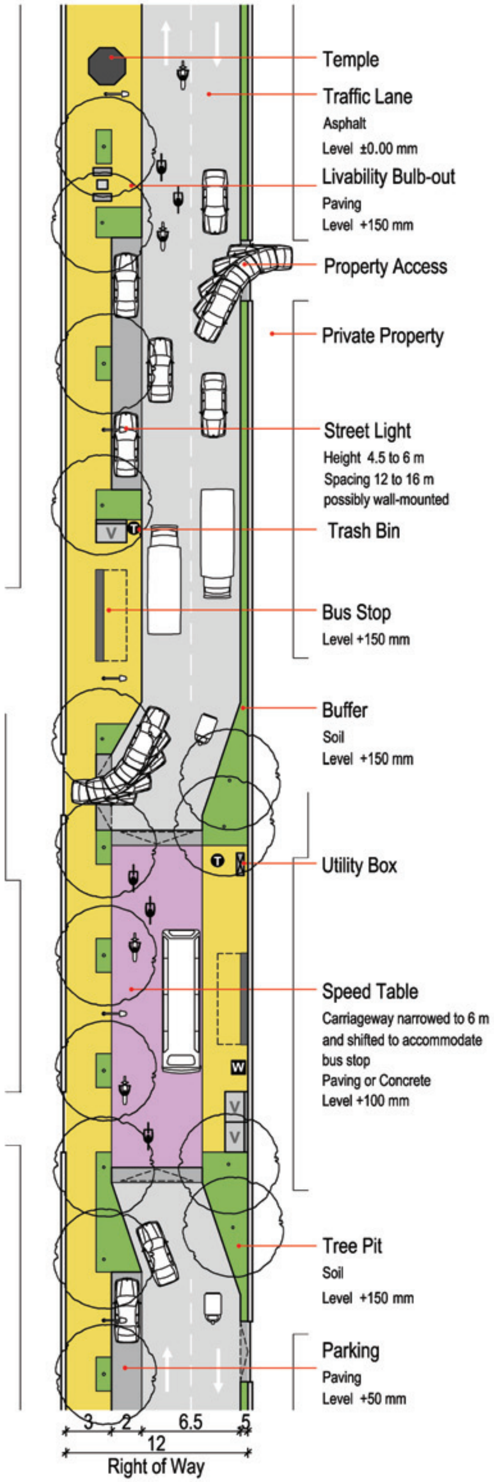
Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility





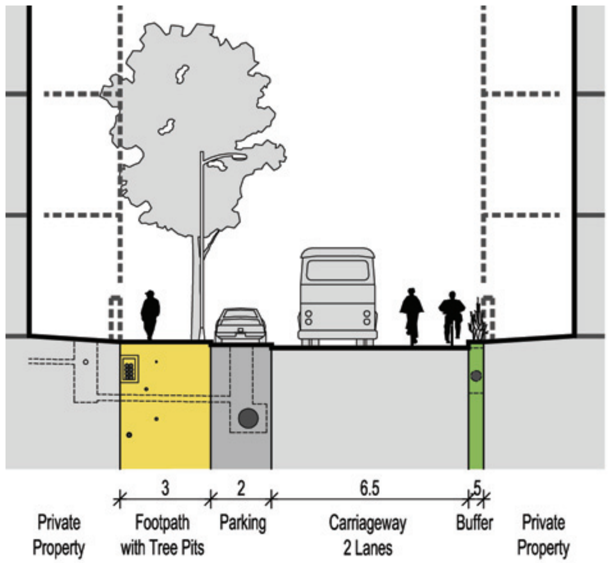


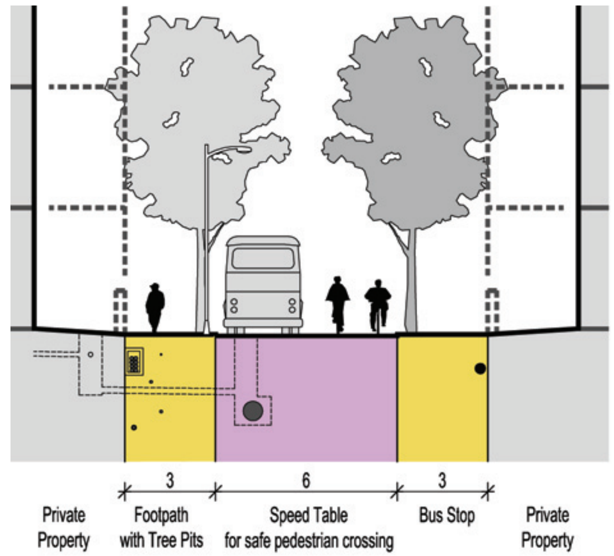




Small streets with footpaths

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway

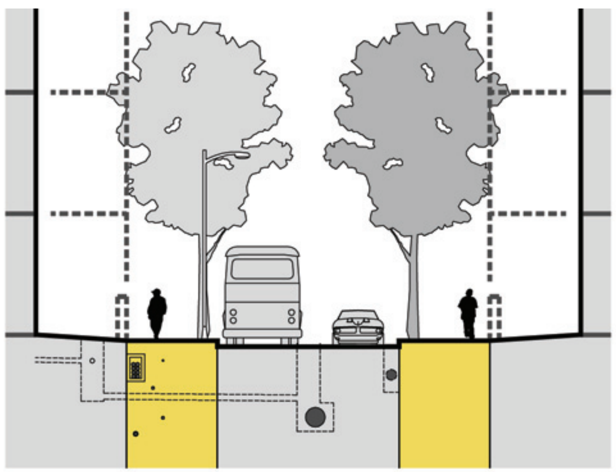


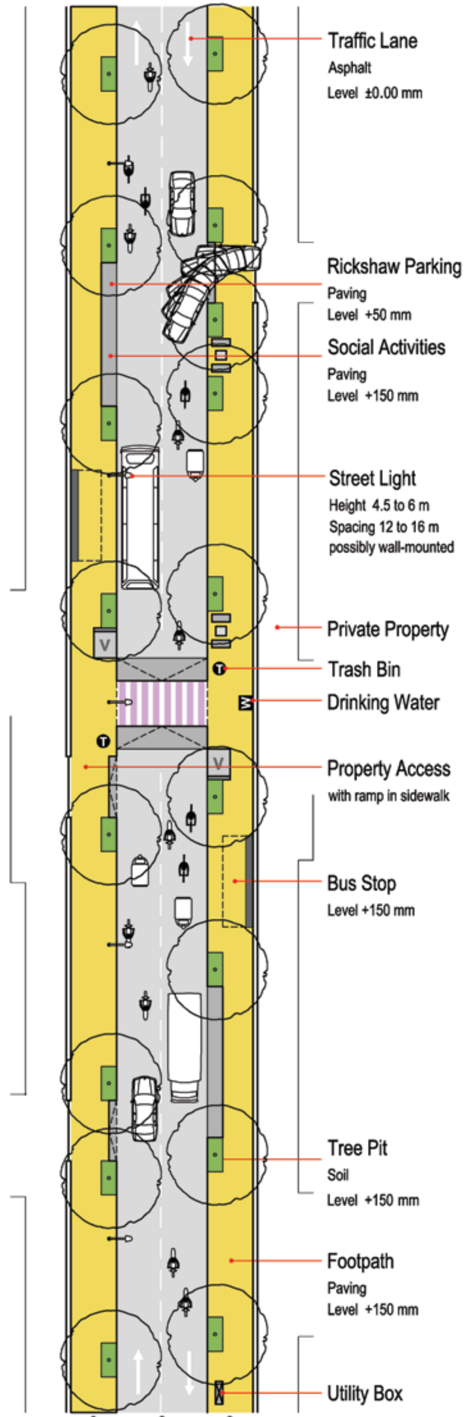


12C

Small streets with footpaths

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility

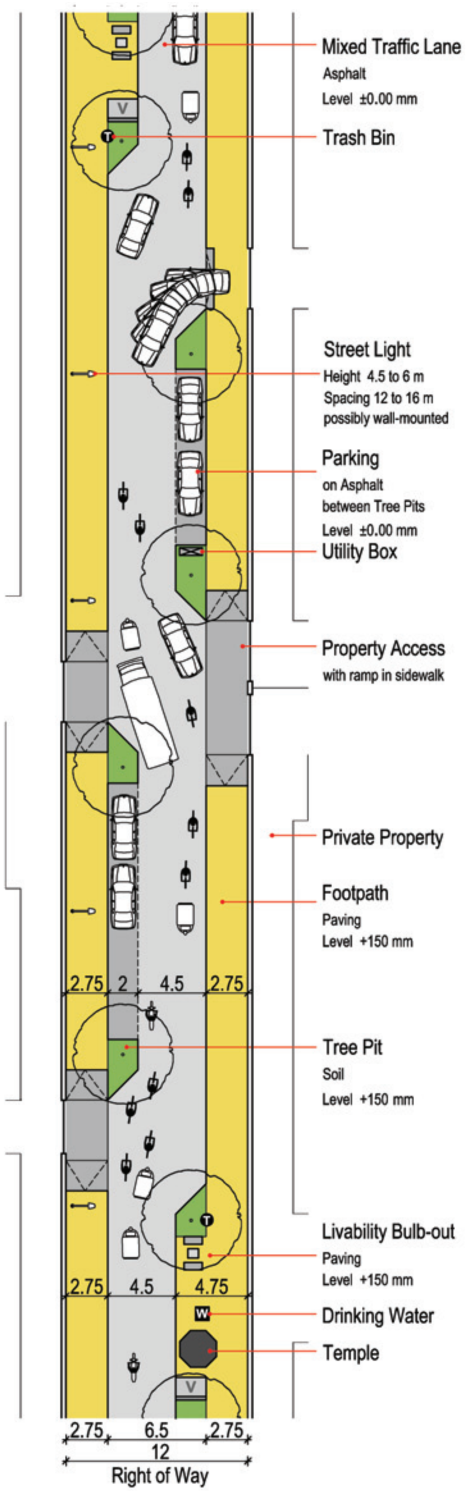


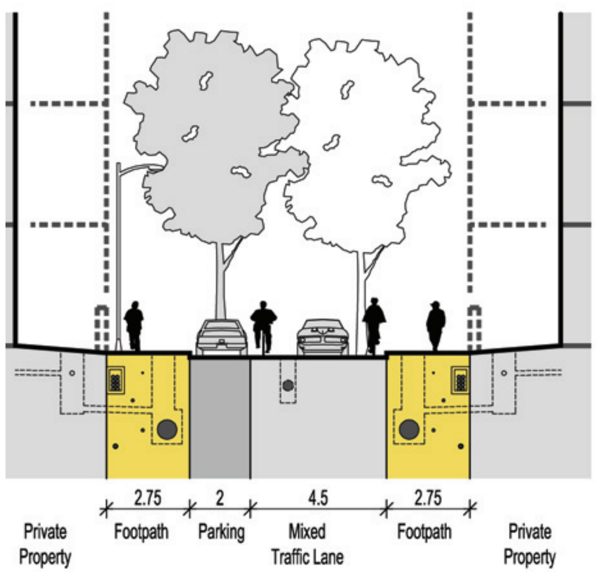


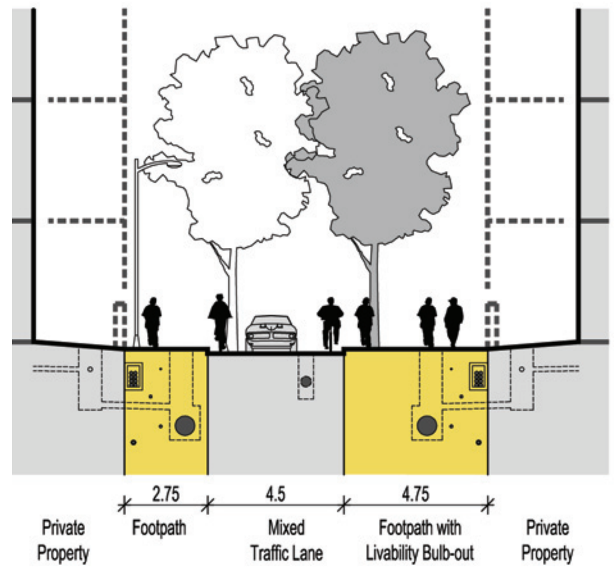
12d

Small streets with footpaths

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway

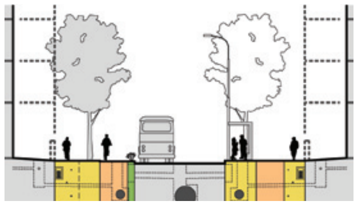




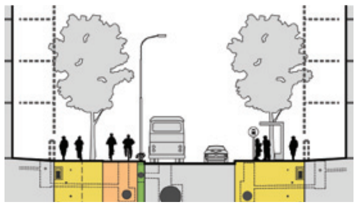


18 m templates

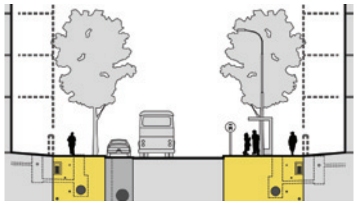
	Small streets with cycle tracks	Small streets with footpaths	Divided carriageways without cycle tracks	Forest streets
Pedestrian mobility and access	**Footpath** / Shared space	**Footpath** / Shared space	**Footpath** / Shared space	**Footpath** / Shared space
Cyclist mobility	Median track / **Side track** / Mixed traffic	Median track / Side track / **Mixed traffic**	Median track / Side track / **Mixed traffic**	**Median track** / Side track / Mixed traffic
Parking and property access	Service lane / **No service lane**	Service lane / **No service lane**	Service lane / **No service lane**	**Service lane** / No service lane
Private vehicle mobility	Divided carriageway / **Undivided carriageway** / No carriageway	Divided carriageway / **Undivided carriageway** / No carriageway	**Divided carriageway** / Undivided carriageway / No carriageway	Divided carriageway / Undivided carriageway / **No carriageway**



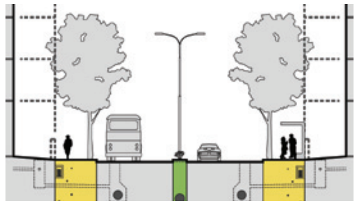
18a



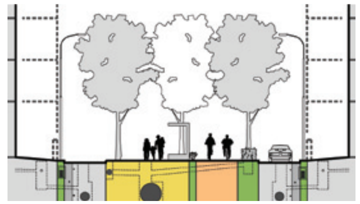
18b



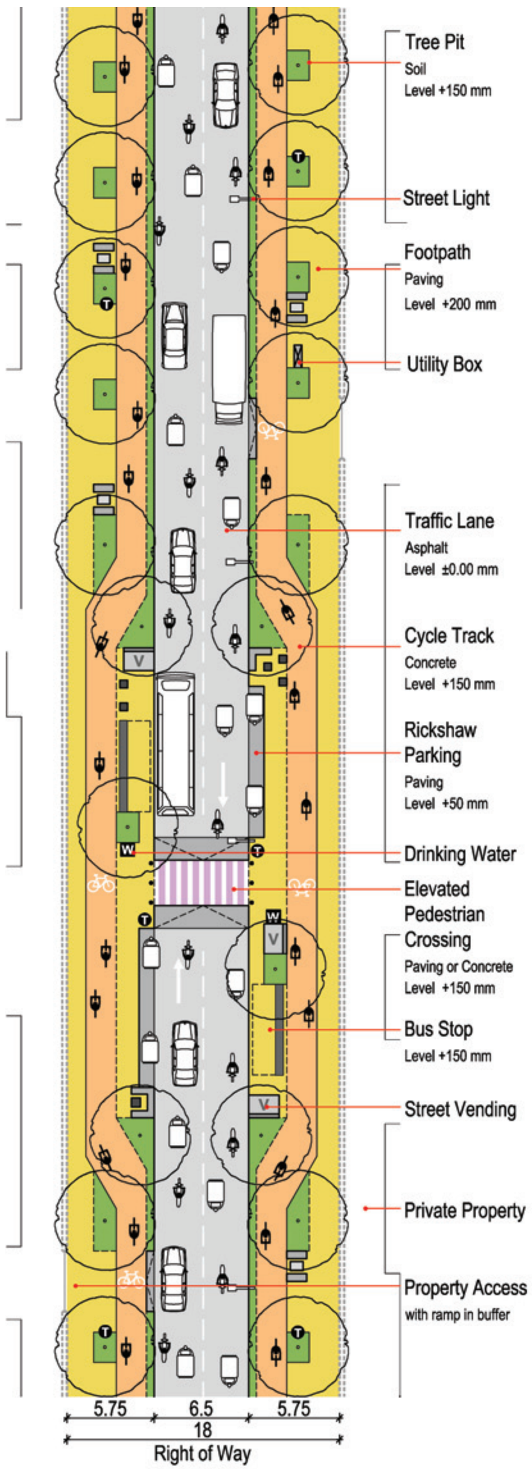
18c



18d



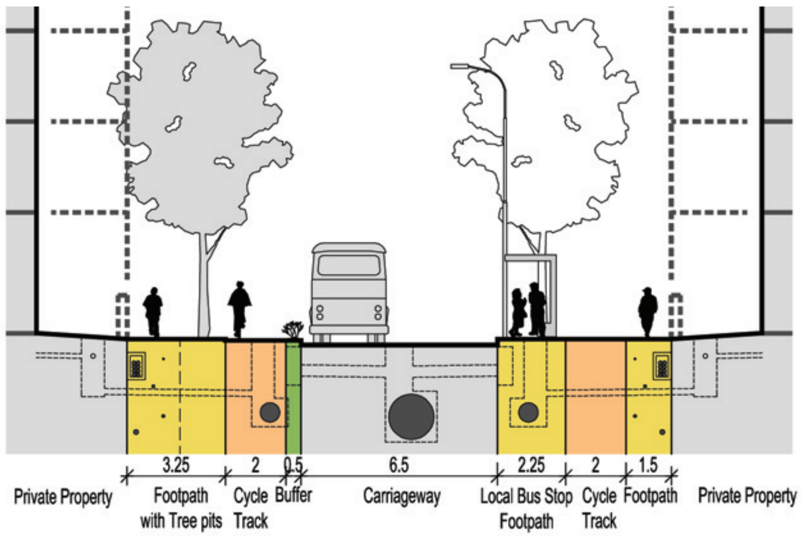
18e



18a

Small streets with cycle tracks

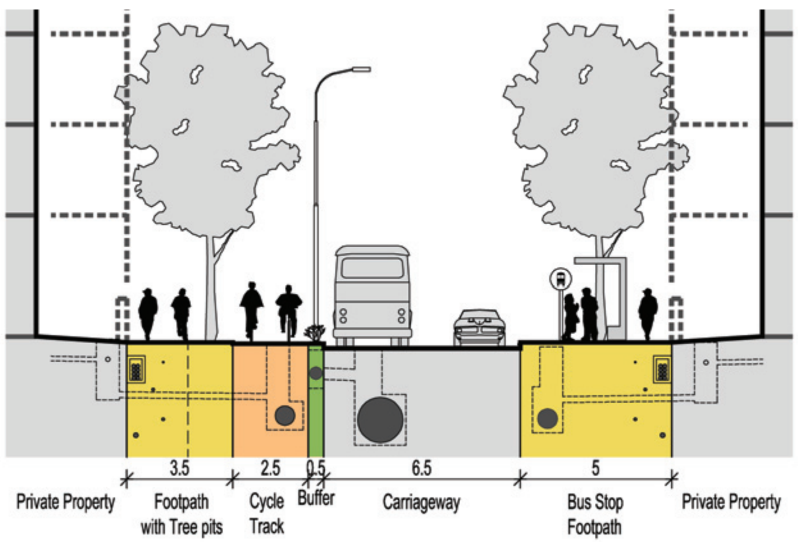
Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	Median track	**Side track**	Mixed traffic
Parking and property access	Service lane	**No service lane**	
Private vehicle mobility	Divided carriageway	**Undivided carriageway**	No carriageway

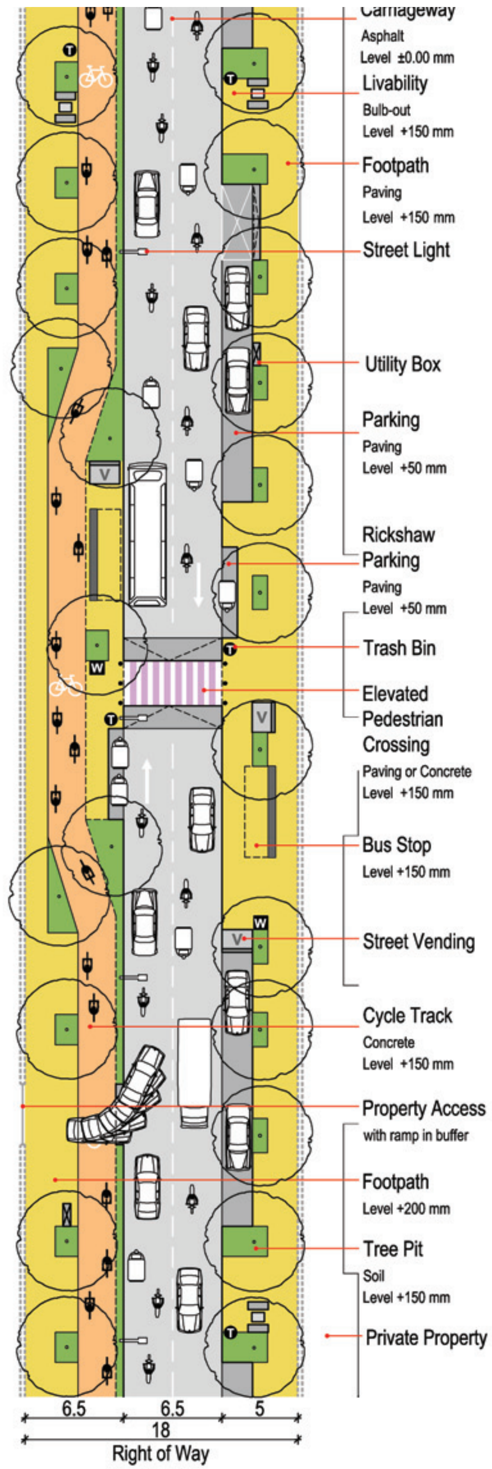


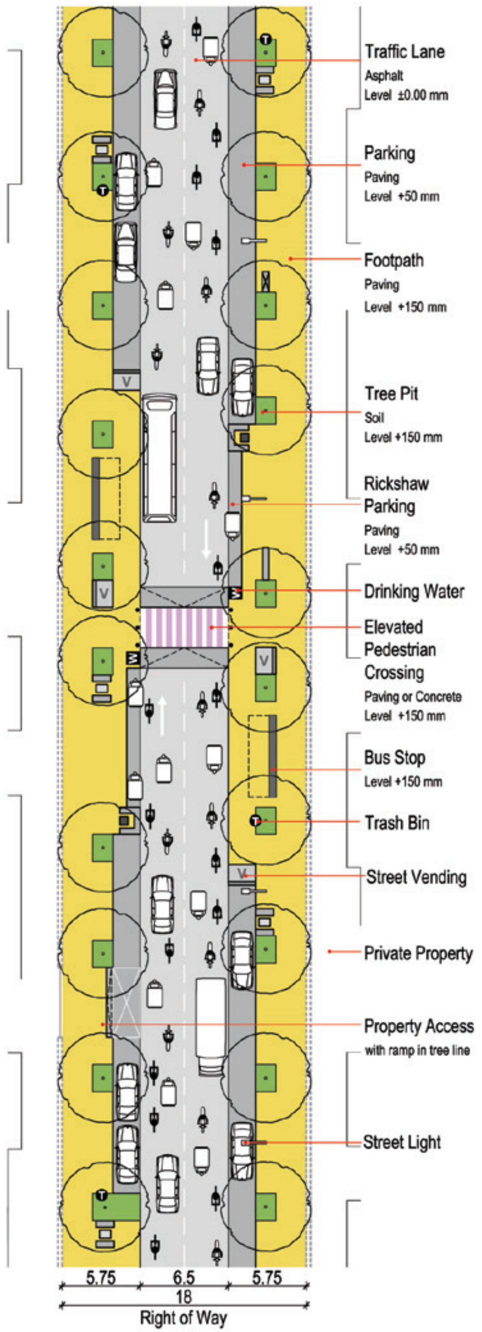
18b

Small streets with cycle tracks

Footpath	Shared space		Pedestrian mobility and access
Median track	**Side track**	Mixed traffic	Cyclist mobility
Service lane	**No service lane**		Parking and property access
Divided carriageway	**Undivided carriageway**	No carriageway	Private vehicle mobility



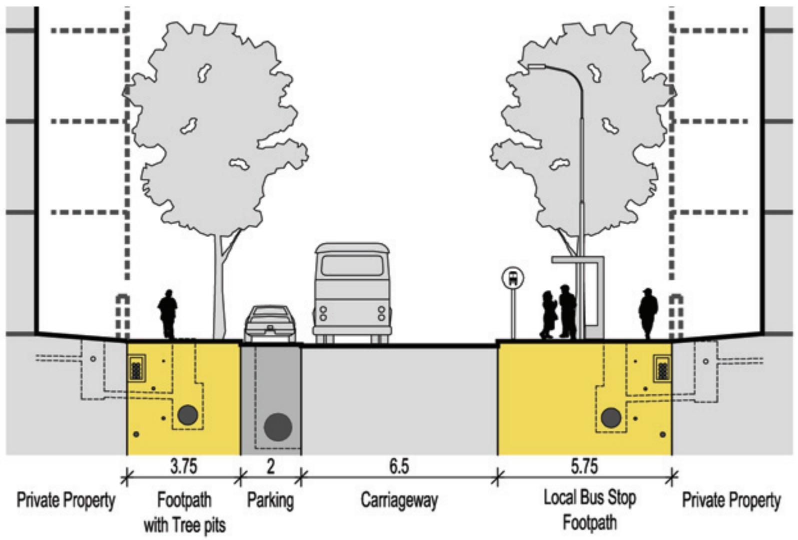




18c

Small streets with footpaths

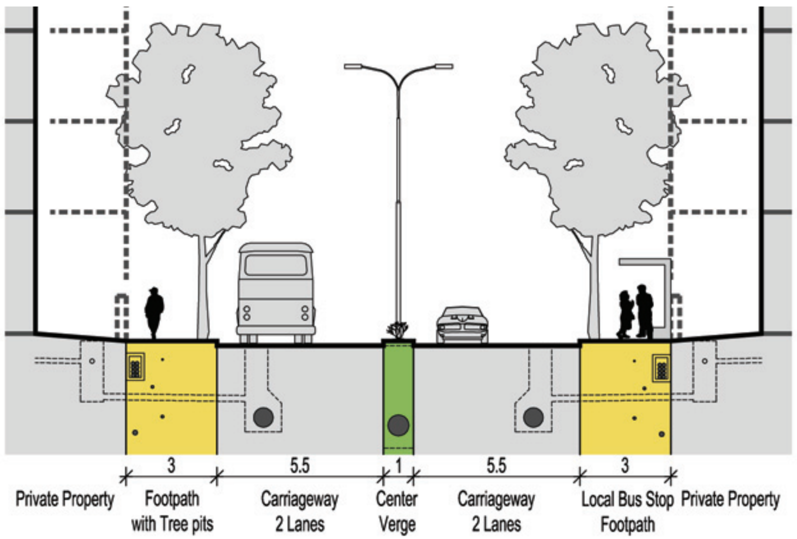
Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	Median track	Side track	**Mixed traffic**
Parking and property access	Service lane	**No service lane**	
Private vehicle mobility	Divided carriageway	**Undivided carriageway**	No carriageway

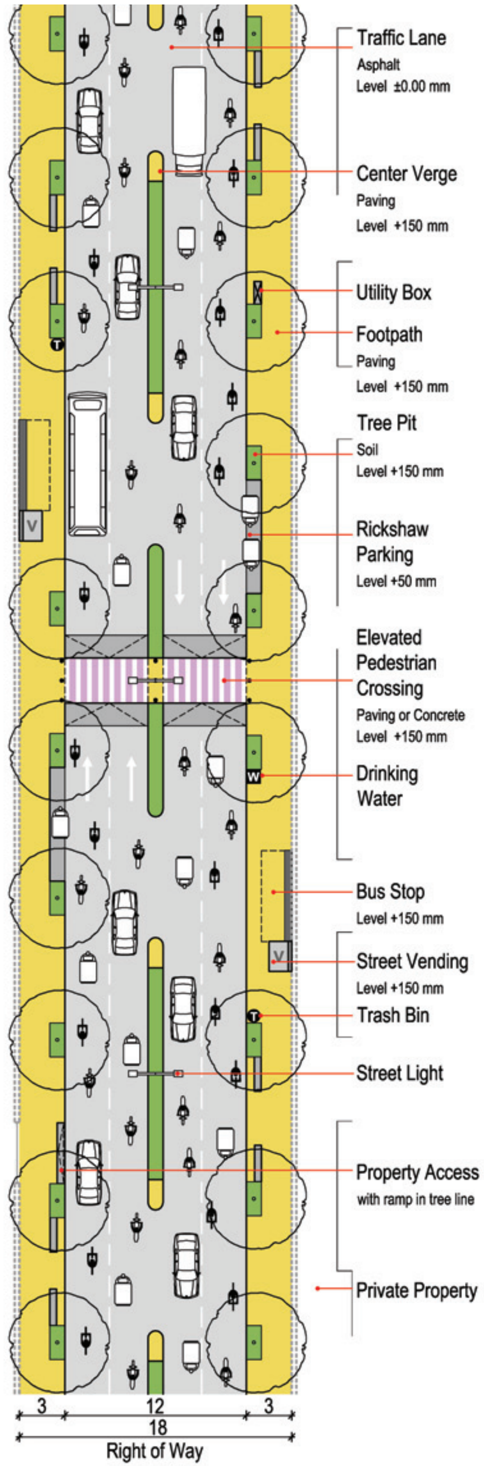


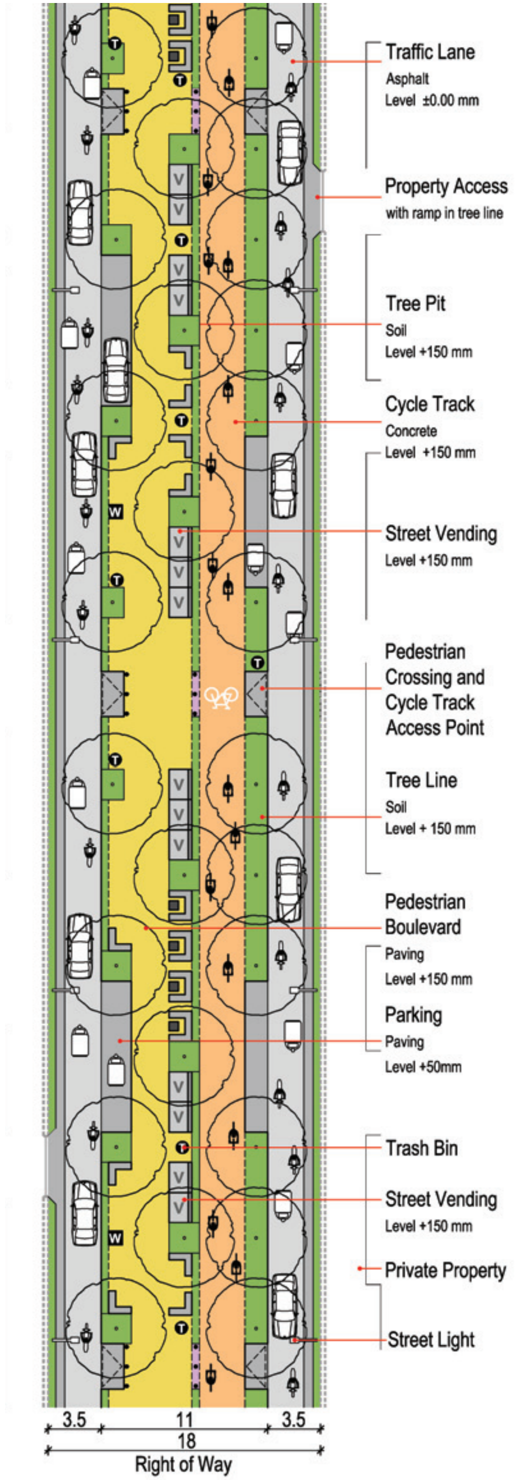
18d

Divided carriageways without cycle tracks

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility



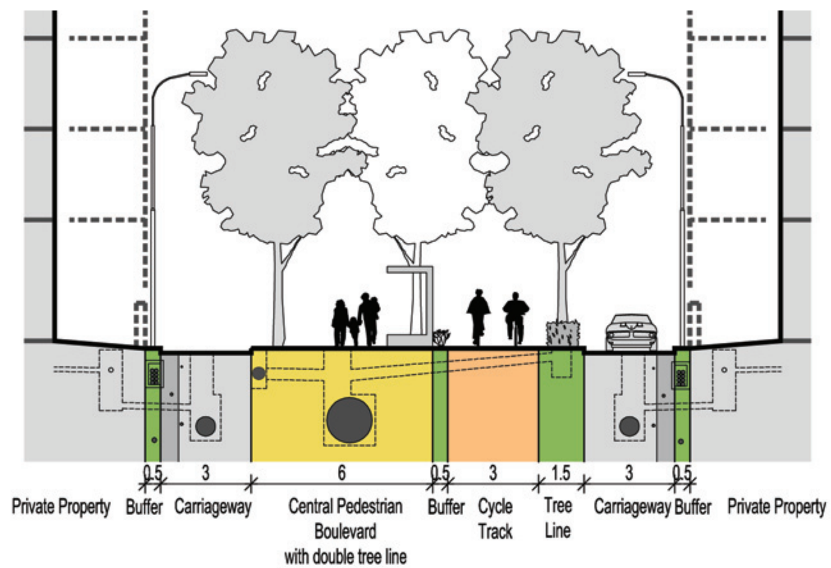




18e

Forest streets

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway



24 m templates

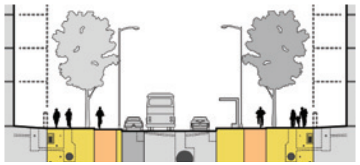
Large streets with median cycle tracks

Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	**Median track**	Side track	Mixed traffic
Parking and property access	Service lane	**No service lane**	
Private vehicle mobility	**Divided carriageway**	Undivided carriageway	No carriageway

24a

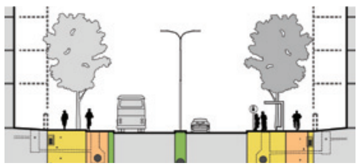
Large streets with side cycle tracks

Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	Median track	**Side track**	Mixed traffic
Parking and property access	Service lane	**No service lane**	
Private vehicle mobility	Divided carriageway	**Undivided carriageway**	No carriageway



24d

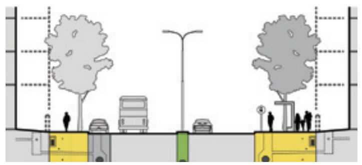
Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	Median track	**Side track**	Mixed traffic
Parking and property access	Service lane	**No service lane**	
Private vehicle mobility	**Divided carriageway**	Undivided carriageway	No carriageway



24b

Divided carriageways without cycle tracks

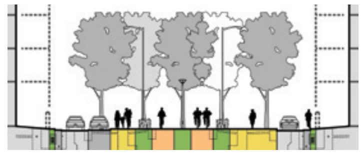
Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	Median track	Side track	**Mixed traffic**
Parking and property access	Service lane	**No service lane**	
Private vehicle mobility	**Divided carriageway**	Undivided carriageway	No carriageway



24c

Forest streets

Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	**Median track**	Side track	Mixed traffic
Parking and property access	**Service lane**	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	**No carriageway**

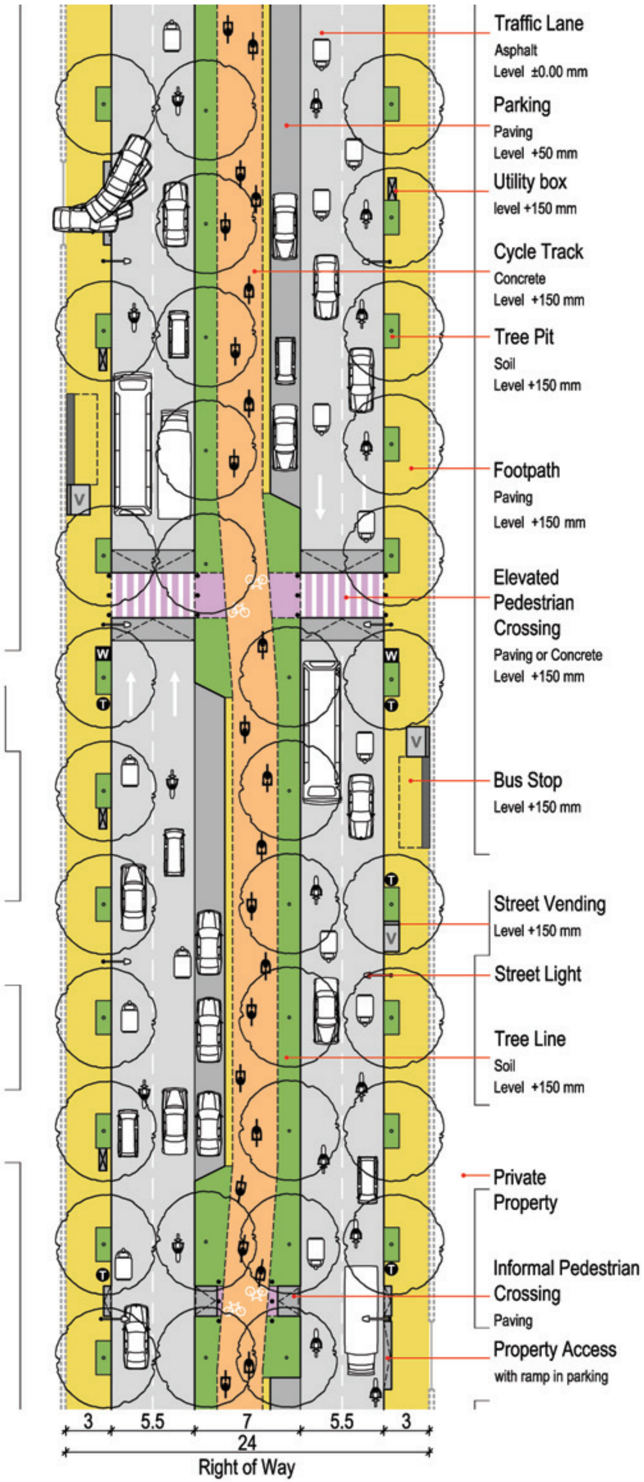


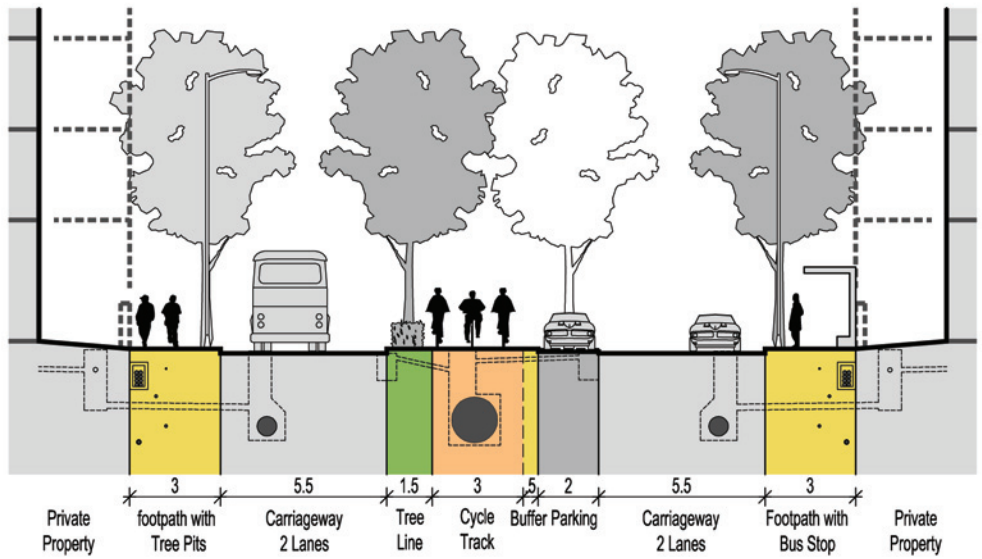
24e

24a

Large streets with median cycle tracks

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway

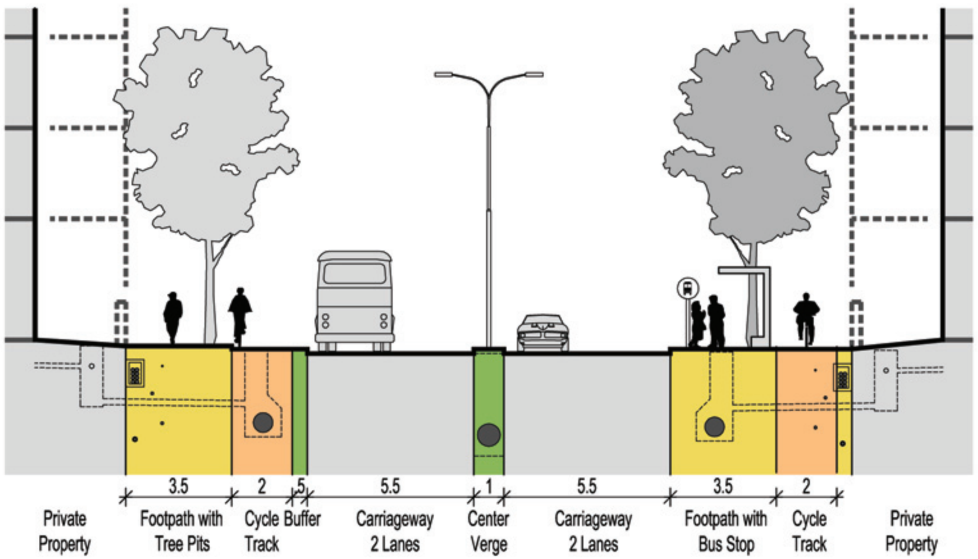


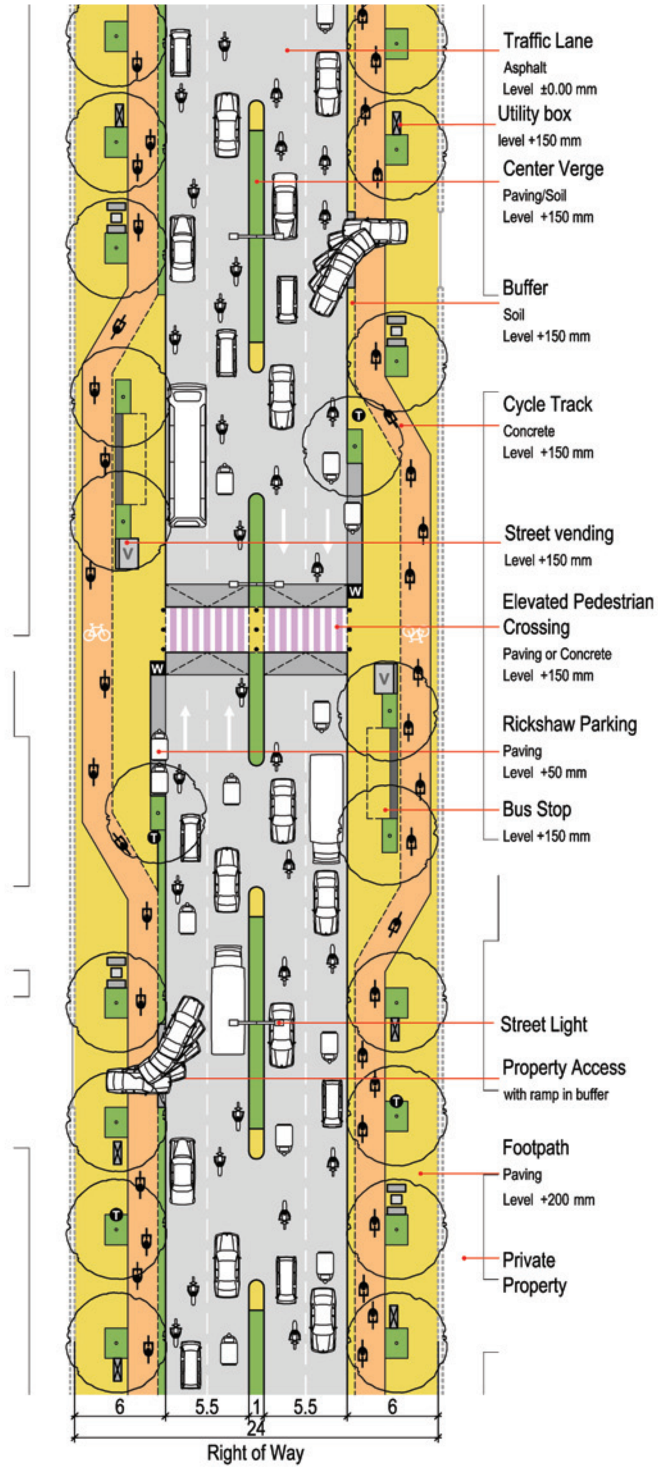


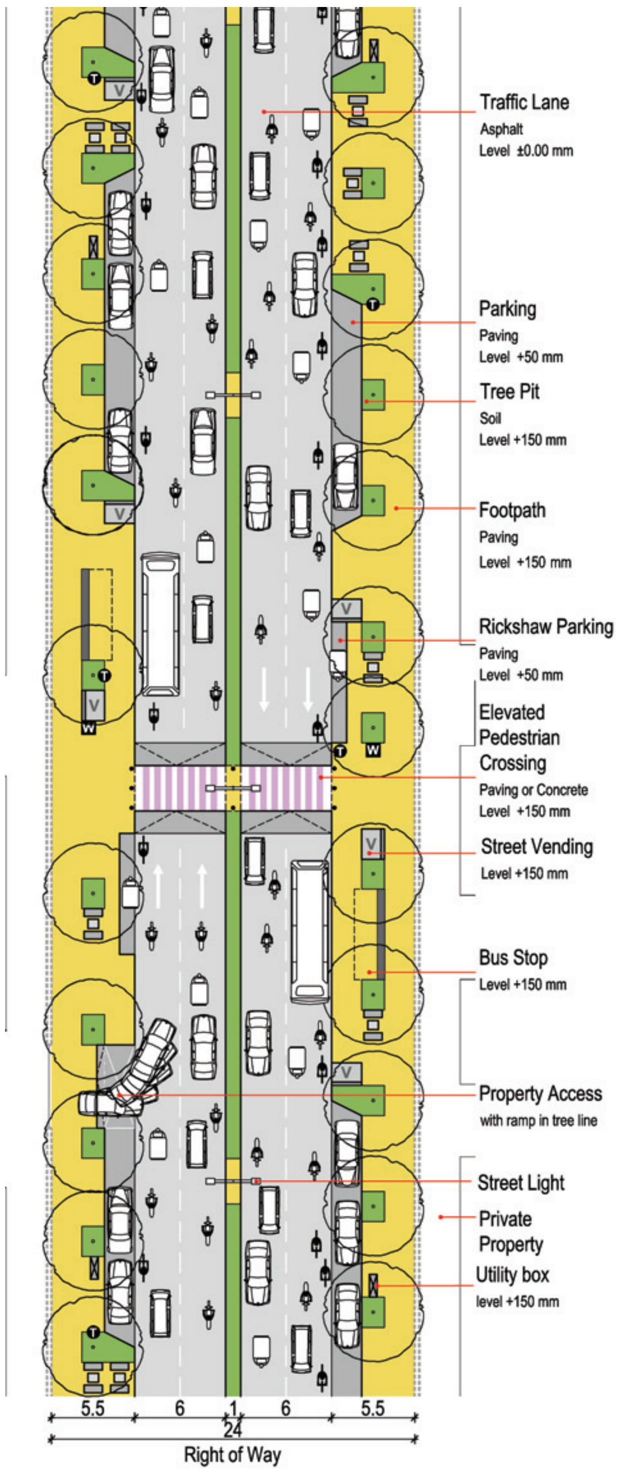
24b

Large streets with side cycle tracks

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility



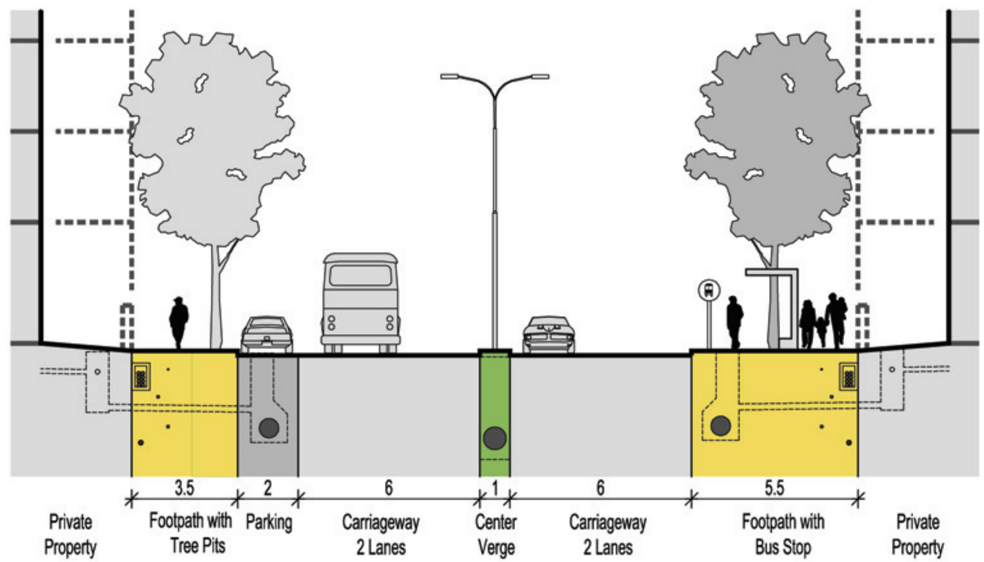




24C

Divided carriageways without cycle tracks

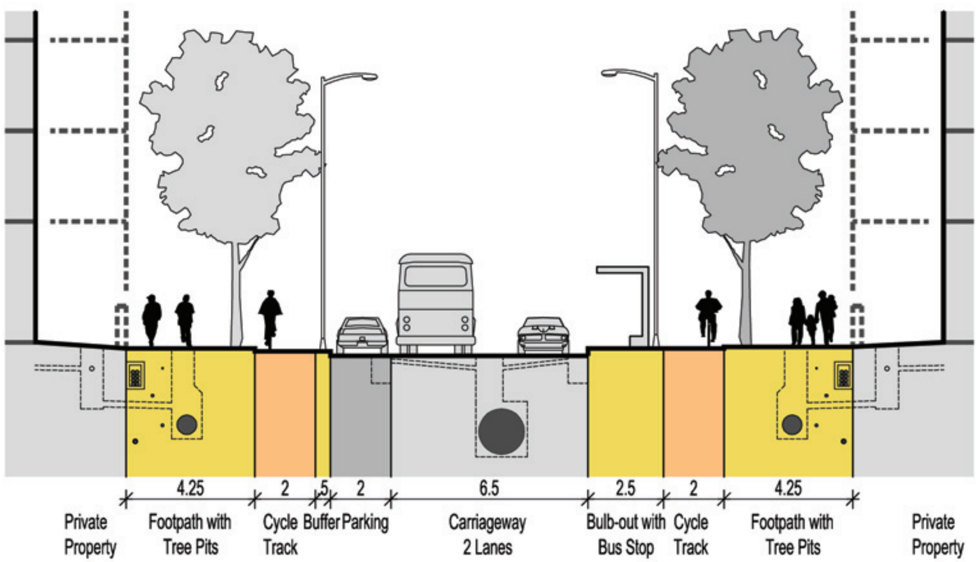
Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	Median track	Side track	**Mixed traffic**
Parking and property access	Service lane	**No service lane**	
Private vehicle mobility	**Divided carriageway**	Undivided carriageway	No carriageway

