Infrastructure for quick-build cycleways – a research note

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John Lieswyn, ViaStrada Christchurch
Axel Downard-Wilke, ViaStrada, Golden Bay
Megan Gregory, ViaStrada Christchurch
Glen Koorey, ViaStrada Christchurch
Warren Lloyd, ViaStrada Christchurch
Luca Ware, ViaStrada Christchurch

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WAKA KOTAHI NZ TRANSPORT AGENCY

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Waka Kotahi NZ Transport Agency
Private Bag 6995, Wellington 6141, New Zealand
Telephone 64 4 894 5400; facsimile 64 4 894 6100
NZTAresearch@nzta.govt.nz
www.nzta.govt.nz

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Inputs:

Lukas Adam, MRCagney, Auckland

Rene Dalton, Transportation Engineer, City of Fremont

Hannah Day-Kapell, Principal, Alta Planning + Design, Portland

Skye Duncan, Director of the Global Designing Cities Initiative, NACTO

Tyler Figgitt, Infrastructure Manager, City of Penticton

Malcolm McAulay, Senior Multi-modal Advisor, Waka Kotahi Auckland

Anna Nord, Urban Mobility Advisor, Waka Kotahi, Wellington

Timothy Papandreou, Emerging Transport Advisors, San Francisco

Clare Piper, Senior Policy Planner, Christchurch

Andrew Quigley, Stantec, Dunedin

Dan Racle, Wellington City Council

Twan van Duivenbooden, Auckland Transport, Auckland

Supplier representatives of RTL, Vanguard, DezignLine, Plasback NZ, Zicla

Steering group members:

Peter McGlashan, Lead Advisor Urban Mobility, Waka Kotahi Auckland

Malcolm Menzies, Senior Research Analyst, Waka Kotahi Wellington

Anita Waring, Ministry of Transport

Reviewers:

Gerry Dance and Mark Edwards, Waka Kotahi Wellington

Emma McInnes, Resilio, Auckland

Dick van den Dool, Barros van den Dool Active Transport Pty Ltd, Sydney

Abbreviations and acronyms

AT	Auckland Transport
CNG	Cycling Network Guidance
Mpa	Megapascals (measure of concrete strength capacity)
NACTO	National Association of City Transportation Officials (North America)
RCA	Road Controlling Authority
SCOT	Separated Cycleway Options Tool
TCD	Traffic Control Device
TTM	Temporary Traffic Management

Contents

Abstract

Some of New Zealand's Road Controlling Authorities (RCAs) are responding to the imperatives of the Road to Zero strategy, the Climate Change Emergency Declaration, and emissions reduction planning by reallocating road space and supporting mode shift to cycling. The Innovating Streets programme of 2020/21 led to the rollout of several demonstration (one day to one month), pilot (one month to one year) and interim (five+ year) cycleways. The demonstration and pilot projects are typically not durable enough for ongoing use, and the interim projects used a wide variety of materials that means cycleways from place to place are not visually consistent. At the other end of the spectrum, permanent design cycleways initiated with the Urban Cycleways Programme (2014-2018) and recent major projects have attracted criticism for high cost.

This research note provides information about the best infrastructure options for installing quick-build (interim) separated cycleways to increase safety and encourage mode shift in a visually, physically and aesthetically consistent manner on a national scale. It provides a review of international practice and lists some of the domestic approaches. Although focused on the infrastructure, this note also highlights some of the process barriers to quick delivery.

A note on terminology

As this report is a review of international practice, terms such as 'protection', 'protector' and 'protected bike lane' (common overseas) are also used herein. The equivalent terms in New Zealand are typically 'separation', 'separator', and 'separated cycle lane'. The word 'protection' is also used when the discussion is about the effect of a separator (ie the level of physical protection, if any, provided by various types of separators) rather than in specific reference to a facility type or device.

The generic term 'cycleway' is not found in New Zealand legislation but is commonly understood by the public and practitioners to mean any type of facility (cycle lane, separated cycle lane, cycle path, shared path, neighbourhood greenway) that is meant for people on bikes. Cycleway is also used in the Cycling Network Guidance (www.nzta.govt.nz/cng), again as an umbrella term. If in future the riders of other kinds of transport devices (eg e-scooters) are permitted to use a cycle lane, popular (if not legal) terminology may again need to be revisited.

1 Introduction

1.1 Background

Some of New Zealand's Road Controlling Authorities (RCAs) are responding to the imperatives of the Road to Zero strategy, the Climate Change Emergency Declaration, and emissions reduction planning by reallocating road space and supporting mode shift to cycling. In addition, the COVID-19 pandemic has led to significant drops in public transport use around the world and people have taken up cycling as a socially distanced way to travel. As described in *Streets for Pandemic Response and Recovery* (NACTO, 2020), local authorities responded by vastly accelerating the rollout of their cycling networks.

Research shows that painted cycle lanes on roads can have limited effectiveness in encouraging more people to take up cycling (BuBose, 2011; FHWA, 2015; Kingham et al., 2011; Monsere et al., 2014; Pucher & Buehler, 2008). Even if such measures improve absolute safety, prospective cyclists' perceptions of risk will often deter them from changing their mode of travel or using these routes (Bowie et al., 2019).

To deliver the maximum benefit in the shortest time, some RCAs are following the example of Denmark and the Netherlands – both of whom rolled out interim cycling networks using low-cost cycle lane separators between approximately 1972 and 2000 (Pucher & Buehler, 2008). However, there is substantial variance in the physical infrastructure used (Bowie et al., 2019).

If RCAs were better informed about the best options for installing 'quick-build' separated cycle lanes, councils would be in a better position to more quickly implement effective infrastructure solutions to increase safety and encourage mode shift in a visually, physically, and aesthetically consistent manner.

These facilities will also encourage use of all micro mobility modes. Current legislation[1] specifies that cycle lanes (separated by only painted lines) may only be used by cyclists, but that physically separated lanes can be used by any wheeled recreational device (this includes e-scooters and skateboards etc). This research note concentrates on quick, low-cost ways of transitioning cycle lanes or other road space to separated lanes thus increasing actual and perceived levels of safety and accessibility for other modes of active transport.

Often the only cycleways being built have multi-million dollar per km price tags associated with streetscaping, widening, or service relocation/renewal, leading to tiny incremental network improvements each year. These costs fuel media and public backlash from those both pro- and anti-cycling when the focus needs to be on real scale if we are to reduce emissions and effect mode shift. For the last few years, Christchurch has been experiencing strong growth in cycling use on the back of a fast-growing network. This results in capacity constraints. There is thus a risk of having to redo expensive cycling infrastructure if growth is sustained and it might be better to install quick-build infrastructure that is easier and cheaper to adjust when use increases.

With budgets for low-carbon transport options likely to grow in the next five to ten years, it is vital authorities are prepared with all the knowledge required to scale up cycleway builds and complete networks. The facilities built now will be the low-emission arteries in the future, with e-scooters and e-bikes tackling congestion and the climate crisis, becoming the lifeblood of a healthy, sustainable transport network.

[1] Land Transport (Road User) Rule 2004 defines a cycle lane as "a longitudinal strip within a roadway designed for the passage of cycles"; while 2.3 (1)(f) of the same rule says that "a driver, when driving, must not use…a special vehicle lane reserved for a specific class or classes of vehicle unless…the vehicle is one of the class or classes of vehicle for which the lane is reserved…". Note that a cycle is a vehicle under the legislation. See also Table 1B and Figure 3B in Accessible Streets: overview to the rules (Waka Kotahi 2020).

1.2 Knowledge gap

Previous research on and guidance for separators has included the collation of information on materials used overseas and in New Zealand (Koorey et al., 2013; ViaStrada, 2019; Waka Kotahi NZ Transport Agency, n.d.; Wilke & Fowler, 2015). This information has not always included details regarding availability (eg timeframes for delivery), suitability for large quick-build network implementation, and compatibility with the Traffic Control Device (TCD) Rule & Manual.

Existing research has also focused on how temporary protection for cycleways performs in the face of damage caused to it by motor vehicles (ViaStrada, 2021).

Less understood is which form of quick-build separators (including material, height, width) provides the best outcomes for people being protected in real terms. Like most countries, New Zealand practice has relied on various types of delineator posts. Auckland and Dunedin have pioneered precast concrete kerb separators that are stronger than those trialled in Christchurch. The Innovating Streets programme led to many councils trying different kinds of separators (mainly planter boxes, but also plastic 'wave' devices).

While the term 'quick-build' has been widely documented in US guides (California Bicycle Coalition & Alta Planning + Design, 2020; Deegan, 2018; People for Bikes, 2016; Walk San Francisco, 2019) and Australia is moving towards a single type of device (the vertical post combined with a low plastic kerb), there is a lack of New Zealand guidance and consistency on the materials needed for quick-build cycleways.

1.3 Research objectives

The objectives of the research were to:

- undertake a review of international literature and experience of infrastructure used for quick-build cycleways
- describe the design of ideal quick-build infrastructure, and
- make recommendations for the introduction of such designs in Aotearoa New Zealand.

Local authorities may use this research to help speed up the introduction of cycleway infrastructure aimed at increasing real (as opposed to perceived) safety, and ultimately feeding through into more positive perceptions of safety and encouragement of mode shift.

The aim is to show how large networks of cycleways can be delivered, at scale here in New Zealand, for cost-effective amounts of money (relative to roading projects).

This independent research is intended to help inform potential enhancements to the Cycling Network Guidance (CNG) on selecting cycleway separators and does not constitute Waka Kotahi-approved guidance. Inclusion of overseas practice does not imply endorsement of any traffic control device. In all cases, practitioners should ensure compliance with the TCD Rule and Manual.

1.4 What is a 'quick-build' cycleway?

As discussed in section 1.1, the facilities investigated in this report involve some form of physical separator device providing protection from motor vehicle encroachment. Many separators also increase the visibility of the delineation, hence improving actual safety by reducing the likelihood of a driver not noticing the facility and improving perceived safety by helping feel like they have a conspicuously designated space.

'Quick-build' is a term mainly found in the US literature (California Bicycle Coalition & Alta Planning + Design, 2020; Culver City, 2022; People for Bikes, 2016) and somewhat synonymous with Tactical Urbanism. The key characteristics of quick-build are:

- **timeline**: total start to finish design process in months, with installation in a few days
- **budget and design life**: temporary enough to be completed on a small budget using interim, flexible materials but durable enough to provide the time, political capital, and budget to evaluate and iterate upon the initial project design
- **materials** include elements that do not change the existing drainage and can be anchored to the pavement or remain in place due to weight (ie concrete kerbs are quick-build if pre-cast and bolted down but not in-situ poured kerbing that requires excavation of the pavement)
- **process**: utilise a people-centric, holistic process to bridge the gap between ephemeral demonstration projects and capital reconstruction, which may be supported by scalable policy/programme development. Provides a pathway to permanence.

Figure 1.1 Quick-build projects within the tactical urbanism spectrum of change (CRCOG, 2020)[2]

Auckland's *Transport Design Manual* defines Interim Design as having a design life up to 15 years, but also requires that there be a plan for a transition to permanence within that period. Quick-build materials may last longer in peri-urban or low-volume environments with suitable environmental conditions, or with ongoing maintenance. This research found that some overseas jurisdictions consider infrastructure that could be installed quickly as permanent. For the purposes of this research, the design life of the materials is expected to be one to five years.

In an international cycling infrastructure best practice study, Dales and Jones (2014) found that:

> *Incremental change: Some cities have shown that it is possible to grow cycling levels significantly over just a few years by employing pragmatic, relatively inexpensive, and sometimes intentionally 'interim' means of securing space for cycling. Upgrading this infrastructure to the standard found in mature cycling cities is not precluded (and sometimes consciously provided for) by the measures initially used.*

[2] Images L to R: tactical urbanism cycle lane - Wellington (Ross Giblin, Dominion Post), rubber separators, flexible bollards and interim bus stop platform - Wellington (G Koorey), concrete separators - Auckland (Auckland Transport), permanent separate facilities – USA (CRCOG)

One of the significant advantages of quick-build cycleways compared with more permanent facilities is the lower cost, allowing for adaptation of multiple factors (such as routing or width) over time with less financial risk. Network building can be piloted through use of these interim or temporary applications. This allows an observational, real world and results oriented approach to cycleway network establishment – a chance to demonstrate a new way of doing things and creating a 'circuit-breaker' in the business as usual approach to transport system management (Mackie et al., 2021). It also means that the full influence of cycleway networks can be experienced in a shorter timeframe and thus evaluated and maximised.

Quick-build helps increase walking and cycling accessibility in a way which gives immediate benefit to the community and is easily changed based on community feedback and monitoring of effectiveness. In addition, the short implementation timeframe allows acceptance and support to increase. There are also risks – if it is easy to install and not much has been invested, it can be just as easy for elected members to demand removal based on public or media backlash. By acknowledging this up front, councils can turn this risk into an asset (the 'fail-fast' approach) and put the effort into neighbourhoods or areas where there is more support (Logan, 2021). The Innovating Streets Pilot Fund results (Mackie Research & Consulting, 2021) and Australian Capital Territory experience (D. van den Dool, personal communication, 8 March 2022) shows that quick-build is more likely to succeed when projects are part of the long term network plan.

1.5 Research methods

The following databases and websites were searched:

- ScienceDirect
- Scopus
- Google Scholar
- Streetsblog.org
- Websites of cities listed in Section 3 and key Australian states
- TRID (TRIS and ITRD integrated)
- Bicycle infrastructure manuals https://bicycleinfrastructuremanuals.com/
- Websites of major US companies designing quick-build cycleways including Alta Planning + Design, Nelson\Nygaard, Fehr & Peers, Street Plans Collaborative

One of the peer reviewers for this research has extensive experience in Australia and helped point the authors towards Australian cities that have installed quick-build cycleways. Search terms used are listed in Table 1.1. While quick-build is not intended to include 'pop-up' or 'demonstration' facilities, these shorter-term projects can still offer interesting insight into potential materials. Thus, these terms were included in literature searches.