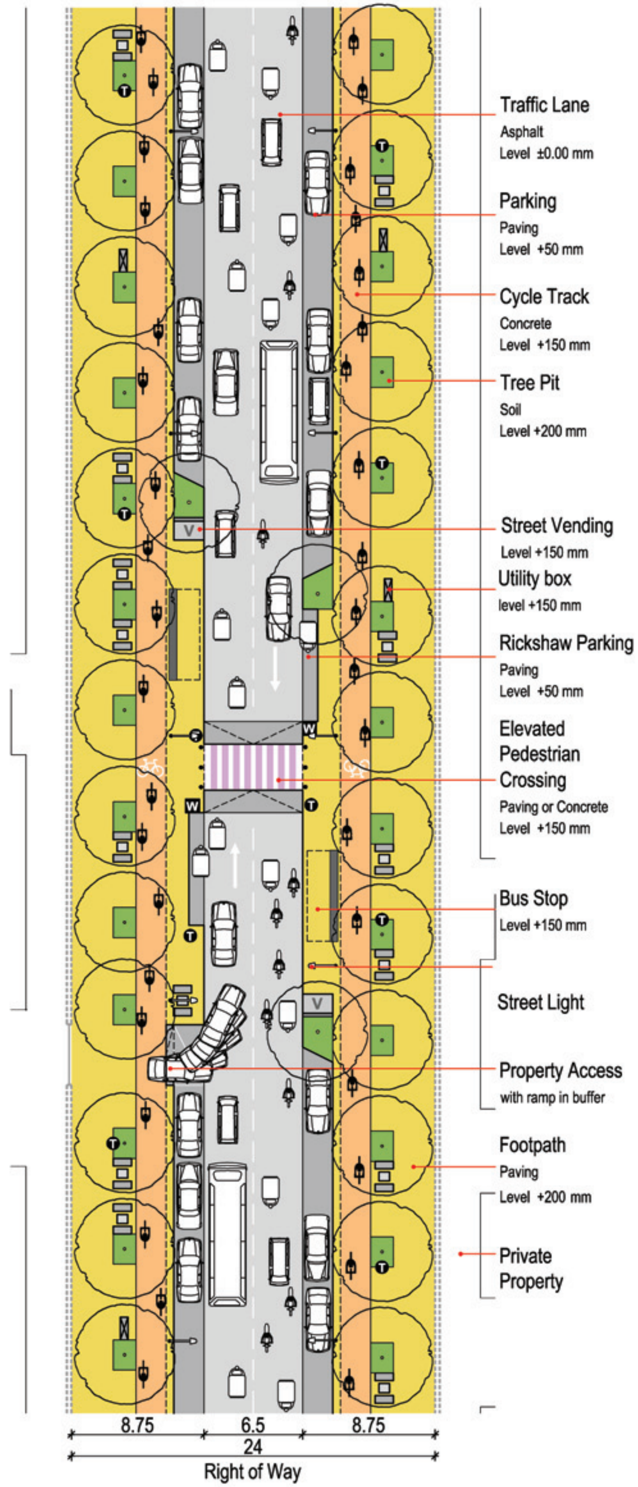


24d

Large streets with side cycle tracks

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility

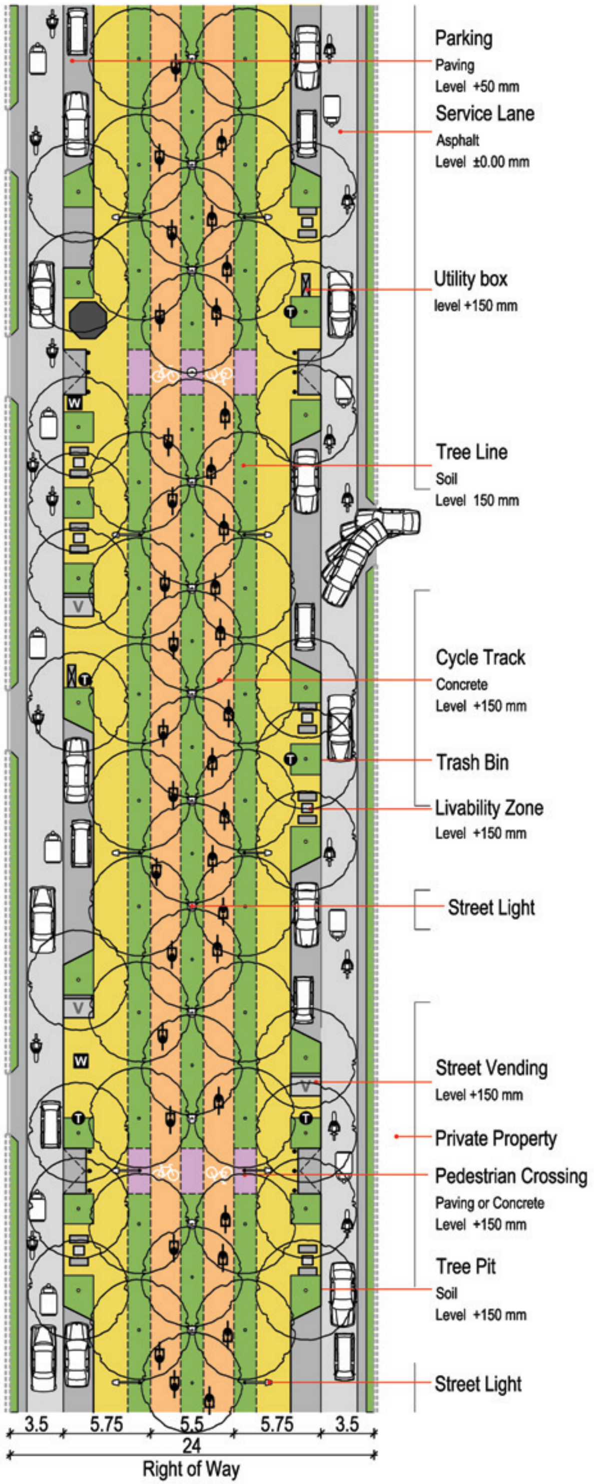


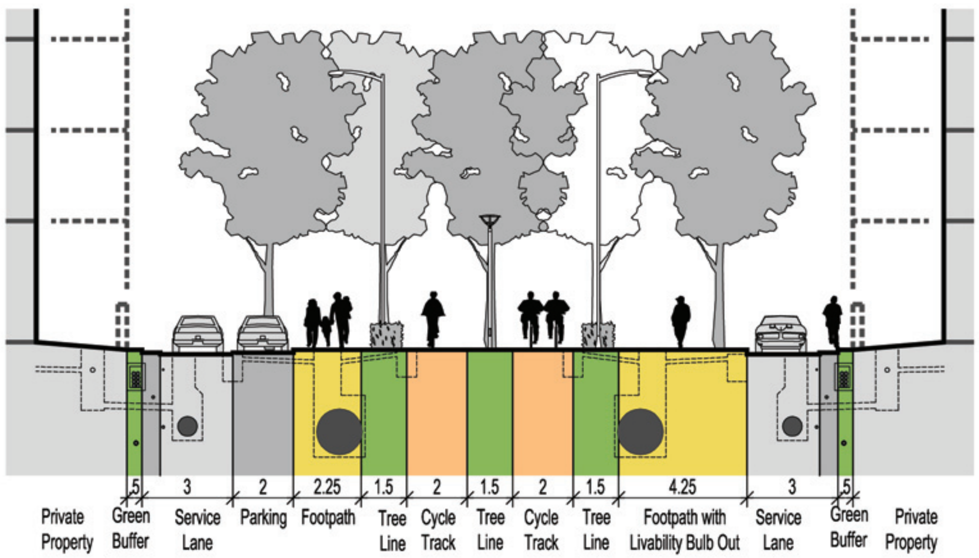


24e

Forest streets

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway

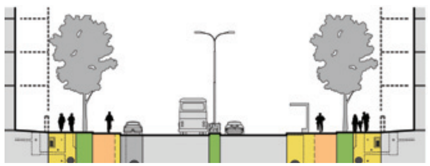




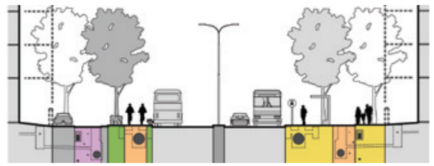
30 m templates

	Large streets with median cycle tracks	Large streets with side cycle tracks	Large streets with service lanes
Pedestrian mobility and access	**Footpath** / Shared space	**Footpath** / Shared space	Footpath / **Shared space**
Cyclist mobility	**Median track** / Side track / Mixed traffic	Median track / **Side track** / Mixed traffic	Median track / **Side track** / Mixed traffic
Parking and property access	Service lane / **No service lane**	Service lane / **No service lane**	**Service lane** / No service lane
Private vehicle mobility	**Divided carriageway** / Undivided carriageway / No carriageway	**Divided carriageway** / Undivided carriageway / No carriageway	**Divided carriageway** / Undivided carriageway / No carriageway

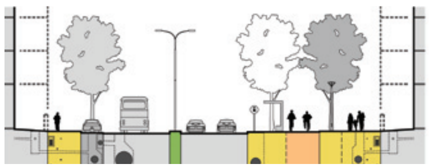
30a



30b



30c



30d

30a

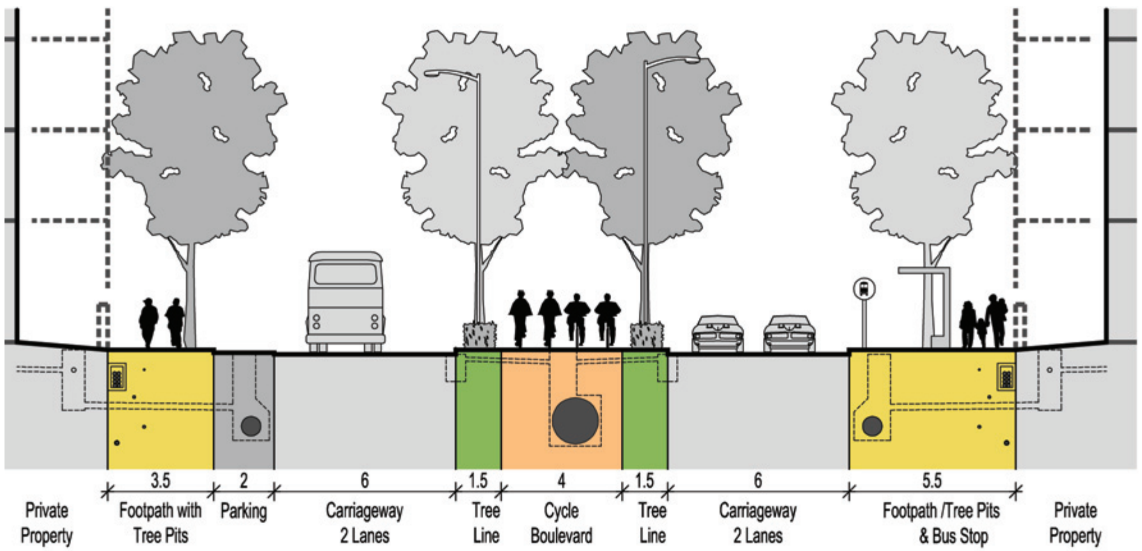
Large streets with median cycle tracks

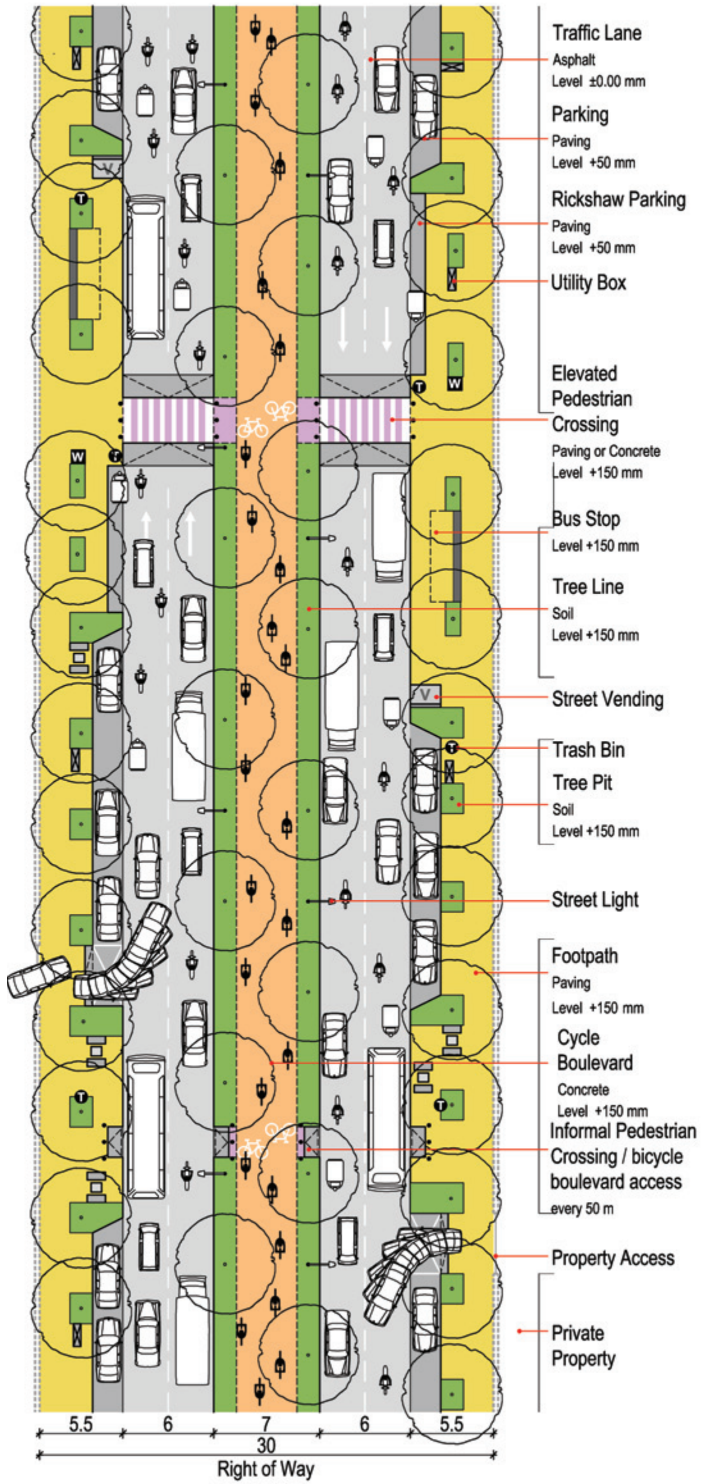
Footpath | Shared space | Pedestrian mobility and access

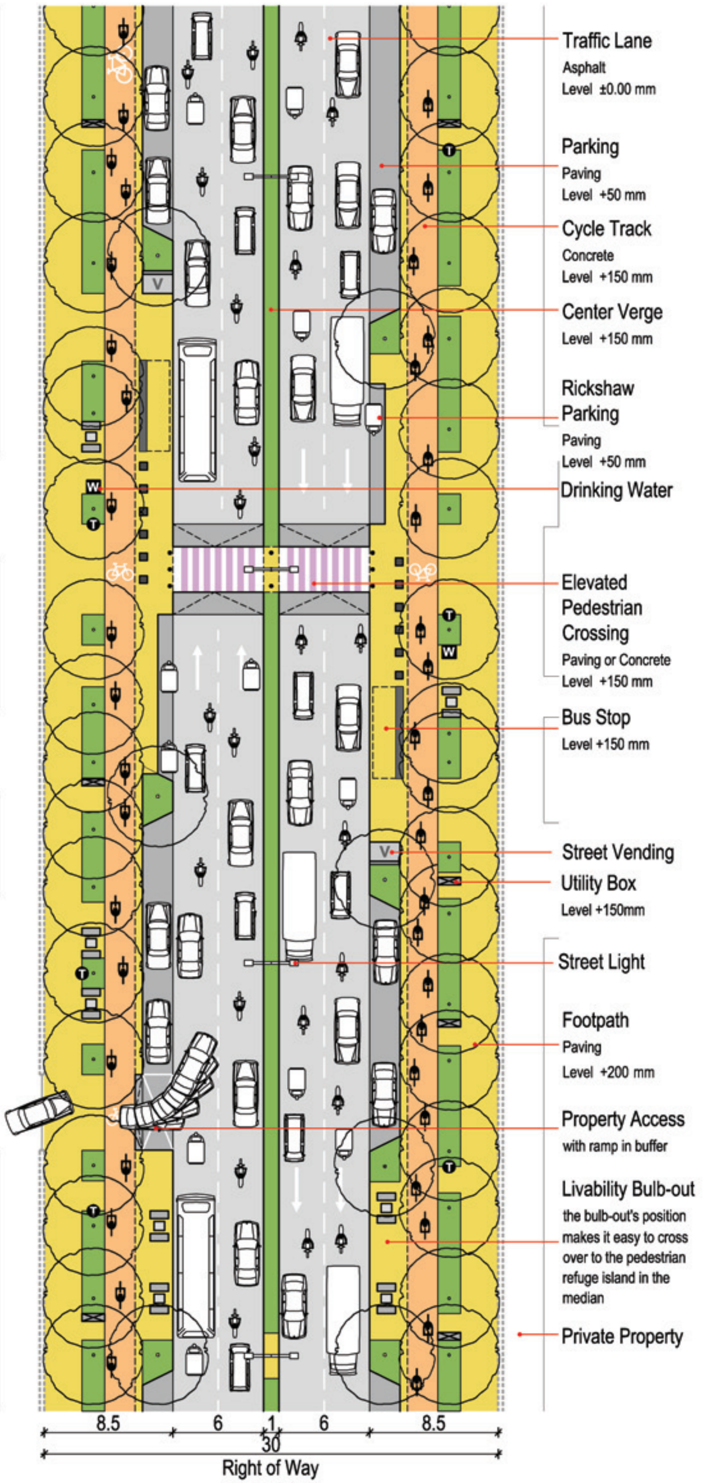
Median track | Side track | Mixed traffic | Cyclist mobility

Service lane | No service lane | Parking and property access

Divided carriageway | Undivided carriageway | No carriageway | Private vehicle mobility



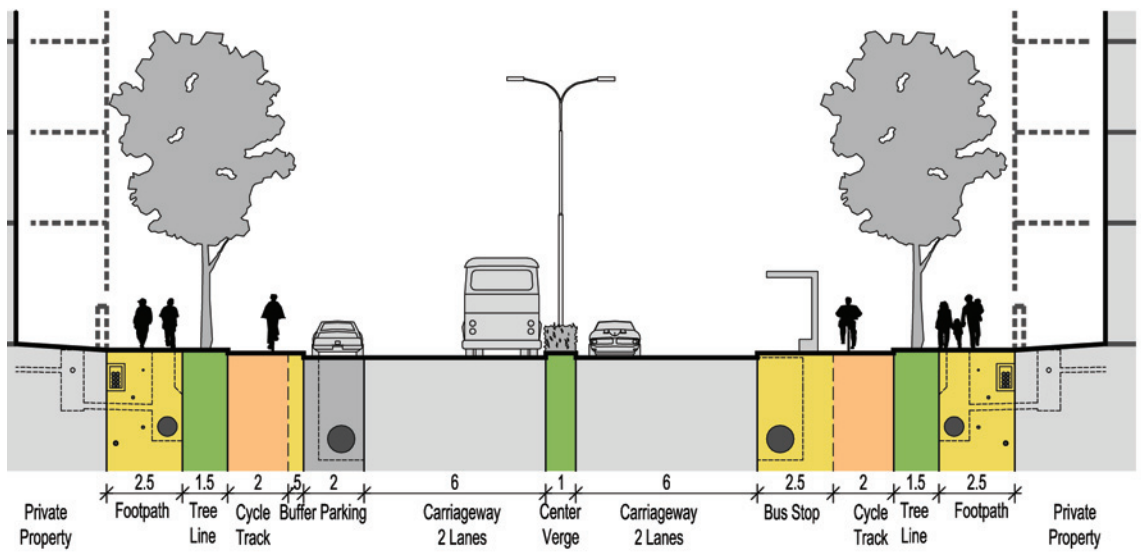




30b

Large streets with side cycle tracks

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway

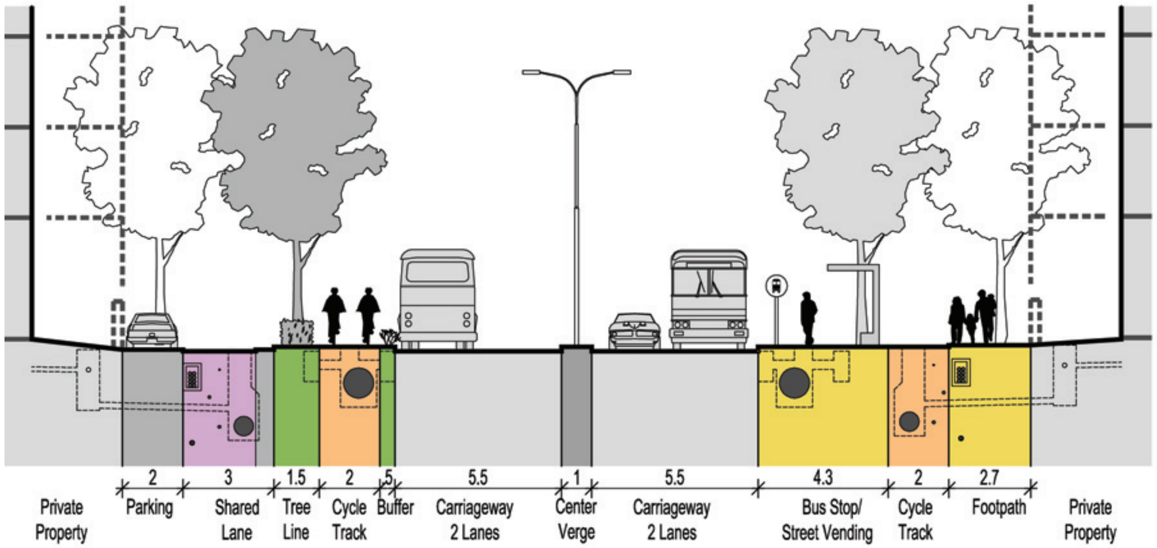


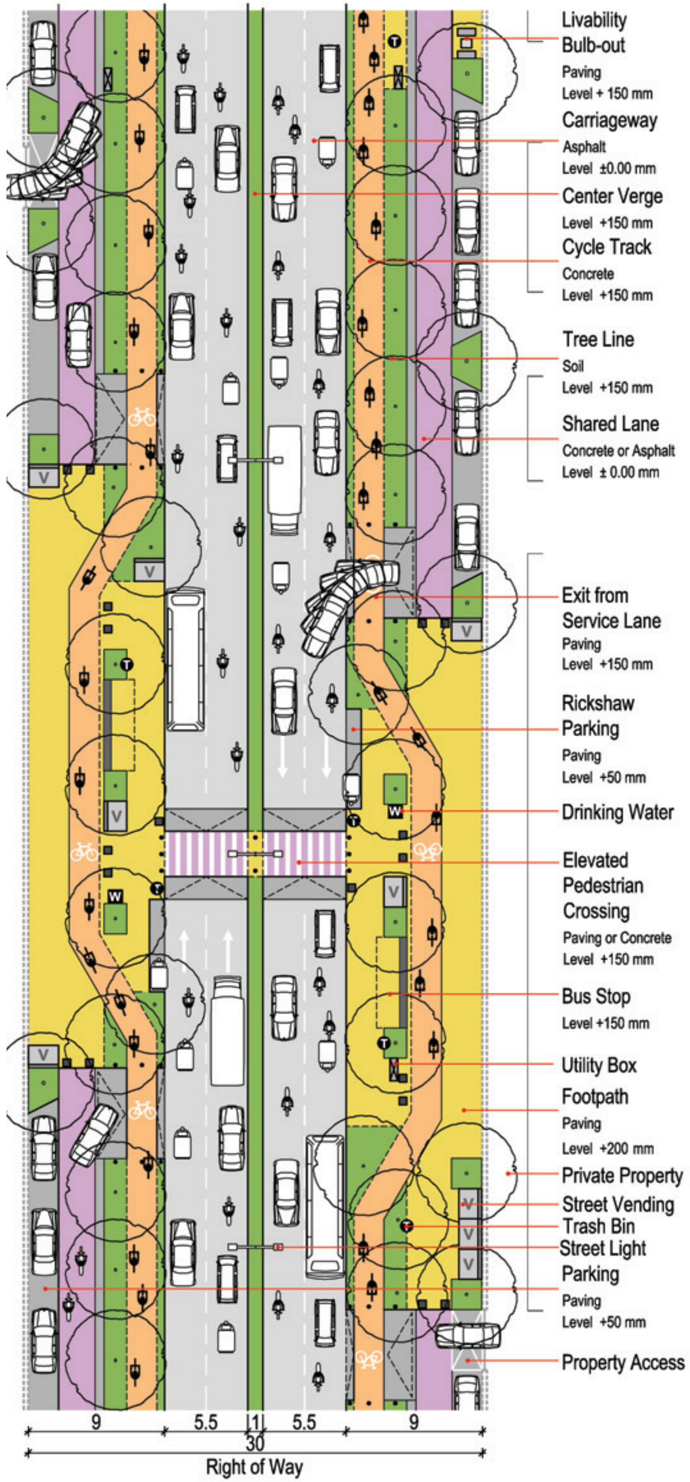
30C

Large streets with service lanes

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility

Note This section does not provide dedicated pedestrian space, but pedestrians can use the service lane provided that traffic calming measures are employed to reduce motor vehicle speeds.

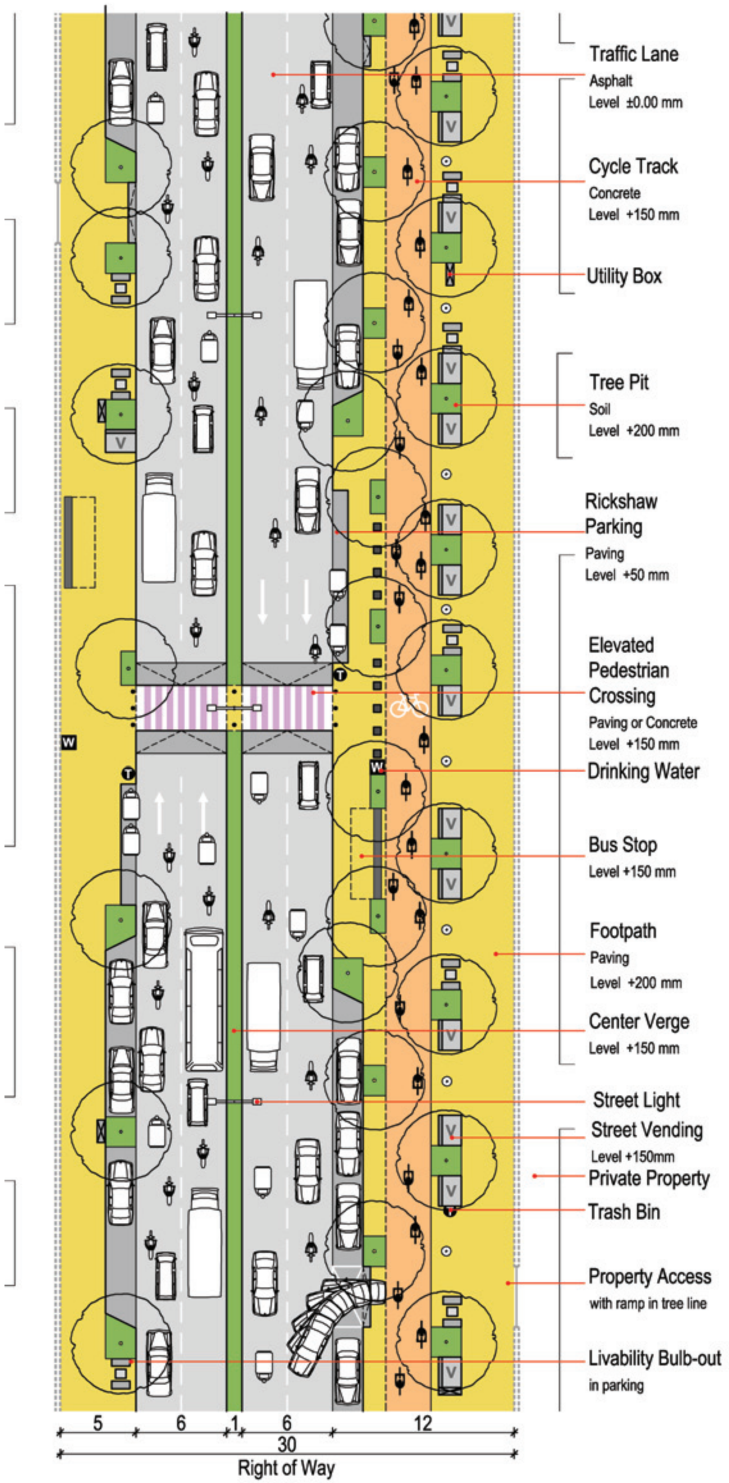


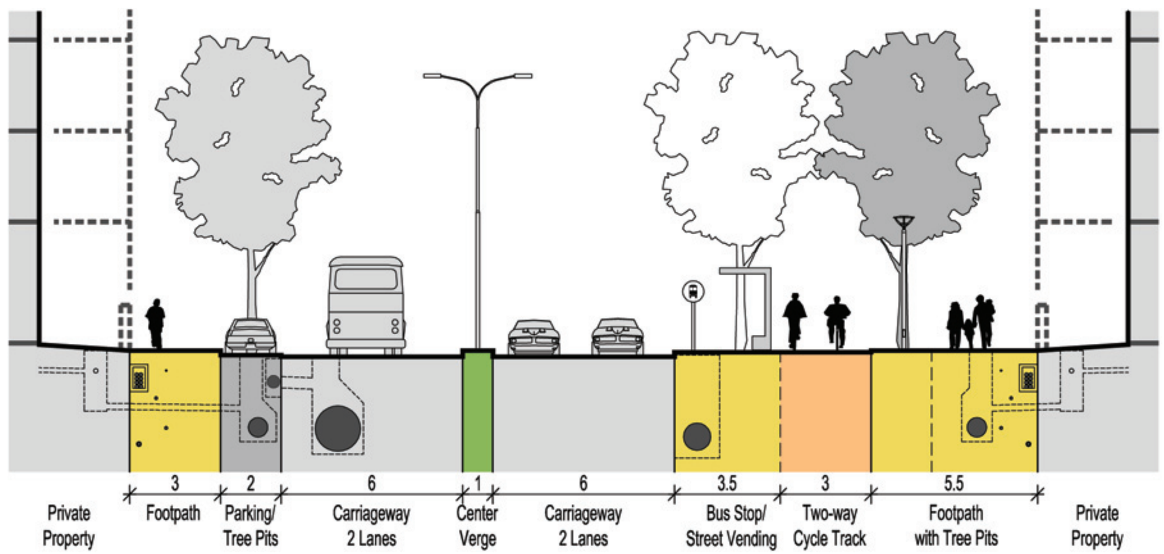


30d

Large streets with side cycle tracks

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway

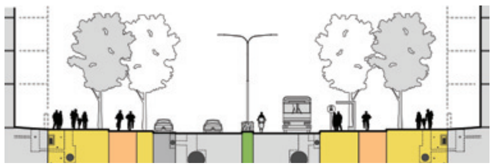


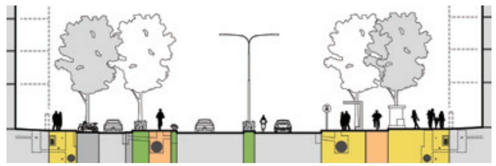


36 m templates

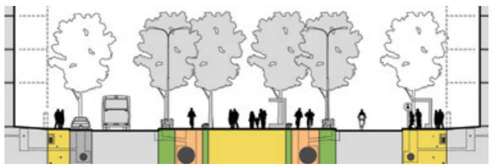
	Large streets with median cycle tracks	Large streets with side cycle tracks	Large streets with service lanes
Pedestrian mobility and access	**Footpath** / Shared space	**Footpath** / Shared space	**Footpath** / Shared space
Cyclist mobility	**Median track** / Side track / Mixed traffic	Median track / **Side track** / Mixed traffic	Median track / **Side track** / Mixed traffic
Parking and property access	Service lane / **No service lane**	Service lane / **No service lane**	**Service lane** / No service lane
Private vehicle mobility	**Divided carriageway** / Undivided carriageway / No carriageway	**Divided carriageway** / Undivided carriageway / No carriageway	**Divided carriageway** / Undivided carriageway / No carriageway


36a


36b


36c

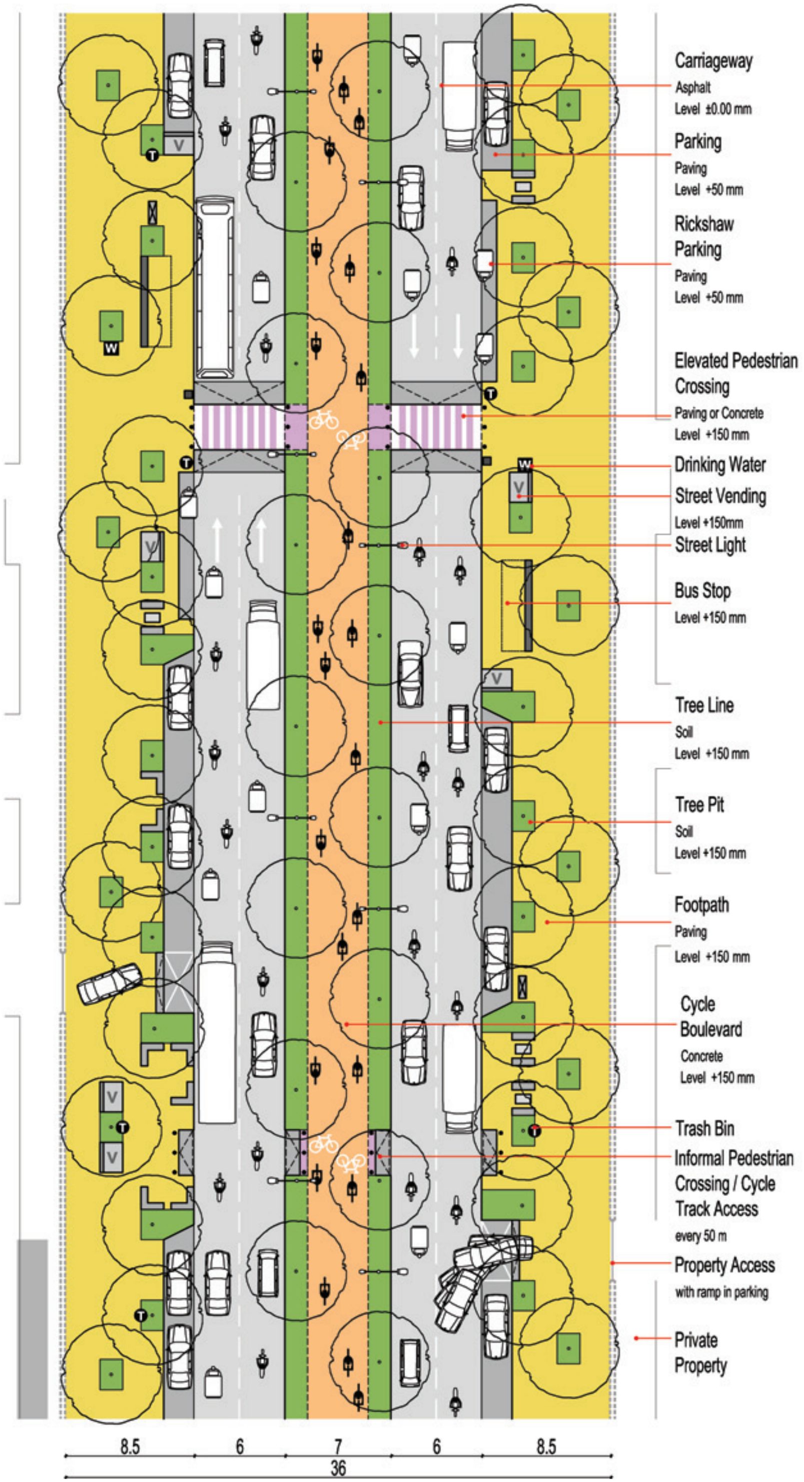

36d

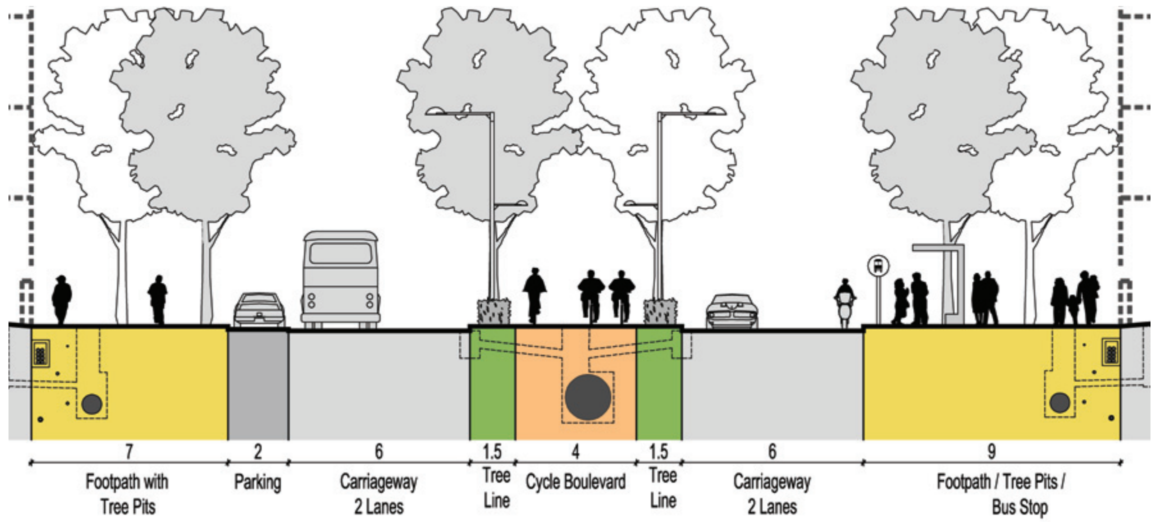

36e

36a

Large streets with median cycle tracks

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway

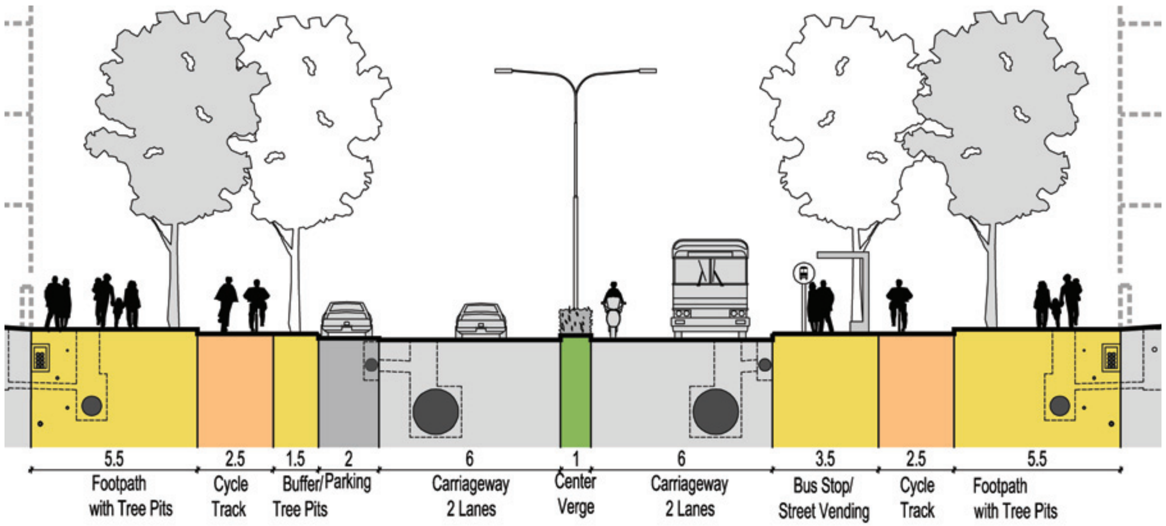


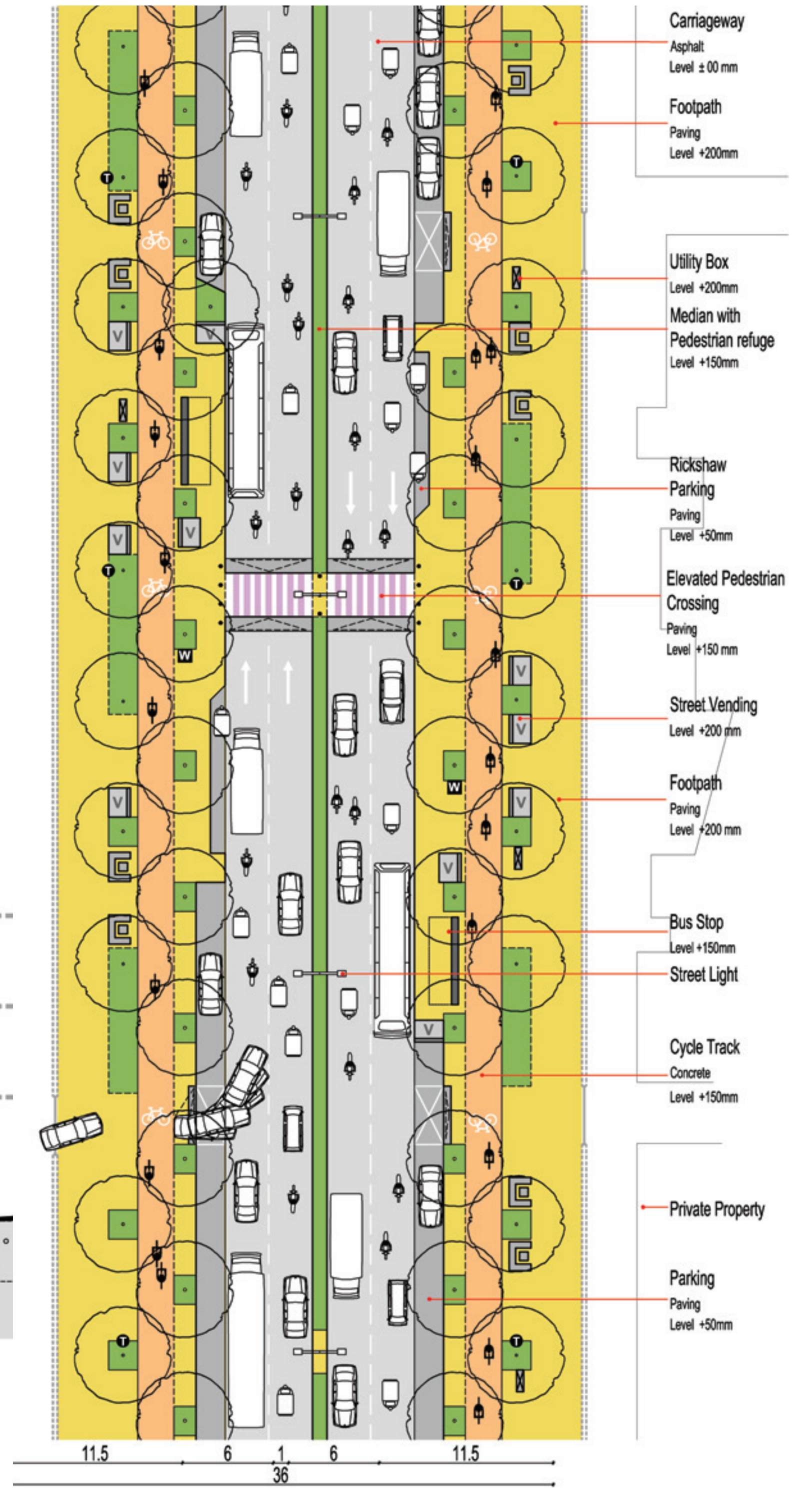


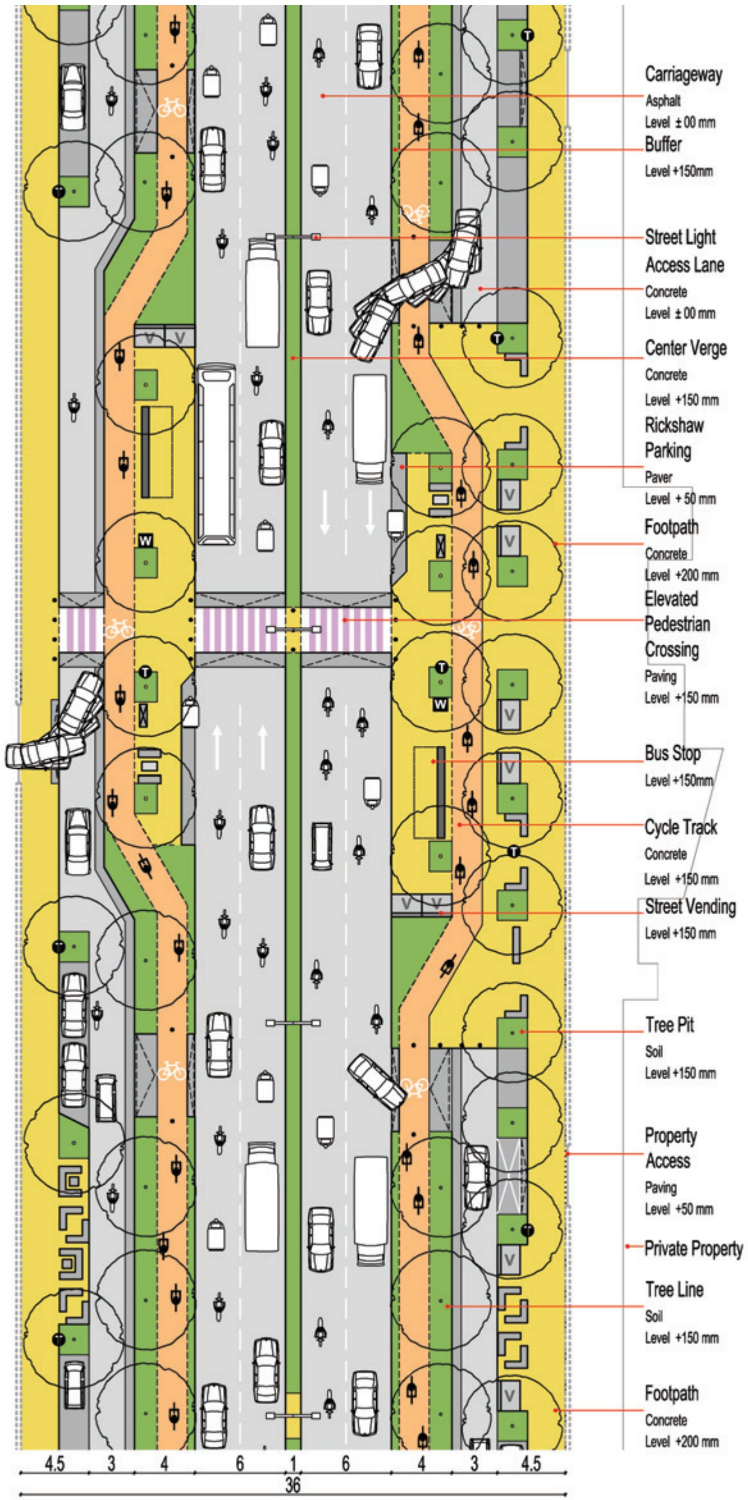
36b

Large streets with side cycle tracks

Footpath	Shared space		Pedestrian mobility and access
Median track	**Side track**	Mixed traffic	Cyclist mobility
Service lane	**No service lane**		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility





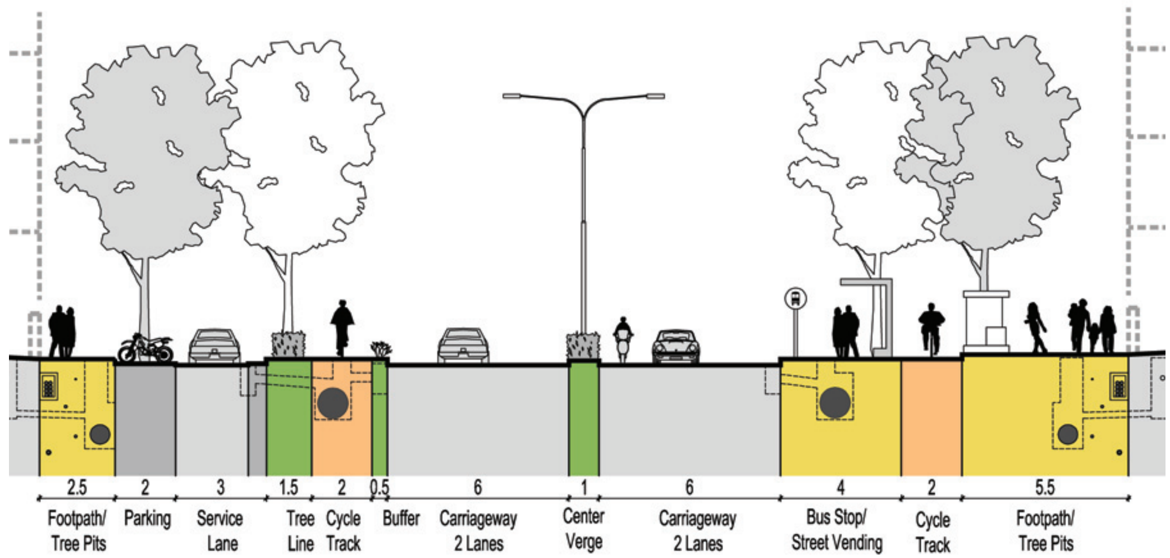


36c

Large streets with service lanes

Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	Median track	**Side track**	Mixed traffic
Parking and property access	**Service lane**	No service lane	
Private vehicle mobility	**Divided carriageway**	Undivided carriageway	No carriageway

Note Depending on adjacent land uses, the footpath can be placed at the edge of the right-of-way. Such an arrangement may be desirable if there are active retail storefronts abutting the street (see Section 2.12).

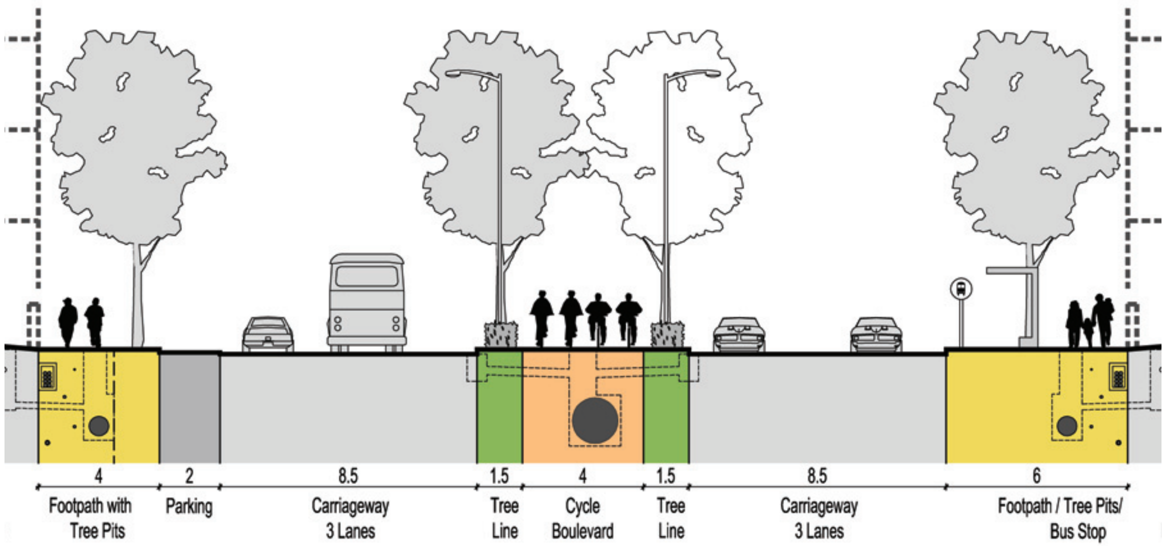


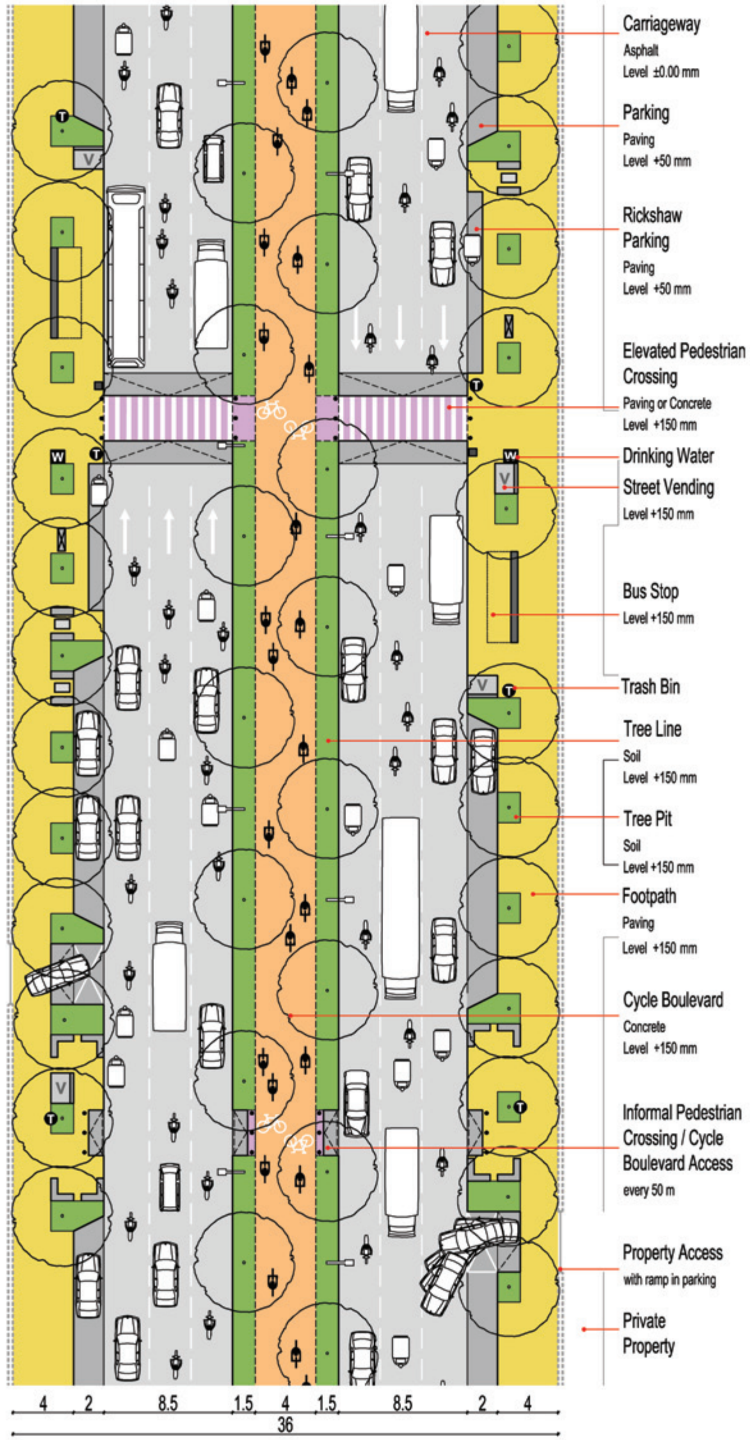
36d

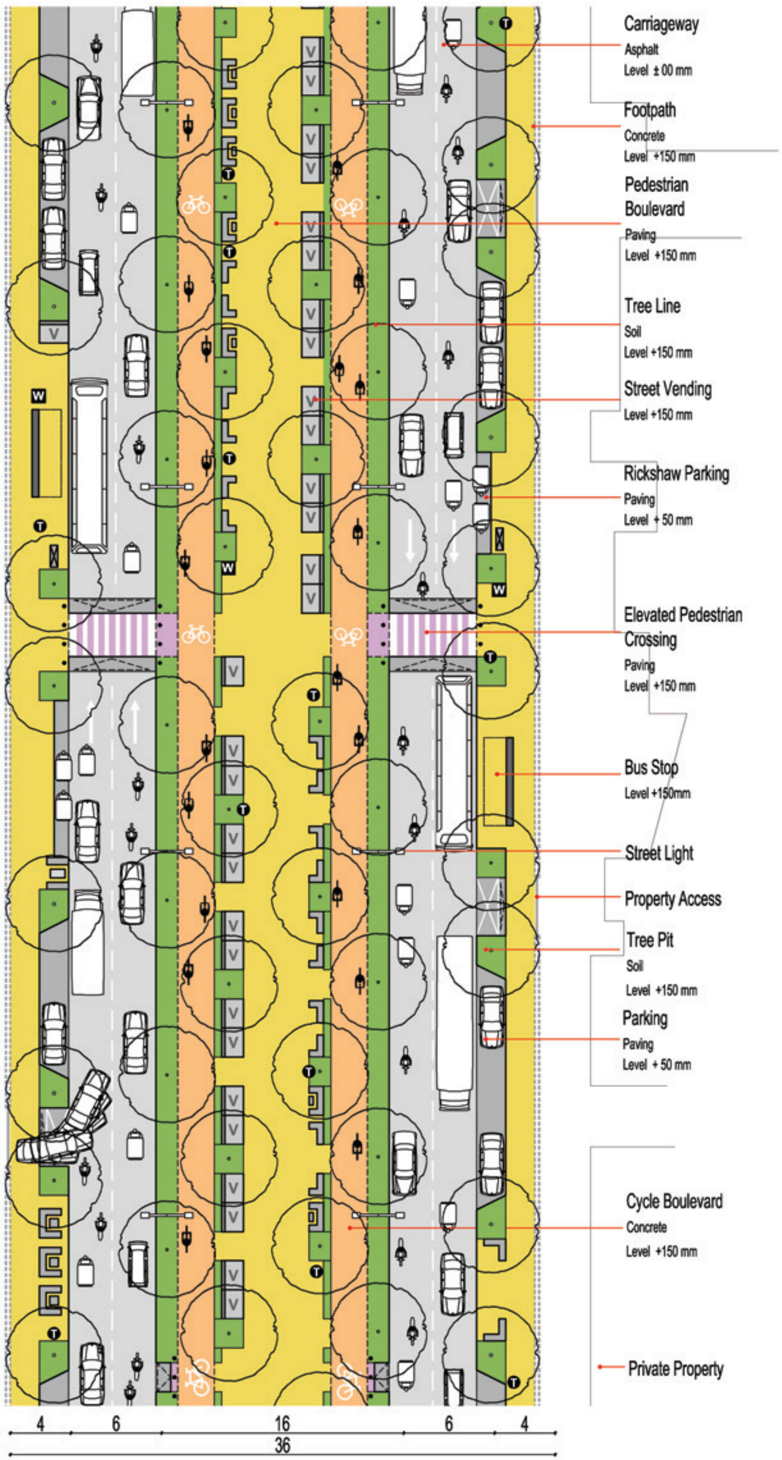
Large streets with median cycle tracks

Footpath	Shared space		Pedestrian mobility and access
Median track	Side track	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility

Note This standard section is similar to template 36a, except that the carriageway has been widened from 6 m to 8.5 m.



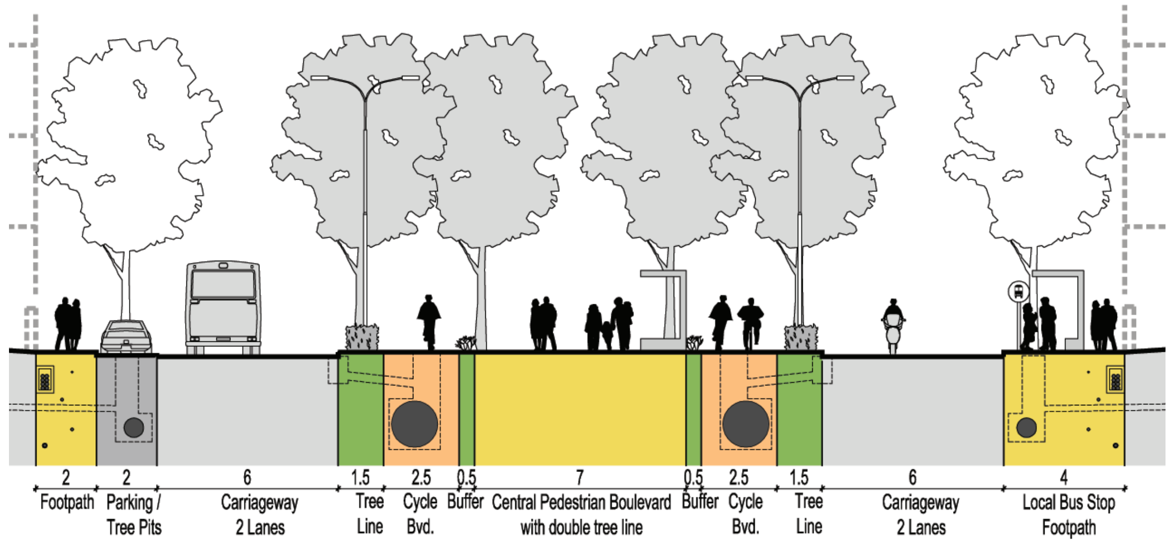




36e

Large streets with median cycle tracks

Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	**Median track**	Side track	Mixed traffic
Parking and property access	Service lane	**No service lane**	
Private vehicle mobility	**Divided carriageway**	Undivided carriageway	No carriageway

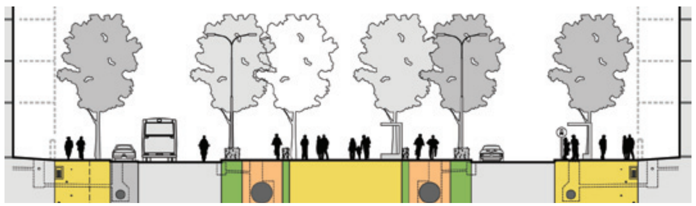


42 m templates

Large streets with median cycle tracks

Footpath	Shared space	
Median track	Side track	Mixed traffic
Service lane	**No service lane**	
Divided carriageway	Undivided carriageway	No carriageway

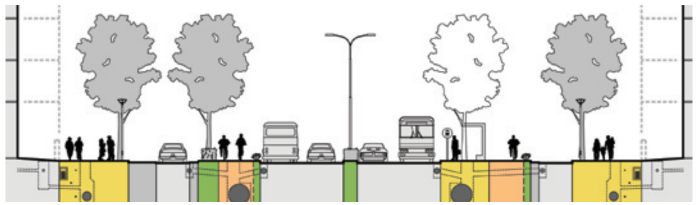
42a



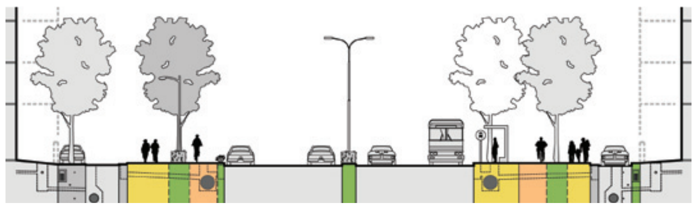
42d

Large streets with service lanes

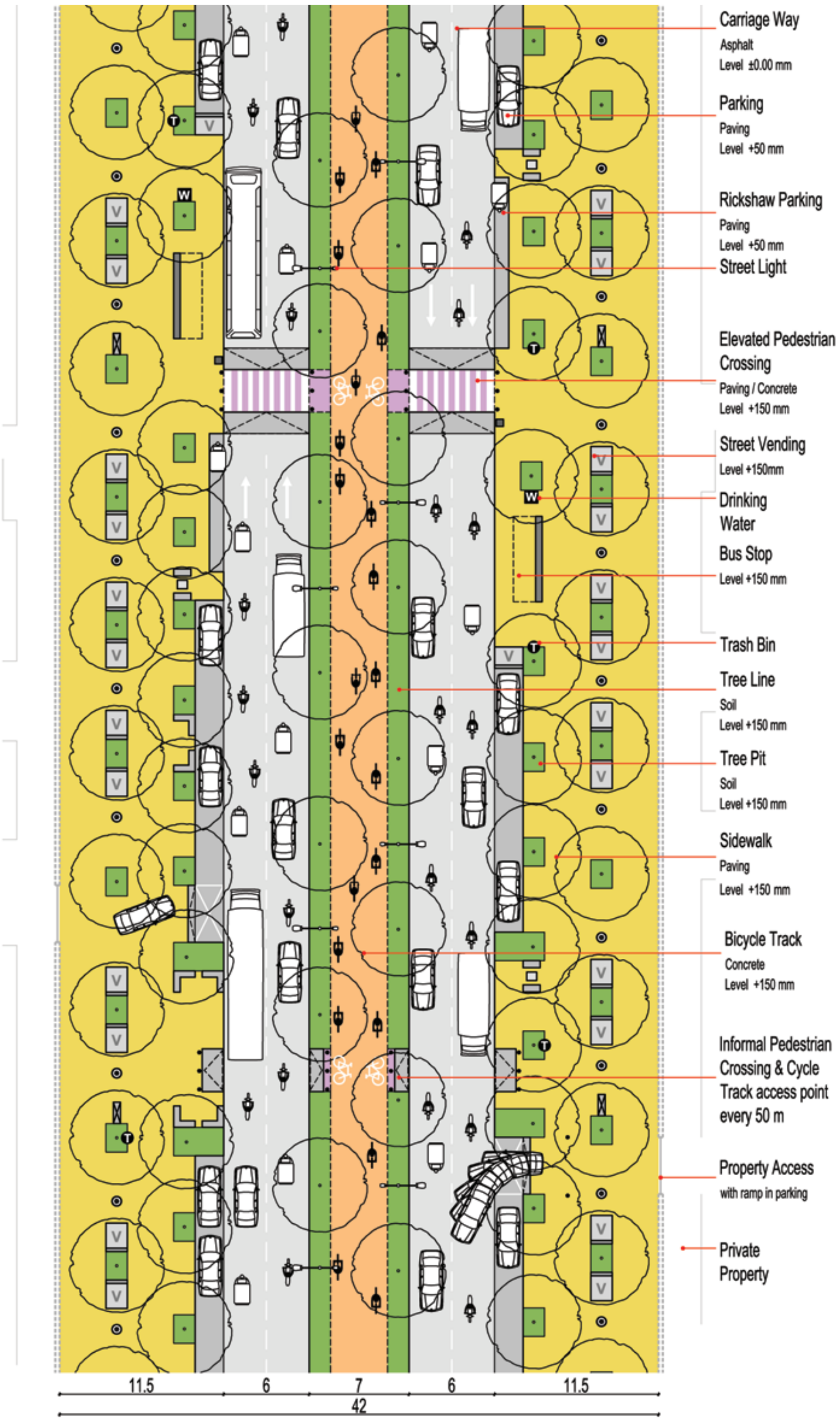
Footpath	Shared space		Pedestrian mobility and access
Median track	**Side track**	Mixed traffic	Cyclist mobility
Service lane	No service lane		Parking and property access
Divided carriageway	Undivided carriageway	No carriageway	Private vehicle mobility



42b



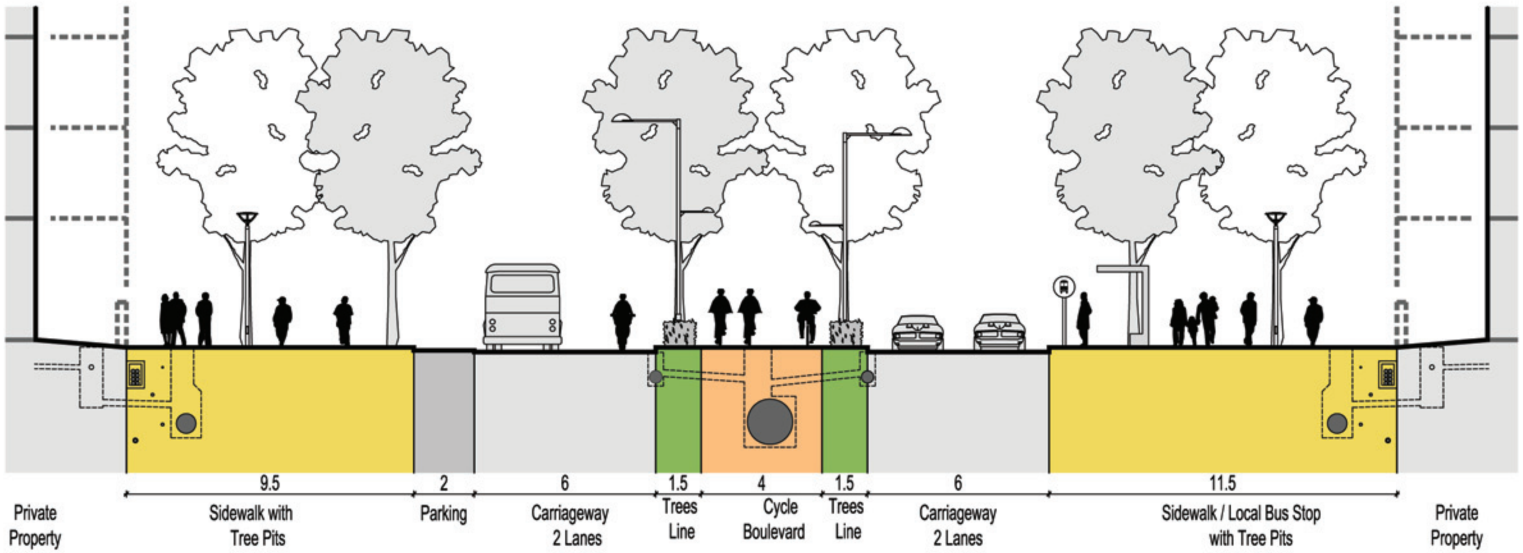
42c

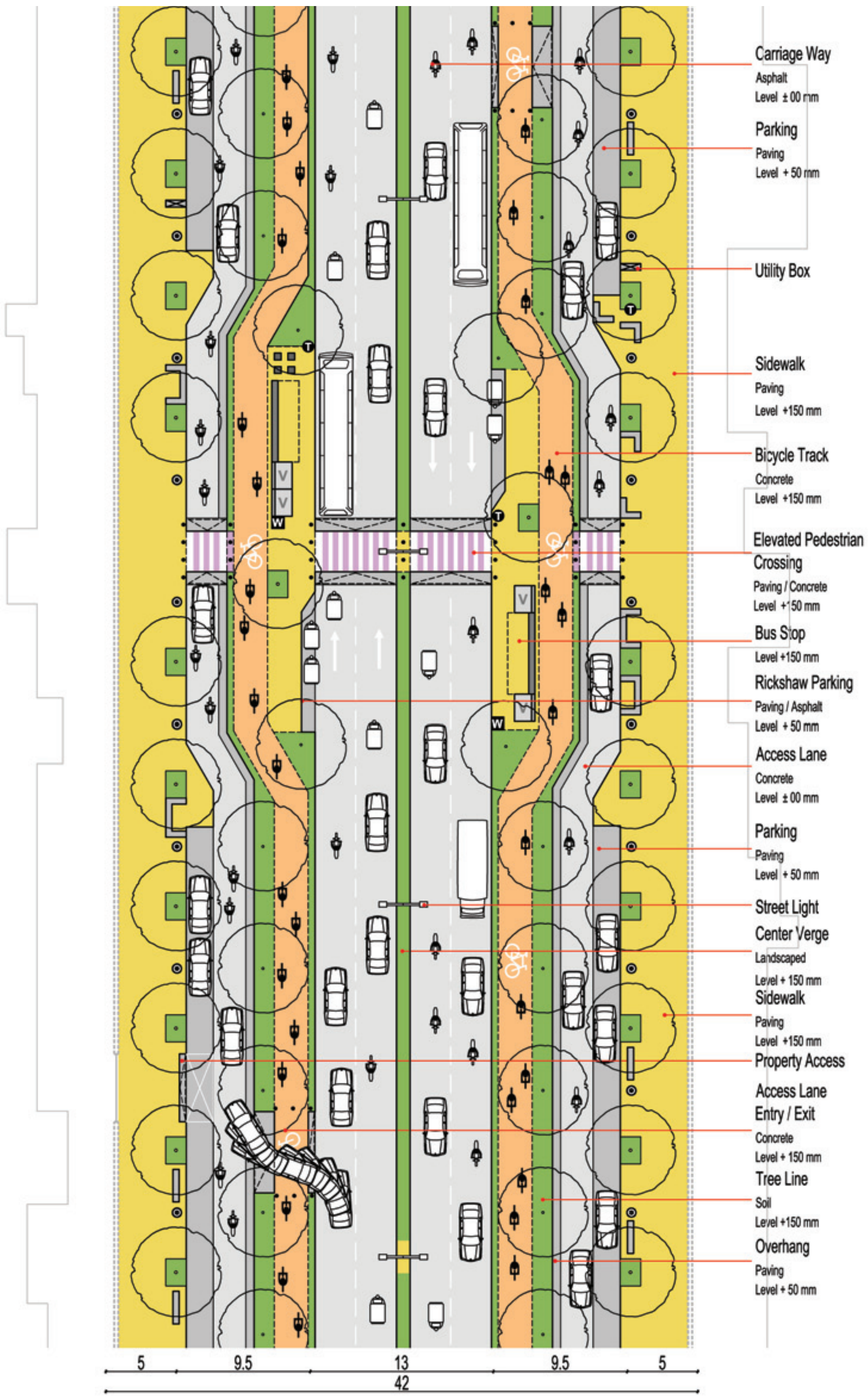

Carriage Way
Asphalt
Level ±0.00 mm
Parking
Paving
Level +50 mm
Rickshaw Parking
Paving
Level +50 mm
Street Light
Elevated Pedestrian Crossing
Paving / Concrete
Level +150 mm
Street Vending
Level +150mm
Drinking Water
Bus Stop
Level +150 mm
Trash Bin
Tree Line
Soil
Level +150 mm
Tree Pit
Soil
Level +150 mm
Sidewalk
Paving
Level +150 mm
Bicycle Track
Concrete
Level +150 mm
Informal Pedestrian Crossing & Cycle Track access point every 50 m
Property Access
with ramp in parking
Private Property
11.5
6
7
6
11.5
42

42a

Large streets with median cycle tracks

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway



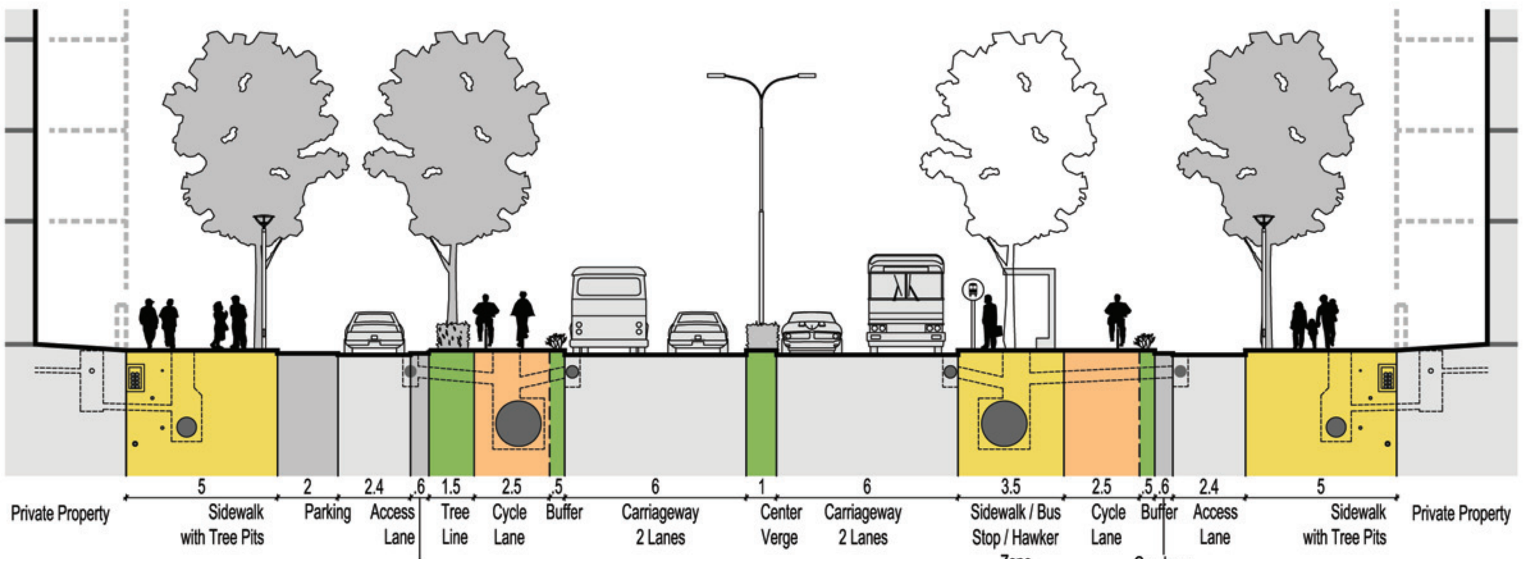

Carriage Way
Asphalt
Level ± 00 mm
Parking
Paving
Level + 50 mm
Utility Box
Sidewalk
Paving
Level +150 mm
Bicycle Track
Concrete
Level +150 mm
Elevated Pedestrian Crossing
Paving / Concrete
Level +150 mm
Bus Stop
Level +150 mm
Rickshaw Parking
Paving / Asphalt
Level + 50 mm
Access Lane
Concrete
Level ± 00 mm
Parking
Paving
Level + 50 mm
Street Light
Center Verge
Landscaped
Level + 150 mm
Sidewalk
Paving
Level +150 mm
Property Access
Access Lane Entry / Exit
Concrete
Level + 150 mm
Tree Line
Soil
Level +150 mm
Overhang
Paving
Level + 50 mm
5
9.5
13
9.5
5
42

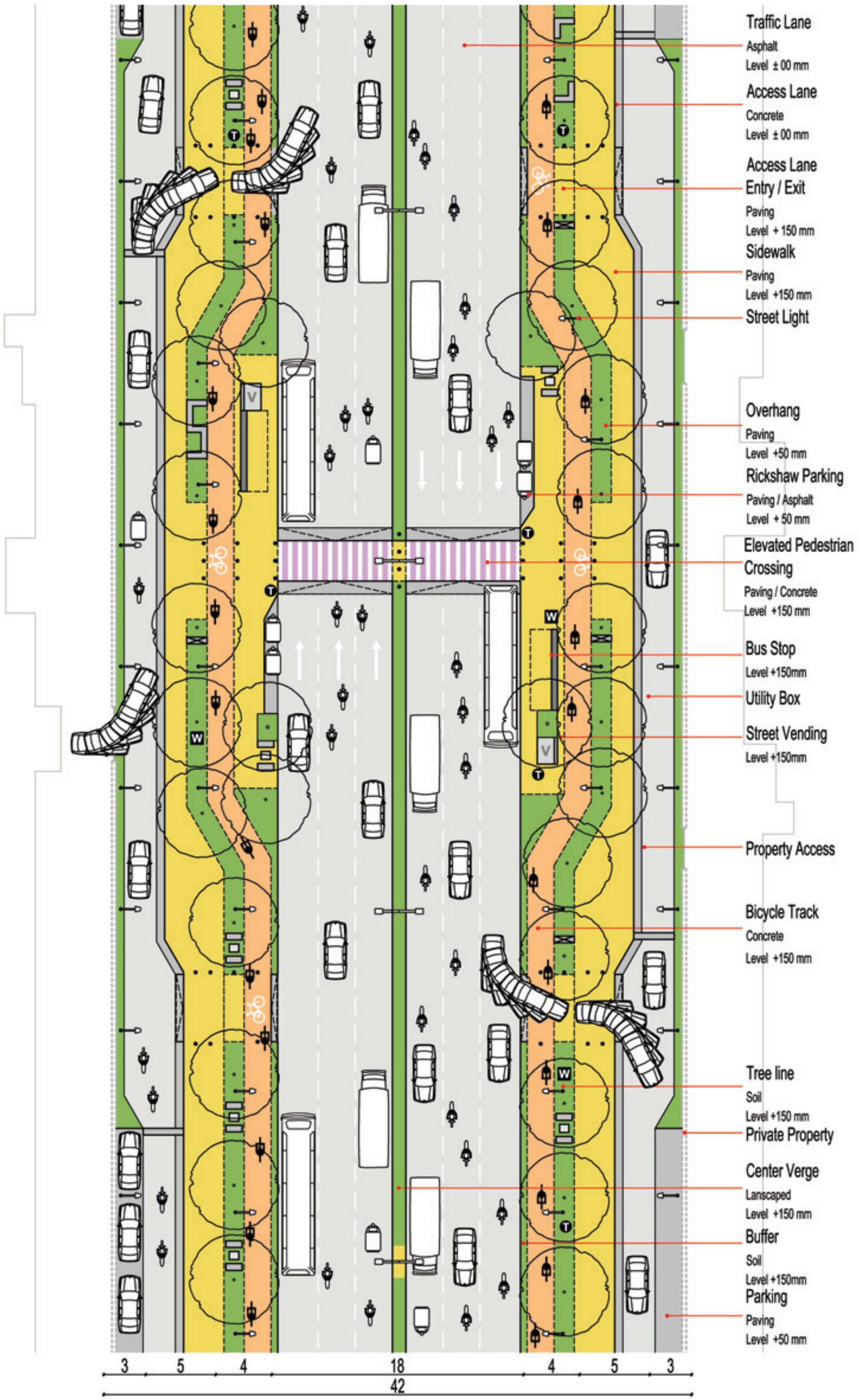
42b

Large streets with service lanes

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway

Note Depending on adjacent land uses, the footpath can be placed between the service lane and the tree line. Such an arrangement may be desirable if there is a high probability of encroachment of a footpath located at the edge of the right-of-way (see template 42c and Section 2.12).





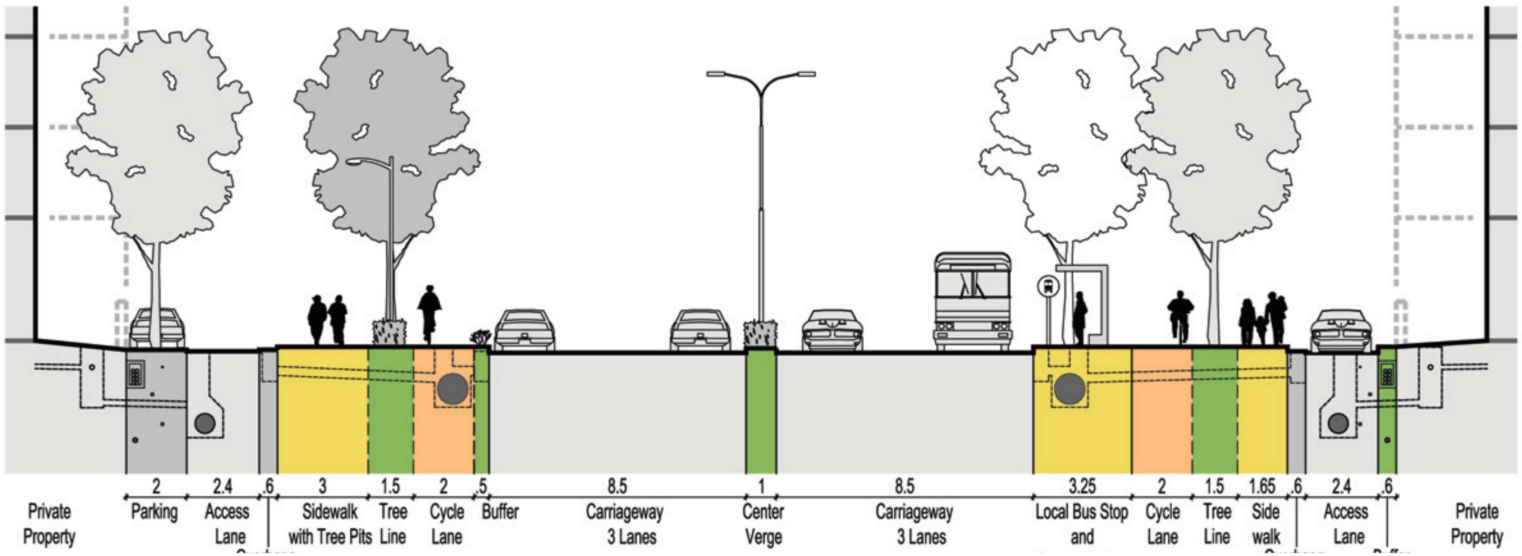
Traffic Lane
Asphalt
Level ± 00 mm
Access Lane
Concrete
Level ± 00 mm
Access Lane
Entry / Exit
Paving
Level + 150 mm
Sidewalk
Paving
Level +150 mm
Street Light
Overhang
Paving
Level +50 mm
Rickshaw Parking
Paving / Asphalt
Level + 50 mm
Elevated Pedestrian
Crossing
Paving / Concrete
Level +150 mm
Bus Stop
Level +150mm
Utility Box
Street Vending
Level +150mm
Property Access
Bicycle Track
Concrete
Level +150 mm
Tree line
Soil
Level +150 mm
Private Property
Center Verge
Lanscaped
Level +150 mm
Buffer
Soil
Level +150mm
Parking
Paving
Level +50 mm
3
5
4
18
4
5
3
42

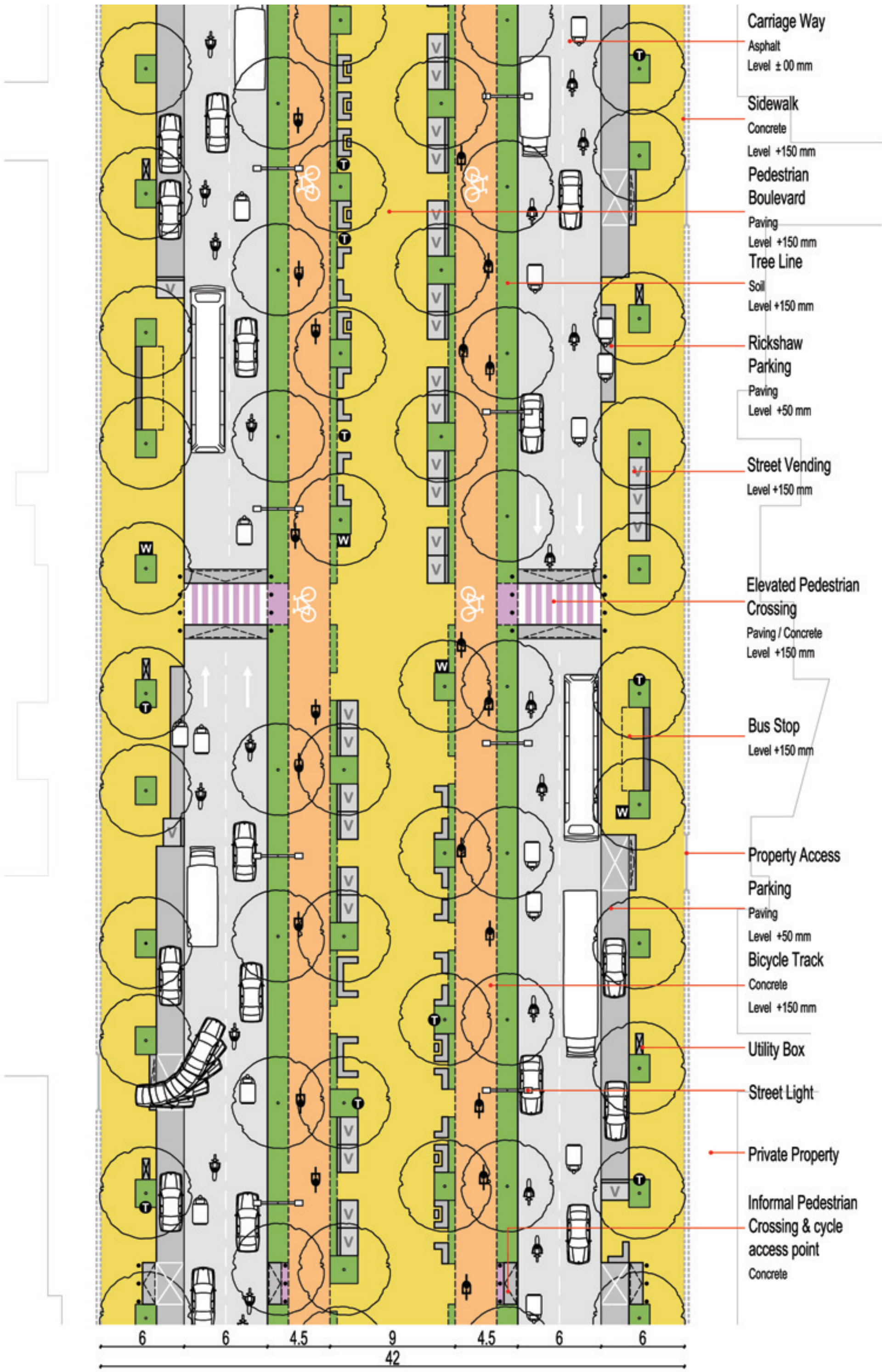
42C

Large streets with service lanes

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway

Note Depending on adjacent ˡand uses, the footpath can e placed at the edge of the ght-of-way. However, given the mited width available for the ɔotpath, it may be difficult to ıaintain sufficient clear width ɔr pedestrians (see template 2b and Section 2.12).