Table 1.1 Search terms

Umbrella term	Related search terms		
Bike, bicycle, and cycle infrastructure	Bikeway (USA term) Bicycle lane Low-stress bikeway Cycle track	Contraflow bike lane Bicycle boulevard Neighbourhood greenway Buffered bike lane	Advisory bike lane Separated cycle lane Separated cycleway Protected bike lane
Quick	Pilot Temporary Interim	Low investment (or low-cost) Pop-up Fast build (or fail)	Cost effective
Facilities	Cycleway separator Barriers	Planter(s), planter boxes Kerbs (curbs)	Separator Delineator

1.6 How to use this report

1.6.1 Complementing the Cycling Network Guidance (CNG)

Waka Kotahi's Cycling Network Guidance (CNG) provides a framework for planning and designing cycling routes. Route developers should consider the context, principles, and process of planning a route to ensure it is in an appropriate location. As noted previously, this independent research is intended to help inform potential enhancements to the CNG on selecting cycleway separators and does not constitute Waka Kotahi approved guidance. In all cases, practitioners should ensure compliance with the TCD Rule and Manual.

The CNG gives design guidance for the various types of provision along a cycle route, with separated cycleways being one of these. Separating cycleways makes it possible to consider having a single two-way cycleway on one side of the road or the other, as well as the conventional configuration of two one-way cycleways on each side of the road – the Separated Cycleway Options Tool (SCOT) and its related technical note can be used to assist in deciding between these options, based on the midblock conditions (number of driveways or side roads, surrounding land use, parking provision) along the route. However, note that the ability to accommodate the cycleway within the space, connections with adjacent cycleway sections, and (in the case of signalisation) timing at an intersection will often be key governing factors in the decision too.

Note that designing a cycleway can be an iterative process, and it is likely that some steps will need revisiting as new decisions regarding the design are made.

1.6.2 Separators matrix

The CNG currently includes a cycleway separation device selection matrix, which introduces a range of devices and indicates their performance with respect to several key criteria. This report is intended to further assist in selecting the type of separation device for quick-build cycleways. We have expanded the list of devices, based on experience throughout New Zealand and around the world and assessed them according to several criteria of importance to quick-build cycleways (chapter 0).

An updated matrix accompanies this research note to include the recommended devices and additional information and enable users to compare the various devices and create short-lists according to their specific criteria more easily. However, this will require some time for consultation and ratification. Readers should consult the CNG page on choice of separator or protection to obtain the latest matrix that has been ratified by Waka Kotahi.

The resultant revision of the matrix includes transposition of rows and columns to accommodate more information, provision of more numerical values or defined categories (eg yes / no, low / moderate / high), and updated photos and examples of applications. The matrix itself may be updated in future to include automatic filtering based on user inputs.

Table 1.2 Matrix updates

Group	Edits
Timing	Incorporate planning, design, local government processes, safety auditing, production, shipping, installation time, whether trial processes are being used
Cost	Per unit and per km (from tables in report)
Dimensions	More details have been provided on length, width, height, and weight (in ranges)

Group	Edits
Recommendations	Prioritise for each type of material, and 'discard' lower scoring materials, based on: • TCD Rule compliance – noting that if the separator is not the primary (ie closest to the traffic lane) delineator then there may be more flexibility in terms of compliance • effectiveness in terms of providing physical separation • traffic compatibility • pedestrian safety considerations • affordability (on a simple five-point scale) • seliverability – are the materials available in New Zealand, or if they come from overseas what are the delivery timeframes? • installation requirements, eg pavement composition and condition, equipment needed • installation speed and scalability • durability – with a focus on those materials that last one to ten years rather than tactical urbanism products that last days or weeks • maintenance considerations • other pros and cons.
Construction / implementation	The current CNG matrix category of 'low impact construction' includes a wide range of descriptions which don't have an obvious ranking. These have been refined.

2 Existing knowledge

2.1 Existing guidance

Overseas, advice regarding quick-build cycleways has been published within general cycle facility design manuals (California Bicycle Coalition & Alta Planning + Design, 2020; Deegan, 2018; Monsere et al., 2014; People for Bikes, 2016; Walk San Francisco, 2019). Current New Zealand guidance on quick-build cycleways is mainly found within broader documents listed in Table 2..

Table 2.1 Current literature in New Zealand

Document	Relevant information included
TCD Manual Parts 4 and 5	Explanation and guidance on how to apply the Traffic Control Devices Rule; the first port of call when considering separators.
Selection and use of non-permanent materials – part of Waka Kotahi's Handbook for tactical urbanism (ViaStrada, 2021)	Safety, durability, and installation overview of delineators, including dimensions, colours, and layout. Other devices for separation such as concrete cubes, barrels, and planter boxes. Attachment and removal considerations; compliance with legislation.
Draft Handbook for tactical urbanism in Aotearoa (Resilio Studio et al., 2020)	Basic concept of quick-build under 'interim installation' List of design considerations and materials (p. 87)
Aotearoa urban street planning and design guide (Waka Kotahi NZ Transport Agency, 2021)	Provides direction as to the long-term vision that should not be compromised. For example, saplings planted for a quick-build project should be of a species that is compatible with the city's approved urban landscape palette.
Cycling Network Guidance: separated cycleways section Separated Cycleway Options Tool (SCOT) choice of separator or protection and matrix	Overarching guidance for planning and design of cycle routes and networks. Specific guidance for designing separated cycleways, including legal considerations, concept design, detailed design, and case studies. SCOT assists in choice between two one-way separated cycleways and one two-way separated cycleway. Current matrix gives rating and mainly qualitative details for cost, benefit, and design considerations (durability, traffic compatibility, aesthetics, construction impact, and minimum space required).
Auckland Transport Design Manual Engineering Design Code – Cycling Infrastructure Section 3.7 (Auckland Transport, undated)	Describes temporary facilities (design life up to 12 months) as part of tactical urbanism trials and interim facilities (design life up to 15 years) with the same principles as permanent separated cycleways but with a lower cost; not permitted for new streets. Buffered cycle lanes by design exception.
Wellington Paneke Pōneke - Bike network plan 2021-2031	Cohesive routes that get people to where they want to go is important for making interim street changes.

2.2 Gaps in the existing knowledge

From this review, the following gaps in the current national understanding were identified:

- local authority approval processes have not been investigated
- existing information is out-of-date given the lessons learned in the Innovating Streets programme and international experience from installing quick-build cycleways in response to COVID-19
- the aesthetics of many existing infrastructure elements ranges from undesirable temporary traffic management (TTM) orange (with attendant adverse public reaction) to the artistic (that may not comply with the TCD Rule, or be polarising amongst the public); there has not yet been a systematic review of overseas practice to assess whether aesthetics are considered or if there are aesthetically superior devices used
- details regarding the integration of separator elements with paint-only buffered cycle lanes
- cost information is currently broad and could include per unit and per kilometre rates
- design layout information (eg spacing of elements) is scattered amongst multiple guides
- installation details relating to chip seal roads, safety durability and future maintenance
- availability of materials, lead times and speed of installation
- safety from a risk analysis perspective (likelihood and severity of injury)
- ranking and recommendations on which materials are best for each use case and pavement type.

The gap analysis indicates that this research should expand on the existing separators matrix to address these missing aspects. This should help provide consistency, economies of scale, and deliverability.

3 Quick-build cycleways around the world

Jurisdictions that were contacted or researched are outlined in Table 3.1. More information is provided in Appendix A. In summary, the review has shown that there is no consistency between countries in the specific infrastructure but that there are some themes:

- many installations began with posts or low separators, but more recent practice is to combine the two
- most separators are brightly coloured, with yellow being most common
- even if just glued or bolted to the pavement, more durable materials such as concrete and steel are often considered permanent (ie the road controlling authority does not have a further 'pathway to permanence')
- after a few adverse outcomes from earlier separator types, key Australian cities are standardising to use black and yellow hatched flag delineation posts on a nearly continuous yellow plastic separator kerb, contained between parallel pavement marking lines (a buffer). This is similar in design but not colour to the product Wellington has settled on
- Australian authorities were very interested in the precast concrete kerbs used in Auckland and Dunedin, in one case saying that New Zealand seems to be ahead of Australia in the state of the practice.

Table 3.1 Alphabetic list of jurisdictions reviewed for this research

City	Planters	Posts	Kerbs	Other
Auckland	Yes	Flexi post	Precast*	
Dunedin			Precast	
Barcelona		Flexi post		Lacasitos, armadillos Modular bus stops
Berlin *pop-up cycleways*				Flag delineators on K1 rubber bases
Bogota			Plastic	Water filled jersey barriers
Chicago, IL		Flexi post (2014+)	Precast (2017+)	
Davis, CA		Flexi post	Wheel stops (1967)	
Fremont, CA		Flexi post (2017) Deformable bollards (2021+)		Armadillos (2017) Amadillos & bollards (2021+)
Houston, TX			Precast (2017+)	Armadillos (2014+)
London *light segregation*		Wands		Armadillos, Orcas, Defenders (flag on rubber kerb base)
Longmont, CO *(trial)*		Flexi posts		Steel BikeRail (on wider cycleways)
Montreal	Self-watering plastic	Plastic bollards	Precast	Flexi post on wheel stops
New York City	Self-watering plastic, concrete	Flexi post		Steel BikeRail Jersey barrier
Paris *Corona Piste*		Deformable bollards	Cast in place Precast	Water filled jersey barrier
Penticton, BC			Wheel stops	Steel BikeRail
San Francisco	Concrete	Flexi post	Plastic, Precast	Botts dots, Modular bus stops
Seattle	Self-watering plastic	Flexi post		
Surrey, BC	Concrete	Flexi post		
City of Sydney	Concrete	Flexi post	Plastic, Precast	Water-filled barrier
Vancouver	Self-watering plastic Concrete		Wheel stops	
Queensland		Flexi post	Plastic	

* Note: within New Zealand the precast concrete kerb separator has also been used in other jurisdictions, including Christchurch and Hamilton – however for the purposes of this research the Auckland and Dunedin treatments provide good examples.

4 Findings by treatment

4.1 Cycleway separators

4.1.1 Delineator posts and bollards

The following summarises the research findings on delineators, with an extract of the current Waka Kotahi guidance provided in Appendix B.

Flexible delineator posts	
 **Flexible delineator posts, Davis CA (John Lieswyn)**	Delineator posts (including the products known as 'flexi-posts') are often used for separation or in conjunction with another element. They are usually installed to supplement a road marking. They may be t-cross section, tubular, or flag (flat) shape. They are frangible so provide limited physical protection to cyclists, and minimal damage to vehicles that do hit them.
Width	Bases 0.19–0.25 m Posts 0.06–0.08 m
Height	Available 0.45–1.1 m; should be 0.8–0.9 m high for cycle lanes.
Weight	Light (can be easily lifted by one individual).
Materials	Base – Polyurethane, recycled rubber Poles – Polyurethane
Colours	White preferred, as yellow is intended for right side of a traffic lane and orange suggests temporary road works. Reflector stripes must adhere to TCD Rule.
Anchoring	Multiple footing / attachment options. Pole bases are bolted or pinned to the surface of the road.
Installation	Can be installed by one person.
Spacing	The average spacing in application is around 1–2 m.
Cost (ea, NZD)	$84–$100
Lead time	Minimal – standard colours are generally readily stocked in the country.
Durability / maintenance	Likely to require replacement every 1 month – 1 year, depending on whether they are hit by vehicles.
Pros	Low cost, readily available, fast installation, good perceived safety, and improved actual safety due to visibility.
Cons	Provides no actual physical protection. Drivers may park between or on top of posts. Generates plastic waste at end-of-life and may need more frequent replacement than alternatives. Can have a 'cheap, temporary' look that some people feel detracts from the street environment. Can be a hazard to riders; can visually narrow the width of a path.

Deformable posts (bollards)

K-71 post (LAdot bike blog, 2015)

CityFlex, Porirua (Oliver McLean)

Width	80–170 mm
Height	800 mm
Materials	Polyurethane or other plastic.
Colour	White, black (with reflective white tape or yellow tape), grey, red, orange, green, blue, yellow; all with reflective tape.
Anchoring	Typically drill a 100 mm hole into the road, insert chemical glue into the hole and then fix the post. Removable anchoring also possible.
Installation	Installation can be easily undertaken by one person.
Spacing	The average spacing in application is between 1–6 m.
Cost (ea, NZD)	$160 (K-71) $140 (CityFlex)
Lead time	One supplier estimates about 250 units are stocked in country at any time.
Durability / maintenance	Replace every 1–5 years, depending on how often they are run over. Some models are manufacturer rated to return to shape after 1,000 vehicle strikes.
Pros	More durable than standard flexible delineator posts and with a larger diameter they are considered more aesthetically pleasing by urban designers than flexi-posts.
Cons	Generates plastic waste at end-of-life and may need more frequent replacement than alternatives. Can have a 'cheap, temporary' look that some people feel detracts from the street environment. Can be a hazard to riders; can visually narrow the width of a path.

Table 4.1 Design for all posts and bollards

Aspect		Rules and recommendations
Safety	Frangibility / moveability	In low-speed environments and / or for demonstrations, it **may** be acceptable for the element to be moveable.
	Visibility	If used to slow traffic, **must** be illuminated or have reflective delineators or reflective signs installed so that the structure is visible. **Should** have retroreflective panels attached per TCD Manual Part 5. If placed in the centre of a road, such as a tree in a planter barrel, **should** be appropriately signed with keep left signs and markings.
		Consider that if increased lighting requires new mains power, the lead time can be up to three months for power companies to attend.
		Must not block intervisibility between road users.
	Trip hazards and universal design	Any use of objects in the carriageway **should** be done in a way that does not compromise accessibility for any person with a mobility impairment; gaps and step-free access needs to be provided at formal and informal crossings. Refer RTS 14.
Durability	Removal	Temporary elements **should** not cause damage or alteration to the existing built and natural environment. In case of minor damage, this **should** be fixed at removal, or the pilot project may be timed to coincide with a renewal or capital project. For longer term installations, some damage may be acceptable – particularly if the street is due for renewal in the same timeframe.
	Colour and shape	Retains colour and shape during the design life of the product, or there is a maintenance plan. Resists UV degradation.
	Fixing methods	Item could be heavy (or installed on a heavy base) and thus difficult to shift.
		Stays in place during the period of installation, with evidence that the fixing method is suitable to a range of pavement types and resists loosening due to environmental factors, vibrations and loading from expected traffic volumes and composition. Could use asphalt to achieve desired shape.
	Maintenance and weather resistance	Resists wind forces. Maintenance programme is amended to regularly check device presence and condition and replace as necessary.
Installation	Sustainability & environment	Elements can be re-used, recycled or are biodegradable (example: hay bales used in demonstration events)
	Colours	Red should not be used on the right side of road. Green should not be used to delineate a space that is not intended as a cycleway. Orange should not be used for a longer-term installation as it is associated with temporary traffic management and yellow should be avoided as it has the same connotations. White and black are more aesthetically pleasing, although white is more likely to get dirty quickly.
	Signs and markings	The TCD Manual Part 5 sets out cycle lane markings; the CNG designing cycle lanes section covers aspects such as broken yellow lines, signage, coloured surfacing, etc.
	Dimensions and layout	Height 800 mm to 1000 mm (may be lower but the leading element **should** be in this range, refer to discussion text); if cyclists will ride immediately adjacent then no more than 900 mm high Delineator posts **must** be installed at regular intervals according to the road alignment and should be no more than 5 m apart (TCD Manual Part 5); for modal filters designed to prevent the passage of cars and trucks, space the elements no more than 1.6 m apart.

Recommendation for inclusion in matrix

There are specific applications for all three main types of posts and bollards presented here – flexible posts may be used in constrained locations where a wider separation cannot be achieved. Deformable bollards are preferrable if more width is available and it is necessary to have a frangible / collapsible device. Rigid bollards are preferred elsewhere, providing they are placed so that they do not pose a risk to cyclists entering or leaving the cycleway.

For any of these devices, the colour should not be orange (unless the installation is temporary), yellow, or red (see table above). Black, white, or another colour that ties in with the surrounding aesthetics is preferred, and the necessary reflective strips must be included.

4.1.2 Planter boxes

<table>
<tr><th colspan="3">Large wooden planter boxes (commercial)</th></tr>
<tr><td colspan="2">
Ferry Road (John Lieswyn)</td><td>Uses include cycleway separation, modal filters, traffic calming and space fillers to reduce trafficable road space.
Examples:
• Ferry Road, Christchurch
• Richmond Innovating Streets modal filters
• Tipahi Street Nelson traffic calming
• SH6, Renwick traffic calming</td></tr>
<tr><td>**Length**</td><td>0.4–1.5 m</td><td rowspan="3">Dimensions can range widely as generally planter boxes are made to the specifications of those contracting their production.</td></tr>
<tr><td>**Width**</td><td>0.4–1.0 m</td></tr>
<tr><td>**Height**</td><td>0.6–1.0 m</td></tr>
<tr><td>**Weight**</td><td>Heavy</td><td></td></tr>
<tr><td>**Materials**</td><td colspan="2">Hardwood or pine slats, galvanised liner and corners and weed mat.</td></tr>
<tr><td>**Colour**</td><td colspan="2">Wooden, black, or galvanised and reflective.</td></tr>
<tr><td>**Anchoring**</td><td colspan="2">No anchoring needed (weight is sufficient).</td></tr>
<tr><td>**Installation**</td><td colspan="2">Forklift</td></tr>
<tr><td>**Spacing**</td><td colspan="2">Varies from 4.0 m (prevents parallel car parking) to 20+ m</td></tr>
<tr><td>**Cost (ea, NZD)**</td><td colspan="2">$900–$2,800</td></tr>
<tr><td>**Lead time**</td><td colspan="2">1–6 months</td></tr>
<tr><td>**Durability / maintenance**</td><td colspan="2">10–20 years depending on timber and maintenance.</td></tr>
<tr><td>**Pros**</td><td colspan="2">Large planter boxes are attractive, heavy, and durable. Their weight makes them difficult for the public to move and so do not require fixing to the road.
The plants they house help create an attractive streetscape, and the outside can feature art or signage.</td></tr>
<tr><td>**Cons**</td><td colspan="2">Require more space than narrower separation devices.
Plants need watering and this may require a TTM plan.
Plants are sometimes stolen or vandalised.</td></tr>
</table>

Self-watering planter boxes	
These boxes include a reservoir below the plant containing water and a rockwool batting filter through which the plant roots absorb the water. The planter can be hung (eg from a jersey barrier) or stand-alone. A filler tube is provided to speed refilling. The reservoir is fully sealed to prevent leaching onto the pavement. Used in many North American cities including Seattle, Portland, New York City, Vancouver etc, in conjunction with other separator products such as delineator posts or low separators.	
 **Hanging on jersey barrier (Sybertech)**	 **With footrest and hold rail, New York City (Dezignline)**
Dimensions	Varies; rectangular models approx. 137 cm (L) 53 cm (H) 66 cm (W) – Sybertech.
Materials	Rotomolded polyethelene (Sybertech) concrete (Dezignline)
Colour	Virtually any colour; Sybertech has two custom 'stone' finishes at extra cost.
Cost (ea, NZD)	$350 + shipping + GST for standard colour (typical Sybertech design).
Cost per km	Varies depending on spacing.
Lead time	6–12 months depending on shipping.
Durability / maintenance	10–20 years. Permanent material. Large water reservoir reduces watering intervals and operating costs.
Supplier(s)	Sybertech (external link), DezignLine (external link)
Information source(s)	Tactical urbanist's guide (external link)
Pros	As per large wooden planter boxes, with the addition that maintenance is reduced due to less need for watering.
Cons	As per large wooden planter boxes.

Other forms of planter boxes include repurposed concrete pipes (Figure 4.1) and polymer plastic (Figure 4.2). As concrete is a non-frangible material, concrete pipes should not be used unless they are placed well clear of a primary delineation device and the street operating speed is low. There are many sources for planter boxes and the specifications vary substantially.

Figure 4.1 Concrete pipe, repurposed as a planter box (John Lieswyn)

Figure 4.2 Large plastic planters, Hendersons streets for people, Auckland (Danielle Clent, 2021)

Recommendation for inclusion in matrix

Large planter boxes introduce a pleasing aesthetic to a cycleway, as well as significant physical separation. Plants require maintenance (less so with self-watering containers) and are often stolen or vandalised. They may be more appropriate in urban centres where speeds are lower (potentially reducing TTM costs), surveillance is better, and they can add place value to high use areas. If authorities are comfortable maintaining planter boxes, they should be free to include them in their toolkit. The exact material (wood, polymer etc) is less important than the design of the shape of the box to fit the space available and still allow visibility at driveways and permeability for cyclists entering or leaving the cycleway at key locations.

4.1.3 Low separators and kerbs

<table>
<tr><th colspan="3">Wooden raised lane separators</th></tr>
<tr><td colspan="2">
Wooden separator, Napier (Napier City Council)</td><td>As part of Auckland’s Streets for People programme, MRCagney commissioned wooden sleepers as separators for cycleways.
The sleepers have also been used in the Napier Innovating Streets trial.</td></tr>
<tr><td>Length</td><td>2.0–2.6 m</td><td rowspan="3">A wide range available thanks to the malleable nature of wood.</td></tr>
<tr><td>Width</td><td>0.1 m</td></tr>
<tr><td>Height</td><td>0.1–0.15 m</td></tr>
<tr><td>Weight</td><td colspan="2">Weights up to approximately 40–48 kg max (estimated three people to lift).</td></tr>
<tr><td>Materials</td><td colspan="2">Macrocarpa (No1 grade)</td></tr>
<tr><td>Colour</td><td colspan="2">Wooden but could be painted in whatever colour is desired.</td></tr>
<tr><td>Characteristics</td><td colspan="2">Any workshop dealing with timber products could produce them easily. Relatively environmentally friendly and relatively aesthetically pleasing. Highly adjustable and easy to modify.</td></tr>
<tr><td>Anchoring</td><td colspan="2">Sleepers are pinned at three points each to a depth of approximately 100 mm below the road surface.</td></tr>
<tr><td>Installation</td><td colspan="2">Many trips on a small truck, timber is heavy. Three people are needed to lift each sleeper. Potchermen or sealer applied on top of holes. Estimated time of 1.5 nights shifts for installation on two streets.</td></tr>
<tr><td>Spacing</td><td colspan="2">When used in Auckland, AT said two sleepers had to be installed side by side to meet safety requirements. Minimal gaps between them will reduce potential end hazards, with occasional access gaps for users.</td></tr>
<tr><td>Cost (ea, NZD)</td><td colspan="2">$264.50 (excluding GST)</td></tr>
<tr><td>Cost per km</td><td colspan="2">$100,000–$125,000 per km (single-width configuration + some gaps)</td></tr>
<tr><td>Lead time</td><td colspan="2">Two weeks for production (time period from local NZ example)</td></tr>
<tr><td>Durability / maintenance</td><td colspan="2">5–10 years depending on whether they are hit by vehicles, in which they might need replacing. Wood will rot eventually or need repainting.</td></tr>
<tr><td>Information source</td><td colspan="2">Luke Adams (MRCagney)</td></tr>
<tr><td>Pros</td><td colspan="2">These offer an easily customisable option for cheap, fast installation, environmentally friendly lane delineators.</td></tr>
<tr><td>Cons</td><td colspan="2">If no vertical element is used, then they can be difficult to see and present a trip hazard to pedestrians.</td></tr>
</table>

Pre-cast concrete kerbs (Auckland)		
 Auckland (**M. McAulay**)		Precast concrete island style separators were first used in Auckland on Carlton Gore Road. Then Nelson Street followed, using the same shape. Another example is Ian McKinnon Drive, showing how incompletely cured mortar was washed onto the cycleway by rain: https://goo.gl/maps/UFiHJw7Qekn5SKvY8 Smaller round topped concrete separators have been used in Whenuapai. https://goo.gl/maps/YSZbtaya997YSwy47
Length	3.00–5.00 m	3.0 m units are the most commonly used in Auckland. 5.0 m units are usually delivered in two 2.5 m segments before connection. 5.0 m is the length of a typical parked car, so the gaps line up with the space between vehicles so pedestrians can walk between them. 5.0 m is considered to be the practical maximum for stormwater from a single traffic lane to be channelled into a stream across the cycle lane.
Width	0.40–0.80 m	600 mm and wider with a flat top enables vehicle passengers to step onto them; placement of signs to enhance reflectivity at night.
Height	0.15 m	Bus body can swing over them, but typical cars cannot straddle them.
Weight	650–1500 kg	
Materials	20 Mpa concrete; webbing for crack control; lifting eyelets that are filled in post installation.	
Colour	Pale (no oxide) on perimeter improves visibility; interior colour an aesthetic choice of 4 kgs/m3 oxide and lightly exposed. Other applications have had slightly darker concrete and have been painted in places.	
Characteristics	Rounded nose enables driveway entry/exit manoeuvres. 45 degree sloped kerb face minimises damage to vehicle wheels during parking and shy space for bicycle pedals. Where a vertical kerb face is specified, 200 mm shy space is allowed for in specifying practical cycleway width.	
Anchoring	30–40 mm concrete mortar bed on asphaltic concrete. Ensure the mortar has time to cure before exposure to rain. Dowel pins provide greater shear strength to resist displacement from vehicular strikes. For the longer units, pins may be omitted (eliminates risk of striking services) but less strength. Consider pins at least for leading units and units near any driveways or side roads. Cannot be pinned to chipseal, so if installed on chipseal there is a greater risk of displacement.	
Installation	Excavation is not recommended as it makes delivery more difficult. Units fit on a 7.5 tonne flatbed truck and can be lifted with a 3.5 tonne jib.	
Spacing	Gaps between the separators are usually 0.5–1.0 m for drainage. Larger gaps (eg up to 3.0 m) reduce the number of units needed but make it easier for cars park in the cycleway.	
Cost (ea, NZD)	$2,500 - $3,500 (for Auckland use, includes installation but excludes TTM)	
Pros	More permanent aesthetic	
Cons	More costly than other separation devices	

Pre-cast concrete separators (Dunedin)		
 **Dunedin, Cumberland Street (Waka Kotahi)**	Precast concrete island style separators were used on the SH1 one-way system in Dunedin. Their design was based on first principles and the lesson learnt from the Beach Road project in Auckland. Education and then enforcement of cars parking in the cycleway is required early in the implementation phase. There are six different shapes of separators along the corridor to mitigate different safety scenarios within each of the 26 city blocks (5.1 lane kms). The four principal shapes are discussed below. Apple green paint used to define the cycleway at conflict locations for cyclists along the corridor.	
Length	2.00–4.00 m	4.0 m long 1.2 m wide units are the most commonly used. 4.0 m long x 800 mm wide units are used alongside parking to mitigate doors opening into the separated cycle lane, 150 mm inverted drainage channels allow water to flow off the carriageway and across the cycle lane. The continuous top surface of these separators mitigates any trip hazards and allows space for people to unload items from cars or babies into buggies without impacting the cycle lane flow. 4 m long x 220 mm wide units separate lanes at traffic signal approaches. 2 m x .22 m x 0.15 m separators are recessed 0.105 m into the pavement surface to continue lane delineation and create a speed bump at high volume accessways.
Width	0.22 m–1.2 m	Varies with surfacing palates and patterns agreed with Council planning team; signs and reflectors placed to enhance reflectivity at night.
Height	0.15 m	Car doors can open over them, but typical cars cannot straddle them.
Weight	300–1800 kg	
Materials	20 MPa concrete; 2 layers SE62 mesh (50 mm cover) for crack control and transfer of vehicle loads; rebar installed 25 mm below surface of hole and filled with 25 MPa Cemix post installation.	
Colour	Peter Fell concrete colour 673 to reduce brightness of new concrete; hard acid / etch to achieve fine sand finish for slip resistance, seal with epoxy sealer with anti-graffiti sealer pigmented to match the different city planning precincts cast into the 3 mm recess on the surface.	
Characteristics	• Rounded nose enables driveway entry / exit manoeuvres. Minimum 50 mm from vertical sloping face to minimise damage to vehicle wheels. • Main separators have octagonal patina. • Off-site construction allows for robust QA and approvals before panels arrive on site.	
Anchoring and installation	Excavation not recommended as it makes installation time consuming leading to stakeholder frustration, increases TTM risks / costs and risks conflict with buried services. Units fit on a flatbed truck and can be placed with a forklift with the correct load capacity. Surface of the cycleway and beneath the separators was milled and new paved surface installed to minimise future maintenance costs and create a flat surface for the separators to be placed on. Separators placed on site and left for 2-3 weeks while drivers got used to them when entering and exiting accesses and streets, and final adjustments to the location were made before anchoring. This also meant that whole blocks of separators could be placed overnight. 3-7 450 mm long 24 mm diameter rebar epoxied into pavement using Hilti HIT 500 V3 Epoxy resin at 600 mm centres. Services check as part of design and confirmed in installation with ground penetrating radar. Some pins were left un-grouted, especially around the new Dunedin hospital site to ease removal of the separators if necessary.	
Spacing	Gaps between the separators vary from zero alongside parking to 1.0 m. Minor adjustments were made on site to make entering and exiting driveways easier. Larger gaps between separators (eg across bus stops or very wide driveways) infilled with speed bump separator or marked clearly.	
Cost (ea, NZD)	$900–$2,800 (for Dunedin use, includes installation but excludes TTM)	
Pros	More permanent aesthetic	
Cons	More costly than other separation devices	