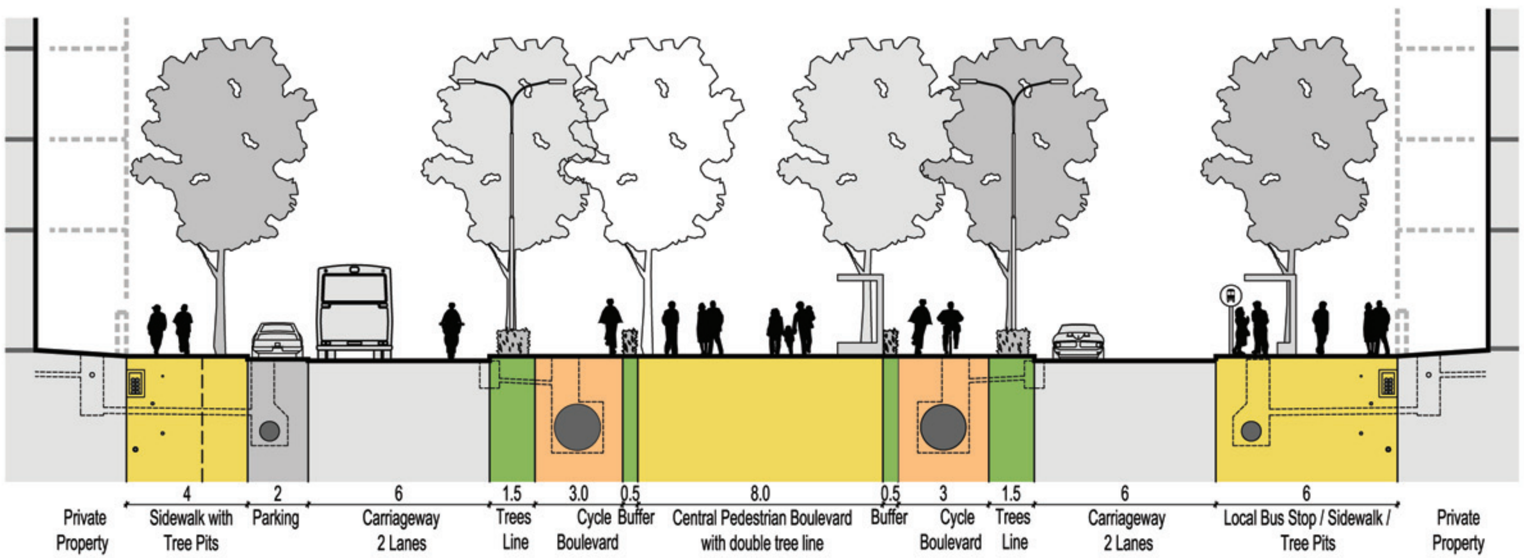



Carriage Way
Asphalt
Level ± 00 mm
Sidewalk
Concrete
Level +150 mm
Pedestrian Boulevard
Paving
Level +150 mm
Tree Line
Soil
Level +150 mm
Rickshaw Parking
Paving
Level +50 mm
Street Vending
Level +150 mm
Elevated Pedestrian Crossing
Paving / Concrete
Level +150 mm
Bus Stop
Level +150 mm
Property Access
Parking
Paving
Level +50 mm
Bicycle Track
Concrete
Level +150 mm
Utility Box
Street Light
Private Property
Informal Pedestrian Crossing & cycle access point
Concrete
6
6
4.5
9
4.5
6
6
42

42d

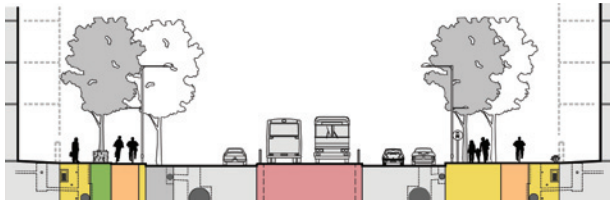
Large streets with median cycle tracks

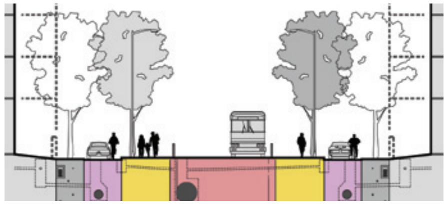
Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway

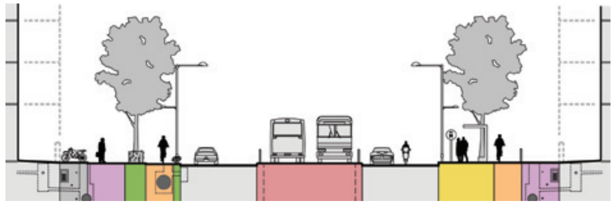


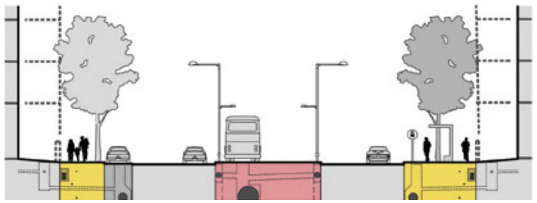
Bus rapid transit templates

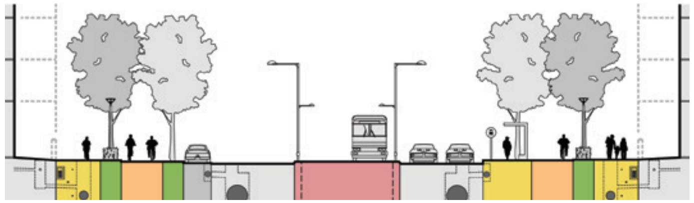

18BRT

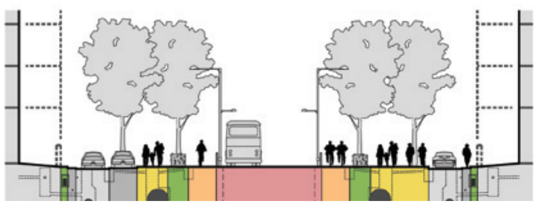

36BRT a

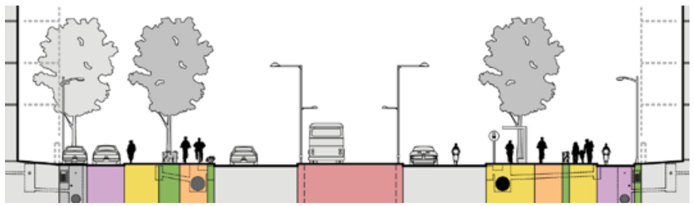

24BRT

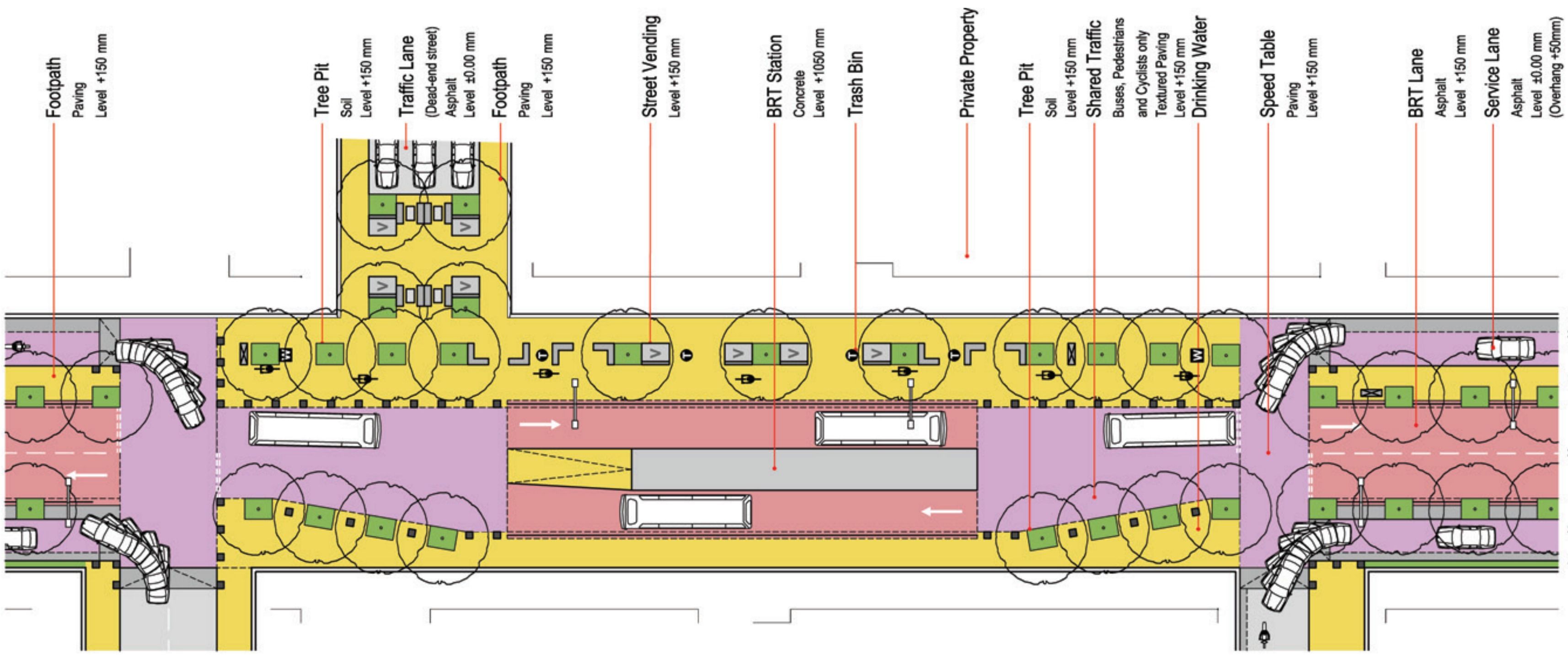

36BRT b


30BRT a

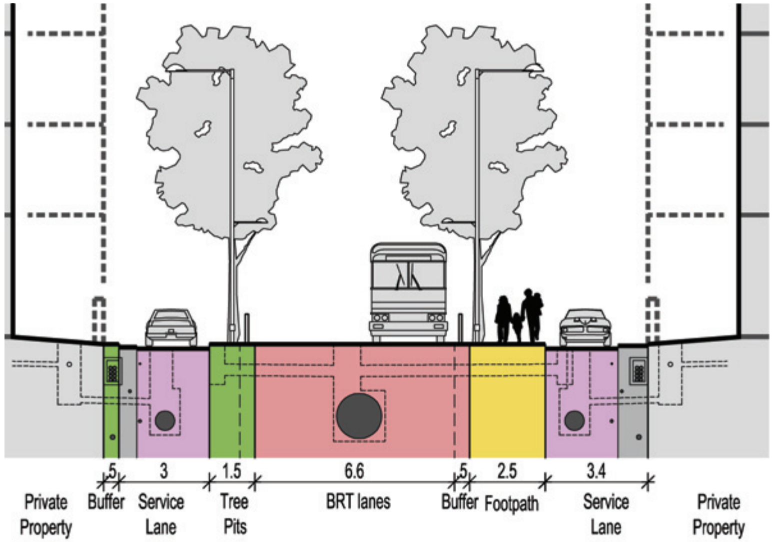

42BRT a

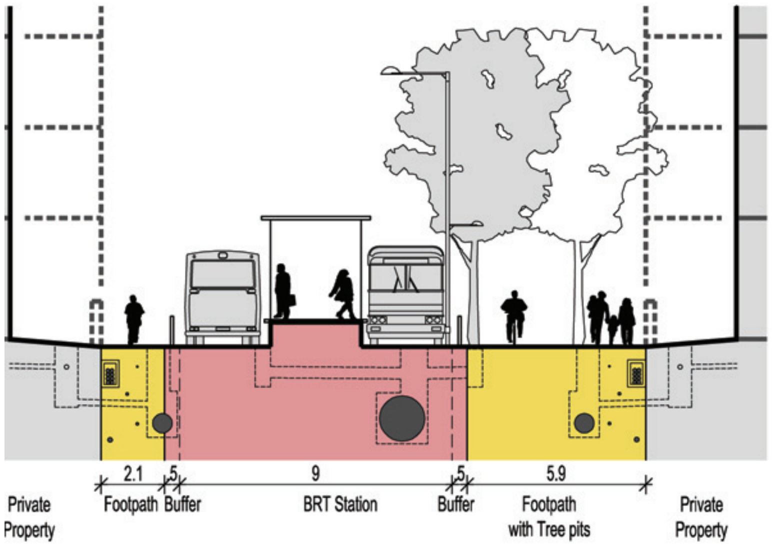

30BRT b


42BRT b


Footpath
Paving
Level +150 mm
Tree Pit
Soil
Level +150 mm
Traffic Lane
(Dead-end street)
Asphalt
Level ±0.00 mm
Footpath
Paving
Level +150 mm
Street Vending
Level +150 mm
BRT Station
Concrete
Level +1050 mm
Trash Bin
Private Property
Tree Pit
Soil
Level +150 mm
Shared Traffic
Buses, Pedestrians
and Cyclists only
Textured Paving
Level +150 mm
Drinking Water
Speed Table
Paving
Level +150 mm
BRT Lane
Asphalt
Level +150 mm
Service Lane
Asphalt
Level ±0.00 mm
(Overhang +50mm)
Right of Way

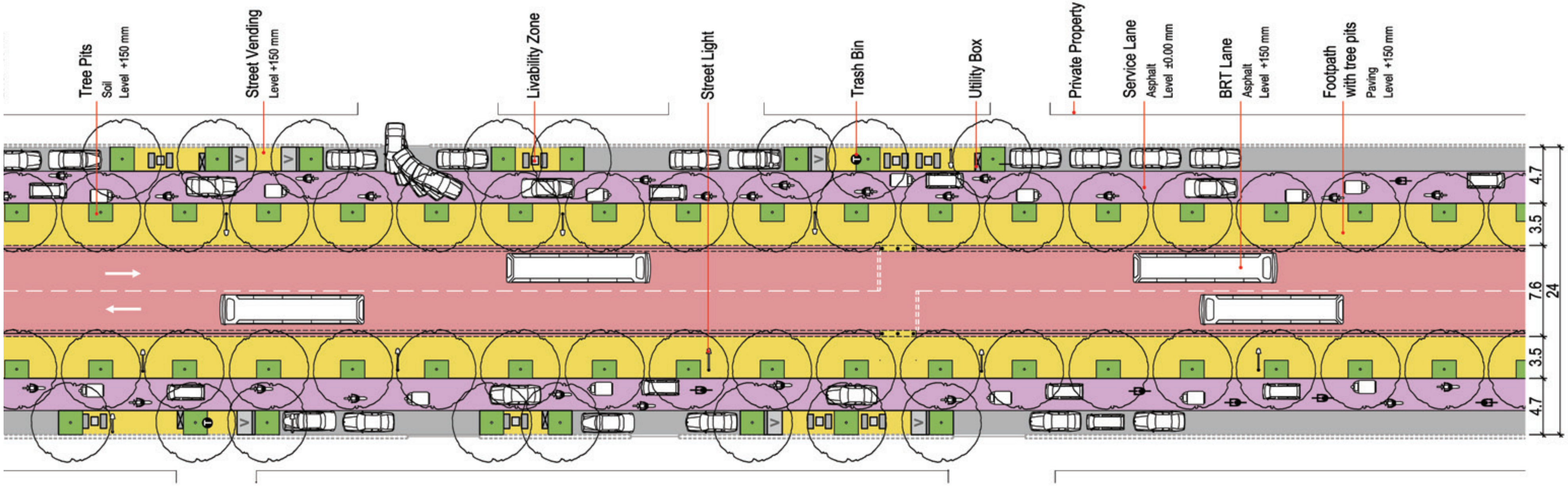
18 BRT

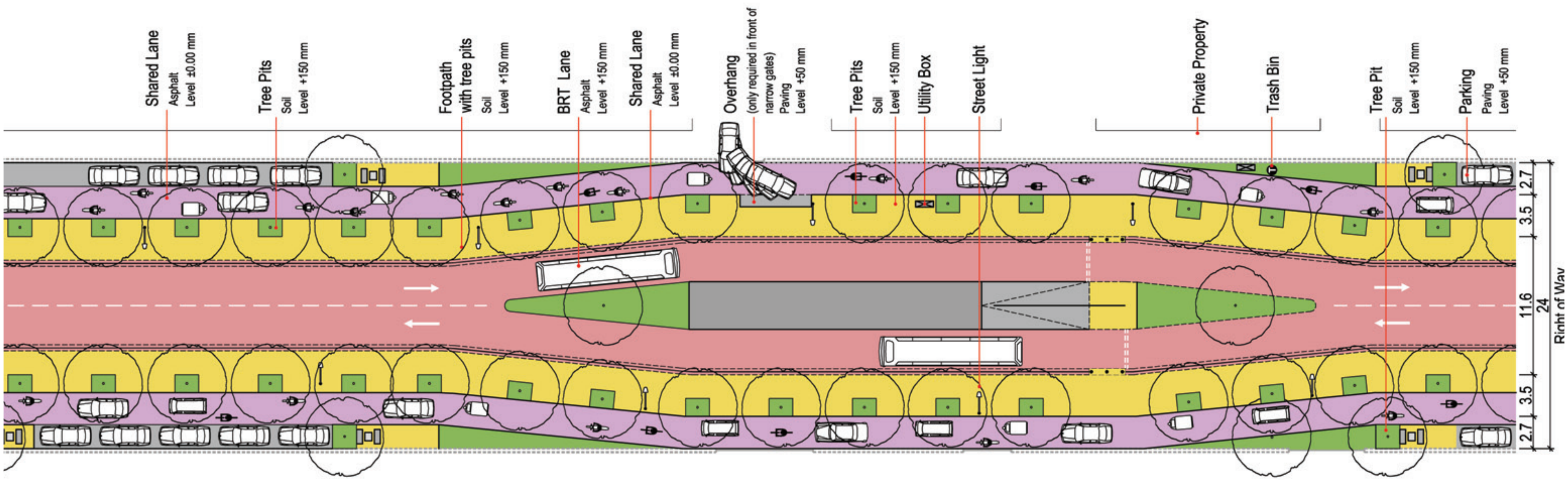


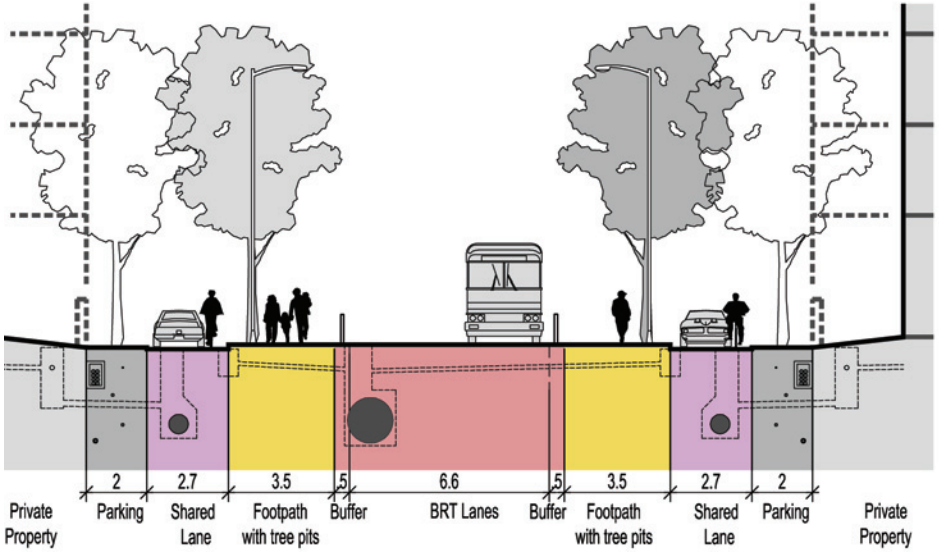


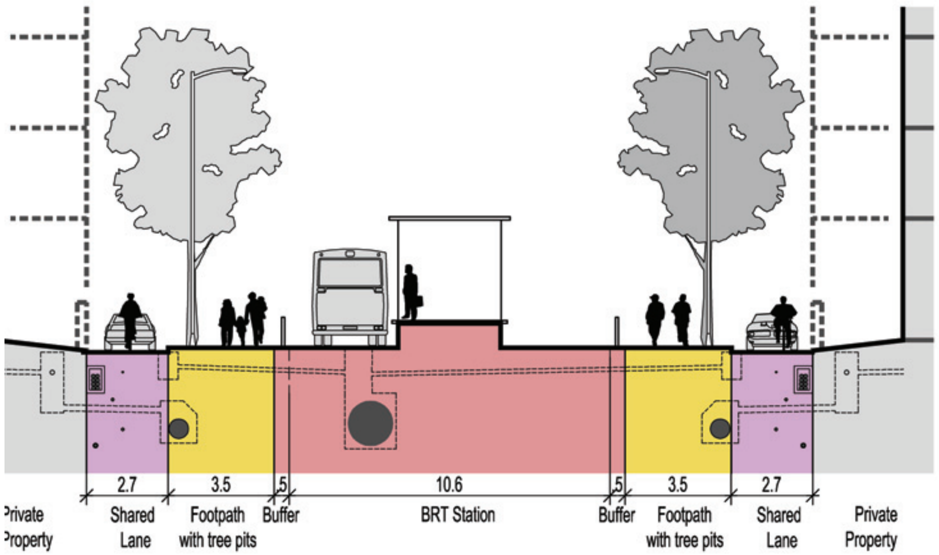
Streets with bus rapid transit

Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	Median track	Side track	**Mixed traffic**
Parking and property access	**Service lane**	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	**No carriageway**


Tree Pits
Soil
Level +150 mm
Street Vending
Level +150 mm
Livability Zone
Street Light
Trash Bin
Utility Box
Private Property
Service Lane
Asphalt
Level ±0.00 mm
BRT Lane
Asphalt
Level +150 mm
Footpath
with tree pits
Paving
Level +50 mm
4.7
3.5
7.6
24
3.5
4.7

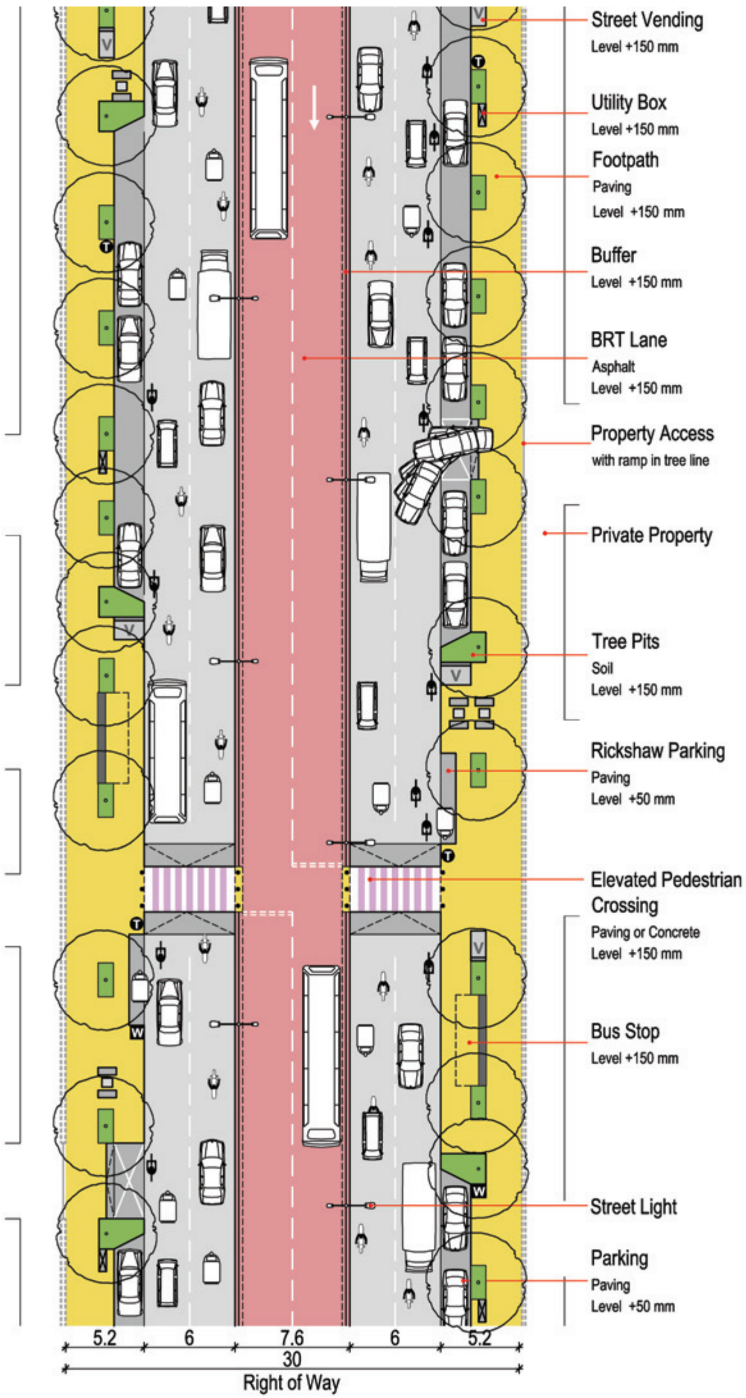

Shared Lane
Asphalt
Level ±0.00 mm
Tree Pits
Soil
Level +150 mm
Footpath
with tree pits
Soil
Level +150 mm
BRT Lane
Asphalt
Level +150 mm
Shared Lane
Asphalt
Level ±0.00 mm
Overhang
(only required in front of
narrow gates)
Paving
Level +50 mm
Tree Pits
Soil
Level +150 mm
Utility Box
Street Light
Private Property
Trash Bin
Tree Pit
Soil
Level +150 mm
Parking
Paving
Level +50 mm
2.7
3.5
11.6
24
Right of Way
3.5
2.7

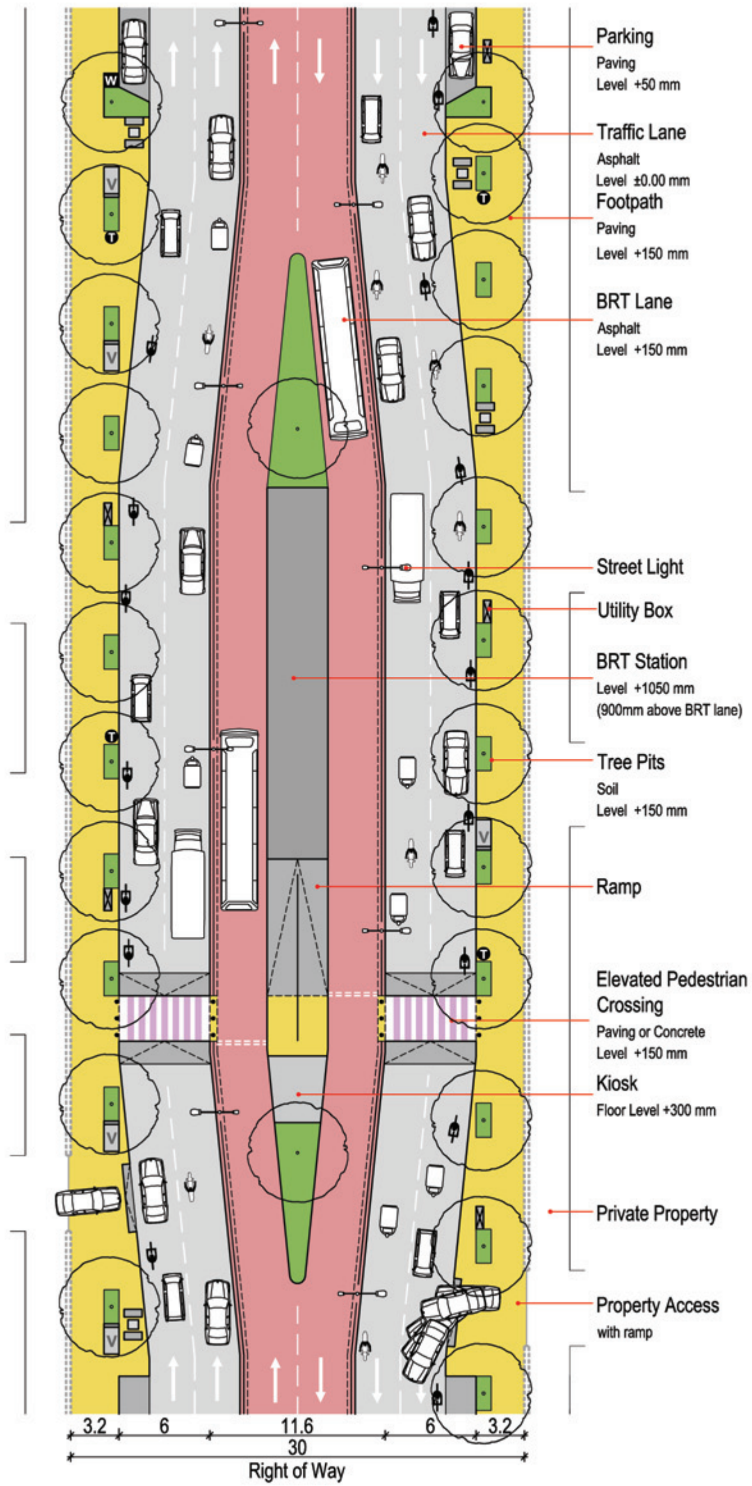




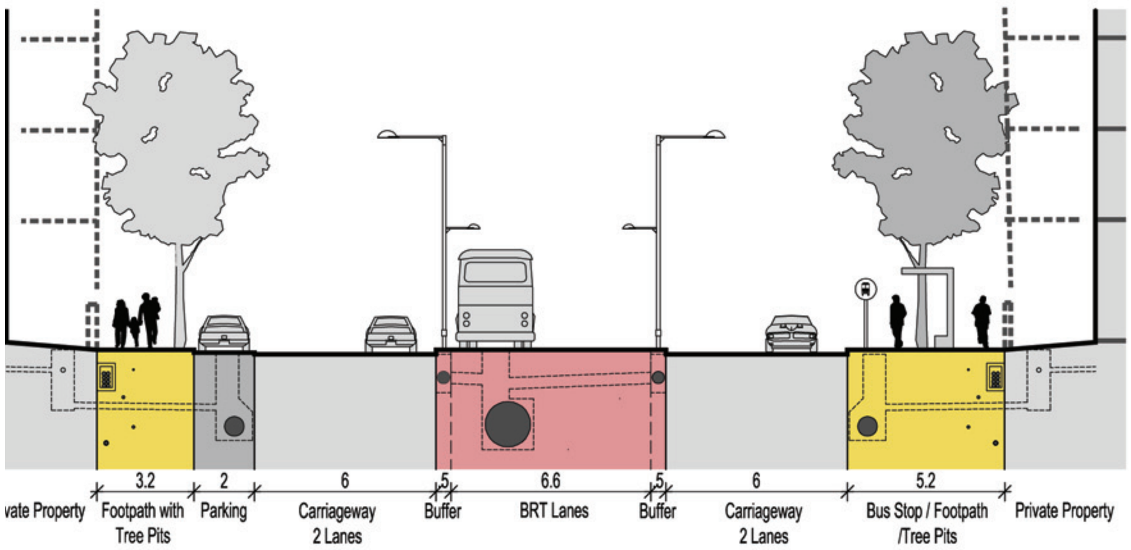
Streets with bus rapid transit

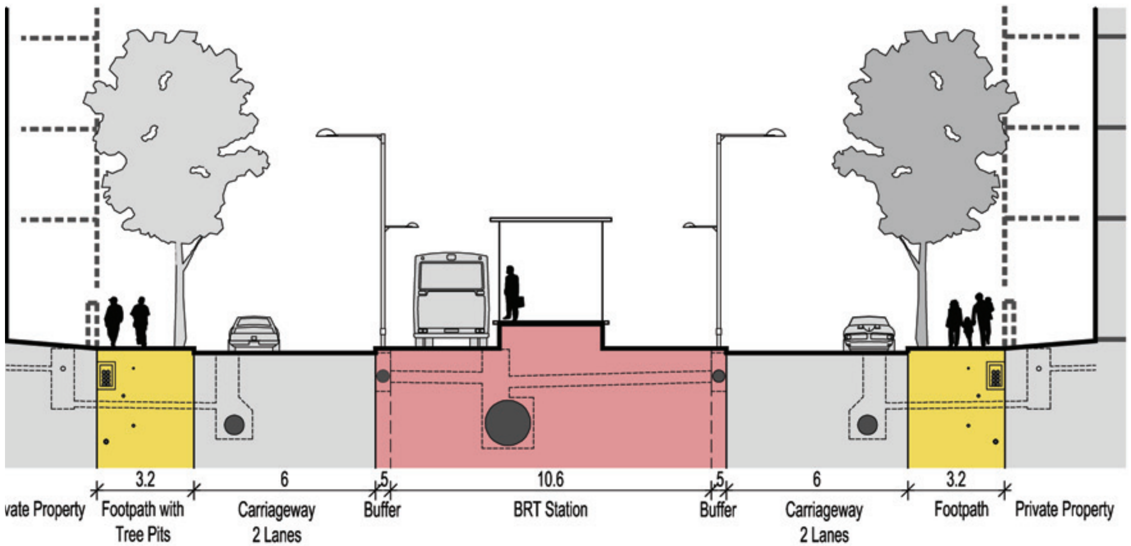
Pedestrian mobility and access	**Footpath**	Shared space	
Cyclist mobility	Median track	Side track	**Mixed traffic**
Parking and property access	**Service lane**	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	**No carriageway**


Street Vending
Level +150 mm
Utility Box
Level +150 mm
Footpath
Paving
Level +150 mm
Buffer
Level +150 mm
BRT Lane
Asphalt
Level +150 mm
Property Access
with ramp in tree line
Private Property
Tree Pits
Soil
Level +150 mm
Rickshaw Parking
Paving
Level +50 mm
Elevated Pedestrian Crossing
Paving or Concrete
Level +150 mm
Bus Stop
Level +150 mm
Street Light
Parking
Paving
Level +50 mm
5.2
6
7.6
6
5.2
30
Right of Way


Parking
Paving
Level +50 mm
Traffic Lane
Asphalt
Level ±0.00 mm
Footpath
Paving
Level +150 mm
BRT Lane
Asphalt
Level +150 mm
Street Light
Utility Box
BRT Station
Level +1050 mm
(900mm above BRT lane)
Tree Pits
Soil
Level +150 mm
Ramp
Elevated Pedestrian Crossing
Paving or Concrete
Level +150 mm
Kiosk
Floor Level +300 mm
Private Property
Property Access
with ramp
3.2
6
11.6
6
3.2
30
Right of Way

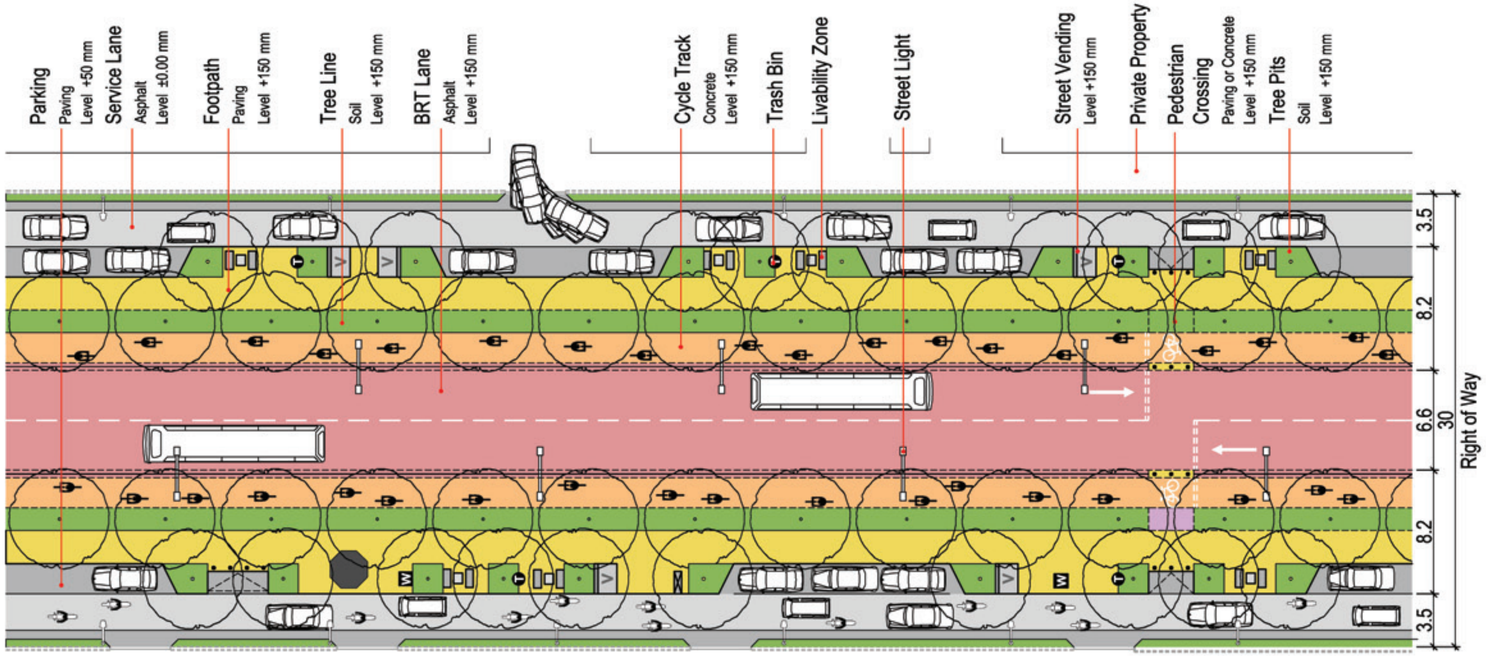
30BRT a

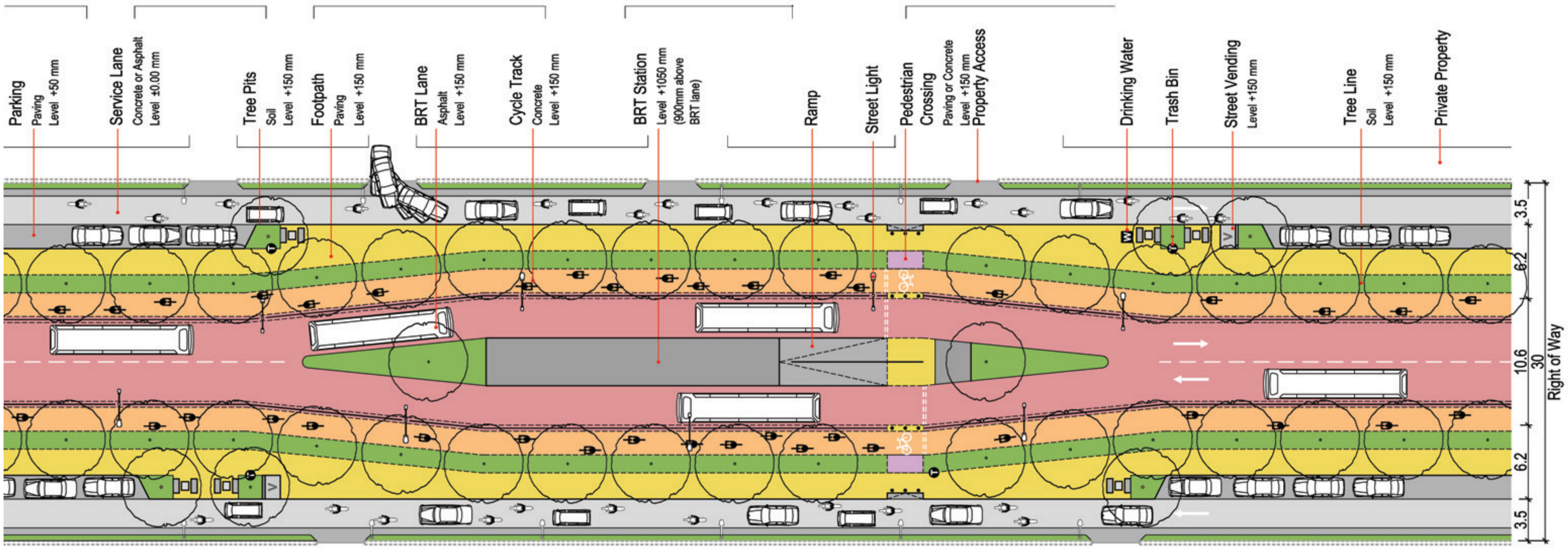




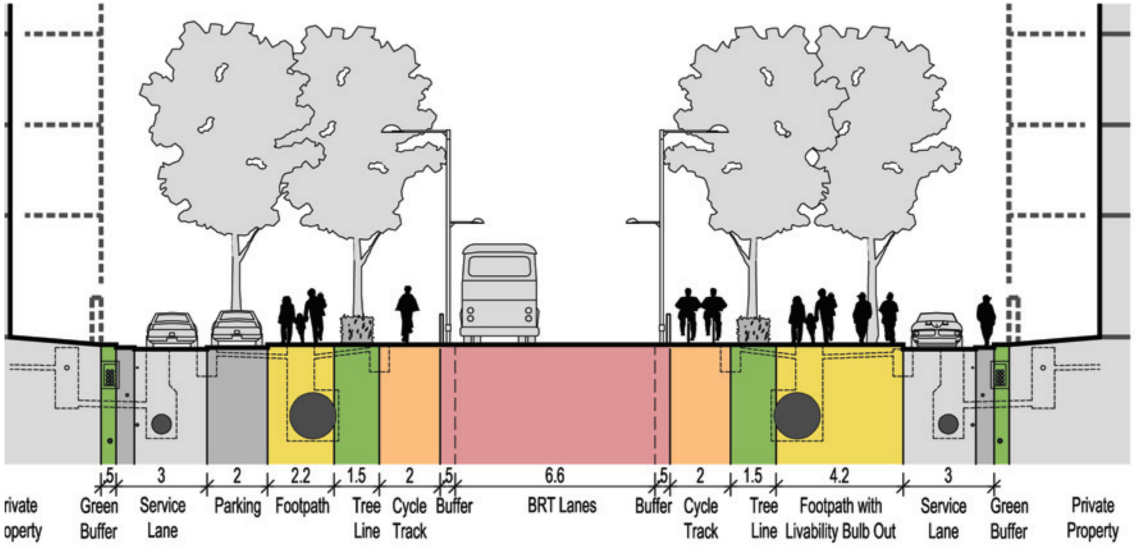
Streets with bus rapid transit

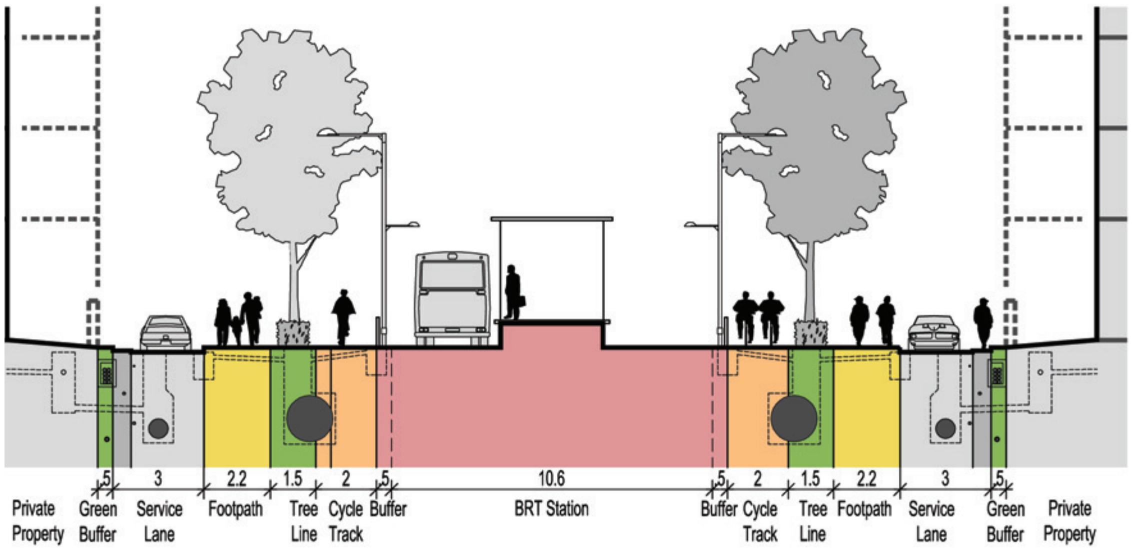
Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway


Parking
Paving
Level +50 mm
Service Lane
Asphalt
Level ±0.00 mm
Footpath
Paving
Level +150 mm
Tree Line
Soil
Level +150 mm
BRT Lane
Asphalt
Level +150 mm
Cycle Track
Concrete
Level +150 mm
Trash Bin
Livability Zone
Street Light
Street Vending
Level +150 mm
Private Property
Pedestrian Crossing
Paving or Concrete
Level +150 mm
Tree Pits
Soil
Level +150 mm
3.5
8.2
6.6
8.2
3.5
30
Right of Way


Parking
Paving
Level +50 mm
Service Lane
Concrete or Asphalt
Level ±0.00 mm
Tree Pits
Soil
Level +150 mm
Footpath
Paving
Level +150 mm
BRT Lane
Asphalt
Level +150 mm
Cycle Track
Concrete
Level +150 mm
BRT Station
Level +1050 mm
(900mm above
BRT lane)
Ramp
Street Light
Pedestrian Crossing
Paving or Concrete
Level +150 mm
Property Access
Drinking Water
Trash Bin
Street Vending
Level +150 mm
Tree Line
Soil
Level +150 mm
Private Property
3.5
6.2
10.6
6.2
3.5
30
Right of Way

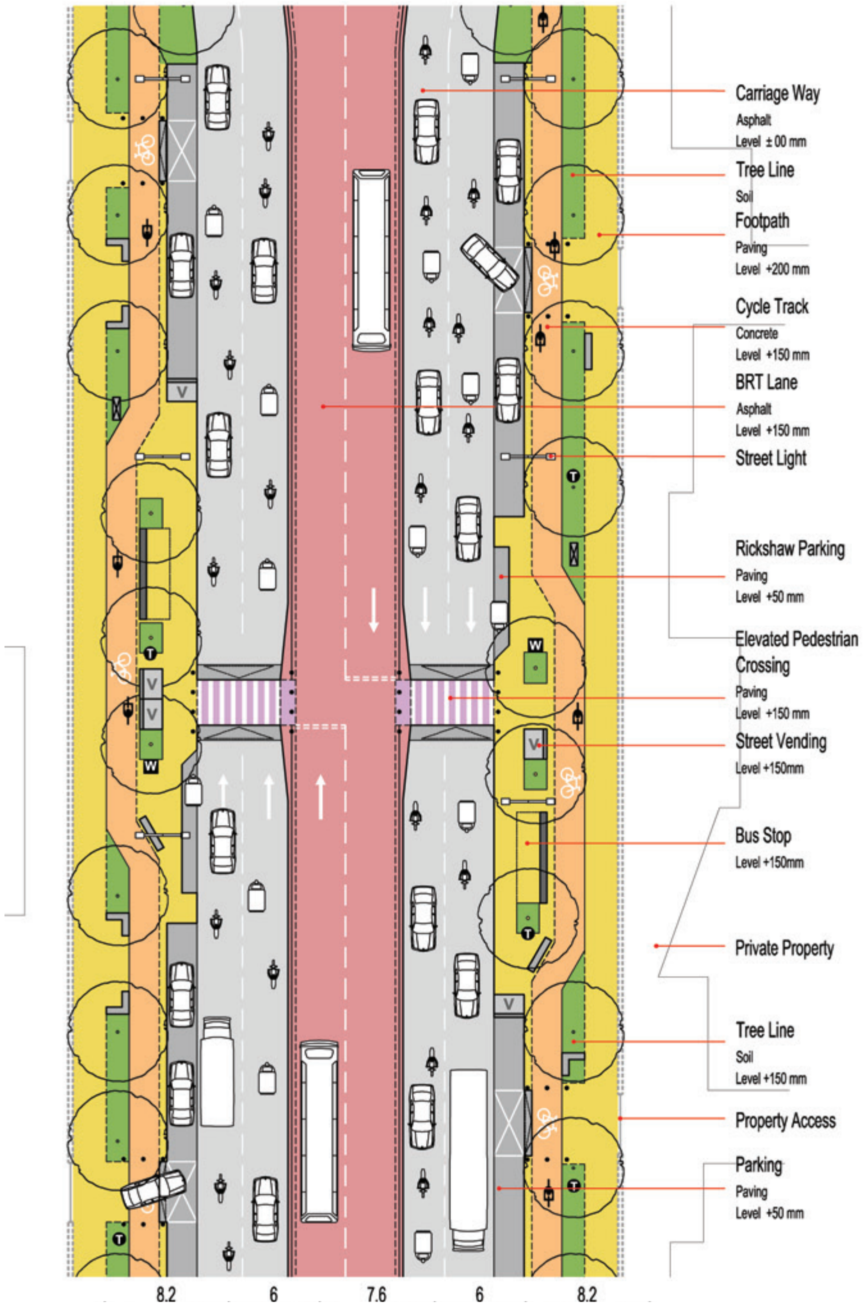
30BRT b

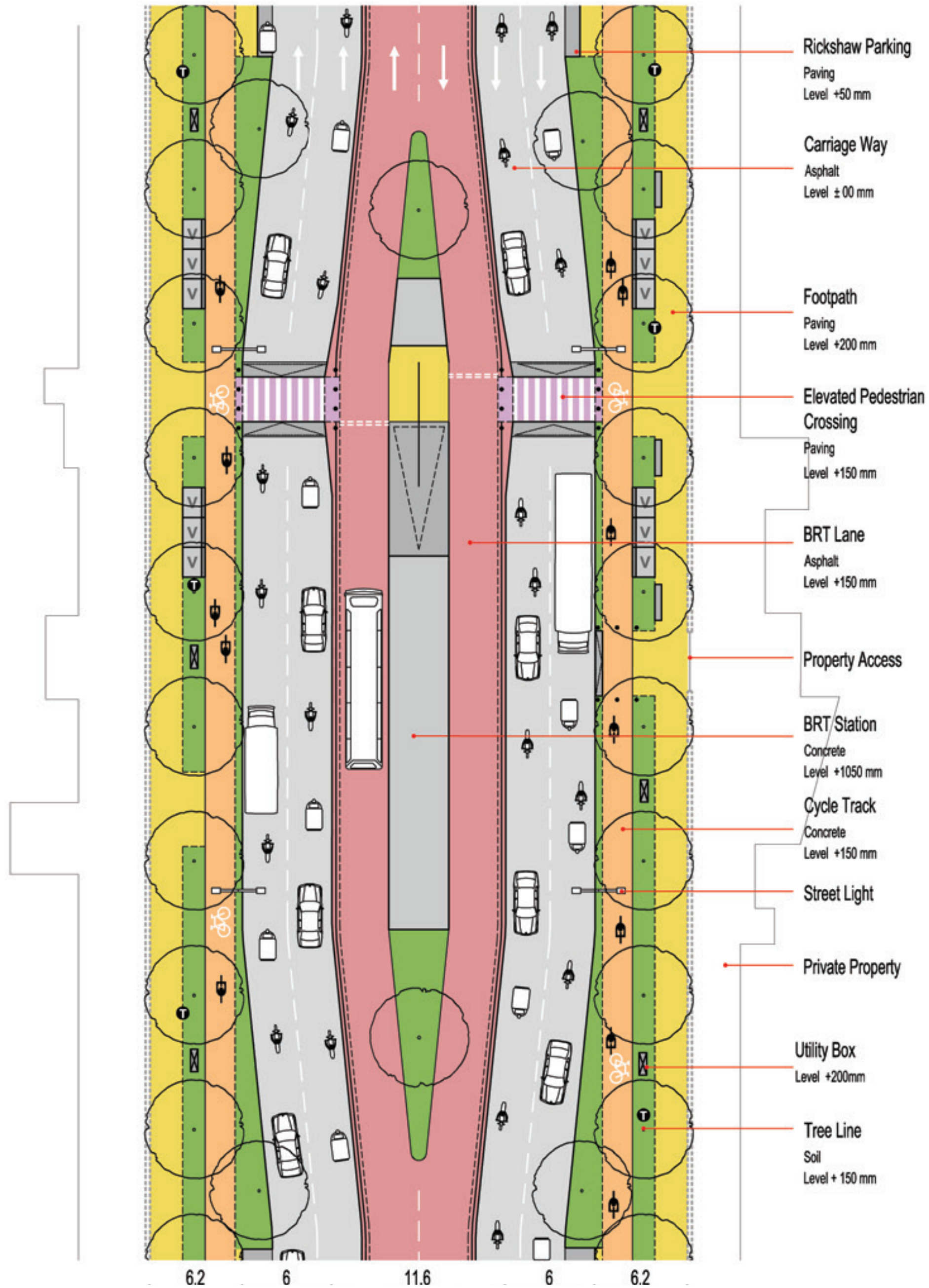




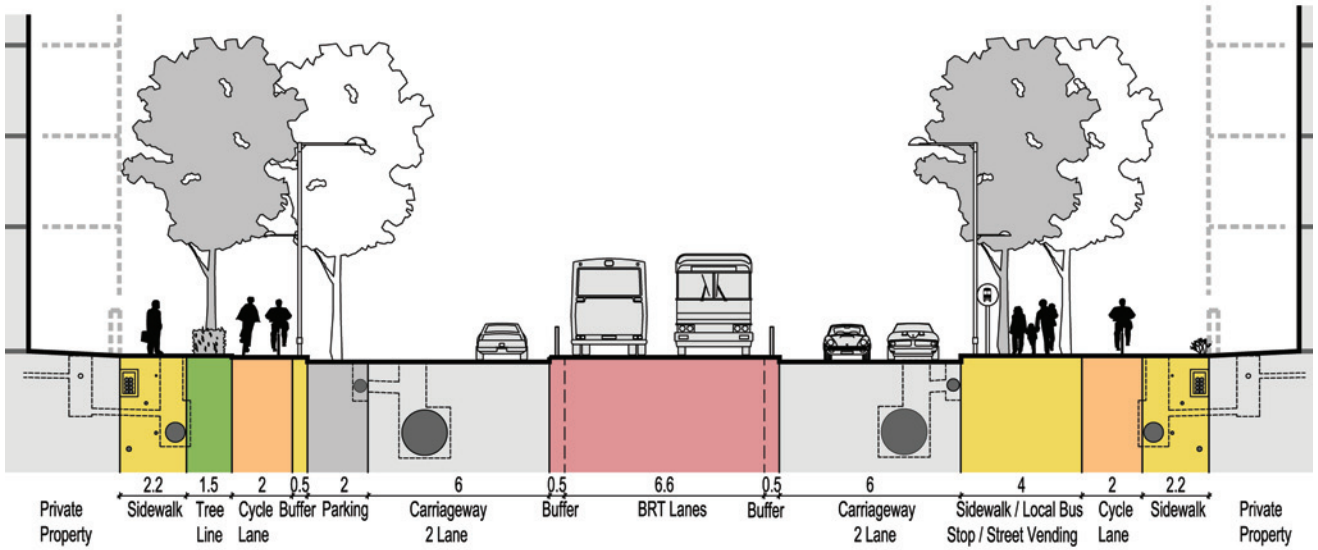
Streets with bus rapid transit

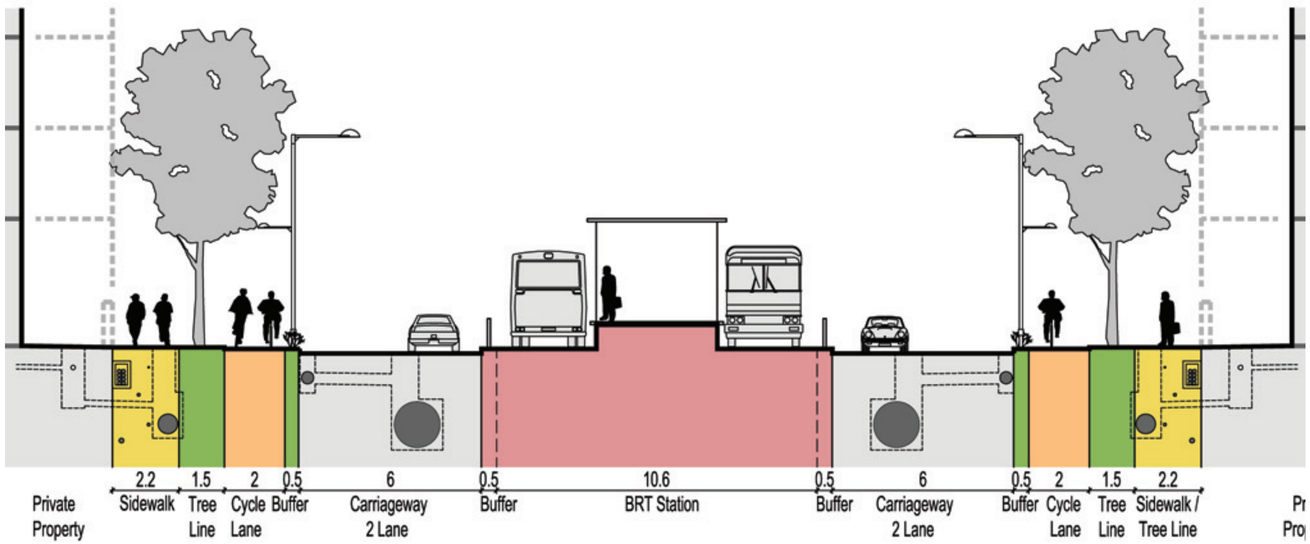
Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway


Carriage Way
Asphalt
Level ± 00 mm
Tree Line
Soil
Footpath
Paving
Level +200 mm
Cycle Track
Concrete
Level +150 mm
BRT Lane
Asphalt
Level +150 mm
Street Light
Rickshaw Parking
Paving
Level +50 mm
Elevated Pedestrian Crossing
Paving
Level +150 mm
Street Vending
Level +150mm
Bus Stop
Level +150mm
Private Property
Tree Line
Soil
Level +150 mm
Property Access
Parking
Paving
Level +50 mm
8.2
6
7.6
6
8.2


Rickshaw Parking
Paving
Level +50 mm
Carriage Way
Asphalt
Level ± 00 mm
Footpath
Paving
Level +200 mm
Elevated Pedestrian Crossing
Paving
Level +150 mm
BRT Lane
Asphalt
Level +150 mm
Property Access
BRT Station
Concrete
Level +1050 mm
Cycle Track
Concrete
Level +150 mm
Street Light
Private Property
Utility Box
Level +200mm
Tree Line
Soil
Level + 150 mm
6.2
6
11.6
6
6.2

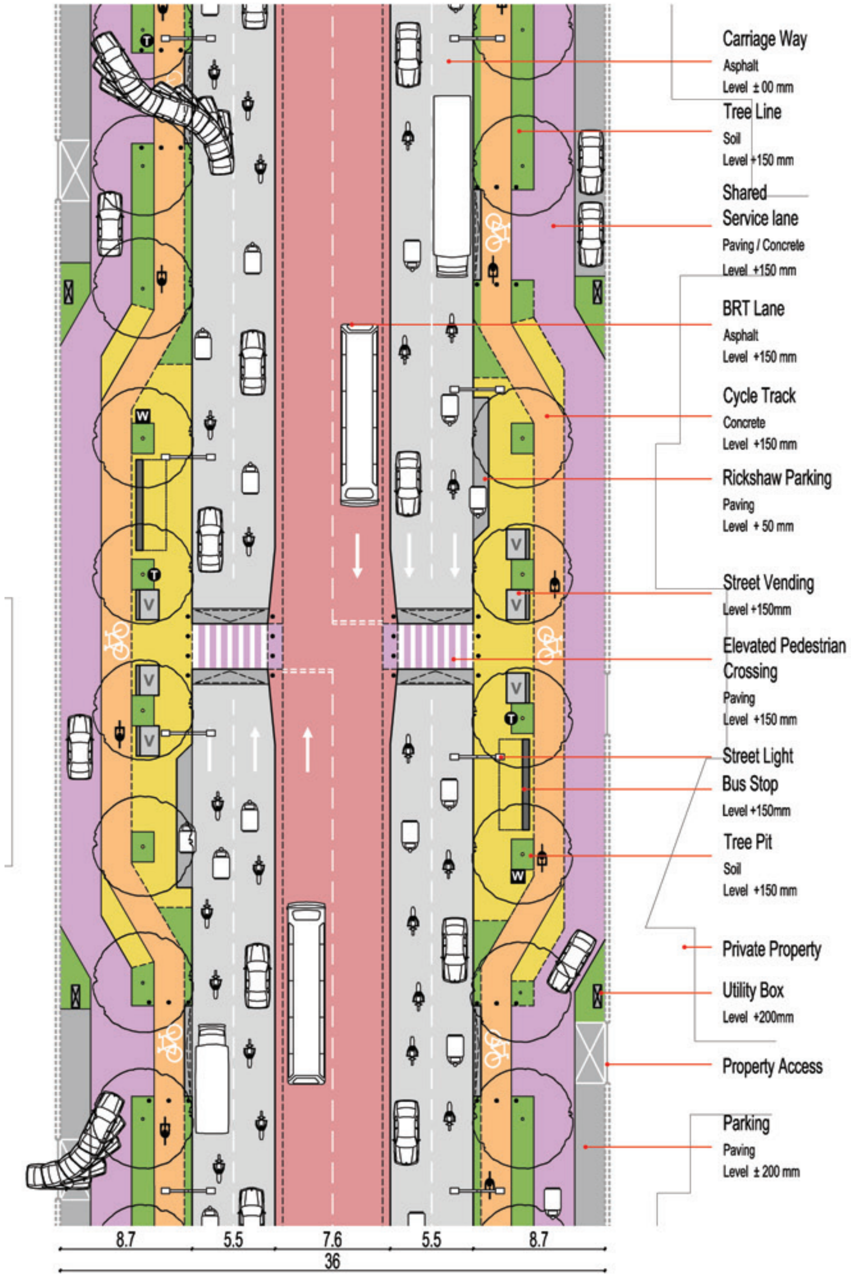
36BRT a

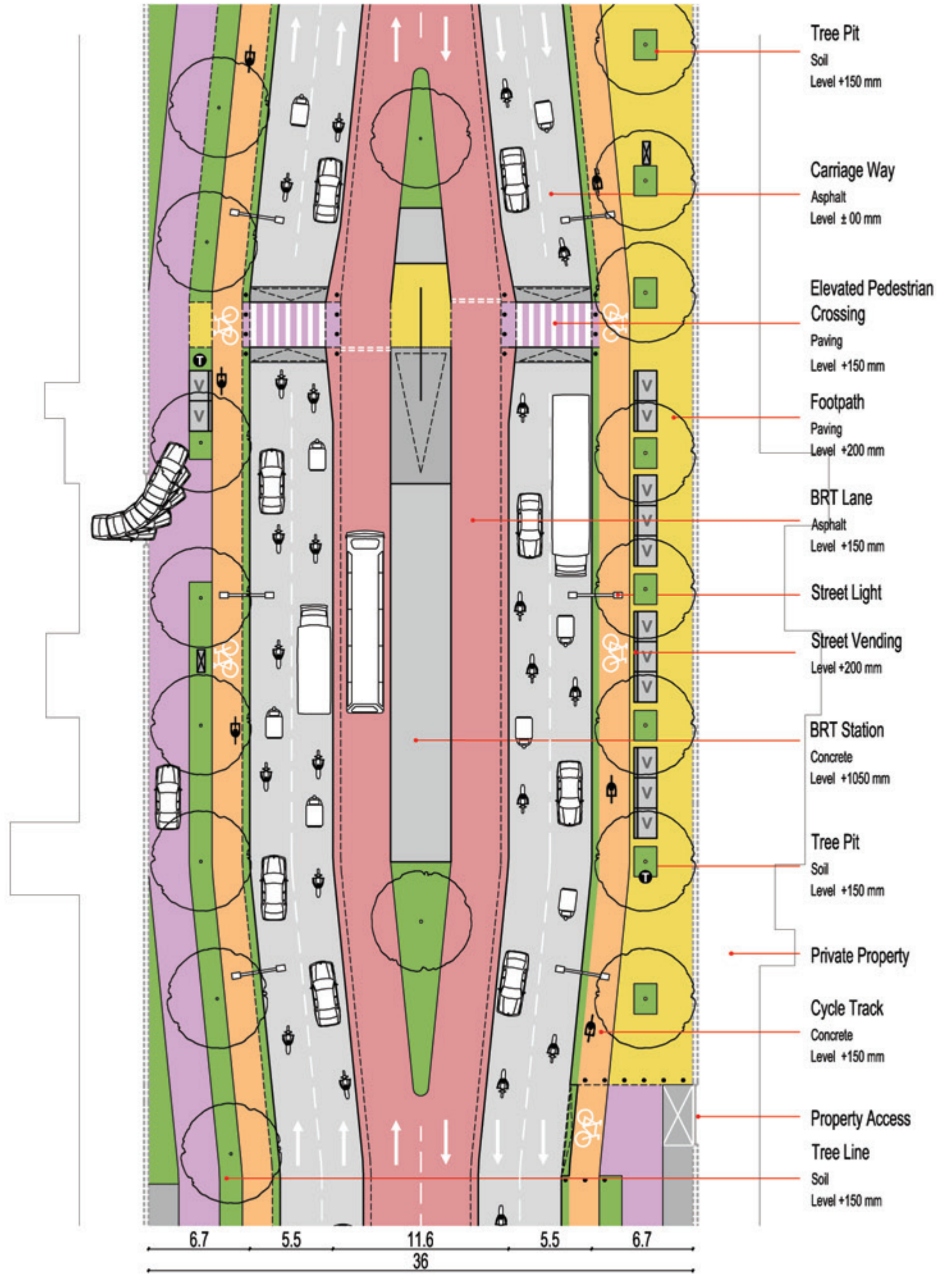


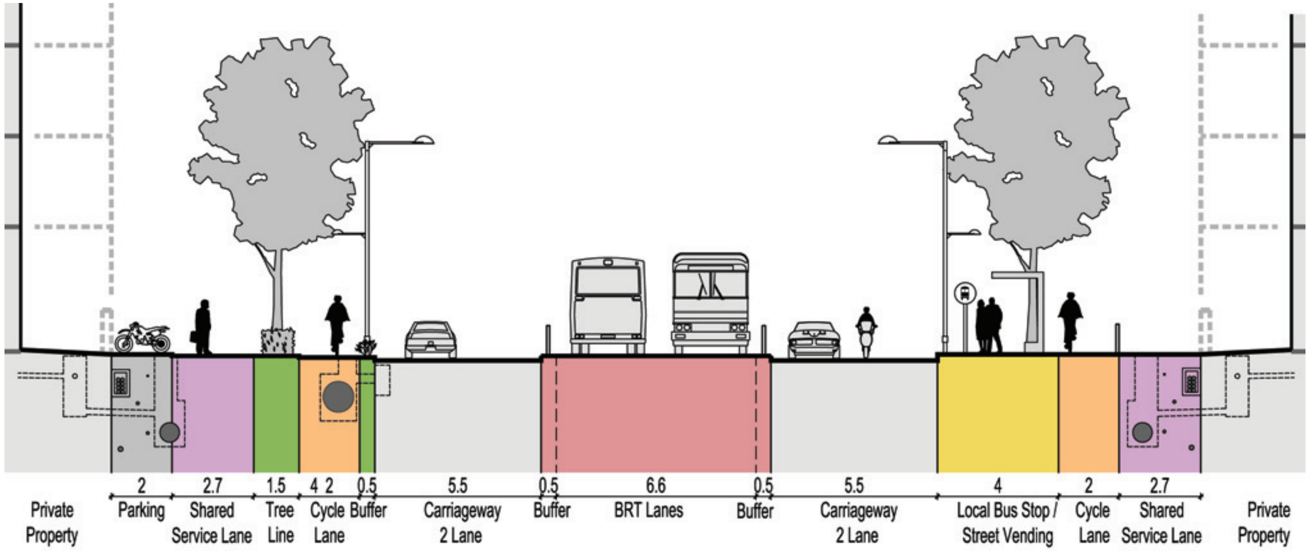


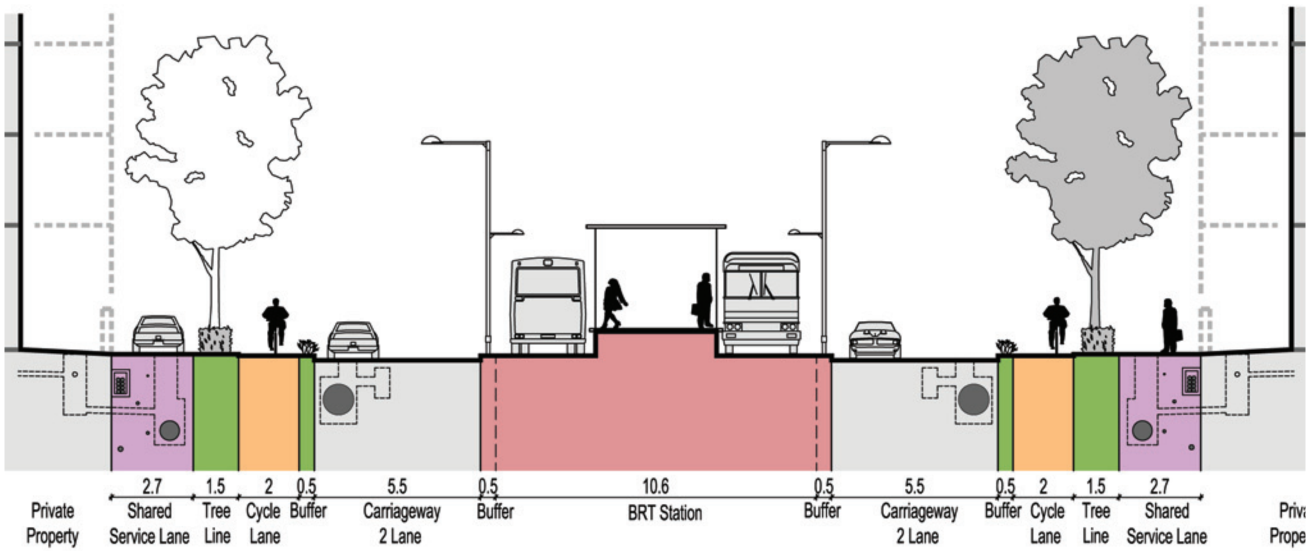
Streets with bus rapid transit

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway


Carriage Way
Asphalt
Level ± 00 mm
Tree Line
Soil
Level +150 mm
Shared
Service lane
Paving / Concrete
Level +150 mm
BRT Lane
Asphalt
Level +150 mm
Cycle Track
Concrete
Level +150 mm
Rickshaw Parking
Paving
Level + 50 mm
Street Vending
Level +150mm
Elevated Pedestrian
Crossing
Paving
Level +150 mm
Street Light
Bus Stop
Level +150mm
Tree Pit
Soil
Level +150 mm
Private Property
Utility Box
Level +200mm
Property Access
Parking
Paving
Level ± 200 mm
8.7
5.5
7.6
5.5
8.7
36

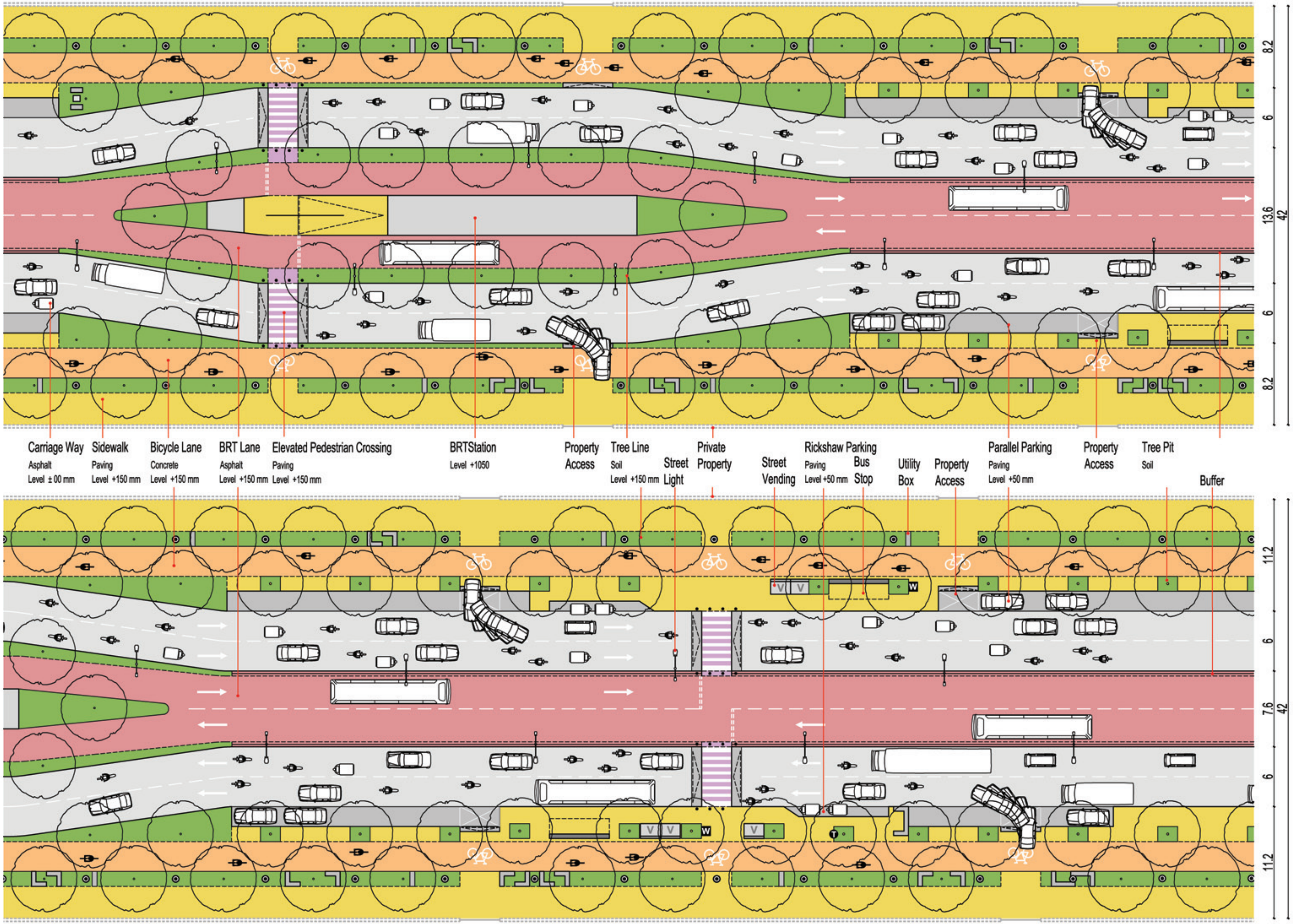

Tree Pit
Soil
Level +150 mm
Carriage Way
Asphalt
Level ± 00 mm
Elevated Pedestrian
Crossing
Paving
Level +150 mm
Footpath
Paving
Level +200 mm
BRT Lane
Asphalt
Level +150 mm
Street Light
Street Vending
Level +200 mm
BRT Station
Concrete
Level +1050 mm
Tree Pit
Soil
Level +150 mm
Private Property
Cycle Track
Concrete
Level +150 mm
Property Access
Tree Line
Soil
Level +150 mm
6.7
5.5
11.6
5.5
6.7
36





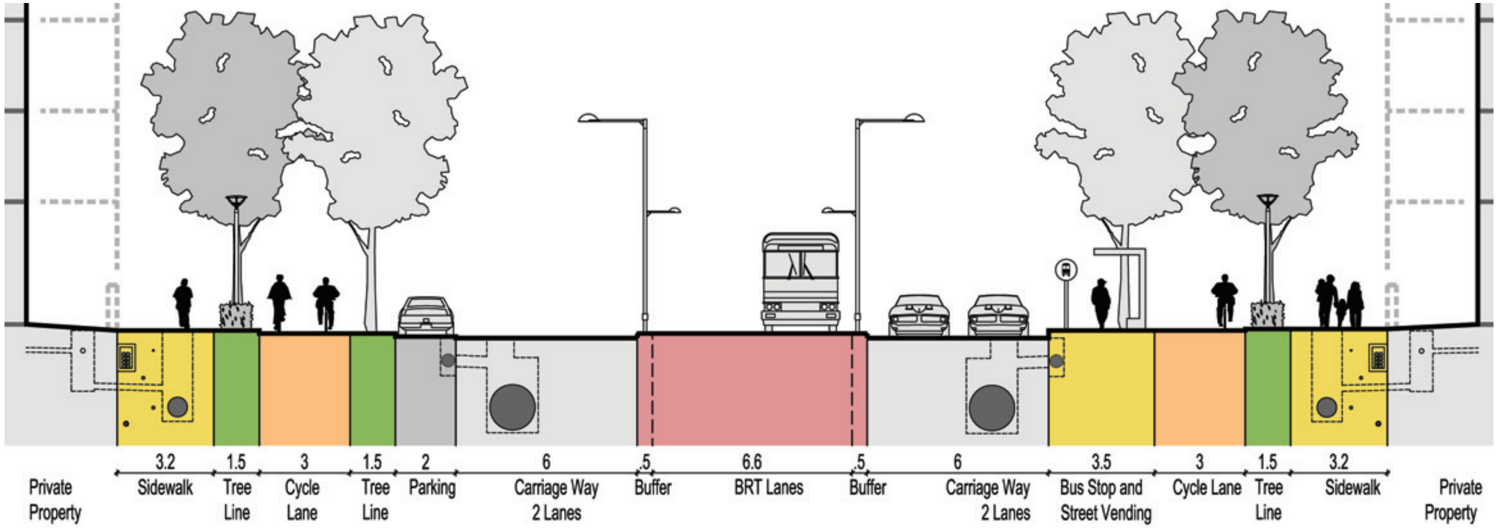
Streets with bus rapid transit

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking and property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway



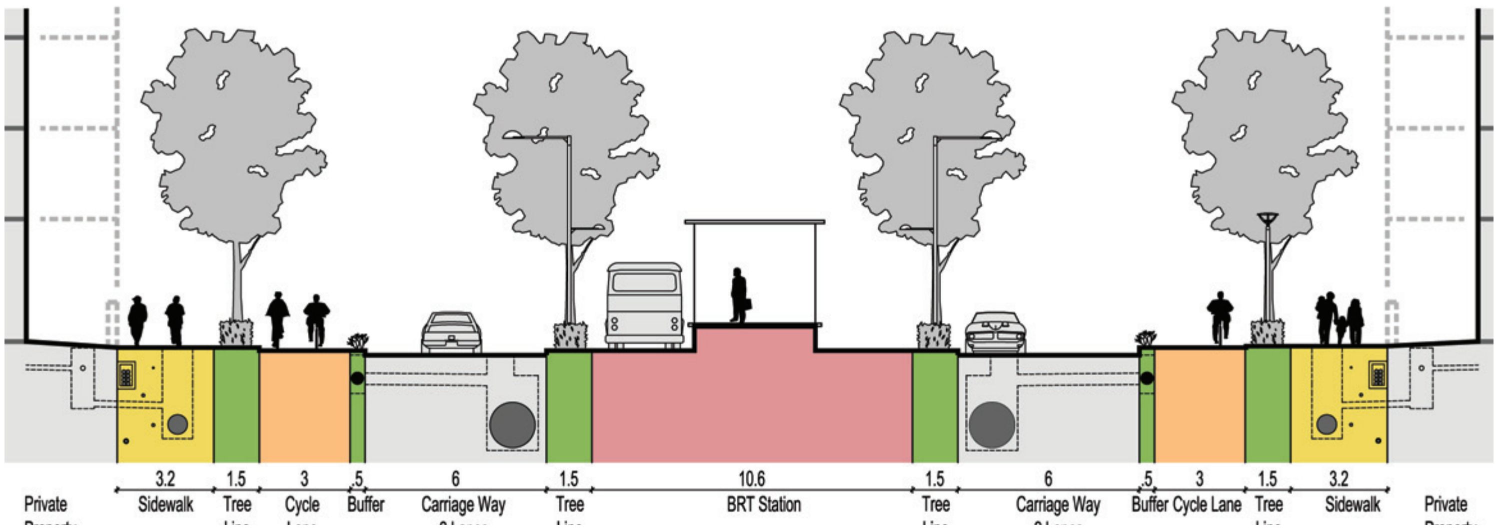
8.2
6
13.6
42
6
8.2
Carriage Way
Asphalt
Level ± 00 mm
Sidewalk
Paving
Level +150 mm
Bicycle Lane
Concrete
Level +150 mm
BRT Lane
Asphalt
Level +150 mm
Elevated Pedestrian Crossing
Paving
Level +150 mm
BRTStation
Level +1050
Property Access
Tree Line
Soil
Level +150 mm
Street Light
Private Property
Street Vending
Rickshaw Parking
Paving
Level +50 mm
Bus Stop
Utility Box
Property Access
Parallel Parking
Paving
Level +50 mm
Property Access
Tree Pit
Soil
Buffer
11.2
6
7.6
42
6
11.2

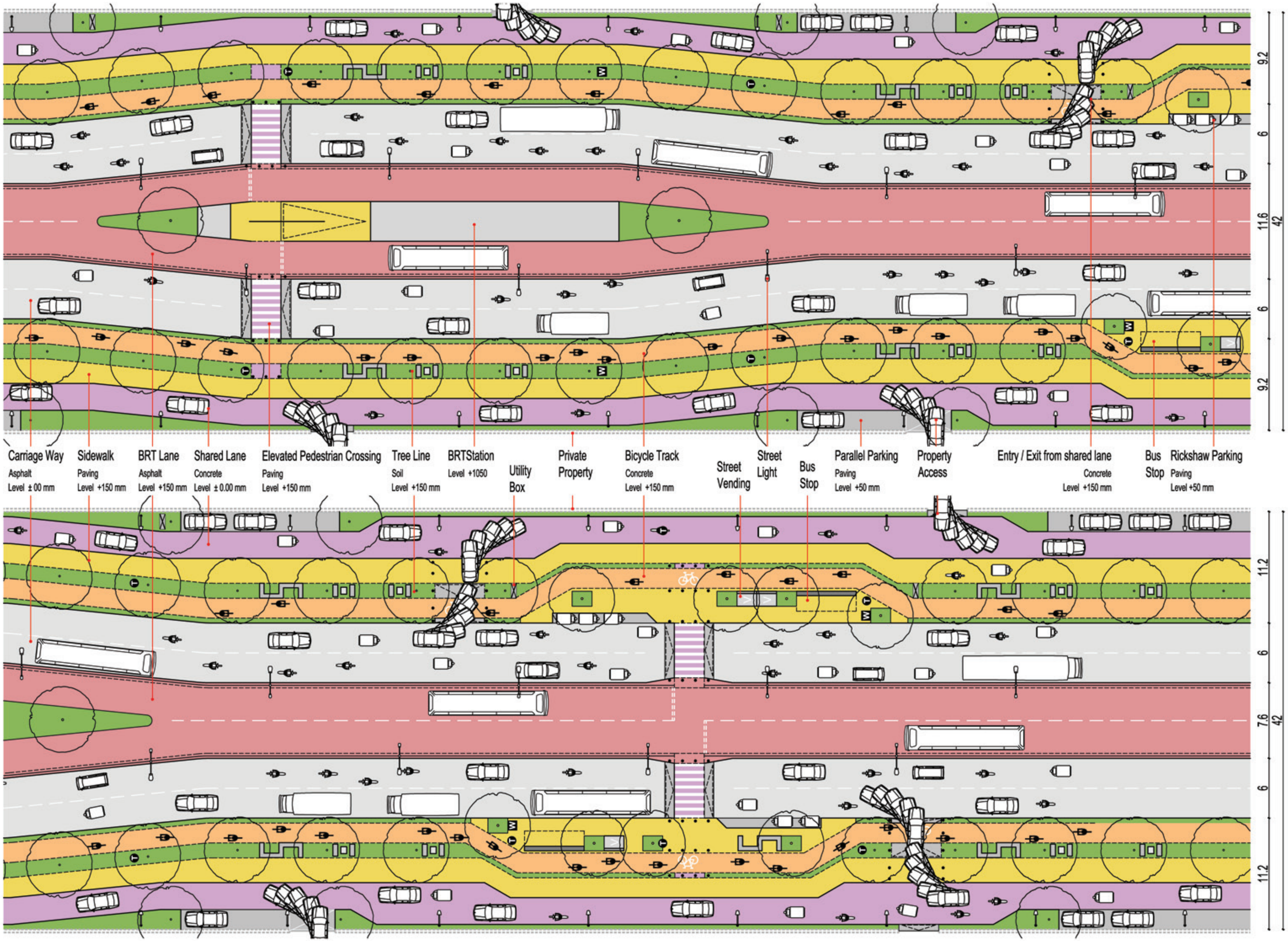
42BRT a



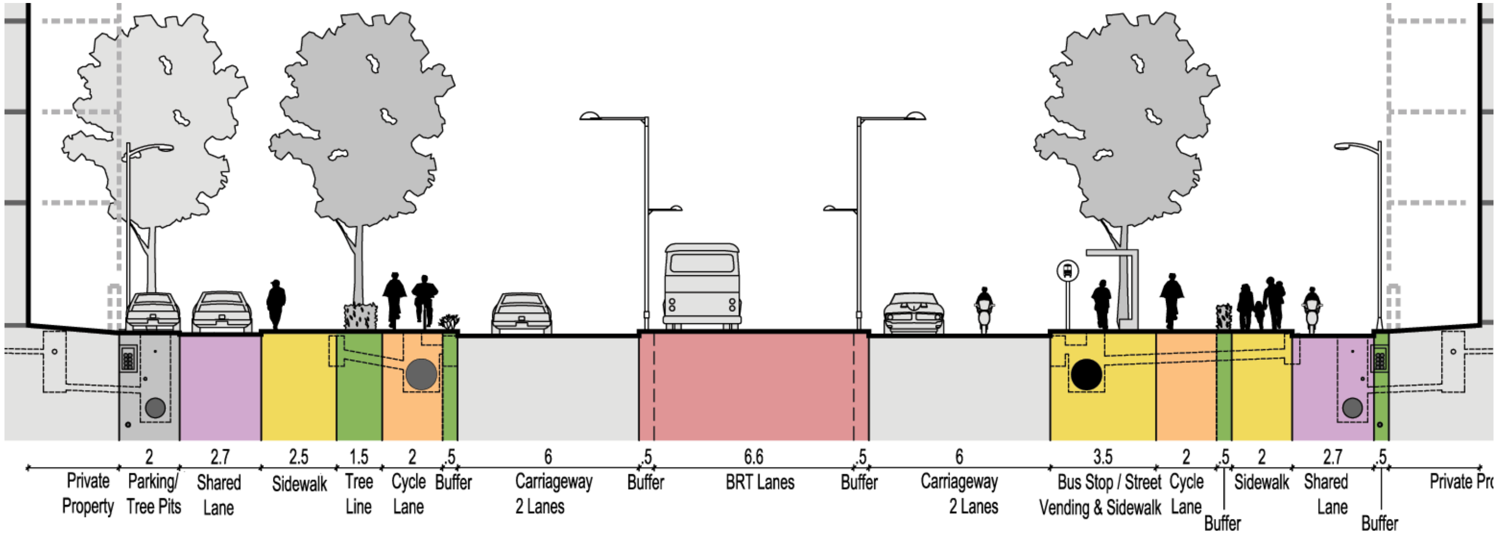
Streets with bus rapid transit

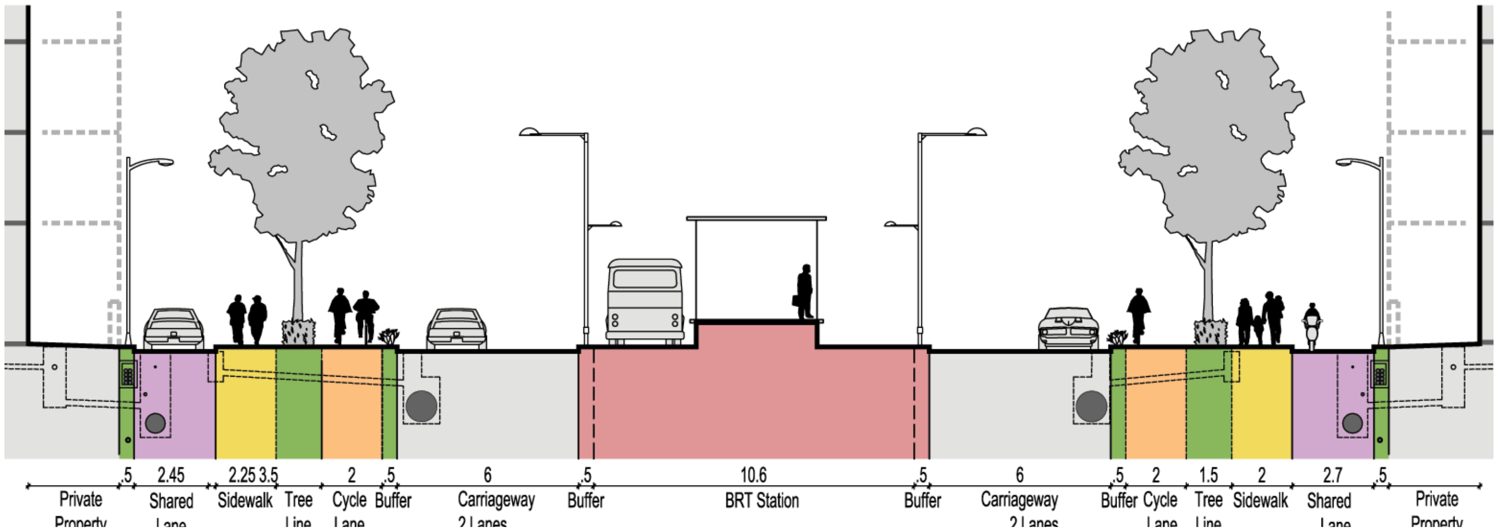
Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking & property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway





Carriage Way
Asphalt
Level ± 00 mm
Sidewalk
Paving
Level +150 mm
BRT Lane
Asphalt
Level +150 mm
Shared Lane
Concrete
Level ± 0.00 mm
Elevated Pedestrian Crossing
Paving
Level +150 mm
Tree Line
Soil
Level +150 mm
BRTStation
Level +1050
Utility Box
Private Property
Bicycle Track
Concrete
Level +150 mm
Street Vending
Street Light
Bus Stop
Parallel Parking
Paving
Level +50 mm
Property Access
Entry / Exit from shared lane
Concrete
Level +150 mm
Bus Stop
Rickshaw Parking
Paving
Level +50 mm
9.2
6
11.6
42
6
9.2
11.2
6
7.6
42
6
11.2





Streets with bus rapid transit

Pedestrian mobility and access	Footpath	Shared space	
Cyclist mobility	Median track	Side track	Mixed traffic
Parking & property access	Service lane	No service lane	
Private vehicle mobility	Divided carriageway	Undivided carriageway	No carriageway

Note Depending on adjacent land uses, the footpath can be placed at the edge of the right-of-way. However, given the limited width available for the footpath, it may be difficult to maintain sufficient clear width for pedestrians (see template 42b and Section 2.12).

4

Intersection templates

Intersection design involves weighing the potentially conflicting goals of safety and vehicle throughput. In the same way that the street templates in Chapter 3 offer varying degrees of liveability, mobility, and accessibility, the quality of an intersection environment can vary significantly, depending on turning radii, the presence of refuge islands, the continuity of cycle tracks, and other design features.

Intersections, rather than the standard section of a street, are the limiting factor in vehicle capacity. Therefore, intersection design needs to take into account the impact of design choices on mobility. However, this emphasis on mobility should not be confused with a emphasis on private motorised traffic. Instead, it may be desirable to design an intersection in such way that prioritises throughput of public transport, cycles, and pedestrians.

This section briefly introduces the basic elements of intersections. It then presents intersection design templates for typical right-of-way combinations. The standard street sections in these templates are drawn from Chapter 3.

Pedestrian safety

Turning radius

The concept of the turning radius is relevant in the context of designing street corners and left turn pockets. Larger vehicles require more space in order to take a turn, so intersection designs need to take into account the size of vehicles that are expected to pass through an intersection.

Since larger turning radii encourage faster vehicle speeds, tighter corners are preferred because they improve safety for pedestrians and cyclists. For local streets that cater to light vehicles, a 4 m radius is appropriate. While larger streets need to take into account the turning radius requirements of buses and trucks, it should be noted that the effective turning radius is often much larger than the radius of the built curb.

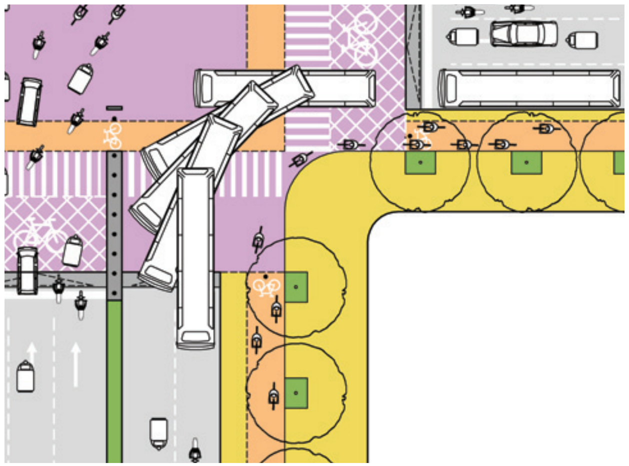


Figure 4.1 An intersection should be sized to minimize pedestrian crossing distances while accommodating left turns of a design vehicle (in this case a 12 m bus). Note that corner radius of the footpath can be significantly smaller than the effective turning radius of the bus.

Left turn pockets

Left turn pockets can increase junction capacity by allowing vehicles to make free left turns. However, if not designed appropriately, they can compromise pedestrian safety.

Traditionally, left turn lanes have been designed with a circular geometry. However, such a design is unsafe for pedestrians because it allows for fast vehicle movements. The preferred design incorporates a 30° angle of approach. Since vehicles enter the outgoing arm at a more abrupt angle, they are compelled to reduce their speeds.

The design should assume that a large vehicle completes the turn in the outermost lane of the exit arm but may enter the central lane while completing the turn. Otherwise, the left turn pocket becomes so large that smaller vehicles are able to travel at full speed around the corner.

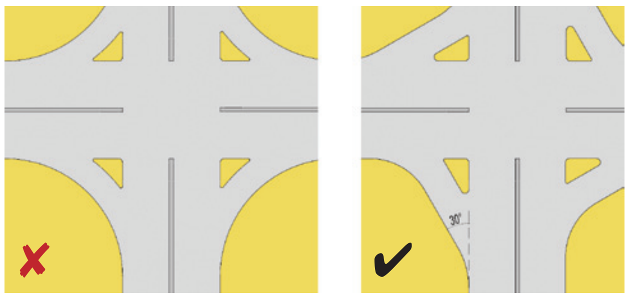


Figure 4.2 In the design of left turn pockets, a sharper angle of approach (right) can help reduce vehicle speeds. In general, left turn pockets should be avoided because they often compromise pedestrian safety.

Refuge islands and medians

Pedestrian refuge islands separate conflicts, so pedestrians can judge whether it is safe to cross by looking at and analysing fewer travel lanes and directions of traffic at a time. Tall, bushy plants should be avoided in medians because they obstruct pedestrian visibility. In the case of triangular islands adjacent to free left turn lanes, the island must remain free of landscaping and fencing in order to serve as a refuge for pedestrians.

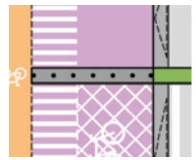


Figure 4.3 If properly designed, pedestrian refuge islands and medians improve safety by allowing pedestrians to cross different streams of traffic in separate stages.