Riley kerb cycle lane delineator		
 **Riley kerb (Glen Koorey)**		This device alerts drivers when they encroach into cycle lanes. It can be dotted between the more costly treatments to bring down overall cost per km. This treatment could also be utilised when space is limited. Helps channel traffic occupying minimal space. Often used in combination with other treatments
Length	2.00 m	Only available in this measurement currently.
Width	0.16 m	
Height	0.03 m	
Weight	Light (easily lifted by one person – 2.5 kg / section)	
Materials	Recycled rubber	
Colour	Yellow	
Anchoring	Attached to the road surface using either a combination of screws (driven into the surface) and epoxy glue or just screws.	
Spacing	1 m	
Cost (ea, NZD)	$290 (estimated from per km cost, includes all fittings)	
Cost per km	$97,100 ($95,300 for delineators and $1,800 shipping)	
Lead time	Moderate lead time, shipped from overseas.	
Durability / maintenance	5–10 years depending on quality of attachment to surface and amount of traffic crossing the treatment.	
Pros	Low cost, quick installation Minimal width fits in many constrained layouts including on the delineation line although the colour should match the line (unless separated from the line). Mountable by motor vehicles	
Cons	Temporary look – if placed without a vertical device then minimal protection from motor vehicles	

Armadillos (zebras)			
 Armadillos, United Kingdom (Helen Morgan, 2014)	First produced in 2009 and runner up in the 2011 best recycled European product awards 2011. Used in Spain, France, UK, United States. Installed on Federal Street in Auckland to retain the planter boxes and provide delineation. One of four approved separators in the London Cycling Design Standards. Should have a vertical element (eg delineator post) at start / end and side road junctions for visibility. May be interspersed between other (more costly) separator elements.		
	Zebra 13	Zebra 9	Zebra 5
Length (mm)	820	775	748
Width (mm)	210	164	120
Height (mm)	130	90	50
Materials	Recycled PVC plastic (from electrical cable sheathing, roller blinds, pipes)		
Colour	Black, with white, yellow, green, red, blue reflective inserts		
Characteristics	Flexible, cushions impacts. Discourages motorist intrusion into cycleway. The shape helps deflect cycles or vehicles if accidental contact is made with the divider. Five year warranty.		
Anchoring	Three holes for pinning to the pavement. A non-styrene epoxy chemical resin comprised of two components and a 12 mm threaded rod with a length no greater than the thickness of the asphalt.		
Installation	May be parallel to street axis or oblique		
Spacing	Parallel: 1.5 m – 2.5 m | Oblique: 1.25 m – 2.5 m		
Cost (ea, NZD)	$70 - $90 each plus shipping from Spain and GST		
Cost per km	$43,000 - assuming 50% shipping premium and 2 m spacing (end to end), no driveways or side roads		
Lead time	14 weeks (6 weeks manufacturing, 8 weeks shipping)		
Durability	1-10 years		
Information source(s)	Pierre Coent (Zicla) – pcoent@zicla.com, Tactical urbanist's guide (external link), Plasback (NZ) (external PDF1, PDF2)		
Pros	Lower cost than concrete separators Good visibility especially if installed obliquely More resistant to anti-social driving compared to flexi-posts		
Cons	Not as aesthetically pleasing as some other devices If placed without a vertical delineator, creates a hazard for riders especially at the start of each run.		

Plastic raised lane separators without post attachments		
 **Auckland, St Lukes (Bike Auckland, 2019)**		These are similar to the Riley Kerb and the rubber traffic lane separators but made from recycled plastic. These are often used for car parking wheel stops but can be reproposed for cycle lane separation.
Length	0.50–1.80 m	
Width	0.15–0.30 m	
Height	0.05–0.10 m	
Weight	Moderate (can lifted by two people, approx 7–15 kg)	
Materials	Recycled rubber and PVC.	
Colour	Black or yellow with reflective beads on each end, yellow and black or black and white.	
Characteristics	• light • relatively durable • easy to install • often used effectively in combination with flexible posts or bollards • widely used and available internationally.	
Anchoring	These are attached to the road surface with bolts (concrete) or spikes (asphalt).	
Installation	Could easily be installed by one individual.	
Spacing	Treatment can be continuous or have intermittent spacing.	
Cost (ea, NZD)	$90 / m	
Cost per km	$30,000 assuming 30% lineal coverage of a route	
Lead time	In stock in NZ	
Durability	10–20 years, depending on traffic interactions	
Information sources	Vanguard (NZ) (external PDF), Start Safety (UK) (external PDF1, PDF2)	
Pros	Lower cost than precast kerb options while still providing protection. Relatively narrow enabling use in constrained layouts	
Cons	Not as aesthetically pleasing as some other devices If placed without a vertical delineator, creates a hazard for riders especially at the start of each run.	

Mountable rubber raised kerb separators		
 **Rubber kerb separator, United Kingdom (Rediweld, undated)**		An aesthetic alternative similar to the classic kerb often seen in permanent separated cycleway networks while still allowing easy installation and removal. Some designs have premade sockets for delineator posts, or posts can be surface mounted. Narrower and lightweight compared to precast kerbs.
Length	0.50–1.00 m	These measurements are for both rounded ends and centre models.
Width	0.25–0.50 m	
Height	0.08–0.13 m	
Weight	Moderate (would require two people to lift, about 16–24 kg)	
Materials	Recycled rubber	
Colour	Red, grey, or white.	
Anchoring	Bolts are recommended by the manufacturer. However, spikes should be considered for used when the road surface is asphalt. Each unit requires 4–5 fixings.	
Installation	These would only require two people for installation thanks to the devices ability to be broken into pieces.	
Spacing	Treatment can be continuous or have intermittent spacing between complete units (two rounded ends and middle pieces).	
Cost (ea, NZD)	$260 / m	
Cost per km	$87,000 / km assuming 30% lineal coverage	
Lead time	In stock in NZ	
Durability	10–20 years, depending on traffic interaction	
Information sources	Vanguard (NZ) (external link), Rediweld Traffic (UK) (external link)	
Pros	Relatively narrow enabling use in constrained layouts Aesthetically similar to permanent kerbs	
Cons	If placed without a vertical delineator, creates a hazard for riders especially at the start of each run.	

Concrete raised lane separators (parking wheel stops)		
 Parking wheel stops, United States (Tactical Urbanist's Guide, 2016)		Precast concrete parking stops are an alternative to larger, more expensive precast options while still providing protection. They should be placed between delineation lines to create a buffer space and reduce the chance of road users striking them.
Length	0.91–2.44 m	
Width	0.15 m	
Height	0.10 m	
Weight	Moderate (would take two people to life safely, approx 64 kg)	
Materials	Concrete – high strength, reinforced with rebar and with premade holes for attachment of posts	
Colour	Grey (natural) or painted.	
Anchoring	Galvanised pins, coach bolts or epoxy (or combination of); easy repositioning. More than two pins are recommended for safety as loss of one pin in a two-pin anchoring could result in the device rotating and causing a serious hazard to road users.	
Spacing	Recommended spacing is 2 to 5 m gaps	
Cost (ea, NZD)	$50–$80 (estimated from 2016 USD cost with inflation and conversion)	
Cost per km	up to $27,000 per km based on 30% lineal coverage	
Durability / maintenance	20+ years	
Information source(s)	Tactical Urbanist's Guide (external link) CGR (NZ), Traffic Islands NZ, Hynds (NZ) (external PDF) and Absolute Concrete(NZ) (external PDF).	
Pros	Relatively narrow enabling use in constrained layouts Aesthetically similar to permanent kerbs	
Cons	If placed without a vertical delineator, creates a hazard for riders especially at the start of each run.	

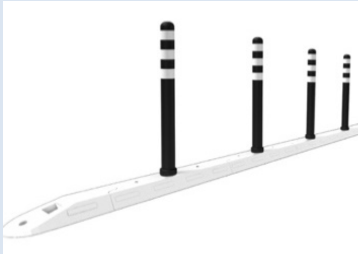
Recommendation for inclusion in matrix

There are appropriate applications for most of the low separator devices presented here. Pre-cast concrete separators are prevalent throughout the country and have proved effective and thus should be retained in the toolkit. Where separator width is constrained, it may be preferable to include a vertical element (eg the metal delineator rail with ribbons, wave delineator, lane separator with posts). Posts less than 900 mm high will not conflict with bicycle handlebars, but greater spacing between posts can reduce 'clutter' and maintenance costs while still providing sufficient delineation.

Simple low separators may be more appropriate between intersections, with the vertical delineator only at the start of each run.

Armadillos do not include the option of mounting vertical elements, or of creating a continuous uniform barrier, nor do they appear to offer any unique advantages over other devices. Therefore, armadillos have been excluded from the decision matrix.

4.1.4 Vertical delineation device on a separator kerb

Low lane separator / divider with posts						
Examples	 **Traffic separator with flexipost (Vanguard)**		 **BikeRail (DezignLine)**		 **CityFlex combo as procured by Wellington City (Vanguard)**	
	Base	Pole	Base	Pole	Base	Pole
Length (range)	0.75–1.00 m		0.61–2.44 m		0.50–1.02 m	0.07 m
Width (range)	18 cm		13.3 cm		20–30 cm	7–15 cm
Height (range)		0.8 m	18.0 cm	91.5 cm	50–90 cm	75– 25 cm
Weight	7–10.5 kg				8–14 kg	1 kg
Material(s)	Plastic (polymer)		Plastic (polymer) and steel		Plastic polyurethane	
Available colour(s)	Black/white, red, grey		Various options		Base – white, black Poles – Orange, yellow, white	
Characteristics	Available as one base and pole (resembles white dashed lines) or longer bases with multiple poles. Low carbon footprint.		Rails sit 0.05 m above road surface for storm water flow. Deflects vehicles up to a certain weight, speed, angle. Sockets accept various posts.		Five-year warranty (FG-300)	
Anchoring	Stainless steel screw, washer, and nylon plug		Expanding wedge or screw anchors		100 mm screws (concrete, AC) or 300 mm spikes (chipseal)	
Installation	1 day per block with one installer.		1 day per block with one installer (quick). Built in post slot; pivots for curves.		1 day per urban block with one installer. Interlocking bases, twist lock posts requires special tool to unscrew.	
Cost (ea, NZD)	$90 / m		$590 / m		$130 / m	
Cost / km	$30,000 assuming 30% lineal coverage		$650,000 (from CAD, including installation)		$43,000 assuming 30% lineal coverage	
Lead time	Available in New Zealand		1 to 4 months		1 to 4 months	
Durability	5 to 10 years		5 to 10 years		5 to 10 years	
Pros	Compared to either the low separator or vertical delineator alone, the combination is more resistant to anti-social driving and provides a higher level of physical protection. Relocatable – anchored via bolts. Treatment can be continuous or have intermittent spacing between units.					
Cons	Compared to a vertical delineator alone, the anchoring must be more robust to prevent the kerb units from becoming a hazard if dislodged.					

Other examples include the Tuff Curb, a US made product recommended by the City of Fremont (refer Appendix A.2.4) and the WandOrca, as specified for use in London (refer Appendix A.1.3). Vertical delineation devices on a separator kerb are the preferred treatment in New South Wales (refer Appendix A.5.3) and Queensland (Appendix A.5.4).

Saris Wave delineator	
 **Saris Wave, Christchurch (John Lieswyn)**	A semi-permeable barrier which was designed as an aesthetic, safe and efficient alternative to traditional flexi posts, bollards and more. One notable use is Ferry Road in Christchurch.
Length	2.70 m
Width	0.14 m
Height	0.70 m
Weight	5 kg
Materials	ABS thermoplastic
Colour	Sliver (reflective) with a black base
Characteristics	• transportable, lightweight, and collapsible • thickness optimized for weight and deflection • chamfered edges and reflective decals • Americans with Disabilities Act compliant • optimised height for drivers and cyclists.
Anchoring	Multiple mounting options (freestanding, temporary, and semi-permanent). In New Zealand application dyna bolts were used. The project managers identify that they are learning on the job regarding the number and depth of bolts needed.
Installation	They are relatively lightweight (5.0 kg) so are easy to transport. The installation does not require excavation or any change to the road surface aside from drilling into the surface. It is important to consider that different types of surfaces will not hold bolts as well as others (for example, chipseal has less structural integrity than asphalt)
Spacing	Designed for either continuous or intermittent installation. Frequently seen as a continuous installation.
Lead time	1–6 months
Durability	1–5 years
Cost (ea, NZD)	$300 (excluding shipping and installation)
Cost per km	$112,000 excluding shipping and installation assuming 371 units / km
Information sources	Clare Piper, Christchurch City Council; RTL.
Pros	Compared to continuous high vertical elements (jersey barriers, fences etc) these enable pedestrians to pass between them easily (they deflect down for wider wheeled pedestrians) Arguably aesthetic / artistic Lower cost than pre-cast concrete kerbing More visible than a low separator alone
Cons	Higher maintenance cost than pre-cast concrete kerbing

Jersey barriers

United States, New York (Bike Tarrytown, 2018)

Jersey barriers provide a significant psychological and physical barrier and can be adapted to the area through painting. The leading (first) barrier creates a safety risk for vehicle end-strike. Therefore, jersey barriers are only suitable for routes without frequent driveways and side roads, or a frangible element should be included at the start of each run.

New Zealand (Fortress fencing, undated)

Water-filled plastic versions are lighter to transport and may be more frangible (hence safer) in event of a motor vehicle collision compared to concrete. Plastic jersey barriers tend to come in 'construction site' colours that may not be aesthetic but could be painted. A painted finish may not last as long as painted concrete and the surface may need to be abraded first.

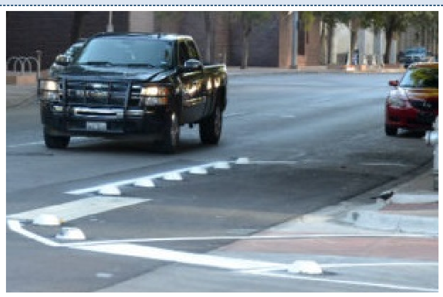
Length	1.98–3.66 m
Width	0.50–0.69 m
Height	0.81–1.00 m
Weight	Heavy (would require machinery to lift, approx 25–150 kg)
Colour	Grey (concrete) or painted (personalised), orange or white (plastic)
Anchoring	Self-anchoring by weight
Installation	Installation (transport and placing) requires TTM and machinery to move and lift units
Spacing	Treatment can be continuous (some producers create interlocking barriers) or have intermittent spacing between units (refer notes above regarding safety)
Lead time	1–4 weeks
Durability / maintenance	15–20 years, depending on amount of transport between sites and interaction with traffic
Cost (ea, NZD)	$700–$1,100 / m excluding transport and installation
Cost per km	$525,000–$825,000 / km assuming 75% lineal coverage
Information sources	Concrete: CGR, Traffic Islands NZ, Hynds and Absolute Concrete. Plastic: Vanguard (external link), Fahey Fence Hire and Jaybro
Pros	High protection level if continuous
Cons	Not appropriate for streets with frequent driveways or intersections. Continuous barriers do not permit passing of slower riders on narrower facilities.

Recommendation for inclusion in matrix

Various low lane separators with posts and Saris Wave delineators are good examples of separators with vertical elements and thus both should be included in the matrix. The yellow / black units used in New South Wales and some NZ Innovating Streets projects are colours that are prescribed for bridge end markers in the TCD Rule and therefore should not be used.

Plastic and concrete jersey barriers provide good physical separation and may be useful in locations next to roads with high volumes and / or fast traffic, especially for quick-build projects with a shorter term. However concrete jersey barriers should be mainly continuous to avoid end-strike risk or a frangible element used at the start of each run. Generally, jersey barriers are not suited to urban streets where crossing opportunities are needed and there are frequent driveways. As authorities may already own stock of these, and can repurpose them from / for other applications, they should be retained in the matrix.

4.1.5 Separators that are not recommended

Separator type		Why excluded from further investigation	Information resource
Painted buffers	 **Christchurch (ViaStrada)**	Buffered cycle lanes by themselves do not meet the research brief of providing physical separation. Paint buffers are often combined with separators to provide shy space and to meet the TCD Rule / Manual in terms of delineation.	CNG (external link) TCD Manual Part 5
Parked cars plus painted buffer	 **United States, Minnesota (The Minnesota Sun, 2018)**	Paint alone is not sufficient to prevent drivers from parking in the buffer or driving into the cycleway.	CNG (external link)
Plastic barrier	 **USA (Tactical urbanism guide, 2016)**	Painted and modified (cut out) plastic jersey barrier Modification of existing known element. Artistic but potentially polarising and does not contribute to a consistent 'look' for network-wide application	Tactical Urbanist's Guide (external link)
Concrete buttons **Botts dots**	 **USA (Tactical Urbanist's Guide, 2016)**	Uncommon usage, primarily in USA. Lack of vertical height means less physical protection and perceived safety. If used, should be part of a system including vertical delineators.	Tactical Urbanist's Guide

Separator type		Why excluded from further investigation	Information resource
Light planters	 **Wellington (Ross Giblin, 2021)**  **Auckland (Auckland Transport, 2019)**	Small planter boxes can be wooden (top left, Wellington) plastic (bottom left, Federal Street Auckland) or steel. They are almost always combined with other separation elements including paint buffers, low mountable separators, armadillos, or delineator posts. Their lightness means they are more likely to be nudged out of position by errant motor vehicles or vandals. They are fine for pop-up, demonstration cycleways but unsuited for interim use.	PlaceKit street furniture (Davis & Buckle, 2019) Tactical Urbanist's Guide galvanised planters (external link) Fayetteville report (external PDF) Bentonville report (external link)
Tactile delineation	 **Milled-in rumble strip, Daly City California (John Lieswyn)**	Rumble strips and other tactile treatments are not likely to be perceived by the target audience as providing enough physical deterrence to motorist encroachment into a separated cycle lane (Kingham et al., 2011). They may be suitable for rural and high-speed roads or to improve safety of existing riders, but that is not the focus of this research.	Rumble strips – questions and answers (New Zealand Transport Agency, 2009)

4.2 Bus platforms

Wellington City Council is procuring quick-build bus stop infrastructure from Zicla (D. Racle, personal communication, 18 February 2022). The components are like Lego – they can be interlocked to create infrastructure of various dimensions. Wellington council staff have been working with the supplier to adapt the products to the TCD Rule. The advantage to using interlocking rubber components is that the infrastructure can be relocated if the bus stop location changes in response to land use or service changes. Concept drawings by the supplier illustrate the use of armadillos and interlocking elevated platform / ramp components at 180 mm height. The current design plans indicate 1:15 gradient 3 mm thick steel plate ramps coated with anti-slip paint. The rough order cost for materials is NZ $25K plus $7-13K for shipping (depending on the size of the order). The alternative is to construct such facilities using lower cost materials such as asphalt and tactile pavers. However, this approach cannot be moved.

Figure 4.3 Bus boarder concept drawing. Image flipped to left hand drive (Zicla)

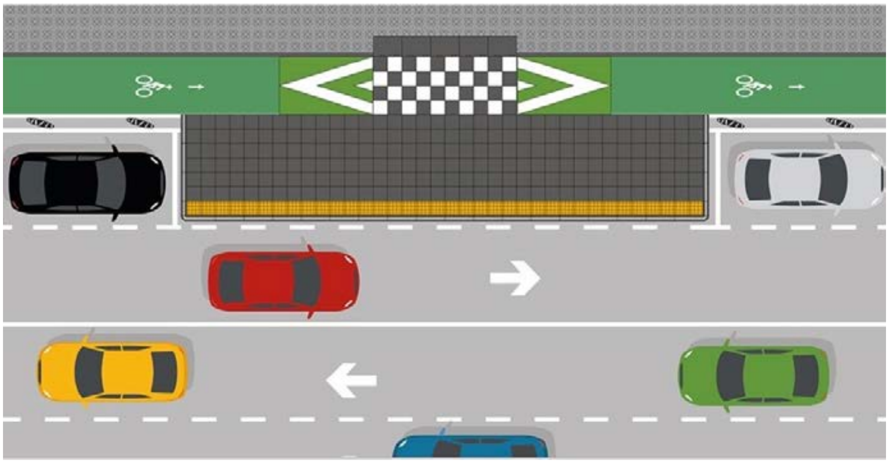


Figure 4.4 Interlocking bus platform components (Zicla)

Figure 4.5 In-lane cycleway / bus stop platform, Charlotte USA (Zicla)

4.3 Driveway treatments

Where a separated cycle lane crosses a side road, or is intersected by a driveway, special consideration should be given. The CNG's Separated cycleways at sideroads and driveways technical note outlines the factors to be addressed.

Where mitigation is required, especially at driveways with high volumes and heavy vehicles, the following devices could be appropriate. It may also be necessary to remove parking to increase visibility.

Mountable raised lane separators		
Humps and speed cushions are used as a complement to other separators and not intended to be the sole device used along a separated cycle lane.		
	 **Speed hump, New Zealand (Vanguard)**	 **Cushion (John Lieswyn)**
Length	0.50 + 0.25 m endcaps	0.90 m
Width	0.40 m	0.50 m
Height	50–75 mm	75 mm
Weight	Moderate (can be broken into sections)	22 kg
Materials	Recycled rubber	
Colour	Black and yellow	
Characteristics	• interlocking system which can be made to any length • can be easily relocated • middle sections have highly visible skid resistant panels • slow vehicles to around 15–20 km/h • works on an uneven surface • reflective cats eyes for night time safety.	
Anchoring	For concrete, 10 mm diameter 75 mm length screws are used. For asphalt, 14 mm diameter 300 mm length spikes.	
Installation	Could easily be installed by one person as the speed hump device can be broken into pieces.	
Spacing	Treatment can be continuous or have intermittent spacing.	
Cost (ea, NZD)	$200 / m + GST	
Information source	Vanguard (NZ) (external link and PDF)	
Pros	Mountable safety improvement for high volume driveways	
Cons	Poor aesthetics compared to no treatment	

4.4 Bicycle streets and neighbourhood greenways

A bicycle street is a concept first introduced in the Netherlands in the 1980s under the term *fietsstraat*. In a bicycle street, the carriageway is mainly for the use by people cycling, but in most cases, other traffic is permitted. The concept is widely used in European countries and was introduced in 1997 in Germany (*Fahrradstraße*), 2008 in Spain (*ciclocalle*), 2011 in Denmark (*cykelgade*), 2012 in Belgium (*fietsstraat / rue cyclable*), 2013 in Austria (*Fahrradstraße*) and 2019 in Switzerland (*Velostrasse*). In most jurisdictions, a 30 km/h speed limit is mandatory and people cycling have priority over all other road users; hence this is a different concept to a neighbourhood greenway (Metron, 2018). The concept is in use in urban areas as well as rural settings; in the latter case, mostly on sealed backcountry street where often only agricultural traffic is permitted apart from cycling.

In the context of quick-builds, this is a useful concept for creating long networks with minimal and localised work only – and often no parking impacts. Most measures are aimed at reducing motor vehicle volumes through road closures or turn bans. Other measures enable the crossing of busy roads. Austroads research report *Low Cost Interventions to Encourage Cycling: Selected Case Studies* (2014) includes a case study of local area traffic management (LATM) enabling a traffic volume reduction from 1,555 to 390 vehicles per day for AU$50K. Several other low-cost modal filters are included in the research report.

Figure 4.6 Local area traffic management treatment in Stanmore, NSW- one way for cars, two way for bikes (Austroads, 2014)

New Zealand guidance and examples are found in the CNG[3] and in the Local Path Design Guide (Auckland Transport, 2016).

[3] Refer to the CNG for more information on neighbourhood greenways as part of cycling networks: https://www.nzta.govt.nz/walking-cycling-and-public-transport/cycling/cycling-standards-and-guidance/cycling-network-guidance/designing-a-cycle-facility/between-intersections/neighbourhood-greenways/

Large concrete or granite blocks

 Concrete blocks forming a kerb extension, Papatoetoe (Auckland Transport)	 Concrete cubes preventing access to cycleway, Sydney (Dick van den Dool)	 Concrete balls preventing access to shared space, Martin Place Sydney (Dick van den Dool)

These are often used for modal filters or temporary kerb extensions. They could also be used as cycleway separators but are generally quite wide.

Length	0.91 m–1.8 m	Typical lengths are 1.2 and 1.8 m
Width	0.46 m–0.6 m	
Height	0.46 m–0.6 m	
Weight	1500 kg	
Materials	Granite, other natural rock, or concrete	
Colour	Grey / stone or painted	
Characteristics	• can use regionally appropriate/ available material • reusable • either a natural aesthetic or could be painted to suit local environment.	
Anchoring	Self-anchoring by weight	
Installation	Installation (transport and placing) would require TTM and machinery to move	
Spacing	Various, dependant on intended use and environment where it is installed	
Durability / maintenance	20–80 years	
TCD compliance	Infrangible – not appropriate for higher speed roads	
Cost (ea, NZD)	$150–$315	
Information source(s)	http://tacticalurbanismguide.com/materials/granite-blocks/ https://www.envirocon.co.nz/pages/retaining-walls-civil	
Pros	Easy to procure and install or relocate	
Cons	Infrangible and could cause serious harm if struck by a motor vehicle – should be positioned well clear of motor traffic lanes and if placed along a cycleway should be part of a series of devices.	

Rigid bollards	
 New Zealand (Tilley Group Ltd, undated)	Bollards come in a very wide variety of colours, material, shapes, and sizes. This range allows an aesthetic appearance. Rigid bollards are not recommended as separators between cycleways and general traffic lanes, as they are not frangible and not continuous. However, they can be used to achieve modal separation between cyclists and pedestrians, and to prevent motor vehicle access to off-road cycleways or shared paths.
Width	0.08–0.17 m diameter
Height	0.70–1.15 m
Weight	Variable
Materials	Stainless steel, galvanised steel, powder coated steel, wood
Colour	Metallic, painted metallic
Characteristics	• preferred by urban designers over plastic flexiposts • durable • can pose a risk to motorists and cyclists, more so the flexible posts. • can incorporate a fixed base and detachable post so easily added and removed over time.
Anchoring	These bollards vary in how they are fixed to the road surface. Options include fixed in ground, removable keylock, removable padlock and surface mounted (with bolts and glue).
Installation	One person
Spacing	1–6 m; spacing > 2 m can lead to vehicle intrusion so 1–2 m recommended. Austroads GRD6A specifies 1.4 m spacing while the Australian Hostile Vehicle guidance (Australia-New Zealand Counter-Terrorism Committee, 2017) specifies 1.2 m.
Cost (ea, NZD)	$175–$1,690 ($175–$255 surface mounted bollards with plain galvanised finish, $195–$285 surface mount bollards with yellow powered coat finish, $945–$1,690 slow stop energy absorbing bollards)
More information	Installations should be consistent with Access control devices on paths (Waka Kotahi 2020). Bollards New Zealand, Vanguard, Street furniture New Zealand
Pros	Can be more aesthetic than deformable or flexible delineation posts.
Cons	High maintenance cost and greater risk of injury if struck compared to deformable or flexible delineation posts Rigid bollards can be a safety hazard for visually impaired users and cyclists. Refer to Table 4.1 for more information.