Levels

The level of the carriageway at intersections and pedestrian crossings can be raised to that of the footpath or cycle track in order to improve safety and convenience for pedestrians. Vehicles from all directions pass over a ramp as they enter the intersection, causing them to slow down. As pedestrians pass from the footpath over the intersection to the footpath on the opposite side, they remain at the same level.

In general, unsignalised intersections should be raised since pedestrian safety is not ensured by any other means. Signalised intersections can be raised if

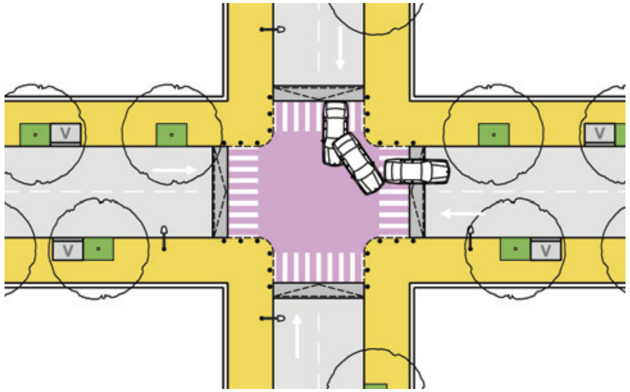


Figure 4.4 In this unsignalised intersection, the carriageway is raised to the level of the footpath (+150 mm) to slow down vehicles and to improve convenience and safety for pedestrians.

warranted by safety concerns. In many cities, signals only operate during peak hours, so a level difference is needed to ensure safety when the signals are not operating. If raising the intersection prevents adequate vehicle throughput, then ramps should be installed at least on left turn pockets.

Crosswalks

Crosswalks delineate an area that is reserved for pedestrian movement while perpendicular traffic is stopped. They should only be marked where vehicles are required to stop, such as at signalled intersections. At unsignalised intersections, painted crosswalks do not necessarily improve pedestrian safety unless accompanied by a physical measure such as a speed bump or speed table. At unsignalised midblock locations, informal crossing points should be provided without painted zebra markings. Occasional formal (i.e. ramped) midblock crossings can be provided (see Section 2.6).

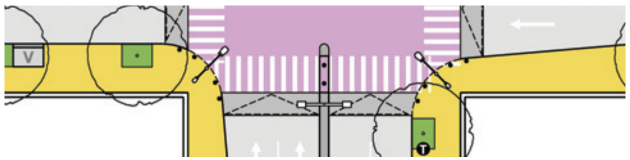


Figure 4.5 The crosswalk is a clear space ahead of the vehicle stop line where pedestrians can cross during the appropriate signal phase. The crosswalk should be aligned with the through movement corridor on the footpath.

The stop lines for vehicles should be located prior to this crossing area. Since many drivers do not respect painted markings, stop lines require vigilant enforcement if the crosswalk is to remain free of queuing vehicles.

Bollards

Bollards help define refuge islands and other pedestrian spaces and prevent vehicles from driving over these spaces. Bollards are especially helpful when a pedestrian area is at the same level as the surrounding road surface. Possible shapes range from slender posts to larger and heavier obstacles that can double as seats. A minimum width of 815 mm is required for the passage of wheelchairs. At entrances to cycle tracks, a wider opening of 1 m is preferred.

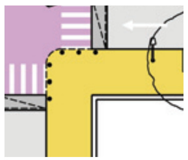


Figure 4.6 The boundaries of pedestrian spaces are defined by bollards to prevent encroachment by vehicles.

Operations

Signal phasing

The physical layout of a intersection must be designed in conjunction with the signal phasing. There are generally several possible sequences of signal phases. The optimal phasing design is determined by the relative volumes of the various movements taking place at an intersection. For example, Figure 4.7 shows two standard phasing plans for a four-arm junction. (The diagrams assume that left turns are uncontrolled and can occur during any phase.) Phasing sequences ensure that the final vehicles from each phase are in a different part of the junction from the starting vehicles in the next phase. For example, for four straight plus right phases, a counterclockwise sequence is preferred.

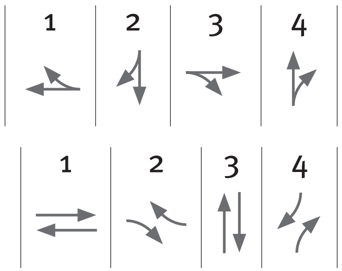


Figure 4.7 Two of the possible signal phasing options for a typical four-arm intersection alternately combine or separate the right turning and straight movements.

The simplification of signal cycles through the elimination of turning movements can help reduce delay at intersections, particularly along BRT corridors. As described later in this section, squareabouts combine straight and turning movements, allowing for a two-phase cycle.

Signal cycles also can be simplified through changes at the network level. For example, a right turn can be substituted by three left turns (see Figure 4.8).

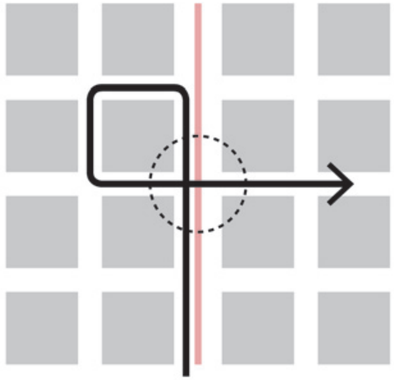
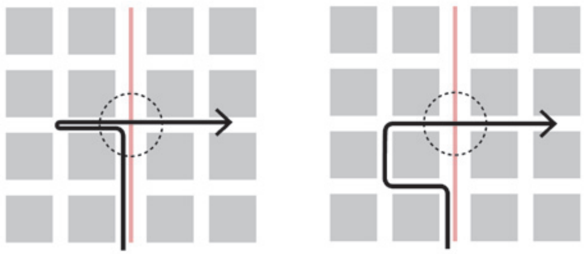


Figure 4.8 In order to reduce intersection delay along a BRT corridor, intersections can be simplified by prohibiting right turns across the BRT corridor. Vehicles can still make the right turn at the circled junction by turning left three times and then crossing perpendicular to the corridor. Two additional options are indicated below. In the diagram at left, the turn is accomplished through a left turn followed by a U-turn. In the diagram at right, vehicles make two right turns at less critical junctions away from the BRT corridor.



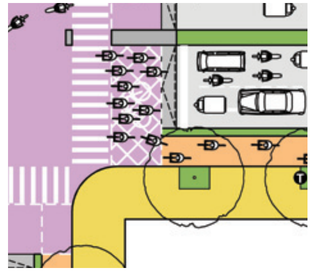


Figure 4.9 A bicycle box allows right-turning cyclists to queue ahead of mixed traffic.

Bicycle boxes

Bicycle boxes typically provide a space for right-turning cyclists to wait at a red light ahead of mixed traffic. When the light turns green, cycles start their turning movements first, and motor vehicles follow immediately behind. Cyclists using a bicycle box have better visibility since they are the first road users to move into the intersection. This feature makes it possible to send them along with main traffic in a single signal phase instead of adding exclusive cycle phases or requiring cyclists to make right turns in two stages with straight-bound motor vehicles. Bicycle boxes also give an advantage to through cyclists who might be cut off by aggressive left-turning motorists.

Bicycle boxes should be at least 3 m deep to accommodate one row of cyclists. For larger intersections with higher cycle volumes, a depth of 5 m is appropriate. Enforcement is necessary to ensure that motorists respect the stop line.

Queuing space

The carriageway can be widened at intersections to provide additional queuing space for vehicles, which reduces overall signal time. Where the additional space is provided, the street's cross section usually becomes asymmetrical—even if the regular street section is symmetrical—in order to claim the additional space evenly from both sides of the cross section instead of eating deeply into the pedestrian/cycle space only on one side. The number of straight-bound lanes entering a intersection should not be greater than the number of outgoing lanes in the same direction. Otherwise, the intersection may become congested as vehicles try to merge into the narrower outgoing carriageway.

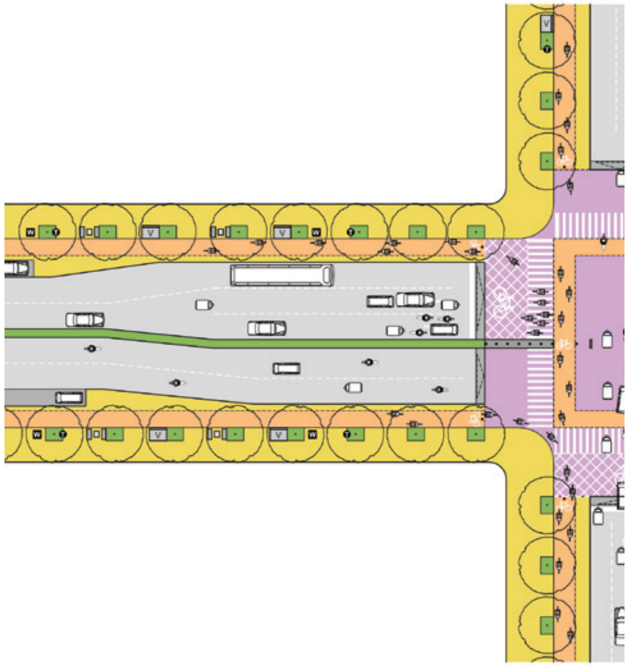


Figure 4.10 The carriageway widens from two to three lanes in the incoming direction in order to provide more space for queuing vehicles. The extra lane occupies space that is used for the parking lane in the standard section.

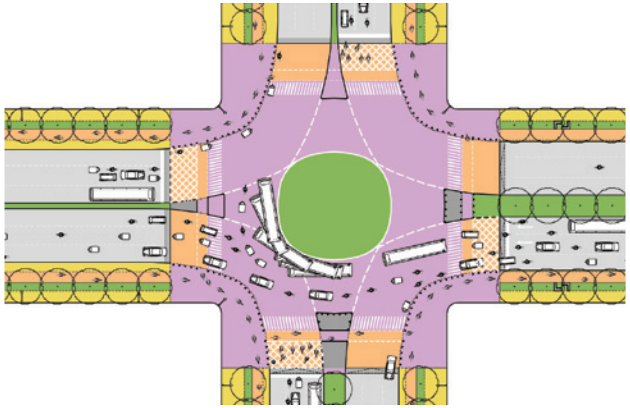


Figure 4.11 Squareabouts allow for two-phase signal cycles, which can reduce total signal cycle times in intersections with median BRT lanes.

Squareabouts

Squareabouts are a means of managing right-turning traffic at large intersections while minimising signal cycle time. Squareabouts make the right-turn phase obsolete by creating right-turn queuing space within the intersection itself. Vehicles queue in this space during one phase and exit during the next phase.

Squareabouts are a valuable option on BRT corridors. While the BRT would require the addition of extra phases to a typical four-phase signal cycle, the squareabout accommodates all turning movements in only two phases.

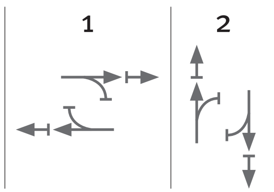


Figure 4.12 The signal phasing plan for a squareabout. Right-turning vehicles enter the queueing spaces during the first phase and exit the ahead of straight-moving traffic during the next phase.

Squareabouts only work where the amount of right-turning traffic can be accommodated in the right-turn queuing space.

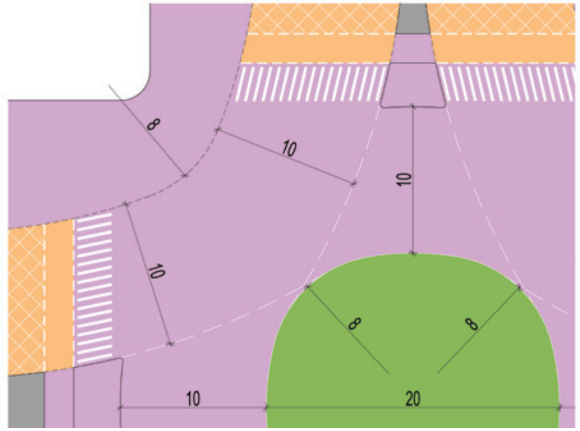
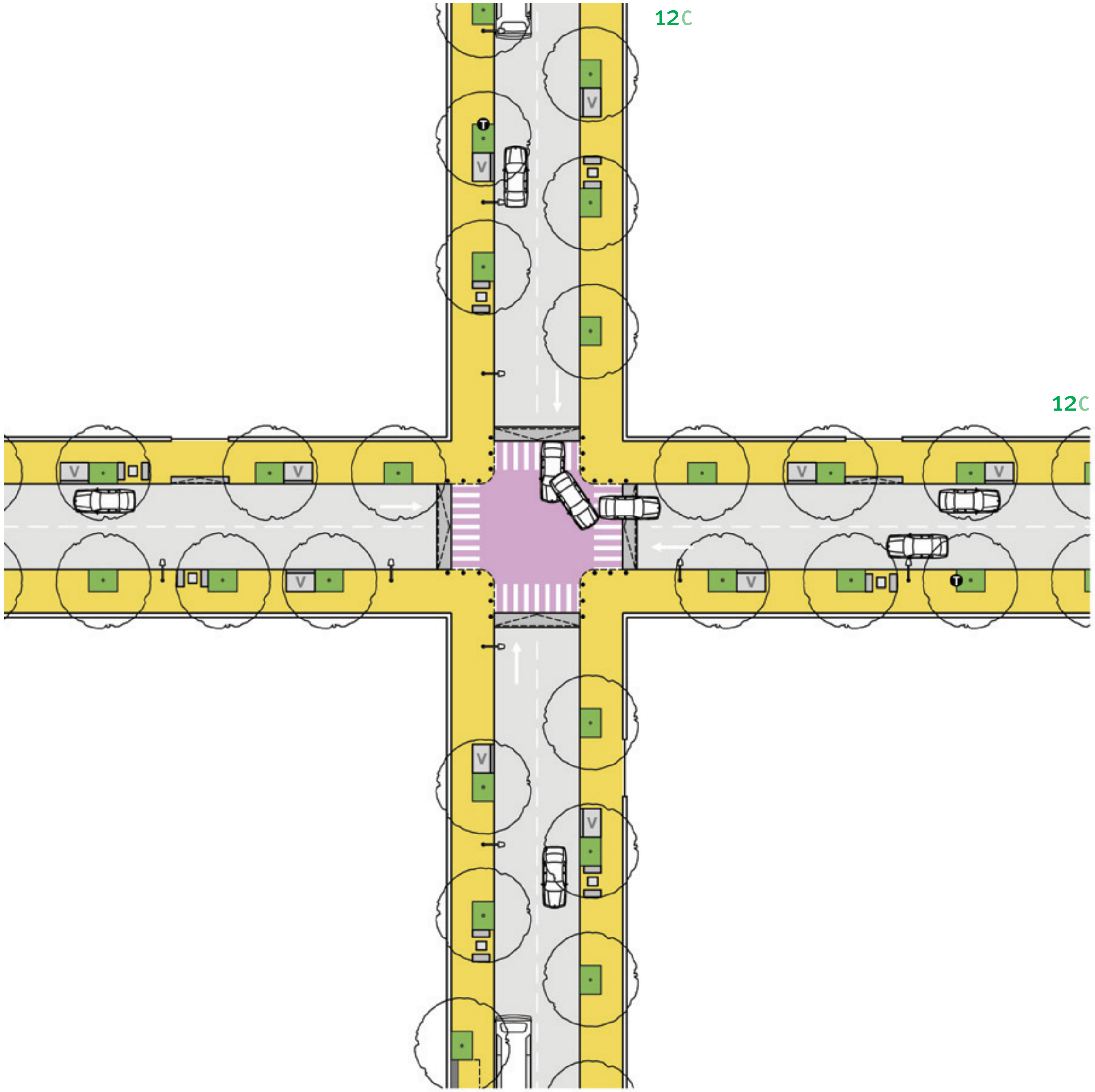


Figure 4.13 The squarish shape of the central island increases the queuing space for right turning vehicles relative to what would be available with a simple circular design.

12C + 12C



Cyclist mobility	Mixed traffic	Mixed traffic
Public transport mobility	Buses*	Buses*
Signalisation	Uncontrolled	

* Only straight-bound movements possible

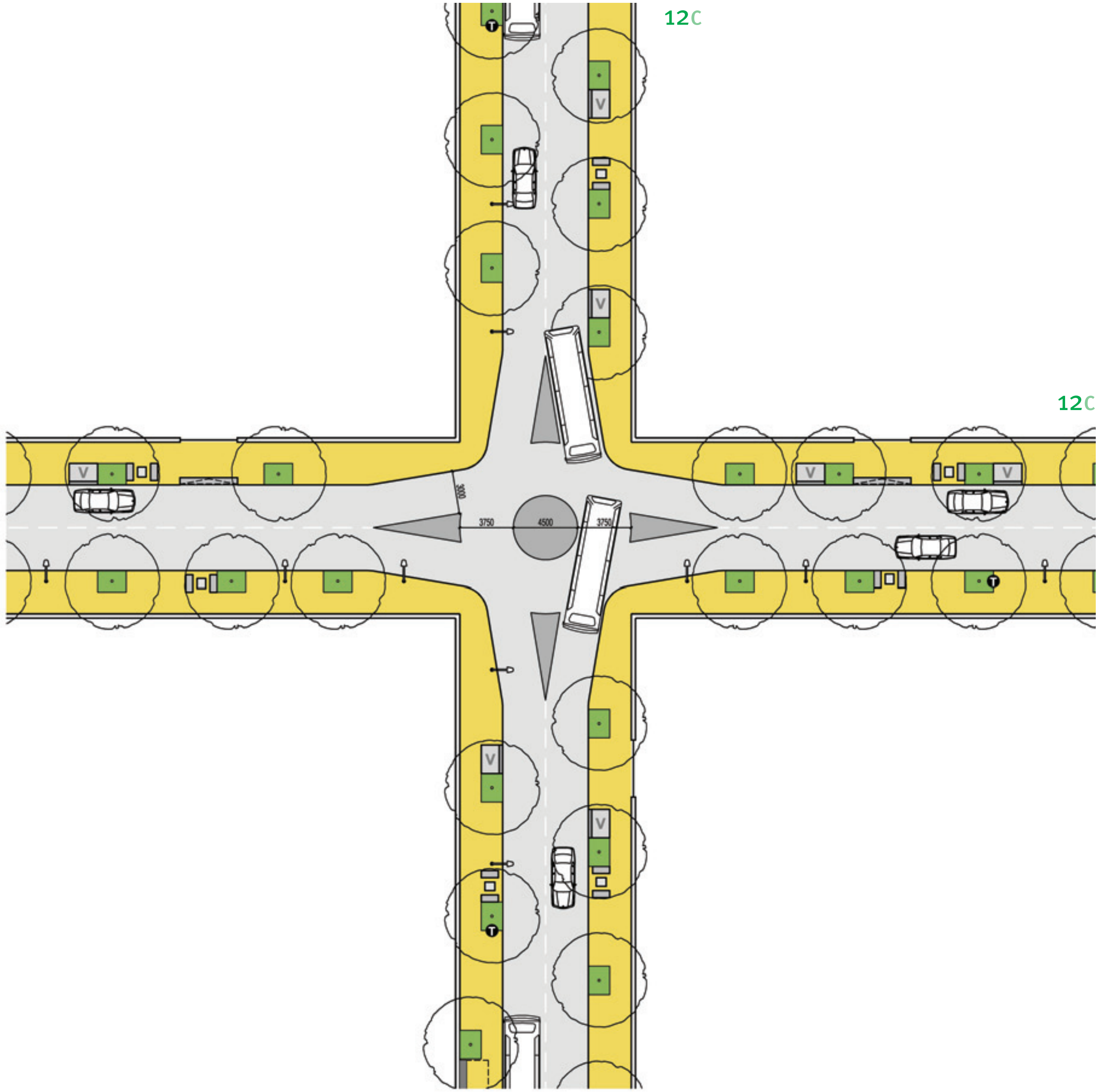
12C + 12C roundabout

Mixed traffic	Mixed traffic	Cyclist mobility
Buses*	Buses*	Public transport mobility
Uncontrolled		Signalisation

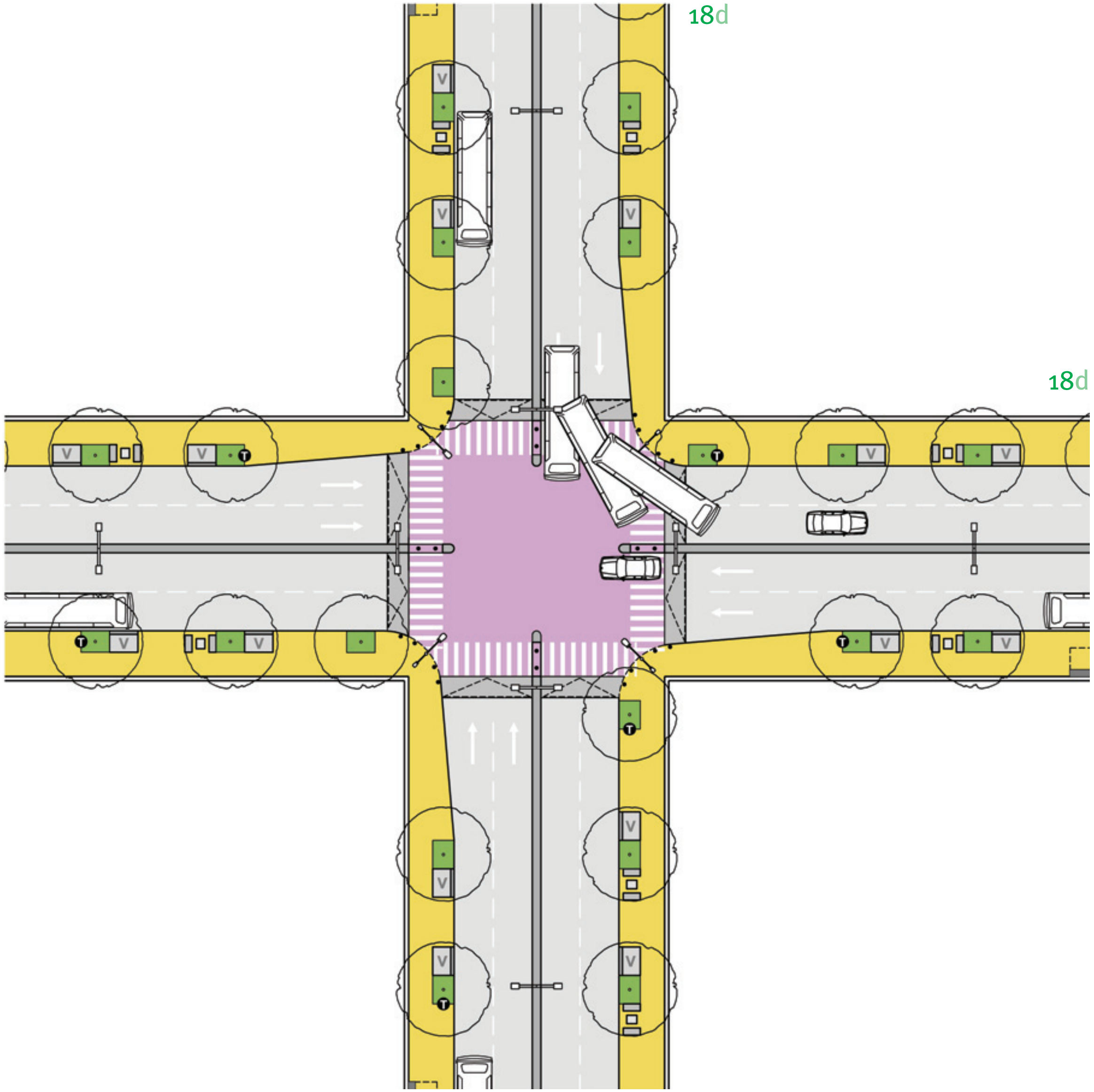
* Only straight-bound movements possible

Note In unsignalised intersections, a roundabout can improve safety by consolidating intersection movements and reducing speeds. Roundabouts also simplify the conflict associated with right turns, which are a major cause of intersection crashes.

In small intersections the roundabout itself as well as the islands in the centre of the four street arms may be constructed with truck aprons that are surmountable by trucks and buses but not by cars and two-wheelers. Such a design accommodates the larger turning radius of heavy vehicles while maintaining a smaller turning radius for other vehicles.



18d + 18d

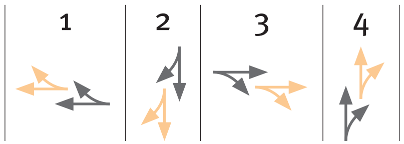


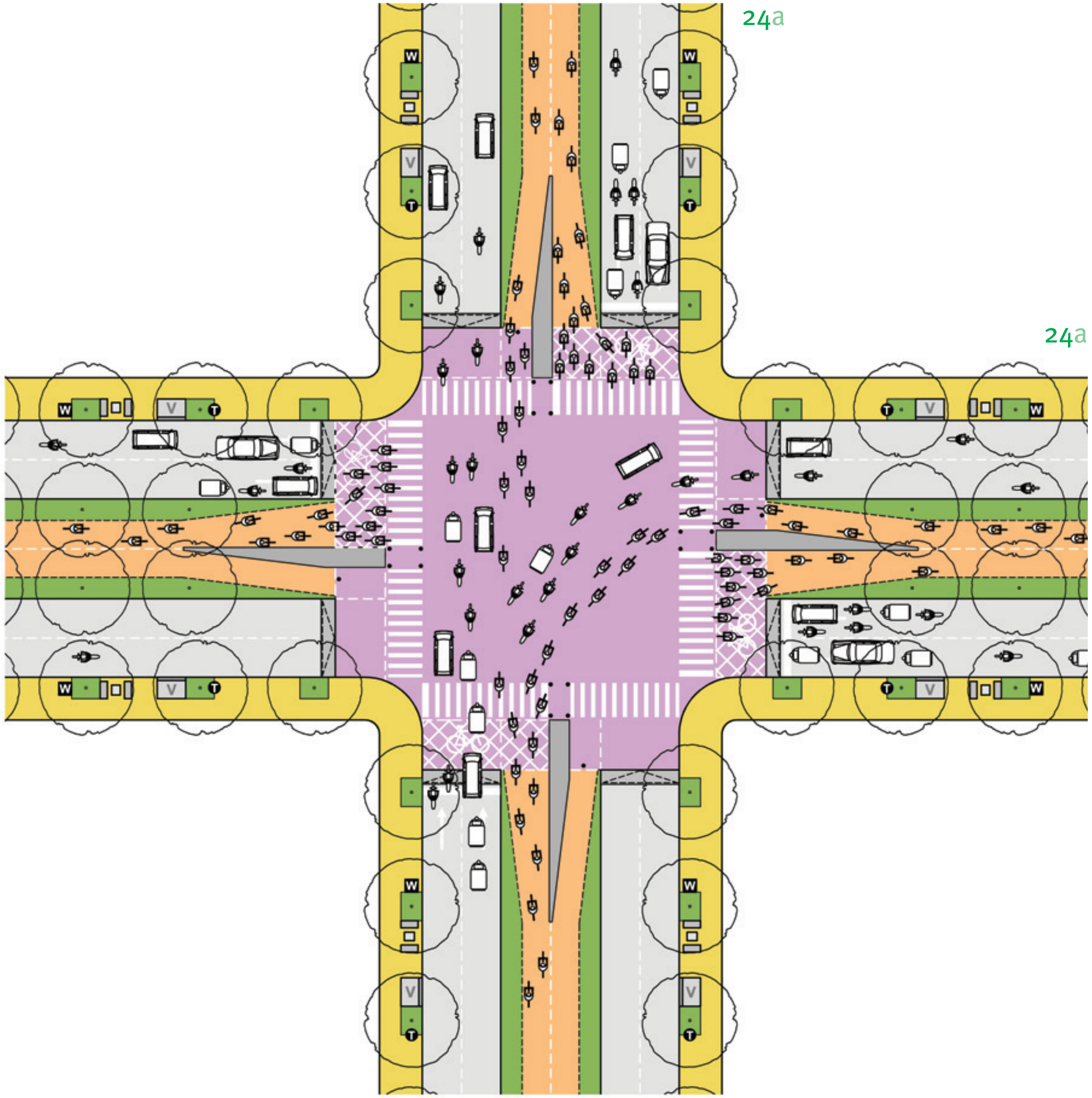
Cyclist mobility	Mixed traffic	Mixed traffic
Public transport mobility	Buses	Buses
Signalisation	Controlled	
Signal cycle	1 2 3 4	

24a + 24a

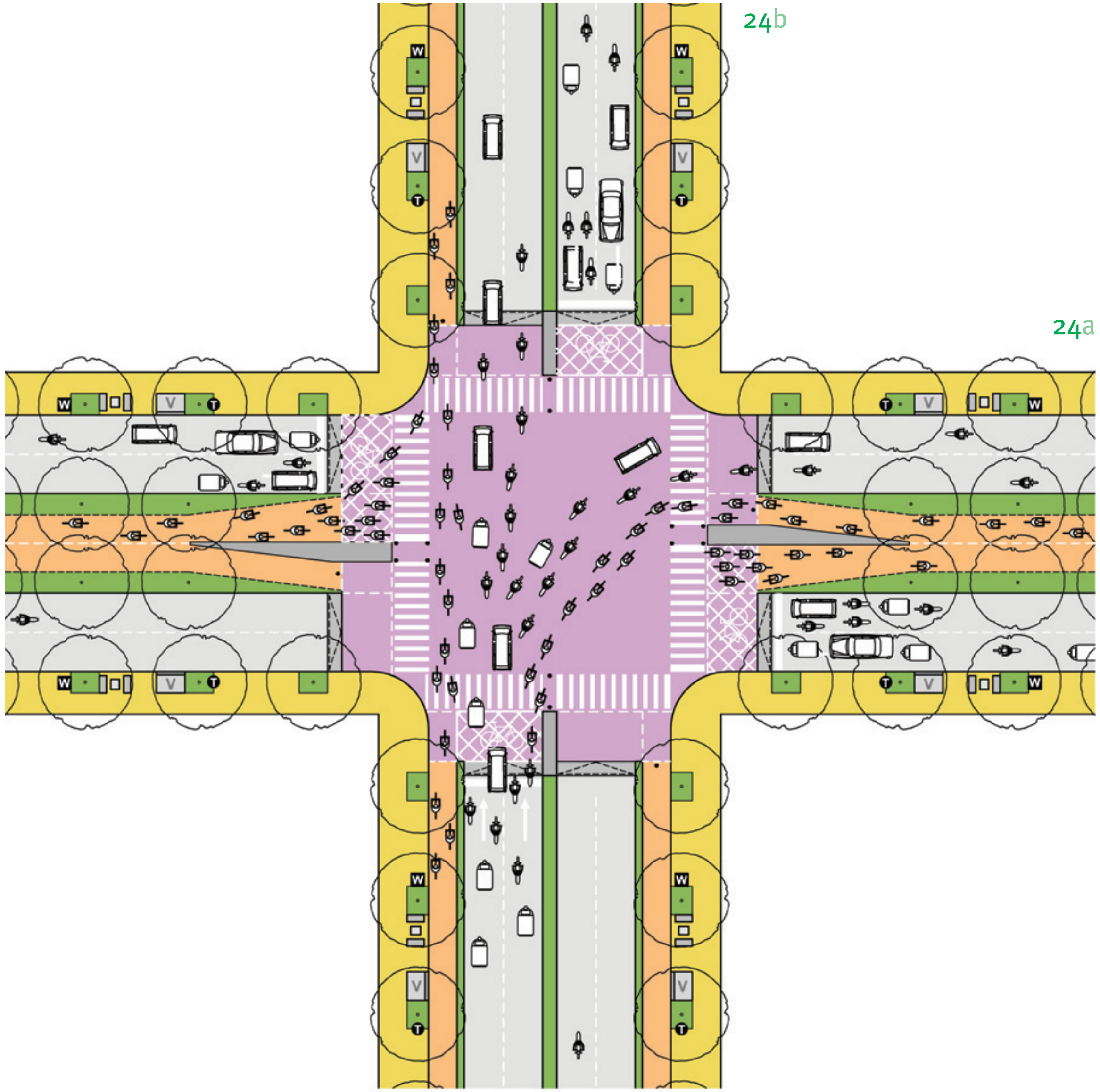
Median track	Median track	Cyclist mobility
Buses	Buses	Public transport mobility
Controlled		Signalisation

Signal cycle



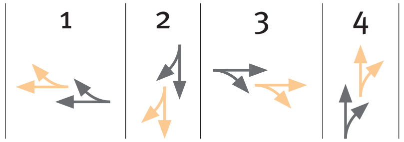


24a + 24b



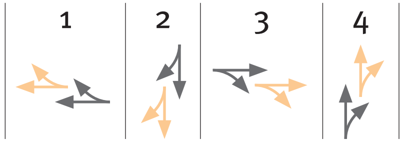
Cyclist mobility	Median track	Side track
Public transport mobility	Buses	Buses
Signalisation	Controlled	

Signal cycle: 1, 2, 3, 4

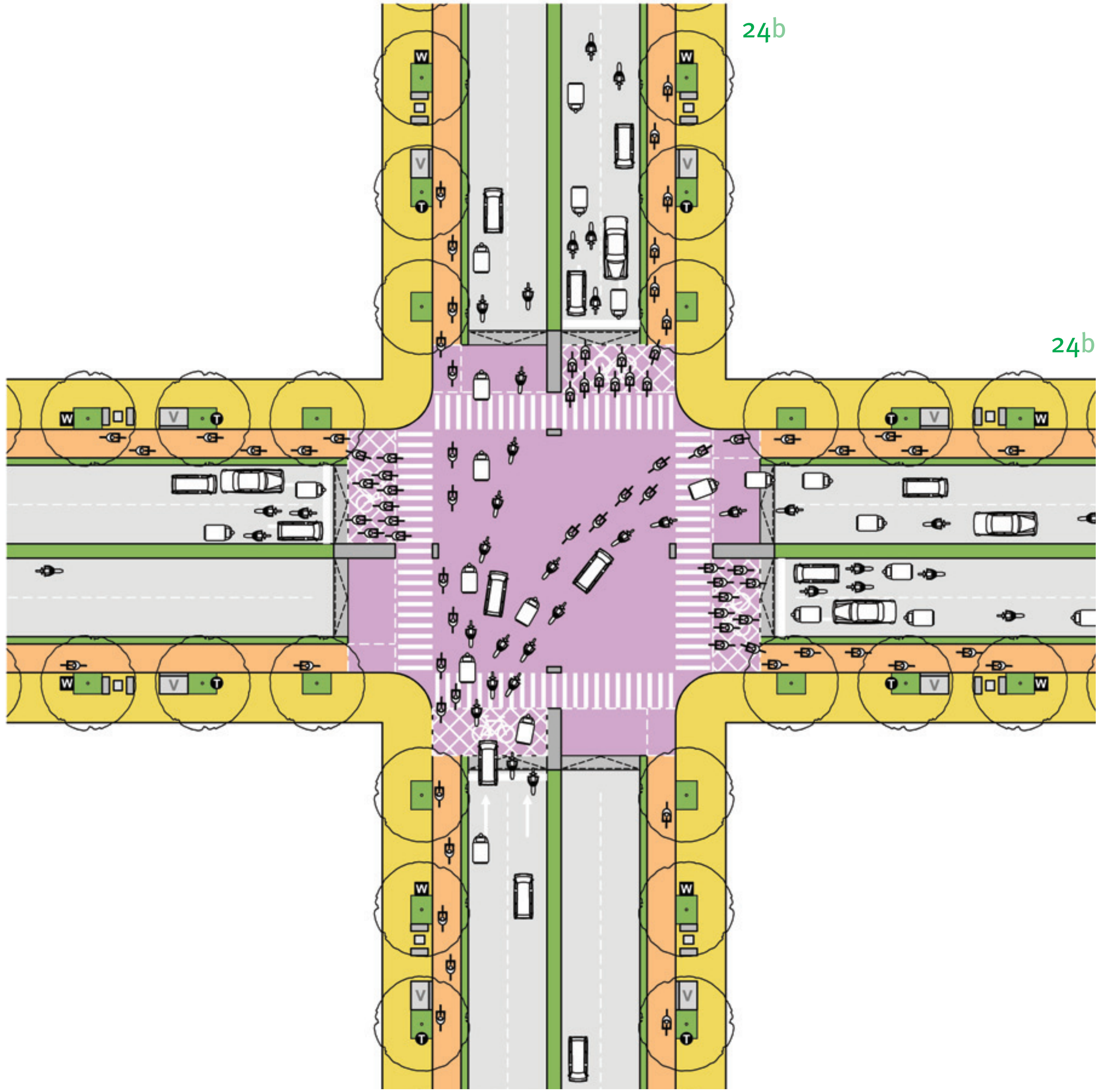


24b + 24b

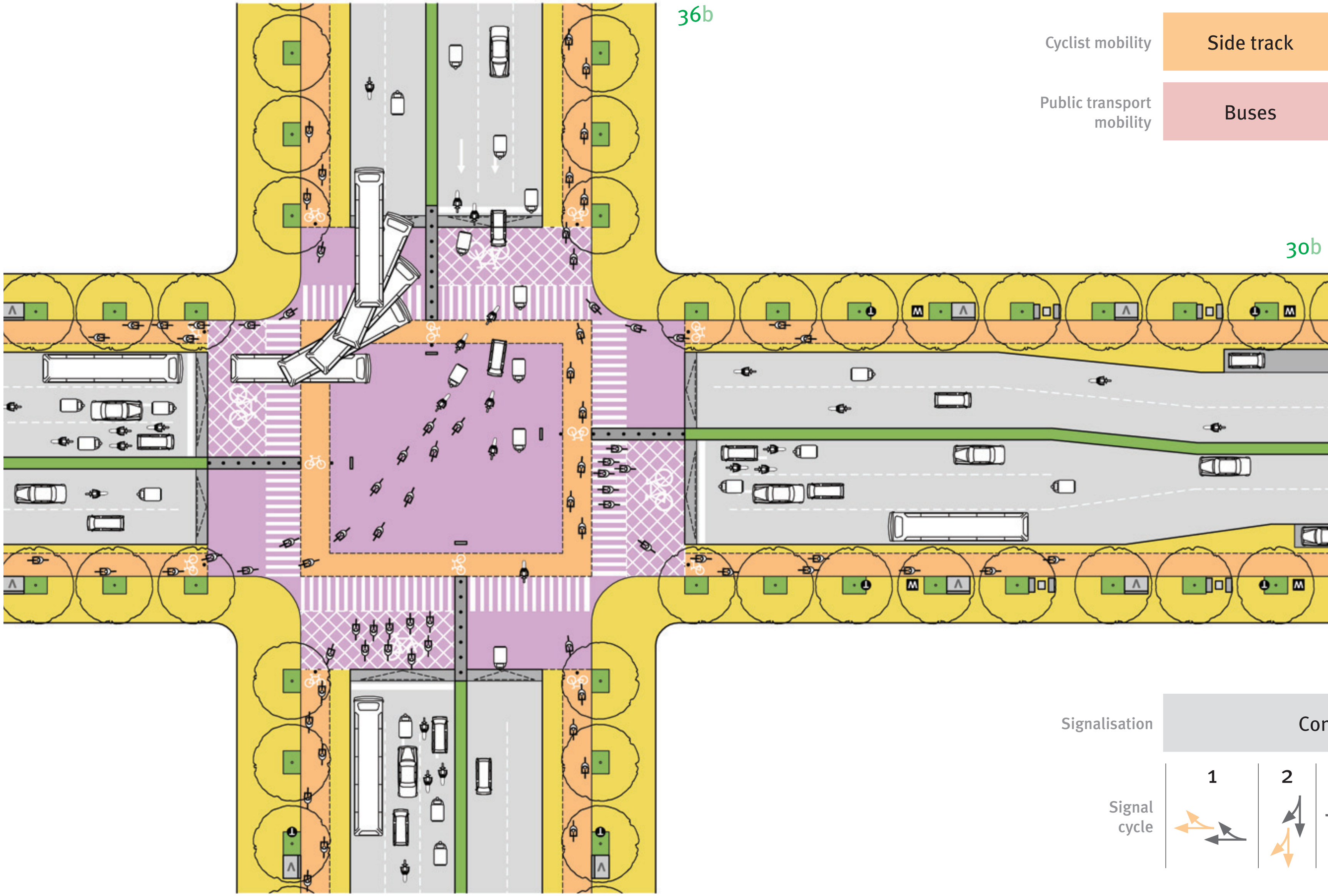
Side track	Side track	Cyclist mobility
Buses	Buses	Public transport mobility
Controlled		Signalisation



Signal cycle



30b + 36b



Cyclist mobility	Side track	Side track
Public transport mobility	Buses	Buses

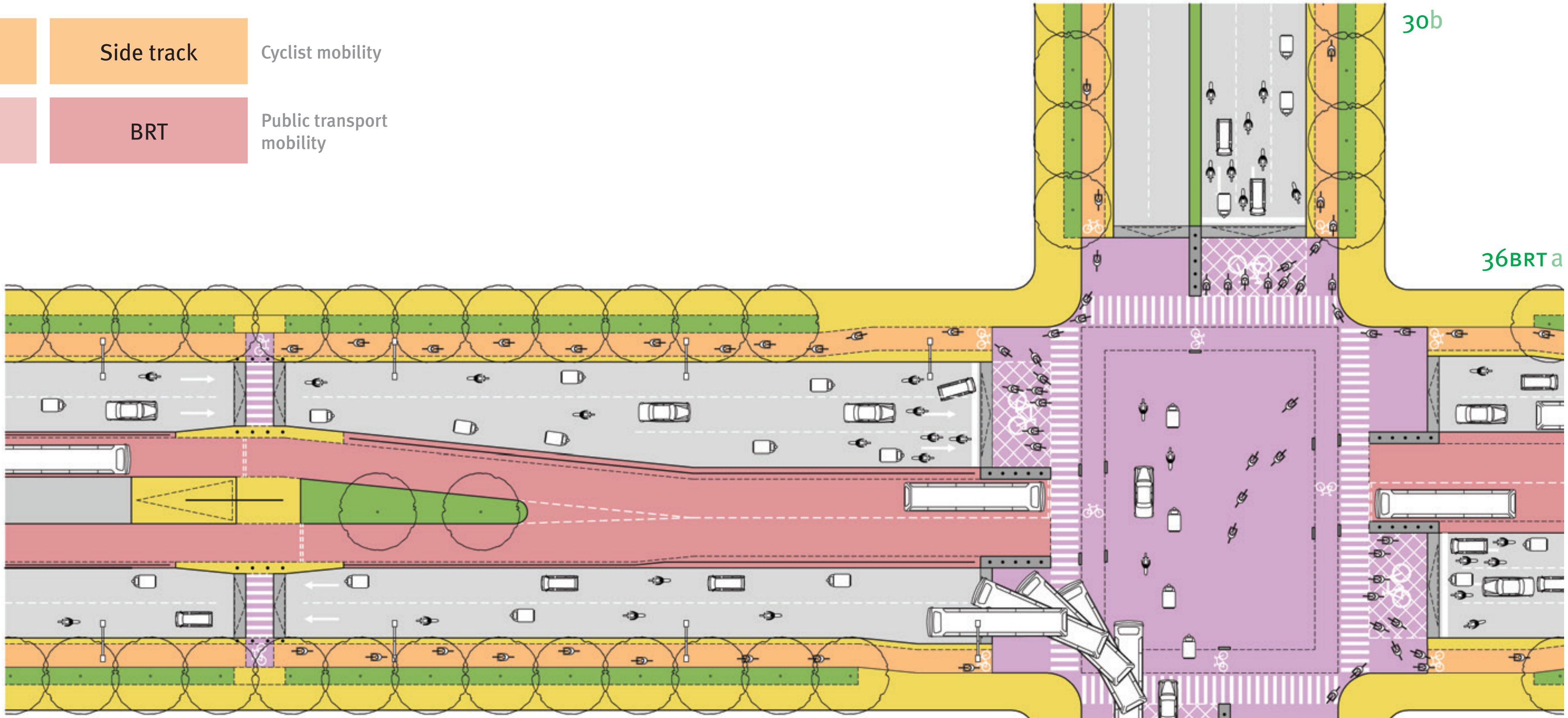
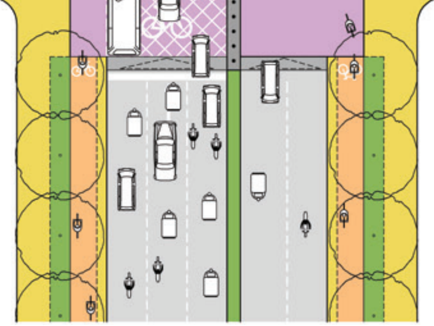
Signalisation	Controlled

Signal cycle

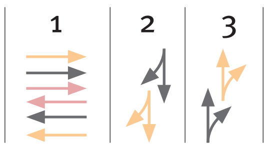
1 2 3 4

30b + 36BRT a

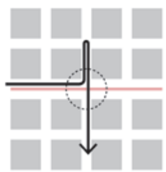
Side track	Side track	Cyclist mobility
Buses	BRT	Public transport mobility

Controlled	Signalisation



Signal cycle

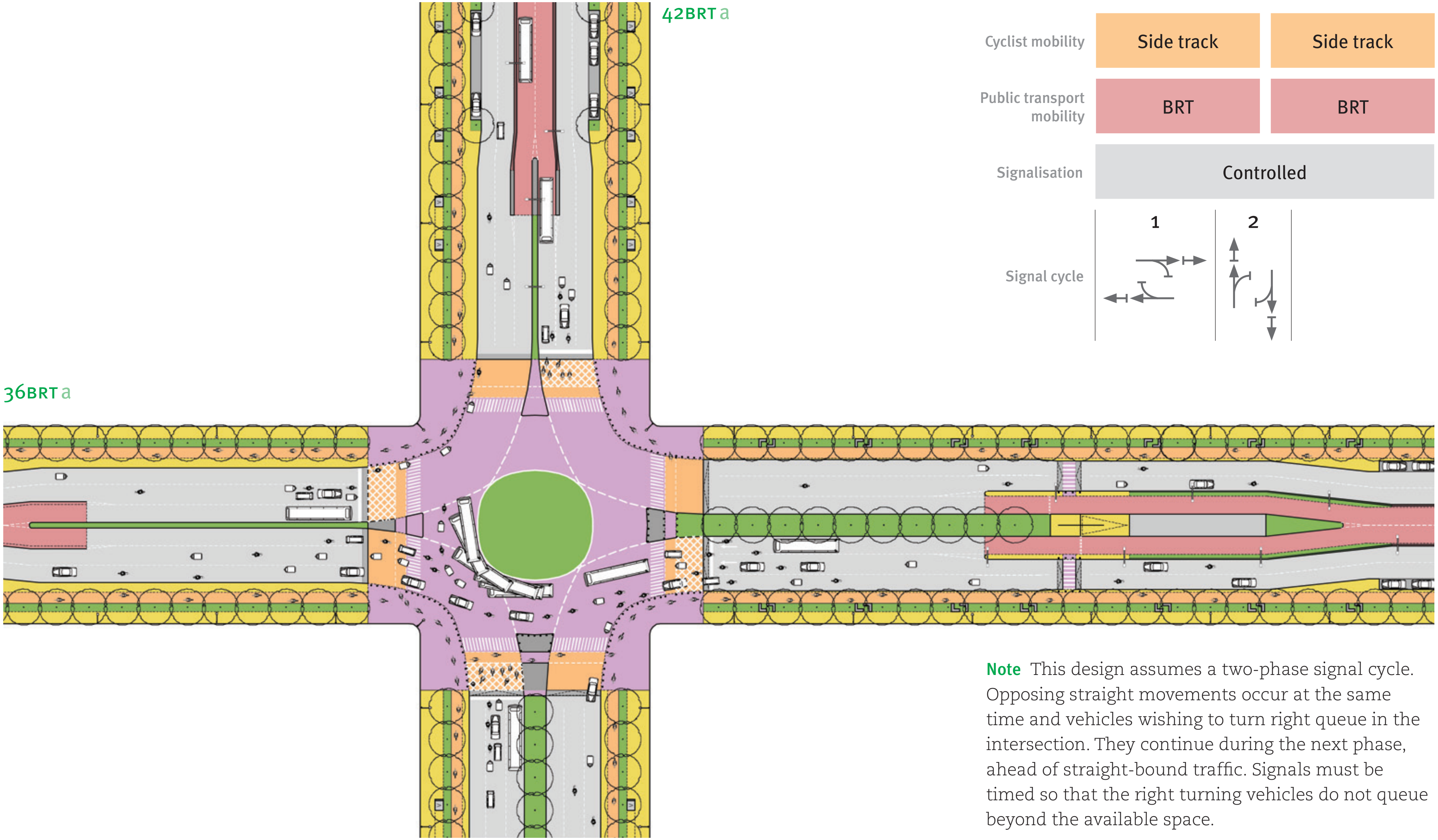


Note To reduce signal cycle time and give priority to BRT, motor vehicle right turns are not permitted at the junction. Right turns can still be completed by taking a left turn followed by a U-turn. See Figure 4.8 for more right turn alternatives.