4.5 Quick-build retrofits for cycleways at traffic signals

The critical part of any cycleway network, in terms of both safety and physical space available, is the intersections. At intersections it is not possible to provide physical separation and therefore there must be a way of providing temporal separation.

Current New Zealand legislation (ie within the Road User Rule and Traffic Control Devices Rule) requires cyclists entering a signalised intersection from a physically separated cycleway to have separate signal phases to general traffic. The current legislation, problems and proposal to change the legislation are outlined in proposal 6C of the Accessible Streets Overview (Waka Kotahi NZ Transport Agency, 2020). This necessitates the following items:

Table 4.2 Traffic signal infrastructure

Item	Indicative cost
Cycle signal hardware	$1,000 per signal head (minimum two per cycleway approach)
Red arrow signal hardware to control vehicles turning across the cycleway (optional in some cases, depending on phasing plan)	$1,000 per signal head (would need up to four per cycle movement)
Changes to painted markings (limit lines, cycle logos, surface colour including changes to general traffic lanes where space has been reallocated, and removal of old markings)	$1,000–$15,000 per intersection
Upgrade signal hardware, including detection hardware	$30,000–$200,000 (assuming inductive loop detection and depending on the age of existing hardware, need to relocate poles, and the presence / availability / capacity of existing cable ducts etc).
Temporary traffic management	$1,500–$7,500 per day (depending on level of road and days required)
Adjust phasing plans, re-code SCATS etc	$1,000–$5,000 per intersection

Costs are based on the Cycle Facility Conceptual Cost Estimation Tool. In an economic model, the time cost to motorists experiencing additional delay due to integrating additional phases would also be considered.

The pending ‘Accessible Streets’ legislation changes aim to revise give way rules and redefine roads (to include separated cycleways), which should achieve a form of temporal separation without the need to run fully separate phases. Therefore, some of the costs for additional signal hardware and changes to phasing plans could be eliminated for some intersections. However, at larger, busier intersections, or for bi-directional separated cycleways, full separation through phasing will still be necessary.

Quick-build cycleway continues to signalised intersection

Signalisation of an interim separated cycle lane in Christchurch (John Lieswyn)

One example of a quick-build cycleway incorporated at a signalised intersection is the Heathcote Expressway on Ferry Road at Barbadoes Street in Christchurch.

The wave barrier (see section 4.1.4) provides physical separation right up to the cycleway limit line. Traffic signals for cyclists have been added, so that the cycle movement can be temporally separated from the conflicting left turners. The red arrow for the left turners was already in place, to provide partial protection for pedestrians.

Barbadoes Street is one-way and the section of Ferry Road on the far-side of the intersection as per the photo above was converted to one-way prior to the cycleway installation. This simplified the task of introducing the separated cycleway somewhat, compared with an intersection of two bi-directional streets.

As the cycleway is bi-directional, it would not have been appropriate to terminate the physical separation prior to the intersection, and it would not be possible to involve any form of motor vehicle mixing with or filtering through cyclists.

This is a good example because the retrofits were much cheaper than most other cycleway projects. In the future if the cycleway needs to be widened to cater for increased cycling demand and the current cycleway separators may need to be removed or repositioned, this type of treatment avoids locking in more expensive options prematurely.

Quick-build cycleway terminated prior to signalised intersection

Dunedin (Waka Kotahi)

The separated cycleway on Great King Street (SH1 northbound) at Saint David Street in Dunedin is an example of a one-way separated cycleway terminating prior to a signalised intersection. The project itself was not 'quick-build', as it did involve significant physical works to the carriageway in other locations and took several years from the concept stage to its actual construction. However, the pre-cast concrete cycleway separators (similar to the Auckland ones illustrated in 4.1.3) and the intersection layout employed could be used for a quick-build cycleway.

This layout involves transitioning the cycleway to a 'mixing zone' – ie a lane shared with right turning motorists (which is possible as both the cycleway and Great King Street are one-way – on a bi-directional street this treatment could be applied to a cycleway on the left kerbside transitioning to a lane shared with left turning motor vehicles). Cyclists are permitted to travel straight ahead from the mixing zone, and the motorists will have reduced their speed to turn the corner, thus making it safer for them to mix with cyclists, although not ideal in terms of some cyclists' perceived safety or level of comfort.

Because the cyclists enter the intersection from a general (shared) traffic lane, there is no need for additional cycle signals or changes to the general traffic signals with this layout. Cyclists travelling straight ahead would be governed by the signals for general traffic, which could cause some confusion if there are separate cycle signals at other intersections along the route, or if a cyclist is stuck behind a turning vehicle waiting at a red arrow while the parallel pedestrian crosswalk operates, and the general traffic has a green signal.

The applicability and design details of a mixing zone should be thoroughly considered before incorporating such a layout. Motorists turning into the mixing zone must have a clear view of cyclists, a clear understanding of the requirements to share the lane, and the design should restrict the speed at which they can enter the zone. Some authorities prefer to maintain complete separation of cyclists from motor vehicles and therefore will not consider mixing zones.

5 Conclusions and Recommendations

5.1 Terminology

Quick-build is taken to mean infrastructure that has an 'interim' lifespan of one to five + years. Auckland considers these facilities to be useful for up to 15 years. Sydney calls them 'Stage 2' facilities with a lifespan longer than pop-up demonstrations but shorter than permanent. But in much of North America, quick-build infrastructure is viewed as potentially permanent (unless there is some other reason to renew the street).

The term is not just a reference to the amount of time required to design, approve, procure, and install infrastructure, but also to the lower cost nature of the materials. The actual duration of project delivery is not determined by the procurement and installation time, but the local government processes (planning, consultation, elected member approval, safety auditing, etc).

5.2 Delineator posts

There are specific applications for all types of posts and bollards presented here – flexible posts may be used in constrained locations where a wider separation cannot be achieved. Deformable bollards are preferrable if more width is available and it is necessary to have a frangible / collapsible device. Rigid bollards are preferred elsewhere (ie behind the kerb, modal filters, etc), providing they are placed so that they do not pose a risk to cyclists entering or leaving the cycleway.

For any of these devices, the colour should not be orange, yellow, or red. Black, white, green or another colour that ties in with the surrounding aesthetics is preferred, and the necessary reflective strips must be included. The colour should match the lane line colour if they are placed on or immediately adjacent to the lane line.

5.3 Planter boxes

Large planter boxes introduce a pleasing aesthetic to a cycleway, as well as significant physical separation. Plants require maintenance (less so with self-watering containers) and are often stolen or vandalised. They may be more appropriate in urban centres where speeds are lower (potentially reducing TTM costs), surveillance is better, and they can add place value to high use areas. If authorities are comfortable maintaining planter boxes, they should be free to include them in their toolkit. The exact material (wood, concrete, polymer etc) is less important than the design of the shape of the box to fit the space available and still allow visibility at driveways and permeability for cyclists entering or leaving the cycleway at key locations.

5.4 Low separators

There are appropriate applications for most of the devices presented here. Pre-cast concrete separators are prevalent throughout the country and have proved effective and thus should be retained in the matrix. Where separator width is constrained, it may be preferable to include a vertical element (eg the metal delineator rail with ribbons, wave delineator, lane separator with posts). Posts less than 900 mm high will not conflict with bicycle handlebars, but greater spacing between posts can reduce 'clutter' and maintenance costs while still providing sufficient delineation.

Simple low separators may be more appropriate between intersections, with the vertical delineator only at the start of each run. Armadillos do not include the option of mounting vertical elements, or of creating a continuous uniform barrier, nor do they appear to offer any unique advantages over other devices. Therefore, armadillos have been excluded from the decision matrix.

5.5 Vertical delineation device on a separator kerb

Various low lane separators with posts and Saris Wave delineator are good examples of separators with vertical elements and thus both should be included in the matrix. The yellow and black units used in New South Wales and some NZ Innovating Streets projects are colours that are prescribed for bridge end markers in the TCD Rule and therefore should not be used.

Plastic and concrete jersey barriers provide good physical separation and may be useful in locations next to roads with high volumes and / or fast traffic, especially for quick-build projects with a shorter term. However concrete jersey barriers should be mainly continuous to avoid end-strike risk or a frangible element used at the start of each run. Generally, jersey barriers are not suited to urban streets where crossing opportunities are needed and there are frequent driveways. As authorities may already own stock of these, and can repurpose them from / for other applications, they should be retained in the matrix.

5.6 Combination of elements

The most effective form of cycleway separation will include:

- horizontal width – to increase physical separation between cyclists and motorists
- physical element – to physically prevent motorists from encroaching into the cycleway
- vertical element – to increase visibility for all road users
- continuous element – to delineate the cycleway for both legal and legibility purposes.

Each of these elements will contribute in different ways to the actual and perceived safety of cyclists. Combining them will achieve the best safety results and feel more comfortable to a larger proportion of cyclists. For example, flexible delineator posts (4.1.1) could be installed on top of concrete separators (4.1.3) at key locations such as curves while mountable low separators (4.1.3) are used at driveways. Some of the devices (eg planter boxes) already combine all the elements.

While it has been identified that painted markings alone are insufficient as cycleway separation, it is necessary to use painted lines to delineate the border between the cycleway and the general traffic lane wherever:

- the cycleway separator is not continuous (eg discrete separators such as posts, or if there are gaps between low kerb separators)
- the cycleway separator is not a legal lane marking colour (generally white, or yellow for some applications) – in which case it cannot sit on the lane line and must therefore be located next to the line.
- it is desired to add a horizontal buffer to the separation design (for example, see the photos for flexible delineator posts, deformable bollards, and the Saris Wave delineator). A wider buffer will give cyclists the impression of being more separated from motor traffic, so becomes increasingly important as speeds and volumes of motor traffic increase. However, it is also necessary to provide sufficient cyclable width in the cycleway, and to not overly constrain the width of the general traffic lane(s). The Quick-Build cycleway separation element matrix provides recommended minimum width of separation device included painting delineation for each separator type.
- it is desired to delineate shy space for either motor vehicles or cyclists to the separation device itself.

A painted edge line on both sides of any separator helps delineate the separator for all road users.

While a device (or combination of devices) may be chosen based on the midblock conditions, it may be necessary to modify this at intersections, and introduce other devices at locations such as driveways and bus stops.

5.7 Process reform

This research has found several examples of cycleways (eg SH1 separated cycleways in Dunedin – seven years from inception to opening) that were built using quick-build to procure and install interim infrastructure but were not at all delivered quickly. Delivery timeframes typically include:

- Local Government Act and council consultation requirements, particularly about the removal of parking
- local decision-making delays while consultation results are incorporated and responded to
- planning and design timeframes, including for required road safety audits.

Precedent exists for legislative and policy reform that would remove barriers to implementation, lower costs, and speed delivery:

- speed management framework reforms that unify all speed limits in a national register and appoint a director to oversee it
- National Policy Statement on Urban Development that requires Tier 1 councils to remove parking minimums.

An example of this is the draft proposal to grant Auckland Transport the power to remove on-street parking for other uses (eg bus, bike lanes) without consulting residents or local boards. If enacted, this could be a model for removing one of the most substantial barriers to building cycling networks.

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Appendix A City findings

A.1 Europe

A.1.1 Berlin

Quick-build cycleways have been termed ‘Pop-up Radweg’ (where *Radweg* translates as *cycleway*) and the public also refer to this infrastructure as ‘Corona-Radweg’. The most common way of providing quick-build cycleways in Germany is to utilise common elements of temporary traffic management. These include yellow road markings (where those are applied, the underlying white markings no longer apply), and flexi-posts on a heavy but removable base. The Senate in Berlin (ie the city’s local authority) has published guidance for quick-build layouts (Senatsverwaltung für Umwelt & Verkehr und Klimaschutz, 2020). Average costs in Berlin are Euro 9500 per km (Von Bodisco, 2020). The conceptual approach in Berlin is to create infrastructure that is wide enough so that users can practice 1.5 m physical distancing. With traffic lanes 3 m wide, converting a vehicle lane meets this public health objective (Diepens et al., 2020). Of course, this also provides plenty of space for overtaking slower riders and riding side-by-side with friends or family.

Figure A.1.1 Quick-build cycleway in Berlin (Bicycle network, undated)

Figure A.1.2 Example of a K1 base used in Germany

There are different categories defined for the bases depending on wind load, sign size and sign height. For the safety barriers shown in Figure A.1.1, the lowest category (K1) would apply, which must withstand a torque of 120 Nm. Bases of category K1 must weigh at least 28 kg. They are between 0.85 and 0.9 m long, have a width of 0.45 m, and cannot exceed 0.12 m in height. There are many different types of bases within these specifications (STEIN HGS). A Berlin popup cycleway map shows the location of new temporary routes.

A.1.2 Paris

In France, the term ‘Coronapiste’ (Corona trail) has been coined for the cycleways developed to cater for a need for social distancing and a desire for exercise in fresh-air during the COVID-19 pandemic. Government guidance on temporary cycleways to be established during lockdowns sets out aims to reduce the number of general traffic lanes to provide more space for cycleways (Cerema, 2020). In some cases, this could involve changing the circulation plan, eg converting a street from bi-directional to uni-directional. The guide recommends that the cycleways be created with general roadworks products which are already readily available, such as plastic waterfilled interlocking jersey barriers and flexible posts. Photos from Paris indicate that concrete jersey barriers, round plastic bollards (Figure A.1.3) and surface-mounted concrete curbs (Figure A.1.4) have also been used in the initial projects in Paris' extensive cycle network expansion plan. The Cerema guide also notes that signage for temporary cycleways may include post-mounted signs or may rely solely on painted markings on the ground. A Paris video shows the temporary cycleways in use.