36BRT a + 42BRT a

42BRT a

36BRT a



Cyclist mobility	Side track	Side track
Public transport mobility	BRT	BRT
Signalisation	Controlled	
Signal cycle	1	2

Note This design assumes a two-phase signal cycle. Opposing straight movements occur at the same time and vehicles wishing to turn right queue in the intersection. They continue during the next phase, ahead of straight-bound traffic. Signals must be timed so that the right turning vehicles do not queue beyond the available space.

5

Design process

This chapter describes the process of designing streets. It begins with thorough analysis of the project area, helping to identify the appropriate set of street elements for local conditions. The procedure follows these steps:

- Developing a vision
- Topographic and landscape surveys
- Pedestrian and activity surveys
- Parking survey
- Right-of-way overlay
- Traffic survey
- Selection of street templates
- Major intersection design
- Public transport design
- Small intersection design

We demonstrate these steps through a case study. Each step is illustrated with sketches and data based on a real-world example involving the redesign of an intersection. The existing conditions in the study area are presented on the following two pages.

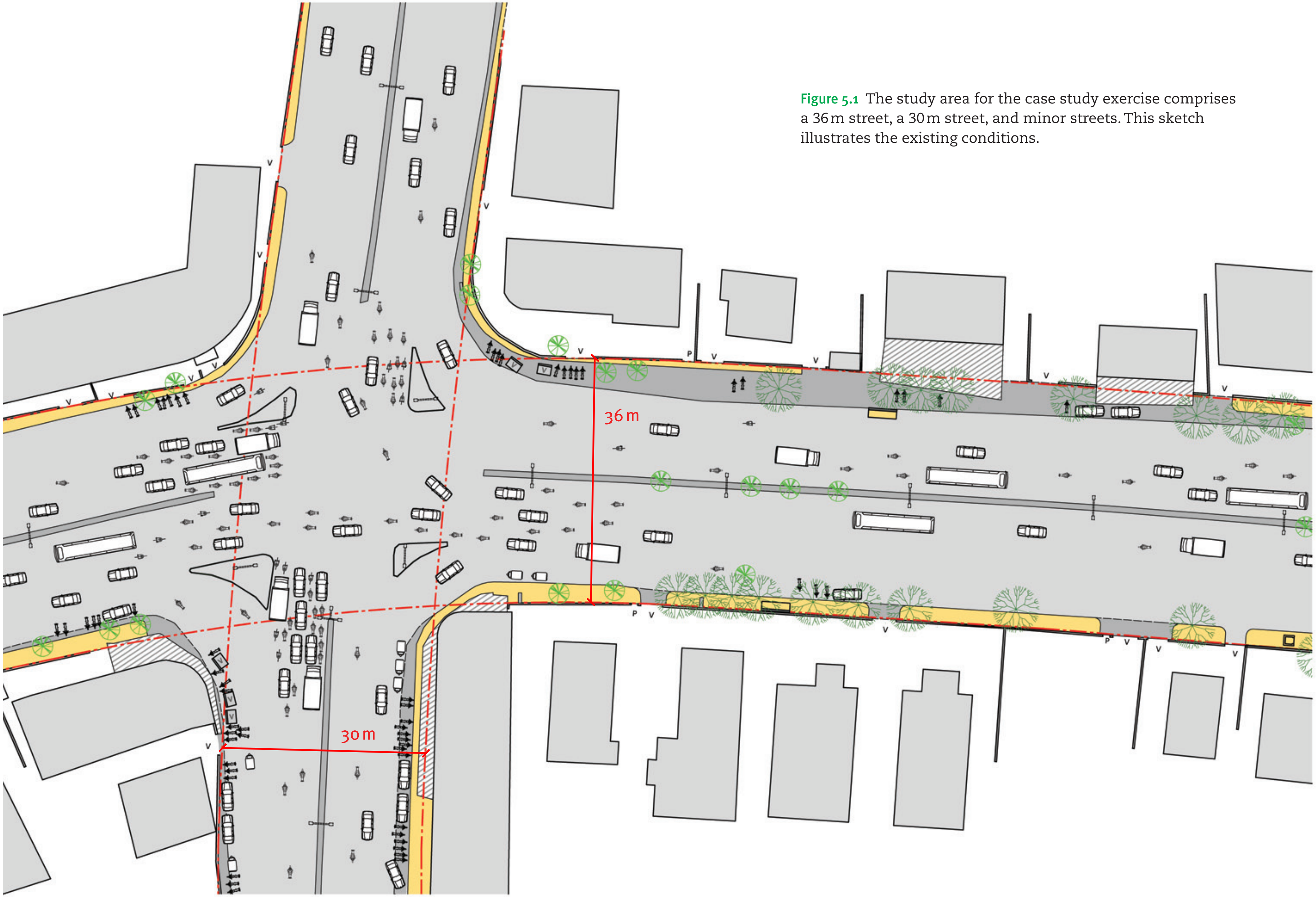


Figure 5.1 The study area for the case study exercise comprises a 36 m street, a 30 m street, and minor streets. This sketch illustrates the existing conditions.

5.1 Sketching a vision

To initiate the design process, it is helpful to brainstorm possibilities that the site holds for creating a more comfortable, people-friendly environment.

The new design can recognise the variety of activities already happening in the public realm by allocating dedicated spaces for street vending and by providing street furniture to complement the vending activities and to give people a place to sit, relax, interact, and people-watch.

Another key component of a people-oriented vision is providing higher quality spaces for walking. At present, the carriageway spans nearly the entire width of the street, forcing pedestrians to share space with fast moving vehicles (see Figure 5.1, previous page). An improved design can provide dedicated spaces where pedestrians can move freely without having to dodge moving vehicles. At potential conflict points, motor vehicle speeds can be kept at a level that improves safety. Pedestrian paths can be developed so as to take advantage of existing trees in the study area, and the design can aim for a major greening of road sections that are not adequately shaded.

Besides walking, the design can promote other sustainable modes of transport. As per existing city plans, the vision incorporates shaded cycle tracks on both streets as well as a bus rapid transit on the 36 m street. Dedicated, shaded cycle tracks have the potential to attract new riders by making cycling safe and comfortable. The BRT system can improve comfort and speeds for public transport customers.

Figure 5.2 At present cyclists travel in mixed traffic on all streets in the study area. The plan envisions safe, continuous, and shaded cycle tracks to improve comfort and safety.

Figure 5.3 There is insufficient public seating and other street furniture in the study area. Wherever possible, benches and tables will be installed to provide dignified places for people to socialise and rest.

Figure 5.4 Existing left turn islands are fenced and landscaped. Instead of serving as refuge islands, they become barriers to pedestrian movement. Islands and medians will be redesigned to be accessible to pedestrians.

Figure 5.5 Especially in the evening hours, the study area is a popular centre for roadside eating. There are mobile vendors as well as formal eateries that utilise the public right-of-way as seating and standing area. However, there is no provision for vending in the existing street design. Pedestrian areas in the new design will be large enough for through movement as well as food-related activities.

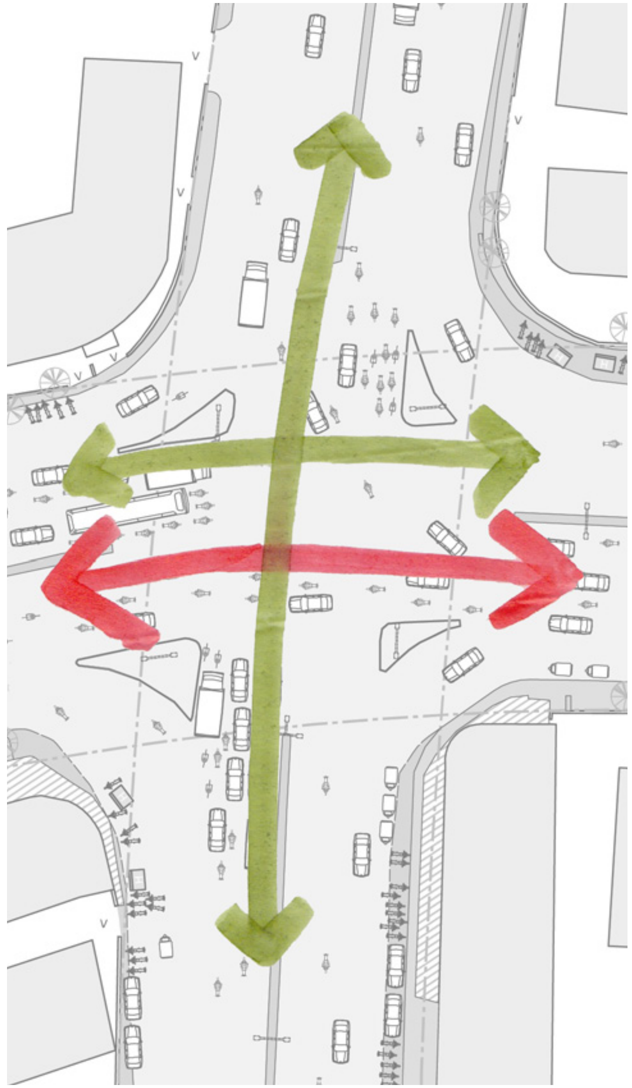


Figure 5.6 Under existing city plans, both major streets are to become part of the city's cycle network with high quality cycle tracks (green). In addition, the 36 m street will have BRT service (red).

5.2 Topographic survey

Figure 5.7 The topographic survey can identify existing trees so that they can be accommodated in the design.

Figure 5.8 The survey should record the location of all fixed structures, even informal or temporary structures.

Purpose

The topographic survey determines the location of natural and man-made physical features, such as buildings, high tension lines, and immovable street furniture. Landscape details, such as the location, spread, and value of existing trees, shrubs, and green areas, are also noted.

Methodology

The survey locates all important features on the site and records three dimensional coordinates, either absolute or in reference to traverse points. The locations of the following objects should be noted in the survey:

- All objects in the roadway (e.g. temples, mosques, light/telephone/electric poles, traffic signals, medians, islands, footpaths, pavements, utility boxes, electric substations)
- Compound walls (including private property gate locations and widths)
- Footprints of structures (both kuccha and pucca) in the property abutting the public right-of-way, including plinth level
- Surface levels
- Trees, differentiated by circumference (< 30 cm, > 30 cm)
- Manholes, drains, and catch pits
- Culverts, open drains, and bridges
- Building names for reference

For trees, further detail can be collected:

- Identification code comprised of street initials and tree number
- Surrounding street component (e.g. road, footpath, median, private plot)
- Diameter at ground level or 1.2 m above ground, whichever is larger
- Largest crown diameter
- Height
- Height of first branch
- Condition (e.g. healthy, satisfactory, declining, poor, dead)
- Name of species

Case study application

As indicated in the topological survey results (see Figure 5.9), boundary walls comprise most of the street frontage along the 36 m street, while some commercial buildings front the 30 m street directly.

The survey determined that a number of mature trees exist in the study area, generally near the edge of the street, which may make it difficult to provide a continuous footpath there.

Figure 5.9 The topographic survey sketch

5.3 Pedestrian and activity surveys

Figure 5.10 A pedestrian survey can identify locations where inadequate footpaths force pedestrians to walk in the street.

Figure 5.11 The survey notes whether existing infrastructure is compatible with pedestrian desire lines.

Purpose

Pedestrian and activity surveys inform the selection of pedestrian and liveability elements and the design of traffic calming features and intersections.

Pedestrian survey methodology

A pedestrian survey maps pedestrian movements to inform the expansion or improvement of pedestrian facilities. It takes note of any obstacles, such as median fences and unsurmountable islands. Observation of pedestrian movements and destinations can inform the placement and design of formal crossings.

In cases where pedestrians are not using existing footpaths, the survey can map possible reasons, such as insufficient width or conflicts with other uses. The pedestrian survey also can identify locations where traffic calming is necessary to improve safety, particularly at junctions.

Activity survey methodology

Social and economic activities may occupy a large portion of street space. Yet they are usually ignored in the street design process.

An activity survey records the type and location of stationary activities, ranging from leisure activities, such as people-watching and games, to street vending. The stationary activity pattern can be recorded at hourly intervals.

The locations of individual street vendors should be marked. Vendors should be interviewed to determine if they have made arrangements with any authority to operate.

A complementary land use survey may be important where uses on private land strongly relate with activities taking place in the street. Building footprints can be colour-coded according to general land use categories (e.g. residential, commercial, mixed-use, public).

Locations of sexual harassment and other criminal activity can be determined unless this would compromise the safety of the surveyors.

Case study application

In the study area, pedestrian through movement is moderate. Students from nearby institutions pass through the area and residents from adjacent colonies travel to and from bus stops and local commercial establishments.

The raised and landscaped median on the 30 m street makes pedestrian crossing difficult. The left turn islands are not accessible by pedestrians. They compromise traffic safety by increasing crossing distances and, instead of serving as refuges, impede pedestrian movements.

The activity survey identified several mobile food vendors in the vicinity of the major intersection in the study area. Since there is no street furniture at the busiest activity areas, people either stand or sit on parked vehicles while eating. Formal food establishments on the 36 m street also generate a lot of street activity.

Figure 5.12 The pedestrian survey identified movement patterns and conflict points.

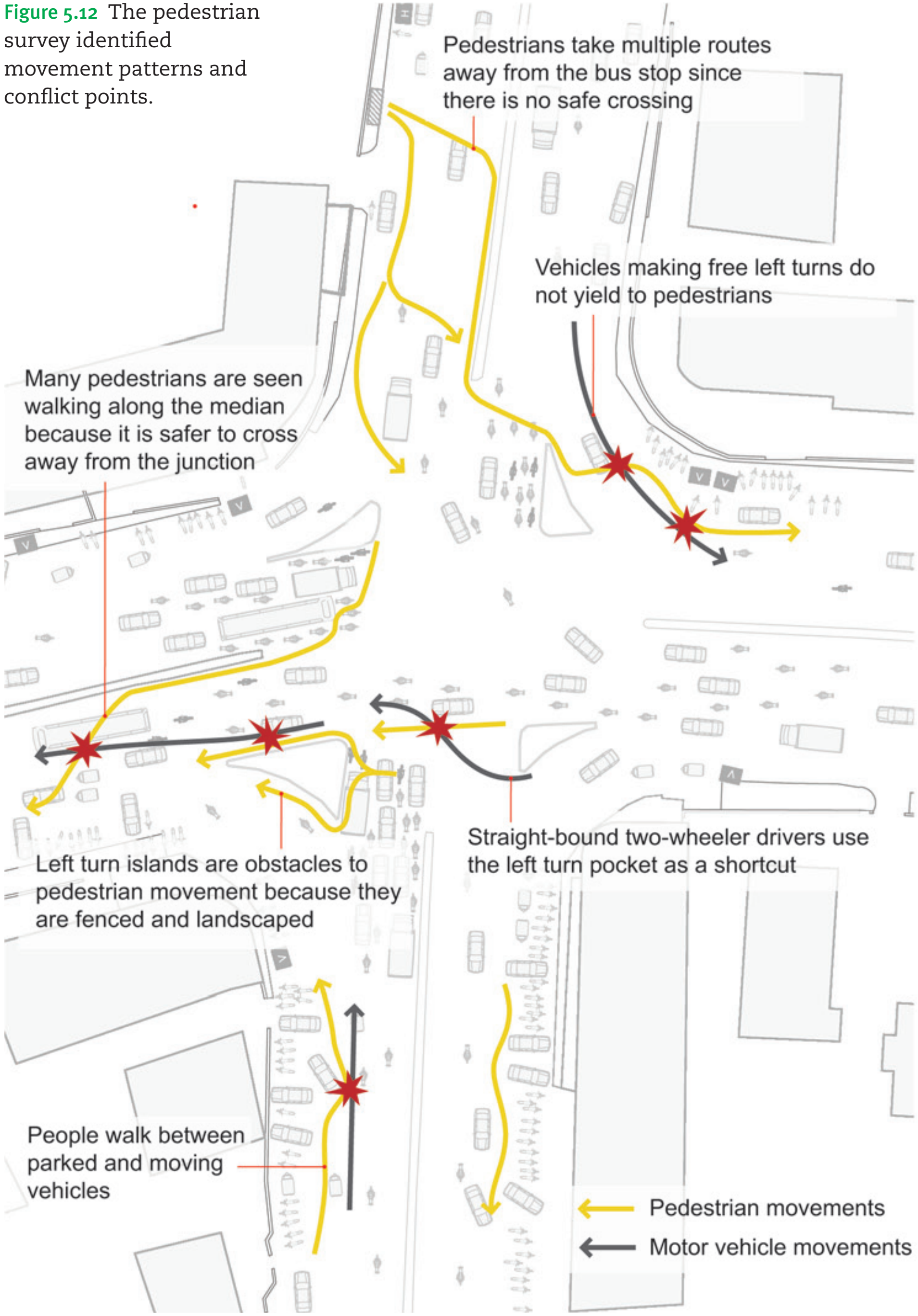
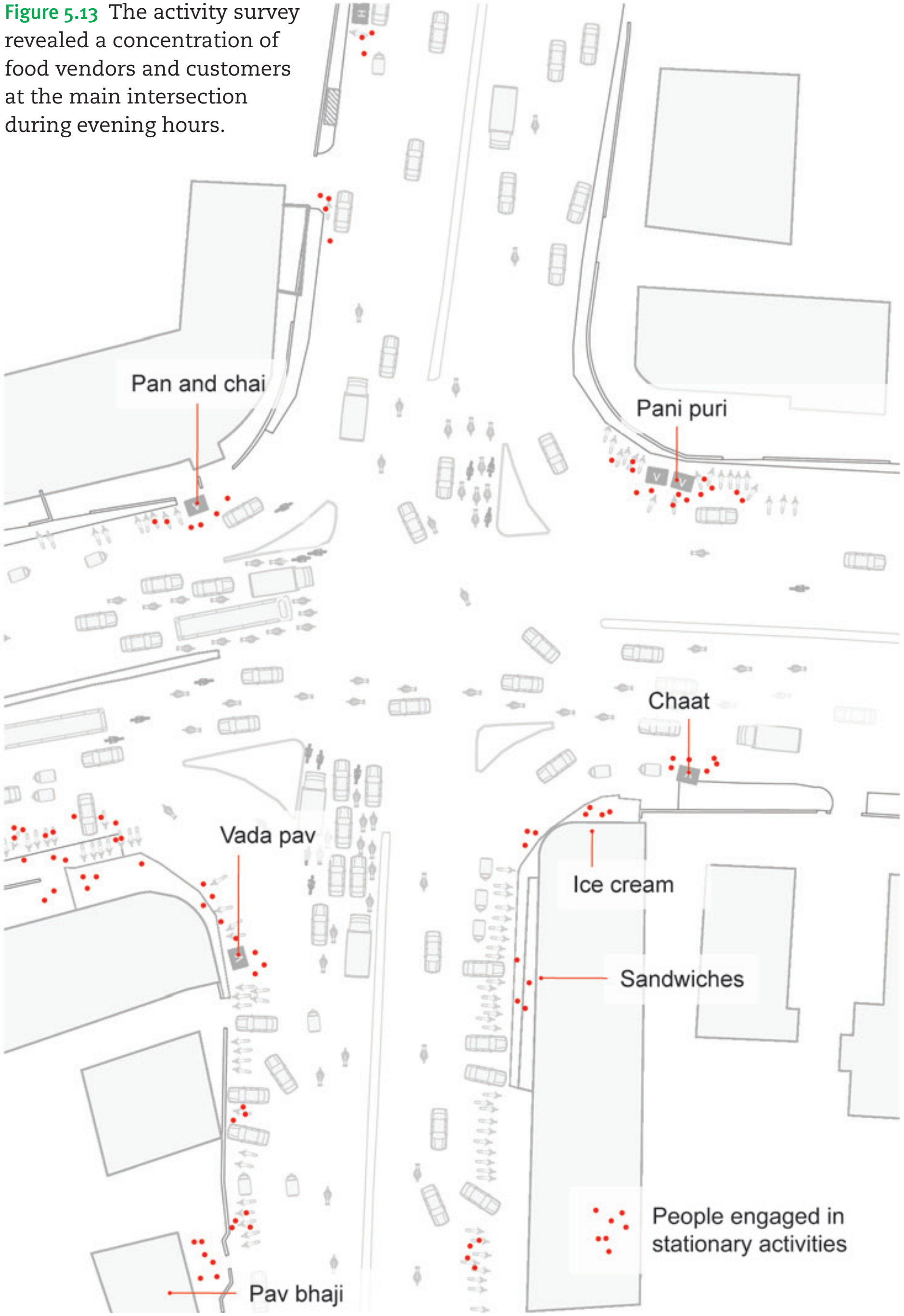


Figure 5.13 The activity survey revealed a concentration of food vendors and customers at the main intersection during evening hours.



5.4 Parking survey

Figure 5.14 On-street parking areas may be crowded despite the availability of off-street spaces. The parking survey can help determine the overall supply and demand.

Figure 5.15 The parking survey takes note of parking encroachments on footpaths.

Purpose

A parking survey should be conducted where a preliminary site visit suggests that demand for on-street parking is high and causes conflicts with other activities.

In some cases, parking may appear crowded and chaotic in certain areas, creating the impression of an overall shortage, despite the presence of empty on-street parking spaces or available off-street parking within a reasonable walking distance. The survey can reveal such imbalances and measures can be adopted to ensure a visible level of availability along the area's most popular blocks. Wayfinding and information systems can ensure that all available options, including off-street facilities, are known and easily accessed.

The surest way to maintain optimal utilization levels is to charge appropriate parking rates based on demonstrated demand. The survey can indicate whether parking fees need to be increased to achieve a desired occupancy rate.

Finally, the survey determines whether the existing level of enforcement is adequate by recording any instances of parking in unauthorised locations, such as footpaths and cycle tracks.

Methodology

The parking survey should determine the number, type, orientation, and location of parked vehicles over the entire area to be designed. The analysis covers all parking locations—both on- and off-street—over a given stretch, making it possible to determine the overall occupancy rate. Including off-street parking in the survey is important because off-street parking, where under-utilised, can serve as a substitute for on-street parking.

The parking survey can also assess turnover rates, either qualitatively or quantitatively, and determine what activities are creating parking demand at different times of the day.

Rickshaw and taxi points should also be shown because they compete with other vehicles for parking space and will idle in the carriageway if they cannot find suitable short-term on-street parking.

Case study application

Most parking activity in the study area occurs in the evening near the commercial land uses on the 30 m street. During the peak period, a solid row of parked vehicles accumulates, resulting in a narrow space for pedestrians between moving and parked vehicles. There is some double parking of autorickshaws and cars. On the 36 m street, parking activity is sparse, with occasional vehicles parked outside of residential premises.

Waiting autorickshaws at the outgoing eastbound arm of 30 m form a second row of parked vehicles on the carriageway at the end of the free left turn pocket. Pedestrians passing the double-parked autorickshaws are forced to walk in the path of vehicles coming from multiple directions, including vehicles exiting the free left turn at high speed.

Figure 5.16 This sketch shows the parking pattern during the evening peak period, as recorded in the parking survey.

5.5 Right-of-way overlay

Figure 5.17 The street design should deviate from the standard section wherever there is an obstruction that is unlikely to be removed.

Figure 5.18 Encroachments that fulfil a helpful role as traffic calming elements can be retained.

Purpose

Municipal authorities can provide right-of-way widths but generally do not have maps showing precise, geocoded locations of the public right-of-way. Therefore, a right-of-way must be defined using information from the topographic survey.

Methodology

The right-of-way is typically determined based on building and compound wall locations. Through an iterative process, the tentative right-of-way is adjusted such that the need for demolition is minimised.

Where no good physical limits are available for defining the right-of-way, important trees and encroaching structures may inform a final decision about where to locate the right-of-way boundary. One may seek to accommodate encroachments at the very edge of the right-of-way, provided that this is compatible with a suitable street template and is legally viable. Alternately, encroachments can be accommodated in the tree line or parking lane of a preferred template in order to ensure the continuity of footpaths and cycle tracks. Thus, the best right-of-way may eventually depend on the chosen standard section.

When defining the right-of-way, one should not take for granted that all encroachments can be removed. Instead, unless the encroachment can be removed before designs are finalised, the designer should attempt to accommodate the encroachments within the street design or define the right-of-way such that potential encroachments lie outside the right-of-way.

The centre line implied by a right-of-way should not be confused with the built median. The previous street design may have been asymmetrical or simply inexact, so the final design should work from the centre line defined by the new right-of-way rather than from any built features alone.

Case study application

Defining the right-of-way for the case study streets was straightforward because the free distance between opposite compound walls complied with the official 30 m and 36 m rights-of-way and because the walls formed a regular and continuous road edge. Therefore, few private properties were found to be encroaching on the right-of-way. Nevertheless, some properties have driveways, platforms, and plazas that extend into the right-of-way.

A small temple, with a footprint of less than 1 sq m, is located near the edge of the defined right-of-way on one arm of the intersection.

Figure 5.19 The right-of-way overlay determines which structures fall on the public street. In this case, the encroachments mainly consist of ottas and ramps.

5.6 Traffic survey

Purpose

The traffic survey quantifies vehicle movements, including non-motorised vehicle traffic, supplementing the pedestrian survey (see Section 5.3). Data from the traffic survey are necessary for intersection design and signal timing optimization. For example, it can identify the need for queuing space, such as dedicated turn lanes in case of high demand for right turns.

While transport engineering traditionally has focused on accommodating peak traffic volumes with minimal delay, a modern approach tolerates some delay in favour of increased pedestrian and cyclist safety and public transport throughput by adapting physical design and signal phasing to the needs of alternative modes.

Methodology

Vehicles should be counted during the peak period when traffic volumes and space requirements are highest.

Counts can be conducted on site or from a video recording. The count should be classified by vehicle type. For a manual survey of a typical signalised four-way intersection, one surveyor can stand at each arm, counting the incoming traffic. (This is easier than counting outgoing traffic because each incoming movement occurs during a different signal phase. However, for design of the queuing space and signal phasing, movements are grouped by outgoing direction.)

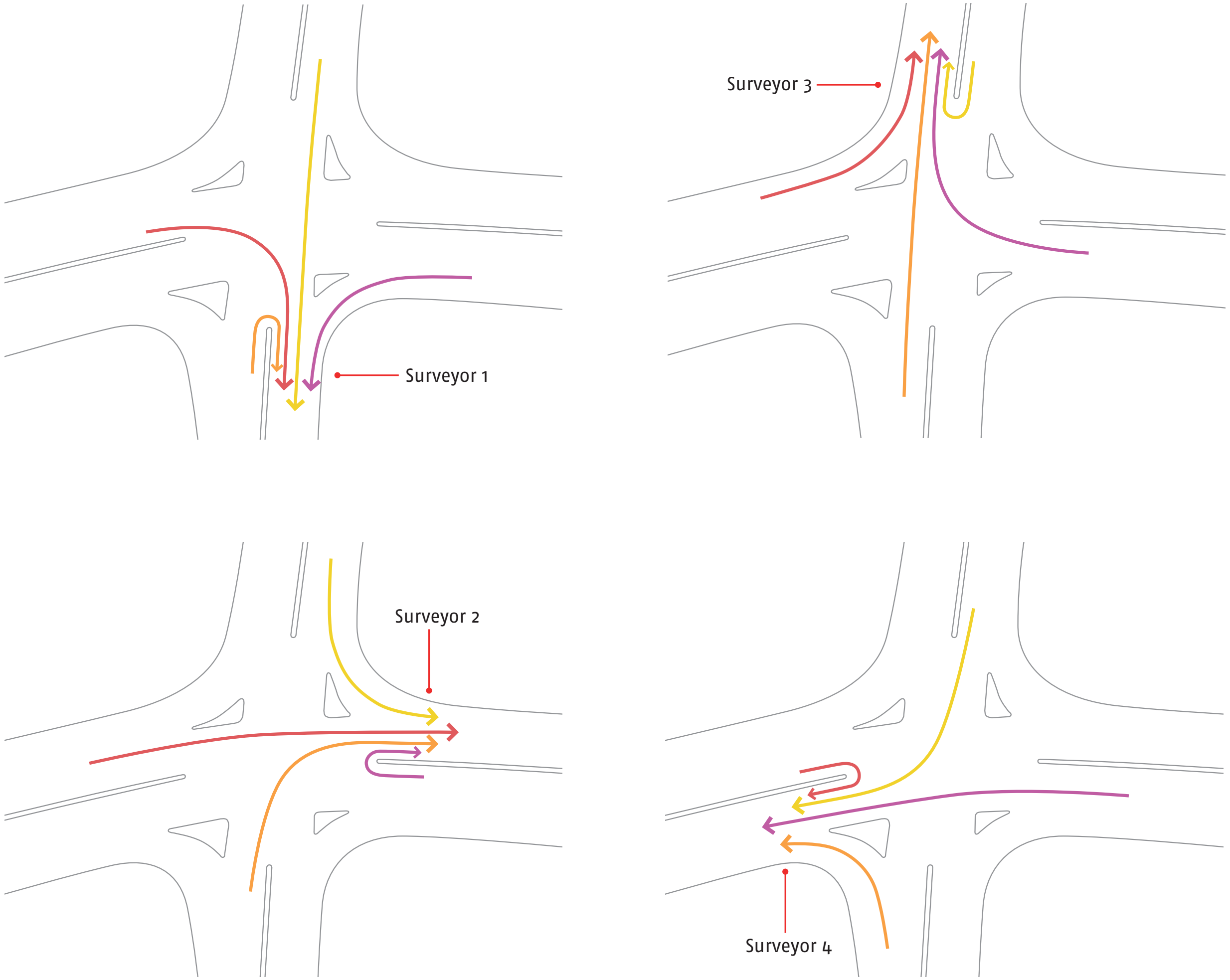
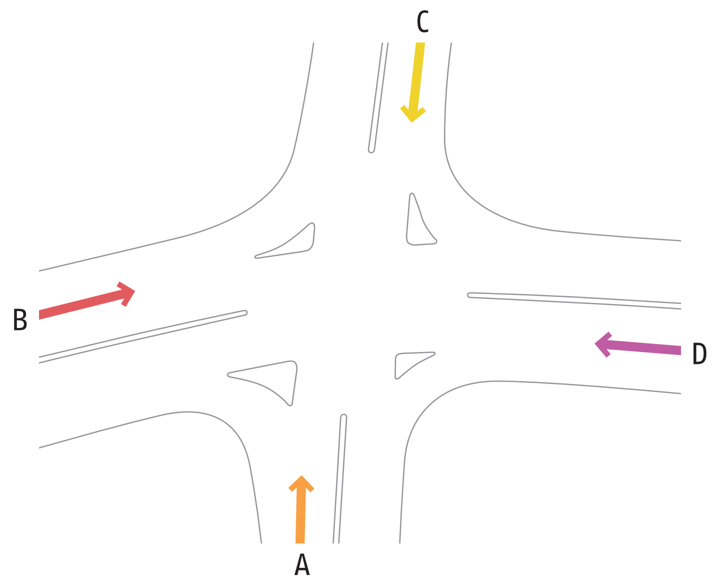


Figure 5.20 The easiest way to conduct a traffic survey is by counting the incoming vehicles, since the traffic from each arm arrives at a different time. If traffic volumes are heavy, a separate surveyor can count left-turning vehicles at each of the four locations.

Table 5.1 Peak traffic volumes (number of vehicles per hour) from each arm. Directions are defined in the diagram to the right

Arm	Direction	Surveyor	Cycle	Pedal rickshaw	Animal-drawn vehicle	Two wheeler	Four wheeler	Autorickshaw	Tempo	Minibus	Bus	Light truck	Heavy truck
A	left	4	36	0	0	183	48	18	0	0	14	0	0
	straight	3	200	3	0	648	117	131	8	2	15	0	0
	right	2	14	3	0	26	15	11	6	0	0	0	0
	u-turn	1	0	0	0	9	8	3	0	0	0	0	0
B	left	3	5	3	0	81	53	21	3	0	5	0	0
	straight	2	41	5	0	557	206	113	3	6	6	2	2
	right	1	6	6	0	108	44	20	0	0	9	0	0
	u-turn	4	2	0	0	20	5	5	0	0	0	0	0
C	left	2	15	2	0	170	101	18	3	0	0	0	0
	straight	1	141	3	0	1,307	464	111	9	0	11	0	0
	right	4	44	0	0	123	84	30	0	0	3	0	0
	u-turn	3	0	0	0	2	8	11	0	0	0	0	0
D	left	1	26	2	0	104	36	15	0	0	2	0	0
	straight	4	159	3	0	755	195	137	14	0	9	5	0
	right	3	50	0	0	357	188	63	3	0	0	0	0
	u-turn	2	5	0	0	0	5	0	0	0	0	0	0



Calculating passenger car units

The traffic survey records vehicle types separately. However, for analysis of the overall capacity of an intersection, the vehicle counts are converted into passenger car units (PCUs) that express the space occupied by each vehicle as a fraction of the space occupied by a typical passenger car. This way, the counts are expressed in a uniform unit and can be summed to determine a single value for the overall traffic volume. The PCU values can be used in capacity and signal timing calculations.

The PCU values shown in the table at right differ from those published by the Indian Roads Congress (IRC).* For cycles and motorcycles, the IRC values of 0.4 and 0.5, respectively, are too high. Drivers usually tolerate closer spacing so we recommend a value of 0.2. Autorickshaws, while sometimes travelling slower than cars, occupy a smaller footprint, so a value of 0.8 is more appropriate than the IRC's 1.2.

Table 5.2 Peak traffic volumes (passenger car units per hour)

Arm	Direction	Cycle	Pedal rickshaw	Animal-drawn vehicle	Two wheeler	Four wheeler	Autorickshaw	Tempo	Minibus	Bus	Light truck	Heavy truck	Total
A	left	7	0	0	37	48	14	0	0	30	0	0	136
	straight	40	3	0	130	117	104	9	3	33	0	0	439
	right	3	3	0	5	15	8	7	0	0	0	0	41
	U-turn	0	0	0	2	8	2	0	0	0	0	0	12
B	left	1	3	0	16	53	17	4	0	10	0	0	103
	straight	8	5	0	111	206	90	4	12	13	3	5	456
	right	1	6	0	22	44	16	0	0	20	0	0	108
	U-turn	0	0	0	4	5	4	0	0	0	0	0	12
C	left	3	2	0	34	101	14	4	0	0	0	0	157
	straight	28	3	0	261	464	89	11	0	23	0	0	879
	right	9	0	0	25	84	24	0	0	7	0	0	148
	U-turn	0	0	0	0	8	8	0	0	0	0	0	16
D	left	5	2	0	21	36	12	0	0	3	0	0	79
	straight	32	3	0	151	195	109	16	0	20	9	0	535
	right	10	0	0	71	188	50	4	0	0	0	0	323
	U-turn	1	0	0	0	5	0	0	0	0	0	0	5
PCU factor: IRC		0.4	1.5	1.5	0.5	1.0	1.2	1.4	–	2.2	1.4	2.2	
PCU factor: preferred		0.2	1.0	1.5	0.2	1.0	0.8	1.2	2.0	2.2	2.0	3.0	

1 See, for example, IRC 86-1983.

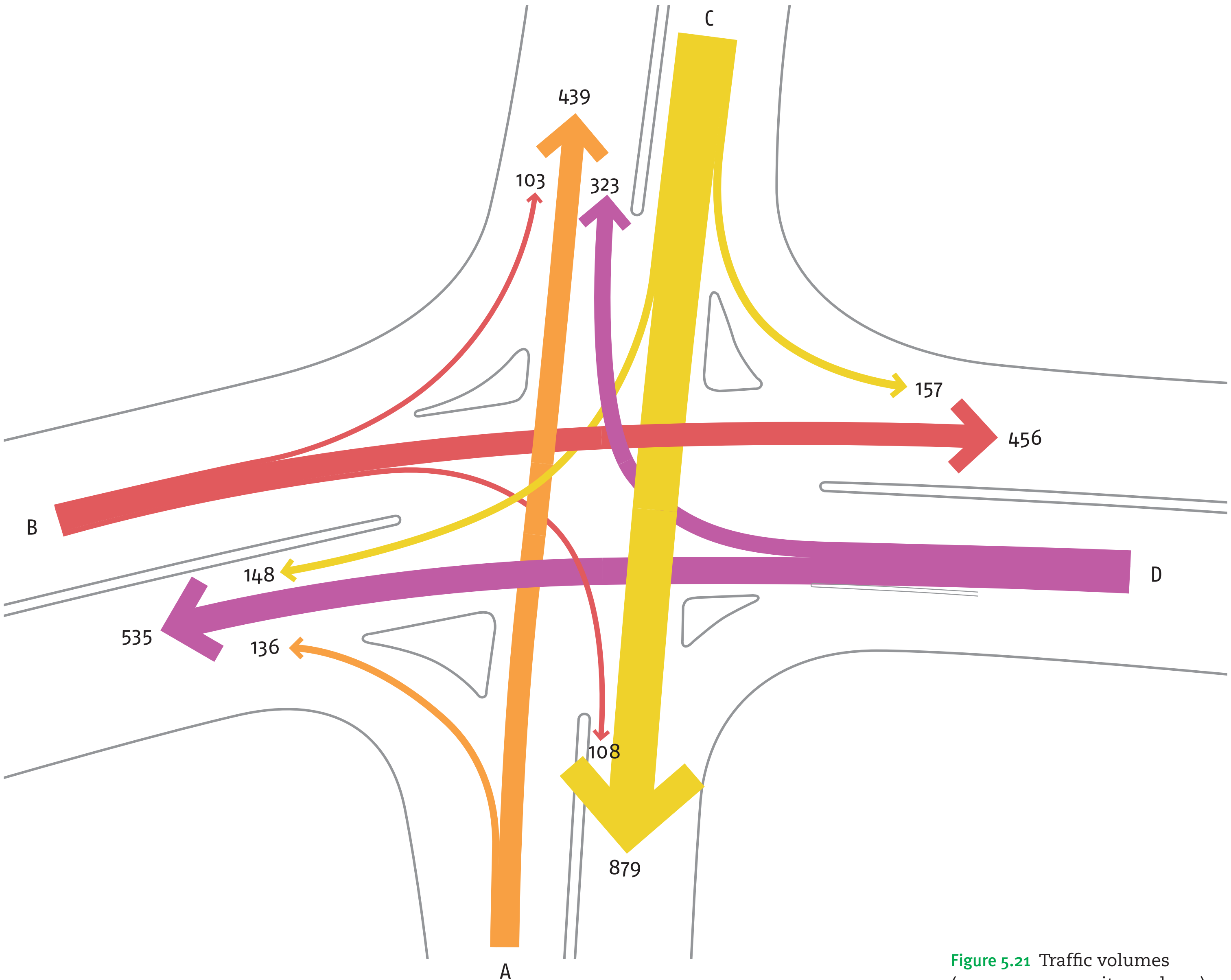


Figure 5.21 Traffic volumes (passenger car units per hour)

5.7 Choosing a standard section

36 m street

Street template 36BRT b was selected for the 36 m street. There were three preconditions for selection of the template. First, the city's public transport plan envisioned the road to become a BRT corridor. Second, the non-motorised transport plan called for construction of a segregated cycle track. Finally, given the high frequency of property access points, a service lane was seen as the best way to reduce conflict points between cyclists, pedestrians and vehicle access.

In most cases, a dedicated pedestrian path would provide better conditions for pedestrians that the shared service lane in the chosen standard section. However, such a design would require parking to be accessed from the carriageway, and the constant crossing movement between parking areas and the footpath might deter cyclists from using the cycle track.

Template 36BRT b incorporates the following:

- Continuous pedestrian mobility on shared service lanes
- Side cycle tracks
- Median BRT lanes
- An arterial carriageway of two times 5.5 m
- Parking and vehicle access through the service lane

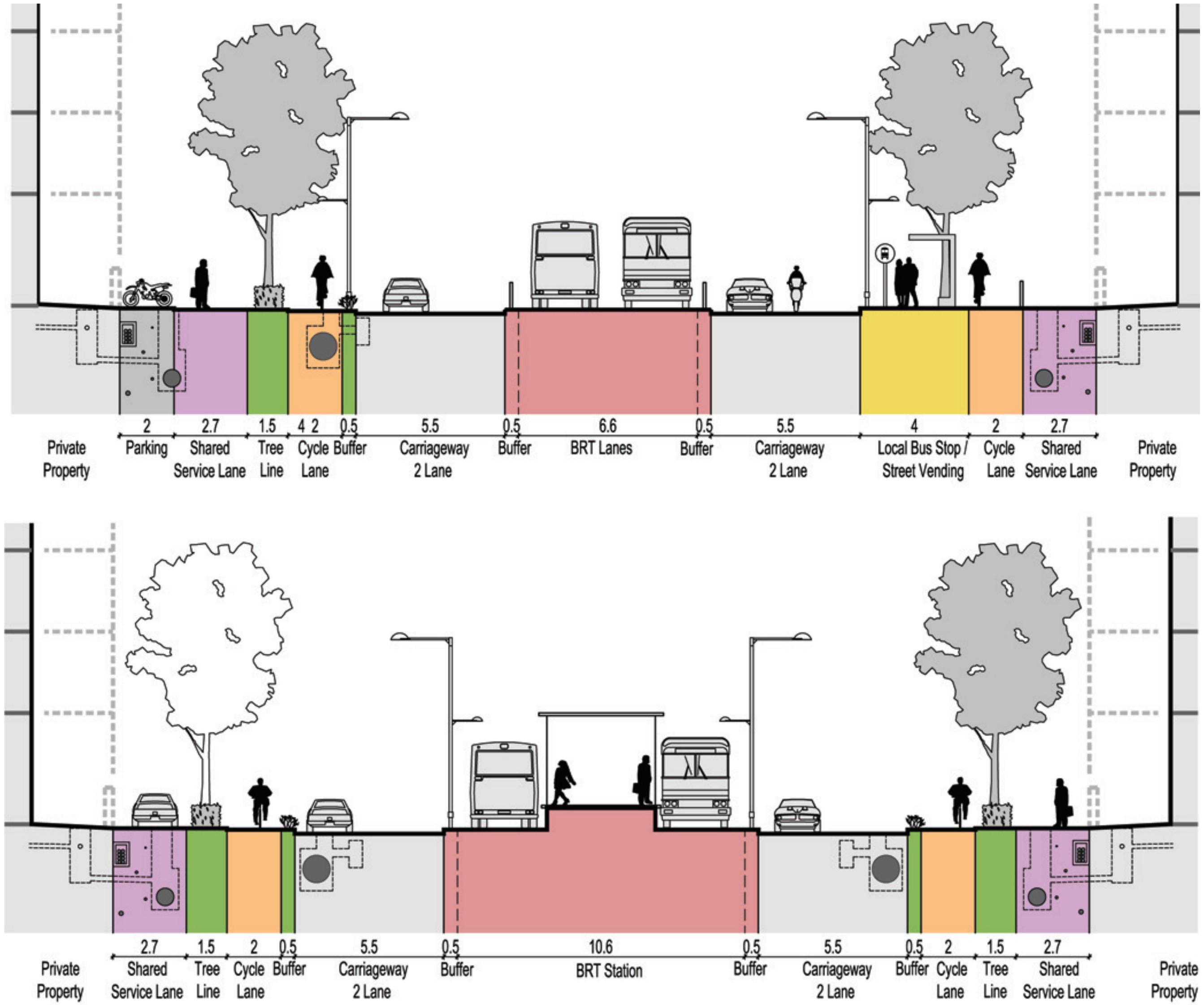


Figure 5.22 The standard section for the 36 m street.

30 m street

Street template 30a was selected for the 30 m street. The citywide cycle plan considers this street an important cycle corridor, so cycle mobility was given a high priority in the design. Given an even higher level of commercial activity compared to the 36 m street, a median cycle track was judged to be the only way to maintain an unencroached, continuous space for cyclists. Generous 3.5 m footpaths are provided on both sides of the street in order to cater to the needs of pedestrians and commercial establishments. The parking lane adjacent to the footpath can be adapted creatively as per local requirements. For example, bulb-outs can provide additional space for multiple purposes, including recreation and street vending. Additionally, space used for parking during the day can accommodate temporary seating for restaurants during the evening hours.

Template 30a incorporates the following:

- High liveability with four tree lines and bulb-outs in the parking lane
- Continuous, shaded footpaths
- A median cycle boulevard, with continuous landscaped buffers and trees on either side
- Bus stop bulb-outs in the parking lane
- An arterial carriageway of two times 6 m
- Parking accessed directly from the carriageway

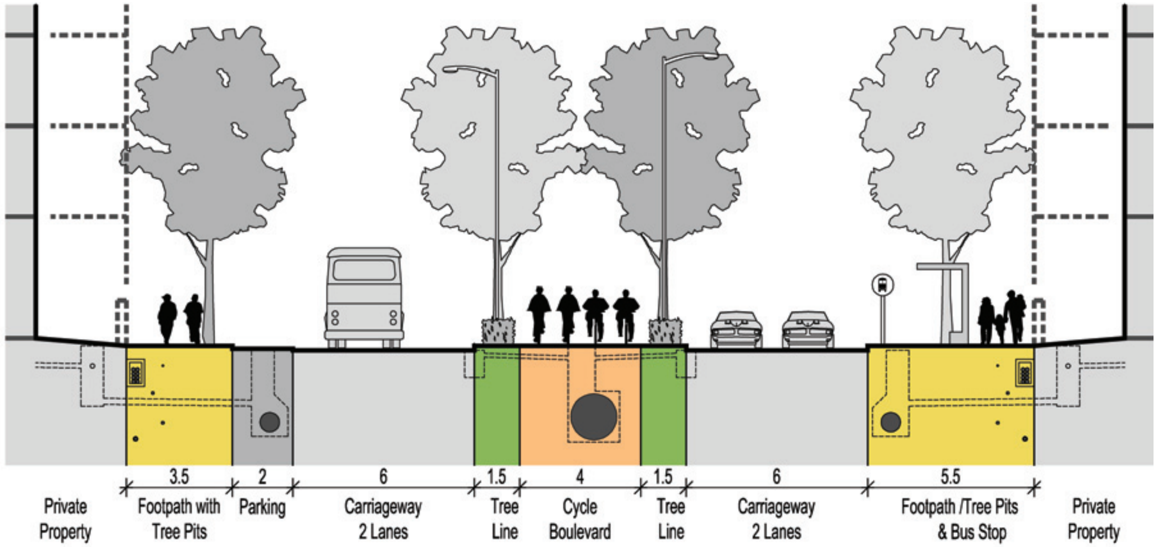
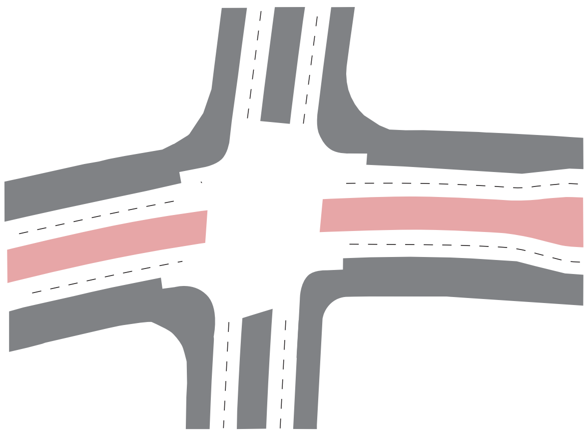


Figure 5.23 The standard section for the 30 m street.