Figure A.1.3 Bollards and barriers, Rue de Rivioli, Paris (Christophe Belin / Ville de Paris)

Figure A.1.4 Concrete kerbs, Avenue de la République, Paris (Christophe Belin / Ville de Paris)

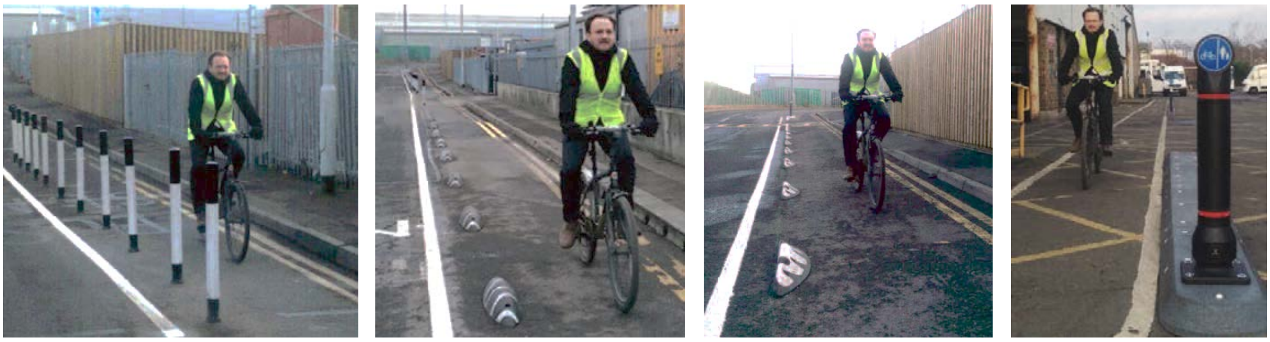
A.1.3 London

The London Cycling Design Standards (p.34–38 in Chapter 4) uses the term *light segregation* to describe quick-build infrastructure (Transport for London, 2016). Layout plans with element spacing and junction design are included. The Waltham Forest Mini-Holland Design Guide (Transport for London, 2020) provides a simpler list and dimensions for light segregation infrastructure:

- wooden planter boxes and bollards for 'modal' filters (to create neighbourhood greenways)

- wands - 800 mm high, 80 or 130 mm diameter white plastic flexible posts
- bollards – green plastic with dual white reflective stripes
- Armadillos – recycled PVC 50, 90 or 130 mm high separators
- Orcas – armadillos with a vertical face on car side
- Defenders – recycled car tyre kerbs, with or without posts.

Figure A.1.5 Left to right – wands, armadillos, orcas, defenders (Mini-Holland Design Guide)



These elements are often combined or alternate (Figure A.1.6).

Figure A.1.6 Alternating armadillos and plastic bollards (Mini-Holland design guide, London)

Deegan (2018) describes the UK's longest (6 km) cycle route with light segregation – the A105 (Green Lanes) in Enfield, North London:

> *Green Lanes varies between a high road layout featuring shops and commercial properties to a connector road featuring residential areas with off street parking and semi-detached properties. Car ownership is high in Enfield compared to the London average and cycling numbers are low. Green Lanes carries over 10 000 motor vehicles a day and so is a busy strategic road.*
>
> *Installing light traffic segregation on Green Lanes faced two major challenges. The first was that access to off street parking was required by cars for long stretches of the route. This meant that vehicles would have to cross the cycle lane to access properties. If full protection using a kerb upstand had been used then less than half the route would have been segregated as there would have been so many gaps. The decision was therefore made to use light segregation that could be driven over to access local properties but the hope was that the objects would still deter encroachment from through traffic.*

The resulting design (Figure A.1.7) is a combination of deformable delineator posts at the start of each block for visibility, larger Orcas and mountable separators at driveways. Bus boarders were used as there was insufficient space to route the cycleway behind the bus stop.

Figure A.1.7 A combination of light segregation elements in Enfield (Urban Movement, in Deegan 2018)

Based on his own assessment, Deegan summarises the light segregation materials as shown in Figure A.1.8. Lacasitos are taller and symmetrical orcas, while Wandorcas are a combination of flexible posts and orcas (like Defenders). The higher rated products are those with greater height and therefore less likely to be struck by motor vehicles.

Figure A.1.8 Product assessment table (Deegan 2018)

Product	Protection	Cost	Durability	Aesthetics
1. Flexible post	★★★	★★★	★★★	★★
2. Lacasitos	★★★	★★	★★★	★★
3. Armadillos	★★	★★★	★★	★★
4. Orcas	★★	★★★	★★	★★
5. Planters	★★★	★★	★	★★★
6. Wandorca	★★★	★★★	★★★	★★

In summary, the London experience shows that combining various elements is needed to address a range of project constraints such as driveway access, visibility, and cost saving,

A.2 United States

The California Bicycle Coalition and Alta Planning + Design (2020) created a how-to guide with many pages of materials characteristics to aid the many cities in California that are deploying quick-build infrastructure. This guidance document contained examples of multiple quick-build treatments including paint and bollard treatments (Figure A.2.1). Walk San Francisco (2019) developed a guide to enhance the accessibility of quick-build bike lanes for pedestrians. Alta (2019) also created a demonstration implementation guide for the State of Minnesota with information relating to material choice and definitions of common treatments.

Figure A.2.1 Paint and white bollard buffered cycleway, Adeline Street Berkeley California (Alta Planning + Design)

A.2.1 Chicago, Illinois

Building on pilot projects begun in 2013 and accelerated as part of Mayor Rahm Emanuel's 100 miles of protected bike lanes in 100 days pledge, Chicago primarily used white safe-hit flexiposts within painted buffers (Chicago DOT, 2015). This author cycled most of the first 20 miles of protected bike lanes over a three-year period during the rapid expansion of the Chicago bikeway network and the following photos illustrate the materials used. It was clear that the lack of vertical delineation on the early kerb separators caused vehicular property damage and is likely to have resulted in cyclist falls as well. This was rectified within days of installation.

Figure A.2.2 T-profile delineators on 18th Street, 19/07/14

Figure A.2.3 Tubular delineators and parking lane protection for two-way bike lane on S.Dearborn St, 19/07/14

Figure A.2.4 Tubular delineators and parking lane for one-way bike lane with bus boarders on Davis Street, 16/07/17

Figure A.2.5 Pre-cast concrete kerbs for two-way bike lane on Chicago Av, 16/07/17

A.2.2 Houston, Texas

Like many US cities, Houston has adopted the zebra (aka armadillo) recycled plastic separator (Figure A.2.6). Houston only places these within a painted buffer where the white lines are the primary legal delineator, and the armadillo discourages motorist intrusion. BikeHouston's executive director notes that while armadillos continue to be used for cost reasons, precast concrete kerbs are preferred as they are more durable (Kinder Institute, 2021). This literature review did not find any examples of high vertical delineators complementing either separator type in Houston.

Figure A.2.6 Armadillo separators in Houston, Texas (John Lieswyn, 2017)

Figure A.2.7 Precast kerbs, Houston (Kinder Institute, 2021)

A.2.3 San Francisco, California

The Metropolitan Transportation Commission (MTC) in the San Francisco Bay Area has produced a table showing a range of different separation devices ('intervention objects') and grouped these into temporary vs permanent for three categories (Figure A.2.8) (Metropolitan Transport Commission, 2020). MTC's permanent category includes low separators such as armadillos, while deformable bollards are considered temporary. It appears the categorisation is made based upon the fixing methods and estimated durability of the materials. Some of these fall under the term quick-build while others do not.

Figure A.2.8 Points, lines and planes are a way of categorising materials used by MTC

San Francisco has made extensive use of delineator posts, but where these are employed in high parking demand areas they have been less successful. The city typically upgrades such infrastructure within three years of installation (T. Papandreou, personal communication, 27 August 2014).

Figure A.2.9 Damaged tubular delineator posts, San Francisco (John Lieswyn)

A.2.4 Fremont, California

Fremont is a city of 235,000 in the San Francisco Bay Area and host of a major Tesla automotive manufacturing plant. In 2017, Fremont trialled armadillos on one side of Walnut Avenue and white plastic safe-hit flexiposts on the other side (T. Dalton, personal communication, 25 February 2022). A combination approach was not considered. A bicyclist survey revealed a preference for the posts based on greater perceived protection from motor vehicles. Public comments on the posts centred on how the white posts felt like a construction zone. From a durability perspective, the armadillos were superior as the posts were repeatedly vandalised by light truck drivers. As the route serves a major new light rail station, funding was allocated to upgrade the two kilometre long corridor with high quality permanent materials including protected signalised intersections and raised asphaltic concrete cycle tracks (City of Fremont, 2020).

Based on the trial results, the city is now planning green K72 delineator posts combined with either armadillos or 'Tuff Curbs' for a new quick-build bike lane on Paseo Padre (T. Dalton, personal communication, 25 February 2022). Tuff Curbs (supplied by Impact Recovery Systems) are injection moulded high impact plastic with slots for vertical delineator posts and a 3M reflector at each end.

Figure A.2.10 Screenshot from the Walnut Avenue protected bike lane trial survey (Armour, 2017)

Figure A.2.11 'Tuff Curb' and delineator post, Paseo Padre Fremont (R. Dalton)

A.2.5 Davis, California

Davis has the highest bicycle mode share in the United States and is the only ‘platinum’ recognised bike-friendly city in the United States (League of American Bicyclists, 2018). Much of this is credited to the 1970’s push to limit roadway expansion and keep motor traffic speeds low (Buehler, 2007). It was also the first city to pioneer bike lanes and land use planning where neighbourhoods back on to wide linear park pathways. The first separated bike lane in the United States was built using parking wheelstops in 1967 (Figure A.2.12). This was not considered a success because no vertical delineation was used and bicycle headlights were not required or powerful enough in those days, so they caused many injuries. They also did not provide space for the car door swing zone.

Figure A.2.12 Parking wheel stops in 1967, Davis (B. Sommer)

Recently, Davis has used safe hit flexiposts and painted buffers to reallocate road space for more bike lanes (Figure).

Figure A.2.13 Delineator posts and paint buffer, Davis (John Lieswyn)

A.2.6 Longmont, Colorado

Longmont is a city of 100,000 near Denver. In 2018/19, the city experimented with four different types of delineators on Pike Road to assess durability, operations (particularly in relation to street sweeping and snow removal), and user perceptions (City of Longmont, 2019). The spacing of the delineators was also tested at different intervals (7.6 m, 9 m, and 12 m) but no difference was found. The city may consider 30 m spacing for any future installations for maintenance vehicle access. They also tested the BikeRail (a low continuous metal rail) but several bicyclist survey respondents:

> *…felt they were "trapped" in the bike lane and unable to avoid debris or pass a slower bicyclist in front of them. This type of separated treatment would be more appropriate for a two-way cycle track or a wider bike lane that allows bicyclists more room to navigate around obstacles or other cyclists.*

A.2.7 New York City

New York City pioneered quick-build infrastructure starting in about 2000 (Pucher et al., 2010). Many of the cycleway projects have used planter boxes and simple white 'safe-hit' flexiposts (Figure A.2.14). More recently these have included self-watering designs with an internal reservoir and footrests / hold rails, interspersed with yellow metal low 'BikeRail' separators bolted to the pavement as seen in Figure (Vuocolo, 2017).

Figure A.2.14 Temporary cycle track along Allen Street, NYC (L. Thorwaldson)

Figure A.2.15 BikeRail and prefabricated concrete and steel planter box used in New York City (Vuocolo, 2017)

New York City has developed a toolkit to better provide for people on bikes at intersections, including means of separating modes using a flashing yellow arrow to minimise infrastructure costs and delay for all (New York City DOT, 2018).

A.3 Canada

A.3.1 Surrey, British Columbia

In 2021 Surrey, British Columbia, was awarded CD$1M from COVID-19 recovery funds to design six kilometres of quick-build cycle routes in the city centre (Surrey, 2021). The plans for these routes utilise extruded concrete kerbs, planter boxes, flexible delineators, raised landscaped medians, and concrete jersey barriers. The selection of treatments in Surrey was based on the previous decade of using quick-build materials in central Vancouver.

A.3.2 Penticton, British Columbia

For the Lake-to-Lake two-way cycleway along three blocks (600 m) of city centre street, this small city of 33,000 in British Columbia sought a durable separator that could withstand vehicular strikes and snowploughs (Tyler Figgitt, pers comm). They chose the DezignLine BikeRail but found that the plastic posts could not support the weight of their required end marker signs. The sockets accept standard steel posts so those have been used as well. Fewer posts were installed than potentially possible. Vertical metal 'wave' elements and panels were selected to provide visibility, added perceived safety, and better aesthetics than just temporary looking posts alone. Some rails are finished in gloss blue, while most of the rest of the separators are galvanized finish. The cost was NZ$350,000 for materials and NZ$35,000 for installation, which took four days. The city engineer reports good public acceptance and durability.

The BikeRail is used in the three-block central city section, with precast concrete parking stops used as bike lane dividers further along the corridor where the vertical panels are not needed, and amenity is not as high a priority. The re-bar reinforced concrete sections accept surface mounted vertical delineators or have pole sockets pre-cast into the units. They are pinned to the surface and have slots for drainage. These are also used in Vancouver.

Figure A.3.1 BikeRail, Penticton (DezignLine)

A.3.3 Vancouver

The author travelled extensively through Vancouver city in July 2013 when a quick-build cycle network was deployed on major routes in less than one year. The lack of separate turn phases at downtown traffic signals enabled the deployment of simple give way to the cycle path signage rather than having to redesign the signals. Vancouver is using a range of separators including medium height jersey barriers, concrete planter boxes, and pre-cast concrete parking wheel stops. For protected bike lanes added to West 1st / 2nd St between Mackay St and West 3rd St, parking wheels stops were part of the design that won BikeHub.ca's 2020 Infrastructure Improvement Award (Figure A.3.4).

Figure A.3.2 Medium height concrete jersey barriers, Vancouver (Paul Krueger, Flickr)

Figure A.3.3 Concrete planter boxes and give way to cycle path sign at traffic signals, Vancouver (John Lieswyn)

Figure A.3.4 Pre-cast parking wheel stops, delineator posts and planter boxes, Vancouver (BikeHub.ca)

A.3.4 Montreal

In 2020, Montreal rolled out the 112 km 'Network of Safe Active Lanes' (Voies actives securitaires) (Copenhagenize.com, 2020) in addition to 88 km of local streets altered to better cater for cyclists and pedestrians, plus a further 127 km of permanent infrastructure modifications for cycling (Ville de Montreal, 2020). Velo Quebec has issued a guide to temporary measures for pedestrians and cyclists (Velo Quebec, 2020) which notes several potential separator types:

- cones, bollards, or beacons
- temporary metal fencing
- pre-cast kerbs (Figure A.3.6)
- Jersey barriers
- planter boxes (Figure A.3.5)
- repositioning parking lanes (parked cars).

On truck routes, the City of Montreal has decided to used pre-cast concrete kerbs embedded into the road surface at a depth of approximately 200 mm (Figure A.3.6). This no longer accords with the definition of 'quick-build' but is arguably a quicker technique than cast-insitu kerbing. Bollards bolted directly to the road surface have been proven a nuisance, as it is too easy for snow plough operators to hit and destroy them. The solution has been to mount the bollards on top of pre-cast concrete kerb islands.

Figure A.3.5 Quick-build cycleway using planter boxes, plastic bollards, Montreal

Figure A.3.6 Pre-cast kerb installation, Montreal (F. Gosselin)

Figure A.3.7 Plastic bollards on pre-cast kerbs, Montreal (F. Gosselin)

The Canadian Clean Air Partnership summarised available quick-build materials and their approximate costs as listed in Table with prices inflated to 2022 New Zealand dollars (Benni et al., 2019). The table has been further refined with information collected in this research.

Table A.3.1 Summary of infrastructure costs in Canada which are defined as quick-build

Treatment	City	Cost / meter	Significant cost components and notes
Bollard protected cycle track	Toronto	$300	Bollards, pavement markings, signage, and installation
Pre-cast parking wheel stops	Vancouver	n/a	Part of a suite of materials including delineator posts and planter boxes
BikeRail and posts	Penticton	$500	Part of a suite of materials including parking wheel stops laid linearly as bike lane dividers
Adjustable concrete barrier protected cycle track	Winnipeg	$144	Prefabricated concrete barriers, bollards, pavement markings and signage (total cost does not include installation)
Modular planter protected cycle track	Hamilton	$193	Planters, pavement markings, signalization and signage, some bollards and rubber curbs, and street resurfacing
Dedicated painted lane	Victoria	$61	Pavement markings, green conflict zone paint, and signage
Painted through bicycle lane at intersection	Saskatoon	$5	Green water-based paint and white pavement markings (for paint only)
Painted bike box	Quebec City	$31,200 (LS)	Green thermoplastic paint with a skid-resistant surface treatment and white pavement markings
Self-watering plastic planters, flexi posts on low precast kerbs, high precast barriers (keyed in)	Montreal	n/a	Montreal video

A.4 South America

Vecchio et al (2021) have interviewed transportation department staff who worked on the rollout of 'emergency' cycleways in response to the COVID-19 pandemic in five South American cities. Table is based upon Vecchio's work unless otherwise noted. Bogota has had the most ambitious quick-build cycleway programme and has used a range of materials from jersey barriers to yellow kerb blocks with delineator posts at the start of each segment (Wood, 2020).

Table A.4.1 Summary of South American quick-build cycleways

City	Population	Cycle network (km)			Materials
		Baseline	Planned	Quick-build	
Salta, Argentina	533,303 (2010)	70	22	22	Paint and delineator posts
Porto Alegre, Brazil	1,481,019 (2016)	-	4	4	Yellow and white painted buffers
Rancagua, Chile	225,563 (2017)	61[4]	-	58	Armadillos[5] in a painted buffer
Bogotá, Colombia	7,363,782 (2010)	550	364[6]	39 (+ 61 km permanent)	Cones and water filled barriers (emergency lanes) Yellow kerb blocks (Figure)
Mexico City, Mexico	20,892,724 (2015)	-	600 (by 2024)	54 – adjacent to BRT lines	Reused BRT and waste materials, water filled barriers, yellow bollards, paint

Figure A.4.1 Yellow kerb blocks, Bogotá (Flickr account Dylan Passmore)

Figure A.4.2 Jersey barriers and mountable separators, Bogotá (Dylan Passmore)

Of these cities, Bogota may have had the most holistic approach with citywide speed limit reductions, 20% of all parking spaces reallocated for bikes (for the duration of the pandemic), increased car parking charges, and a bike registration drive to combat bike theft (Jaramillo, 2020).

[4] https://www.diarioelpulso.cl/2019/02/06/rancagua-es-la-comuna-con-mas-kilometros-de-ciclovias-en-chile/

[5] https://www.zicla.com/en/200317_ciclovia-rancagua-chile-movilidad-sostenible-2/

[6] https://www.bloomberg.com/news/articles/2020-08-10/to-tame-traffic-bogot-bets-big-on-bike-lanes

A.5 Australia and New Zealand

A.5.1 Auckland

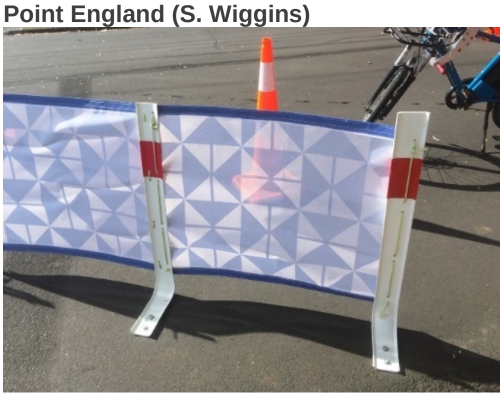
Auckland **pilot** projects include Federal Street, Point England, Quay Street, and the Henderson Streets for People. The latter project web page notes some aspects of this installation ended up being adapted for interim duration (Auckland Transport, 2021). The treatments used included road surface artwork and plastic circular planters (Figure A.5.1) and printed retroreflective mesh (intended to highlight tree planters to vehicles) supported by marker posts (Figure A.5.3).

Figure A.5.1 Armadillos and small planters, Federal Street

Figure A.5.2 Quay Street engagement plan

Figure A.5.3 Wooden sleepers and large planters, Henderson (L. Adam)

Figure A.5.4 Edge marker posts and mesh, Point England (S. Wiggins)



Auckland's **interim** cycleway projects include Carlton Gore Road, Nelson Street, and Ian McKinnon Drive. These use precast concrete kerbs; more detail is provided on page 25.

A.5.2 Dunedin

In 2015 Waka Kotahi started a project to provide one-way separated cycle lanes on SH1 in Dunedin using pre-cast concrete kerbs (Figure A.5.5) and modification of traffic signals. Benefits of this approach included cost saving, time saving and the ability to modify the cycleway easily over time. The designers used six different shapes of the same precast separator to address specific site factors. To minimise maintenance costs and provide a flat surface for kerbs to rest on, the cycleway was repaved prior to installation. Kerbs were finished off with anti-graffiti and slip resistant sealer and colour coded using epoxy in patterns to match Dunedin's precinct themes for added aesthetics. Separators were left unattached to the carriageway for two to three weeks allowing easy modification of their placement based on observed behaviour. Lessons learned included the need to educate and enforce rules associated with the new facility (eg parking restrictions).

Figure A.5.5 Re-cast kerbs, Dunedin, Cumberland Street (source: Waka Kotahi)

A.5.3 Sydney

In 2010, Sydney had a 1% cycle to work mode share, congestion, hostile traffic, and narrow roads (Campbell, 2010). The council approved a plan to aim for 10% cycle mode share, a connected network of separated cycleways, and a suite of complementary actions. The design cross-sections were for 2.4 m wide two-way cycleways on one side of arterial roads, clearly insufficient for higher volumes of cycle traffic and fraught with difficulties at traffic signals and side roads. However, many new (at the time) treatments were included in the design proposal that remain best practice – narrow side road thresholds, bends around bus stops, and use of green colour at conflict points. The current design thinking is reflected in the Transport for New South Whales (TfNSW) Cycleway Design Toolbox.

In response to the pandemic, seven kilometres of separated 'pop-up' cycleways were built in six months by the City of Sydney in partnership with TfNSW after previously averaging two kilometres per year. The pop-up cycleways were built with flag delineators on yellow low plastic kerbs (Transport for NSW, 2020). More information is available from TfNSW including a map of popup cycleways. The City of Sydney is undertaking the community consultation and approval process to replace the temporary pop-up cycleways with permanent designs and materials.

At the end of 2021 the city had 20 km of separated cycleways built. The design principles being applied to reduce project cost are focused on the reallocation of road space and restricting works within the existing kerbs and carriageway width, and the transition away from two-way separated cycleway on one side of the street. This preferred approach avoids major drainage works, particularly at intersections, and provides separation between the cycleway and motor vehicle traffic using intermittent separators.

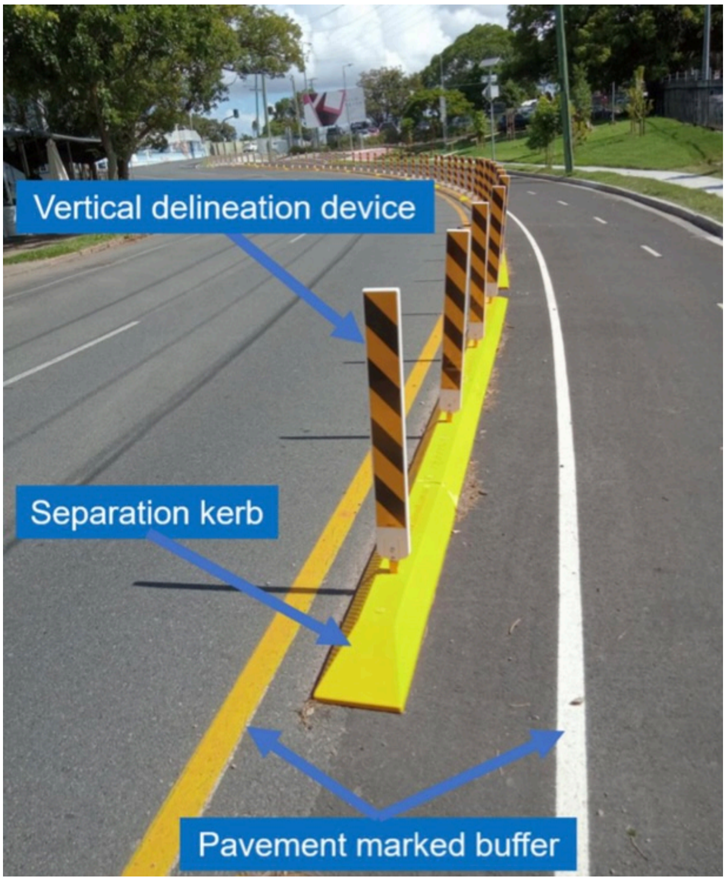
Figure A.5.6 Quick-build cycleway in Sydney (Transport for NSW 2020)

Figure A.5.7 Concrete cubes used to prevent vehicle access to quick-build cycleway, Sydney (Dick van den Dool)

A.5.4 Queensland

The Queensland Department of Transport and Main Roads (Queensland Department of Transport and Main Roads, 2021) undertook an assessment of separators used in two case studies and concluded that the preferred separator is a vertical delineation device on a separation kerb, within a pavement marked buffer (Figure A.5.8). This is similar to the separator used in Sydney.

Figure A.5.8 A vertical delineation device on a separation kerb, within a pavement marked buffer (DTMR 2021)



A.5.5 Wellington

The Wellington bike plan (Wellington City Council, 2021) describes a ‘transition programme’:

> *Our transition programme, led by Wellington City Council and alongside LGWM, will take a new approach to community engagement and installation to help increase the pace of change. By using lower-cost materials that can be adjusted once they are in place, we can install an interim bike network and gain feedback in real time. This will also inform future permanent changes while gaining benefits earlier.*
>
> *We’re looking to make changes around the city from 2022 – protected bike lanes (that can also be used by scooters) with walking and bus improvements where possible and events and community activations. These changes will be monitored and evaluated, then adapted based on insights from data, observations and public feedback.*
>
> *…*
>
> *This approach will mean we can get more of the planned bike network and connections in place relatively cheaply and quickly providing practical solutions for the time being.*

Examples of currently existing quick-build cycleways includes yellow and black kerb separators (Figure A.5.9) and similar mountable treatments (A.5.10).

Figure A.5.9 Wellington quick-build cycleway on Brooklyn Road (source: Bike Plan 2021) p.47

Figure A.5.10 Brooklyn Road Innovating Street quick-build cycleway (p.59)

To support the transition programme, the city procured custom colour deformable posts that are screwed into rubber traffic separator bases (D. Racle, personal communication, 18 February 2022). The posts cannot be unscrewed without tools. The rubber bases are secured with 100 mm pins for shorter durations or 300 mm rebar spikes for longer term use. Each rubber base is 1.0 m long and any number can be connected together. End caps have a mountable chamfer. The lead time for this product was four months. The city chose black posts for aesthetic reasons because white posts show scuffs from vehicular impacts more prominently.

Figure A.5.11 Deformable posts and rubber traffic separators custom made for Wellington (O. McLean)

A.5.6 Christchurch

Most of the 13 Major Cycle Routes (MCRs) are being constructed with more permanent materials (concrete kerbs poured in situ and keyed into the pavement surface). Compared to Auckland, more of the street network is chipseal and this may be one reason why pinned and glued precast concrete kerbs are not as common. For the Ferry Road Innovating Streets project, flexible and wave delineators, riley kerbs, and wood / metal planter boxes were used. All following images on this page were taken by John Lieswyn.

Figure A.5.12 Planter box structure enables drainage and forklift movement

Figure A.5.13 Planter box, stainless insert

Figure A.5.14 Saris Wave separator enables easy able-bodied pedestrian crossing at any point, Ferry Road

Figure A.5.15 Saris Wave is not a hazard if collapsed

Most Christchurch separated cycle lanes use embedded concrete kerbed islands poured in-situ. Where kerbs are not 'keyed' into the pavement surface but simply contain concrete pavers, the islands are frequently displaced by motor vehicles (Figure A.5.16).

Figure A.5.16 Surface mount kerbed island separators are often dislodged, Tuam Street Christchurch (John Lieswyn)

Figure A.5.17 Not 'quick-build': excavation and pouring of separator kerbs, Antigua Street Christchurch (John Lieswyn)

Figure A.5.18 Access control separators lost their flag delineators and have become traffic hazards, Antigua Street Christchurch (John Lieswyn)