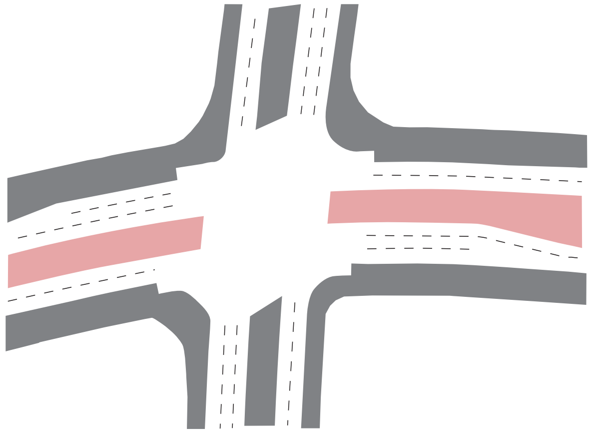
5.8 Preparing the intersection design

Applying the selected standard street sections is the first step in the design of the intersection. The sketch on the facing page shows the standard sections. If traffic volumes were low, and if there were no need to accommodate heavy vehicle turning movements, then the intersection design could be derived directly from the standard section.

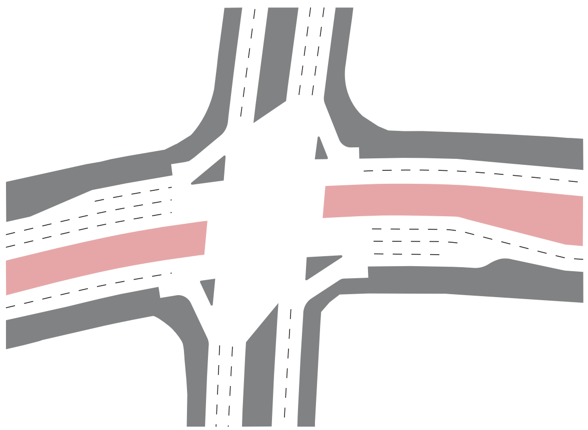
However, in our case—with BRT and cycle tracks in the medians and with heavy traffic flow—the intersection needs to be adapted to these conditions. To do so, we assess three alternative options for the queuing space and signal phasing:



- **Option A** is a minimal deviation from the standard template. In order to provide adequate turning space for large vehicles and to improve pedestrian safety, it adds left-turn pockets with pedestrian refuge islands.



- **Option B** adds a third queuing lane on all arms to increase the throughput of each signal phase and, thus, reduces the waiting time for all modes.



- **Option C** adds of a fourth lane on the 36 m wide street, with the intent of further reducing the waiting time by providing a dedicated lane for free left turns. Left turn islands are provided to reduce the crossing distance for pedestrians. However, time savings are minimal but come at a high cost because the fourth lane eats deeply into the pedestrian and cycle space.

The relative merits of the three options are discussed in the conclusion, Section 5.11.

When planning BRT systems, it is often possible to simplify turning movements and reduce signal cycle time by making modifications at the network level. Right turns can be completed through a series of left turns or U-turns (see Figure 4.8). In the case study intersection, network constraints make it difficult to implement these solutions. In addition, it would be problematic for the large volumes of right-turning vehicles to take U-turns across the median cycle track. Thus, the design options assume that existing turning movements are accommodated at the intersection.

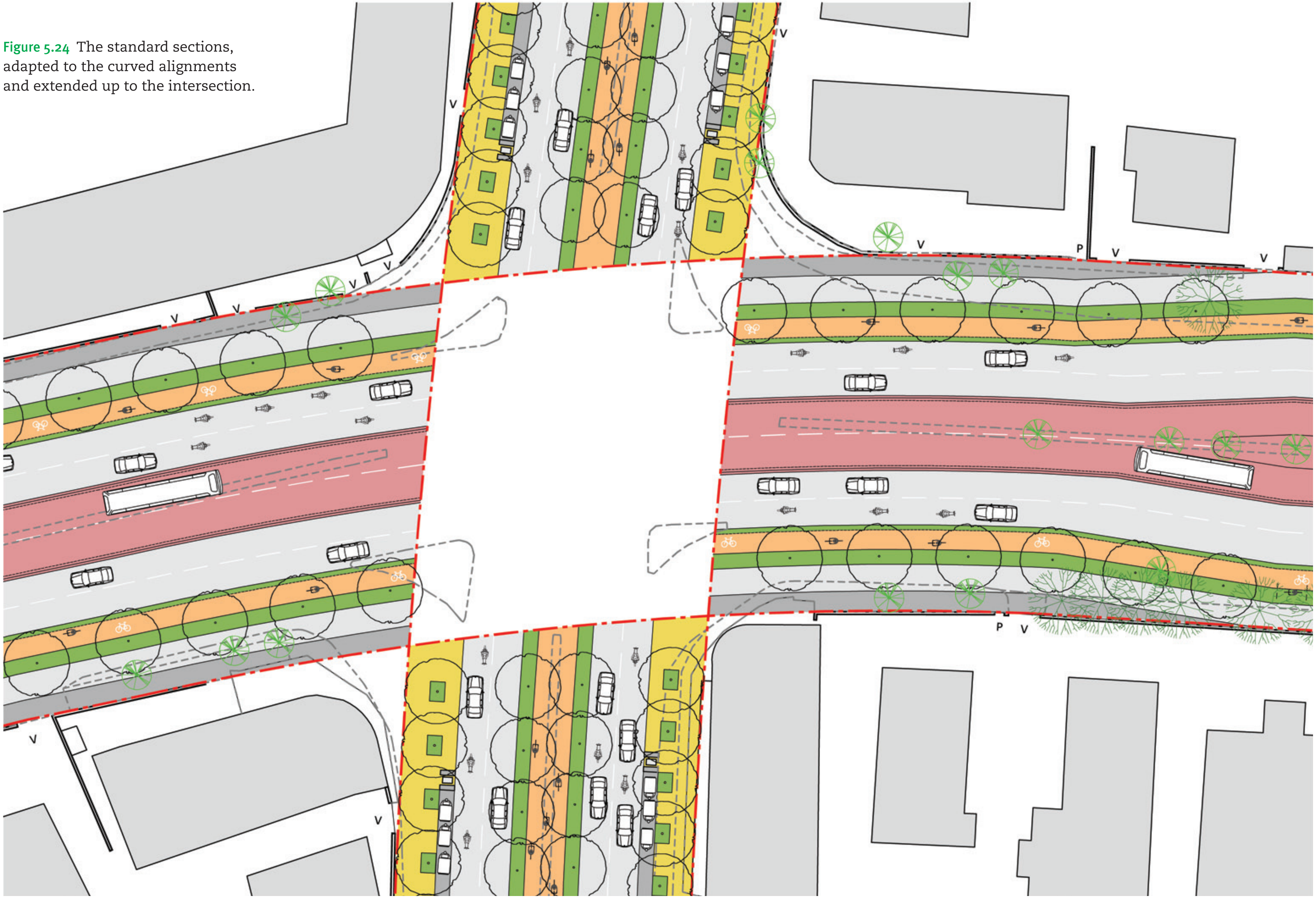


Figure 5.24 The standard sections, adapted to the curved alignments and extended up to the intersection.

Intersection design: option A

The first intersection design modifies the standard sections only to the extent necessary to accommodate left turning movements of large vehicles. Otherwise, the design maintains two traffic lanes in each direction, thereby maximizing the amount of space available to pedestrians, cyclists, vendors, and trees. This ensures high liveability.

Safety for pedestrians and cyclists

To reduce the risk of fatal pedestrian and cyclist injuries, the entire intersection is constructed at a level of +150 mm and surfaced with textured paving. Vehicles enter and leave the intersection over ramps. Since left turn movements are not signalised, the ramps are important for reducing the speed of left-turning vehicles. The left-turn pockets have been removed and the left-turn radius has been reduced to the minimum necessary to accommodate a standard 12 m bus, thus helping to reduce speeds. There are no ramps on the BRT lanes, which are already elevated 150 mm above the carriageway. Pedestrian crossing distances are reduced significantly relative to the existing intersection.

Cyclists queue ahead of motor vehicles in designated bicycle boxes. This arrangement helps make cyclists more visible to motor vehicle users. When the light turns green, cyclists clear the junction ahead of motor vehicles.

Continuity for pedestrians and cyclists

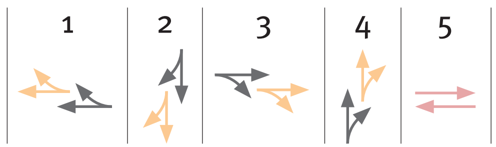
Since the mixed traffic area maintains the same width up to the intersection, there is no displacement of the cycle tracks on the 36 m street in the approach to the intersection. Straight-bound cyclists continue on the same linear path toward the cycle track entrance on the opposite side of the junction.

At the intersection, cyclists need to merge with left-turning vehicles. The carriageway ramps make this easier for cyclists by reducing vehicle speeds.

Since the entire intersection is a raised to the same level as the cycle track (+150 mm), cyclists do not experience any vertical grade difference as they cross the intersection.

Signal phasing

The most feasible signal phasing sequence incorporates four straight/right phases and one BRT phase. The phases are indicated in the diagram below. Cyclist movements from bicycle boxes are colour-coded in orange and BRT movements are shown in red.



Designating one of the two lanes for right turns would not be desirable unless right-turning vehicles comprised a larger fraction of the traffic entering most arms.

Unless long waiting times are accepted, existing traffic volumes exceed the capacity of this design. (Webster's formula recommends phase lengths of over 9 minutes.) The two lanes offer little queuing space and unless extra phases for buses are added, the design would also slow down BRT passengers.

Conclusion

Given the benefits for non-motorised transport, this design would be ideal in a situation where traffic volumes are low, but with observed volumes, the intersection design implies very long waiting times for cyclists, BRT passengers, and private vehicle users alike.

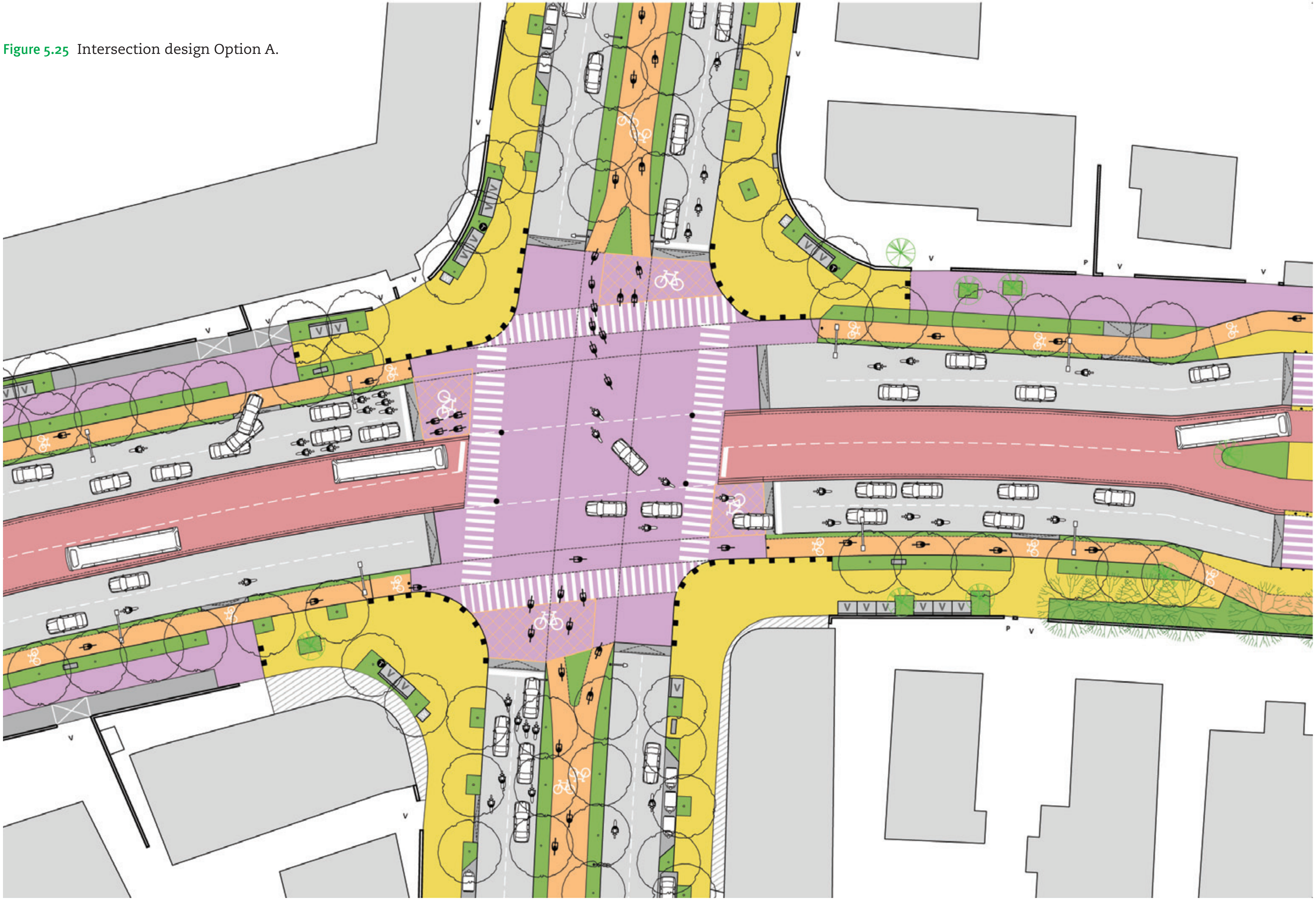


Figure 5.25 Intersection design Option A.

Intersection design: option B

The second option adds a third queuing lane on all approaching arms.

Safety for pedestrians and cyclists

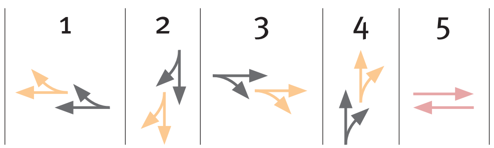
The intersection design incorporates the same safety features found in the first intersection. However, the extra queuing lanes increase crossing distances.

Continuity for pedestrians and cyclists

To accommodate the extra traffic lane on the 36 m street, the cycle track is slightly displaced. However, once at the junction, cyclists travel straight to reach the outgoing cycle track on the other side. Pedestrian spaces are narrower compared to Option A, but still offer good connectivity. There is still some space for accommodating social and economic activities at the intersection itself, though it is reduced.

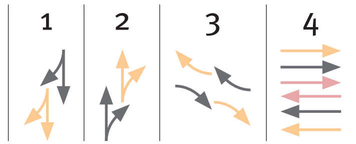
Signal phasing

There are three basic phasing alternatives. One alternative is the same cycle as intersection design Option A. Cyclist movements from bicycle boxes are colour-coded in orange and BRT movements are shown in red.



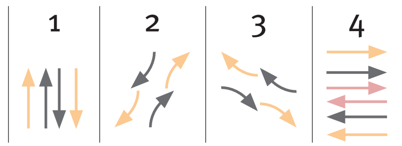
Assuming 9 m of queuing space per direction and no dedicated left turn lane, the cycle time would be approximately 64 seconds, excluding the BRT phase.

With the addition of a third queuing lane, there is a possibility of introducing right turn lanes on the 36 m street and operating a modified signal cycle:



However, for the observed traffic volumes, the separate straight and right phases are actually less efficient than combined straight and right phases, causing the overall cycle time to increase to 72 seconds. Unless the BRT buses require more than 8 seconds to clear the intersection, the combined straight and right phases imply a shorter signal cycle. This trade-off should be considered in selecting the final signal design.

In the third alternative, dedicated right turn lanes and signals can also be introduced on the 30 m street:



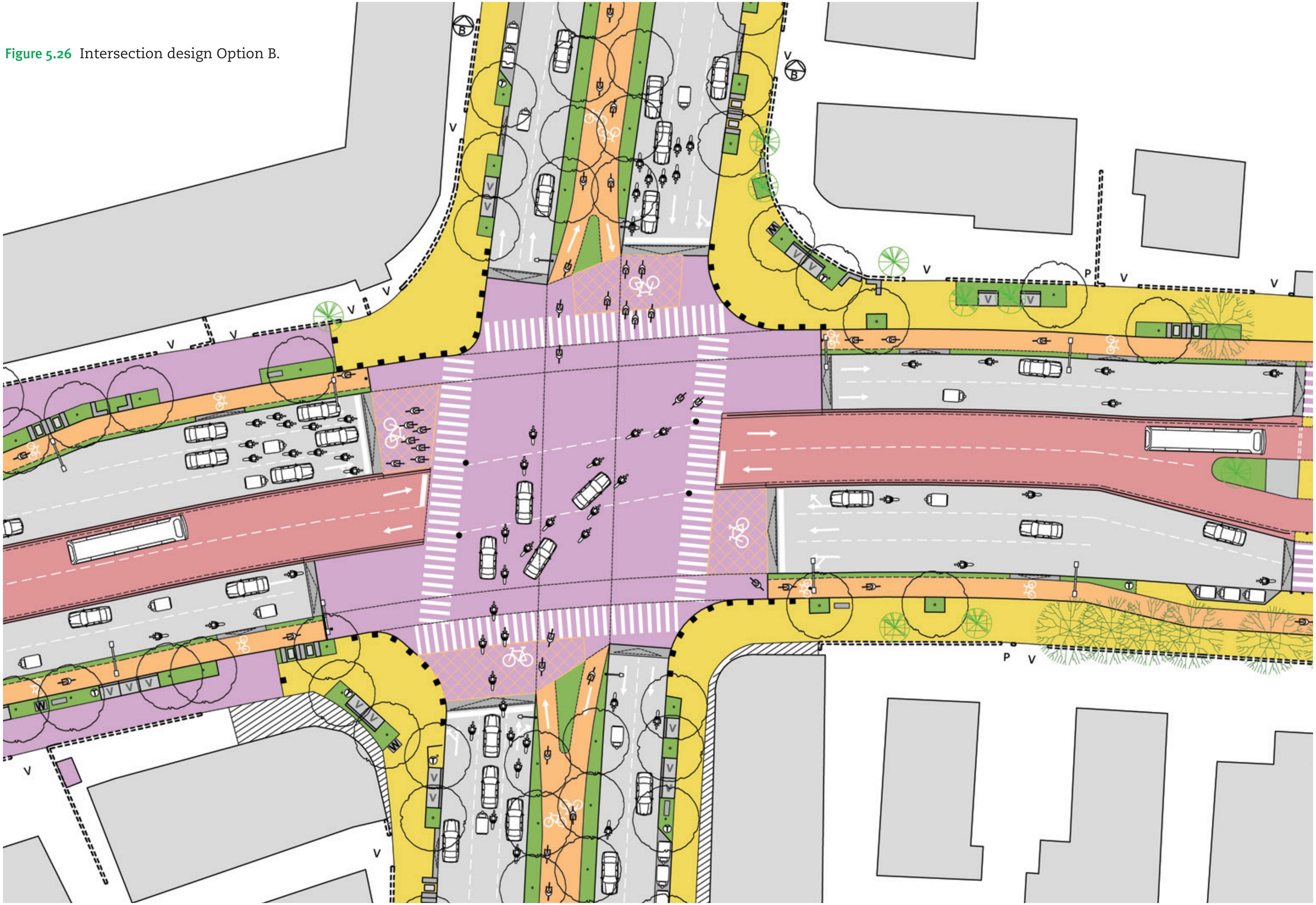
However, the right turn volumes are not balanced, and there is no benefit in terms of the overall signal cycle length.

Conclusion

The increase of the queuing space from 2 to 3 lanes significantly shortens the signal cycle, thus improving throughput. With respect to the signal phasing alternatives, separate right turn lanes on the 36 m street may reduce overall cycle time, depending on the volume of BRT buses. Separate right turn lanes on the 30 m street are likely to increase cycle time.

Compared to Option A, the shorter signal cycle may also benefit pedestrians and cyclists, who along with motor vehicles would face shorter waiting times. However, there is less space for social and economic activities at the intersection.

Figure 5.26 Intersection design Option B.



Intersection design: option C

Compared with Option B, an additional lane for left turning vehicles is added on both arms of the 36 m wide road. Again, the space for the additional lane is gained by reducing the size of the footpaths and landscaping buffers. Safety and comfort for pedestrians and cyclists is worse than in Options A and B, and there is less space for landscaping and street vending.

Safety for pedestrians and cyclists

Since crossing distances become longer in this option, left turn pockets and pedestrian islands are introduced to allow pedestrians to cross the intersection in stages.

Continuity for pedestrians and cyclists

The left-turn lane necessitates further displacement of the cycle track where the left turn lanes begin. Cyclists can no longer travel straight through the intersection. They must now navigate through or around the pedestrian refuges. For straight-bound pedestrians, the route through the triangular refuges represents a deviation from the relatively direct crossing path they enjoyed under Options A and B. Pedestrian spaces are reduced to a bare minimum of 2 m at the corners of the intersection.

Continuity for BRT vehicles

The asymmetrical design due to the wide four-lane queuing space on the 36 m road introduces a large offset for the BRT lanes on either side of the intersection. This increases the risk of accidents and may cause discomfort for BRT passengers—as well as for all other modes.

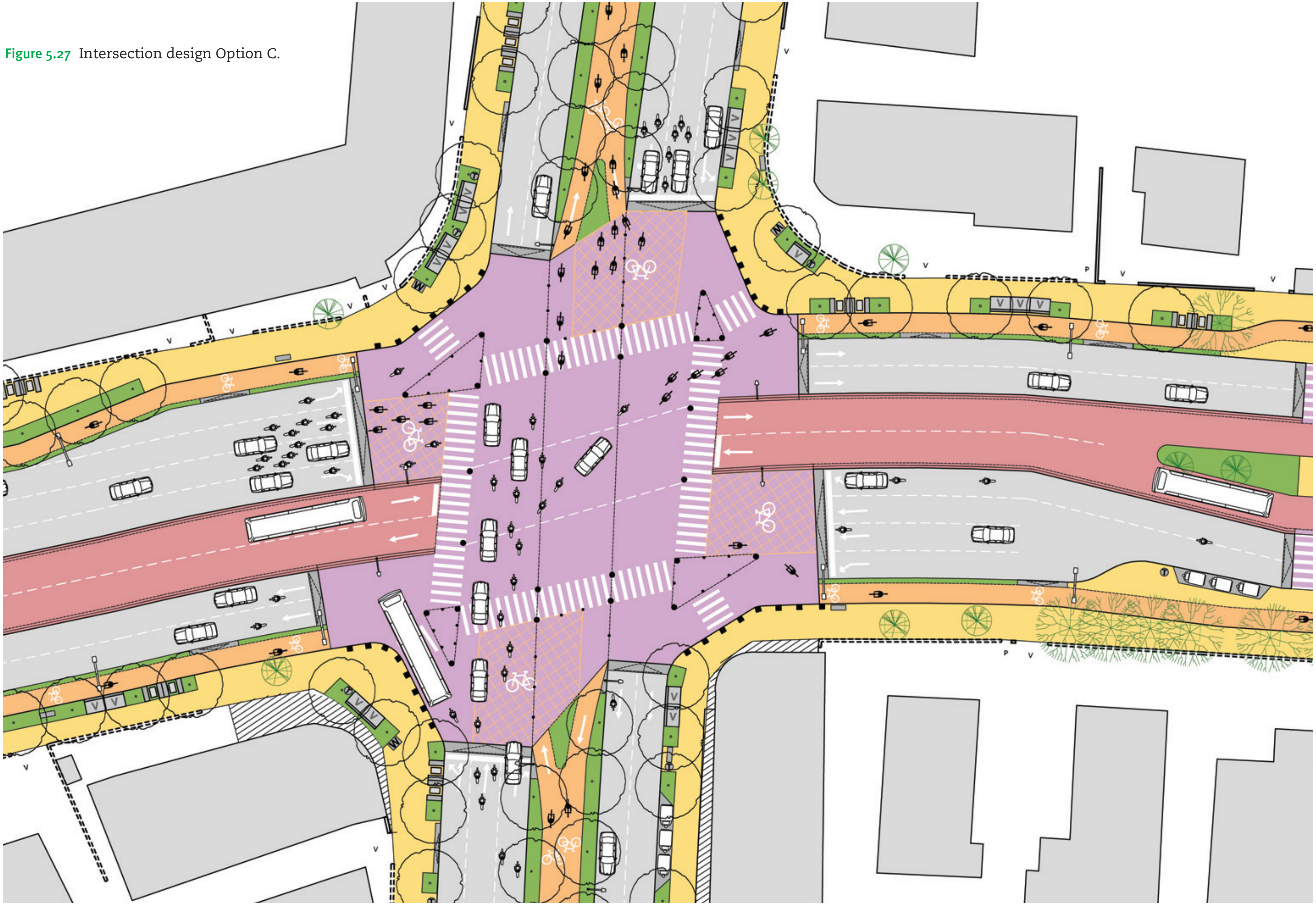
Signal phasing

The signal design could follow either of the options presented for intersection design B. The free left turn may reduce the signal cycle for mixed traffic by approximately 20 percent relative to option B, from 64 seconds to 51 seconds.

Conclusion

The additional free left turn lanes reduce the cycle time by and improve traffic throughput. However, they come at a very high cost. First, they cut deeply into the pedestrian space. Second, the cycle tracks suffer from a large offset. Third, there is virtually no space for social and economic activities at the intersection. Finally, there is insufficient space for good tree cover that would provide shade to pedestrians and cyclists waiting to cross the road, and some existing trees would need to be removed in order to maintain the continuity of the pedestrian space.

Figure 5.27 Intersection design Option C.



5.9 Public transport and intermediate modes

The BRT station with integrated rickshaw stands and local bus stops requires major design modifications of the standard section.

BRT station location

In order to minimise walking distances for public transport users, the BRT stop is positioned near the major intersection. Most destinations, including bus stops for perpendicular routes, are located at the intersection. However, the distance between intersection and station should be large enough to accommodate at least one, and preferably two, BRT buses so that these can clear the station regardless of the signal phase.

Under intersection design Options B and C, displacing the station from the intersection increases the amount of queuing space for mixed traffic. Under alternative A, the station can be placed closer to the intersection.

Pedestrian access to the BRT station

The pedestrian crossing to the BRT stop is raised 150 mm above the carriageway. The grade difference ensures that vehicles slow down at the ramps, and is not dependent on compliance with traffic signals or the presence of enforcement personnel to ensure safety.

A divider down the middle of the BRT station ramp prevents two-wheeler drivers from using the pedestrian crossing to make U-turns.

Buses and rickshaws

Local bus stops and rickshaw parking areas are provided adjacent to the BRT station to make intermodal transfers as convenient as possible.

In these locations, pedestrian areas are provided at the edge of the carriageway so that waiting passengers do not need to stand on the cycle track or carriageway.

Retention of existing trees

The design works around most existing trees, but the resulting pedestrian space is somewhat fragmented and there is a risk of pedestrian encroachment on the cycle track. The improved comfort provided by mature trees was considered a reasonable trade-off for the compromises in the geometry of the cycle track.

Where footpath space is limited, the pedestrian area can be increased by placing permeable grates or paving over the tree pits. (In the sketch on the facing page, such a design is indicated by a yellow hatch and green boundary line, instead of the green hatch and black boundary used for regular tree pits).

Adaptation of service lane space

The cross section near the BRT station and local bus stop lacks sufficient space to accommodate a continuous service lane. Instead, the design provides a ramp at each property entrance.

A large pedestrian zone with ample space to accommodate street vending is also provided. The formal provision of vending locations organises the vendors rather than creating a situation in which they occupy the cycle track and footpath in a way that blocks through movement. Whether or not formal locations are provided, vendors will attempt to move into the area, given the concentrated pedestrian traffic around the BRT station.

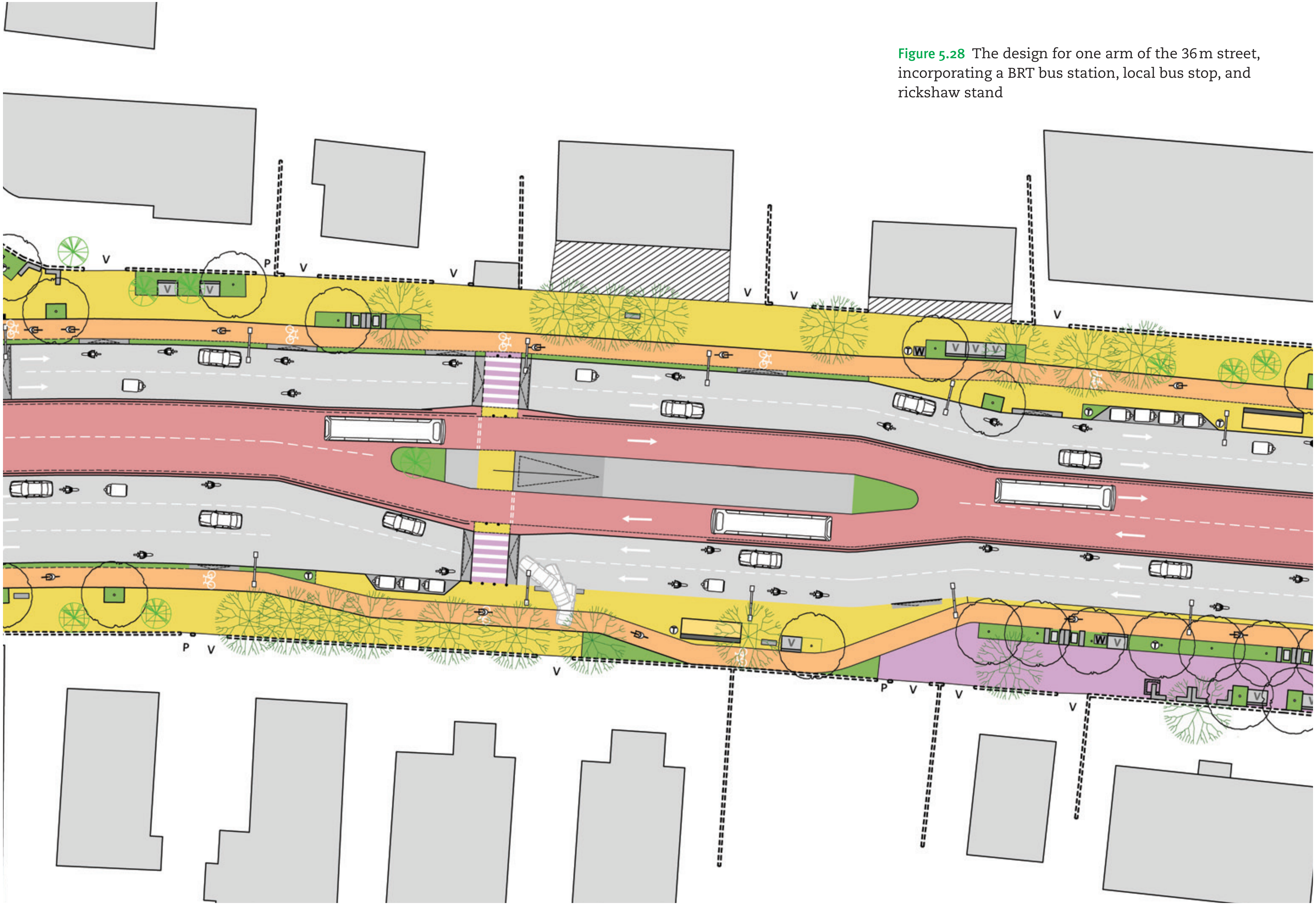


Figure 5.28 The design for one arm of the 36 m street, incorporating a BRT bus station, local bus stop, and rickshaw stand

5.10 Street arm with a minor intersection

Figure 5.29 Similar to the intersection pictured above, the design proposes to raise the entrance to the small street by 150 mm so that motor vehicles slow down when they cross the footpath and cycle track.

Figure 5.30 The cycle track is routed behind the bus stop to avoid conflicts between cyclists and waiting bus passengers.

Approximately 150 m from the major intersection, there is a T-intersection with a small street.

Vehicle restrictions

Given the minor street's proximity to the main intersection, the minor intersection is closed to motor vehicles but left open for cyclists and pedestrians. Barriers prevent motorcycles, scooters, rickshaws, and cars from crossing over the median. Cyclists can move through the barriers if they dismount. Depending on local preferences, the barrier may be less restrictive, perhaps also permitting motorcycle and scooter crossings.

Pedestrian crossing safety

The intersection is not signalised. To ensure safety, the pedestrian crossing is constructed as a raised speed table at a level of +150 mm. Mixed traffic passes over ramps and must slow down.

The median between the BRT lanes and the main carriageway is widened to 1 m at the crossing location in order to provide refuge islands. This has the additional traffic-calming effect of slightly deviating the main carriageway.

Design of minor street

The 9 m wide intersecting street is envisioned as a shared space. Thus, one of the footpaths on the 36 m street continues around the corner but is ramped down to the street level. The other footpath turns into a bulb-out that provides space for street vending and furniture. Beyond the portion of the street pictured on the facing page, the street can support pedestrian islands of varying shapes, sizes, and positions within the right-of-way. By creating a meandering space for through movement, these islands can help reduce motor vehicle speeds.

Resumption of service lane

Past the small intersection, most existing trees are located close to boundary walls, leaving enough room for a service lane between the trees and the cycle track. The parking space can be used creatively as bulb-outs that provide space for street vending and places to sit.

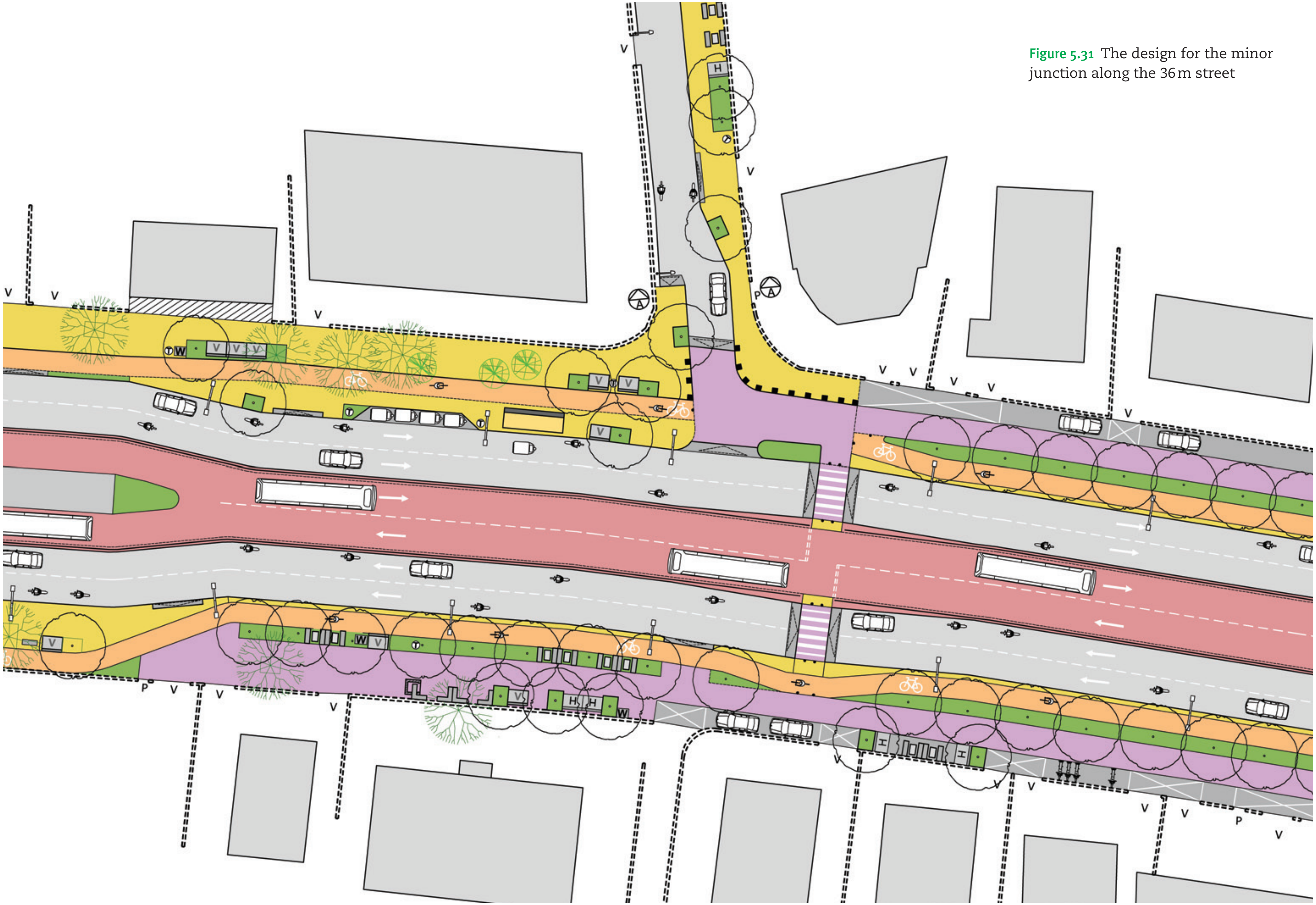


Figure 5.31 The design for the minor junction along the 36 m street

5.11 Conclusion

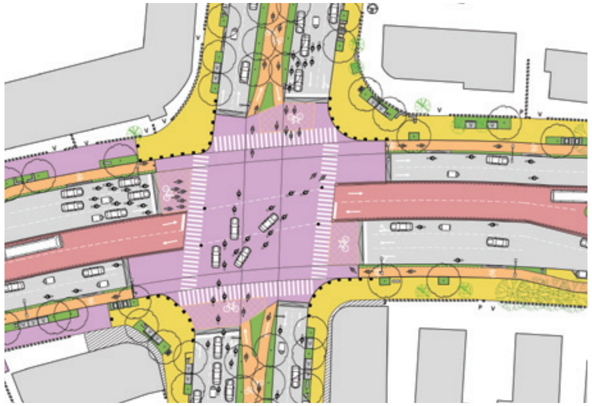


Figure 5.32 Option B is the preferred intersection design.

To conclude, we summarise the process that led from the standard sections to the final arrangement. In addition, we discuss the relative merits of intersection Options A, B, and C. Finally, we point to some of the enforcement challenges that may arise after the design is implemented.

Modifications to the standard sections

Though the design started from standard templates, the templates were modified significantly in response to site conditions and to meet functional requirements. At the intersection, parking lanes were discontinued to improve traffic flow. Next to the BRT station, the service lane was discontinued to make room for local bus stops and for the BRT station itself. Existing trees introduced some constraints in the alignment of the footpath and cycle track.

Decision on the design to be implemented

The intersection design alternatives illustrate the trade-offs between liveability and vehicle throughput that are fundamental to street design. Option A deviates minimally from the standard section and allocates the greatest amount of street space to pedestrians, cyclists, and vending activities. At the other extreme, Option C handles maximum vehicle throughput but severely compromises conditions for non-motorised transport users and social activities.

Given the many negative outcomes of Option C, this design is inferior to Options A and B—even though the signal cycle is shorter. Option B will be implemented because it provides the best balance between pedestrian and cyclist comfort and traffic mobility. As a concession to advocates of Option A, the city has agreed to hold a car-free day every Sunday on the 30 m street!

Facilitating adoption of the new design

In the interest of increasing the amount of space available for pedestrians and to increase intersection capacity, the design removes much of the on-street parking that was present close to the junction. Furthermore, the design allocates the parking closest to the junction to rickshaws. If one considers slightly longer stretches extending away from the intersection, there is still an overall parking surplus, assuming that demand remains at present levels. However, vehicle users may balk at the prospect of having to walk 100–200 m from parking spaces, given that they presently park immediately in front of their final destinations. Enforcement will be necessary to ensure that they do not encroach on the footpaths or cycle tracks.

Another enforcement issue is related to the placement of the motor vehicle stop lines, which are shifted back to make space for the cycle boxes. The stop lines will need to be enforced by traffic officers during hours when signals are operating.

Despite these challenges, the design introduces ramps, reduced turning radii, and other self-enforcing elements in order to improve safety for all users.

Further reading

Better Streets Plan
San Francisco Planning Department (2008).

http://www.sf-planning.org/ftp/BetterStreets/proposals.htm

The Boulevard Book
Alan Jacobs, Elizabeth Macdonald, and Yodan Rofé, (Cambridge, Massachusetts: MIT Press, 2002).

Bus Rapid Transit Planning Guide
Institute for Transportation and Development Policy (2007).

http://www.itdp.org/index.php/microsite/brt_planning_guide/

Cycle-inclusive policy development: A handbook
Sustainable Urban Transport Project and Interface for Cycling Expertise (2009).

http://www.gtz.de/en/themen/28407.htm

Design manual for bicycle traffic
Kenniscentrum voor Verkeer, Vervoer, en Infrastructuur (CROW) (2007).

Great Streets
Alan Jacobs, (Cambridge, Massachusetts: MIT Press, 1995).

Indian Roads Congress.
Guidelines on various street design topics.

http://irc.org.in/ENU/Publications/Pages/default.aspx

Life and Death of Great American Cities
Jane Jacobs, (New York: Random House, 1961).

London Cycling Design Standards
Transport for London (2005).

http://www.tfl.gov.uk/businessandpartners/publications/2766.aspx

The Pedestrian and City Traffic
Carmen Hass-Klau (London: Belhaven Press, 1990).

Public Places–Urban Spaces: The Dimensions of Urban Design
Matthew Carmona, et al (Oxford: Architectural Press, 2003).

Streetscape guidance
Transport for London (2009).

http://www.tfl.gov.uk/businessandpartners/publications/4858.aspx

Streets and Patterns
Stephen Marshall (London: Spon Press, 2005).

Street Design Guidelines
Unified Traffic and Transportation Infrastructure (Planning and Engineering) Centre, Delhi Development Authority (2010).

http://uttipec.nic.in/writereaddata/linkimages/7554441800.pdf

Street Design Manual
New York City Department of Transportation (2009).

http://www.nyc.gov/html/dot/html/about/streetdesignmanual.shtml

Urban Street Design Manual
Abu Dhabi Urban Planning Council (2009).

http://www.upc.gov.ae/guidelines/urban-street-design-manual.aspx?lang=en-US

Notes

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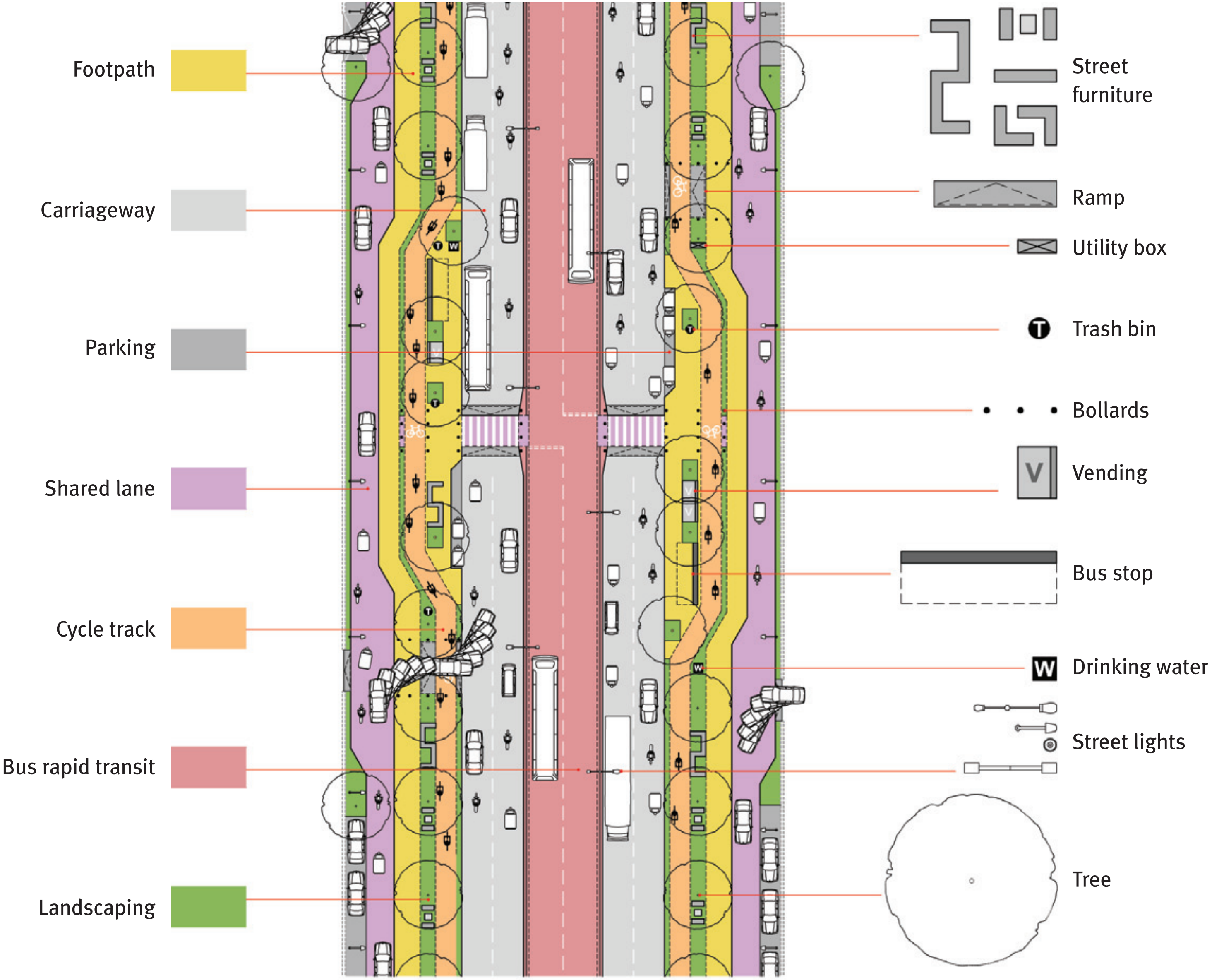
Symbol & colour key



The following symbols are used to indicate good and bad design practices in photos and diagrams:

✔ Preferred alternative

✘ Design to be avoided

www.itdp.org/betterstreets

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